HORTICULTURAL DEVELOPMENT IN THE HINDU-KUSH HIMALAYAN REGION

Editor

S.S. TEAOTIA

The present book gives the stage of development of horticulture in the horticultural important countries of the region, viz., India, Pakistan, China (Tibet and Himalayan region), Nepal and Bhutan which were represented at an International Expert Meeting on horticultural development in the Hindu Kush-Himalaya. The themes covered are production and productivity of horticultural crops, diversification of horticulture through ancillary horticultural programmes and marketing and utilisation of horticultural produce. The strategies proposed by different countries for the future may give an important message for the scientific development of horticulture in the region. It also proposes for organising an E.E.C.-type cooperation of the Hindu Kush-Himalaya countries to cover marketing and development of horticulture to meet the demand of the non-temperate region of Asia and western countries.

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Foreword

The unsustainability of agriculture and the pressure of population has increased the importance of horticultural development throughout the Hindu Kush-Himalayan Region. Agro-climatic conditions are suitable for the establishment of various types of horticulture, but its full potential has not been realised because of the various problems faced and the lack of technical back-up or support systems. In the interest of integrated development, and considering the fragile condition of the Himalayan Region, it was considered appropriate to exchange experiences in horticultural development amongst tne countries of the Region. ICIMOD, being the only central agency to monitor the integrated development of the Himalayan Region, organized an International Expert Meeting on Horticultural Development in collaboration with the Ministry of Agriculture/HMG, Nepal, and the Food and Agriculture Organization (FAO) of the United Nations.

The present volume of papers, presented by the horticulturists of the Region at the first International Expert Meeting on Horticultural Development in the Hindu Kush-Himalayas, is important because it records the evolution of the commercialisation of a farming system under fragile and difficult mountain conditions. Although the meeting concentrated more on the stage of horticultural development in each individual country, attention was also given to integrated development, thus covering aspects such as marketing and post-harvest operations. The role of ancillary horticultural activities was also highlighted because of their importance in the context of the small and marginal farms that dominate the Himalayan Region. The unique features of the discussions are well-reflected in the earlier Expert Meeting Summary Report and this volume provides the full and edited versions of the Expert Meeting Papers.

It is hoped that horticultural programmes and information exchange on horticultural development will increase and improve in the best interest of the scientific development of mountain horticulture. In the meantime, on behalf of the joint sponsors of this international expert meeting, I would like to express our thanks to those who contributed country papers and to all those, most notably Dr. S.S. Teaotia of ICIMOD, who have worked hard both in the organization of the workshop and in the arduous but rewarding tasks associated with the editing and publication of the papers presented here. Special appreciation is extended to Prof. L.R. Verma and Mrs. Dr. Uma Partap of ICIMOD for critically reading this manuscript.

I would like to express my appreciation of the efforts of the former Director of ICIMOD, Dr. Colin Rosser, for the efficient organization of the Meeting.

E.F. TACKE
Director, ICIMOD

Preface

The climatic conditions of Hindu Kush-Himalaya are suitable for the cultivation of a variety of horticultural crops such as fruits, vegetables, potatoes, mushrooms, flowers, spices and medicinal plants. So far, only fruits and vegetables and potatoes have been grown for a commercial market, though in a limited area. The numerous small and marginal farmers are yet to be attracted to these crops. The main reason for their reluctance is their lack of resources and know-how.

In certain countries of the Region, with the creation of some infrastructure for the extension and back-up of research, horticulture development has become a sustainable farming system which is supposed to be a basic need for the preservation of fragile mountains. To boost horticulture development, some countries have given it priority in their development plans.

Horticulture development involves heavy long-term expenditure which is not easily available to the developing countries of the Region. However, with the recent availability of resources and the emphasis on systematic development, some successful stories are available for certain crops, which can be profitably repeated in other areas with similar conditions. This would not only save the expenditure of evolving a new technology but also help in the speedy economic development of the area.

This book contains the present status of horticultural development in the Hindu Kush-Himalaya Region. Some of the strategies proposed for the future development may be helpful in the expansion of the programmes throughout the region. Thrust on ancillary programmes has also been highlighted which may create a lot of local employment potential which is specific to the area. The marketing and utilisation aspects, which are the backbone of the economic development of the mountains, have been clearly brought out in the book.

S.S. TEAOTIA

Introduction

The Himalayan region is known to possess the richest flora in the world. Most horticultural species have been in use in various forms for hundreds of years to meet the needs of the people. It was in the last century that, with the expanding population and the consequent need for more food, importance was given to growing more cereal crops. Extensive deforestation caused by the unplanned use of land resulted in serious soil erosion and soil degradation. Now, with the overuse of land, its fertility has depleted and agriculture has become unsustainable in large plants of the Hindu Kush-Himalayan Region.

During the past few decades the importance of horticulture crops has been realised in the Hindu Kush-Himalayas. Promotion of horticulture is included in the national priorities of most of the countries of the region. In additions to refurbishing the mountain economy, horticulture helps to promote environmental conservation in the region. Mountain horticulture also supplements the national food grid by providing fresh and processed fruits and vegetables and nuts. However, due to the lack of a proper infrastructure, difficult terrain, and want of suitable knowledge, proper emphasis has not been given to this important occupation.

Some horticultural crops have very specific agroclimatic and soil requirements. Cultivation is, therefore, limited to certain areas only; the Hindu Kush-Himalayan Region has features that are favourable for the development of certain horticultural crops. There are other crops which have greater adaptability and can be grown in various locations, provided the basic requirements are met wholly or partially, either naturally or artificially.

In the Hindu Kush-Himalayan Region both temperate and subtropical fruits can be grown successfully. In certain areas, even tropical fruits such as mangoes, pineapples, lychees, and bananas are cultivated, but such cultivation is localised. In temperate regions, fruits and nuts; such as apples, peaches, pears, apricots, plums, cherries, walnuts, pecans, hazelnuts, and almonds; as well as berries, e.g., strawberries, raspberries, loganberries, and currants are grown at different elevations. At lower elevations, subtropical fruits, such as citrus fruits, pomegranates, and stone fruits, have been grown successfully.

Temperate fruits have a monopoly in the Region because they can only be grown under temperate conditions and therefore do not compete with the kinds of fruit grown on the plains. Sub-tropical and tropical fruits have the additional advantage of maturing later because of the lower temperatures and, therefore, give a better economic return to the farmer because they can be marketed. It is also observed that hill fruits have a better colour and taste.

Apples and citrus fruits are two important crops which have been cultivated off-season on a commercial scale in the Hindu Kush-Himalayas. While there is emphasis on the cultivation of apples in India (Western and Central regions), Pakistan, and China (Tibetan region), Nepal and Bhutan are preparing master plans for the wide-scale cultivation of citrus fruits in their middle-hill regions. Substantial investments will be required in the initial stages and for maintenance in the gestation period. In certain areas these crops have been planted without considering their all-round requirements, and this has created serious problems, especially to small-scale and marginal farmers.

Besides fruits, vegetable cultivation creates employment and generates income as their cultivation is labour-cum-capital intensive in nature and there are appreciable financial returns. Diverse agroclimatic and soil conditions in the Himalayan mountains are congenial for growing a wide range of temperate and sub-tropical vegetables. Among the temperate vegetables, cabbages, cauliflowers, capsicums, tomatoes, and beans are important crops which have scope for providing "off season" supplies to the plains. Two or three crops can be grown in a year at different elevations. There is also scope for raising vegetable seeds in temperate conditions. There is a selection of good quality vegetables (cabbages, cauliflowers, and carrots [Nantis]) producing better seeds in cool temperate conditions, and the mountain regions are ideal for raising the seeds of these vegetables. There is a great deal of demand for the seeds, both in the hills and on the plains, in winter which is the main season for the cultivation of temperate vegetables in the plains.

There are opportunities for the development of ancillary horticultural crops in the Hindu Kush-Himalayas because of the suitable agroclimatic conditions. In India, floriculture and mushroom cultivation have been given some priority and, in certain areas, they have become popular, although the cultivation of these crops has still to gain impetus in other countries of the region. However, the cultivation of spices and medicinal plants and the practice of apiculture are carried out all over the region with varying degrees of success. There is a need to develop technologies on different aspects of these undertakings before they can be launched commercially.

With the increase in production of horticultural crops, especially fruits, vegetables, and potatoes, marketing has become a serious problem in the Himalayan mountains. The markets are far away from the production areas and the produce has to pass through different types of climates before reaching the market. Marketing of horticultural produce includes not only the commercial transactions of buying and selling but also physical distribution. This physical distribution includes all the handling and forwarding activities such as harvesting, collecting, grading, packaging, storing, and subsequent dispersal through the markets to the consumers. In addition, there are various other auxiliary functions of marketing such as pre-harvest information, market finance and administration, marketing intermediaries, market training, and extension and research.

Fresh fruits and vegetables are perishable commodities and their physical distribution and marketing often cause substantial losses through loss of quality, physiological and pathological spoilage, or due to a glut in the market. These physical losses frequently occur in the countries of the Hindu Kush-Himalayan region because of inappropriate or inadequate application of the correct pre-harvest or post-harvest practices and considerations. Further, there are no official standards for the marketing of horticultural produce. The standard applied to fresh produce can be described as common acceptance of the practice of classifying a product and offering it for sale in context of quality.

The development of horticulture in the Hindu Kush-Himalayas is of recent origin. The technology adopted for the cultivation of different crops is mostly based on technology borrowed from western countries. The agroclimatic conditions in the region are quite different from those of the west. It would, therefore, be appropriate to evolve a suitable technology applicable to local conditions. Some initiatives have already been taken to establish institutes in the Himalayan region which will ultimately cater to regional requirements and address the problems faced by the horticultural industry. However, it would be beneficial if exchange of knowledge in the region took place frequently and if results were made available for implementation in the field.

Against this background, the International Centre for Integrated Mountain Development (ICIMOD), together with the Ministry of Agriculture/Nepal and the Food and Agriculture Organization of the United Nations (FAO), sponsored the International Expert Meeting on Horticulture from 19th to 21st June, 1989, in Kathmandu. The purpose of the meeting was to review the present status, future prospects, and constraints and to suggest sound strategies for the development of horticulture in the Hindu Kush-Himalayas.

The specific objectives of the Horticultural Expert meeting were:

- to facilitate a systematic exchange of experiences in horticultural development in the Hindu Kush-Himalayan region;
- to facilitate discussion on the linkages involved in production and processing technologies, marketing organization and extension services, and the economic management of input supply and marketing systems;
- to assess the environmental issues in large-scale horticultural development in mountain areas; and
- to examine the role of mountain horticulture, within national strategies, as a component of a sustainable farming system.

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Contents

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Expert Meeting Discussions

S.S. Teaotia

Production and Productivity of Horticultural Crops

Regional Overview of Prospects and Problems

The importance of horticultural development is recognized by all the countries of the Hindu Kush-Himalayan region. In India, Nepal, Pakistan, and Bhutan, priority has been given to horticulture in development plans, and this is clearly reflected in their policies and programmes. In China, importance has been given to horticulture in the new Responsibility System and further modifications have been suggested to give horticulture better facilities. The country papers presented emphasized the importance of a scientific approach to the development of mountain horticulture in ultimately checking degradation and promoting environmental improvements.

Climatic conditions are suitable for the cultivation of a variety of horticultural crops, such as fruits, vegetables, potatoes, mushrooms, flowers, spices, and medicinal plants. So far, only fruits, vegetables, and potatoes have been grown commercially. In the fruit category, apple cultivation has received priority in almost all the countries of the region. Apples grow well above 2000 m under rainfed conditions. The Delicious group is the most popular variety. The principal citrus fruits cultivated are mandarin oranges (*Citrus reticulata*) and malta (*Citrus sinensis*).

Large numbers of farmers, in particular small and marginal farmers, are discouraged from growing horticultural crops because of the initial heavy investment required and long crop gestation periods. The amount of investment required to produce apples, oranges, vegetables, potatoes, and ginger clearly indicates that, without institutional credit assistance, small and marginal farmers will not be able to establish and maintain cultivation. In certain regions, along with other facilities, horticultural loans are made available on easy terms at subsidized interest rates and this has encouraged horticultural development. The success experienced by farmers in such regions will, it is hoped, be repeated elsewhere. Nevertheless, land holdings in the mountains are small, and farmers find it difficult to find alternative sources of income during the long crop gestation periods.

In some areas intercropping is recommended for both income generation and improvement of soil fertility. For intercropping, leguminous crops are usually planted. However, where irrigation facilities exist, vegetables can be grown. On flat land, short-term fruit crops, such as guavas, peaches, plums, and citrus fruits, can be grown, especially in sub-tropical conditions. It is essential to remove these plantations before commercial production commences in the main orchard. Intercropping should not interfere with the bearing behaviour of main crops. For example, irrigation during flowering of the intercrop may upset the bearing patterns of some fruits. High humidity at this stage helps spread diseases such as powdery mildew and pests such as hoppers. In some areas, pineapples and bananas are successful intercrops in mango orchards. Use of fertilizers is important, however, because these intercrops are heavy feeders.

At higher elevations, in the temperate regions where orchards are planted on terraces, beans are intercropped both for improved soil fertility and additional income. The crop is harvested and the vegetative growth ploughed back into the soil. As it grows in the rainy season, it does not deprive the fruit of moisture. The management of intercrops is a critical factor in orchard development.

In certain areas, spice cultivation (e.g., ginger) is not economical. Crops cannot compete with those grown in the plains where cultivation costs less and yields are greater because of favourable environmental conditions. Off-season cultivation, a peculiarity of mountain regions, is more lucrative.

Potatoes are an important mountain crop. Hardy disease-resistant varieties have been introduced but cultivation has become environmentally risky because of faulty cultivation. Mountain areas are suitable for cultivation of disease-resistant potato seeds and these are more profitable commercially than table potatoes. In some areas, potatoes are cultivated as cash crops. Other crops, such as mushrooms and flowers, are not popular despite favourable agroclimatic conditions.

The varied agro-ecological conditions, which range from sub-tropical to temperate, soil types permit successful cultivation of almost all deciduous fruits and a wide variety of vegetables and flowers. Seeds of flowers and vegetables are also propagated. However, for commercial purposes it is important to examine the ecological zonation before recommending new crop patterns in the mountains. In some parts of the region broad zonation on the basis of elevation has been recommended and development programmes have been introduced on that basis. This has not been successful in all areas, due to abrupt variations in elevation and temperature of the mountain location. However, while there are other factors that contribute to a low rate of horticultural production regionally, proper zonation for cultivation purposes is an important factor in the success of horticulture. In addition to elevation, for some crops, such as apples, there is a specific chilling requirement and if that is not present the tree will not bear fruit. In recent years, some low-chilling varieties of apples have been propagated for lower elevations (mid-hills) but their quality is not as good. Similarly, there are certain varieties of stone fruits which require specific elevations in order to produce quality fruits.

As far as vegetable cultivation is concerned, there are specific agroclimatic requirements for certain vegetables such as cabbages, cauliflowers, and carrots (v. Nantes), and unless these are met, quality and production deteriorate despite the best management. In the Hindu Kush-Himalayas, there are many varieties growing at the same elevation, depending upon aspect and proximity to the snowlines or river basins. Proper location studies are essential for maximizing horticultural production.

The cultivation of off-season vegetables has increased near the townships in the mountains and in areas from where they can be distributed easily to the plains when temperate vegetables are not available. The mountain sites are also suitable for raising the seeds of vegetables that do not set in the plains because they require a temperate climate. Remote areas that are suitable for vegetables, but are inaccessible, can cultivate seeds, which have high value and low volume. Such areas are ideal for raising hybrid seeds because cross-pollination with other varieties or species can be avoided in the new areas by suitable combinations of crops which are not compatible with each other. There is a specific distance for each crop to eliminate cross-pollination in the hybridization programme.

The yield per unit area is very low in comparison to international standards. The main reason for this is that the strains, or the varieties, earlier introduced did not have yield capacity or resistance to pests and diseases as found in new varieties. Furthermore, there was no research back-up to the programmes and various problems have arisen such as scab disease in apples, brown rot in potatoes, and die-back in citrus fruits. With the establishment of research centres in different regions to handle basic and applied research programmes, it is expected that the serious problems will be resolved. In the meantime, the industry can import modern technology if proper quarantine measures are adhered to.

The importance of post-harvest technology is not realized, and marketing is carried out in a traditional manner either through commission agents or pre-bloom contractors. It is estimated that only about 40 per cent of the produce reaches the consumer and this ultimately affects the income of the grower.

Highlights of Individual Country Situations

India

India has placed great emphasis on the development of horticulture in the Himalayan region, through both state and central departments and agencies. Horticultural development takes priority in policy decisions. Various facilities such as supplies of inputs (plant material and seeds, fertilizers, insecticides, and pesticides) at subsidized rates, long-term loans for plantations on easy terms, and provision of technical services in the production areas are provided to the farmers to encourage horticulture for economic development.

In recent years, the importance of marketing has been realized and integrated marketing programmes have been introduced in the public sectors in Jammu and Kashmir and Himachal Pradesh. In the northeastern region, a cooperative marketing organization has been established. Consequently, a programme of integrated marketing for the hill areas has been established, and it covers all aspects of marketing from quality production to storage and processing. To help farmers in marketing their produce, support prices have been introduced for principal fruit crops in the states of Himachal Pradesh and Uttar Pradesh (hills). This has been a help to this industry, which has been passing through a critical phase due to lack of suitable marketing facilities and systematic support. The problem of packaging is still serious and efforts are being made to find alternatives to wood in order to save the mountain forests.

Research into the development and expansion of horticultural programmes has increased. There are four agricultural universities in the hill regions and horticulture has been given a special place in their programmes. A separate university for horticulture has been established at Solan in Himachal Pradesh and it will handle basic and applied research on all aspects of horticulture. A separate Institute of Horticultural Research has been sanctioned, to be established at Srinagar in Kashmir.

It is expected that in India, by 2000 A.D., apple cultivation will produce 2,000,000 tons.

Nepal

In recent years, Nepal has given importance to the development of horticulture. In the Sixth Plan a clear policy decision was taken and zonation was undertaken for different crop systems. Priority areas have been marked out in the middle hills. There is, however, no research support for different horticultural programmes on the basis of the progress made.

Marketing is the main problem and has not improved in spite of demand for different types of fruits and vegetables in the country. A large quantity of fruits and vegetables are imported into the country, while off-season vegetables and citrus fruits are possible exports (Gurung, Chapter 5).

With FAO assistance, vegetable cultivation has attained importance in the last decade. The main reason for this is the quality seed production project. A new marketing arrangement, under the Kalimati Marketing Project, will encourage the farmers to cultivate vegetables on larger areas. It is estimated that by 2000 A.D., under the Basic Needs Programme, vegetable production will increase and raise rural incomes, improve nutrition, and create export earnings (Rekhi *et al.*, Chapter 6). A master plan for horticultural development is being prepared.

BHUTAN

As in Nepal, little work has been done in Bhutan to tackle production problems of the horticultural industry, due to resource constraints. Bhutan being a land-locked country, emphasis has been given to the cultivation of apples, citrus fruits, potatoes, and other vegetables. By taking integrated farming systems approach, the government is now introducing a programme that emphasizes the role of horticultural crops as a sub-sector of the whole agricultural industry. It has been decided to implement an Integrated Horticultural Development Plan to encompass the different agroclimatic zones of the country (Wangchuck, Chapter 9).

PAKISTAN

In Pakistan, production of horticultural crops is a tradition, especially in Baluchistan and the North West Frontier Province. With the reclamation of land, harnessing of water resources, and the awareness of the nutritional value of fruits and vegetables in the diet of indigenous people, a new dimension has been given to horticultural development. Various schemes have been launched for the production of these crops. However, there is an obvious need for an integrated horticultural programme.

As in other countries of the region, in Pakistan the constraints caused by the lack of modern production technology, the inadequacy of applied research in the field, and inefficient marketing systems are present. The government is now giving high priority to horticulture because of the foreign exchange potential that can be realized by exporting to the Middle East, Southeast Asia, and other countries. It is estimated that because of faulty picking, poor packing and handling techniques, poor means of communication between producing areas and consuming centres, inadequacy of storage facilities, poor marketing information, and outmoded methods in existing market conditions, 25 to 30 per cent of the produce is wasted and written off as post-harvest losses. Recently, a well-coordinated Fruit and Vegetable Marketing and Storage Project has been launched.

CHINA

The Himalayan-Hengduan mountain region of China has an abundance of wild fruits both in the temperate and in the sub-tropical regions. Commercial plantations started after 1950. The major fruits grown are apples and pears. There is no surplus production. It is strongly felt that the government should support collective orchards and also encourage individual cultivation. Encouragement should be given to strengthen the management of the orchards with modern technology. Potatoes and vegetables are also grown for commercial purposes. Tea cultivation has also been introduced into the area. It is suggested that the government give preference in its policies to the development of horticulture in the Responsibility System. Integrated development will take care of marketing and post-harvest operations that are now lacking in the mountains (Zheng Du *et al.*, Chapter 11).

Diversification of Horticulture through Ancillary Horticultural Programmes

The main emphases, throughout the Hindu Kush-Himalayan region, have been on fruits, vegetables, and potatoes. The success of programmes has been variable depending on the existing infrastructure. As most areas of the Hindu Kush-Himalayas are rainfed, the cultivation patterns adopted are based on available technology for prevailing land and climatic conditions.

Crop selection and traditional cultivation practices have caused problems that have a direct bearing on the quality and production of crops. The monoculture of apples and potatoes is responsible for the spread of various pests and diseases. Scab disease in apples is spread due to the continuous cultivation of apples in an area without proper orchard management. Similarly, brown rot in potatoes has spread due to continuous cultivation in the same area, without proper crop rotation, and the introduction of diseased seed material. Abnormal weather conditions, such as spring frost and hailstorms, have also affected the production of apples and other fruit crops. Similarly, the continuous cultivation of citrus fruits is responsible for die-back, due to the incidence of greening virus and other pathological diseases, and this has destroyed the citrus industry in many areas. Further, the heavy initial and maintenance expenditure needed for fruit and vegetable cultivation has discouraged a large number of farmers from making a commercial investment. Avoidance of monocropping and undercropping long-gestation tree crops (such as mangoes) with shorter-gestation fruit crops (such as pineapples, papayas, and bananas) and vegetables, as well as mixed crop combinations, are obvious approaches that can spread the risk and enhance profitability.

The Himalayan mountains are also a source of various genetic resources that can be used for the economic development of the region (Partap, Chapter 13). Some of the material has scope even for solving cultivation problems. For example, rootstock can be used to improve existing varieties by breeding for resistance.

Some crops are found in wild form and with modifications they can be adapted for commercial purposes. In China, Seabuckthorn, a wild shrub, is an excellent source of alcohol, soft drinks, and many other products (Lu Rong-Sen, Chapter 14). It has changed the economy of some areas and its various sub-species can be found over a wide range of climates.

Lastly, cultivation of ancillary crops such as mushrooms, flowers, medicinal plants, and spices, for which the agroclimatic conditions are suitable, can be established with the technology now available. Ancillary crops can become important sources of employment and income generation.

Mushrooms

Cultivated mushrooms are becoming popular and in certain areas they are cultivated under employment programmes with technical facilities and institutional finance provided. The mushrooms thus cultivated are *Volvariell* sp. (tropical paddy straw mushroom), *Lentinus edudis* (shistake), and *Agricus bisporus* (button, a white, European temperate mushroom). *Agricus bisporus* is commercially cultivated in India. Under these programmes young entrepreneurs are given loans, spawn, and pasteurized compost. They are also trained in different aspects of development. This has created employment opportunities. Mushroom cultivation does not require land, which is already a scarce commodity in the mountains. A modern research institute for mushroom cultivation has been established at Solan in Himachal Pradesh and it conducts proper follow-up activities for the programme.

Other countries of the region have not entered the market on a commercial scale so far because of the lack of technology and marketing problems. However, mushroom cultivation could give a new dimension to economic development in the mountains.

Floriculture

Flowers are another well-known resource of the Hindu Kush-Himalayas. Commercial cultivation has not been established because of lack of proper packaging and cultivation practices, scarcity of genuine plant material, and lack of technology for packing and storage. Flowers such as gladioli, roses, carnations, and orchids have export possibilities and their cultivation should be developed.

In certain regions of the mountains, gladioli and tuberoses are grown on a commercial scale and their economic returns are encouraging. Cut flowers are available off-season, when they are not available in the plains. Further, there is a demand for winter flowers in the plains. Some of the demand for seeds is met by imports from western countries, but they degenerate after cultivation in the plains because of the climate. There is, therefore, scope for raising seeds in the hilly regions where the agroclimatic conditions are suitable. There is also scope for raising the bulbs and corms of tulips, irises, lilies, amaryllis, and gladioli for supply to the plains.

Some mountain areas are famous for orchids, but they are not marketed commercially because of a number of limitations, especially lack of proper technology for packing, storage, and transport. In the United States, large numbers of hybrids have been cultivated from material collected from the northeastern region of India. The eastern Himalayan region, which is the home of a large number of orchid species, has been ruthlessly denuded because of indiscriminate collection. It is important that haphazard collection of orchids from the forests be stopped and regeneration maintained.

Agroclimatic conditions are suitable for growing certain kinds of flowers, such as geraniums, roses, and lavender, on a commercial scale for the perfume and oil industries. The quality of products from these plants grown in the mountains is superior and preferred in the market. The income derived from such crops is quite high.

Spices

The agroclimatic conditions in the Hindu Kush-Himalayas, especially in the valley areas, are suitable for growing spices such as ginger, turmeric, onions, garlic, chillies, and saffron. Some of these crops, depending on their marketing potential, have been commercially cultivated. However, some of the spices are also successfully grown in the plains. To be commercially viable, therefore, mountain products have to compete with those of the plains. The cost of cultivation is lower in the plains than in the hills. This is the main reason why spice cultivation in the mountains is not gaining momentum in spite of the emphasis given to these crops. In dry regions, saffron cultivation provides a steady source of income.

Medicinal Plants

The mountain regions of the Hindu Kush-Himalayas contain a large number of medicinal plants. Many plants are used, in both fresh and dried forms, as curatives and preventives for various diseases and ailments. Their importance has, however, increased because of the commercialization of extraction and purification methods. The latter methods are essential for the active ingredients to exert the desired effects. Due to increasing demands for plants that are exploited too drastically without concomitant measures for their regeneration, and because of the depletion of natural resources, the present demands cannot be met. In order to meet the demands of the pharmaceutical industry, efforts are made to preserve plant materials and to cultivate them where facilities are available. In Tibet, the wide use of medicinal plants has encouraged their development and conservation (Yang Yongchang, Chapter 17).

Marketing and Use of Horticultural Produce

Originally, horticultural development in the Hindu Kush-Himalayas was established in an ad hoc manner without considering post-harvest operations and product marketing. Marketing is mostly in the hands of the middlemen or commission agents. These people manipulate operations so that they take the major share of the consumer price. The farmer gets only 20 to 25 per cent of the consumer price and the balance of 75 to 80 per cent is shared by the middlemen. In order to stabilize and enhance agricultural production and income generation in the mountains, marketing must become an important and essential component in horticultural development (Banskota, Chapter 23).

Markets

There are no regulated markets for fruit and vegetables. Transactions are carried out in wholesale markets which are managed and operated by associations, fruit and vegetable merchants, or commission agents. In some wholesale markets, transactions, are carried out by open auction, whereas in other markets they are done 'under cover'. In the prevailing marketing system, neither the grower nor the consumer derives appropriate benefits. If horticulture is to be profitable for growers, and if consumers are to buy fruits and vegetables at reasonable prices, in comparison to the cost of production, then the present marketing system will need revising.

Unless an alternative system is developed, it will be difficult to replace the middlemen who are already entrenched in the fruit and vegetable trade. Marketing perishables is expensive because of the need for facilities such as post-harvest operations, storage, and transport. These are beyond the financial capacity of the individual farmer. At this stage, an alternative to the current system would be to establish cooperative marketing centres for fruit and vegetable farmers and to establish government-run wholesale marketing organizations in different regions. This involves long-term perspectives because of the problems involved in handling perishables. In addition, a price forecasting system for horticultural crops would help stabilize crop production (Nasol, Chapter 18).

Storage

Storage is important for efficient marketing. There should be a definite time for harvesting fruits and vegetables, because after the peak harvesting period the quality and texture of the produce deteriorate. Storage at low temperatures maintains the quality of the fruit for a certain period by retarding the physiological deterioration and reducing water loss (Anand and Grover, Chapter 20). Cold storage removes field heat but is often not viable as the produce will be transported ultimately over long distances to different markets. Field-located cold storage facilities can be used for two to three months of the year. For longer storage periods, facilities have to be located in consumer areas. Such facilities are expensive and require financing from cooperatives or government organizations.

Packaging

Unlike the practices prevalent in the fruit- and vegetable-producing countries of the West, there are no standards concerning types of packaging and methods of packing. Since packaging provides protection, in the absence of established standards, packing with whatever materials are available is not only unsuitable but sometimes even harmful to, rather than protective of, the produce. Packing practices need regulating in size of packaging, structural design, methods of packing, proper cushioning, and stacking durability during transit and storage.

In some areas, the expansion of the horticultural industry in the Hindu Kush-Himalayas has precipitated a crisis. In the mountains, soft woods such as silver fir, and pine (*chir*) are used for packing cases. Silver fir takes about 100 years to mature and pine about 50 years. In India alone, about 0.85 million cubic metres of wood is required annually for packing apples and the demand will increase when additional areas are involved in commercial fruit production. The use of such large amounts of forest timber for packing cases upsets the ecological stability of the mountains and indirectly hampers the growth of the horticultural industry. Various task forces for integrated development in the Himalayas, constituted in India, have made a strong case for the need to preserve the environment and check deforestation. In order to encourage horticultural development and maintain mountain environments, alternative packaging will have to be introduced.

Corrugated board is a satisfactory substitute for packing apples. This can be made of cheaper wood and cellulose waste, is lighter (1.5 kg as against 4 kg for a wooden case), causes much less damage to fruit, is easier to handle, and when printed and coated projects a better product image. Other agricultural waste materials such as paddy straw, wheat straw, scrap wood, and brushwood can also be used in the manufacture of corrugated fibre board. This type of packaging has almost replaced wooden boxes in the developed countries.

Processing

The processing industry plays a significant role in horticultural development because of the quantity of fruits and vegetables absorbed, especially culls that are not marketable because they are over- or undersized. This ensures fair prices for farmers and avoids distress-selling during seasons of plenty and glut. The industry facilitates the economic use of horticultural products in inaccessible areas from where transport of fresh fruit is difficult. On the principle of low volume and high value, concentrates of apples and other fruits maximize the economic returns from horticultural crops.

In India, marketing and processing has been assigned to certain government organizations. These corporations are welcomed by farmers because they have created some infrastructure for grading, packing, and processing and thus helped to improve the quality of the produce. However, due to the rapid expansion of the horticultural sector during the last four decades, the present facilities are unable to cope with demand and the Government of India has launched an Intregated Horticultural Development Project for the scientific marketing of horticultural produce in the mountains.

Similarly, to enhance horticultural development in Pakistan, a Fruit and Vegetable Marketing and Storage Project has been sanctioned. This will establish infrastructural and institutional support systems and is expected to result in a cost-effective marketing system, reduction in wastage, and improvement of product quality. The main emphases will be on the development of wholesale markets, improvement of marketing information systems, and post-harvest technology.

In China, a complete system combining production with marketing, storage, and processing is planned.

In Bhutan, the Master Plan for Horticultural Development covers all aspects of marketing as well as post-harvest operations. The marketing complex at Kalimati, to be created in Kathmandu, Nepal, will provide the modern facilities of a regulated market (Rekhi *et al.*, Chapter 6).

Horticultural Research Requirements

The cultivation technology adopted for various crops is based on technology borrowed from western countries. However, the agroclimatic conditions in the region are different from those of western countries. It would, therefore, be more appropriate to evolve a technology that is suitable to local conditions. Steps have already been taken to establish institutes that will cater to regional requirements. It would also be beneficial for countries of the region to exchange knowledge and compare results on a regular basis. Some of the important problems that need to be solved if the industry is to thrive are as follows.

Fruits

Spur-bearing varieties of apples introduced into western countries have shown more yield potential. These should be introduced to enhance production per unit area. There are a limited number of sweet varieties in the region and, therefore, it is important to propagate sweet varieties that are capable of withstanding the agroclimatic conditions.

Present varieties suit the conditions of the mid-hills (1500–2500 m). Suitable varieties should be propagated in order to use the vast areas above 2500 m and below 1500 m. For lower elevations, low chilling varieties are essential and for higher regions higher chilling varieties are needed. It is important to ensure that the quality of such varieties matches the present quality of apples produced in the mid-hills.

Studies on yield potentials; development of suitable practices in temperate and sub-tropical fruit crops for grafting, budding, and dwarfing; and development of disease-resistant varieties are essential. Before any improved technology is released, performance records should be critically analysed.

The performance of dwarf and semi-dwarf rootstocks for high density plantations needs to be analysed at different elevations before they are recommended to farmers. Since their use has given fresh impetus to the apple industry in western countries, research trials under Hindu Kush-Himalayan conditions should test their local efficacy.

Special attention should be given to walnuts because of their high value for both fruit and timber. They are largely propagated by seed for want of suitable vegetative propagation methods. Vegetative methods could enhance the early ripening and dwarfing structure of the plant and propagation techniques need to be standardized to achieve this objective.

Under the Nursery Act, cultivars resistant to mildew and woolly aphid should be propagated. The work to evolve scab-resistant rootstock for apples should be intensified.

Integrated pest management employing biological control agents for pests of temperate fruits, particularly of apples, should be standardized.

Some basic research should be carried out on crop and growth manipulation, including plant growth regulation, to resolve the problem of biennial bearing and environmental hazards such as early frost.

Vegetables

- Evolve varieties possessing durable resistance to major diseases and insect-pests, particularly curd rot and alternaria blight of cauliflowers, and adaptable to wider areas.
- Develop F1 hybrids in cabbages, cauliflowers, radishes, and turnips.
- Research on seed production and location of new disease-free seed production areas.

Potatoes

- Replacement of the susceptible varieties with blight-resistant, high-yielding varieties, possessing durable resistance.
- Develop brown rot-resistant varieties for hill soils.
- Develop potato-based cropping systems for efficient use of nutrients and to reduce the incidence of soil- and tuber-borne diseases.

Citrus

- Propagation of nucellar lines of citrus plant material for wider use. Improved hybridization techniques would help develop virus-resistant varieties.
- Study biochemical changes in citrus plants because of viruses and die-back disease.
- Programmes for the inspection and registration of viruses from mother-trees need to be revised. In this respect, the study of virus-vector relationships and the sterilization of vectors by eradication techniques will be useful, as well as the induction of resistance against severe strains of viruses by cross-pollination with milder strains.
- Study the causes of decline in yield of citrus varieties and to recommend a suitable course of action.
- Collection of germplasm found in the Himalayan region before it is lest through neglect and indiscriminate destruction of vegetation.

Ginger and Cardamom (Major)

- Develop high-yielding, fibreless varieties of ginger for foreign markets.
- Propogation of high-yielding, virus-free cardamom (major).

Mushrooms

- Develop high-yielding *Agricus bisporus* spawn.

Flowers

Flowers are an important resource in the mountains for which there has been little development. For economic purposes several types of study need to be carried out. Some of the important ones are:

- Enhance storage life of locally available cut flowers. This study will include flowers cut at different stages of their growth and under different climatic conditions.
- Influence of packaging and transport conditions.

Post-harvest Technology

- determine maturity indices and harvesting periods for different fruits and vegetables.
- post-harvest pathology and wastage control.
- packaging practices to suit different commodities, in terms of, structural design, mode of stocking during transit and storage, and provision of proper cushioning to minimize bruising and damage.
- low-cost drying methods, as well as the selection of cheap packing material for dried products.

Conclusions and Recommendations

On the final day of the Expert Meeting, participants were divided into three groups:

Group A: Production and productivity of horticultural crops

Group B: Diversification of horticulture through ancillary horticultural programmes

Group C: Marketing and use of horticultural produce.

Extensive and in-depth discussions took place in all three groups during the final plenary session. The summary of the discussions from each group is as follows:

Production and Productivity of Horticultural Crops

As the cultivation of horticultural crops has developed under different climatic conditions, throughout the countries of the region, these experiences should be exchanged periodically by organizing conferences and publishing reports and periodicals. Visits of orchardists and horticulturalists, from one region to the other, should be arranged in order to exchange views with those engaged in cultivation programmes. The International Centre for Integrated Mountain Development should take the responsibility for organizing these activities.

Arrangements should be made by ICIMOD to replicate the successful experiences with suitable technologies from some countries of the region. This can be done through demonstration effects and by comparing the successes achieved.

There is no data base system for horticulture germplasm in the region and this is a bottleneck in the systematic planning of programmes. Such data base systems should be initiated in the different countries of the region, and information should be exchanged in the interests of horticultural development.

Horticultural programmes are generally launched on an ad hoc basis, without reference to market development and disposal, and this sometimes results in programme failure. Integrated programmes, covering all aspects of horticultural development, should only commence after thorough study. The master plan approach may be a solution to many of the problems occurring after the production stage. Marketing and post-harvest technology ought to be an integral part of such programmes.

Horticultural programmes should be established according to land-use patterns. Proper surveys should be carried out of the areas involved, taking into consideration the elevation, aspects, infrastructure (available or to be developed), and the weather conditions.

Horticultural development should include a proper emphasis on watershed management. Market analyses should be carried out before launching specific programmes. Incentives should be given to encourage farmers (small and marginal farmers in particular) to adopt scientific cultivation techniques.

Traditional crops should not be neglected but, rather, modified by new technologies and by the introduction of new strains and varieties.

Pilot testing should be done in the areas concerned before new technologies and successful examples from other regions are introduced on a commercial scale.

The application of insecticides and pesticides is increasing but their deleterious effects are not known. Proper studies should be undertaken before recommending them to farmers.

In order to introduce planned programmes to achieve the above objectives and conduct periodical evaluations, international support should be sought.

ICIMOD should publish the papers of this Expert Meeting in book form to serve as a reference source.

Diversification of Horticulture through Ancillary Horticultural Programmes

Cropping patterns need to be diversified through the introduction of useful innovations and augmented horticultural activities, sustainability of horticultural activities needs to be enhanced, and diverse biological resources made increasingly available.

The approach to diversification should commence with exploration, development, and utilization.

Emphasis should be given to linking the conservation of genetic horticultural resources with sustainable development in the field.

Research on these resources should focus not only on their identification but also on providing horticultural, genealogical, and biological information about them and assessing their cash crop potential.

In harnessing numerous underused biological resources, the guiding principle should be their potential to relieve the severe problems of mountain regions.

Exchange of information among countries of this region and other mountain regions of the world, as well as the creation of a mountain information network, is needed.

Horticultural, genealogical, and biological surveys should be organized by ICIMOD in collaboration with national agencies.

Specific recommendations were made to establish the following activities on a priority basis for diversification of horticulture in the mountain areas:

floriculture,
aromatic and medicinal plants, and
apiculture.

Marketing and Use of Horticultural Produce

There is a need to develop the concept of marketing as a system, from production to consumption. The shift from subsistence farming to cash crop production depends on the efficient marketing of cash crops.

Proper locational strategies need to be identified for the development of market places in hill districts. The help of disciplines such as spatial planning is required for this purpose.

Supply of price information is an important component for the better organization and grouping of producers. Price systems have an important role to play in the evolution of marketing systems.

Agro-based industries and post-harvest technology have a pertinent role to play in promoting the processing of surplus produce, because of the perishable nature of fruits and vegetables. Agro-based industries also increase off-farm employment opportunities in hill and mountain areas.

Other important aspects of marketing that deserve further attention are: price mechanisms, organization of farmers, and the changing role of the public and private sectors in marketing.

PART 1

Production and Productivity of Horticultural Crops

1

Development of Mountain Horticulture in the Indian Himalaya

R.M. Pandey and S.S. Teaotia

India, the seventh largest country in the world, with a total geographical area of 328.73 million hectares, is ideally suited for growing large varieties of temperate, sub-tropical, and tropical fruits and vegetables, including potato, flowers, spices, and mushrooms. The country can be divided into three well-defined regions (Figure 1.1):

- the Himalaya in the north, from west to east,
- the Indo-Gangetic plains, primarily the basins of three major rivers: Indus, Ganges and Brahmaputra, and
- the Deccan Plateau,

These regions have a typical agro-ecological situation, with wide fluctuations, in temperature, sunshine, relative humidity, and rainfall. Soils of the country are grouped into 27 different types with four groups, alluvial, black, red, and laterite, being the most predominant.

Horticulture covers a wide range of crops: fruits (including nuts), vegetables (including potato), flowers and ornamental crops, medicinal and aromatic plants, plantation crops, spices, and mushroom. The statistics on area and production of horticultural crops, except in the case of banana, onion, garlic, potato, and chillies, which are forecast crops, are not available. The data on these crops are collected by the Directorate of Economics and Statistics of the Department of Agriculture and Cooperation. However, in accordance with the data compiled by the Horticulture Division of the Ministry of Agriculture the total production of fruits at the end of the Sixth Plan period was estimated to be 23.5 million tons, which rose to the level of 26.6 million tons, during the third year (1987/88) of

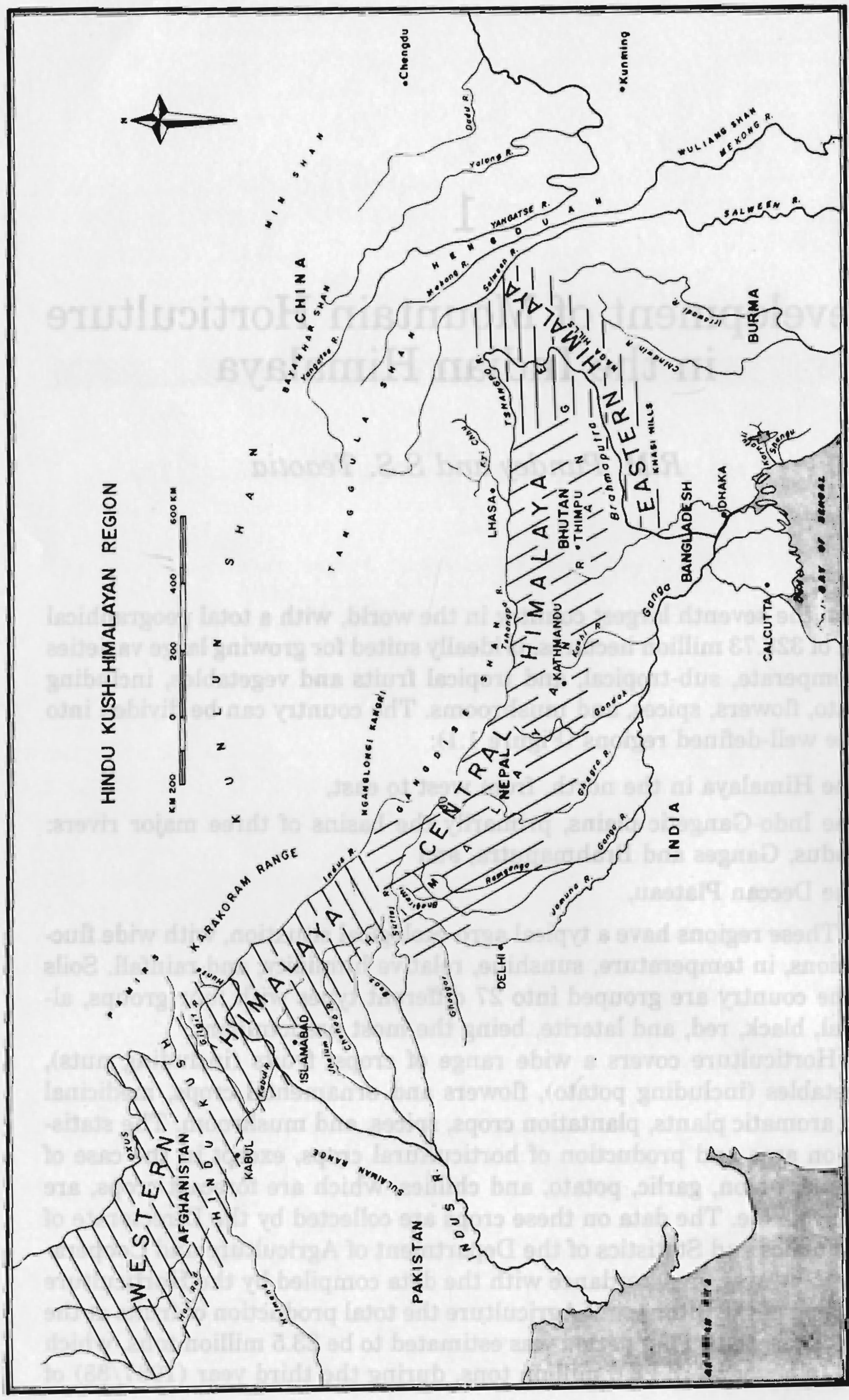

Figure 1.1: Showing different regions of Indian Himalaya

the Seventh Plan against the target of 28.0 million tons (Annex 1). The total production of vegetables in the terminal year of the Sixth Plan was estimated to be 34.0 million tons, which was increased to 48.5 million tons during the third year (1987/88) of the Seventh Plan, against the target of 50.0 million tons (Annex 2).

Productivity of fruits and vegetables, in general (barring grape and potato), is lower than in other developed countries. The overall productivity of fruits is around 9.77 tons/hectare (Annex 3). For example, the average yield of citrus works out to be about 8 to 10 tons as compared to 17 to 30 tons/hectare in Spain, Italy, and Japan, and the yield of pineapple to 15 to 20 tons as against 60 to 70 tons/hectare obtained in the Philippines and Hawaii. In India, the average yield of onion, tomato, and cauliflower is 9.96, 9.51, and 7.33 tons/hectare, respectively. The corresponding world averages are 14.32, 23.49, and 13.52 tons/hectare, respectively. The main reason for low productivity is unorganized orchard and vegetable growing, poor orchard efficiency, old heterogeneous population of trees, poor or low-yielding varieties, multiplication of plants grown of unknown pedigree, and poor quality seeds. The factors responsible for higher productivity, therefore, need greater attention.

The per caput availability of fruits (30 g per day) and vegetables (180 g per day) in the country is far below the minimum dietary standards prescribed by the Indian Medical Association and the National Institute of Nutrition, Hyderabad. In its report the National Commission on Agriculture recommended that the area under fruits be increased to 4 million hectares by 2000 A.D., with the possibility of doubling the average yield by various research and development measures so that the total production of fruit crops could be increased by more than four times. The target for vegetable production under the Seventh Five-Year Plan is around 50 million tons calculated on the basis of 280 g per person per day as recommended by dieticians.

Although horticultural crops occupy around 6.73 per cent of the total cropped area in the country, their contribution to the Gross National Agricultural Output was 18.84 per cent, as per the National Accounts Statistics for the year 1970/71 published in 1986 (Annex 4). In the production of vegetables the country ranks second in the world, next only to China. However, in the production of fruit it has slipped down to third position after Brazil and the United States (FAO Production Year Book, Vol. 41, 1988).

Based on soil and agroclimatic conditions, the country has been broadly divided into the following major agroclimatic zones:

(1) Humid Western Himalayan region, comprising the states of Jammu and Kashmir, Himachal Pradesh, and the hilly areas of Uttar Pradesh;

(2) Humid Eastern Himalayan region and Bay Islands comprising the states of Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Sikkim, Meghalaya, and Andaman and Nicobar Islands;
(3) Humid Bengal, which includes the states of West Bengal and Assam;
(4) Sub-humid Sutlej;
(5) Arid western plains;
(6) Semi-arid plateau and central highlands;
(7) Humid semi-arid western ghats; and

Zones 4 to 7 have not been described since the paper covers only the Himalayan mountain region of the country.

The mountainous region of India consists of two regions:

- *Northwest hill region*, comprising the states of Jammu and Kashmir, Himachal Pradesh, the hilly areas of Uttar Pradesh, Kumaon and Garhwal Divisions (Districts of Dehradun, Tehri Garhwal, Pauri Garhwal, Chamoli, Uttar Kashi, Pithoragarh, Nainital and Almora).
- *Northeast region*, comprising primarily seven states: Assam, Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Nagaland, and Tripura. This region also includes the states of Sikkim and the Siliguri-Darjeeling area of West Bengal.

Horticulture in the Northwest Hill Region

The Himalayan hill region covers more than one-eighth of the total land area of the country, stretching from Jammu and Kashmir in the west to Arunachal Pradesh in the east. The northwest hill region is located between 20° and 36° N, having elevations ranging from 300 to 8400 m above sea level. Some of the areas at the higher altitude are sparsely populated. Basic statistics for this region are given in Table 1.1.

TABLE 1.1
Basic statistics for northwest hill region

State	Population (million)	Total area ('000 km^2)	Area of fruit trees ('000 ha)	Area of vegetables ('000 ha)
J & K	5.98	222	166	15.5
HP	4.28	55	142	40.0
UP	4.84	51	160	51.0
Total	15.10	328	468	106.5

Source: National Horticultural Board, Ministry of Agriculture, Government of India, Gurgaon, 1988.

Fruits

Fruit trees cover about 20 per cent of the total cultivated area of the region. Apple is the major fruit, contributing around 40 per cent of the total area under fruit trees and 80 per cent of the volume of production. The area and production of fruits and nuts in this region are given in Table 1.2.

TABLE 1.2
Area and production of fruit and nuts in northwest hill region

Commodity	Area ('000 ha)				Production ('000 tons)			
	J&K	HP	UP	NWHR	J&K	HP	UP	NWHR
Apple	67	55	51	173	427	259	153	839
Other temperate fruits	9	26	34	69	2	26	61	89
Nuts and dried fruits	55	11	60	143	30	20	128	178
Sub-tropical fruits	35	48	60	143	30	20	128	178

Source: National Horticultural Board, Ministry of Agriculture, Government of India, Gurgaon, 1988.

Vegetables

Almost all kinds of vegetables are grown in this region. However, the important ones are potato, tomato, peas, beans, lettuce, artichoke, asparagus, and cucurbits. Perennial vegetables, because of frequent occurrence of frost, are not successfully grown. Vegetables in the hilly areas are primarily grown as off-season vegetables and are highly priced during that season because they are not available in the plains, the main consuming market. The region is also ideally suited for seed production of different vegetables. Statistics on area and production for individual vegetables grown in this region are not recorded on a regular basis. However, the estimated area and production of vegetables, including potatoes, in this region are given in Table 1.3.

Mushroom Cultivation

Under the diversification of crops in the hills, mushroom cultivation has become popular, especially among unemployed youths. *Morchella* sp. (*gucchi*), *Pleuroties ostreatus*, and *Chanterelle* sp. are the typical mushrooms of the region. *Morchella* sp. has received major attention. It grows in the coniferous forests of high hills at elevations between 2500 and 5000 m above sea level in Himachal Pradesh, Jammu and Kashmir, and Uttar Pradesh (hills). The agroclimatic conditions are also suitable for the cultivation of *Agaricus bispores*, which has been taken up on a

TABLE 1.3

Area and production of vegetables and potatoes in northwest hill region

State	Crop	Area (ha)	Production (tons)	Yield (tons/ha)
J& K	Vegetables	13,600	104,000	7.64
	Potato	1,900	3,300	1.73
H.P.	Vegetables	24,000	351,848	14.66
	Potato	16,750	110,000	6.9
U.P.	Vegetables	37,783	175,719	4.65
	Potato	13,038	233,249	17.89

Source: National Horticultural Board, Ministry of Agriculture, Government of India, Gurgaon, 1988.

commercial scale in all the three major hill states under various programmes. To encourage mushroom cultivation emphasis has been given to training farmers, providing technical guidance, and supplying spawn. Facilities have also been provided to advance loans on easy terms to create the necessary infrastructure. In Jammu and Kashmir, the programme has progressed very well under the cooperative sector. In Himachal Pradesh, small and marginal farmers have been provided with various incentives by way of supplying pasteurized compost and spawn. However, these farmers are facing difficulties in marketing their produce. In Uttar Pradesh (hills) unemployed youths have been encouraged to take up mushroom cultivation and the programme has been very successful.

To boost mushroom cultivation a mushroom development project with collaboration from the Netherlands government has been initiated in all the hill states. The main emphasis has been placed on training and the supply of pasteurized compost to mushroom growers. It is also proposed to introduce high-yielding strains to get better yields per unit area. The necessary infrastructure has been provided for the project in the main mushroom-growing areas.

A National Research Institute on Mushroom Research has been established at Solan in Himachal Pradesh. This centre has helped the hill states to identify technical problems in mushroom cultivation and to suggest corrective measures. It is also an important centre for the production of spawn, supplied to farmers on a no-profit no-loss basis. The Horticulture Station at Chaubattia is also helping farmers by following their technical problems and supplying them with spawn.

Floriculture

The Himalaya are a rich source of flora but, unfortunately, no concentrated efforts have been made to exploit it commercially. In recent years, some attempts have been made to grow gladioli and tuberoses in Uttar Pradesh and Jammu and Kashmir. The cut flowers fetch good prices in Delhi and other big city markets, and they can be supplied in summer when there are no good flowers available in the plains. However, although the marketing of flowers is a serious problem, no systematic research has been done on any aspect of floriculture. It would, therefore, be worthwhile to initiate research on packing and storage, so that small and marginal farmers may be attracted towards this new occupation.

Floriculture has developed specially in the cities of the plains. But it is facing difficulty for want of suitable good seed and plant material. Imported seed material is very expensive and only a few people can take advantage of it. Furthermore, in the plains, it degenerates after some time and the quality of the flowers deteriorates. The climatic conditions of the hill areas are suitable for raising the seed of flowers which can find an easy market in the plains. Large varieties of bulbous plants can also be multiplied under hill conditions.

The northeastern region is a rich source of orchids which has not been commercially exploited. The production of new and attractive hybrids under controlled conditions can give a new impetus to the flower industry.

Spices

The agroclimatic conditions of the Indian Himalaya are suitable for growing spices such as ginger, cardamom, turmeric, onion, garlic, chillies, and saffron. Some of these crops, depending on market requirement have been commercially cultivated. However, some of the spices are also successfully grown in the plains. To be commercially viable, therefore, mountain products have to compete with those of the plains. The cost of cultivation is lower in the plains than in the hills. This is the main reason why spice cultivation in the mountains is not gaining momentum in spite of the emphasis given to it. In one study conducted by the Horticultural University, Solan, it was revealed that ginger cultivation by the farmers in Himachal Pradesh is done at a loss, and the farmer does not count his labour in its cultivation. But an alternative system of farming has not been adopted so far in these areas due to constraints like non-availability of irrigation and climatic conditions. In the sub-arid region of Kashmir valley, saffron cultivation has become a steady source of income for the farmers.

Medicinal Plants

The mountain regions of the Hindu Kush-Himalaya contain a large number of medicinal plants. Many plants are used, in both fresh and dried forms, as preventives for various diseases and ailments. Their importance has increased because of the commercialization of extraction and purification methods. However, there is no regular programme in any of the hill states for the development of medicinal plants. These plants are mostly found growing wild in the forest areas but they are exploited too drastically without concomitant measures for their regeneration. Because of the depletion of natural resources, and the present demands of the pharmaceutical industry, some efforts are being made to preserve plant material.

Apiculture

The Hindu Kush-Himalayan region is a centre for the origin and evolution of honey bees and has the maximum concentration and diversity of biological forms. Apiculture is an old profession in the Indian Himalayan region. With the development of horticulture, mountain beekeeping has attained greater importance since it helps in the better setting of fruits; honey extraction has become of secondary importance.

There are four main species—*Apis cerana*, *A. mellifera*, *A. dorsata*, and *A. florea*—which are found in the Indian mountain region. In the sub-tropical region (300–1500 m), *A. mellifera*, a European species of honey bee, has become very popular and has replaced the native domesticated species, *A. cerana*. The main problem with this species is that it has a tendency to abscond and to swarm frequently. The climate of this zone varies from moderate to extremely hot. In this zone *A. mellifera* and *A. cerana* are kept for producing honey, but for pollination purposes (1350–2000 m), both *A. cerana* and *A. mellifera* are becoming popular. *Apis dorsata* migrate to this zone during the summer. All three species are a good source of pollination in this zone.

The most important area for apple production is the temperate zone. This is the area where the fruit crop is invariably affected by adverse weather conditions. Apiculture with *A. cerana* has attained importance in this zone, because it can withstand the adverse conditions. It is noted that pollination with *A. cerana* not only helps to better set the apple bloom, but also improves the quality and size of the fruit. In the last few years there has been a spread of sac brood virus disease, which has damaged important fauna, and this has ultimately affected the production of apple. In Himachal Pradesh and Uttar Pradesh, for better setting of fruit blossoms, beehives are available on hire from the Department of Horticulture. With the expansion of the horticultural industry, apiculture will play an important role in the setting of fruits and improving the vegetable and flower seed industry. Follow-up research for the proper maintenance of beehives will be essential in the larger interest of the horticultural industry. The state government frequently runs special training courses in apiculture for the benefit of the farmers.

Horticulture in the Northeast Region

The total population of the northeastern region is 26.6 million (1981 census) and agriculture is the main occupation. The agriculture practised in the region is broadly of two distinct types: that practised in plains, valleys, foothills, and terraced lands on slopes is settled agriculture, and the other followed on slopes of all possible gradients is shifting cultivation or 'Jhuming', practised by the tribal people of the hill areas. Settled agriculture accounts for 14 per cent (37 million hectares) of the total geographical area. Banana, pineapple, and mandarin orange are predominant, followed by apple, stone fruits, coconut, mango, litchi, guava, jackfruit, and papaya. Among plantation crops, tea cultivation is an old and established industry. Introduction of coffee and rubber has been successful. Among vegetables and spices, potato and ginger are the major crops, producing a large marketable surplus, followed by chillies, tapioca, sweet potato, and green vegetables.

The region is known as a major centre for citrus, producing about 17 species with 52 varieties. It has been reported that *Citrus limon Burn, C. medica* Linn., *C. gambhiri* Lush., *C. ichengensis* Swingle, *C. Latipes* Tanaka, *C. macroptera* Montr., *C. arsamensis* (a new species), *C. indica* Tanaka, and *C. aurantium* Linn are indigenous to this region. The Indian wild orange *Citrus indica* is found in the Naga Hills and the Garo Hills of Meghalaya.

The total area under fruit cultivation in the region is more than 200,000 hectares (Table 1.4) with an annual production of about 700,000 tons, of which mandarin, banana, and pineapple constitute about 85 per cent in both area and production. In mandarins, the Khasi mandarin, also known as soh-nia-matara, Jatinga orange, Shella orange, Lushia orange, is the main cultivar grown as a seedling on slopes or even steep gradients. Cultivation of the mandarin is distributed among all the states of the region, with Meghalaya leading in area, followed by Manipur. Mandarin plantations were widespread in Tripura, Manipur, and Meghalaya before the partition of the country in 1947, when the trade routes were through the area now in Bangladesh. Now, due to neglect, the orchards do not produce optimum yields. With proper care the yield could reach up to 6 tons per hectare. The Indian Council of Agricultural Research, Shillong, found that the decline in citrus is not due to virus but to the attack of trunk borer (*Monohammus versteegi*) and *Phytoptopthera* root rot to a large extent, accentuated further by attack of powdery mildew, scales, mites, leaf miner, and above all heavy weed growth. However, the greening virus, which is a damaging disease, is also present.

Besides the mandarin, Assam lemon is the other citrus species grown on a commercial scale in the region. The fruit also holds promise for the extraction of pectin, oil, and citrates.

TABLE 1.4

Area and production of fruit and vegetables in Northeast Region

State	Fruit		Vegetables	
	Area (ha, 1986/87)	Production (tons)	Area (ha, 1986/87)	Production (tons)
Assam	102,263	666,979	92,797	384,961
Arunachal Pradesh	10,045	23,629	18,439	64,899
Manipur	17,030	175,260	51,734	4,760
Meghalaya	20,389	172,897	4,827	45,170
Mizoram	3,827	13,944	7,227	57,588
Nagaland	3,248	5,889	2,987	32,477
Sikkim	9,380	16,820	8,950	56,200
Tripura	39,122	279,970	24,700	36,500
Total	205,304	1,363,388	211,661	772,555

Source: North Eastern Council, Shillong (1986).

Pineapple cultivation, like that of mandarin, is old and spread through the whole region, on slopes under rainfed conditions with two cultivars, Giant Kew and Queen. The highest acreage of pineapple is in Meghalaya, Manipur, and Assam. The yield is only 8 to 10 tons against the optimum yield of 40 tons per acre, this low yield being primarily due to low plant population and poor management practices.

Banana occupies the largest area among fruits, occupying 40 per cent of the total area and contributing about 50 per cent of the total production of fruit in the region. However, the yield is very low. The main cultivars are Jahaigi, Malbhog, and Chini-champa.

Under temperate fruits, the species of *Malus*, *Prunus*, and *Rubus* genera are found growing wild. The crab apple (*Malus baccata*) is found growing wild at higher elevations of Arunachal Pradesh. The Shillong plateau of the Khasi Hills, in Meghalaya, accounts for many *Prunus* species, such as *P. nepalensis sev.*, *P. punctata* HK × *P. undulata* Ham., *P. cerasoides D. Don.*, *P. genkinsii H.K.f.* and *Th.*, *P. accuminat* Wall, *P. persica Benth* and *H.K.f*, *P. communis* Hud., and *P. triflora* Roxb. (or *P. salicina Lindl*). Pyrus species like *Pyrus pashia* Ham, *P. pyrifolia var.*, *Culta Nakai*, *P. communis Linn.*, and *P. khosiana* Dene are also found in Khasi Hills and Northeast Manipur district.

Regular cultivation of temperate fruits is confined to higher elevations of Arunachal Pradesh, Meghalaya, Manipur, Nagaland, and Assam Hills. Apple is quite successful in Bomdila, Tawang, adjoining areas of Kameng district and zero area of Subansiri district of Arunachal Pradesh. The fruit quality of apples from Kameng district of Arunachal Pradesh is excellent, with fruit size and colour being quite attractive.

Vegetables

The cultivation of vegetables is very old in the northeastern region. The recorded area under different vegetable crops in the region including tubers, rhizomestus, and bulb crops, but excluding greens, is more than 200,000 hectares with an annual production of about 7,70,000 tons. The other vegetable crops like cole, cucurbits, legumes, and solancens are grown on a limited scale. About 36 different types of vegetables are found growing in the region, which include six species of *dioscorea*, four species of *arum*, and many kinds of bean. In addition, several indigenous vegetables, not common to other parts of the country, are grown for local consumption. These include tree bean (*Parka roxburghii G. Don*), and a tuber crop, *Vigna vixilata*, grown by the tribals of Tripura. The plant produces edible pods like cowpea and underground tubers like sweet potato, both being edible and rich in nutrients. Nodulation is commonly observed on the root system.

Under vegetables, potato is an important crop, grown both in the plains and on the hills in the region. With the introduction of disease-resistant varieties like *Jyoti Kufri*, production is increasing. Ginger is cultivated all over the region. Improved varieties like Maran, Poona, and Nadia have been introduced as commercial plantations.

Marketing

In spite of good potential, the horticultural industry is not doing as well as might be expected for want of proper marketing facilities. Among the horticultural crops, the problem is mainly the disposal of pineapple, orange, ginger and potato. Export outside the region is mainly directed to the Calcutta market, disposed mainly through private traders, who purchase from the farmers either through pre-harvest contract or through spot purchase from village markets.

The cooperative societies organized earlier to market horticultural crops have performed a limited role as they are not active.

The inadequacy of transport facilities in the region is a major handicap to its overall development. At present, the bulk of the foods traffic to and from the region is carried by the railways, while within the region road transport is predominant due to the extensive hilly terrain. Lack of communications and long-distance transport add to the marketing cost of horticultural produce, which ultimately finds it difficult to compete in the open market with the produce of the plains, for example, pineapples from Siliguri and oranges from Nagpur. Furthermore, the post-harvest loss is as high as 30 to 40 per cent for pineapple.

Although there are about 30 processing units in both the public and the private sector, they are small units which cannot compete against produce from the plains. Their cost of production is very high. New units under NAFED management may find some solutions to the problem of use of horticultural produce.

Research Facilities

There is no systematic coverage of research on all aspects of horticulture in the region. The research complex of the Indian Council of Agricultural Research at Gangtok has taken up work on production problems. Some useful recommendations have been released from the regional research station in Shillong on potato. Due to import of plant material from unreliable sources, virus in citrus and pests and diseases in apple have already been introduced into the region, and they are going to be serious problems in the development of these crops in the region.

Commercial Varieties

Commercial varieties of fruits and vegetables grown in the northwestern and northeastern regions are given in Annex 5.

Central and State Sector Programmes

Agriculture including horticulture is a state subject. Till the Fourth Five-Year Plan, the entire attention of the central sector was devoted towards food security, whereas horticulture did not receive any attention. A token provision of Rs. 0.5 million for fruits and vegetables was made during the Fourth Plan period in the central sector. Once the importance of these more remunerative and nutritious crops was realized, central sector allocations were increased subsequently as follows:

Fifth Plan: Rs. 20 million
Sixth Plan: Rs. 86.8 million
Seventh Plan: Rs. 330 million
Eighth Plan: Rs. 2,500 million (anticipated)

Central Sector Programmes

With the meagre allocation in the central sector, only a few developmental programmes could be taken up. The important programmes taken up on fruits and vegetables in this region under the central sectors during the Seventh Plan period are detailed below.

ESTABLISHMENT OF ELITE PROGENY ORCHARDS

A central sector scheme has been implemented through State Farm

Corporation of India from the Sixth Plan period and continued during the Seventh Plan period. It is proposed to continue this scheme during 1990–91 in the Eighth Plan period. The main objective of this scheme is to produce elite planting materials of fruit trees and to generate good quality of vegetable seed. There are 10 farms on which planting materials are being produced covering an area of 500 hectares. Out of this, 464 hectares have already been covered. The scheme has four components: collection block of mother trees, progeny tree testing block, seed garden, and nursery. The nursery has so far produced 265,587 quality plants to be distributed to the farmers.

Improved Technology for Quality Apple Production

A scheme was started in 1983/84 in the states of Himachal Pradesh, Jammu and Kashmir, and Uttar Pradesh to produce quality fruits, increase production, ensure remunerative price to growers, and offer direct employment to unemployed youths through panchayats and cooperatives. Subsequently, Arunachal Pradesh was also included in the scheme.

For controlling insects, pests, and diseases and to maintain good quality, foot sprayers and power sprayers were provided. Foot sprayers were given to individual farmers at 50 per cent subsidy and power sprayers at 50 per cent subsidy to service organizations like cooperatives and panchayats. Under the scheme 6359 foot sprayers, 494 power sprayers, and 1029 anti-hail nets have been distributed. An area of 4200 hectares has also been covered under a micro-nutrient application programme.

Production and Supply of Quality Planting Material of Fruit Trees

The pilot project for production and supply of quality planting material for fruit trees was implemented in 1986/87 for a period of three years. The main objective of the project was to strengthen the infrastructure of fruit nurseries for additional production of quality planting material. Under the project 21 government fruit nurseries in 19 states and union territories have been strengthened for production of an additional 125 million quality planting material per year.

Development of Horticulture in the Uttar Pradesh Hills

The pilot project for development of horticulture in the Uttar Pradesh hills was implemented during 1986/87. The National Horticulture Board provided 100 per cent financial assistance for implementation of this project. The project was implemented for one year only. Its main objective was to demonstrate the technology for grading and packing of commercial fruits grown in the hills, particularly apples, and to ensure timely supply of critical inputs such as fertilizers and insecticides to small and marginal apple growers through the provisions of a revolving fund. The project was implemented by the Directorate of Horticulture and Fruit Utilization, Ranikhet. Financial assistance was provided for construction of five grading and packing sheds and purchase of equipment. The Board also provided assistance for installation of a telex unit at Government Garden, Rudrapur (Nainital) through which daily market information from important terminal markets like Delhi, Bombay, Madras and Bangalore, is collected and supplied to farmers' organizations engaged in the marketing of fruit and vegetables.

Alternate Structure for Marketing of Fruit Juice and Fruit-based Beverages

A scheme for marketing of fruit juice and fruit-based beverages was initiated in 1987/88 for a period of three years. The main objective of the project was to ensure supply of nutritious fruit juices at a reasonable price within the reach of the masses and also to avoid gluts during peak harvest season and ensure remunerative returns to farmers. The project envisages the installation of 600 refrigerated juice vending machines at important locations, initially in cosmopolitan and metropolitan towns, at places which have a floating population: bus stands, railway stations, theatres, cinema halls, and canteens catering to large establishments. During the 1988/89 and 1989/90 period, the Board provided assistance to various organizations for installation of 548 juice vending machines.

Post-harvest Management of Horticultural Crops

A project was started in 1987/88 for a period of four years to strengthen the post-harvest management infrastructure and all its important components except processing. The National Horticulture Board is paying attention to: (1) construction of grading and packing centres for marketing of graded products and store-cum-office for marketing of graded fresh fruits and vegetables for assured supply of critical inputs; (2) supply of recyclable rigid plastic containers and crates; (3) organizing better transportation system; (4) arranging retail outlets to ensure speedy sale and reduce the middleman's margin; (5) development of an appropriate type of cold chain for pre-cooling to ensure retention of quality during transport and adequate storage facility at the production centres to avoid seasonal gluts and distress sale. The benefit of these facilities is being given to organized sectors, namely, cooperative societies, corporate sector and registered farmers, and voluntary organizations and associations of farmers. The Board is providing 50 per cent financial assistance for such facilities. The project has had good response from the cooperative societies.

MARKET INFORMATION SERVICE OF FRUITS AND VEGETABLES

The market information project was initiated in 1987/88 for a period of three years. Now it is proposed to extend the project further during the Eighth Plan period. The group on Perishable Agricultural Commodities headed by Dr. M.S. Swaminathan, in their report, had expressed concern for the urgency of strengthening market information service for fruits and vegetables, where price support operations are not possible due to limited budgetary support. The group had also stressed that such a service should be organized under the aegis of the National Horticulture Board. Therefore, with a view to providing the latest information about rates, market trend, and market behaviour, three markets in the mountain region, Srinagar, Shimla and Guwahati, have been linked to 18 other important terminal markets connected to a computer at Delhi, interfaced with the main computer at the National Horticulture Board, headquarters at Gurgaon. The information is being provided daily through newspapers, All India Radio, and Doordarshan.

PACKAGE PROGRAMME ON PINEAPPLE

A package programme on pineapple was initiated in 1975/76. Its main objective was to improve the production of pineapple and banana by high-density planting. For this purpose, demonstration plots were laid out in farmers' fields with 100 per cent subsidy. The banana programme was implemented in Goa and the pineapple programme in Andaman and Nicobar Islands and Arunachal Pradesh. The size of each demonstration plot for banana was 3.22 hectares and for pineapple 0.4 hectare. For pineapple 900 demonstration plots were laid out covering 360 hectares, and for banana 124 demonstrations were laid out covering about 400 hectares.

INDO-AUSTRALIAN APPLE TECHNOLOGY EXTENSION PROJECT

The apple technology extension project was implemented only in Jammu and Kashmir from 1983 to 1987. The main objectives of the project were: (1) to demonstrate scab control measures; (2) to demonstrate various pruning training methods; (3) to trace and monitor periodic nutrient requirements; and (4) to demonstrate the management and integrated control of insects and pests. An area of 150 acres has been covered under this project.

INDO-ITALIAN PROJECTS ON DEVELOPMENT OF TEMPERATE FRUIT CROPS

The project on development of temperate fruit crops was started in August 1984 in the states of Jammu and Kashmir, Himachal Pradesh, and Uttar Pradesh. It broadly envisaged improvement and development of temperate fruit production, processing and marketing, adoption of imported fruit varieties to local conditions with a special emphasis on olive, and training of Indian personnel on the basis of Italian experience in India by Italian experts. Under the project so far 14,360 plants have been planted in the demonstration plot, of which 5433 are of olive the remaining 8927 are other temperate fruits. Under the project, six trainees, two from each state, have been trained in Italy for six months. Four senior officers, one from each state and one officer from the Ministry, went on a study tour for two weeks. Two persons were also trained in olive oil processing.

INDO-BULGARIAN APPLE TECHNOLOGY PROJECT

A project was initiated in Jammu and Kashmir to improve apple technology with the assistance of the Bulgarian Government. The main objectives of the project were: (1) to introduce high-yielding spur type Red Delicious Apple strains and assorted clonal rootstock for use under high density plantation system; and (2) to develop drip irrigation system to meet the farm requirements and demonstration for its adoption on a large scale. The project envisaged import of improved apple seedlings and rootstocks from Bulgaria for plantation at the pilot project site in Jammu and Kashmir on an area of 50 hectares. Half the area has been covered with grafted planting material of commercial variety Red Delicious from Bulgaria and the other half has been covered with Ambri variety grafted on Bulgarian rootstocks.

INDO-DUTCH PROJECT FOR DEVELOPMENT OF MUSHROOM CULTIVATION

The project was started with the assistance of the Dutch Government in 1986. It is being implemented in Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh and Karnataka. The aims of the project are twofold: to increase the yield of mushroom by improving the quality of compost, spawn, and casing soils and to generate employment opportunities and income for small and marginal farmers. The duration of the project is four years. About 250–300 farmers will be benefited around each centre.

INTENSIFICATION OF VEGETABLE CULTIVATION THROUGH DISTRIBUTION OF MINIKITS

The scheme for intensification of vegetable cultivation through distribution of minikits was sanctioned by the Government of India in September 1985 for a period of two years 1985/86 and 1986/87. Its main objective was to increase vegetable production and popularize high-yielding disease-resistant varieties of vegetables among farmers for increasing yield per unit area. The Board provided 100 per cent assistance for distribution of vegetable minikits, which contain seeds of high-yielding varieties, adequate quantity of fertilizers to cover 1/20th part of an area, and pesticides to control diseases and pests. During that period 178,760 minikits were distributed.

Constraints

The major constraints faced by the horticulture industry in general, and by fruit and vegetable growers in particular, are described.

WEAK DATA BASE

The data base for horticultural crops, including fruits and vegetables, is very weak and no authentic data except that for banana, potato, onion, and some other tuber crops, are available. Because of the lack of data base it is not possible to identify gaps or evolve perspective plans for the development of this industry.

NON-AVAILABILITY OF QUALITY PLANTING MATERIAL

There is an acute shortage of quality fruit and vegetable planting material in India. This problem will be further aggravated if additional area is to be planted. Moreover, uniformity in standardization of rootstocks and of planting material is not being followed. Even the Nursery Registration Act is not in operation in most of the states. The certification of planting material is not being undertaken at all.

LOW PRODUCTIVITY

Productivity of almost all the crops in India (except in the case of grapes), is much below international standards, which adversely affects the income of farmers. The processed food industry has also been making serious complaints about the high cost of raw materials. One of the basic factors contributing to the low productivity, apart from non-availability of quality planting material, is improper agro-techniques or orchard management. Farmers are unaware of the modern techniques, developed within and outside the country. While liberalization of the seed policy will help in overcoming this problem to some extent, other factors affecting productivity should not be lost sight of.

LOW QUALITY OF THE PRODUCE

Because of lack of awareness of appropriate inputs to be made and agro-techniques to be followed, the quality of most fruits is not at par with that of horticulturally advanced countries or the produce of farmers who are well versed in such agro-techniques.

Long Gestation Period and Heavy Initial Investment

Most of the fruit trees grown on a commercial scale have a very long gestation period. In setting up an orchard a heavy initial investment has to be made which is beyond the means of the majority of individual farmers, particularly small and marginal farmers who take up this venture. Fruit growers face financial hardship during the period when the trees are not bearing. Investment has also to be made after the fruit trees have been planted.

High Rate of Interest

The present rate of interest on loan for horticultural crops is around 12.5 per cent. When an orchard is bearing and repayment has to made, the liability of the fruit growers for repayment of the principal amount and interest thereon increases by around 100 per cent. This is a deterrent to the plantation of fruit trees. Most of the state governments also charge stamp duty on the funds borrowed from financial institutions, which further adds to the miseries of farmers.

Inadequate Budgetary Support

Horticulture in general and fruit trees in particular did not receive due attention in the past. Investment in central sectors and in most states is very meagre. In view of meagre budgetary support, very few schemes were taken up for the development of fruit and vegetable crops in the country.

Weak Post-harvest Management Infrastructure

The Group on Perishable Agricultural Commodities, in its 1981 Report, mentioned that post-harvest losses in fruits and vegetables are to the extent of thousands of crores annually because of weak post-harvest management infrastructure. In horticulturally advanced countries even the marketable surplus is used by the processing industry. In India we do not use more than 5 per cent in our processing. The absence of road linkages with market centres and the distant location of orchards further adds to the miseries of producers and increases post-harvest losses.

Inadequate Research and Extension Support

Fruits of different kinds are grown in almost all the states and union territories but extension support at village or block level either is not available or consists of only a skeleton staff. The same is the case at central level.

LAND CEILING

The land laws in India do not permit the setting up of large-scale orchards and do not provide land on lease for the setting up of orchards.

Future Directions

Keeping the above constraints in view, efforts are under way to place the Indian horticulture industry on a sound footing. Some of the steps described below have already been initiated by the government:

(1) Liberalization of import of seed and planting material from anywhere in the world, subject to phytosanitary safeguards.

(2) Placing the food processing industry in Appendix I, allowing entry of multinationals and large industrial houses into the setting up of a fruit processing industry.

(3) Liberalization of import of technology, machinery, and equipment on preferential basis and reduced import levies.

(4) Establishment of 26 agricultural universities, including one specially for horticulture and forestry in Himachal Pradesh. The mountain region, apart from having a horticulture university in Himachal Pradesh, has one agricultural university each in the states of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Assam, and Nagaland and North-Hill University Campus with headquarters at Shillong and stations in almost all the hilly areas of the northeast region.

(5) The All India Coordinated Vegetable and Fruit Improvement Project on major fruits and vegetables grown in the mountain region, already in operation under the aegis of the Indian Council of Agricultural Research.

(6) Setting up of a National Research Centre on Mushroom at Solan, in Himachal Pradesh.

(7) An Integrated Horticultural Development Project for NWHR with World Bank assistance, being negotiated.

(8) Strengthening of the data base.

(9) Regulating the supply of genuine seed and quality planting material in order to increase production and productivity both for local consumption and for export.

(10) Elimination of shifting cultivation in the northeast region.

(11) Encouraging the adoption of modern agro-techniques and strengthening the transfer of technology.

(12) Strengthening of post-harvest management infrastructure.

(13) Developing captive plantations around big processing units for an assured supply of raw materials and markets for the produce.

The following thrust areas have also been identified:

Area Expansion Programme

An area expansion programme is proposed to be taken up for various fruits in areas suitable for growing different fruits. Apart from encouraging the individual farmers to plant more fruits trees, assistance is proposed for bringing an additional area of around 80,000 hectares under fruits which are of commercial importance for export, the processed fruit industry, and the domestic market.

Strengthening Supply of Quality Planting Materials

The Elite Progeny Orchard Scheme, being implemented by the State Farm Corporation of India, is proposed to be continued during the Eighth Plan period also. The existing fruit nurseries in the states are proposed to be strengthened. Assistance is also proposed to be provided for establishing new fruit nurseries. Voluntary farmers' organizations would be encouraged to participate in the efforts of strengthening the supply of planting materials. The need for strict implementation of the Nursery Registration Act and certification of planting material would be impressed upon the state governments.

Increasing Productivity and Quality of Fruit Trees

Major factors contributing to low productivity are: non-availability of quality planting material; unproductive old orchards; non-adoption of improved agro-techniques; insect pests and diseases; uneconomic holdings; and inadequate input supplies. To increase the productivity, the following measures are proposed:

- Rejuvenation of old orchards
- Re-planting of gaps
- Supply of plant protection equipments
- Making available drip irrigation facilities
- Adoption of improved agro-techniques

All these programmes are proposed to be taken up in the central sector through state governments. Besides the major areas indicated above, thrust will also be given to the following areas to put the horticulture industry on sound footing:

- Strengthening of data base
- Increasing producers' share in consumers' price
- Utilization of cull fruits

- Strengthening grading, packing and storage facilities
- Reduction in transit losses
- Export-oriented horticulture estates
- Development of captive plantation for the benefit of both the producers and processors
- Customs services for control of insect pests and diseases
- Supply of maturity kits
- Human resources development
- Setting up of a publication and propaganda unit
- Transfer of technology through training and visits
- Fruit shows, Udyan Pandit competitions, seminars, symposia and workshops

Similarly, the main thrust areas proposed in vegetables during the Eighth Plan period are:

- Production of planting materials
- Area expansion of vegetable crops
- Promotion of Nutrition garden
- Training and publicity
- Intensification of vegetable cultivation around big cities
- Promotion of vegetable cultivation in tribal and non-traditional areas having potential
- Promotion of rainfed cultivation of vegetable crop varieties in peninsular India and hills

In recent years a potential market has developed for flowers in the Middle East, which India could profitably exploit. India has the advantage of growing most of the flowers during winter also. At present there are no centrally sponsored schemes on floriculture in any state. Realizing the importance of floriculture in the country, the working group on horticulture has identified production of planting material and demonstration-cum-training as essential to its promotion.

Introduction of desired varieties from sources within the country and from foreign countries, evaluation of their performance in different agro-climates and rapid and mass multiplication of selected varieties for distribution are necessary. It is proposed to take up this programme initially in nine states during the Plan period. In each state demonstration-cum-training centres may be taken up in a few selected flower-growing states. At each such centre emphasis will be on propagation of selected material for distribution to growers and demonstration of the best agro-techniques for growing flowers. These centres will impart practical training to growers in flower cultivation, post-harvest handling, and packaging.

Annex 1

State-wise area and production of fruits for the year 1987–88

State	Area (in ha)	Proportionate % Share	Production (tons)	Proportionate % Share	Productivity (tons/ha)
Andhra Pradesh	284,720	10.06	3,184,330	11.94	11.18
Arunachal Pradesh	11,130	0.39	26,030	0.09	2.34
Assam	57,410	2.11	621,760	2.35	10.83
Bihar	227,710	8.04	2,232,040	8.07	9.80
Goa (including Daman and Diu)	4,600	0.16	33,800	0.12	7.35
Gujarat	84,000	2.97	1,854,400	6.70	22.08
Haryana	24,570	0.87	380,623	1.38	15.49
Himachal Pradesh	142,000	5.02	309,000	1.12	2.18
Jammu and Kashmir	166,422	5.88	470,754	1.70	2.83
Karnataka	190,586	6.73	2,950,856	10.66	15.48
Kerala	195,820	6.92	893,068	3.23	4.56
Madhya Pradesh	52,068	1.84	733,433	2.65	14.09
Maharashtra	69,890	2.47	1,684,658	6.09	24.10
Manipur	17,730	0.59	175,260	0.63	10.48
Meghalaya	21,935	0.77	190,480	0.69	8.68
Mizoram	3,848	0.14	18,959	0.07	4.93
Nagaland	2,810	0.10	5,880	0.02	2.09
Orissa	146,980	5.19	1,422,020	5.14	9.67
Punjab	56,925	2.01	521,800	1.89	9.17
Rajasthan	16,787	0.59	1,178,760	4.26	70.22
Sikkim	9,450	0.33	19,500	0.07	2.06
Tamil Nadu	119,440	4.22	2,311,900	8.35	19.36
Tripura	35,435	1.25	128,326	0.46	3.62
Uttar Pradesh	779,000	27.51	5,320,000	19.22	6.83
West Bengal	104,451	3.69	932,204	3.37	8.92
Andaman and Nicobar	2,677	0.09	21,086	0.08	7.88
Chandigarh	110	0.00	12,080	0.04	109.82
Dadra and Nagar Haveli	760	0.03	6,890	0.02	9.07
Delhi	29	0.00	150	0.00	5.17
Pondicherry	430	0.02	5,907	0.02	13.74
Lakshadweep	215	0.01	442	0.00	2.06
Total	2,829,938	100	26,648,096	100	9.42

Annex 2

State-wise area and production of vegetables

State	Area (ha)	Proportionate % Share	Production (tons)	Proportionate % Share	Productivity (tons/ha)
Andhra Pradesh	79,958	2.01	705,152	2.03	11.97**
Arunachal Pradesh	18,062	0.44	62,969	0.13	3.49**
Assam	92,979	2.26	384,961	0.79	4.14*
Bihar	844,173	20.49	6,824,401	13.95	8.08**
Goa (including Daman and Diu)	170	0.00	590	0.00	3.47**
Gujarat	88,000	2.14	1,461,000	2.99	16.60***
Haryana	51,887	1.26	621,870	1.27	11.99**
Jammu and Kashmir	15,500	0.38	107,300	0.22	6.92**
Karnataka	169,953	4.12	2,741,691	5.60	16.13***
Kerala	207,740	5.04	3,317,587	6.78	15.97*
Madhya Pradesh	119,636	2.90	2,348,137	4.80	19.63*
Maharashtra	142,980	3.47	858,627	1.75	6.01**
Manipur	51,734	1.26	94,760	0.19	1.83**
Meghalaya	24,327	0.59	301,170	0.62	12.38**
Mizoram	2,110	0.05	6,263	0.01	2.97**
Nagaland	2,988	0.07	32,480	0.07	10.87*
Orissa	685,000	16.62	5,710,000	11.67	8.34**
Punjab	78,200	1.90	1,331,000	2.72	17.02***
Rajasthan	52,100	1.26	158,215	0.32	3.04**
Sikkim	8,950	0.22	56,200	0.11	6.28**
Tamil Nadu	115,627	2.81	2,640,560	5.40	22.84**
Tripura	25,250	0.16	210,500	0.43	8.34**
Uttar Pradesh	1,103,000	26.77	15,985,000	32.67	14.49**
West Bengal	103,500	2.51	1,994,830	4.08	19.27**
Andaman and Nicobar	2,700	0.07	16,200	0.03	6.00**
Chandigarh	NA	NA	1,970	0.00	***
Dadra and Nagar Haveli	1,520	0.04	13,560	0.03	8.92*
Delhi	4,381	0.11	287,642	0.59	65.66***
Pondicherry	709	0.02	12,039	0.02	16.98**
Lakshadweep	325	0.01	368	0.00	1.13***
Total	4,117,282	100	48,588,890	100	11.80

* 1987/88

** 1986/87

*** 1085/86

Source: Ministry of Agriculture, Horticulture Division (1988).

Annex 3

Estimated area, production and productivity of important fruits in India (1987/88)

Area in '000 hectare
Production in '000 tons

Fruit	Area	Percentage of total	Production	Percentage total area	Productivity (ton/ha)	Potential production
Apple	205.4	8.74	1540	4.83	7.5	30.00
Banana	336.61	14.32	8085	25.34	24.02	–
Citrus	279.34	11.89	2940	9.22	10.52	30.00
Grape	8.29	0.78	496	1.55	27.1	–
Guava	191.46	8.14	3390	10.63	17.71	–
Mango	1206.5	51.32	12540	39.31	10.4	30.00
Pineapple	113.3	4.82	2970	9.31	26.21	80.00
Total	2350.9	100.01	31960	100.19		

Annex 4

National income contribution of horticultural crops

Crop	1970/71	1984/85	1970/71
Banana	1,378.9	7,235.94	24.7
Potato	2,423.3	8,410.8	47.1
Chillies	2,295.6	8,167.1	255.8
Tapioca	1,113.0	1,512.7	35.9
Other fruits and vegetables	12,688.0	51,061.2	307.4
Coconut	3,623.2	15,917.0	426.5
Arecanut	688.0	3,975.3	477.4
Cashewnut	305.0	2,080.5	582.0
Pepper	137.0	634.8	363.3
Other spices and condiments	1,770.5	8,925.7	404.1
Tea	1,208.4	8,586.4	610.5
Coffee	604.7	3,187.6	427.1
Rubber	307.7	2,142.2	596.2
	27,943.9	121,836.6	336.0
Total value of agricultural crops	17,564.5	646,734.0	268.3
Percentage of horticultural crops to total agricultural crops	15.91	18.84	

Source: National Accounts Statistics 1970/71 to 1984/85 compiled by the Central Statistical Organization of India.

Annex 5

Important varieties of fruits and vegetables grown in states of the Himalayan Region

A. Apples

1. Himachal Pradesh

   Delicious group, 90 per cent —Red, Starking (Royal),
   Golden delicious,
   Rich-a-Red

   Others, 10 per cent —Red June, King of Pippin, Worcester Pearman (early varieties), Red Gold, Granny Smith, Rust Pippin, Winter Delicious (late varieties).

2. Jammu and Kashmir

   Maharaji (white dotted red), 40 per cent
   Delicious group, 30 per cent
   Kesari, 5 per cent
   American (Apirouge), 5 per cent
   Ambri, 1 per cent
   Others, 14 per cent

3. Uttar Pradesh (hills)

   Red, Starking, Golden Delicious, Rymer, Buckingham, Fanny, Benoni, Early Shanberry, Jonathan, Chaubatia Princess (Red Delicious × early Shanberry).

B. Other Fruits

1. Northwest hill region

   Peach—Elberta, July Elberta, J.H. Hale
   Plum—Santarosa, Mariposa, Greengage
   Apricot—New Casetel, Safeda, Kaisi and Ambrosie, Nari

   Cherry—Red and Black Heart
   Walnut—Mostly plants from seedlings
   Almonds—Thin-shelled, nonpareil

2. Northeast region

   Pineapple—Giant Kew is the major variety. Queen and Mauritius are also grown.

C. Vegetables and Potato

A large number of varieties of vegetables are grown in this region. Certain high-yielding varieties have been identified under the All India Coordinated Vegetable Improvement Project of the Indian Council of Agricultural Research and are given below:

Brinjal—Pusa, Purple Long, Pusa Purple Cluster, PH-4, Pusa Kranti, Pant Samrat, Azad Kranti, Arka Navneet, Pant Rituraj, T-3, Jamuni, Arka Kasumkar, Punjab, Bahar

Chilli—Andhra Jyoti, Bhagyalakshmi, Kovilpatti

Cauliflower—Pusa Deepali, Pant Subhra, Improved Japanese, Pusa Synthetic, Pusa Snowball-1, Pusa Snowball K-1

Carrot—Pusa Yamdagni

French bean—VL-Boni-1

Musk-melon—Hara Madhu, Pusa Sarbati, Pusa Madhuras, Arka Rajhans, Arka Jeet, Durgapura-Madhu

Onion—Pusa Red, N-2-4-1, N-53, Pusa White Round, Pusa White Flat, N-780, N-257-9-1, Agrifound Dark Red, Arka Kalyan, Arka Niketan

Peas—Arkel, Bonneville, Jawahar Matar-1, Jawahar Matar-4, Early December Pant Uphar, P-88

Tomato—Pusa Ruby, HS-101, S-12, Sel.-120, T-1, Sweet-72, Pusa Early Dwarf, Sious, Pusa Gaurav, Pb. Chuhara, KS-2, Pant Bahar

Water-melon—Durgapura Madhu, Sugarbaby, Arka Manik

Garlic—G-41 (Agrifound White)

Potato—Kufri Chandramukhi, Kufri Sandhuri, Kufri Badshah, Kufri Jyoti, Kufri Jeevan, Kufri Deva

D. Spices

1. Cardamom (large), mainly grown in Sikkim:

   Export (1978/88)—154.88 tons
   Value—Rs. 7,021,990

2. Tejpat

   Export (1978/88)—9.00 tons
   Value—Rs. 60,050

3. Ginger

Total production 135,460 during 1987/88 as detailed below:

State	Area (ha)	Production (tons)
Himachal Pradesh	2,050	300
Manipur	350	600
Meghalaya	6,030	30,100
Mizoram	1,240	4,500
Nagaland	170	70
Tripura	720	1,190
Arunachal Pradesh	720	3,600
Sikkim	2,600	12,600
West Bengal	4,690	7,460
Kerala	15,410	42,980
All India	53,690	135,460

Source: Directorate of Economics and Statistics—All India Estimate on Ginger 1987/88.

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Apple Cultivation in India

H. Singh

Introduction

Horticultural development in the mountains in India has been concentrated in the temperate zones for the most part. In fact, horticultural development in these areas is generally considered synonymous with the development of hill fruits, in general, and temperate fruits in particular. This paper, therefore, is primarily focused on temperate horticulture although the observations and recommendations may apply equally to all fruit crops in the region. The Himalayan hill region covers more than one-eighth of the total area of India and makes up the entire boundary of the country running from Jammu and Kashmir in the west to Arunachal Pradesh in the east. It is divided into two distinct sub-regions: the northwest hill region and the northeast hill region (NWHR and NEHR). The NWHR covers the states of Jammu and Kashmir and Himachal Pradesh and Uttar Pradesh hill districts.[1] The NWHR has an area of 324,000 hectares and a production of 948,000 tons. Apple is the most important fruit and the NWHR has 99 per cent of its area under apple cultivation. The basic information of this region is given in Table 2.1. The NEHR includes the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Tripura, and Sikkim. However, most of the NEHR has sub-tropical and tropical fruits. The entire NEHR has only 7469 hectares under temperate and sub-temperate (hill) fruit cultivation and this is distributed as presented in Table 2.2.

In view of the facts explained above, the main focus of this presentation is on temperate fruits, which are primarily confined to the NWHR.

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[1] Uttar Pradesh in this paper refers to the eight hill districts and not the plains areas.

TABLE 2.1

Basic statistics of NWHR

Area	Population (million)	Total area ('000 Kms)	Area under tree crop ('000 ha)	Area under apple ('000 ha)
Jammu and Kashmir	5.9	222	166	67
Himachal Pradesh	4.28	55	142	55
Uttar Pradesh	4.84	51	160	51
Total NWHR	15.10	328	468	173
NWHR as per cent total Himalayan hill region	62	56	76	99

TABLE 2.2

Fruit production in NWHR

State	Area (ha)	Production (tons)
Arunachal Pradesh	4,756	9,500
Manipur	1,750	24,700
Meghalaya	631	3,175
Nagaland	317	830

Source: National Horticultural Board, India, 1988.

However, the technology for development, observations, and recommendations made will apply to the entire mountain region.

Climatically, for the purpose of fruit growing, the NWHR can be divided into four distinct horticultural zones. These are given in Table 2.3.

The suitability of different tree crops to specific areas is governed primarily by climate. In the NWHR the climate can change within short distances because of the abrupt change in elevation or proximity to the plains or to snow-covered peaks. Although total rainfall in the NWHR is good, distribution is such that moisture stress is often experienced at critical stages of fruit growth. Almost all the orchards in Uttar Pradesh about 80 per cent of those in Himachal Pradesh, and 60 per cent in Jammu and Kashmir are rainfed. It is estimated that of the total area of 468,000 hectares under tree crops in the NWHR, about 80 per cent is subject to moisture stress at some time of the year.

The expansion of tree crops was rapid in this region and by 1985/86 they covered about 20 per cent of the cultivated area. The state-wise figures are presented in Table 2.4.

A part of the area under tree crop cultivation has been diverted from grasslands, wastelands, and even cultivable wastes. Therefore, the percentage figures for the cultivated areas are just a rough indicator. The exact figures for the cultivated areas that have been diverted to horticulture are not available.

TABLE 2.3

Annual rainfall and important fruits of different zones

Zone	Annual rainfall (mm)	Most significant fruit crops
Temperate zone: high hills with low winter temperatures, experiencing snowfall.	600–1000	Apple, pear, cherry, walnut, almond, and chestnut
Dry temperate: high elevations very cold in winter, very little rainfall.	130–300	Apple, grape, prune, and drying varieties of apricot. These can be grown if irrigation is available.
Sub-temperate: hills lower than in the temperate zone; winters are less cold (no snowfall).	800–1000	Stone fruits such as peach, plum, apricot, almond, pear, pecan, nuts and olive.
Sub-tropical: low hills and valleys adjoining plains.	800–1000	All sub-tropical fruits such as mango, citrus, guava, oriental pear, fig, and grape

TABLE 2.4

Area under tree crops in NWHR (1986/87)

	Jammu and Kashmir	Himachal Pradesh	Uttar Pradesh	Total NWHR
Cultivated area ('000 ha)	817	601	698	2116
Area of tree crops ('000 ha)	166	142	162	468
Per cent under tree crops	20	23	23	22

Source: National Horticultural Board.

In most of these areas there is severe degradation of land. Many hills are devoid of vegetation, others have no soil and still others have only a thin layer of soil, which is also in the process of being washed away. Therefore, the resources are shrinking. The implications for crop production (or productivity improvement) of this fragile ecological base have not been given serious thought. Many people believe that overexploitation of forests and vegetative cover has adversely affected the weather, that there is less rain and more hail and frost whereby the conditions for fruit growing are becoming more unstable.

Status of Horticulture in NWHR

The holdings are small and are being further fragmented. The per caput holding in Jammu and Kashmir is 0.15 hectare and in Himachal Pradesh and Uttar Pradesh it is 0.14 hectare. Such small parcels of land are not productive enough to meet the cost of basic needs such as food and clothing. Therefore, the cultivation of high-value, labour-intensive tree crops has been encouraged in the region. Holdings that are very small require a different dimension of horticultural development.

The agroclimatic conditions of the NWHR are eminently suited to commercial cultivation of a large variety of temperate, sub-temperate, and sub-tropical crops. A tremendous expansion in area and production has taken place during last two decades. Apple is the predominant crop and accounts for 40 per cent of the total area and 80 per cent of the production. The area and production of different tree crops in the NWHR is given in Table 2.5.

TABLE 2.5

Area and production of fruits and nuts in the NWHR

Commodity	Area ('000 ha)				Production ('000 tons)				Yield T/ha
	J & K	HP	UP	NWHR	J & K	HP	UP	NWHR	
Apple	64	50	49	163	760	175	165	1100	6.5
Other temperate fruits	04	24	32	60	6	21	51	78	1.3
Nuts and dried fruits	50	10	13	73	16	2	8	26	0.35
Sub-tropical fruits	30	36	54	120	10	10	126	146	1.21
Total	148	120	148	416	792	208	350	1350	

Note: Figures relate to 1985/86 for J&K and UP and 1984/85 for HP.

Out of the total production of 1.34 million tons, apples alone account for 1.1 million tons, which is about 81 per cent of the total fruit production in the region. In the states, apples constitute 43 per cent of the area and 96 per cent of production in Jammu and Kashmir; 42 per cent of the area and 84 per cent of the production in Himachal Pradesh; 33 per cent of the area and 47 per cent of the production in Uttar Pradesh. Comparative figures of area and production of other fruits are presented in Table 2.6.

TABLE 2.6

Percentage of area and production of different fruits in each state in the NWHR

Commodity	Area ('000 ha)				Production ('000 tons)			
	J & K	HP	UP	NWHR	J & K	HP	UP	NWHR
Apple	43	42	33	39	96	84	47	81
Other temperate fruits	3	20	22	14	1	10	15	6
Nuts and dried fruits	34	8	9	18	2	1	2	2
Sub-tropical fruits	20	30	36	29	1	5	36	11

The major emphasis in the region has been on apples. The development of other fruits has been generally neglected. As a result, those areas suitable for growing other temperate fruits and sub-tropical fruits have not received the attention they deserve.

Apple Plantation

There has been a rapid expansion under apple cultivation in the NWHR. From 1975/76 to 1985/86, cultivated areas increased by about 50,000 hectares and the average annual rate for the decade was 5000 hectares. Himachal Pradesh increased the area by 19,988 hectares from 1965/66 to 1975/76. Uttar Pradesh increased its area by 19,240 hectares. The progress of apple plantation on the region is presented in Table 2.7.

TABLE 2.7

Progress of Apple Plantation in NWHR (area in ha)

Year	Jammu and Kashmir	Himachal Pradesh	Uttar Pradesh	NWHR
1950/51	NA	400	NA	
1955/56*	NA	1,023	NA	
1960/61**	NA	3,992	7,540	
1965/66	NA	15,088	12,260	
1970/71	NA	26,735	19,600	
1975/76	47,342	35,076	31,500	113,918
1980/81	60,286	43,331	40,000	143,617
1985/86	63,796	51,400	48,700	163,896
1986/87	67,031	52,399	49,924	169,154
1987/88	67,402	54,912	57,148	173,462

*relates to 1961/62

**relates to 1966/67

NA not available

Apple Production

In India apple production increased tenfold from 1966/67 to 1984/85. Production figures from 1966/67 to 1987/88 are given in Table 2.8.

Production, has, by and large, increased on account of expansion in the area. As is evident from the figures for Himachal Pradesh there have been considerable fluctuations. Production, in terms of yield increase, has not been impressive. Except for the last two years in Jammu and Kashmir, where the average yield has increased by 18 per cent to 30 per cent, there has not been much impact on yields. For instance, three years of moving averages (up to 1985/86) for the last 10 years in Himachal Pradesh were 7.7, 6.4, 5.4, 7.0, 6.6, 7.8, 5.9, and 6.0 tons/hectares. Yield per hectare is the real indicator of the efficiency of management in orchards. One of the most important aspects of tree crops in the region

TABLE 2.8

Apple production in the NWHR ('000 tons)

Year	Jammu and Kashmir	Himachal Pradesh	Uttar Pradesh	Total NWHR
1966/67	50	26	21	97
1970/71	157	76	40	273
1971/72	213	98	46	357
1972/73	230	30	53	313
1973/74	205	113	61	379
1974/75	362	43	70	475
1975/76	328	200	68	596
1976/77	311	119	NA	—
1977/78	348	131	NA	—
1978/79	450	121	NA	—
1979/80	463	135	NA	—
1980/81	562	118	95	795
1981/82	523	307	120	950
1982/83	471	139	130	740
1983/84	642	258	NA	—
1984/85	672	171	155	998
1985/86	760	175	165	1100
1986/87	724	259	165	1148
1987/88	427	179	165	771

Source: National Horticultural Board, Government of India.

should be stability of production along with increased yield per unit area. Apple yields in the three states of the NWHR are given in Table 2.9.

TABLE 2.9

Yield of apples in the NWHR

Year	Yield (ton/ha)		
	Jammu and Kashmir	Himachal Pradesh*	Uttar Pradesh**
1975/76	7.35	15.73	2.70
1976/77	6.40	7.83	NA
1977/78	6.96	7.48	NA
1978/79	8.70	6.03	NA
1979/80	8.77	5.77	NA
1980/81	8.90	4.41	2.76
1981/82	8.13	10.84	3.57
1982/83	7.03	4.48	3.69
1984/85	10.12	5.07	4.04
1985/86	11.92	4.98	4.24
1986/87	10.80	9.20	4.26
1987/88	6.30	4.72	2.80

*Assuming the previous 10 years were without harvest.

**Assuming 25 per cent of the area is without harvest.

Source: National Horticulture Board, Government of India.

The yields presented in Table 2.9 are much below the international standard of 30 tons/hectare. There is, therefore, considerable scope for improvement. Yields in Uttar Pradesh are the lowest and range from 11 to 17 kg per tree (250 trees per hectare). The yields in Himachal Pradesh have failed to equal the level of 1975/76. Many factors are responsible for this, e.g., unfavourable weather conditions, rapid expansion, plantation in marginal areas, lack of proper orchard management and inadequate fertilizer. These factors apply to other states also. The yield per tree in Himachal Pradesh ranged from 63 kg in 1975/76 to 20 kg in 1985/86.

In Uttar Pradesh a substantial number of orchardists are absentees. There is great variation in yields among districts (450 kg to 7000 kg/hectare), indicating the difference in level of management and perhaps also agroclimatic conditions. This variation is presented in Table 2.10. It is essential to analyse the factors responsible for low productivity and to take remedial measures.

TABLE 2.10

Variation in production and yield in Uttar Pradesh hills

District	Area (ha)	Production (tons)	Average yield (ha/ton)
Nainital	11,622	71,500	6.15
Almora	7,300	26,500	3.60
Pauri	6,300	5,000	0.79
Tehri	6,450	11,500	1.78
Uttarkashi	5,808	11,500	1.98
Pithoragarh	4,420	31,000	7.00
Chamoli	3,500	6,500	1.97
Dehra Dun	3,300	1,500	0.45
Total	48,700	16,500	3.39

Source: Department of Horticulture, Uttar Pradesh Government.

The Agro-Economic Centre of Himachal Pradesh University has conducted several studies on yields. In one study it was found that the yield was only 4.23 tons/hectare under 10 years of age, 14.90 tons/hectare for those between 10 and 15 years. The average of all years was 14.23 tons/hectare (Plantations were only of seedling rootstocks). This shows that it takes about 15 years for the full development of a tree. Until then the planting space remains vacant. Therefore, efforts have to be made to attain full bearing area in the shortest possible time. High density plantations need to be given special attention. Local requirements must be kept in mind when selecting rootstocks and scions.

Potential

During these studies (NWHR horticultural review field trips), a number of orchards with yields ranging from 30 to 60 tons/hectare were seen. These included both private and government stations. The Agro-Economic Centre's studies also show yields of up to 23 tons. Fertilizer (NPK) trials in Chaubattia in the UP hills showed a yield of 22.5 tons. This aptly demonstrates, that, given better management, there is a potential for improvement.

At the Regional Fruit Research Centre, Mashobra, Himachal Pradesh, a 15-year trial on the performance of 13 varieties of apple revealed that Red Delicious gave the highest average yield of 102 kg per tree and 25.5 tons/hectare. These results were achieved despite the fact that Mashobra is considered to be an unfavourable zone for tree crops because of the frequent occurrence of hail, frost, and strong winds. The results are presented in Table 2.11.

TABLE 2.11

Comparative performance of apple cultivars, Regional Fruit Research Centre, (Himachal Pradesh)

Name of Cultivar	15-year kg/tree	Average yield (tons/ha)
Red Delicious	102	25.5
Royal	102	25.5
Allington Pippin	100	25.0
Red Gold	82	20.5
Lord Lambourne	70	17.5
Tydeman's Lali Orange	68	17.0
McIntosh	65	16.25
James Grieve	62	15.4
Golden Delicious	60	15.0
Northern Snap	60	15.0
Tydeman's Worcester	41	10.25
Granny Smith	25	6.25
Rome Beauty	25	6.25

Role of Proper Management in Production and Returns

Trials conducted at the Horticultural Station, Chaubattia, Uttar Pradesh showed that balanced doses of fertilizer (300 g urea, 200 g DAP, and 500 g N and P per tree) increased the yield by 400 per cent and the colour by 100 per cent (The colour red attracts consumers and determines the price of the apple.) There was also improvement in T.S.S. and sugar. The results are given in Table 2.12.

The need for application of balanced doses of fertilizer cannot be overemphasized. Improper fertilization is one of the important contributing factors to low productivity in existing orchards.

Under the Indo-Australian Apple Project in Jammu and Kashmir, Australian experts used an area of 4 ha with 1257 apple trees to demon-

TABLE 2.12

Impact of fertilizer on yield (Uttar Pradesh)

Treatment	Year kg	Yield (full)	Colour (per cent)	Sugar (per cent)	T.S.S. (per cent)	Acidity (per cent)
Fertilizer application	I	96.3	79.5	11.58	13.0	0.248
	II	109.2	71.0	11.22	13.0	0.241
	III	62.2	85.3	12.79	13.0	0.268
	Average	89.4	78.6	11.86	13.0	0.250
Control	I	19.2	58.0	10.28	12.0	0.295
	II	30.5	30.5	9.82	11.0	0.268
	III	11.0	32.0	10.37	12.0	0.268
	Average	20.2	40.2	10.57	11.7	0.277

strate convincingly the impact of improved orchard management on the production and quality of fruits. The trees belonged to 13 farmers. Out of 1237 trees, 945 (67.4 per cent) were of large size, 183 (14.8 per cent) of medium size and 109 (8.8 per cent) of small size. The following treatment was given for three years:

- Two doses of fertilizer in March-April and after the harvest.
- Winter pruning.
- Ethrel spray for thinning.
- Scab spray (6–7) at 10- to 14-day intervals, commencing from the time the green shoots appear and continuing until the end of June.

The results obtained from this treatment are given in Table 2.13. Results have been analysed for the years from 1983 to 1985. The figures for 1982 have not been included because production during this year related to bud formation in 1981, prior to the commencement of imported husbandry practices. Gross income varied from Rs. 44,000 in 1981 to Rs. 141,000 in 1984, with an average gross return for 1983–1985 of Rs. 108,500 for the whole block (Rs. 27,167/hectare). The average net return per hectare comes to Rs. 11,667. There has been a slight increase in yield from 625 to 744 boxes per hectare. The average increase in gross income is 146 per cent (from Rs. 11,000 per hectare in 1981 to the 1983–1985 average of Rs. 27,167), compared to an increase in yield of only 19 per cent. Thus the major benefit has come from improvement in the quality of fruit. However, there is still considerable scope for increasing production when we compare the apple yields in areas with similar natural resources. Whereas the response to quality improvement techniques in disease-affected fruit (e.g. scab) is rapid and can be achieved in one year, the yield response to improved husbandry takes longer for tree crops.

TABLE 2.13

Indo-Australian apple technology and extension project orchard management field demonstration

Year	Cost	Total production (20 kg boxes)	Total gross return (Rs.)	Total net return (Rs.)	Production per ha (20 kg boxes)	Hectare gross return (Rs./ha)	Hectare net production
1981		2,510	44,000	625	11,000		
1982	14,800	1,761	44,000	29,200	440	11,000	7,300
1983	34,000	3,358	79,000	45,000	840	19,750	11,250
1984	79,000	3,650	141,000	62,000	912	35,250	15,500
1985	73,000	3,127	106,000	33,000	782	26,500	8,250
Total: 1983–1985	186,000	10,135	326,000	140,000	2,534	82,500	35,000
Annual Average 1983–1985	62,000	3,378	108,667	46,667	844	27,187	11,667
Increase throughout 1981 (base yr.)	NA	878	64,667	NA	219	16,167	NA

The average yield for the three years from the other demonstration plots is approximately 17 tons/hectare. The maximum average annual yield from the plots was for 18 tons/hectare in 1984, compared to the state average of almost 12 ton/hectare (an increase of 50 per cent). Studies conducted on the plots of 42 different farmers in different areas throughout Himachal Pradesh have revealed that yield increase with modern technology can be as high as 225 per cent more than the yield procurement from traditional management techniques. The results have shown that modern technology improved yields by 50 per cent (more than traditional management) in 33 per cent of the plots, 20–50 per cent in 36 per cent of the plots, and less than 20 per cent in 32 per cent of the plots.

Production per unit area of the existing plantations can be doubled if orchard management is improved. During the next five years Jammu and Kashmir should aim for a yield of 18 tons/hectare; Himachal Pradesh should attempt to achieve at least the 1981/82 level; Uttar Pradesh should make efforts to achieve 6 tons/hectare, which is the present level of the Nainital District (6.15) and Pithoragarh (7.00). All three states should review their targets in 2000 A.D. Some indication of the projected targets has already been given. They are 3.61 tons/hectare for Uttar Pradesh, 7.5 tons/hectare for Jammu and Kashmir. The actual position as projected in Table 2.14 needs improvement in production and yield. This will be the major factor in improving the returns of the farmers as there will be limited scope to decrease the cost of marketing and to increase gross sales.

TABLE 2.14

Apple production and productivity 1985/86–2000

State	Area ('000 ha)		Production ('000 tons)		Yield (tons/ha)	
	1985/86	2000	1985/86	2000	1985/86	2000
J & K	63.8	77.8*	760	1000	11.9	12.8
HP	51.4	73.8	175	557	4.3	7.5
UP	48.7	67.4	165	244	3.4	3.6
NWHR	163.9	219.0	1100	1801	6.7	8.2

* The figures for Jammu and Kashmir for 2000 are a rough estimate based on the increase from 1984/85 to 1989/90. The projections for yields and production need to be upgraded as suggested in the text.

Improvement of Quality

It has been seen that balanced nutrition and scientific orchard management improves the quality of the fruit and the return on it. The impact of these two factors and disease control is illustrated below:

Particulars	Quality grades (per cent) *A*	*B*	*C*
Good weather (J & K)	10	25	65
Good weather (HP, UP)	20	30	50
Bad weather, no disease (scab) control	2	2	96

These figures are based on general observations and discussions during field visits. In Uttar Pradesh about 50 per cent of the fruit is packed in boxes and the rest is marketed in gunny bags. Among a variety of reasons given for this practice is that of poor quality. These estimates may be somewhat high but the proportion of poor quality fruit is indeed large. The quality can be substantially improved and gross sales can be increased connsiderably.

Improvement in Size Grades

By and large about 10 per cent of the fruit on an average tree (at present) is super and extra large, 65 per cent large and medium, and 25 per cent small and below. Average proportions of different grades, as calculated in Himachal Pradesh, are given in Table 2.15.

TABLE 2.15

Average production of size grades (Himachal Pradesh)

Size grade	Size (mm diameter)	Percentage	
Super large	85	2	10 (I)
Extra large	80	8	
Large	75	22	65 (II)
Medium	70	43	
Small	65	18	25 (III)
Extra small	60	3	
Pitto (very small)	55 and below	4	

The maximum income comes from group II (large and medium, 65 per cent). The upper group I (extra large and super large), though attractive, gets damaged in handling. However, its percentage is likely to remain stable. It is the third group (25 per cent) which should receive special attention as far as reductions in percentage are concerned. This can be done with better orchard management, canopy management, thinning, and application of fertilizer related to load of crop. At least 50 per cent of this group could be upgraded to group II bringing the total yield of group II from 65 to 77 per cent.

Apple Varieties

At present the Delicious group of apples dominates production. These account for about 45 per cent of the yield in Jammu and Kashmir, 83 per cent in Himachal Pradesh, and 30 per cent in Uttar Pradesh. The status of different cultivars in NWHR is as indicated in Table 2.16. The distribution by variety in Jammu and Kashmir, Himachal Pradesh, and Uttar Pradesh is given in Tables 2.17, 2.18, and 2.19.

The region as a whole has to look for a strategy for future plantations, so that the harvesting and marketing operations overlap to the minimum extent possible. At present only 10 per cent of the total production of the NWHR is early (June and July), 75–80 per cent is mid-season (August, September and part of October), 10–15 per cent is late (latter half of October and November). There is scope for increasing harvest in the early and late seasons so that there is the minimum possible pressure during mid-season, or main harvest seasons, when gluts are the order of the day. The possibility of diversification of varieties, by harvesting 25 per cent in early season, about 55 per cent in mid-season, and about 20 per cent in late season, should be explored for the region as a whole. The marketing period can be extended by means of cold storage facilities.

TABLE 2.16

NWHR share of apple varieties

Variety	Area (ha)	Percentage
1. Delicious group (J&K, HP, UP)	87,178	54
2. Maharaji (J&K, 22 per cent)	13,443	8
3. American (J&K, 8 per cent)	5,000	3
4. Early Shanberry Banoni Fancy (UP, 30 per cent)	14,160	8
5. Rymer/Buckingham (UP, 40 per cent)	19,480	12
6. Golden Delicious (HP, 11 per cent)	5,654	3.5
Total	145,015	89
NWHR	163,000	100

TABLE 2.17

Estimated varieties, area, and percentage of apples in Jammu and Kashmir (1985/86)

Variety	Area (ha)	Percentage area
Ambri	837	1.3
W.D. Red	13,443	22
American	4,953	8.2
Red Delicious	26,906	44.6
Golden Delicious	321	0.5
Cox's Orange	3,630	6.0
Pippen Benoni	1,259	2.1
Irish Peach	335	0.6
Others	8,631	14.3
Total	60,315	100

Source: Department of Horticulture, Jammu and Kashmir Government.

Improvement in Varieties

Most of the present strains are outdated and have also degenerated. This is also one of the factors contributing to low productivity and low quality production. New strains have to be introduced from abroad and local trees of outstanding merit should be earmarked. It is time for the establishment of a national variety foundation as a repository for all commercially grown varieties/stocks.

Moisture Stress

About 80 per cent of the NWHR is rainfed. Generally, in most areas, the bulk of the precipitation takes place during three or four months (mostly

TABLE 2.18

Varietal distribution in Himachal Pradesh

Variety	Percentage area
Red Delicious	25
Star King Delicious	44
Rich-a-Red	14
Total Red Delicious	83
Golden Delicious	11
Other varieties	6
Total	100

Source: Department of Horticulture, Himachal Pradesh Government.

TABLE 2.19

Varietal distribution in Uttar Pradesh

Variety	Percentage area
Early: Fanny, Shanberry, Banoni	30
Mid season: Delicious	30
Late: Rymer, Buckingham	40
	100

Source: Department of Horticulture, Uttar Pradesh Government.

the monsoon period). The remaining periods are more or less dry. The trees suffer from serious moisture stress during those periods. This is one of the important contributing factors to low productivity. Because of the concentration of rainfall within a short period, and the hill gradients, two of the most important natural resources, i.e. soil and water, go to waste for want of appropriate conservation measures. The rain water travels down the hill slopes at high velocity, erodes the soil, makes gullies, and has very little chance of being absorbed by the soil because of its speed. This causes floods during the rainy season and drought or moisture stress afterwards. The technology for the conservation of moisture in soil is now available and consists of (1) planting behind vegetation contour lines and (2) establishment of vegetation hedges or fences (with species having crowns below ground level), so that they develop into dense barriers for filtering soil out of the water and reducing the velocity of the rain. These hedges are established at suitable intervals depending upon the slope.

The distance or space between two lines of a plantation (1 above) serves as a catchment area for water and soil. Reduced water velocity encourages more infiltration to the soil. Even a minor amount of rainfall can be collected. Consequently, this helps to overcome the stress. The species already identified for sub-tropical and temperate regions are listed below:

Sub-tropical region	Temperate region
Vetivera zizanioides	*Idigofera hetrantha*
Dodonaea viscosa	*Plectranthus ruqosus*
Adhatoda vasica	*Viburnum foetens*
Agave sislana	*Parrothi jacquemontiana*
A. americana	*Onobrycus vicifolia*
Carissa spinaeum	*Cotoneaster baccilaris*
Woodfordia fruticosa	*Crataeva varia*
Vitex nigundo	*Coronella varia*
Desmodium	*Rhus pur viflora*
	Rubus ellipticus
	Bareris spp.

Two sketches showing the contour layout and hedges in new orchards and the contour hedges in existing orchards are shown in Annexes 1 and 2.

Contour layouts in the hills have been recommended for a long time. However, planting of contour vegetation hedges is a new technique. Its impact has yet to be effectively demonstrated before the system is adopted on a large scale.

In addition to overcoming the problem of moisture stress in orchards, contour layouts have many other advantages:

- prevention of soil erosion
- regenerate vegetation on hill slopes
- prevention of floods in lower areas
- accumulation of water in the soil profile and improvement of the water level in wells
- availability of fuelwood from some shrub species thus reducing the pressure on forests
- additional production of grass or grass legume mixtures in the spaces between hedge or tree lines

Adoption of this technology means that tree crops will improve the environment and ecology of the region as a whole.

Summary of the Present Situation

The present situation of apple cultivation in the NWHR is characterized by:

- low production per unit area,
- fluctuations in production from year to year,
- low quality produce, and
- low and discouraging returns, giving no incentive to the farmer to improve the production finality by investment.

This situation is the result of many factors. Some of these are:

- poor quality plants,
- low-density plantations (waste of space),
- long gestation periods,
- gaps in plantations, waste of valuable land resources,
- moisture stress at critical phases of tree and fruit development,
- poor orchard soil management,
- inadequate nutrition, in fact, malnutrition in many cases,
- inadequate control of pests and diseases, and
- lack of coordination among producing states, growers, and marketing agencies.

The problems referred to above relate to management of existing orchards and the plantation of new orchards. While the former needs immediate attention and improvement, the latter needs medium-range planning and strategy.

Post-harvest Management

The post-harvest management of horticultural crops has not kept pace with the expansion of production. This has led to lopsided development and imbalances in the industry. However, some efforts have been made to create a modern infrastructure for post-harvest handling of apples in Himachal Pradesh and Jammu and Kashmir through World Bank-assisted projects for apple marketing and processing. Although the projects have been created, and a network of packing houses, cold storage plants and other facilities along with juice concentrate plants have been established, the real benefits have fallen short of expectations. Himachal Pradesh and Jammu and Kashmir corporates (HPMC) were expected to handle about 25 per cent and 12 per cent of the production respectively but they have handled only 2 per cent. Recently the North Eastern Region Agriculture Marketing Corporation has been created in the northeastern region for processing and marketing horticultural produce.

Notwithstanding the creation of such an infrastructure, post-harvest management of fruits has remained grossly inefficient. Added to its inadequacies is the mismanagement which results in its being advantageous to middlemen at the cost of the grower and the customer. There is a long chain of handling for perishables during the process of marketing. Each step in the chain adversely affects the quality of the fruit resulting in low net returns and high marketing costs. Horticulturalists have no control over consignments once they have left their premises. The negligible care taken in handling the fruit at various stages demonstrates that no one has the interests of the produce in mind. The stages through which the fruit passes for marketing are:

- picking,
- assembly in the packing shed,
- sorting and grading,
- packing,
- transport (mainly head loads) to the forwarding areas,
- loading (in lorries),
- transport,
- unloading in the wholesale market,
- storage[2] or
- sale in the market to retailers or bulk purchasers,
- In case of bulk purchasers, unpacking, regrading, packing, loading, transport, unloading in other markets, and sale to retailer,
- transport by retailer to his retail shop,
- consumer.

Because of the lack of post-harvest quality control, a substantial part of the produce is damaged and is much below its optimum consistency, flavour, and taste. Many factors are responsible for this. Examples of these are:

- lack of understanding of maturity standards (picking as against eating),
- use of poor quality packing material,
- lack of proper grading,
- packing of fruits of different maturity in the same lot,
- packing too tight or loose,
- protracted transport, transhipment, and delays in sale or disposal,
- frequent transhipments, loading, and unloading that involves rough handling,

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[2] The stored fruit again passes through loading, transport, and unloading. It could also be stored in production areas.

- exposure to variations in temperature, sunshine, rain and
- lack of proper temperature and humidity control in cold stores.

As a result of the lack of proper handling, the produce is sold at low prices. In the majority of cases, the farmer is disappointed and is not inclined to invest in more and improved produce.

Post-harvest technology has received very little attention as a result of which its deleterious factors have not been accurately identified. The ultimate goal of an efficient post-harvest management system (or marketing in its entirety) is that the fruit reaches the consumer (after passing through so many stages) at its optimum consistency, taste, and flavour, at minimum cost and optimum returns. The present system of marketing simply consists of putting the consignments in the market. It cannot be described as scientific marketing.

Post-harvest management can be divided into on-farm and off-farm operations. The on-farm post-harvest operations include picking, grading, packing, and on-farm storage, if required. Sufficient information on improvement of these operations is available. Extension workers and farmers should be given intensive training in it and it should become an integral part of their expertise.

Maturity Standards

The picking maturity standards should be fixed and widely disseminated amongst horticulturists. The storage (long and short period), distant or nearby markets, and other aspects have to be kept in mind. Unripe fruit shrivels and does not develop the requisite flavour. On the other hand, fruit picked at optimum eating maturity will be overripe by the time it reaches the consumer. Either situation should be avoided.

Grade Standards

Grade standards, both quality and size grades, despite the fact that they have been fixed in consultation with the involved states and the central government, are not being followed. Proper grading should be introduced, first on a voluntary basis and subsequently through legislation if need be.

Packing Cases

Packing cases have been causing serious problems. So far, the entire apple industry has been dependent on wooden packing cases. Whereas in Jammu and Kashmir one ton of fruit is packed in about 0.7 cu m of wood, in Himachal Pradesh and Uttar Pradesh about 1 cu m and 1.25 cu m are used, respectively. At this rate the NWHR will require about 800,000 cu m of wood annually. This wood will be supplied by

130,000 hectares of natural pines, or 80,000 hectares of planted pines, eucalyptus, and poplar, or 40,000 hectares of irrigated eucalyptus and poplars, annually. These are colossal requirements and have direct impact on the environment. It is gratifying that steps for the use of substitute packing cases have been taken. The Government of India has waived the duty on cartons. Himachal Pradesh will supply these cartons in bulk (approximate total of 2 million in 1989) on a subsidized bases. Himachal Pradesh is also establishing a modern plant for the manufacture of cartons of the latest quality. Other states should follow suit as quickly as possible.

Distribution

Unfortunately, the distribution of apples in the market is unbalanced. The Delhi market receives about 60–70 per cent of the apples from Himachal Pradesh and Jammu and Kashmir but it consumes only 16 per cent, regrades the remainder, repacks them, and sends them to other markets. This involves additional expenditure, more middlemen, more handling, more damage, and more deterioration. The distribution is such that, whereas there is a glut in Delhi and the surrounding areas, in other places there may be a scarcity. Unless consignments are sent to the markets and towns directly, in accordance with their requirements, there will be very little change in the pricing structure for apples.

New Markets

There is a case for starting new markets in the production areas themselves. However, it must be understood that almost the entire crop should be sent outside the production areas. The new markets, as in the case of Haldwani in Uttar Pradesh, should not become satellite markets for Delhi, because this will mean another set of middlemen and additional infrastructure. What needs to be ensured is the direct despatch of consignments in accordance with the requirements of towns and markets. This may require market studies.

Bulk Handling

In view of the scarcity and high cost of packing material, an alternative approach in the form of bulk handling may entail truck loads of loose fruit or assorted packs in returnable master containers. The results of a trial in Jammu and Kashmir under IAATP showed that mixed sizes and grades of fruits, when carried loose in trucks, had the same amount of bruises as apples packed in wooden boxes. Another alternative is to take the shipments to markets and towns and sell them in returnable wooden or plastic boxes, or in cartons which need not be as solid nor cost as much as those required for long-term use. Storage accommodation will be required for this purpose in these places.

Transport

Transport remains a major problem throughout the NWHR. On average (1985 figures), the present production of marketable apples needs 100,000 truck journeys. Most of these journeys take place in the months of August, September, and October. The transport system has been built or is suitable for hardware; it has not been designed for perishables. There is a great deal of pressure during the peak harvest periods, and often transport is not available in accordance with requirements. There is at least one transhipment in most cases, if not more. The situation becomes untenable. The share of railway transportation is insignificant. The following measures need attention:

- Designing of trucks and rail wagons specially suited for perishables.
- Substantial increase in the share of railways.
- Quick transport and delivery. Railways should not take more time than road transport.
- Extended period of marketing through varietal diversification and storage in producing areas.
- Careful handling during loading, unloading and other such operations.
- Covered sheds at transhipment centres.
- Avoiding congestion in main distribution markets, such as Delhi, by direct dispatch to other markets.

Cold Storage

Cold storage (including pre-cooling) has become an integral part of the production, planning and post-harvest management system. Increase in cold storage capacity has become imperative under Indian conditions, where production is already creating temporary gluts. Transport and marketing problems have increased considerably and the fruit available in the Indian market is in poor condition.

The technology to supply garden-fresh apples almost throughout the year is now available and has been tried successfully within the country. Ordinarily, apples are harvested at between 55°F (mean minimum) and 70°F (mean maximum). At the same time temperatures in the main market of the country (Delhi) vary from 79° to 93°F. There is, therefore, a difference of 23°F. Fruits continue to respire after harvest. The higher the temperature, the higher the respiration rate, and the quicker the

TABLE 2.20

Normal storage life expectancy of delicious apples

Temperature	(°F)	Storage life (days)
Held at	70	20
	60	30
	50	50
	40	90
	36	130
	32	220
	30	280
Cooled to	30 in 7 days and held	250
	32 in 7 days and held	200
	36 in 7 days and then to 32 in 4 weeks	180
	40 in 7 days held at 40 for 21 days, then cooled to 32 for 28 days	137
	36 in 7 days and held at 36	110
	36 in 6 weeks and held at 30	90

Source: Harbans Singh, Cold Storage of Apples in the Pacific North West by Sainbury.

deterioration in quality and eventual breakdown. The storage life for apples has been worked out as given in Table 2.20 in the United States.

The pre-cooling of apples before storage and even for immediate marketing is essential, as is evident from Table 2.20. Pre-cooling for fresh markets will prolong shelf life. This is in fact a key factor in marketing. Should cooling facilities not have been established, the fruit should be picked early in the morning when the temperature is at its lowest. Cooling can also be done by picking in the evening and leaving the fruit outside in the open and/or by sprinkling with cold water if available. This, though not ideal, will help to some extent.

The storage of fruits, apart from extending the period of marketing and the availability of high quality fruit, will also reduce the pressure on transport and markets. A strategy for short and long duration storage should be developed. Short-duration storage will be required for marketing in December, January, and February, and long-duration storage from March to May, or even early June. It may be appropriate to plan for the storage of about 25 per cent of the crop, which is approximately 275,000 tons at the current production level.

An ideal system may also require refrigerated vans in general and railway wagons in particular. This may be necessary for the export of quality fruit in the beginning.

Marketing Cost and Returns

The marketing costs and returns vary considerably with the cost of packing, transport area, and other factors. However, it would be appropriate to refer to some studies as models. The Agro-Economic Centre, Shimla, gives the figures presented in Tables 2.21 and 2.22 for good quality apples sold on the Delhi market.

TABLE 2.21

Share of growers in consumer rupees (Delhi, 1984)

Particulars Total	Percentage share Rs.	Rs.	Progressive Rs.
Farm gate price	48.20	57.94	57.94
Marketing expenses by farmers	23.31	28.02	85.96
Expenses by commission agent	4.28	5.16	91.12
Retailers expenses Expenses 1.50 + Losses 10% 9.11	8.83	10.61	101.73
Retailer's margin	15.38	18.50	120.00
Consumer's price	100.00	120.00	120.00

Source: AEC, Shimla, 1984.

TABLE 2.22

Price of different varieties: five-year average, AEC, Shimla (per 18q kg case)

Starking Delicious	Rs. 46
Rich-a-Red	Rs. 41
Red Delicious	Rs. 34
Golden Delicious	Rs. 28

It appears that the farmer's share in the consumer's rupee is only 48 per cent (farm gate price). The marketing expenses of farmers average 23 per cent, the expenses of commission agents 4 per cent and that of retailers 15 per cent. In addition, retailers charge about 9–10 per cent against losses. In all, the retailer receives 25 per cent. This shows that 52 per cent of the price paid by the consumer is spent in the market. Out of this, the margins of the middlemen account for 30 per cent. Reduction in prices results in a decrease in the percentage received by farmers, wholesalers, and retailers. This is because the cost of packing, transport and other items will remain the same irrespective of the price of the fruit. The margin retained by the retailer against losses is an indication of the absence of post-harvest quality control. This could be reduced by 75 per cent at least in a comparatively stable commodity such as apples.

Other studies undertaken in 1974, 1979, and 1984, in Himachal Pradesh by AEC produced the data given in Table 2.23.

TABLE 2.23

Marketing cost and returns, Himachal Pradesh

	Rs./Box		
	1974	1979	1984
Wholesale price	37.83	46.63	85.96
Marketing expenses	17.17	21.70	33.18
Net returns (farm gate price)	20.66	24.93	52.78
Farm gate price/kg (@ 18 kg./case)	1.15	1.38	2.93

Impact of Grades on Prices

There is a difference in the prices of different grades of apple. As far as quality is concerned, better coloured and better quality fruit get higher prices. Apples that are marked by hail, scab, or other diseases cannot be sold at A grade price. They will be sold at B or C grade prices which are about 15 per cent or 30 per cent less than that of A grade. A firm, ripe consignment gets a better price than soft or overripe fruit. The impact of colour and size grades on the sale prices is evident from Table 2.24.

TABLE 2.24

Sale rates of different grades

Rs./Box

Variety	Size grades		
	Large	Medium	Small
Starking Delicious	46.16	41.28	33.65
Rich-a-Red	41.23	35.20	29.39
Red Delicious	33.70	30.70	27.70
Golden Delicious	28.06	22.83	18.64

Source: AEC, Shimla, 1975/76

The Starking Delicious is a deep red strain. It is followed in quality by Rich-a-Red Delicious, and Red Delicious in descending order. Golden Delicious is golden in colour. The first two keep better than Red Delicious. The difference in sales shows the market value of each and the importance of colour.

Recommendations

The following are broad recommendations for modernizing the horticultural industry in the hill areas. They are not a substitute for detailed project proposals, which should be independent exercises governed by local conditions.

Production Aspects

The wide gap between the technology now available and actual application by the farmers should be bridged by reorganizing and strengthening the Department of Horticulture so that competent, professional horticultural extension services can be provided.

For easy adaptation of horticultural technology at the farm level, demonstrations should take place at the site. These should include: (1) orchard management, (2) tree canopy management, (3) density of plantation, (4) moisture conservation *in situ*, (5) tree nutrition, (6) integrated pest and disease management, and various aspects of these in accordance with the requirements of specific localities.

The quality of saplings should be improved so that future plantations are established with trees of outstanding merit. To achieve this, the following procedures should be undertaken:

- introduction and testing of new varieties and rootstocks.
- establishment of a national variety foundation as a repository for commercially grown varieties in India.
- encouragement of private sector nurseries which should use plants made available by the national variety foundation.

A horticultural development plan, along with a strategy for implementation, should be prepared. The plan should incorporate appropriate crop diversification and the requirements of the industry in respect of planting stock, inputs, management, pest control, packing, storage, transport, marketing, and research needs and other aspects up to the year 2000 must be taken into account.

The problems and constraints that are being faced in each area, district, and block, should be identified in order of importance so as to initiate remedial measures. This should be done after appropriate in-depth studies.

Provision of essential production support services, such as laboratories, for plant tissue analysis and plant protection must be made.

Creation of data banks at national and state level to provide information on area, production, and yield of each crop, budgets, and other allied aspects should be undertaken.

Inter-state coordination with the active support of the central government and the National Horticultural Board must come into play.

Simplified credit procedures for farmers should be provided.

Post-harvest Management

The gap between actual requirements and the facilities available should be bridged as soon as possible. Post-harvest quality control must be given top priority.

The established grading standard for size and quality should be introduced immediately. It should be uniform throughout the states concerned. A start can be made by encouraging people to adopt them on a voluntary basis and this can be followed by legislative measures if necessary.

Wooden packing cases used should be replaced by corrugated fibre board cartons and similar packing materials to conserve resources and present better quality fruits.

Bulk handling of apples should be encouraged in order to reduce the per unit cost.

In order to avoid gluts and to regulate supplies throughout the year the marketing period for apples should be extended by establishing cold storage network.

The transport system should be improved. Cableways and roads should be constructed where necessary in the areas of concentrated production.

Imbalances in the distribution of apples in the market should be reduced. Efforts should be made to consign them directly to the market in accordance with requirements. Market studies should be conducted for this purpose.

States which propose to develop new markets should ensure that they do not become satellites of already existing terminal markets.

Distribution markets should be set up in production areas.

There should be effective and meaningful cooperation and coordination among the three states. The National Horticultural Board must play a leading role in bringing about such cooperation.

A long-term strategy and development plan for the creation of post-harvest handling and marketing facilities should be drawn up and the existing infrastructure strengthened.

The HPMC in Jammu and Kashmir and Himachal Pradesh and NERAMAC in the northeastern region should play the role of horticultural development corporations. They should encourage the promotion of facilities and infrastructure required for post-harvest handling.

A compilation of problems faced in the post-harvest handling and marketing of apples should be undertaken and financial incentives required by the growers or private trade should be made available.

Transfer of technology in respect of on-farm post-harvest operations (including pre-harvest picking, maturity standards, handling operations such as picking, grading, packing and storage) should become the responsibility of horticultural extension workers.

An efficient market information service should be provided.

3

Present Status of Horticulture Development in Himachal Pradesh

K.C. Azad

Introduction

The problem of a widening gap between increasing human population and food production has been emphasized by various people and the gravity of the situation in India and other developing countries has been highlighted. The problem is, however, not of quantitative shortage alone. The quality of available food has been causing equally great anxiety to planners, scientists, and administrators alike and it is in this context that the cultivation of horticultural crops, particularly fruits, has gained much importance.

In India, the possibilities of horizontal expansion of agriculture are small. In fact, India has almost reached the physical frontiers of possible cultivation. In this country, there is already about 47 per cent cropping of the total reported area (1977/78). The total culturable wasteland is hardly 17 million hectares, which is 5.6 per cent of the total area. The extension of agriculture to this area is costly and of low economic feasibility, as it requires expensive soil and water conservation measures. However, with the fast-expanding development of horticulture in the Himalayas, it has been observed that such areas can be treated more economically by planting perennial horticultural crops which will not only help soil and water conservation, but also provide economic returns to the farmers. Thus the only prospective of increasing food production and meeting the need for food and cash crops in the country lies in increasing the yield per unit of land with suitable diversification of area under high-yielding varieties of cereals and bringing culturable wastelands under perennial plantations.

Horticulture is an important sector of Indian agriculture. The country is endowed with a wide range of agroclimatic conditions suitable for growing a variety of fruits, vegetables, and flowers, ranging from temperate to tropical. Statistics on area and production of horticultural crops in India are not as accurate as of the major field and plantation crops. However, it is estimated that fruits and vegetables account for 6.7 per cent of the total cropped area in the country and that about 70 million tons of various types of fruits and vegetables are produced. Out of a total estimated area of 11.6 million hectares under horticultural crops, the area under fruits in 1986/87 was around 2.94 million hectares, with a total production of 25.5 million tons. Mango leads with a 40 per cent share, followed by banana, with an 18 per cent share, citrus fruits occupy the third place, and guava and apple take the fourth and fifth positions respectively.

Keeping in view the importance of fruits and vegetables in the Indian diet and the fact that our per caput consumption of fruits and vegetables in one of the lowest, the National Commission on Agriculture proposed that the area under fruits should by the turn of the century be raised to 4 million hectares with a production of 40 million tons and vegetable production should plan for 80 million tons from an area of 4 million hectares. If this goal set by the National Commission on Agriculture is to be achieved, strenuous efforts will have to be made. All our efforts in the past have been to attain self-sufficiency in cereals, i.e., food security. The time has now come to pay special attention to nutritional security. With the population explosion, efforts in this direction need to be intensified.

Horticultural crops have also big export potentials. The emerging trend in the dietary habits of affluent populations in the developing countries is to reduce the consumption of cereals, whereas the consumption of fruits and vegetables is increasing. Fruit and vegetable development has a bright future specially in the developing countries.

Himachal Pradesh—An Overview

Geography

Himachal Pradesh is situated in the nothwestern Himalayan region bordering Uttar Pradesh in the east, Jammu and Kashmir in the northwest, Tibet and China in the northeast and Punjab and Haryana in the south. The state has a geographical area of about 55, 673 sq. km. It has 12 districts and 4,280,818 people living in 16,807 villages and a score of towns. The physiography of the state consists wholly of mountainous tracts, with elevations ranging from 350 to 6975 m above mean sea level.

Climate

The climate varies from hot to severe cold, depending upon elevation. The state has relatively hot summers and mild winters in the south, mild summers and cold winters in the interior and severe winters and pleasant summers in the inner parts of the north. In the inner zone, summers are experienced late in the months of July and August and the temperature drops rapidly after October. The state has the highest and the lowest average of annual rainfall, about 300 cm at Dharamsala (District Kangra) and 35 cm at Pooh (District Kinnaur), which is further reduced to 18 cm in the interior of Spiti. For the whole of Himachal Pradesh, the average annual rainfall is 150 cm. While a large proportion of it is concentrated in the monsoon season in the outer zone, the monsoon comes only in the form of a misty drizzle in parts of the inner zone, which gets most of its moisture in winter in the form of snow.

Early winter fogs are characteristic of the outer valleys of Manali and Bilaspur. The occurrence of fog provides some insurance against delay of winter showers required for the sowing of winter crops. In the higher valleys of the interior, frost occurs in areas where the temperature drops very low during winter. The greatest intensity of hail has been marked within 15 km of the main ranges, particularly along Dhauladhar in Kangra-Mandi and Kullu-Seraj tracts.

Taking both temperature and rainfall into consideration, the climatic types in the state range from outer zone wet sub-tropical areas of Kangra-Mandi, Bilaspur, and lower Sirmour to cool humid temperature areas in the interior and at higher elevations of the outer Himalayas, of which Chamba, Dalhousie, Kullu, Karsog, Solan, Shimla, and Jubbal are representative.

Cold moist temperature areas are marked in the inner parts of the lesser Himalayas, as in Tissa-Bhandal, Bharmour-Pangi, Mandi, and Rampur-Kalpa tracts. To the north of Pir Panjal and the central axis of the great Himalayas, a cool dry temperature verging on a Tibetan climate is found in Lahaul Spiti and Kinnaur districts.

Horticultural Zones

The state can broadly be divided into four horticultural zones, details of which are given in Table 3.1.

Soils and Terrain

In a mountainous tract such as Himachal Pradesh, the percentage of area under cultivation is very low. There are small valleys, stretches of river banks and the banks of rivulets and streams, hill tops and ridge

TABLE 3.1
Horticultural zones of Himachal Pradesh

Particulars	Elevation (m)	Rainfall (mm)	Important fruits grown
Low hills and valley areas near the plains (Hamirpur, Una, parts of Kangra, Bilaspur, Mandi, Shimla, Solan, Kullu, and Sirmour districts)	350–950	1250–1750	Mango, litchi loquat, guava, citrus, papaya, fig, sand pear, early variety of grape
Mid-hills, Sub-temperate (parts of Solan, Sirmour, Shimla, Kullu, Bilaspur, Mandi, Chamba, and Kangra district)	950–1500	1250–2500	Stone fruits, peach, plum, apricot, almond, persimmon, pear, pomegranate, pecan nut
High hills and valleys in the interior (parts of Shimla, Solan, Kullu, Mandi, Sirmour, Chamba, and Kangra District)	1500–2500	850–1750	Apple, pear, cherry, walnut, almond, chestnut
Cold and dry zone (Kinnaur, Lahaul and Spiti, Pangi, and Bharmour areas of Chamba district)	1500–3200	180–400	Grapes, prunes, drying type of apricot, almond, chilgoza, Sarda melon, pistachio

tops, where the land is more or less flat and level. Barring these areas, cultivation is carried out on terraces. Entire hillsides are found dotted with villages set amidst terraced fields.

The soil in the state varies greatly within small areas. Its profile, depth, and characteristics change according to gradient of slopes. These differences are caused by climate, vegetation, parent material topography, drainage, and time. Soil on nearly level areas may be imperfectly drained and soil on depressed areas is usually poorly drained, but soil on steeper slopes is usually well drained. On ecological basis the state can be divided into five zones: low hill mid-hill, high hill, mountain, and cold arid zone.

LOW HILL

The low hill area covers the southern margins of the state in the Shiwalik zone, is distributed between 450 and 750 m altitude, experiences 125–175 cm of yearly rainfall, and has a humid, hot tropical climate. Most of the area is found on the banks of rivers and streams. The soil reaction is mostly neutral. The C:N ratio is around 10:1. The zone comprises the entire districts of Una and Hamirpur and parts of Bilaspur, Kangra, Mandi and Sirmour. Solan and Chamba districts are suitable for sub-tropical fruits such as citrus, mango, litchi, and guava.

MID-HILL

The mid-hills cover the next altitudinal belt extending up to 1500 m. This area receives 125 to 250 cm annual rainfall under sub-tropical conditions. The soil is mostly sandy loam, loamy sand, snowed clay, and silt loam. The soil has a varying percentage of pebbles and stones and is susceptible to severe drought. The soil reaction is neutral to slightly acidic. The C:N ratio is greater than in the low hill soil. This zone comprises parts of lower Shimla, Solan, Kangra and adjoining parts of Chamba, Mandi, and the lower area of Sirmour districts. This area is suitable for stone fruits, peach, plum, apricot, almond, persimmon, pear (hard varieties) and pomegranate.

HIGH HILL

This zone is distributed between 1500–2100 m above mean sea level. The area receives an average annual rainfall of 85 to 175 cm. The soil is deep and fine-textured, varying from silt loam to clay loam, and is of a light to dark brown colour. With a good reserve of humus and a limited quantity of mineral and plant food, the soil is fairly productive. The soil reaction is slightly acidic. Because of high fertility, the soil is excellent for the cultivation of temperate fruit crops, apple, pear, cherry, walnut, and chestnut. The zone covers Shimla, Kullu, and some parts of Mandi and Kangra districts.

MOUNTAIN

This zone is distributed in elevations ranging from 2100 to 3050 m and found on high mountain ranges where precipitation occurs largely in the form of snow. The precipitation amounts to about 85 cm a year. The process of soil formation is slow. The soil varies from silty loam to loam in texture and is dark brown in colour. The area is mainly under forest. The soil reaction is slightly acidic to moderately acidic and has great moisture-holding capacity. The zone comprises parts of Shimla, Kangra, and Kullu districts. In some parts, apple is grown successfully.

COLD ARID ZONE

This zone covers elevations above 2500 m in the inner valleys of Lahaul Spiti, Kinnaur, Pangi Bharmour of Chamba district, and Bara Bhangal of Kangra district. The climate is cold moist temperate to cold arid type. The soil is mostly sandy loam to loam and slightly alkaline in reaction. The productivity of the soil in this zone is very low, however, it is suited for growing fruits such as almond, walnut, grapes, apricots, Sarda melon, and hops, some of which are dried to produce raisins, prunes, dried apricots, etc.

Land-use Pattern and Size of Holding

Agriculture is the mainstay of about 76 per cent of the total rural population. Out of 614,000 hectares cultivated area 23 per cent is under horticultural crops. The total number of operational holdings are 6,38,081, out of which 78 per cent are 2 hectares or less (i.e. small and marginal farmers). The average size of a holding is 1.62 hectares, but a large number of holdings are less than one hectare. The availability of land for agriculture is limited as is evident from the fact that per caput cultivated land is only 0.15 hectare as against 0.34 hectare in the country as a whole and the minimum required is 0.48 hectare to support and provide livelihood for an individual.

Importance of Horticulture

Due to the inherent problems of low land to man ratio, undulating physiography, a cold humid climate, and limited availability of solar energy, farmers cannot depend solely on cereal production as a means of livelihood in Himachal Pradesh. On the other hand, the cold climate and well-drained soil provide ideal conditions for the production of a wide range of fruits crops, from sub-tropical to temperate, besides a number of plantation crops, plants of ornamental value, off-season vegetables and other horticultural crops for markets on the plains. Temperate fruits such as apple, peach, pear, plum, apricot, cherry, almond, and walnut, and sub-tropical fruits such as mango, citrus, litchi, guava, fig, pomegranate, and olive, hops, and a number of temperate zone ornamental plants and vegetables are grown. These are mainly high pay-off crops with the capacity to yield the highest returns per unit area even under the low productivity conditions of Himachal Pradesh soil.

Productivity can be increased by increasing either the yield or the value of the product per unit area. Since it is not possible to substantially increase the yield of traditional crops, the only alternative is to select a pattern of agriculture that will give maximum returns per unit area. In recent years, it has been proved that the productivity of land can be dramatically increased by raising cash crops such as fruits and vegetables. Horticulture thus plays an important role in the economic upliftment of the poor and small farmers of Himachal Pradesh.

Horticultural Development in Himachal Pradesh

Before Independence, hardly any attention was paid to the development of horticulture in the hilly areas of Himachal Pradesh, which was ruled by minor royalty who had neither the resources nor the urge to develop horticulture along scientific lines. Commendable pioneering efforts were, however, made by a few Christian missionaries and European settlers who planted orchards in pockets like Kotgarh area in Shimla Hills and in the Kullu valley. These plantations later served as a nucleus for the development of the horticulture industry in the state.

After Independence, when Himachal Pradesh was formed in 1948, horticulture was started from scratch by the Department of Agriculture and it was soon realized that it could play a vital role in improving the economy of the state. A separate horticulture section in the Department of Agriculture was created in 1953 which played a commendable part in the proliferation of orchards in the temperate regions of the state. Horticulture was given top priority in the state plans and a separate Department of Horticulture came into existence in September, 1970. Since then horticulture has been gaining momentum very fast throughout the state.

Present Status

The fruit industry of Himachal Pradesh, the sole avocation for the economic upliftment of the mainly agricultural population of Himachal Pradesh, has made remarkable progress during the last four decades. The area under various kinds of fruits increased from 793 hectares in 1950 to 142,000 hectares in 1987/88, an increase of 178 times over the period of 37 years. This area under fruits accounts for about 23 per cent of the total cultivable area of the state (see Table 3.2).

The area under temperate fruits during the year 1987/88 was 93,266 hectares, making up about 65 per cent of the total area under fruits. Apple has been the major temperate fruit crop of the state, accounting for 38.5 per cent of the total area under fruits. The trend towards fruit plantations during the past three decades reveals that whereas at the end of the Second Plan, i.e. in 1960, out of the total area of 6004 hectares under fruit crops in the state, 50.38 per cent was under apple alone, it increased to 56.85 per cent in 1965/66 and 57.85 per cent of the total area in 1973/74. However, after this, there has been a steady decline in the proportion of apple grown in the total area, which dropped to 48.81 per cent at the end of the Fifth Plan; 41.34 per cent at the end of the Sixth Plan, and finally to 38.6 per cent in the year 1987/88. The reverse is true in the case of all the other fruits, which is perhaps due to the

TABLE 3.2

Progress made in bringing additional area under fruits (hectares)

Fruit	1950/51*	1960/61**	1965/66***	1984/85****	1986/87	1987/88
Apple	400	3,025	12,711	49,840	52,399	54,912
Other temperate fruits		900	4,147	23,649	25,964	26,728
Nuts, dry fruits	393	231	708	9,804	10,930	11,628
Citrus		1,125	2,780	23,802	29,546	31,226
Other sub-tropical fruits		623	6,020	13,485	16,146	17,559
Total	793	6,004	9,804	120,580	134,985	142,051

Data for the average area under fruits is available only after 1960/61.

* Advent of First Five-year Plan.

** End of Second Five-year Plan

*** End of Third Five-year Plan; also the year of merger of hilly areas of Punjab with Himachal Pradesh at the time of reorganization of the states.

**** End of Sixth Five-year Plan.

Source: Department of Horticulture, Himachal Pradesh, 1988.

increased emphasis given by the state to the development of sub-tropical fruits in the low hill regions of Himachal Pradesh.

The production of fruits has made significant strides during the last four decades, increasing from 1200 tons in 1950/51 to 400,508 tons in 1986/87, a 333-fold increase over a period of 37 years (see Table 3.3). The production of the temperate fruits accounted for about 93 per cent of the total fruit production during the years 1986/87 and 1987/88, while sub-tropical fruits had a share of only 7 per cent. Among the temperate fruits, apples dominated production, constituting about 90 per cent of the total fruit during the peak production year of 1986/87. This is due to the fact that apple growing is the oldest horticultural activity in the state and a large proportion of the plants are in full bearing while the other fruits are only of recent origin. The production of these fruits is also likely to increase in coming years, as more and more plantations enter bearing age.

Productivity

The production figures of various kinds of fruit in Himachal Pradesh reveal considerable variation in yields over the years. The factors which affect the yield are the genetic potential of the varieties planted, the effect of climate and environment, and management practices. The data on the highest average yields obtained by the major fruits grown in the state are given in Table 3.4.

TABLE 3.3

Progress made in fruit production

Fruits	1950/51	1960/61	1965/66	1984/85	1986/87	1987/88
Apple	1,000	12,000	24,000	170,629	359,321	259,277
Other temperate fruits			4,400	26,406	12,432	26,861
Nuts, dry fruits	200	6,719	500	2,224	2,800	2,716
Citrus			6,010	3,947	11,915	10,875
Sub-tropical fruits other than citrus			2,000	12,714	14,040	8,904
Total	1,200	18,710	36,910	215,920	400,508	308,693

Source: Department of Horticulture, Himachal Pradesh.

TABLE 3.4

Peak average yields of fruits in Himachal Pradesh since 1960/61

Fruits	Yield/hectare (tons)
Apple	23.9 (1969/70)
Temperate fruits other than apple	11.00 (1971/72)
Nuts and dry fruits	4.4 (1970/71)
Citrus	9.2 (1968/69)
Sub-tropical fruits other than citrus	9.00 (1968/69)

Source: Department of Horticulture, Himachal Pradesh.

Time series data indicate wide fluctuations in productivity from year to year. For example, taking the average for the state as a whole, the productivity of apple ranged from a low of 4.06 tons (1988/89) to a high of 15.73 tons (1975/76) per hectare over the period 1975/76 to 1988/89, as indicated in Table 3.5.

The variations in yield from year to year were due to the alternate bearing habit of the varieties and unfavourable environmental conditions prevailing in different years. These yield levels are, however, below the international of 30–40 tons per hectare. The Agro-Economic Centre of the Himachal Pradesh University has undertaken several studies on apple yields in Himachal Pradesh and one of these studies found that the average yield of an apple orchard over 15 years of age was 23.43 tons per hectare, the average yield of orchards of all age groups being 14.23 tons per hectare. The results of 15-year trials held at the Regional Fruit Research Station, Mashobra (Shimla), regarding the performance of different apple cultivars, indicated that Red Delicious and Golden Delicious cultivars give an annual yield of 25.5 tons and 15 tons per hectare respectively.

In some efficiently run private orchards it is not uncommon to find

TABLE 3.5
Apple production and productivity in Himachal Pradesh

Year	Production ('000 tons)	Productivity (tons/hectare)
1975/76	200	15.73
1976/77	119	7.83
1977/78	131	7.48
1978/79	121	6.03
1979/80	135	5.77
1980/81	118	4.41
1981/82	307	10.84
1982/83	139	4.48
1983/84	258	8.03
1984/85	171	5.07
1985/86	175	4.98
1986/87	359	9.78
1987/88	259	6.66
1988/89	165	4.06

Plants below 10 years are assumed to be non-bearing

Source: Department of Horticulture, Himachal Pradesh, 1989.

holdings obtaining a yield of 30–60 tons per hectare. These facts illustrate the potential that exists to improve productivity using only currently available technology.

Varieties

Apple

In the case of apples the Delicious group dominates production. It is estimated that 83 per cent of the total planting of apple comprise the Delicious group, namely Red Delicious (25 per cent), Starking (Royal) Delicious (44 per cent), and Rich-a-Red Delicious (14 per cent). Golden Delicious, which is the main pollinizer variety, constitutes 11 per cent of the total planting, while the rest (6 per cent) is made up of miscellaneous varieties, such as Tydeman's Early Worcester, Black Ben Davis, Red Gold, Red June, Cox's Orange Pippin, Rust Pippin, and Granny Smith. Almost the entire plantings are mid-season cultivars and are the progeny of stock which was imported in the first quarter of this century, almost at the time when they were first developed in the United States, and they now require to be enriched by new cultivars.

Pear

Pears are also being grown successfully in Himachal Pradesh, the main varieties being Babugosha, Williams, and Red Bartlett under high hill conditions, Sand Pear and Keiffer in low hill areas. The main thrust achieved in pear cultivation all over the state has, however, been through the improvement of the wild pear (Kainth) trees by the technology of top-working.

Stone Fruits

The mid-hill zone of Himachal Pradesh is suited for the cultivation of stone fruits such as peach, plum, and apricot. Although a large number of varieties have been recommended for peach cultivation, the cultivar Elberta still remains the favourite peach in Himachal Pradesh. An improved strain of Elberta, known as July Elberta, occupies the maximum area. In the case of plums, the salicina group (Japanese plum) has proved successful and cultivars such as Santa Rosa Mariposa, Beauty, Climax and Formosa are recommended, of which the first dominates in the mid-hill region. The cultivar Beauty has been found to act as a good pollinizer for Santa Rosa and these cultivars are generally interplanted in commercial plantations.

The cultivation of apricot is confined to the mid-hill regions and the cold and dry regions, and suitable varieties have been identified for these areas. In the mid-hill regions, the cultivars Early Shipley, Newcastle, Kaise, and St. Ambrose have been recommended. The cultivars Saffaida, Charmagz, and Shakarpara are doing well in the high hills and cold and dry regions.

Almonds were earlier grown only in cold, dry regions but of late cultivation is being extended even to the mid-hill and low hill areas, mainly for use as green almonds. Cultivars such as Nonpareil, Texas (Mission), Ne Plus Ultra, and Peerless, are recommended for cultivation in the low hill and valley areas. Almond cultivars being self-incompatible, it has been the experience in Himachal Pradesh that at least two pollinizer varieties should be planted to obtain maximum yields.

Sub-tropical Fruits

Among the sub-tropical fruits, citrus and mango are by far the most dominant. In the case of citrus fruits, more emphasis has been given to the plantation of Kinnow Oranges and blood red Malta in the sweet orange group and to locally developed Kagzi lime strains in the lime and lemon group. So far as the mango is concerned, Dasehri is the most favoured cultivar. The introduction of regular bearing varieties such as Amrapali is still in the experimental stage.

Orchard Management Practices

Taking into consideration the physiographic and agroclimatic conditions prevailing in Himachal Pradesh, the main objective of the orchard soil management programme to be followed is to increase the humus content of the soil, conserve soil moisture and prevent soil erosion, maintain soil fertility, and improve soil structure for better aeration and water availability. It has been found that sod culture with clean basins is the most suitable system of orchard management followed in most orchards. The sod should, however, be continuously mowed and added to the basin to act as mulch and also as a source of organic matter in the soil. The mulching of tree basins during dry periods has been found to be the best method for soil moisture conservation.

For orchard nutrition management, Himachal Pradesh has adopted the latest technology of leaf analysis both as an analytical tool to understand nutritional problems and as a means of estimating the fertilizer needs of fruits crops. In fact, Himachal Pradesh was the first state in the country to initiate a fruit plant nutrition advisory service based upon the leaf analysis technique, in 1974. So far, three plant nutrition laboratories equipped with sophisticated equipment have been established at Shimla, Dharmsala, and Kullu. Every year over 15,000 leaf samples are collected and analysed in these laboratories.

Post-harvest Managements

The provision of efficient post-harvest management is a necessary adjunct to any fruit production programme. A sound beginning was made for the creation of post-harvest management infrastructure in the state in 1974 with the implementation of a World Bank-assisted apple processing and marketing project. At present the state has developed an infrastructure with a capacity to grade and pack 30,000 tons of fruit, to store 5000 tons of fruit in the production areas and 8250 tons in the terminal markets (Delhi, Bombay, and Madras), and to process 26,000 tons of fruit within the state. The apple juice concentrate plant established at Parwanoo in Himachal Pradesh ranks as one of the largest in the country. A specialized organisation, the Himachal Pradesh Horticultural Produce Marketing and Processing Corporation, has been created with the sole objective of providing marketing and processing facilities to Himachal fruit growers. The HPMC operates fruit shops in all the major fruit markets of the country and has developed an extensive network for the sale of fruit products all over India. In addition, efforts have also been made to collect and disseminate market intelligence by the use of modern communication technology under a centrally sponsored scheme operated by the National Horticulture Board.

Horticultural Infrastructure

Apart from an extension set-up to village level, there are a number of centres of horticultural activity in the state under the Department of Horticulture: 92 progeny-cum-demonstration orchards and nurseries, 21 fruit nurseries, 6 olive development stations, one walnut development station, 7 floriculture nurseries, 9 fruit canning units, 45 beekeeping stations, 64 plant protection centres and sub-centres and 3 plant nutrition laboratories.

Government Policy for Horticulture Development

Horticulture development in general involves permanent investment for the development of long-gestation enterprise producing high-value commodities, most of which are perishable by nature; hence the desirability of an appropriate government policy for production, planning, and ultimate utilization of the produce. The involvement of the State Government of Himachal Pradesh in horticultural production and marketing has been by way of:

- Creation of suitable organizations for the supply of various inputs, services, and technical know-how;
- Provision of technological support to the state's horticultural industry by promoting local research and development efforts and the introduction of advanced technology from abroad;
- Legislation measures to ensure increased production of quality fruits and the regulation of marketing activities;
- Provision of price support;
- Provision of incentives to involve the weaker sections of society in the fruit plantation programme and increased adoption of improved methods of horticultural production by the large number of fruit growers.

The approaches adopted by the Himachal Pradesh Government for the development of horticulture in accordance with the above policies are described in the following paragraph.

Growth Centre Approach

For the development of horticulture as a new area in the agricultural economy of Himachal Pradesh, the State government has established progeny-cum-demonstration orchards for different fruits in suitable areas. These orchards were set up with the objectives of (1) stocking fruit trees of outstanding merit for the supply of bud-wood; (2) multiplying pedigree and disease-free plants for supply to prospective fruit growers; (3) acting as model and demonstration orchards; (4) conducting adaptability trials for various-fruit varieties and cultural practices; and (5) acting as centres for the field training of orchardists, and supplying inputs and technical advice. Each orchard with an area of impact of about 10 km served as a horticultural service centre in which all technical inputs for horticulture development were available under one roof. These horticultural growth centres served as a nucleus for the proliferation of horticulture in the area of impact. In fact, convinced of the efficacy of such units, the other state governments have emulated this scheme.

Today there are 336 centres of horticultural activities established all over the state which serve as a nucleus for the development of various specialized horticultural activities in the areas around them.

Exploitation of Regional Potential

The policy of the State government relating to horticultural development is to promote fruit production in all areas, depending upon their potential. Areas have been delineated for different kinds of fruits, depending upon their agroclimatic conditions. The success of horticulture is, however, at present most pronounced in the temperate zone of the state. The lower hills and valley areas in the state were earlier considered horticulturally marginal but appropriate horticultural planning for these areas in recent years has proved this erroneous. Besides Kinnow (a mandarin variety), other sub-tropical fruits, such as mango, litchi, and sand pear have been grown with great success. Hill lemon and Kagzi lime are the other potential fruits specific to lower areas, especially in frost-prone areas.

The mid-hill region (950—1500 masl) in the state is suitable for stone fruits, particularly the canning varieties of peach, and other fruit crops such as pecans, olives, and figs are being promoted in this region. The mid-hill region of the state has abundant wealth in the form of millions of wild species of fruit trees like Kainth (*Pyrus pashia*), Kahu (wild olive *Olea cuspidata*), Jardaloo (wild apricot, *Prunus armeniaca*), and fig (*Ficus carica*), which are being converted into superior varieties of economic importance by the technique of top-working. Such top-worked plantations are, however, confined to village common lands in the form of community gardens for the benefit of the entire local population.

At higher altitudes, where apple and other temperate fruits are grown extensively, there are still large unexploited areas with vast potential particularly in the cold and dry regions of the state. Efforts made in recent years indicate that the Lahaul valley in the tribal regions of the state is most suitable for the production of best quality hops. The State Department of Horticulture has successfully grown on a trial basis the Sarda melon and pistachio in Kinnaur District. In addition to these, almond, walnut, hazel nut, drying types of apricot, prunes, and raisins are some of the fruit crops which have great promise in the cold and dry climatic region of the state.

Diversification

Efforts are being made to bring diversification into the state's fruit industry by developing ancillary horticultural activities such as floriculture, apiculture, and mushroom production in suitable areas. Himachal Pradesh was the first state in the country to introduce the modern technology of bulk pasteurization for the production of compost for growing mushroom. At present, Himachal Pradesh produces about 500 tons of mushroom annually.

The olive has been identified as another promising fruit crop and is being developed in the state to provide a sound base for the olive oil industry. The olive has a wide range of adaptability and climatic conditions in some areas of Chamba, Kullu, Mandi, Sirmour, and Solan districts. A large number of improved olive varieties have been introduced from Italy and are under experimentation. Besides the olive, improved plant material of other temperate climate fruit crops such as cherry, almond, walnut, hazelnut, fig, apple, and peach have also been introduced.

The varied climatic conditions available in Himachal Pradesh offer vast potential for the development of floriculture. The Himalayas are a rich source of flora but, unfortunately, no concerted efforts for the identification and commercial exploitation of resources have been made so far. There are only a dozen private floriculture enterprises in the state, located in Kangra, Shimla, and Solan districts. As already indicated, a wide range of floriculture plant material can be propagated in Himachal Pradesh as a specialty of the hills, provided suitable infrastructure for germplasm collection, multiplication, floriculture extension, and marketing is developed. Floriculture based upon the production of bulbous plants are an especially good economic venture for temperate hilly areas like Himachal Pradesh. There is also much potential for the development of an industry in ornamental and foliage plants and cut flowers with the objective of supplying these to the plains.

The vast floral wealth of the state can provide a sound base for apiculture. Besides developing apiculture as a cottage industry to provide an additional source of income to farm families, beekeeping has vital importance in orchards for the effective pollination essential to obtaining good fruit yields. For the guidance of prospective growers, the State Department of Horticulture runs 45 beekeeping stations at various places, serving as a nucleus for beekeeping development in the surrounding areas.

Research and Development

The research needs of biological industries such as horticulture are of great importance because the intensive system of cultivation creates new problems, like spread of pests and diseases, especially viruses and scab disease of apple. Furthermore, there is nothing static in science. New methods and technologies must be developed to keep the industry in business.

Being aware of the importance of horticulture to the economy of the state and of the need to strengthen the research base of the industry, the Himachal Pradesh government has established a University of Horticulture and Forestry which is the first institution of its kind in Asia devoted to research and education in this vital field of our economy. The university imparts horticultural education up to the doctorate level and has regional research stations in all the agroclimatic regions to take care of the location-specific research needs of various horticultural crops. In addition, besides establishing a National Institute for Mushroom Research devoted to the research and training needs of the mushroom industry, the Indian Council of Agricultural Research has also established horticultural research stations in Himachal Pradesh at several locations.

Introduction of New Technology

To give a new orientation to horticulture development programmes through application of modern science and technology, efforts are also being made to introduce new technology relevant to the situation in Himachal Pradesh from horticulturally advanced countries. In order to benefit from new cultivars of fruit trees developed abroad, the state government has recently imported a large consignment of improved cultivars and rootstocks of apple, pear, cherry, and walnut from the United States of America, in order to study their adaptability under local conditions and subsequently to develop bud-wood banks of the most suited cultivars. Efforts are also under way to import improved germplasm of floricultural plant material.

For the development of specific horticultural commodities such as mushroom, olive, fig, and pistachio, special projects for the introduction of technology have been implemented with bilateral assistance from advanced countries. Special mention may be made of the project for the development of mushroom implemented with assistance from the United National Development Programme and the Netherlands Government at Solan and Palampur respectively and the project for the development of olive and other temperate fruit implemented with the assistance of the Italian government. Improved technology in the field of marketing and processing was also earlier introduced under the purview of an apple marketing and processing project assisted by the International Development Agency. In addition, horticultural development forms an important component of the Rs. 800 million Hill Area Land and Water Development Project currently under implementation with the assistance of the United States Aid for International Development (USAID). Other externally aided projects currently in the pipeline are the proposed Chamba Valley Cash Crop Development Project, to be implemented with the assistance of the Federal Republic of Germany and a World Bank-assisted Integrated Horticultural Development Project to be implemented at a cost of Rs. 700 million.

Department of Horticulture

Transfer of Technology

Research and development or the efforts made to introduce new technology are of no use unless the new knowledge so generated reaches the actual users. Over the last few years, efforts have been made to develop a well-knit horticultural extension organization in Himachal Pradesh under the control of a separate Department of Horticulture with its headquarters at Shimla. It had over 1800 employees on its payroll in 1988.

For the efficient execution of development programmes, the state has been divided into two zones; the department for the temperate zone has its headquarters at Shimla and the department for the sub-tropical zone has its headquarters at Dharmsala in district Kangra. The development of horticulture in the sub-tropical zone is under the control of the Additional Director of Horticulture, while horticulture development in the temperate zone is looked after by the Director of Horticulture, in addition to his responsibilities as head of the department. The temperate zone comprises the districts of Shimla, Mandi, Kullu, Kinnaur, Chamba, and Lahaul and Spiti, substantial parts of which fall under the temperate/cold and dry zones. The remaining six districts, Bilaspur, Kangra, Una, Hamirpur, Solan, and Sirmour, fall broadly under the sub-tropical zone.

At the directorate level, there are Senior Subject Matter Specialists in the field of plant protection, marketing, fruit technology, plant nutrition, and planning and also experts on horticultural economics and information to provide technical support to the Director of Horticulture, besides heading their respective divisions.

For the efficient transfer of technology to the growers, the state government has reorganized the horticultural extension organization on the training and visit system under the auspices of a special IDA-assisted project. Under this scheme, village horticultural extension officers have been provided up to the field level and each such worker has been employed to provide extension service to about 600 farm families. Messages regarding different fruit crops are developed by the scientists of the State Horticultural University and the Subject Matter Specialists of the Department and are transferred to contact farmers through the village extension officers on time-bound fortnightly schedules of visits. Subject Matter Specialists in fields such as pomology, floriculture, plant protection, post-harvest physiology, and agronomy have been provided at district level and Senior Subject Matter Specialists in the field of pomology, floriculture, and plant protection have been posted at state level to provide technical support to the extension service.

Input Supply

The nursery plant is the most vital input for any fruit production programme. Government policy with regard to the supply of this input is to develop fruit plant multiplication facilities, in both public and private sectors, backed by nursery certification regulations under state legislation to keep a check on the quality of material being supplied. So far, 89 fruit nurseries in the government sector and 733 nurseries in the private sector with a capacity of production of over 3 million fruit plants annually have been established. The state is not only self-sufficient in the production of temperate fruit plants but is also exporting a considerable quantity of such plants to other temperate zone states. However, the supply of some species of sub-tropical fruit plants, mango, litchi and kinnow, is met by way of imports from nurseries in the adjoining states. Such imports account for only about 15 per cent of the total demand for all kinds of fruit plants and 25.6 per cent of the total demand for sub-tropical fruit plants.

The distribution of other horticultural inputs such as pesticides, fertilizers, micro-nutrients, and horticultural tools and implements is done in the private, cooperative and public sectors, of which the latter predominates. The Department of Horticulture, Himachal Pradesh, has now set up horticultural sales centres even in the remote interior. The supply of inputs is also arranged through block agencies and by the progeny-cum-demonstration orchards and nurseries. Recently, steps have been initiated to open up more distribution points by giving incentives to unemployed youths to set up input supply centres in the interior under the Government of India's sponsored employment programme.

Incentives and Credit Facilities

A wide range of economic incentives in the form of liberal subsidies on production inputs from the government and credit facilities from financial institutions is available for the development of horticulture. The economic incentives consist of subsidies for weaker sections and subsidies for plant protection.

Subsidies for weaker sections are available at the rates of 25 per cent to 50 per cent of the cost of various inputs, depending upon the category of farmers involved. Thus, for the small farmers, the subsidy is 25 per cent, for the marginal farmers 33.3 per cent, and for the scheduled castes, scheduled tribes, and the farmers of notified backward areas 50 per cent of the total cost of inputs supplied.

Inputs for plant protection, such as apple scab fungicides, micronutrients, plant equipment, and anti-hail nets under special centrally sponsored schemes are available at 50 per cent of their cost.

Credit support, both short- and long-term, is easily available from commercial and financial institutions for the development and maintenance of horticultural enterprises such as fruit cultivation, mushroom cultivation, beekeeping, and floriculture through special schemes refinanced by the National Bank for Agriculture and Rural Development.

Marketing and Fruit Utilization

The policy of the government with regard to the marketing of fruits is to encourage the establishment of marketing and processing facilities in the public, cooperative, and private sectors to ensure economic disposal of marketable and processing grade fruits. In this regard, the state government has intervened to the extent of inviting foreign collaboration to set up such facilities. Under an IDA-assisted project, a chain of packing and grading houses, processing plants; transhipment centres, and cold stores has been developed in Himachal Pradesh. The HPMC has been established to look after the marketing of horticultural produce in Himachal Pradesh.

Price Support

Himachal Pradesh gives price support for horticultural commodities so as to stabilize market prices. This scheme of price support was implemented in 1986. Fruits at these prices are procured by state agencies to be stored, processed, or marketed as fresh fruit through the state's marketing system. Table 3.6 gives the details of the prices fixed for different fruits during the years 1986 to 1988 and the fruit procured by state agencies against these prices. In addition to fruit crops, a support price is also fixed for potato, ginger, and honey from year to year.

TABLE 3.6

Support price for different fruits and the quantity of fruits procured from 1986 to 1989

	1986/87	1987/88		1988/89
		Farmers having up to 25 bighas of orchard	Farmers having more than 25 bighas of orchard	
Support price (Rs./kg)				
Apple	1.30	2.00	1.50	2.25
Galgal	1.00	1.10	1.00	1.10
Kinnow/orange	2.20	2.80	2.40	3.15
Guava				
(winter season)	–	1.60	1.50	–
(rainy season)	–	0.80	0.75	–
Ginger	–	3.50	3.20	–
Procurement of Fruits (tons)				
Apple	252.26	221.00		183.57
Galgal	12.74	32.14		N.A.
Orange	70.52	88.96		N.A.

Source: Department of Horticulture, Himachal Pradesh, 1989.

General Problems of the State Horticultural Industry

Notwithstanding the spectacular achievements in the production of different kinds of fruits in Himachal Pradesh, problems needing urgent remedial measures have also become more acute. Low productivity is one of the most important constraints preventing the accelerated development of the fruit industry. There is a large gap between current and potential yields which needs to be narrowed to keep the industry in the line of business. Some of the factors affecting productivity which need improvement are discussed in the following paragraphs.

Genetic Potential of Cultivars

Most of the present strains of different fruit crops, particularly those of apple, have become outdated and have degenerated. This is one of the contributing factors to low productivity and low quality production. Steps have to be taken to introduce new strains from abroad, besides earmarking trees of outstanding merit locally. Besides using the resources of the state, efforts are also under way to reorient the horticultural industry of the state under an Integrated Horticultural Development Project wherein, besides the introduction of improved plant material, facilities for rapid multiplication of plants will also be established so that the future horticultural industry of the state is based upon new plant material. This project is likely to be financed by the World Bank.

Plantation Density

The latest concept throughout the world is optimum utilization of available space—both horizontal and vertical—to achieve the maximum level of production per unit space by accommodating a maximum number of plants in a given area and obtaining maximum solar energy for photosynthesis. With the existing extensive system of plantation, not only is the yield per unit area very low, but the gestation period of the plantation is very long and the plants being vigorous they pose problems of management. For overcoming these problems, high-density plantation as followed in Europe and the United States will have to be taken up on a large scale in future planting programmes. The idea in high-density plantation is to raise only fruit varieties that have yield potential; to dwarf rootstocks in order to get high productivity per unit area; to maintain the size of trees which is most convenient for handling, besides reducing cost of cultivation. It is possible to accommodate 2000 to 3000 trees per hectare under this system as against 250 to 300 trees per hectare under the extensive system presently being followed in Himachal Pradesh. The high-density plantation system not only ensures precocity in production, but also substantially increases yield and also enhances quality.

The proposed density to be followed in any fruit plantation depends upon topography, soil fertility, climatic conditions, pest and disease problems, irrigation facilities, and other factors. Since orchards in Himachal Pradesh are generally located on steep lands, the high- and ultra-high-density plantations being followed in other countries involving very high capital investment will not be practicable for these conditions. Other constraints under which the fruit producers in Himachal Pradesh operate are poor soil fertility, non-availability of assured irrigation, heavy precipitation during the monsoon, heavy snowfall during the winter and hail during the spring in several areas. Diseases and pests like woolly aphid, root rot, and apple scab are also major problems. Therefore, very dwarfed rootstocks requiring fertile soil, flat land, assured irrigation, and provision of support in the form of stakes or trellis will not be suitable, except in valley areas. In steep areas, the rootstock itself should be able to provide support to the main tree. Under these conditions, rootstocks are required which are semi-vigorous, with good anchorage so as to support heavy crop loads and the weight of snow during the winter. Drought resistance and resistance to such pests and diseases as woolly aphid and collar rot, in the case of apple, is also required. Semi-intensive plantation densities involving a plantation of 800 to 1000 trees per hectare with free-standing trees should be the goal when developing future plantations. Besides using semi-dwarf rootstocks, the naturally dwarf mutant and suitable pruning practices would also be helpful. Besides apple, high-density plantations using suitable rootstock and pruning practices could be used for crops such as peach and cherry. The use of varieties such as Kinnow for mandarins and Amrapali for mango offer promise in the development of intensive plantations.

Moisture Stress

Horticulture in Himachal Pradesh is mainly practised under rainfed conditions and serious moisture stress is commonly experienced at the critical periods of plant growth and development. Though rainfall is sufficient, it is not well distributed. The rain water generally flows down with high velocity because of the slopes and hilly terrain. This does not allow water absorption through infiltration into the soil to its optimum capacity. Most of the precipitation runs off through the drainage system. Technology for moisture conservation *in situ* is available and should be applied. First, future plantations must be made on contours because plantations should follow the natural lie of the land. Second, vegetative barriers (in the form of vegetative bunds) will have to be created as dense hedges or fences along contours at suitable intervals. These fences will stop the water flow and force it to filter through these barriers, leaving the soil behind. The velocity of water will thus be reduced and consequently also its solid erosion capability. Such a practice will allow maximum possible infiltration of water into the soil and will also help to recharge the soil profile with water.

To provide artificial irrigation during the moisture stress period, the only possibility in many orchard areas is to use rain water in a high-efficiency irrigation system. Among the traditional yet sophisticated methods of irrigation, drip irrigation has high potential to increase fruit production through conservation and management of scarce water resources in rainfed areas. Research and commercial experiments in the country have established the suitability of the drip system for raising fruit crops and this system of irrigation is already in operation in many states. However, the high installation cost may limit its large-scale and fast adoption by orchardists. Provision of financial support in the form of liberal subsidies and cheap credit facilities from the government or financial institutions could go a long way toward the adoption of this efficient method of irrigation by growers.

Natural Calamities

Unfavourable climatic conditions such as hail, drought, excessive rainfall, and frost also play an important role in reducing fruit production in some years. Of these the occurrence of hail in some areas is an important natural calamity which considerably damages fruit crops and renders them unmarketable. The use of anti-hail nets can help in saving the crop from this, but at present, suitable anti-hail nets are not available in the country. The material available at present is meant only for fishing and has a short life. The development of some suitable material with a longer life of at least 10 years is, therefore, an urgent necessity.

At present, no insurance against the risk of natural calamity is available to the horticultural industry. Suitable crop insurance programmes are required to be devised by insurance organizations so that the risk factor does not act as a disincentive to investment in the horticultural sector.

Marketing and Processing

Substitute Packing Cases

With increased production of fruits, the demand for packing cases for packing and marketing of fruits has also increased considerably. Since a large proportion of fruit is still marketed in conventional wooden packing cases, the demand for wood has resulted in tremendous pressure on forests. The annual requirement of wood for the manufacture of packing cases at the current level of production has been estimated at 200,000 to 300,000 cubic metres, which will increase proportionately as production increases. There is thus no alternative except to switch over to an internationally accepted mode of packing, i.e. corrugated fibre board (CFB) cartons with trays. Keeping this in view, the state government has decided to implement a project for the manufacture of craft paper corrugated cartons within the state at a total cost of Rs. 200 million in the first phase. The project is in an advanced stage of implementation and is expected to be commissioned in 1990 when it will be possible to meet the entire demand for CFB cartons for the packing of fruits within the state itself. The state government is also promoting the use of CFB cartons for the packing of fruits by supplying the same at subsidized rates. During the last 10 years, a total of 404,470 cartons were supplied to the growers.

Marketing Infrastructure

The development of marketing facilities in the state have not been commensurate with fruit production. It has been realized that the facilities for post-harvest handling of fruits, grading and packing houses, cold storage etc. are far below the actual requirements of the fruit industry. There is an urgent need to introduce mechanized grading and packing facilities down to the village level and also to increase storage facilities in the production areas.

State Fruit Markets

About 90 per cent of the fruit produce of Himachal Pradesh is marketed in the terminal markets located in other states and 80 per cent of the apple produced is consigned first to the Delhi fruit and vegetable market, from where it is redistributed to other markets. However, the state government has no control over these terminal markets to safeguard the interests of the fruit growers. It has, therefore, been realized that there is a necessity to establish a fruit market within the state itself to avoid dependence on Delhi and other markets. One such market with modern amenities and infrastructural facilities is being established at Parwanoo, a township on the national highway at the Haryana-Himachal border, to act as a state fruit market. Financial assistance from the World Bank under an IDA-assisted Integrated Horticultural Development Project is also expected to be available for the development of this market.

Transportation

Although many orchards in Himachal Pradesh are serviced by a well-developed road network, difficulties are generally experienced by fruit growers in the interiors, who have to carry their produce up to the road head, resulting in heavy transport costs and delay in transport of the produce which ultimately affects quality and price. It is not possible to link all the villages and orchards with roads; the only alternative would seem to be to link remote villages and orchards with road-heads by means of a gravity cableway. The experience of some entrepreneurs in the installation of such cableways in Shimla district have been encouraging. The programme requires to be extended on a mass scale with the assistance of the government and financial institutions.

Diversification in Processing

At present fruit culls are being used by processing units for the preparation of juices and other fruit products. During bumper crop years, or when widespread damage has occurred to fruit crops in the state due to natural calamities, the processing industries are not in a position to use all the unmarketed fruit. Therefore, for maximum utilization of culled fruit, there is a need to diversify the processing industry. In fact, there is an urgent need to install a wine industry in the state.

Fragmented Land Holdings

The small and fragmented land holdings held by a majority of the farmers are also an important constraint to the further development of the fruit industry. Horticulture requires permanent investment and would benefit from government policy on land reform and consolidation of holdings. This would act as an incentive to investment in fruit production. Alternatively, this problem could be conveniently handled by establishing consolidated plantations in the form of garden colonies by pooling the lands of small farmers within a common fence. Such a programme would, however, require liberal assistance from the government. The results of such plantations in Himachal Pradesh have been encouraging.

Future Prospects of Horticulture Development in Himachal Pradesh

Although there has been tremendous development of horticulture in Himachal Pradesh during the last four decades, we are still far from reaching the actual potential given Himachal Pradesh's agroclimatic and vegetative resources. In Himachal Pradesh, about 98.6 million hectares are under grasslands, 224,000 hectares under culturable wasteland and land put to non-agricultural use, and 54,000 hectares are fallow (currently or permanently). Therefore, there is still a large untapped area for horticultural development if proper use is made of the available land resources. An ambitious plan for the development of horticulture up to the end of the century has, accordingly, been formulated. The data presented in Tables 3.7 and 3.8 give an idea of the perspectives of area and production of fruit up to the end of the century.

Horticulture As an Afforestation Activity

The environmental degradation of the mountain regions of the Himalayas due to excessive use of forest resources has made the development of tree plantations, especially plantations of fruit trees, an important economic measure for the environmental conservation of the hills. Fruit trees provide permanent green cover to the soil and act as soil binders, preventing solid erosion and retaining nutrients which would otherwise be lost as a result of erosion. Fruit trees thus offer higher productivity, environmental conservation, and optimum and economical use of resources, compared with any other economic activity, in the most ecologically acceptable manner. The vast stretches of fruit plantations developed on our hills thus fit very well into the campaign to 'Save the Himalayas'.

There is an erroneous impression that horticulture in general and

TABLE 3.7

Projections of area under fruit in Himachal Pradesh up to 2000 A.D. (hectares)

Year	Apple	Other temperate fruits	Nuts and dry fruits	Citrus	Other sub-tropical fruits	Total
1989/90	58,112	29,326	12,628	35,226	19,759	155,051
1990/91	59,612	30,626	13,328	37,426	21,059	162,051
1991/92	61,112	31,926	14,028	39,626	22,359	169,051
1992/93	62,612	33,226	14,728	41,826	23,659	176,051
1993/94	64,112	34,526	15,428	44,026	24,959	183,051
1994/95	65,612	35,826	16,128	46,226	26,259	190,051
1995/96	67,112	37,126	16,828	48,426	27,559	197,051
1996/97	68,612	38,426	17,528	50,626	28,859	204,051
1997/98	70,112	39,726	18,228	52,826	30,159	211,051
1998/99	71,612	41,026	18,928	55,026	31,459	218,051
1999/2000	73,112	42,326	19,628	57,226	32,759	225,051

TABLE 3.8

Projection of production of fruits in Himachal Pradesh up to 2000 A.D. (tons)

Year	Apple	Other temperate fruits	Nuts and dry fruits	Citrus	Other sub-tropical fruits	Total
1988/89	377,298	38,772	6,892	28,942	20,534	472,438
1989/90	389,979	42,490	7,671	33,644	21,656	495,440
1990/91	408,015	44,368	8,487	39,438	23,742	524,050
1991/92	426,186	47,298	9,009	43,852	25,280	551,625
1992/93	434,628	4,988	9,804	47,604	26,970	568,894
1993/94	448,560	51,918	10,455	54,730	29,806	595,469
1994/95	459,927	53,452	10,930	59,178	32,215	615,703
1995/96	471,591	56,052	11,628	62,452	35,118	636,841
1996/97	494,208	58,652	12,128	66,452	37,318	668,758
1997/98	508,608	61,252	12,628	70,452	39,518	692,458
1998/99	523,008	63,852	13,128	74,452	41,718	716,158
1999/2000	537,408	66,452	13,628	78,452	43,918	739,858

the apple industry in particular is solely responsible for the depletion of forest resources because of the demand for wooden packing cases. The industry has, therefore, been considered counterproductive and an indirect threat to the ecology of the Himalayan mountain region. This view is not based upon facts. According to the records maintained by the Department of Horticulture during the last four decades (1950/51 to 1988/89), a total of 138.3 million apple boxes have been exported from the state for marketing in other states. The packing requirements of this fruit were met by using 4.047 million CFB cartons and the balance of

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132.26 million apples were packed in wooden boxes. Since it is possible to manufacture at least 50 standard apple boxes from a standing volume of one cubic metre of wood and about 200 cubic metres of wood (standing volume) can be extracted from a hectare of forest area, it should be apparent that during the last 39 years, about 2,645,261 cubic metres of wood derived from 13,226 hectares of forest area has been used for packing fruit. Against this depletion of forest cover, the apple industry in Himachal Pradesh has helped to provide vegetative cover for about 54,500 hectares. During the same period, the horticultural industry as a whole contributed to provide green cover to about 142,000 hectares, thus supplementing the afforestation programme and improving the ecology of the hills of Himachal Pradesh.

Conclusion

Horticulture in Himachal Pradesh has witnessed significant progress during the last 40 years and is steadily poised to move towards a multi-dimensional phase when the present heavy pressure on traditional farming will be reduced to a great extent. This will not only liberate the state from economic inertia in the agricultural sector, but will also supplement the state's efforts to provide green cover to the hills, promoting environmental conservation. It is expected that by the end of the century, horticulture in Himachal will develop into an industry with a turnover of 5000 million rupees per annum in the rural sector. It will be next only to the public sector power industry in total investment and turnover, and the biggest industry of the state in the private sector employment potential, Himachal Pradesh synonymous with horticulture and power.

4

Horticulture Development in Uttar Pradesh Hills

J.N. Seth

The hill region of Uttar Pradesh lies between 28° and 32°N latitude and 77° and 81°E longitude. It comprises eight districts with a geographical area of 51,125 sq.km and the altitude ranges from 400 to 8000 m above sea level. The total population of the hill area is 4,836,000 (1981) with a density of 95/sq.km.

Out of the net sown area of 1.346 million hectares, 85 per cent has no irrigation facilities, making the growing of agricultural crops totally dependent on weather conditions. Generally, once in four or five years, farmers are able to get normal yields, but more often they suffer a total loss. Therefore, horticulture is definitely a better economic proposition than growing cereal crops.

Fruit plants of different varieties, however, can only be successfully grown in such dry lands if the agroclimatic and soil conditions are right. In irrigated areas, the cultivation of off-season vegetables and off-season flowers and their seed production can give very high returns to growers who market them in the plains.

Considering these facts, the state government has given greater emphasis to horticultural development in the hill region of Uttar Pradesh. Due to its consistent efforts, the area under fruit cultivation has increased from 2400 hectares in 1952/53 to 100,000 hectares by the end of 1987/88. The development has been in apple, peach, plum, apricot, citrus, mango, and litchi cultivation, as shown in Table 4.1. Similarly, the area under vegetables has increased from 34,141 hectares in 1984/85 to 37,783 hectares by the end of 1987/88 and that under potato from 11,407 hectares in 1984/85 to 12261 hectares by the end of 1987/88. For

TABLE 4.1

District-wise area and production of different fruits in Uttar Pradesh hills

District	Apple		Pear		Peach		Citrus	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
Almora	7,685	23,000	2,235	3,125	1,785	3,800	3,465	5,500
Nainital	12,073	27,000	1,480	2,550	3,340	6,300	1,825	4,250
Pithoragarh	4,723	19,000	997	2,450	1,149	2,280	2,640	5,300
Tehri	6,750	17,000	1,145	2,300	1,395	1,720	1,925	4,900
Pauri	6,504	16,000	827	2,590	727	2,150	2,641	3,550
Chamoli	3,785	17,000	1,007	2,075	1,266	2,465	3,331	7,800
Uttarkashi	6,033	16,000	785	1,310	1,040	2,036	1,150	3,500
Dehra Dun	3,590	18,000	936	2,180	970	1,230	1,600	3,200
Total	51,148	153,000	9,392	18,580	11,672	21,980	18,557	38,000

District	Mango		Plum/Apricot		Litchi	
	Area	Prod.	Area	Prod.	Area	Prod.
Almora	2,585	7,390	2,915	5,425	475	810
Nainital	4,485	18,580	1,295	3,660	745	1,062
Pithoragarh	1,065	3,000	1,905	4,020	855	936
Tehri	1,990	6,200	1,611	3,520	1,020	990
Pauri	2,900	5,500	1,888	4,200	1,710	1,230
Chamoli	328	830	1,510	3,630	367	756
Uttarkashi	301	800	1,249	3,420	80	350
Dehra Dun	3,795	3,700	1,112	2,320	2,362	2,270
Total	17,449	4,600	13,485	30,195	7,614	8,404

quick, scientific development of horticulture in the state, the government provides several facilities.

Supply of Plants, Planting Materials and Seeds

With a view to supplying true-to-type, disease-free plants of superior clones, 108 progeny orchards and nurseries have been established in different agroclimatic zones of the hill area. At least one nursery is functioning in each developmental block. There are 89 blocks in the hill region. These orchards and nurseries are on average supplying 2.5 million plant saplings every year. Some of the plants produced in these nurseries are also being supplied to other northeastern states and to Bhutan.

Recently, five more elite gardens have been established where virus-free cultivars of exotic temperate fruits as well as their rootstocks have been introduced. Locally selected clones, after being indexed against important viruses, have also been planted. Outstanding cultivars from them will be planted in all the progeny orchards as mother plants.

To supply healthy, disease-free seed of important vegetables such as cabbage, cauliflower, tomato, capsicum, European type carrot, and radish, eight vegetable farms have been established. The breeder seeds obtained from agricultural universities and research institutes are sown to raise foundation seed. This foundation seed is supplied to registered growers for certified seed production.

The hill region has 10 potato farms. In the main farms at Kashipur, Gagar (Nainital), Balanti (Pithoragarh), and Joshimath (Chamoli), breeder seeds obtained from the Central Potato Research Institute, Shimla, have been sown to raise Foundation-1 seed. This Foundation-1 seed is sown in departmental farms to raise Foundation-2 seed, which is given to farmers to raise certified seed.

Extension Support

Extension service is provided by the Department of Horticulture and Fruit Utilization to help orchardists and growers to lay out new orchards, select varieties of fruits and vegetables for a particular area, supply true-to-type planting material, and provide other technological guidance like training, pruning, pest and disease control, harvesting, grading, and packing. For vegetables, potato and flowers, the time of planting varies according to agroclimatic conditions, particularly altitude and aspect of the site, towards or against the sun.

For these extension activities 186 mobile teams function in the entire hill area. They are located in such a way that each developmental block has at least one mobile team and in horticulturally developed areas there are two to three mobile teams. These mobile teams also supply other inputs such as fruit plants, vegetable seeds, potato seeds, insecticides, and fungicides. The staff employed in these mobile teams are regularly trained at the horticultural and experimental training centres and at the agricultural universities.

The work of these mobile teams is supervised and coordinated by the District Horticulture Officer and the Potato and Vegetable Development Officer with the help of Zonal Senior Horticultural Inspectors located in a group of four to five blocks. The officers also regularly issue guidelines for extension workers as communicated by the department or the state government.

The knowledge of the officers as well as the inspectors is regularly kept up to date by regular training at the horticultural experiment and training centres, the Indian Council of Agricultural Research Institute, and the agricultural universities. The institute also arranges the training of external officers in different fields. Some of the extension officers are also exposed to the modern technology prevalent in other countries through training and visit programmes or fellowships offered by these countries under various externally aided projects.

Financial Assistance of Growers

Initial investment in establishing orchards in the mountains is rather high because of heavy expenditure involved in operations like preparation of the land and terracing the field, digging of pits, and fencing. This has been found to come in the way of horticulture development work, especially among people with poor means. The difficulty is further enhanced because of the long waiting period involved in such crops before they reach economic bearing age. In order to encourage such people to take to fruit farming and improve their economic conditions the state government granted long-term horticultural loans on liberal terms and conditions, which has given a fillip to the development activities.

Means of communication in the mountain region have not yet fully developed. The situation is especially bad in the interior areas. Transportation of planting material, grafts, and seeds is not only cumbersome and time consuming, but very costly too. In order to provide relief to the growers, provision for a subsidy has been made by the government on the cost of transport of these commodities up to the block headquarters and village-level worker centres connected by motorable road.

Research Support

The department has its own set-up for research into various horticultural crops. There is one main Horticultural Experiment and Training Centre at Chaubattia (Almora) which is the oldest horticultural research station in India (1932/33). It has 12 main sections Pomology; Vegetables; Fruit; Vegetable and Medicinal Plant Breeding; Floriculture; Soil Science and Nutrition; Plant Physiology; Mycology; Virus and Mushroom Cultivation; Entomology; Production Economics; and Extension and Publicity.

This Centre has its sub-centres as well as field stations in different agroclimatic zones. The main sub-centres are at Jeolikote (Nainital), Pithoragarh, Matela (Almora—vegetables), Srinagar (Pauri), Chakrata (Dehra Dun), and Dunda (Uttarkashi). The field stations are at Rudrapur (Nainital), Kothialsen (Chamoli), and Kotdwar (Pauri).

The sub-centres are engaged in research on field-based problems such as varietal development, standardization of cultural practices, including propagation of aseptic planting material through tissue culture, improvement in productivity, and standardization of post-harvest handling of fruits, vegetables, and flowers, including marketing, storage, and processing. These centres also engage in research on mushroom cultivation, honey bees, and medicinal and aromatic plants to help local orchardists to have a subsidiary source of income. They also impart training on all these aspects to the staff of the Directorate of Horticulture and Fruit Utilization as well as to the growers of the areas.

All the infrastructural facilities created in the department have helped in the rapid development of areas under fruit, vegetable, potato, and flower cultivation. However, many new problems, such as low productivity, lack of marketing facilities, lack of storage facilities and wastage of fruits in transportation due to outdated modes of transport (e.g. on mules, by head loads, or by trucks on rough roads) have cropped up. The actions initiated to solve these problems are described.

Productivity

To increase productivity, a massive programme has been initiated since 1987/88 under which demonstrations are conducted in the growers' fields and orchards under the supervision of the technical staff of the department. In fruits, 10 fruit trees are selected in an orchard, preferably that of a small or marginal farmer. All the cultural operations such as training, pruning, fertilizer application, control of pests and diseases, including physiological disorders, provision of proper pollinizers, gap filling with modern cultivars, and changing of unproductive cultivars through top-working or frame working are done under the supervision of technical staff. Each demonstration is repeated every three years on the same tree so that the effects of weather conditions on the productivity of fruit trees may also be assessed.

Marketing

To solve the problem of poor marketing facilities, the state government has started a price support policy for apple since 1988 which will be extended to other fruit crops. Under this scheme, Rs. 1.50 per kg is paid for cull apples at the collection centres and Rs. 3.00 per kg is paid for A and B grade apples. Besides this, the orchardists are also provided with a 50 per cent subsidy on transport charges from orchard to road head (collection centres), if their orchards are more than 2 km away from the road head.

The department has also prepared a future plan which will concentrate on plantations with one or two types of fruit trees in a particular area tō which it is most suited. This will help to facilitate marketing operations like harvesting, packing, grading, and transportation of fruits, because a large quantity of fruits will be available in concentrated pockets. It will also help in conducting pest and disease operations effectively, as the medicines and equipment necessary can be made available in good time. The staff posted to these pockets will also get expertise through training and experience with these fruits.

In this plan, a block has been taken as a unit and fruit species have been identified on the basis of their agroclimatic and soil conditions. The guidelines prepared to plant specific cultivars in different agroclimatic conditions are given in Annex 1.

Soil Analysis

Soil profile and the chemical status of soil are always to be studied before new orchards are laid out to select suitable plant species. Soil analysis of existing orchards is also to be done every third or fourth year. For this, two soil testing laboratories are working in the area—one at Chaubattia (Kumaon division) and one at Srinagar (Garhwal division). They give regular recommendations regarding the type of crops to be grown or planted and the fertilizer doses to be applied. They also recommend soil amendment treatment if there is need due to high acidity or alkalinity.

Vegetable Development

Vegetable cultivation in the hills is a highly remunerative venture.

Vegetables such as cabbage, cauliflower, pea, capsicum, carrot, radish, tomato, and French bean can be produced in those seasons when they are not available in the plains, where there is a large demand for them in the big cities. In the hills the cultivation of these vegetables can be extended for 8 to 10 months if they are grown at different elevations.

The seeds of vegetables such as cabbage, cauliflower, capsicum, turnip, spinach, lettuce, and European carrot can only be produced in sub-temperate and temperate climates, but their seed is required for the entire country. There is also great scope to export these seeds to Middle Eastern and Southeast Asian countries.

There are several highly populated cities in the hills where it is difficult and costly to transport even the cheaper vegetables from the plains. These vegetables deteriorate in quality by the time they reach the consumer. Therefore, it is always better to produce vegetables locally. The purchasing power of the population of these areas is also quite high.

Off-season vegetable cultivation in Uttar Pradesh hills has already developed in certain pockets of three hill districts—Almora, Nainital, and Tehri. The main emphasis is on early cauliflower, cabbage, capsicum, tomato, French bean, and green pea. By taking up cultivation of these crops the farmers of these areas have considerably improved their economic condition. The government now envisages the development of such areas in other districts which are suitable either for off-season vegetable cultivation or for seed production. Encouragement is also being given to vegetable cultivation around hill cities.

For this purpose 5498 demonstrations are being conducted every year on growers' fields where all the inputs like seed, fertilizers, pesticides, fungicides, and bacterial cultures are given for 1/50th of a hectare. All the modern practices are adopted in these areas under the supervision of technical staff.

Floriculture

Gladiolus, carnation, lily, dahlia, tuberose, and other flowers are produced in the hills at a time when they cannot be produced in the plains. Similarly, tulips, daffodils, red-hot poker and other flowers can only be produced in the hills, and the planting material of these flowers can also be produced there. Cut flowers and their planting material fetch remunerative prices and large-scale testing and multiplication of different cultivars of these varieties is being done at selected orchards in Dehra Dun and Nainital districts. Large-scale distribution of gladiolus corms at 50 per cent subsidy has been made for the last three years. This has helped to considerably augment the income of orchardists.

Olive Cultivation

It is a well-known fact that olive oil is now considered one of the best edible oils in the world and is also being used in medicines. The country imports Rs. 3 to 4 million worth of oil every year. The agroclimatic conditions of Uttar Pradesh hills are favourable to the growing of olive plants, particularly in the outer hills up to 1200 m above sea level. The wild plants of *Olea cuspidata* are to be found in these areas. Hence, a project in collaboration with the Italian Government was started in 1985 to develop olive cultivation in the Uttar Pradesh hills. In this project, 17 cultivars of olive, suitable for both oil and pickling, were introduced. For rootstock purpose, plants as well as seeds of *Olea europea* were imported. Two centres for the maintenance and propagation of these plants were established at Dhakrani (Dehra Dun) and Jeolikote (Nainital). These centres have all the facilities required for mass multiplication of plants, mist-chambers, glasshouses (temperature controlled), net houses, and sprinkler and drip irrigation. Ninety-three demonstrations both at government farms (27) and at private farms (66) were planned in agroclimatically selected localities. Some of the cultivars such as Pendolino, Leccino, Coratina, Frantoio and Cipressino are already doing well in some of these areas. Large-scale multiplication of these cultivars has been started both by cutting and by grafting. The plants raised by grafting will be planted under rainfed conditions, while those raised from cutting will be planted in irrigated areas.

Mushroom Cultivation

Mushroom cultivation was taken up to provide an extra source of income to hill growers. For this, a loan of Rs. 10,000 was provided for a 100-tray unit at a nominal rate of 5.5 per cent interest. The loan is recoverable in five years and recovery starts from the third year. Now the quantum of loans has been increased to Rs. 25,000 and the loan will be distributed by the Land Development Bank and other commercial nationalized banks with an interest of 5.5 per cent. The difference in interest rates will be borne by the Department of Horticulture.

Besides this, spawn is supplied by the Horticultural Experiment and Training Centre, Chaubattia (Ranikhet) on a no-loss no-profit basis. This centre, along with its sub-centre Valley Fruit Research Station, Srinagar (Pauri Garhwal), also organizes 15 days' training of prospective growers in different districts. A stipend of Rs. 75 is given to the trainees. These centres also provide technical supervision with the help of extension staff to all units producing mushroom in the hills.

This has helped in the establishment of about 125 units with the production of about 800 quintals per year. A pasteurization tunnel of 50 tons per shift compost capacity is being set up at Jeolikote (Nainital) under the Indo-Dutch Project. This will further help mushroom production in the area. A similar project is envisaged at Dehra Dun.

Beekeeping

Beekeeping not only helps to provide a subsidiary source of income to the hill population, but also increases the production of fruits and vegetables, particularly of cross-pollinated crops such as apple, pear, plum and litchi and seed production in cabbage, cauliflower, carrot, turnip, radish, and other vegetables.

The Department of Horticulture, to develop the beekeeping industry, provides the following facilities to the local population:

- *Training in beekeeping*: Progressive beekeepers are provided four months' (200 persons) and 45 days' (900 persons) training on all aspects to beekeeping at two centres located at Jeolikote (Nainital) and Talwari (Chamoli).
- *Distribution of bee colonies*: The two centres give bee colonies at subsidy rates developed at the centres. About 350 colonies are distributed every year.

- *Distribution of beehives*: Small and marginal farmers are given beehives at 50 per cent subsidy to encourage them to take up beekeeping on commercial lines. About 400 boxes are distributed each year by the two centres.
- *Extension support*: The two centres, with staff posted in the districts, also help beekeepers to solve their day-to-day problems like control of pests and diseases, division of colonies, and arranging migration of colonies in winter.

Fruit Preservation

About 25 per cent of total fruit produce is cull fruit which is not suitable for table purposes. Similarly, a large amount of vegetables are wasted in storage and transport. For the proper utilization of cull fruits in the interior areas, as well as to cultivate the habit of consuming preserved fruits to enrich the local diet, fruit preservation was started by the Department of Horticulture.

The department has established 40 Community Canning Centres in several areas of the hills and two Food Craft Institutes at Nainital and Kotdwar (Pauri). The Community Canning Centres help the local population to preserve fruits and vegetables to the extent of 400 metric tons and imparts 15 days' training in home preservation techniques to local housewives and students. About 12,000 people are trained every year. The two Food Craft Institute give a one-year diploma in three courses: fruit preservation; cookery; and bakery and confectionery. Ten students per course are enrolled at each centre. Besides this, refresher courses for the staff engaged by the department are also arranged.

Annex 1

Cultivars recommended for different zones in Uttar Pradesh hills

Climatic zones	Fruit	Varieties
1. Tarai-Bhahar and area, Dehra Dun valley	Mango	Bombay Green, Bombay, Yellow, Langra, Chausa, Dasehri
	Citrus	Eureka Lemon, Kagzi kalan
	Litchi	Early Large Red, Calcutta, Rose Scented, Dehra Dun, Late Seedless
	Guava	Lucknow-49, Safeda
	Jackfruit	Local
	Papaya	Ranchi Dwarf, Pusa Nanha, Coorg Honey Dew (mainly Bhahar areas)
2. Humid valleys and hills of outer Himalayas up to 1500 m above sea level	Mango	Same as in 1
	Citrus	Sweet orange, Lemon (Round) (Malta Common), Mandarin (Hill Orange), Kinnow, Hill Lemon, Eureka
	Sand pear	Gola
	Walnut	Grafted plants on terraces and seedlings in ravines
	Peach	Florida Sun, Crawford Early, Early Alberta
	Plum	Santa Rosa
	Apricot	Kaisa, Shipley's Early
3. Hot and dry valleys and low hills up to 1500 m above sea level	Peach	Same as in 2
	Pear	Same as in 2
	Citrus	Sweet orange (Malta Common), Mandarin (Srinagar and Kinnow). Hill Lemon, and Kagzi lime
	Mango	Same as in 1
	Almond	California Paper Shell, Brig's Hard Shell, Ne Plus Ultra, Drake
	Walnut	Same as in 2
	Apricot	Same as in 2
4. Mid-hills from 1500 to 2500 m, 1600 to 2200 m above sea level in outer hills	Apple (early)	Early Shanberry, Chaubattia Princess, Fanny and Benoni

Contd.

Annex 1: Contd.

Climatic zones	Fruit	Varieties
	Apple (middle)	Red Delicious, Royal Delicious (preferably in Uttarkashi, Dehra Dun, Pauri and Tehri), Red Gold and Golden Delicious as pollinizers, Spur varieties like Red Chief, Oregon Spur and Stark Spur Red.
	Apple (late)	Buckingham and Rymer
	Hazelnut	Daviana, Homischezeller, and Ronnda Roman
	Walnut	Same as in 2
	Peach	Crawford Early, Early Alberta, Peregrine
	Plum	Same as in 2
	Apricot	Charmagz, Royal, Turkey, Moorepark, New Large Early, Chaubattia Madhu

5

Horticultural Development in Nepal: Progress, Potential and Problems

H.P. Gurung

Introduction

Nepal, situated along the slopes of the Himalayas, is a land-locked country bordered by India to the east, south, and west and China to the north. Rectangular in shape, it has an area of approximately 147,181 sq.km, extending roughly 880 km from east to west and 130 to 240 km from north to south. The topography is highly variable, ranging from the plains of the terai, with an elevation of 60 to 300 m above mean sea level, to the deep valleys and high mountains 8838 m above mean sea level. From the south to the north, Nepal can be divided into three parallel ecological zones, each of which extends east to west across the country: the terai, the mid-hills, and the high mountains. The terai, accounting for about two-thirds of the country's total cultivated area (2,653,300 hectares), is the bread basket of Nepal. The mid-hill region has considerable potential for horticultural development. The high mountains, usually under perpetual snow, are largely unsuitable for cultivation. Administratively, Nepal has been divided into 75 districts, 14 zones, and 5 development regions (Figure 5.1).

At present, the population of Nepal is over 17 million, out of which 44 per cent live in the terai and 56 per cent in the hills. The population is growing with an annual growth rate of 2.6 per cent.

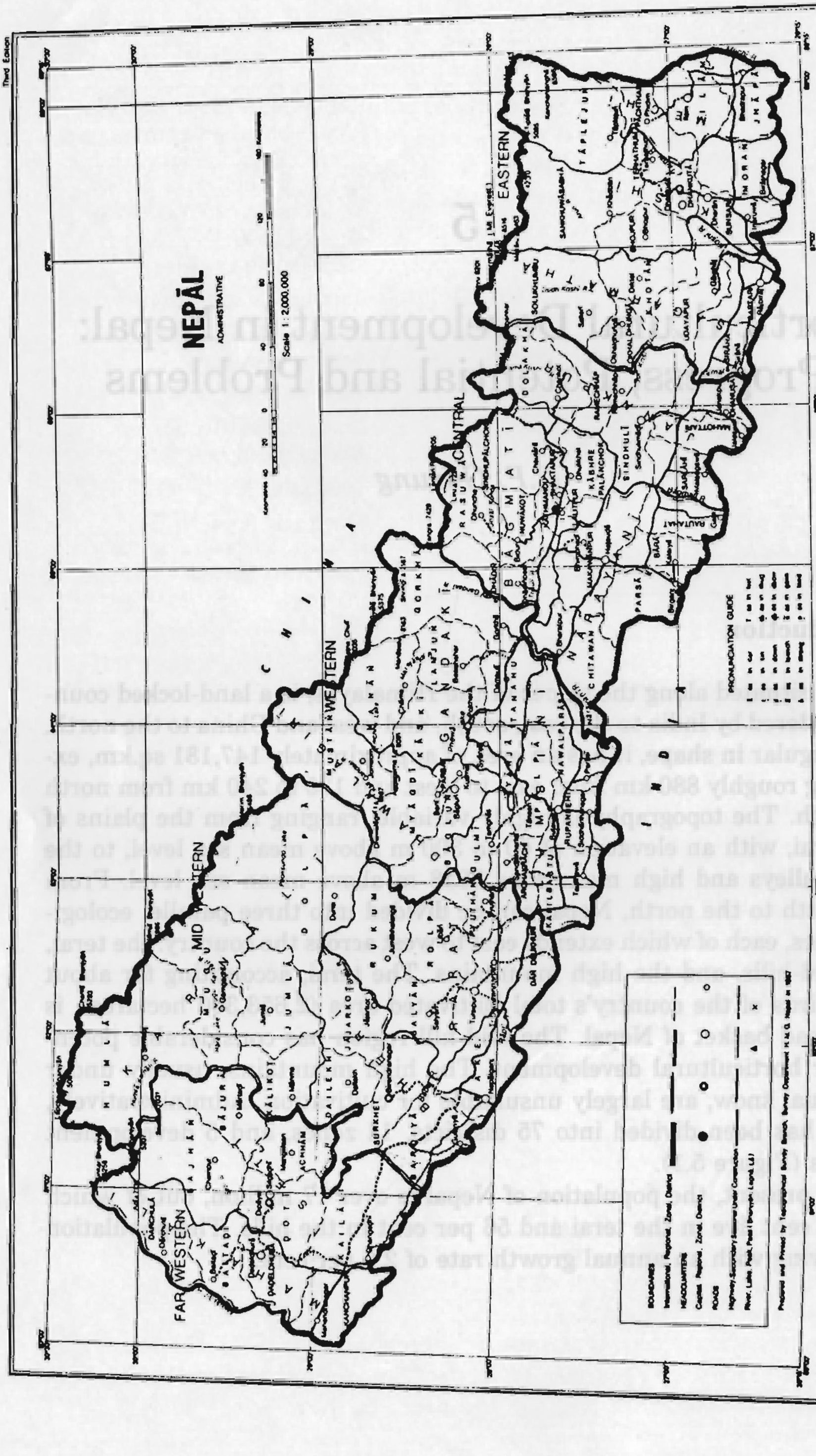

Figure 5.1: Showing Different Zones, and Development Region.

Status of Agriculture

Agriculture is the dominant economic sector in Nepal on which nearly 93 per cent of the total population are at least partially dependent for their livelihood. The agricultural sector generates about two-thirds of the gross domestic product and provides about 75 per cent of all exports. In fact, agriculture is the backbone of Nepal's economy.

The terai accounts for 23 per cent and the hills (including mountains) for 77 per cent of the Nepal's total land area. The average size of land holding is about 0.5 hectare in the hills and 1.8 hectares in the terai. At present, only about 15 per cent of the total cultivated land is irrigated while the rest of the area is rainfed. The use of chemical fertilizers is about 16 kg of plant nutrient per hectare of cropped area.

The principal agricultural crops of Nepal are paddy, maize, wheat, barley, millet, sugar cane, tobacco, oilseeds, pulses, and potato. Crop yields are generally low.

Horticultural Situation

Geographically the kingdom of Nepal lies within the sub-tropical zone (26° 15′ to 30° 30′ N latitude and 80° 00′ to 88° 15′ E longitude), but due to wide variations in altitude, and climates consequently ranging from tropical to alpine types, a wide range of horticultural crops (fruits, vegetables, spices, herbs, and flowers) are grown successfully. In the 1960s, keeping in view the tremendous scope of horticultural development in Nepal, His Majesty's Government of Nepal launched horticultural development programmes to improve the economic and nutritional status of the people. Since then, 33 horticultural farms have been established (Annex 1) and are located at different parts of the country, representing diverse agroclimatic conditions. These farms provide improved planting material, seeds, and technical services, and are used as testing sites for research and training centres for farmers.

Fruit Production

The southern plains of the terai, being tropical areas (below 1000 m above mean sea level), are suitable for growing fruits like mango, litchi, guava, banana, pineapple, papaya. The sub-tropical areas of the mid-hills (1000 to 1800 m) are particularly suitable for growing citrus, pear, peach, and plum (warm temperate). In temperate areas between 1800 and 2800 m altitude, fruits like apple and walnut (in the low rainfall areas) are grown very successfully (Figure 5.2).

In Nepal, the hills being more suitable for fruits crops, the hill region is by far the major producer of fruits. The orange and apple are both commercially important fruits of the hills.

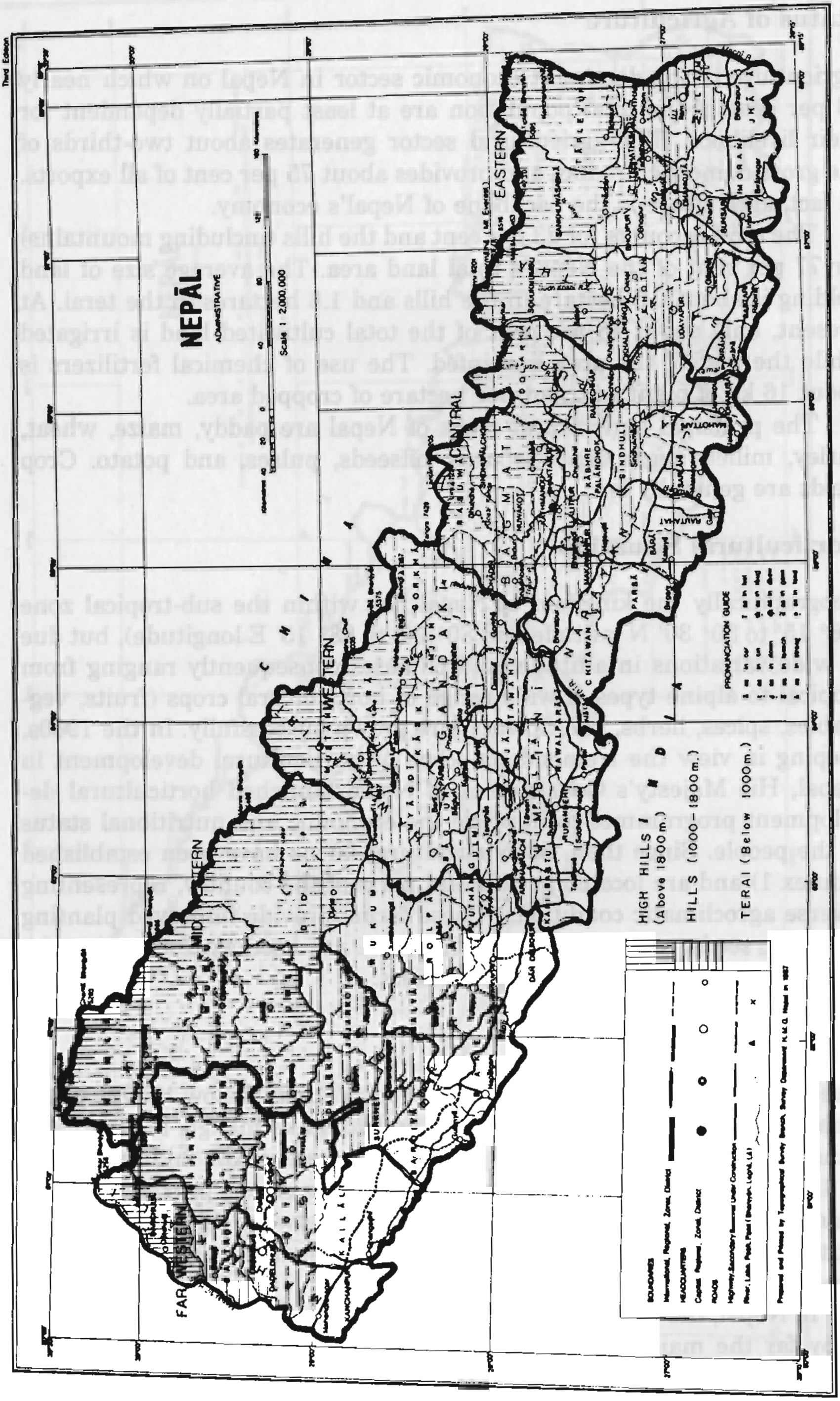

Figure 5.2: Showing Different Ecological Zones in Nepal.

Cultivation of fruits is largely limited to backyard gardens and the produce is used mainly for home consumption. However, Table 5.1 provides estimated acreage and production of different fruits in 1984/85. On the basis of total production given in the table, the per caput, consumption of fruits is about 20.5 kg. Out of the total area (51,176 hectares) under fruits, the central development region occupied the maximum area of 17,795 hectares (34.8 per cent), followed by the eastern development region 10,670 hectares (20.8 per cent), the western development region 10,484 hectares (20.5 per cent), and the mid-western development region 4,710 hectares (9.2 per cent). The distribution of area and the production of fruits by development regions has been summarized in Table 5.2.

TABLE 5.1

Area and production of fruits in Nepal

Fruits crops	Area (ha)	Production (mt)
Citrus	7,857	45,100
Non-citrus	43,319	297,935
Total	51,176	343,035

TABLE 5.2

Area and production of different fruits by development regions (1984/85)

Development region	Area (ha)			Production (mt)		
	Citrus	Non-citrus	Total	Citrus	Non-citrus	Total
Eastern	2,270	8,400	10,670	14,017.0	57,775	71,792.0
Central	2,674	15,121	17,795	13,539.0	104,000	117,539.0
Western	1,959	8,525	10,484	12,375.5	58,630	71,005.5
Mid-western	601	6,916	7,517	3,364.5	47,560	50,924.5
Far western	353	4,357	4,710	1,804.0	29,970	31,774.0
Total	7,857	43,319	51,176	45,100.0	297,935	343,035.0

The central development region contributed about 34.3 per cent of the country's total fruit production, the eastern development region 20.9 per cent, the western development region 20.7 per cent, the Mid-western region 14.8 per cent, and the Far western development region 9.3 per cent.

In Nepal, systematic fruit development activities started in the 1960s. With only a few thousand hectares of land under fruit cultivation at that time, the area has increased to 56,164 hectares with a production of 390,282 metric tons in 1986/87.

The progress of fruit development programmes from 1974/75 to 1986/87 has been summarized in Table 5.3. The table shows that the

TABLE 5.3

Fruit development 1974/75 to 1986/87

Particulars	Area ('000 ha)	Production ('000 mt)
Situation at the end of Fourth Plan (1974/75)	32.5	254
Situation at the end of Fifth Plan (1979/80)	41.8	274
Situation at the end of Sixth Plan (1984/85)	51.0	343
Situation at 1986/87	56.0	390
Target for Seventh Plan period (1985–1990)	63.0	462
Target for 2000 A.D.	87.6	702

total area under fruit crops increased by 72.3 per cent and the total production of fruit by 53.5 per cent between 1974/75 and 1986/87.

Priority Districts for Fruit Production

Considering the performance of various important fruit crops and their potential for the production of quality fruits, some districts have been identified for the intensification of commercial production of different kinds of fruit in various development regions, which are prioritized for commercial orchard development (Table 5.4). The central development region leads the other development regions in fruits.

Fruit Production Programme

Keeping in view the increasing demand for fruit in the country, several fruit production programmes are under implementation. Table 5.3 shows that during the Seventh Plan period, the total area under fruits was planned to be increased from about 51,000 hectares to about 63,000 hectares a net increase of about 11,900 hectors (23 per cent). Similarly, the total production of fruits was planned to be increased from 343,000 mt to 462,000 mt, a net increase of about 34.5 per cent. Among the various fruits, major emphasis has been laid on citrus.

In order to develop citrus fruits a National Citrus Development Programme was started in 1972 with its headquarters located at Paripately, Dhankuta in the eastern development region. The major objective of this programme is to bring about all-round development of citrus fruits. This programme recommends various rootstocks, plant propagation techniques and cultural and plant protection to citrus farmers.

Apart from this, His Majesty's Government has launched a National Priority Programme for the development of citrus fruits on a commercial scale since 1983/84. Initially, this programme was implemented in five selected districts. Dhankuta, Sindhuli, Ramechhap, Kaski, and Dailekh—but will be extended to 15 other districts prioritized for commercial development of citrus fruits (see Table 5.4). Under this pro-

TABLE 5.4

Districts prioritized for commercial fruit development

Fruit	Priority districts				
	Eastern	Central	Western	Mid-western	Far western
Citrus	Illam, Panchthar, Dhankuta, Bhojpur, Tehrathum, Sankhuwasabha	Sindhuli, Ramechhap, Kabhrepalanchok, Dhading	Gorkha, Lamjung, Tanahun, Syangja, Kaski, Palpa, Gulmi	Salyan, Dailekh	Dadeldhura
Apple	Solukhumbu	Sindhupalchok, Rasuwa	Mustang	Jumla, Dolpa, Kalikot, Rukum	Doti, Baitadi, Darchula
Walnut				Dolpa, Jumla, Kalikot, Rukum	Baitadi, Bajhang, Darchula
Pear			Sindhupalchok, Kabhrepalanchok, Bhaktapur, Lalitpur, Makwanpur, Dhading, Rasuwa, Nuwakot	Palpa	
Grape				Manang, Mustang	Banke, Bardia
Mango	Sunsari, Saptari, Siraha	Dhanusha, Mahottari, Sarlahi, Bara, Rauthat Parsa, Chitwan	Nawalparasi, Rupendehi, Kapilbastu	Dang, Surkhet	
Banana		Dhanusha, Mahottari, Sarlahi, Chitwan, Kabhrepalanchok, Nuwakot, Dhading			
Pineapple		Sarlahi, Chitwan, Nuwakot, Dhading			

gramme, farmers are encouraged to grow grafted plants and are provided with 50 per cent subsidy towards the cost of plants, plant protection chemicals, fertilizers, horticultural tools and implements, and irrigation. A number of private nurseries have been established in these districts to supply grafted plants. A total area of 4385 hectares was earmarked to be covered under this priority programme within the Seventh Plan period.

Two special projects for the development of fruits are already in operation. The Horticultural Development Project with technical and financial assistance from the Government of Japan has been implemented since 1986/87. The main objectives of the project are to develop fruit production techniques for Junar (Sweet Orange), grape and chestnut through technical development and training of extension workers and fruit farmers. Under this project, research and training facilities have been created at Kirtipur Horticulture Research Station. The project is promoting Junar in Sindhuli and Ramechhap, grape in Banke and Bardia, and chestnut in and around Kathmandu Valley and Kakani hills of Nuwakot districts at selected locations.

With loan assistance from the Asian Development Bank and technical assistance from UNDP, the Hill Fruit Development Project has been implemented since July 1988. The project area covers 11 hill districts of the eastern development region and the development of citrus fruit forms the main component of the project. Under this project, 5000 hectares is proposed to be brought under various fruits. Out of this total area, 4000 hectares will be covered under commercial orchards and 1000 hectares under homestead gardens.

Most of the Integrated Rural Development Projects and Integrated Agricultural Development Projects under implementation in Nepal have fruit development as a minor component.

The expansion of horticulture in Nepal, and the hills in particular, is limited by lack of roads and storage and marketing facilities. Because of these constraints, commercial fruit growing has been developed in accessible areas, particularly along roads and highways, near urban areas and areas within a 20 km radius of district headquarters.

Important Fruits of Nepal

Citrus

Citrus fruit represents the most important group of fruit in Nepal. Citrus fruits are extensively grown in the mid-hills of Nepal, covering an area of 9495.5 hectares with an estimated production of 64,132.0 metric tons of fruit annually (1986/87) as shown in Table 5.5.

In Nepal, mandarin orange (Suntala), sweet orange (Junar), lime (Kagatee) and hill lemon (Nibuwa) constitute the major citrus fruits of

TABLE 5.5

Area, production of citrus fruits by development region (1986/87)

Development region	Area (ha)	Production (mt)
Eastern	2,609.0	18,874.0
Central	3,381.5	21,101.0
Western	2,242.0	16,586.0
Mid-western	721.5	4,841.0
Far western	9,495.5	64,132.0
Total	9,945.5	64,132.0

Source: Department of Agriculture, Horticulture Section.

the hills. Among these citrus fruits, the mandarin orange, the most important fruit grown in the kingdom, is extensively cultivated in more than 20 districts of the mid-hills (1000 to 1500 m altitude). The majority of mandarin plants are still raised from seed. Junar, a locally grown variety of sweet orange, is of exceedingly good quality and is grown in Dhankuta, Bhojpur, Ramechhap and Sindhuli districts. It is grafted on rough lemon or trifoliate rootstocks. In some parts of Nepal such as the Pokhara Valley, citrus greening virus disease has adversely affected the production of high quality fruit.

Mango

Mango ranks second to citrus fruits and covers an approximate area of 7515 hectares with a production of 54,209 mt. It is cultivated in more than 15 districts of the terai. Most of the varieties grown in Nepal are the same as in India, commercially important varieties including Dasehri and Langra chausa. Mango hopper and mango stone weevil are important pests and powdery mildew a common disease. Mango malformation is also a common problem.

Apple

Among the various fruits, apple is of late introduction in the country. Now it is commercially grown in the temperate regions of northwestern parts of the country, at an altitude of 2000 m or above, where there is low rainfall with good snowfall in winter. It occupies an area of 5000 hectares with a production of 50,000 mt. Apple is grown in more than 11 districts, the important ones being Mustang, Jumla, Dolpa, Solukhumbu, Rasuwa, and Baitadi districts.

The most commonly liked and widely grown apple varieties are Red Delicious, Golden Delicious, and Jonathan. Crab apples are used as rootstock. Malling series rootstocks have also been introduced.

Inadequate storage facilities and lack of transport are the major problems in expanding apple cultivation.

Vegetable Production

Area and Production

Because of the diverse agroclimatic conditions in Nepal, there is tremendous scope for vegetable growing. Increase in population, change in food habits of the people due to increased knowledge of the nutritional value of vegetables, and the tourist influx into Nepal have made vegetable cultivation more important. According to the Seventh Five-year Plan, 140,500 hectares of cropped area was brought under vegetable cultivation, thereby producing 970,000 mt of fresh vegetables. The production of fresh vegetables in 1984/85 was estimated to be 741,600 mt from the cropped area of 138,000 hectares. The average productivity was 5.37 tons/hectares, which is rather low compared to that of other countries. With this production, the per caput consumption comes to only 45.5 kg per annum (except potato) in Nepal as against the international standard of 100 kg. Hence, the present production of fresh vegetables has to be doubled, which is a challenging task. Table 5.6 gives the area and production of fresh vegetables by development region (1984/85).

TABLE 5.6
Area, production of vegetables by development region

Development region	Area (ha)	Production (mt)
Eastern	39,882	214,322.4
Central	63,480	341,136.0
Western	20,700	111,240.0
Mid-western	9,798	52,653.6
Far western	4,140	22,248.0
Total	138,000	741,600.0

Out of the total area under vegetables, the central development region occupied the maximum area of (46 per cent), followed by the eastern development region with (28.9 per cent) and the western development region (15 per cent), but the mid-western and far western regions are still far behind in vegetable cultivation with 3 per cent.

Similarly, in the production of fresh vegetables the various development regions contributed in exactly the same ratio as shown under area cultivated. In some of the areas in the central region the standard of vegetable cultivation is fairly high.

TABLE 5.7

Vegetable development 1974/75 to 1986/87

	Area '000 ha	Production '000 mt
1974/75	82.0	407.5
1979/80	96.0	485.4
1984/85	138.0	741.6
1986/87	138.9	838.9
1989/90*	140.5	970.0
2000 A.D.*		1,515.0

* Planned targets

The progress of vegetable development programmes from 1974/75 to 1986/87 has been summarized in Table 5.7.

The total area under vegetable crops increased by 69.4 per cent and the total production of vegetables by 105.8 per cent between 1974/75 and 1986/87. However, as area under vegetables is going to continue to be a limiting factor, the productivity per unit area has to be increased from now onwards. Attempts are being made to achieve this objective by adopting new improved technologies.

Priority Areas for Vegetable Production

Areas which have motorable roads and access to markets in the vicinity have received priority for the launching of special programmes of vegetable production. (However, the general programme is launched all over the country with little support of seeds and technical services.) Commercial production of vegetables will be intensified in some selected pocket areas near highways and main consumption centres (urban areas).

Vegetable Production Programmes

In order to cope with the increasing demand for fresh vegetables in the country, several production programmes are already in operation. In the current plan period, the total area under vegetables is planned to be increased from about 138,000 hectares to about 140,500 hectares, which is a net increase of 2,500 hectares (2 per cent), while the total production of vegetables, which was 741,600 mt in 1984/85, will be increased to 970,200 mt, a net increase of 228,600 mt (31 per cent).

The whole production programme has been divided into three categories—special, general, and kitchen gardening programme. Thirty districts are covered under the special programme, covering an area of 4,800 hectares with a production target of 7,200 mt. Seeds, fertilizers, chemicals, sprayers, and credit are provided under this programme.

Cultivation of off-season vegetables is being specially encouraged in the hills. In order to make the country self-sufficient in vegetable production and to promote export, the production of fresh vegetables will be increased from 10 to 15 mt/hectare.

Under the general programme, the demand for fresh vegetables from local areas will be fulfilled by placing 24,000 hectares of land area for production of 192,000 mt of vegetables, thereby increasing productivity from 7 to 9.5 mt/hectare. Composite vegetable seed packets will be provided for the cultivation of vegetable crops.

Under the kitchen gardening programme in the rural areas, 606,000 mt of fresh vegetables will be produced by covering 111,700 hectares of area. Fertilizer, technology and extension services are provided under the scheme.

Important Vegetable Crops

Popular vegetables in Nepal are cauliflower, cabbage, tomato, brinjal, onion, radish, carrot, beans, sweet pepper, peas, chilli, bhindi, turnip, broad leaf mustard, cucumber, and pumpkin.

Because of the availability of a wide range of agroclimatic conditions for cultivation of various vegetable crops, winter vegetables of the terai such as tomato and brinjal can be easily grown as summer vegetables in the mid-hills. Similarly, temperate vegetables such as cauliflower, cabbage, radish, and carrot etc. are grown on the high hills during summer as off-season crops. In this respect Nepal is in an advantageous position. With improvement of the north-south transportation system, these main season and off-season vegetables can be made available to urban populations all year round.

Vegetable Seed Production Programme

The most important input in vegetable production is good quality seed. To make the vegetable programme a success, an effective distribution system with timely availability of seeds is crucial. The demand for vegetable seeds exists throughout the country. In order to cater for the increasing demand for good quality seed, a seed production programme was launched in different agro-ecological zones for different kinds of vegetables. Various seed production pockets such as Marpha, Bhaktapur, Mushikot, Dhankuta, Sarlahi and Dolpa have been identified so far.

At the central level, the Vegetable Development Division is responsible for the production and organization of foundation seed. Vegetable programmes at various horticultural farms are technically controlled by the division. Seeds produced in horticulture farms are of two categories: foundation seed for further multiplication and improved seed for sale in commercial production pockets. Improved seed is handed over to the Agriculture Inputs Corporation for distribution.

A total quantity of 84 mt of seeds was produced in 1986/87. This year (1989/90) there is a target of 132 mt of seeds.

Since 1981, an HMG/FAO Vegetable Seed Production Project, financed by the Government of Switzerland, has been operating in Nepal. The project, which is in the third phase of its operation, has been designed to assist the Vegetable Development Division to increase vegetable production in the country and to develop a sound vegetable seed industry in the private sector. So far, the project has been able to identify vegetable varieties suitable for Nepal and has provided training for technical personnel and seed growers. Facilities have been created by the project for processing and storage of vegetable seeds at five horticulture centres located in different agroclimatic regions. Besides this, other infrastructural facilities have been created for research and seed production.

Under the banner of the project and with funding from the United Nations Capital Development Fund (UNCDF), additional assistance will be provided to create a wholesale market facility for fresh fruit and vegetables, to be located at Kalimati, Kathmandu. From UNCDF funding, support to private ventures in the areas of food processing, storage, and seed production will also be provided.

As with fruits, vegetable development also forms a minor component of various foreign-assisted Integrated Rural Development Projects and Integrated Agricultural Development Projects.

Potato Production

Among the major crops of Nepal, potato is grown at various altitudes, such as high hill, mid-hill, and terai, during different times of the year and is used as a vegetable and as a substitute for cereal food. It is mainly a cash crop in the terai and mid-hills and a main food crop in the high hills. In the context of the Basic Needs Fulfillment Programme potato is considered a basic food crop and a cheaper source of the calories required by the people.

Area and Production

The potato development programme in the Seventh Five-year Plan aimed at increasing the overall potato production and productivity in the country to maintain the present per caput consumption rate of 20 kg per annum. During the current plan period, keeping the production area unchanged, the present production of potato is targeted to increase from 420,000 to 521,000 mt and productivity from 6.9 to 8.7 mt per hectare.

TABLE 5.8

Area, production and productivity of potatoes by development region (1984/85)

Development region	Area (ha)	Production (mt)	Productivity (mt/ha)
Eastern	22,190	136,490	6.1
Central	24,090	167,350	6.9
Western	8,780	56,500	6.4
Mid-western	6,720	39,150	5.8
Far western	3,760	20,670	5.5
Total	65,540	420,160	6.4

Table 5.8 gives the area and production of potatoes by development region in 1984/85. It indicates that during 1984/85, out of the total area (65,540 hectares) under potatoes, the central development region occupied the maximum area of 24,090 hectares (36.8 per cent), closely followed by the eastern development region with 22,190 hectares (33.9 per cent). The western mid-western and far western development regions have also picked up potato cultivation (13.4, 10.2, and 5.7 per cent respectively) but these regions require further intensification to make potato popular. Similarly, on the production front, the central development region contributed about 39.8 per cent, followed by the eastern development region with 32.5 per cent. The western, mid-western and far western regions contributed only 13.5 per cent, 9.3 per cent, and 4.9 per cent respectively.

In Nepal, the three ecological belts—the terai, mid-hills and mountain—have shown significant differences in potato production, which is summarized in Table 5.9. The table clearly shows that the hills produced little more than half the total quantity of potatoes (53.2 per cent), whereas the terai contributed 26.5 per cent and the mountains 20.3 per cent. In that year area under potato cultivation was 35,720 hectares (54.5 per cent) in the hills, 16,430 hectares (25.1 per cent) in the terai, and 13,390 hectares (20.4 per cent) in the mountains. However, no particular difference was observed in productivity among the three ecological belts.

TABLE 5.9

Area, production and productivity of potatoes by ecological belt (1984/85)

Belt	Area (ha)	Production (mt)	Productivity (mt/ha)
Mountain	13,390	85,230	6.4
Hill	35,720	223,770	6.3
Terai	16,430	111,160	6.7
Total	65,540	420,160	6.4

The progress of potato development programmes from 1974/75 to 1986/87 is summarized in Table 5.10. The total area under potato cultivation increased by 37.8 per cent and the total production of potato by 28.7 per cent between 1974/75 and 1986/87. Strangely enough, productivity decreased considerably during that period.

TABLE 5.10

Potato development 1974/75 to 1986/87

	Area ('000 ha)	Production ('000 mt)	Productivity (mt/ha)
Situation at the end of Fourth Plan (1974/75)	53.7	307	5.7
Situation at the end of Fifth Plan (1979/80)	51.0	278	5.4
Situation at the end of sixth Plan (1984/85)	65.5	420	6.4
Situation at 1986/87	74.0	395	5.3
Target for Seventh Plan (1985–1990)	60.0	521	8.7
Target for 2000 A.D.	66.0	869	13.1

Source: Department of Agriculture, National Potato Development Programme

Priority Districts for Potato Production

The National Potato Development Programme (NPDP), with its headquarters located in Khumaltar, Lalitpur, is responsible for providing healthy and improved seed to potato growers. The government farms are mainly engaged in the production of basic seed to be supplied to certified private growers. These certified private growers are encouraged to produce commercial seed potato. Private seed growers' associations have been formed in many potato-growing districts. The programme supervises seed production activity in special potato production districts, which are 57 in number. Distribution by development region is as follows:

Eastern	11
Central	16
Western	10
Mid-western	12
Far western	8
Total	57

The districts for the potato programme are put under the supervision of various agriculture and horticulture farms and centres.

Potato Production Programmes

To maintain the present per caput consumption status of potato at 20 kg per annum, the strategy is to strive for an increase of yield per unit area rather than to expand the cultivated area at the expense of other crops. In order to achieve this target, two types of production programmes—special and general—are being launched at farmers' level. Under the special production programme, farmers are being encouraged to increase productivity to 17.14 mt/hectare by adequate use of fertilizers at the rate of 150:100:50 kg NPK. For general programme and in unirrigated areas an application of fertilizer at a ratio of 75:50:25 kg NPK is recommended to raise the productivity to 6.98 mt/hectare. Besides this, the application of 10 mt of farmyard manure per hectare is also recommended to improve soil condition. The farmers are being encouraged to use plant protection measures. In order to increase production and productivity, it is planned to bring from the general programme to the special programme an additional area of 7000 hectares. Farmers who followed the recommended practices and who planted newer varieties in a normal year obtained the following encouraging yields:

Hills	10–15 mt/ha
Kathmandu valley	25–35 mt/ha
Terai	25–30 mt/ha

Potato Seed Production Programme

Healthy and improved potato seed plays a major role in potato production. The use of *in vitro* and rapid multiplication techniques are already in application at NPDP headquarters. Disease-free germplasm seed materials (tuberlets) thus produced are multiplied in government farms and their affiliated farmers' fields. The production of disease-free tuberlets from true seed is also in process. Foundation seed thus produced in government farms and by their affiliated farmers are multiplied further and distributed. Foundation seeds are made available to farmers through District Agriculture Development Offices' (DADO) extension services. The NPDP has made provision to distribute 10 per cent of its basic tuberlet seeds to selected farmers with the help of DADOs in remote hill areas in all five regions. These farmers are expected to produce 20 mt of foundation seed for their area. These foundation seeds are further multiplied as improved seed which will be distributed to farmers for commercial potato production.

The Swiss Development Cooperation has been supporting the NPDP technically and financially since 1978. Their joint effort has increased production and productivity of potato. The NPDP has entered into its third phase and is planned for a period of four years (mid-1988 to mid-1992).

During this third phase, NPDP will concentrate on trial and research, seed production, training and extension work, and playing a coordination and leadership role in potato development in Nepal.

Construction of cold stores in the terai and rustic stores in hills and high hills will be encouraged in the private sector. The establishment of potato processing industries in technical support of the Central Food Research Laboratory is envisaged in the Seventh Plan period.

Mushroom Production

Edible mushroom is considered a very delicious and nutritive food. It contains protein, vitamins, and minerals in good amount. Though the protein content of mushroom is less than in meat, it is more than in vegetables. Mushroom has proved beneficial to diabetic and cholesterol patients. Because of its nutritive value, mushroom cultivation has been encouraged. In Nepal, where there is the problem of malnutrition, mushroom cultivation can provide supplementary nutrition.

In Nepal, scientific mushroom cultivation was started in 1982 by the Department of Agriculture with the establishment of a mushroom production unit under the Plant Pathology Division in Khumaltar with the following objectives:

- To develop technology for increasing mushroom production through necessary research;
- To extend knowledge and technique of mushroom cultivation as a cash crop to small farmers;
- To stop mushroom import and make the country self-sufficient in mushroom production; and
- To encourage mushroom export in order to earn foreign currency.

When mushroom cultivation techniques were first made available to farmers the number of farmers was very few. Now more than 200 farmers are engaged in mushroom cultivation. Mushroom cultivation is completely different from cereal and vegetable cultivation. Temperature and humidity play a major role in mushroom cultivation. In developed countries, mushroom is cultivated in special rooms where temperature and humidity are regulated. Though our farmers cannot yet afford such facilities, they can cultivate mushroom (Agaricus type) making use of their traditional houses. Two crops of mushroom can be easily harvested under Kathmandu conditions.

According to the Seventh Plan mushroom production was to increase from 75 to 300 metric tons. Taking into account the urban demand for mushroom, production programmes have been confined to the districts of Kathmandu, Lalitpur, and Bhaktapur. In Dadhikot village panchayat of Bhaktapur district, 20 to 25 families are engaged in mushroom cultivation.

The mushroom production unit of Khumaltar is solely responsible for appropriate technology development, technical advice, training, and seed production of mushroom. Mushroom farmers have to contact this particular unit for seed supply.

Marketing of Horticultural Crops

All horticultural crops are bulky and highly perishable by nature. It is therefore important to dispose of the produce as early as possible to avoid loss in weight and rotting. The losses can be reduced to the minimum through proper packaging, transport, cold storage, and handling.

There are no separate markets for fruits and vegetables in rural areas. However, 'Hat Bazaars' or periodic markets, mainly on a weekly basis, are in existence. Rural markets are needed to support the development of livestock, horticulture, and special crop production programmes. The marketing of horticultural crops has become a problem in some commercial production areas; commercial growers sell the produce either directly to the consumer or to middlemen or retailers who make a high profit. Usually the middleman's profit is added to the consumer price, which is always 100 per cent higher than the price paid to the farmer. There are no regulated and organized wholesale markets for fresh fruits and vegetables. Nepalese farmers are good producers, but poor sellers. Usually they sell their products to traders at very low prices.

Problems of Fruit and Vegetable Marketing

Inappropriate packaging, improper grading, lack of transportation and storage facilities, and poor market information and market facilities are common problems in Nepal. At present, it is the Department of Food and Agricultural Marketing Services (DFAMS) of the Ministry of Agriculture which is responsible for providing infrastructural support for marketing of agricultural produce, including horticultural produce. However, to date, there is no separate division in the DFAMS to look after the fruit and vegetable marketing aspect.

Marketing Development Programmes

As a result of horticultural development programmes launched in the country, increasing quantities of fresh fruit and vegetables are coming into production. More fruits will be produced as the percentage of fruit-bearing trees is increasing steadily. Some steps are now taken to improve marketing of the most perishable crops such as fruits and vegetables, but these are not sufficient.

In order to develop an organized wholesale market for fresh fruits and vegetables in the Kathmandu valley, a master plan for the Kalimati site has been prepared which FAO supports under the Fresh Vegetable and Vegetable Seed Production Project. The DFAMS has already made a start on the construction of infrastructure and this Kalimati site will remain under its management.

The Hill Fruit Development Project has a major component for the overall development of marketing of fruits only in the project area. Under this project, Dharan and Birtamod will be developed as assembly markets and Biratnagar as a major terminal market for fruits. Katari will be another market for the Sagarmatha zone, to be developed in the latter part of the project. Kathmandu, Biratnagar, Dharan, and Birtamod market centres will be equipped with telex facilities for market information. A mechanical size-grader will be installed at Dharan, but Birtamod will have manually operated graders. Training will be provided to field staff.

Apart from this, the DFAMS is carrying on the following activities for the development of fruit and vegetable marketing:

- Formation of a producers' marketing group. Small financial incentives are provided to these groups.
- Construction of marketing sheds. Such sheds have been built at Naxal in Kathmandu city.
- Formation of rules and regulations for operation and management of markets.

Future programmes envisaged by DFAMS to develop fruit and vegetable marketing are as follows:

- Creation of wholesale satellite markets of Kalimati at 33 town panchayats.
- Establishment of 99 collection centres near roads and highways.
- Arrangement of retail market sites.
- Arrangement for humidifiers and cold rooms.
- Construction of cold storage in 10 towns.
- Construction of cellar storage in hills and high hills.
- Provision of processing facilities.
- Establishment of supermarkets in main towns.
- Construction of feeder roads to connect production centres and highways.
- Formation of farmers' groups.
- Provision of marketing extension services.

Processing of Fruits and Vegetables

Fruit and vegetable processing in Nepal has not been able to keep pace with the commercial production of fruits and vegetables. Much of the fruits and vegetables are sold fresh but increasing amount could be processed to stabilize prices and avoid gluts in the market. Promotion of processing industries in the private sector would be a way to use surplus fruit and vegetables. A number of processing factories have come up in the private sector but their scale of operation is modest. There are two processing units in operation in the eastern development region. Nepal Beverages and Food Products Ltd. at Tanke Sinawari, Morang district collaborating with KISSAN of India, and Rijal Tashi Industries Pvt. Ltd., Itahari, Sunsari district, collaborating with TASHI of Bhutan.

In Marpha and Jumla, where apples are cultivated on a large scale, the culls and other fruit unfit for the table are used for jam, jellies, dried slices, brandy, and wine. Similarly, surplus tomatoes in the terai region are processed into ketchup and sauces on a limited scale.

The Central Food Research Laboratory (CFRL), established under the Ministry of Agriculture, is doing a considerable amount of training in preservation and quality control and is also conducting research into different aspects of fruit and vegetable processing.

Problems of Processing Industries

A majority of fruit and vegetable processing industries are small-scale industries, mainly located in the Kathmandu valley. Raw materials are costly and their supply most irregular and unreliable. Packing materials such as tin cans, bottles, jars, and caps are imported, mainly from India. Other items such as food colours, essences, and chemical preservatives are also imported. Sometimes these are not available in time due to low volume of demand or delayed order.

Almost all the small-scale industries are managed by family members and the so-called technicians have very limited skills and knowledge about processing. Usually their products are sub-standard and quality is not consistent or uniform. Such products face problems in marketing.

The supply of raw materials such as sugar is not guaranteed and processing industries need to have a special quota for sugar.

Development Programme for Processing Industries

Fruit and vegetable processing through improved methods was first started in Nepal nearly 25 years ago when a Fruit Preservation Laboratory was established at Kirtipur Horticultural Research Station under the Department of Horticulture. Students, housewives, and small entrepreneurs were given short-term training in fruit and vegetable preservation. Thereafter, many cottage processing units were started, mainly in the Kathmandu valley. Later on this Fruit Preservation Laboratory CFRL, is the only institution in the country with the responsibility to develop the storage and processing of food products, including fruits and vegetables. It conducts short-term training in fruit and vegetable processing. There is also an Institute of Food Technology at Dharan which trains food technologists.

Out of 40 cottage-level processing units that were registered, hardly 10 such units are now in operation. Their total quantity of production is not more than 86.7 mt per year. The two medium size processing industries, Nepal Beverages and Food Products Ltd. and Rijal Tashi Industries Pvt. Ltd., are running at about 50 per cent of their rated capacity, which is about 2900 mt per annum. Given the problem of availability of production it does not appear rational to add more fruit and vegetable processing industries, at least for the time being.

Under the Hill Fruit Development Project implemented in the 11 hill districts of the eastern development region, two demonstration-cum-training centres for fruit preservation are to be established, one in Solukhumbu and the other in Dharan. A total of 300 farmers (mainly women) are to be provided with seven days' training during the project period.

Storage of Fruits and Vegetables

Perishable commodities such as fruits and vegetables need ideal storage conditions to prolong their storage life. With the increase in production of fruits and vegetables in the country, more storage facilities are necessary. At present, there are 14 cold stores of varied capacity at different locations in the country. The total capacity of these cold stores is about 12,600 mt. Kathmandu valley has two private cold stores in operation, one in Bhaktapur (1000 mt capacity) and other at Balaju (2 × 1000 mt capacity). These cold stores are mostly used to stores potatoes and operate for five to six months of the year. Out of the 14 cold stores, three belong to the Agricultural Development Bank and the rest are owned by private entrepreneurs. Licenses have already been issued to construct more cold stores.

In the villages, farmers have their own traditional way of storing fruits and vegetables. Potatoes, root crops (turnip, carrot), and oranges are stored in underground pits. Apples are stored in rooms on wooden racks. These traditional methods of storage are not ideal. Loss in weight, wastage due to rotting, and danger from pests and rodents are always there.

Cellar stores constructed with locally available materials such as stone, wood, and mud, have given encouraging results. In apple-growing districts the demand for this type of store is increasing every year. Apples can be stored for at least three to four months without much loss in quality or quantity. Cellar stores have proved equally good for storing oranges also.

In the cooler hills, rustic stores have proved very good for storing potatoes. These stores have wooden racks with thatched roofs to protect against rain.

Problems of Storage

Unfortunately, almost all the cold stores were constructed without being linked to the production area of fruits and vegetables. This is the main reason why they are often faced with problems of availability of fruits and vegetables for storage. The existing facilities are often used to store potatoes.

The construction of modern cold stores is very expensive. Electric supply is erratic. It takes years to construct and operate cold storage. In the absence of improved cold storage facilities, growers are forced to sell fruits at a cheaper rate during the glut period. Moreover, there is loss and wastage due to shrinkage and rotting.

Proposed Programmes

The construction of nine more cold storage units are proposed at Jhapa, Biratnagar, Sunsari, Saptari, Siraha, Kathmandu, Chitwan, Pokhara and Nepalgunj, because these places are main markets as well as main consumption areas and are connected with the production areas of fruits and vegetables. Three cold storage units already constructed at Pokhara, Butwal, and Sarlahi (each with 10000 mt capacity) are to be brought under operation. Two cold storage units, one in Dang (500 mt capacity) and the other in Dhangadi (400 mt capacity) are under construction.

Construction of low-cost, small, on-farm cellar stores of 3 to 5 mt capacity should be encouraged in production pockets. Altogether, 23 cellar stores have been constructed in Mustang's apple-growing areas with the financial assistance of UNDP. The construction of this type of cellar store should be subsidized in other apple-growing areas. Citrus-growing areas should also be encouraged to have cellar stores.

Under the Hill Fruit Development Project, it is proposed that a total of 40 cellar storage units (total capacity 250 mt) be constructed in Solukhumbu. Similarly, the Citrus Development Project for selected mid-hill districts of Nepal has also proposed to construct 162 cellar stores in different product pockets of the project area.

The proposed wholesale market at Kalimati, Kathmandu, will have cold storage facilities to store fruits, potato seeds, fish, and vegetables.

Annex 1

List of horticultural farms

Eastern development region

1. Cardamom Development Programme, Fikkal, Ilam
2. Dhankuta Agriculture Station, Paripatle, Dhankuta
3. Agriculture Station, Horticulture Unit, Tarhara, Sunsari
4. Horticulture Farm, Salleri, Solukhumbu.

Central development region

5. Horticulture Farm, Janakpur, Dhanusa
6. Horticulture Centre, Nawalpur, Sarlahi
7. Sindhuli Agriculture Farm, Sindhulimadi
8. Horticulture Farm, Bonch, Dolakha
9. Nucleus Potato Seed Farm, Nigale, Sindupalchok
10. Horticulture Farm, Sermathang (Helembu), Sindhupalchok
11. Horticulture Farm, Panchkhal, Kavrepalanchok
12. Horticulture Farm, Godavari, Lalitpur
13. Vegetable Research and Seed Production Centre, Khumaltar, Lalitpur
14. Horticulture Research Station, Kirtipur, Kathmandu
15. Horticulture Farm, Kakani, Nuwakot
16. Horticulture Farm, Trishuli, Nuwakot
17. Horticulture Farm, Dhunche, Rasuwa
18. Horticulture Farm, Dhunibesi, Dhading
19. Horticulture Farm, Daman, Makwanpur
20. Agriculture Station, Horticulture Unit, Pariwanipur, Bara
21. Horticulture Farm, Yagyapuri, Chitwan

Western development region

22. Horticulture Research Station, Malepatan, Pokhara, Kaski
23. Ginger Development Programme, Malepatan, Pokhara, Kaski
24. Horticulture Farm, Tansen, Palpa
25. Coffee Development Farm, Anpchour, Gulmi
26. National Temperate Horticulture Research Station, Marpha Mustang

Mid-western development region

27. Horticulture Farm, Rajikot, Jumla
28. Horticulture Farm, Darma, Humla
29. Vegetable Seed Production Centre, Musikot, Rukum
30. Horticulture Farm, Dailekh
31. Agriculture Station, Horticulture Unit, Khajura (Nepalgunj), Banke.

Far western development region

32. Vegetable Seed Production Centre, Dotighatal, Dadeldhura
33. Horticulture Farm, Satbanj, Baitadi

6

Vegetable Development in Nepal: Present Status, Future Strategy, and Constraints

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Introduction

Vegetables are important because they help to maintain a satisfactory nutrient level and hence are a protective food. Global consumption patterns indicate that roughly 75 per cent of all vegetables produced are consumed in the developed countries. In the developing countries, where malnutrition and food scarcity prevail, the consumption of vegetables is very low. In spite of the fact that vegetables and pulses are the cheapest sources of vitamins and proteins, compared to other sources such as meat, fish, milk, and eggs, the increase of vegetable production in developing countries has received inadequate attention. This is confirmed by the consumption pattern given in Table 6.1 which compares average consumption in countries of this region with the average given for developed countries.

Need to Increase Vegetable Consumption

The low intake of vegetables in the developing countries can be attributed to the fact that the major emphasis so far has been on the increased production of cereal crops. In the light of recent food production trends, a perceptible shift is already seen in the agricultural and food policies of some countries of this region. A number of them have achieved self-sufficiency in food. The increase in cereal production has been especially satisfactory during the last decade or so in the Asia-Pacific region. A point

TABLE 6.1

Consumption of vegetables by developing countries in comparison to developed countries

Countries	Per caput consumption of vegetables per year (kg)
Nepal	45.5
India	45.0
China	73.0
Indonesia	20.0
Malaysia	34.3
Average of developed countries	125.0

has now been reached where more attention to nutritional adequacy is essential. At present, we are guided by national average figures which mask inequalities in access to food by poorer sections of the population. Efforts should be made to express food availability in terms of those commodities that increase nutritionally adequate consumption at provincial, district, and household level, so that disparities in food availability are revealed. Where a single staple food forms an extremely high proportion of the food intake, deficiencies are almost certain to occur.

Source of Quality Food

Careful consideration, therefore, is required to mobilize some resources to improve the quality of food. This can be done by giving due priority to increasing the output of dairy products, meat, fish, eggs, fruits, and vegetables. However, since the average income of people in the developing countries is too low to meet expenses for higher consumption of dairy and meat products, the immediate need, or priority, should be to increase the production and consumption of nutritive horticultural products because these can be produced without involving high costs. Within the horticultural group, vegetable crops offer better scope due to their short maturation period, high rate of productivity per unit area, and their traditional use in local diets.

Proposed Strategy for Development

To achieve the desired goal of increasing vegetable production, an appropriate strategy needs to be developed. In the context of constraints in the developing countries, where population pressure on the land has already reached the limit, large-scale diversification of land use from important food and commercial crops may not be possible. The only strategy, therefore, is to increase the productivity. If we look into the production levels of horticultural crops, including vegetables, the yield in the developing countries is less than half that of the developed countries. Therefore, a close analysis of the reasons for these low yields is needed and an appropriate programme must be initiated on the following lines:

- development of suitable varieties of vegetables that thrive under the day lengths of winter months in the tropics and sub-tropics,
- improvement of indigenous varieties of underexploited traditional vegetable crops,
- development of appropriate production technology for stress conditions,
- improvement in the availability of indigenously produced high quality seed,
- provision of appropriate extension support,
- provision of proper marketing, storage, processing, and price control mechanisms that assure fair prices for farmers as well as consumers.

In the light of the above strategies, His Majesty's Government of Nepal has given high priority to increasing vegetable production in order to satisfy the basic nutritional requirements of the people and to improve the standard of living of small farmers.

Various schemes launched by HMG/Nepal for these purposes, their achievements, and future strategies are presented in this paper.

Socioeconomic Significance of Vegetables in Nepal

Complementarity of Production Areas

Approximately 93 per cent of the population is involved in agriculture, and the average land holdings are 0.5 hectare in the hills and 1.5 hectares in the terai. The total population at present is 17 million, and the current growth rate is 2.6 per cent per year. The proportionate share according to geographical area indicates a growth rate of 1.3 per cent in the high hill and mountain areas, 1.8 per cent in the middle hills, and 14.1 per cent in the terai. As in other countries, in Nepal a substantial increase in urban population is taking place. In the Kathmandu valley the population has almost doubled during the last decade because of migration from rural areas. In the other urban areas of Nepal, the population growth trend is similar. In addition to the above population growth, the number of tourists visiting Nepal is also on the increase, and this means that at certain periods, additional demands for resources have to be met.

Due to the rapid urbanization process, the increase in demand for vegetables in urban areas has resulted in an excessive flow of vegetables from across the Indian border. This has happened because local production has not been able to meet the demand.

In rural areas, traditional vegetable production was restricted to a few limited varieties grown in kitchen gardens. The consumption pattern indicates that the current per caput consumption is 73 kg per annum in urban areas and 45.5 kg per annum in rural areas.

Transport and access problems in rural and remote areas means that vegetables are generally grown for local consumption only. The traditional farming community Jyapoos grow vegetables on a commercial scale for the expanding urban markets. In Kathmandu, as well as other urban areas, they practise intensive cultivation of small market gardens. Due to the rapid expansion of residential and industrial areas in the Kathmandu valley, there was a tremendous increase in land prices, which made these small farmers sell their land. This resulted in a reduction in the area under cultivation within the suburban area. To meet the demand for vegetables, commercial scale production has increased in some rural areas during the last decade. Taking advantage of the development of roads and the variety of agroclimatic conditions at different altitudes, the farmers have started growing vegetables during different seasons in order to meet the demand of consumption areas where vegetables cannot be grown all the year round. Table 6.2 outlines the vegetables supply network for Kathmandu valley.

Similar systems of supply and production exist for other towns and cities also. Generally, during the season, vegetables are produced locally and are not brought in from other areas because of the cost of transport and other expenses. Out of season, vegetables are brought from the outlying areas as high prices compensate for transport expenditure.

It is an increasing trend for farmers to establish vegetable production in areas that are less than five or six hours' walking distance from the road. Figure 6.1 shows the areas where commercial vegetable production has been established after the construction of roads. From Figure 6.1 it can also be seen that commercial vegetable production is expanding in the terai along the east-west highway, while off-season production is developing in the high hills, mid-hills, and inner valley regions located within the access corridors of the roads.

The important north-south corridors for vegetable production are:

- Dhangadhi to Dadeldhura—far western region
- Nepalgunj to Surkhet and Dang—mid-western region
- Bhairahwa to Tansen, Palpa, and Pokhara—western region
- Birgunj to Hetauda, Chitwan, Daman, Naubise, Kathmandu, Ranipauwa, Trishuli, and Panchkhal—central region
- Biratnagar to Dhankuta, Hille, Sidhuwa, Angdim, and Ilam—Western region

TABLE 6.2

Supply of fresh vegetables to Kathmandu from different sources

Crop	Period of supply	Production areas
Tomato	Oct. to Feb.	Sarlahi, Dhanusa, Bara
	March to May	Dhading, Nuwakot,
	June to Sept.	Panchkhal, Kathmandu, Azamghat
Eggplant	Sept. to Dec	Sarlahi, Dhanusa, Bara
	Jan, Feb	
	Mar, April, May	Dhading
	June to Aug.	Kathmandu, Pokhara
Onion	April to June	Dhanusa, Nuwakot, Bara, Saptari, Kathmandu valley
Radish	May to Oct.	Palung, Ranipauwa
	Nov. to Feb.	Kathmandu valley
Cauliflower	Nov., Dec., Feb., March	Kathmandu valley
	Sept. to Jan.	Bara
	Oct. to Dec.	Nuwakot
	May to July, Sept., Oct.	Tistung, Palung, Daman
Cabbage	June, July	Daman
	Dec. to March	Bara, Parsa
	April to June	Kathmandu
Carrot	June, July	Daman, Palung
	Nov. to May	Kathmandu valley
French bean	April to July	Kathmandu valley
	Oct. to Dec., March to May	Dhading
Sweet pepper	March to June	Dhading
	June to Sept.	Kathmandu valley
	Nov. to March	Lalbandi
Pea	Aug. to Oct.	Tistung, Palung
	Oct. to Feb.	Bara
	March, April	Kathmandu valley

Profitability of Vegetables

Specialized production techniques have been adopted by farmers, and, together with the naturally diverse climatic conditions, they have resulted in an attractive off-season vegetable market. Compared to food crops, vegetables are much more profitable in different areas of the country (Table 6.3).

Small Farmers' Participation in Vegetable Farming

Due to very small holdings (1.5 ha in the terai and 0.5 ha in the hills), most of the farming in Nepal is of a subsistence type. In the hills, partic-

Figure 6.1: Vegetable production areas in Nepal

ularly, the small size of the holdings together with the low soil fertility and lack of irrigation facilities make it very difficult for farmers to meet the minimum costs of living. This results in migration to urban areas, and to the terai, in order to find work.

Experience has shown that the introduction of high-yield, high-return vegetable crops, supported by a proper market mechanism, can greatly improve the incomes of small farmers, particularly in the hills, where labour is underused.

During the development of the vegetable programme in Nepal, it was found that, in the initial stages, farmers having larger holdings were attracted towards vegetable cultivation because of the profits involved. The programme started to expand because of the easy availability of inputs and technical know-how and consequently the participation of small farmers also increased. This resulted in an increase in labour costs and hence the profitability became less attractive for larger farmers. A new trend in vegetable cultivation, by landless farmers on land rented for a season, expanded because landless farmers were able to use family labour in production and marketing.

If we analyse the gross income a small farmer receives from marketing vegetables, we may well find that vegetable growing is more profitable when family labour is used. A breakdown of income based on an average gross return of Rs. 3000 from one *ropani* (500 m) is illustrated in Fig-

TABLE 6.3

Gross income received from vegetable cultivation in different areas of Nepal

Area	Crop	Gross income per hectare (Rs.)	Remarks
Hills			
Naubise	French bean	60,000	Irrigated
District Dhading	Sweet pepper	70,000	Irrigated
	Eggplant	40,000	Irrigated
	Cucumber	50,000	Irrigated
	Tomato	60,000	Irrigated
Daman, Palung	Radish	40,000	Unirrigated
District Makwanpur	Cauliflower	55,000	Unirrigated
	Pea	40,000	Unirrigated
Ilam	Pea	45,000	Unirrigated
Kathmandu valley	Cauliflower	48,000	Irrigated
	Radish	25,000	Irrigated
	Pea	40,000	Irrigated
	Early cabbage	50,000	Irrigated
Terai			
Nawalpur	Tomato	30,000	Unirrigated
District Sarlahi	Sweet pepper	80,000	Unirrigated
	Tropical cauliflower	50,000	Unirrigated
	Watermelon	40,000	Unirrigated

Source: Department of Agriculture, Vegetable Division, 1988.

ure 6.2, which clearly demonstrates the attraction of vegetable cultivation for landless families and small farmers due to possibility of increasing family income by the use of family labour.

Agro-ecological Conditions and Institutional Support

The total surface area of Nepal is 145,685 km^2 and it is 880 km in length and 130 km to 240 km in width. The country is situated on the southern slopes of the Himalayas between 80° and 88°E longitude and 27° and 30°N latitude. The total area under cultivation in Nepal is 2.6 million hectares; one-third of this area is in the hills and two-thirds in the plains or foothills. The agroclimatic conditions, ranging from hot and humid in the terai to a typical temperate alpine climate in the high mountains, with a variety of ecological conditions at various altitudes, make it possible to grow a wide range of vegetable crops from tropical in the terai to sub-tropical and temperate in the middle and high hills. Every increase in altitude leads to cooler temperatures, and in winter sub-arctic to arctic conditions are experienced at high altitudes.

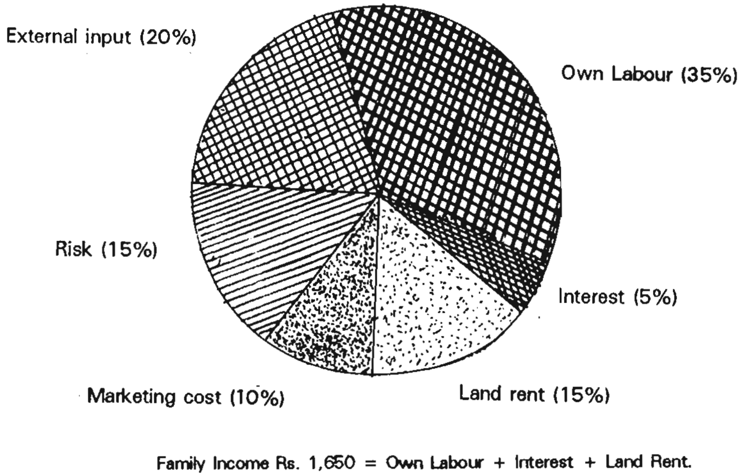


Figure 6.2: Cost structure on small farms, Rs. 3000 ropani gross income from vegetable growing in hills

Main Agroclimatic Regions

A short description of different agroclimatic regions of Nepal and their suitability for growing different vegetable crops is given below.

THE TERAI REGION

The terai is a flat region with elevations ranging from 50 to 500 m. The climate is tropical. The average daily temperature fluctuation is from 7°C to 24°C during December and January, and from 24°C to 34°C during May and June. The annual rainfall varies from 1000 mm (western parts) to 2000 mm (eastern parts). In the terai a wide range of vegetables are grown. The most important ones are tomato, eggplant, chilli, cucurbit, okra, onion, cauliflower, cabbage, potato, and sweet potato.

THE MID-HILLS REGION

The mid-hills consist of gently sloping hill and fertile valleys. The elevation ranges from 600 to 2000 m and, therefore, the climate is classified as sub-tropical to warm temperate depending upon altitude. The average daily temperature ranges from 2°C to 17°C in December and January and from 20°C to 27°C in May and June. The annual rainfall is essentially the same as that of the terai.

THE HIMALAYAN REGION

The Himalayan region is a high altitude area above 2400 m above sea level with snowfall in winter. The average daily temperature ranges from 1°C to 10°C in December and January and 12°C to 21°C in June and July. During the warmer season radish, turnip, broad leaf mustard, and other vegetables are cultivated. These vegetables only require short growing seasons.

THE INNER HIMALAYAN REGION

The inner Himalayan region consists of dry, cool valleys similar to those of the Tibetan plateau. The elevation ranges from 2400 to 5000 m. The average daily temperature ranges from 1°C to 10°C in December and January and from 12°C to 21°C in June and July. Because of the arid conditions and plenty of irrigation, this area is most suitable for seed production of cabbage, carrot, late cauliflower, and beet.

Place of Vegetables in Cropping Patterns

The cropping pattern in Nepal is mainly rice-based because rice is the staple food of Nepal. In the high hills, however, where rice cannot be grown due to low temperatures, short-duration millet, pseudocereals, and maize are the main crops.

In the terai and mid-hills under irrigated areas vegetables are always grown as winter crops after rice. Vegetable farmers, however, who have developed proper drainage and irrigation facilities, grow vegetables very intensively round the year.

In a rice-based farming system, vegetables grown as a winter crop is beneficial to farmers for two reasons. First, economically it competes well with wheat and second, due to flooding for rice cultivation, the intensity of many soil-borne diseases is reduced.

In the hills under rainfed conditions, radish, pea, and cauliflower are grown as summer off-season crops. The classic example of this may be seen in Daman, Palung, Ranipauwa, and other similar areas. The relative returns from these vegetables are much higher than from the traditional millet and maize crop.

Institutional Support

For the development of vegetable production, a Vegetable Development Division was established in 1972 within the Department of Agriculture for vegetable research and promotion and generation of new technology. Thirty-three horticultural farms were established under different agroclimatic regions of Nepal to support the programme through verification of production technology and dissemination to the farmers in their respective command areas, using the extension services of the Department of Agriculture. These farms also support seed production and distribution of seeds.

On the basis of agroclimatic suitability, seven main farms have been selected as centres of excellence to support research, variety maintenance, and breeders and foundation seed production (Table 6.4). In the vicinity of these farms, contract seed production through contract farmers is also organized.

TABLE 6.4

Important farms used as centres of excellence to support vegetable programme

Name of place	Altitude (m)	Location
Marpha, District Mustang	2522	Located in inner Himalayan region, representing alpine temperate climate.
Juffal, District Dolpa	2242	Located in inner Himalayan region, representing alpine temperate climate.
Dadeldhura, for western region	1500	Located in mid-hill region, representing warm temperate climate.
Mushikot, District Rukum, mid-western region	1400	Located in mid-hill region, representing warm temperate climate.
Khumaltar, Kathmandu (as main centre and headquarters of Vegetable Development Division)	1350	Located in mid-hill region, representing warm temperate valley in central region climate
Paripatle, District Dhankuta, eastern region	1200	Located in mid-hill region, representing warm temperate climate.
Sarlahi, District Nawalpur, central region	100	Located terai, representing tropical climate.

Multidisciplinary Support

The Vegetable Development Division, though attached to the Department of Agriculture, receives multidisciplinary support from the National Agriculture Research and Service Centre (a newly established organization under the Ministry of Agriculture to support research activity) through the Division of Plant Pathology, the Division of Entomology, and the Division of Agronomy.

Marketing Support

For providing marketing support and a price information system there is the Department of Food and Agriculture Marketing Services (DFAMS). This department actively cooperates with the Vegetable Development

Division in identifying market problems and develops programmes to solve them.

Vegetable Production Programmes

Past Achievements

Although statistical data are scarce, a reasonable picture of the expansion of vegetable production during the last decade is presented in Table 6.5 which shows estimates of cultivated area and production under different programmes. From the table, it is evident that there has been a steady growth of vegetable production in terms of both area and yield. During the last 10 years the areas under vegetables increased by 35 per cent and total production by 85 per cent. The productivity per hectare is estimated to have increased by 38 per cent.

Types of Production Programmes

From the figures given in Table 6.5, it can be seen that major increases have been achieved by launching special production programmes. In view of the limited resources, this approach of launching special production programmes in selected districts and areas, by mobilizing all available resources, seems the most appropriate way of increasing productivity.

The three categories of programme approach adopted are described below:

SPECIAL PRODUCTION PROGRAMME

The special production programme is used in areas that have access to motorable roads and, hence, access to external markets. The inputs for increased production are provided by facilitating the availability of necessary resources. These include credit from the commercial banks, agricultural inputs such as seeds, chemicals, and fertilizers, training through extension programmes, field demonstrations, and farmers' field days.

Initially the programme is launched in two or three selected panchayats, because the diverse climatic conditions render any uniform practice approach impracticable. It has been found that when success in a specific area is achieved, the programme spreads more rapidly. Table 6.6 gives an indication of the success of this programme compared to the general and least priority programmes.

GENERAL PRODUCTION PROGRAMME

Under the general production programme no special efforts are made to mobilize facilities because of lack of resources and trained manpower.

TABLE 6.5

Vegetable production programme: Area and production, 1980/81 to 1989/90

Production programme		1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Special programme	Area (ha)	1,306	1,445	2,020	2,735	3,200	3,665	3,800	4,125	4,430	5,032
	Prod. (mt)	7,836	13,005	18,004	27,350	32,000	40,755	45,600	53,949	62,202	75,380
General programme	Area (ha)	7,211	14,227	15,138	17,420	1,800	18,911	20,464	22,382	23,000	23,748
	Prod. (mt)	36,055	99,589	107,223	121,940	126,000	142,580	164,122	187,474	207,000	223,282
Least priority programme	Area (ha)	95,489	102,500	108,535	110,007	117,000	116,010	114,700	122,993	112,603	111,704
	Prod. (mt)	477,445	512,500	542,562	551,034	585,000	599,199	62,922	6,633,100	653,098	668,064
Total national programme	Area (ha)	104,006	118,172	125,694	130,162	138,200	13,586	138,964	139,500	140,033	140,524
	Prod. (mt)	521,336	265,094	667,789	700,324	743,000	782,534	838,948	874,523	922,118	967,167
Productivity in mt per hectare		5.0	5.28	5.31	5.38	5.37	5.64	6.03	6.26	6.58	6.88

TABLE 6.6

Estimated vegetable productivity by programme (mt/hectare)

Plan period	Special production programme	General production programme	Least priority programme	National average
Sixth Plan	10.0	7.0	5.0	5.37
Seventh Plan (1990)	15.06	9.06	5.98	6.88
Eighth* Plan (1995)	21.0	12.5	7.2	9.053

*Targets.

This programme is carved out with whatever resources are already available within the general framework of the government's developmental policies. Inputs are supplied as per requirements. The principal objective of this programme is to grow vegetables for local use in order to improve nutritional requirements.

LEAST PRIORITY PROGRAMME

The least priority programme has been initiated in the remote regions of the country where access to markets and roads is non-existent. The principal objective of this programme is to promote kitchen gardens. Logistically, farmers in these areas can only adopt low-input technology.

Future Targets and Policies of the Government

His Majesty's Government of Nepal, under its programme to meet the basic needs of the people of Nepal by the year 2000, has given priority to increase vegetable production in the country (Table 6.7) so as to raise rural income, improve nutrition, and increase exports. Towards achieving this objective, targets have been set to increase vegetable production from 970,000 to 1,515,000 mt by the year 2000, (Fig. 6.3) and to raise the per caput consumption of vegetables from 45.4 to 64.0 kg per annum.

Since population pressure on land is already very high, it has been realized that it may not be possible to diversify areas from other crops. The strategy, therefore, is to increase productivity.

Past experiences under the special vegetable production programme have proved that productivity per hectare can be increased by 300 per cent through the priority programme and 200 per cent through the general production programme.

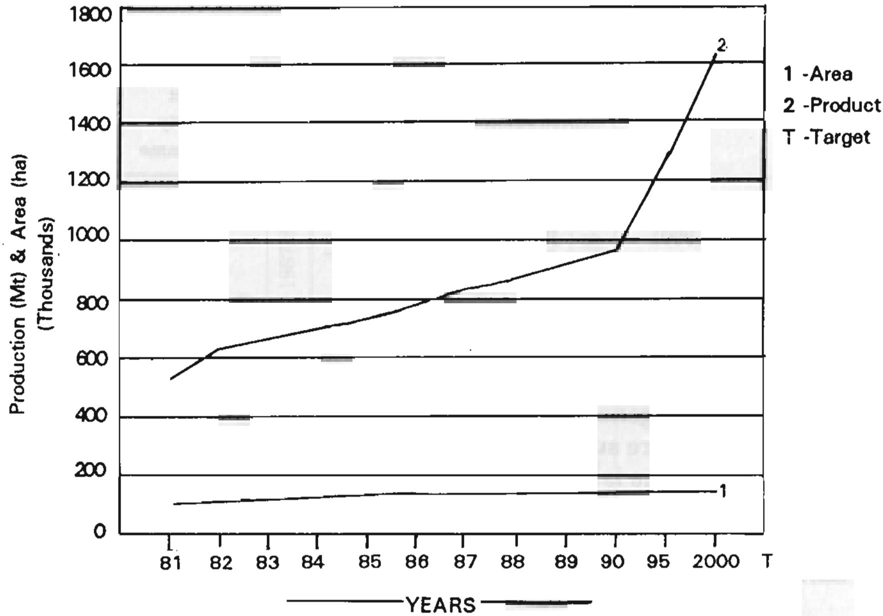


Figure 6.3: Growth trends of vegetable production in Nepal

TABLE 6.7

Targets of vegetable production programmes

Production programme		Eigth Plan	Ninth Plan
Special programme	Area (ha) Prod. (mt)	8,300 167,300	14,300 37,800
General programme	Area (ha) Prod. (mt)	29,000 362,503	34,000 510,000
Least priority programme	Area (ha) Prod. (mt)	103,200 743,042	92,200 756,045
Total national programme	Area (ha) Prod. (mt)	140,500 1,272,845	140,500 1,637,845
Productivity in (mt/hectare)		9.05	11.65

The Vegetable Seed Industry

Past Trend and Present Status

On the basis of area coverage, the annual requirement of vegetable seed in Nepal is estimated as 500 mt. Out of this total demand, current effective demand of seed that needs to be replaced every year due to poor storability, cross-pollination, and specific areas required for seed production, is estimated to be 300 mt. The remainder, since it is easy to produce by the farmers, is supplied through the farmer-to-farmer seed exchange system.

The progress of organized seed production of assured quality through the efforts of Vegetable Development Division, Agriculture Inputs Corporation, and Seed Testing and Improvement Programme is given in Table 6.8. Organized seed production during the last 10 years has increased gradually from 10 mt to 131.0 mt in 1989/90. The target is to produce 210 mt during 1989/90, which is 42 per cent of the total demand for seed in the country.

TABLE 6.8

Progress of seed production in government farms and under the government-supported programmes through contract farmers

Years	Foundation and improved seed in government farms (mt)	Production in farmers' fields (mt)	Total (mt)
1975/76	9.0	1.0	10.0
1976/77	9.5	3.6	13.1
1977/78	10.4	5.2	15.6
1978/79	10.0	14.6	24.6
1979/80	12.0	8.0	20.0
1980/81	9.2	15.4	24.6
1981/82	9.5	29.2	38.7
1982/83	12.9	25.6	38.5
1983/84	11.6	26.0	11.8
1984/85	11.8	21.4	33.2
1985/86	11.0	38.7	49.7
1986/87	11.0	58.5	69.5
1987/88	11.0	70.0	81.0
1988/89	11.0	120.0	131.0
1989/90 Target	16.0	194.0*	210.0

*Out of this 50 per cent is for private entrepreneurs.

From table 6.8, it can also be seen that until 1984/85, the production of seed had been static. The main reason for this was poor marketing of seed, as the credibility of seed produced under the programme was not established among the farmers and the Agricultural Inputs Corporation's seed promotional programme was weak.

Profitability of Vegetable Seed Production

To improve the economy of farmers in remote hill areas vegetable seed production offers good scope. Due to low volume, high value (average price Rs. 50 to 100 per kg), and its non-perishable nature (if properly dried and packed), vegetable seed production is becoming popular with farmers in remote areas such as Dolpa, Marpha, Tehrathum, Bhojpur, and Rukum. Care, however, is necessary to see that only such vegetable seeds be encouraged in remote areas which cannot be economically produced in the areas connected by road. Such seeds are of onion, radish, cauliflower, cabbages, leafy vegetables, sweet pepper, carrot and turnips.

Vegetable seed production is a risky venture, needing skilled and experienced farmers. Crop duration is longer and the input requirement is high, but in totality it offers good returns to the farmer. Table 6.9 gives an idea of the seed yield levels possible in Nepal and the gross return on current seed purchase prices. For comparison, seed yields that were obtained in developed countries are also listed.

TABLE 6.9

Comparative-seed yield/hectare and gross return from seed production

Crop	Area of production in Nepal	Max. seed yield in Nepal kg/ha	Gross return (Rs. /ha)	Seed yield in other countries (kg/ha)
Cabbage	Marpha	1000	120,000	1000–1200
Carrot	Marpha	1000	100,000	1200–1500
Radish	Kathmandu	1200	54,000	1500–1800
Cauliflower	Dolpa	300	60,000	300–400
Tomato	Nawalpur	160	28,000	200–300
Eggplant	Nawalpur	400	40,000	300–500
Pea	Bara	1200	18,000	1500–1800
Bean	Belkot	1000	50,000	1500–1800
Onion	Rukum	500	50,000	300–400
Chilli	Nawalpur	250	15,000	300–400
Okra	Nawalpur	1200	18,000	1200–1500

Organization for Seed Production

The Vegetable Development Division, with support from seven selected farms, Pakhribas Agricultural Centre, and Lumle Agriculture Centre, is responsible for the identification of suitable varieties and their maintenance through zoning at appropriate farms. Required quantities of foundation seed are also produced by these farms.

Commercial seed production is organized through contract farmers in the vicinity of farms responsible for seed production. Field verification is provided by trained technical officers from the respective farms. Checks and field inspections are carried out by the Seed Certification Inspector from the Seed Testing and Improvement Programme.

Seed lots from approved lots are tested in the programme's seed testing laboratories. Seed is cleaned at the farms where small-scale cleaning equipment is available.

Seed that meets the standards is procured by the organization on whose behalf the seed was produced by contract farmers. The main agency to procure seed from farmers so far has been the Agricultural Inputs Corporation—a public sector organization. Recently, private entrepreneurs have also started seed production through this system.

Role of Public Sector in Seed Industry Development

In the context of Nepal, AIC is a public sector organization supporting vegetable seed production and distribution. In any developing country where a competitive private seed industry does not exist, the public sector company can play an important role in programme development. To a large extent, the AIC has performed this function. The way has been paved for contract seed production, the procedures of commercial-scale production have been established, a pricing system has been developed, a certain level of quality standards has been set, and a seed distribution system through seed dealers has been developed.

A further function of this organization is to refine its operations and to provide fair competition to the private seed industry to maintain a commercial level of prices and quality.

Role of Private Sector in Seed Industry

In any country, it is impossible for a single public sector organization to handle the country's entire seed trade. To give a wider horizon to the seed programme, the participation of the private sector is very important.

Until recently, private sector participation in an organized vegetable seed programme was almost negligible in Nepal. Seed traders purchased seed from any source and marketed it to farmers at good profit. Within three years the demand for seed production by private entrepreneurs reached 100 mt, which is almost 50 per cent of the total organized seed production targeted for 1989/90.

Recently, an association of vegetable seed entrepreneurs has been established in Nepal. The participation of private enterprises in the vegetable seed trade has infused seriousness into the seed business and efficiency in production and distribution is improving.

Export of Vegetable Seed

Nepal has high potential to produce a wide range of vegetable seed due to availability of suitable agroclimatic conditions ranging from tropical to temperate. Comparatively cheap farm labour is another factor which makes this labour-intensive production more attractive and economical. The demand for vegetable seed in the countries of the region is increasing. The climatic conditions of most of the countries of this region are not congenial to commercial-scale seed production, so it offers Nepal a great opportunity to establish a seed export business with these countries.

A start has already been made in this direction. For the last two years, Nepal has exported radish seed to Bangladesh. During the current year, there is a confirmed demand for 25 mt of radish seed. Through unofficial channels, the seed of radish and cauliflower produced in Nepal is also finding its way into the bordering states of India. This trade needs to be regularized.

Hybrid Seed Production

Because of the problem of patents and a demand for uniform and higher-yielding cultivars, the demand for F1 hybrid seed is on the increase. In some crops, hybrid seed production needs emasculation and pollination through manual labour. Due to cheap farm labour, this is one area which can be exploited by Nepal. In most cruciferous crops, though hybrid seed production is carried on by using self-incompatibility, the maintenance of self-incompatible lines requires a large labour force to undertake bud pollination. This can be undertaken in Nepal very economically.

For any developing country, it is very difficult to undertake research projects to develop its own hybrids, because of the high cost involved. To use farm labour and improve the economy of small farmers, hybrid seed production could be successfully launched through international cooperation and through organized custom production.

A start in this direction has already been made in Nepal. Through cooperation with the Asian Vegetable Research and Development Centre, hybrid seed production with heat-tolerant Chinese cabbage has been successfully launched. Under the ambient conditions of the mid-hills, it is possible to get excellent flowering and seed set of Chinese cabbage; successful maintenance of parental lines through bud pollination has been achieved. Hybrid seed produced in Nepal and the seed of parental lines have been tested by the centre and good results have been obtained. The testing of hybrid seed production on farmers' fields has been successful. Per hectare, a seed yield of 300 to 400 kg of hybrid seed has been achieved.

Hybrid seed production in tomatoes through a custom production arrangement with a private multinational company of the Unites States has been initiated through the participation of private entrepreneurs in Nepal. If successful, the programme will be expanded to other crops.

The FAO Fresh Vegetable and Seed Project

To support the HMG/Nepal effort to increase vegetable seed production in Nepal with a view to improve the nutrition of people and the economy of small farmers, a project of vegetable seed production was conceived in 1980. This FAO project of three years' duration was started in 1981 with funding from the Government of Switzerland. On the basis of successful implementation, the project entered into its second phase from 1984 to 1987. As the project created an impact and the need to support second generation problems was felt, the project was extended into a third phase of four years' duration that started from June 1987. Activities supported by the project and its impact are described in brief.

The First Phase, 1981–1983

The project activity in 1981 started with the objective of increasing the quality and quantity of seed production within the country, seed being a vital input for increasing production and productivity of vegetables.

For this, the project screened suitable varieties and, wherever possible, new stock seeds were imported to replace deteriorated seed stocks. Seed production technology was amended and field verification and seed standards were established. Seed production, processing, and storage facilities at five identified seed centres were completed.

Intensive seed production training to farmers, field-level technicians, and senior planners and officers was organized.

A systematic programme for variety maintenance and breeder and foundation seed production was started.

Since the development of a seed programme is a long-range activity, the project was extended into a second phase.

The Second Phase, 1984–1987

To achieve the main objective of increasing vegetable production through the use of locally produced high quality seed, a large number of field demonstrations were organized (annually 4000). These demonstrations were conducted only in selected pockets in the areas covered by the special production programme. Through these demonstrations, the credibility of seed produced within the country was established. This resulted in increasing demand for seed. The acreage under vegetable production started increasing and second generation problems such as lack of market facilities, increased input supply, and proper pricing to farmers started to emerge.

On the seed production front, due to increased demand and by way of promoting private entrepreneurs, a need was felt to improve the seed distribution system through AIC. To meet increasing demand for seed from farmers, it became necessary to expand foundation seed production facilities, identify more areas for seed production, and train more farmers who could undertake seed production.

A need was also felt to identify appropriate measures to support a marketing and distribution system. To accomplish all these activities, the project was extended to a third phase of four years' duration, 1987–1991.

The Third Phase, 1987–1991

The project expanded its demonstrative vegetable production in 21 districts, covering 60 pockets supporting 2000 hectares of vegetable production. Inputs are supplied to farmers at commercial prices. Free support is given in the form of demonstrations (4000 annually) and intensive training and field days.

For making the programme self-sustainable, vegetable nurserymen are appointed in each production area. Through these nurserymen, vital inputs, i.e., chemical and technical know-how, are disseminated to farmers. Dealers linkages are established between these nurserymen, seed entrepreneurs, and plant protection chemical companies. In the area of seed production, sustaining support is provided to maintain varieties for foundation seed production and to introduce new technologies, including schemes for hybrid seed production. Support is provided to private entrepreneurs to increase seed production through contract farmers.

The Vegetable Seed Campaign Programme

With support from the FAO Fresh Vegetable and Vegetable Seed Production Project, funded by the People's Republic of China, the Vegetable Seed Campaign Programme was launched in 1982/83. Under this programme, a large number of field demonstrations were organized in the districts covered by the special production programme. Through massive field demonstrations and field days an impact was made on the farmers and sales of seed picked up. Growth of vegetable seed production during the last 10 years is given in Figure 6.4.

The Marketing Component

When the programme started expanding, second generation problems arose, such as the need for systematic marketing through development of

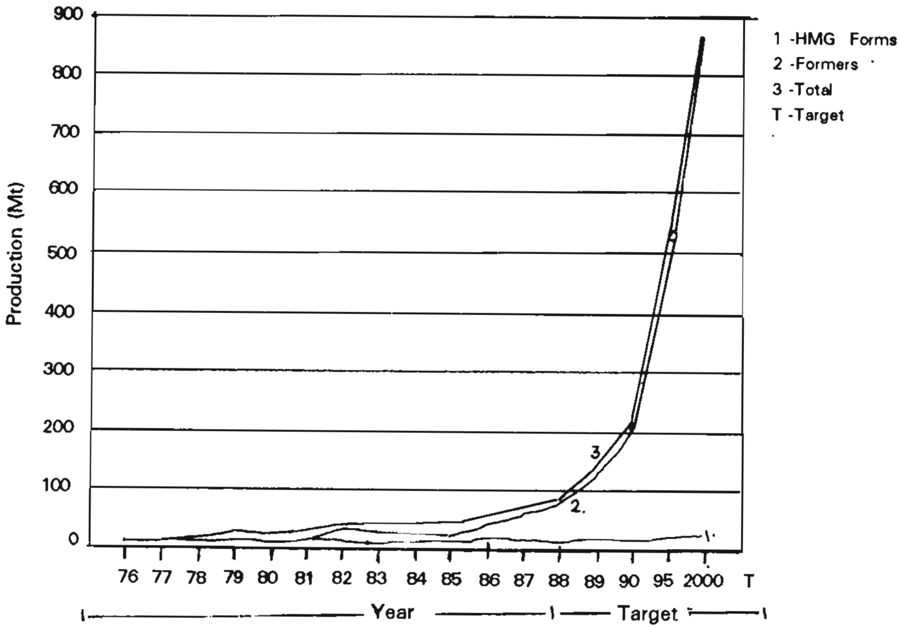


Figure 6.4: Growth trends of vegetable seed production in Nepal

farmers' markets and the establishment of collection centres and market yards.

Through the marketing component in the project, pilot-scale studies to establish wholesale markets and collection centres have been initiated. On this basis, more support to improved marketing has been approved through the United Nations Capital Development Fund (UNCDF). A memorandum of understanding has already been signed between UNCDF and HMG to support market-related activities with a financial outlay of US$ 11.8 million. This also includes support to private entrepreneurs through a venture fund to establish food processing, storage, transport, and seed industry.

Geographical Coverage of FAO Project

Details of project areas supported by the FAO Project are given in Figure 6.5.

Future Strategies and Programmes

Removal of Production Constraints

As vegetable production on a commercial scale is a new operation in Nepal, there are various constraints on production. Some of the con-

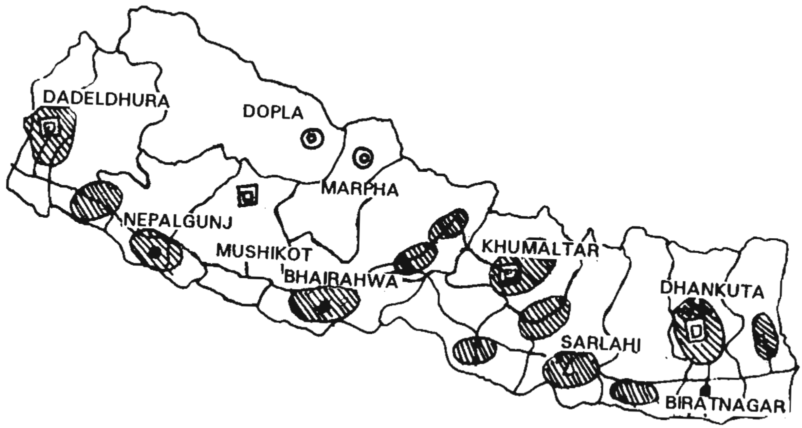


Figure 6.5: Location of project support areas
- Alpine climate seed production centres
- Warm temperate seed production centres
- Tropical vegetable seed production centres
- Transit seed stores
- Demonstrative vegetable production pockets
- Roads

straints that need immediate attention are listed below:

1. Safe use of plant protection chemicals: Due to the low educational level of farmers, insecticides and fungicides are used indiscriminately. As there are no legal regulations for the safe use of these chemicals, a clear government policy needs to be developed. Haphazard import of insecticides and fungicides must be discouraged and only safe chemicals with low residual effects should be allowed importation or formulation in the country.
2. Breeding of varieties suitable for local conditions: With regard to the breeding of vegetable varieties on a global basis, all activity is in the hands of private multinational companies. It is difficult for developing countries to undertake this activity due to financial and manpower constraints. There is a need for a cooperative research programme between the countries of the region. International institutions such as the Asian Vegetable Research and Development Centre and ICIMOD can play an important role in bringing about this cooperation and should provide necessary support. Research activity being of a long-range nature, developmental aid programmes are unable to support this activity. Activity of this type has to start as a country programme rather than as a project.
3. Improvement of traditional vegetables: There are some vegetables tra-

ditionally grown in the countries of the region. Since these are of no commercial value, no multinational has done any research to improve cultivars for these crops.

There is great need for improved strains of these vegetables through simple selection and maintenance breeding.

As vegetables are grown under the short to intermediate daylength of the tropics, cultivars should be developed that can perform well under these conditions. This is perhaps the main reason that the yield of vegetables in this region does not match the yield of western countries.

4. Reduction of post-harvest losses: In the context of countries of this region, it is estimated that 25 per cent of fruits and vegetables are spoiled in post-harvest loss. If this loss is minimized by using appropriate and simple techniques such as taking out field heat, the availability of vegetables can be increased to meet the growing demand.
5. Promotion of processing industry: For all perishable fruits and vegetables, there is always a glut in production during the peak harvest season. Due to poor storage and distribution systems, prices drop to such a low level that farmers incur great loss. This glut could be avoided by promoting a food processing industry, developing the use of locally produced food products, providing incentives to the processing industry, and avoiding import of such items from other countries. There is great scope for both cottage-level and small-scale processing industries.

Improvement of Marketing Facilities

The success of any production-oriented programme depends upon the efficient marketing of produce. If produce is not sold at prices which are remunerative to farmers, further production is hampered and all efforts are in vain. In the vegetable development programme of Nepal, when it was realized that production levels had reached a commercial scale of operation, action to improve the marketing system was initiated.

Based on a pilot-scale support provided by the FAO project, HMG of Nepal acquired 2 hectares of land to establish a wholesale vegetable market in Kathmandu. The FAO project prepared a master plan to develop this area into a modern market for farmers. The UNCDF and HMG approved the investment of US$ 4 million in various structures, including cold storage.

To provide support to the farmers in production areas, the UNCDF has also committed support to the development of collection sheds, market yards, and farmers' markets in other towns. Provision has also been made to develop approach roads between the production villages and the market yards and collection centres, through peoples participation.

Provision has been made to develop a master plan for fruit and vegetable marketing in Nepal so that all the activities in this direction are taken up in a properly coordinated way to avoid duplication.

Promotion of Private Participation through Venture Funds

It has been realized that the entire programme of production and marketing of agro-industries cannot be undertaken by government alone and that active participation of private entrepreneurs is a must.

To promote this, in addition to financial support, technical know-how in the management of the industry is very essential. For this, UNCDF has committed assistance to promote private participation in food processing, storage, transport, and seed industry through a venture fund.

A scheme is under consideration to establish a venture capital fund unit in collaboration with the banks and technical line ministry or departments. The venture fund will provide 30 per cent equity to project proposals with good potential which are duly approved by the technical departments. Private entrepreneurs will provide 10 per cent equity share in the form of land, building, equipment, or cash. Under this co-ownership, the responsibility of the technical department will be to oversee the proper financial management, accounting, and growth of the venture. The commercial bank concerned will provide credit to the extent of 50 per cent of the total equity value of the venture (see Annex 1 for model of the proposed venture capial fund).

It is also envisaged that when the scheme is successful, entrepreneurs can become the shareholders of the venture capital fund unit.

Annex 1

A model of the proposed Venture Capital Fund

Objective

To assist emerging entrepreneurs to develop and expand their business.

To assist with short-term funds for new venture investments.

To assist entrepreneurs to replicate (take over or expand) present investments in horticulture and seed production and to extend present marketing and storage facilities.

To support entrepreneurs with skills in:

- technical know-how,
- general accounting and auditing,
- marketing and sales promotion,
- generation management, and
- financial analysis as to budgeting, break-even, cash flow, and other required analysis programmes.

To complement existing financial like the Intensive Banking Programme or general bank lending.

Background

Small emerging entrepreneurs need assistance to start and consolidate business in horticulture seed production, storage, and marketing.

The business needs to be assisted by financial input and appropriate know-how.

Existing financial sources are mainly bank loans or credit extended by suppliers, but a new venture most often has to find its own financial source during its inception. To obtain bank financing for new ventures is also a cumbersome procedure, especially when the equity in the project is limited and the project is a new venture. The support of a venture-capital fund (equity participation) will assist entrepreneurs by:

- helping to achieve higher equity, which will strengthen the project's possibility to attract bank financing,
- the presence of a co-owner who can assist in management and other technical back stopping, and
- lessening the financial burden on a new venture through equity participation.

Proposal

A Venture Capital Fund is established through a grant from . .

A Venture Capital Fund is managed by an autonomous board of directors representing:

- Ministry of Agriculture,
- Nepal Rastra Bank,
- two major commercial banks (NBL 51 per cent HMG and RBB 100 per cent), and
- a selection from future clients who have benefited from the Fund and made contributions towards the Fund.
- Technical support is made available through
- the project (Ministry of Agriculture),
- the project (Nepal Rastra Bank), and

— two major commercial banks (the technical support shall not debit any cost to the Venture Capital Fund or to any prospective client).

Duties/ Obligations

Ministry of Agriculture (unit ...) responsible for technical clearance, technical know-how, close supervision of the project

Nepal Rastra Bank (unit ...) responsible for monitoring and maintaining the fund

Commercial banks (unit ...) responsible for financial analysis

The fund will build up its own competence in the field of:

- management,
- accounting and auditing (which can be charged), and
- marketing and sales promotion.

Procedures

Applications must always be channelled through the Ministry of Agriculture, which is responsible for:

- appraisal,
- technical clearance, and
- necessary market surveys.

Financial clearance as to equity participation is approved by the Board of Directors of the Venture Capital Fund after financial analysis.

Client/applicant should always be able to support the investment with his own equity of at least 10 per cent of total financial requirements. This equity can come from contributions of land, buildings, machinery, vehicles, cash, or bank accounts.

The Venture Capital Fund can contribute additional equity up to three times the clients contribution.

Other necessary financing shall be obtained from bank/supplier or other common financial institution through ordinary application procedure (and preferably assisted by the technical staff involved).

Bank finance will be 'secured' by an equity ratio up to 40 per cent which is for more than ordinary loan applications,

Example

Total financing requirements	NRs. 1,000,000 out of which:
working capital	NRs. 200,000
fixed assets	NRs. 800,000
financing	NRs. 1,000,000
client's own contribution	NRs. 100,000
Venture Capital Fund contribution	NRs. 300,000
bank financing	NRs. 600,000

Only bank financing will carry any cost, while the equity will give a return when the project has reached a sufficient level of viability.

Equity participation by the Venture Capital Fund is expected to be repaid from profits generated by the investment, thus leaving the entrepreneur as sole owner of the project within a given time.

As long as the Venture Capital Fund is co-owner of the project, the Fund shall have a final right to:

- close the project if mismanaged, unavailable, or not utilized as planned,
- recover any amounts from project assets/proceeds whenever needed,
- obtain information from bank accounts, project accounts, or any other information deemed necessary, and
- monitor the progress of the project and assist in know-how.

The entrepreneur is the sole manager of the project and shall furnish the Fund with information as agreed upon.

The entrepreneur shall always have the right to cease participation of the Fund by repayment of the equity contribution made by the Fund.

Repayment to the Fund shall be made by the project (entrepreneur) from the profits generated on a scheduled basis.

As long as the project obtains equity participation from the Fund, the entrepreneur is obliged to purchase shares in the Fund on a yearly basis in advance up to a value of 2 per cent of equity contributed by the Fund.

Example

1st Jan. 1989 Equity from the Fund	NRs 300,000
Shares to be purchased	NRs 6,000
1st Jan. 1990 Equity from the Fund	NRs 250,000
Shares to be purchased	NRs 5,000
1st Jan. 1991 Equity from the Fund	NRs 150,000
Shares to be purchased	NRs 3,000
1st Jan. 1992 Equity from the Fund	
Nil	

The entrepreneur will retain shares with a face value of NRs. 14,000 in the Fund.

Future Objectives

To make the Venture Capital Fund autonomous

To have the participation of successful entrepreneurs on the board of directors of the Fund

To employ a managing director of the Fund

To generate sufficient earnings from capital investments to sustain losses (write-off) and managerial expenditure.

A Venture Capital Fund of US$ 2.5 million will:

- On an annual and on-going basis be able to assist some 50 entrepreneurs with an equity participation of NRs. 200,000 each (or 10 entrepreneurs with NRs. 2,000,000 each)

With the following prerequisites the Fund will be able to invest balances kept at around 10 per cent.

- Entrepreneurs make a yearly contribution of 20 per cent towards increasing the equity of the Fund.
- Entrepreneurs make an average repay to the Fund five years after an initial grace period of two years
- Failing projects (total write-off) do not exceed 10 per cent.

7

Horticultural Development in Bhutan

D.K. Wangchuk

Introduction

Physiographically, the Kingdom of Bhutan can be divided into three broad agroclimatic zones, all running from east to west. The northern zone is about 30 km wide, with altitudes above 4000 m. It is covered by perpetual snow, glaciers, and barren rock. The central zone is about 70 km wide, and lies between 2000 and 4000 m in altitude. This zone contains the major forest areas of the country, and enjoys temperate climate and vegetation. The southern zone, about 50 km in width, comprises the foothills of the Himalayas, rising to an altitude of around 2000 m. The climate and natural vegetation in this zone are sub-tropical to tropical.

Due to the wide variation in altitude, the mean monthly maximum and minimum temperatures and annual rainfall are very different in each of the agroclimatic zones (Figure 7.1).

The population of Bhutan is estimated at about 1.4 million. About 90 per cent of the people live in rural areas and are directly engaged in agricultural activities. The population is concentrated in the broader river valleys of the central zone and in the lowlands of the foothills in the southern zone.

Agriculture and animal husbandry account for about 50 per cent of the gross domestic product. At present, about 91 per cent of the total land area is under forest, alpine pasture, and snow cover. Only about 410,000 hectares, or 9 per cent of the land area, is considered suitable for agriculture; out of this, about 129,000 hectares of land area is under crops, about 32 per cent of the potential agricultural land area. Out of the total cropped area, 28,380 hectares, or 22 per cent, is irrigated land, synonymous with paddy cultivation.

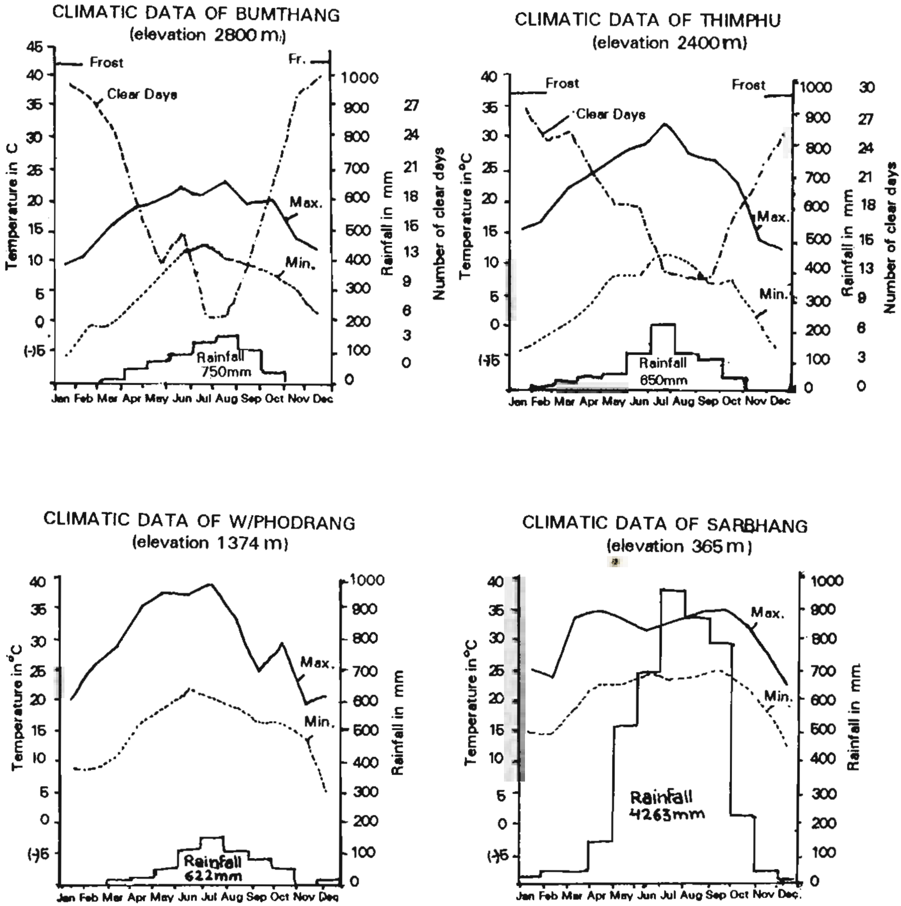


Figure 7.1: Climatic data of different regions of Bhutan

The rest of the cropped area, i.e. 78 per cent, is rainfed, and is variously classified as dry land, 'tsheri' (or shifting cultivation) land, and orchards. Orchards occupy 14,000 hectares, or 11 per cent of the total cropped area. Vegetables are mostly grown in kitchen gardens and comprise about 1000 hectares, or 1 per cent of the total cropped area.

Review of Policy and Strategies

Policy Directions and Strategies for Agriculture

The long-term goal for the formulation, implementation, monitoring, and evaluation of agricultural development is stated in the Sixth Plan as follows: To maximize the contribution of agricultural development to national self-reliance and overall economic growth, while safe-guarding the agro-ecology from undue degradation.'

Agricultural development objectives lay strong emphasis on achieving self-sufficiency in food grain production, increasing the per caput income, the nutritional level of the rural population, and the productivity per unit of farm labour and agriculture land. Another objective is to increase the contribution of agriculture to the gross domestic product and to export. Also of concern to the government is the need to improve soil and water conservation.

The basic agricultural strategy emphasizes the intensification of agricultural production in all possible arable areas. The government's strategy to intensify the production of crops is based on a rice-based cropping pattern in the irrigated wetland areas, a maize-based cropping pattern in the low to medium altitude rainfed dryland areas, and a potato-based cropping pattern in the high altitude rainfed dryland areas.

Tied to these three cropping patterns is a recently initiated National Horticultural Programme which will emphasize the production of trees and other horticultural cash crops in those parts of the rainfed areas where environmental considerations preclude the production of field crops. Under this programme, vegetables will be grown as part of the wet and dryland farming system and in kitchen gardens.

The Role of Horticultural Crops

Many horticultural crops are already popular with Bhutanese farmers as their main source of cash income (Table 7.1). The increased production of existing and appropriate new horticultural crops can make a major contribution towards achieving the sectoral objectives. They can increase rural incomes and national export earnings, as well as improve the nutritional level of rural communities. A characteristic of horticultural crops is that a significant proportion of those suited to Bhutan's varied soil and climate conditions have a high, or very high, value-to-weight ratio. As such, they can sustain relatively high road transport costs, or justify air freight. In economic terms, the crops constitute an optimum use of Bhutan's scarce resources of land and labour.

The implementation of a programme to develop horticultural production need not conflict with the nation's food self-sufficiency objectives for the following reasons:

- Increasing the output of cereals is intended to be yield increase by greater use of high-yielding varieties and optimum use of inputs and appropriate crop rotation.

TABLE 7.1

Acreage, yield and export of major cash crops (1986)

Crop	Area (acres)	Fruit-bearing trees (per cent)	Yield (tons/acre)	Export	
				Quantity (tons)	Value (Nu '000)
Apple	3,656	53	2.4	4,600	5,087.1
Orange	19,395	63	4.0	15,500	17,634.7
Other temperate fruit	67	93	N/A	9	73.0
Sub-tropical fruit	243	—	N/A	N/A	N/A
Ginger	1,147	—	1.9	1,223	1,824.3
Chilli	2,408	—	1.5	34	290.2
Asparagus	20	—	—	N/A	N/A
Other vegetables	1,820	—	—	39	70.1
Cardamom	21,699	51	—	939	38,546.8
Lemon grass oil	—	—	—	3.7	3,222.9
Potatoes	5,100	—	9.8	9,965	21,070.0

- Vegetables, especially those with nitrogen-fixing properties, have a place in the crop rotations of rice, maize and potato-based farming systems.
- Many horticultural crops, particularly tree and shrub species, can be grown satisfactorily on hill slopes unsuited to rice or maize; in fact, current Department of Agriculture recommendations for apple and orange stress the avoidance of planting on rice terraces.

Historical Overview of Horticultural Development

In the early years, horticultural development was done on a piecemeal basis, focusing on individual crops. Most attention was given to the distribution of seeds and seedlings, as well as marketing aspects.

Recent efforts to develop horticultural crops have focused primarily on processing and marketing aspects, as evidenced by the UNCDF-funded Horticulture Produce, Processing and Storage Project, and marketing intervention by the Food Corporation of Bhutan (FCB) through support price purchasing of various horticultural products, and running of auction yards.

The UNCDF project, and related technical assistance, is funding the construction of three auction yards at Phuntsholing, Gaylephug, and Samdrupjongkhar, and equipment for the apple-processing plants at Bumthang and Bondey Farm. It also provided a lump sum for a Horticultural Revolving Fund for small and medium scale investment in production and processing facilities. But relatively little work has been done to tackle production-related problems of the horticulture industry due to resource constraints.

There is now a need to address the imbalance by refocusing on these problems, and to recognize the need for integration between production and marketing.

Taking a farming system approach, the government is now initiating a horticultural development programme that emphasizes the role of horticultural crops as a sub-sector of the whole agricultural industry.

Horticultural Crops in Bhutan

Currently Significant Crops

APPLE

The major apple-growing zone lies in the temperature climate districts of Thimphu, Paro, and Bumthang. Production systems in Bhutan are extensive, with tree populations of around 100/acre. This factor, combined with often inappropriate rootstocks and cultivars and low levels of management, is responsible for the low average yields (2.4 mt/acre). Even with such yields, it is expected that apple production in the next five years will double as the substantial plantings of recent years come into bearing. At current price levels, apple growing can be extremely profitable for above average growers (4–10 mt/acre).

ORANGE

The majority of oranges (mandarin type) grown in Bhutan are planted in the southern belt in marginal soils of low fertility and are poorly maintained. Orange growing is largely a part-time activity to generate cash income for both subsistence farmers and the few relatively wealthy farmers. Subsistence food crops, such as maize, millet, and beans, are grown on more level and fertile soil. In many of the orange-growing areas, oranges are the only cash crop which can be assured of an expanding demand with a reasonably rewarding income for minimal inputs. However, as a consequence of the lack of even basic management practices, yields are extremely low.

With significant new plantings in the drier areas of Chirang, Samchi, and Samdrupjongkhar, production is expected to increase to 26,000–27,000 mt by 1989/90 and 37,500–38,500 mt by 1992/93. Expectations are that the Indian market is probably capable of absorbing a substantial increase in volume of this order, with only slight price reductions. Export to Bangladesh commenced in 1988 and is expected to expand.

POTATO

Potato is the principal cash crop of Bhutan. It is widely grown all over the country, mainly in the hilly regions where the climate remains cold. It is commonly classified into red and white. Although the production of white potato is greater, the red potato commands a premium price in the market. The harvest and marketing season runs from June to December.

The marketing of potatoes is done through auction yards of the FCB.

VEGETABLES

Significant market potential exists in India during the summer monsoon period for a range of vegetables. These include cabbage, cauliflower, eggplant, spinach, onion, peas, beans, and tomato.

With modern production systems, the climatic conditions exist in some areas of Bhutan for high-volume production of these crops, yielding incomes higher than from most other existing cash crops. There is also scope to produce and export dried peas, beans, and pulses.

While legume production can be readily integrated into maize-based farming systems, summer-grown vegetables tend to conflict with rice growing. However, the area required for commercial vegetable growing would be relatively small.

There is also scope for import substitution. In 1986, recorded onion and garlic imports totalled 235 mt (Nu. 585,715) at an average price of Nu. 2.5 kg. Japanese varieties have been grown successfully. Provided these would be acceptable to consumers, or the more pungent Indian red-skinned which can also be successfully raised, there are a number of areas where commercial onion growing should be feasible. Tomato imports were 174.4 mt (Nu. 432,523) and chilli imports 69.3 mt (Nu. 255,530); these crops would also appear to offer import-substitution opportunities. A wide range of vegetables can be grown during winter on irrigated paddy terraces at low altitudes to replace imports from India.

A limited amount of asparagus has been grown in the Thimphu, Haa, and Paro areas for more than 10 years. In the past year the area has more than doubled to around 10 acres. Output is either sold fresh in the local market or brought by Bhutan Fruit Products for canning at a fixed contract price. In addition to a substantial increase in purchases by the Bhutan Food Products factory at Samchi, there is some potential for export.

CARDAMOM

Cardamom is the most important export crop with recorded exports in 1986 of 939 mt valued at Nu. 38.45 million, plus some unrecorded export. The 1984 Department of Agriculture crop survey reported 21,699 acres under cardamom, of which around 50 per cent were bearing, indicating prospects of a significant increase in production.

World production of the large brown Himalayan cardamom is concentrated in India, Nepal, and Bhutan, with Pakistan and the Middle East as the main consuming areas. Opportunities may well exist for Bhutan to expand export.

Crops with Significant Future Potential

TEMPERATE TREE FRUITS

There have been a number of trial plantings of apricot, peach, plum, cherry, and pear which suggest that these crops would be grown successfully in many parts of Bhutan.

Several growers in Paro district are already supplying peaches to a processing outlet in Siliguri, and Bhutan Food Products factory has also expressed interest in the crop. Because peaches come into bearing rapidly, they offer prospects of quicker returns than apples. Given the interest of processors, there is scope to expand the acreage grown, particularly on irrigated valley slopes. It would, however, be advisable before embarking on large-scale plantings to assess the scope for long-term supply contracts with the canners.

TEMPERATE SOFT FRUITS

Favourable climatic conditions exist in the drier, central areas between altitudes of 1800 and 3000 m for currants, gooseberry, blackberry, raspberry, and loganberry production. These crops are all highly perishable and while there is scope for limited planting for domestic consumption and local demand, commercial-scale production would have to be linked to a local processing outlet. A limited amount of strawberry has been grown at Bondey farm for some 14 years, indicating that high yields can be achieved. Marketing trials also confirm that there is a high-priced demand for fresh strawberries in Calcutta.

TROPICAL AND SUB-TROPICAL FRUITS

A wide range of tropical and sub-tropical fruits (mango, guava, litchi, banana, kiwi, and fig) can be grown successfully at lower altitudes. For mango in particular, there are export opportunities if the crop can be harvested to follow the main crop in other parts of the region. In the same off-season period, there may also be opportunities for litchi. In addition, there is scope for limited plantings of a wider range of tropical fruits to meet domestic consumption and local market demand.

GINGER

Ginger is grown in all the southern districts of Bhutan but there is an absence of reliable production and market information for this crop. Officially recorded export of fresh ginger was 1223 tons valued at Nu. 1.8 million in 1986. If, in addition, there are unrecorded exports, ginger may be a more important cash crop than has been supposed. Market prices show significant seasonal and annual fluctuations. Reported yields are low (2–4 mt/acre), suggesting scope for increasing yield by a factor of at least two.

OTHER SPICES

In addition to chilli, ginger, and cardamom, a wide range of spices could be grown in low-altitude areas. Black pepper, in particular, is a prospective commodity for isolated areas with poor road access, given its high value-to-weight ratio.

LEMON GRASS AND OTHER OILS

Essential oil production from occurring lemon grass and its distillation by small holders in domestic scale units has become established as a major source of cash income in Mongar, Lhuntshi, and Tashigang districts. Success has been due to limited alternative sources of cash income (since the actual rates of return appear relatively low), and to the provision of technical expertise and market outlets by Bhutan Aromatics and Phyto-chemicals Company of Tashi Commercial Corporation.

There appears to be good potential for increasing lemon grass oil production from collected natural grasses. Under the current FAO Essential Oils Project, adaptive research and trials will be carried out on other essential oil plants such as palmarosa, eucalyptus, citronella, cinnamon, and geranium, all of which currently command high prices in the world market. There may also be scope to exploit other naturally occurring plants such as artemesia. Because of serious risks of deforestation under the existing collection system, any expansion needs to be based on a new production system—which appears to be entirely feasible—which will integrate timber production (for still fuel), grazing improvement, and erosion control, including use of nitrogen-fixing plants.

MUSHROOM

A beginning has been made in the establishment of mushroom cultivation, especially of varieties such as oak or shiitake, which use locally available oak logs and sawdust.

Specialized drying equipment is required if export quality production is to be achieved. This favours a concentration of the industry around central drying facilities. The capital investment required is relatively high, both to the farmer and in terms of the support services (mycelium bank) provided by the government. Mushroom growing requires a high level of expertise and attention to detail.

NUTS

Walnuts grow well under a wide range of climatic conditions and at varying altitudes. The nut is popular with the Bhutanese and the small amount currently available reportedly commands high prices at gateway towns. There is, in addition, a substantial world trade in all nut species. Subject to confirmation of local and export market opportunities, extensive planting on non-arable slopes would offer a long-term cash crop opportunity and a timber resource, as well as providing some protection from erosion.

The potential for other nut species, chestnut, hazel, pecan and macadamia, all of which can be grown, is yet to be assessed.

Constraints to Horticultural Development

Macro-economic and Market Considerations

Rural wage levels have risen rapidly over the last year due to the increase in the official minimum wage combined with the increased opportunity for wage employment in non-rural sectors and general buoyancy of the economy. This trend, which can be expected to continue for some time, underscores the need to secure improved crop yields and labour productivity if the existing horticultural export is to remain competitive and the new opportunities outlined above are to be realized.

It is also evident that fruit and vegetable production in the region is undergoing commercialization, with certain areas becoming major producers of particular crops that do well in Bhutan. Improvements in the quality of packing and presentation and in yield are usually associated with emerging specialization. This trend adds urgency to the need both for improvements in the quality of Bhutanese produce and for lower unit costs.

There is only a limited demand for added marketable surplus in the domestic market of Bhutan, particularly for fruits and vegetables. Thus, any expansion in output must find marketing outlets in the neighbouring countries. So far, India provides the largest and most convenient outlet. The prospect of export to Bangladesh is being explored, and consignments of apples and oranges were exported to this market in 1988.

A survey of Bhutanese agricultural products in India was completed in 1988. The study identified the following products as having the highest potential for sales and market expansion in India: apple, orange, potato (seed and table), dry chilli, soybean, beans, and cowpeas. Off-season green vegetables, namely, peas, cabbage, cauliflower, tomato, capsicum, and squash, also have large potential. Vegetable seeds, flower seeds, walnuts, and almonds are considered to have substantial potential as new items in the market.

The study concluded that although the large cardamom and green ginger are some of the most economically significant produce of Bhutan presently sold in India, there is no immediate prospect of further increasing sales in this market. Similarly, radish, green beans, chilli, mushroom, asparagus and other temperate fruits such as pear, peach, and plum did not have much potential for increased sales.

The small size of Bhutanese markets limits the domestic base from which expansion in the output of most horticultural products would be initiated. For many commodities, inlets into neighbouring country markets are also limited. Horticultural development will, therefore, have to be supplemented by well-organized planning and market development activities.

Planting Materials and Rootstocks

Many orchards suffer from low tree vigour and poor tree shape, which decrease yields. In the case of apples, this often arises from the indiscriminate planting of trees, grafted on seedlings or unsuitable rootstock. In the case of oranges, most planting materials are farmer-grown, not standardized, and are low-yielding. For other temperate fruits there has, to date, been only a limited systematic evaluation of varieties and rootstocks and few demonstration trials.

Generally, kitchen gardens supply their own vegetable seed or obtain it from neighbours. The National Agricultural Seed and Plant Production Programme (NASEPP) is the sole supplier of improved vegetable seeds intended for commercial production. The NASEPP has limited sources, often leading to low germination rates and high variability of its vegetables seeds. In order to develop an efficient vegetable export trade, these constraints have to be resolved.

Planting Systems and Crop Management

Sometimes orchards have been planted on marginal soils and on steep slopes. Where such areas lack the possibility of irrigation, there may be little scope to increase yields. On some windy sites, poor pollination often contributes to low yields. This could be overcome by wind breaks or more pollinizers.

The majority of orchards are planted at lower than recommended density. Greater fruit yield could be achieved by increasing plant density.

Often, trees are not trained and pruned properly and this too affects yield.

Many orchards, especially in the case of cardamom, are located some distance from the owner's house, and consequently receive little management. Often farmers are unaware of recommended fertilizers or the means of identifying and controlling trace elements (especially in vegetables).

Harvesting

Rough treatment during harvesting and transport to markets can have a detrimental effect on the price of produce. In the case of oranges, harvesting is sometimes done by twisting fruit off the bearing branches, which results in removal of the calyx from the fruit, leading to exposure to fungal infection and rotting. Additionally, branches may be injured, adversely affecting output in future years. In the case of vegetables, farmers are sometimes unaware of the optimum time to harvest.

Grading and Packing

Inadequate grading, presentation, and packing lowers the market value of produce, especially in external markets. Poor handling methods also contribute to low quality with high waste. Farmers often do not attempt to reject poor quality produce or to improve packaging. Such practices may have little effect on local sales, but they are major constraints to the development of export sales.

The development constraints are further elaborated in Table 7.2.

Current Status of Services and Facilities

Research and Extension

The centre for Agricultural Research and Development was established in 1982 with its headquarters at Wangdiphodrang and sub-stations at Bhur (Gaylephug) and Khangma (Tashigang). It has its main focus on grain and oilseeds. Some work is now being done on vegetables as a component of a rice-based farming system; work on mushroom, asparagus, other vegetables and flowers, has continued at Simtokha (Thimphu). At Bondey Farm (Paro) work on new cultivars was started in the early 1980s as a back-up to the rice-based extension service to farmers of Paro district. This has continued as part of NASEPP, particularly on vegetables, including asparagus, soft fruits, especially strawberries, kiwi fruit, and pome. At the same time, it has provided ad hoc but useful technical advice to growers of apples and other experimental crops. Yusipang in Thimphu district was established in 1964 and designated as the temperate zone horticultural research station.

TABLE 7.2
Development constraints to be addressed by Integrated Horticultural Development Programme

Problems	Causes	Evidence
Sectoral or Sub-sectoral level		
Insufficient food to meet country's needs	Mainly subsistence-level farming, limited surplus for sale	Food and horticulture imports.
Low cash incomes	Traditional preference for food crops for farm self-sufficiency, rather than cash	High-value cash crops not being cultivated in areas suited to such crops
	Insufficient income-generation opportunities and knowledge (e.g., of cash crops)	Lack of farm management/budget data to demonstrate feasibility of alternatives.
Insufficient foreign exchange to meet country's requirements	Insufficient quantity and variety of export products	Balance of payments deficit
Project level (technological, cultural, institutional)		
Low horticulture crop yields and poor product quality	Poor root and genetic stocks	Inadequate research programme, non-availability of suitable planting materials
	Inadequate irrigation	Irrigation canals not built
	Insufficient manure/ fertilizer and other inputs	Manure/fertilizer not being applied according to recommended practices
		Limited credit facilities for input purchase
	Improper/outdated planting and cultural techniques	Limited knowledge of planting and harvesting techniques, irrigation, etc.
	Low manpower productivity	Poorly trained farm workers with limited knowledge of planting techniques
	Limited institutional framework and extension activities for development	Absence of horticultural section in Department of Agriculture

Contd.

Table 7.2: Contd.

Problems	Causes	Evidence
		Lack of horticulture professionals and training facilities/programme
		Inadequately trained extension workers Limited extension service
	Poor packaging and rough handling during transportation	Bruised and damaged produce reducing market value and lowering farm incomes
	Poor export value for horticultural produce	Poor presentation and marketing of produce.
		Lack of export market studies

The main emphasis of extension work is on the principal crops, (rice, wheat, maize, and potato) and the cropping patterns associated with these crops. Extension personnel have limited training in horticultural crops and most are able to offer the farming community only limited support. Nevertheless, advice on production, post-harvest aspects, and a pest control service have been provided to farmers in the main apple, orange, and cardamom growing areas.

The Department of Agriculture has recently established a Horticultural Unit within the Research and Extension Division. This unit will be the focal point of operation for the Integrated Horticultural Development Programme.

Supply of Planting Materials

The NASEPP was formed in 1984 with headquarters at Bondey Farm and activities at eight other farms. It is the government agency responsible for the production and procurement of all government-approved planting materials. Other Department of Agriculture farms, not under the administrative control of NASEPP, are providing some vegetable seeds and fruit plants, but Bondey and its satellite farms are the main source of vegetable seeds. Apple saplings are supplied by Bondey farm, which imports the country's needs from India pending the development of its own supplies. Most orange growers raise their own seedlings.

Through Japanese aid NASEPP is currently being provided with new, fully equipped headquarters at Chungdu-Dinkha near Bondey Farm comprising seed store, seed processing unit, seed treatment, seed packaging, specialist in seed storage facilities, and a complete range of facilities for tissue culture. These facilities should greatly enhance NASEPP's ability to produce and supply genetically pure, disease-free planting material. The programme plans to continue producing seed at its Bondey production farm and its satellites at Chiufu, Lapsetanka, and Panbesa, at branch farms at Nasphyel, Chenary, Tashiyangtshi, and Bhur, at a leased farm at Changyulthang near Punakha, and through registered growers in various areas.

Marketing Mechanisms

The Royal Government of Bhutan has established infrastructure and various institutions for agriculture crop marketing. For the internal market, the urban marketplaces have been constructed and managed where Sunday markets are held, where farmers and traders sell produce directly to the public. The use of these markets is growing fairly rapidly as both farmers and consumers recognize their value. The markets at Thimphu and Phuntsholing have already become twice-weekly events.

For export to India, the FCB operates auction yards at Phuntsholing, Gaylephug, Samdrupjongkhar, and Samchi. At present, these auctions handle potatoes, apples, oranges, vegetables, and pulses, and operate daily during the harvest season. The auction yards and the auctions conducted by FCB officials have been accepted as the best form of marketing support. Action to upgrade the infrastructure at the auction yards is being initiated.

All transactions are conducted by the FCB on behalf of the farmer. After collection of payment, the FCB takes 2 per cent of the transaction value, i.e. 1 per cent each from farmer and trader.

The FCB provides free storage to farmers for three days. Although there are no funds allocated for transportation, such facilities exist that once produce is at the yard, a farmer may take up to 50 per cent of the estimated value of his produce to pay the transporter.

The FCB also provides training to farmers in the handling of produce. Past training programmes have included instruction in plucking, grading, sorting, packing, and transportation. Stock from the training programme goes on special sale in the auction yards as a way to demonstrate post-harvest operations to a wider range of farmers.

The FCB has recently a godown in the market at Siliguri, which has the largest agricultural produce market in northeast India. It holds auctions for Bhutanese growers who prefer to take their produce to Siliguri and also for produce which FCB sells on behalf of the growers when prices offered at auctions in the gateway towns are too low. The Siliguri auction was well used in the 1988/89 season.

Processing

Seasonality of production, the smallness of internal markets, and the need to salvage produce that is not fit for the fresh table market give rise to the need for processing facilities. The biggest commercial processing outlet for horticultural produce in Bhutan is the Bhutan Fruit Products factory in Samchi, which is run by the privately owned Tashi Commercial Corporation. The corporation also owns the Bhutan Aromatics and Phyto-chemical factory at Mongar, which is the main outlet for lemon grass and other essential oil products. In addition, there are three government-owned food processing units in Bumthang, Paro, and Simtokha (near Thimphu).

For the produce required by its processing factories, Tashi Commercial Corporation offers guaranteed purchasing prices. So far this has applied to oranges, asparagus, and lemon grass oil and fresh, cut lemon grass. Although as a general rule government policy is not to offer guaranteed prices, the Department of Agriculture plans to develop similar arrangements with Tashi Commercial Corporation for the purchase of shiitake mushrooms grown by farmers who have spawn and assistance from the National Mushroom Centre. The present mechanisms are, in general, working satisfactorily although there is scope for improvement of physical facilities, auction procedures, and market information to farmers.

Future Plans

Climate, soil, market and other conditions favour the development of a versatile horticulture industry in Bhutan. The government has decided to implement the Integrated Horticultural Development Master Plan in order to take advantage of this favourable situation. The plan, which will initially involve substantial external technical assistance, is summarized in Tables 7.2 and 7.3.

It is envisaged that the IHDP will operate over a 10-year period divided into two phases each of five years. Financing for the first phase is sought by the Government of Bhutan from UNDP.

TABLE 7.3

Project output and activities

Output	Activities	Responsibility	Success criteria
A cadre of Bhutanese horticulturists within the government	Preparation of long-term training/manpower development plan, involving:	Horticulture section and Department of Agriculture personnel Officer	Those selected for overseas training attend and successfully complete courses
	• selection of candidates for overseas training		Horticulture Section fully staffed and functioning effectively
	• identification of suitable training institutions		
	• planning and implementation of practical workshops		
	• on-the-job training of national staff		
A comprehensive and up-to-date base on all aspects of horticultural crops and production systems	Desk study of reports Collection of data from field surveys	Experts and national staff in Horticulture Section	
	Preparation of crop budget for specific crops	Consultants commissioned to execute specific studies. Reports produced in time and and together with the data base used in the detailed planning of IHDP activities	
	Report with latest data on horticultural crop area, yields, profitability, cropping patterns, and constraints		

Contd.

Table 7.3: Contd.

Output	Activities	Responsibility	Success criteria
	Regular collection of market information on the main horticultural crops		
	Studies of domestic and regional markets for specific crops		
A completed programme on adaptive trials on research stations, NASEPP farms and farmer's land	Planning and design of trials	Horticulture Section, NASEPP and CARD staff	All target trials established, well maintained, used as demonstrations and yielding useful results
	Preparation and issue of trial kits	Horticultural specialists at Dzongkhag level	
	Establishment of trials		
	Measurement and analysis of results		
	Monitoring and supervision of trials		
Advisory leaflets in extension manual form and practical workshops for extension staff and farmers about recommended production and post-harvest management practices for existing crops grown under varying conditions, new varieties of existing crops, and new classes of crop	Collection of information from horticultural data base and from results of adaptive research trials	Horticulture in Horticulture Section, in association with Extension Sub-Division, Dzongkhag agricultural staff, and DCSD	Leaflets used by agents
	Preparation of texts of advisory leaflets		Effective message in leaflets successfully conveyed at workshops to farmers
	Preparation and running of workshops		

Contd.

Table 7.3: Contd.

Output	Activities	Responsibility	Success criteria
Integrated development plans for new varieties of crop and new classes of crop	Execution of production trials Conducting of marketing studies	Horticulture Section staff, consultants and FCB	Development plans successfully implemented
	Conducting of test marketing surveys Preparation of plans		
Advice to input supply agencies on horticultural crops	Quantitative and qualitative assessment of farmer's needs for planting material, fertilizers, plant protection chemicals, tools, equipment, and credit	Horticulture Section staff in collaboration with NASEPP, Procurement Officer of Department of Agriculture, AMC, Bhutan Development Finance Corporation, and Royal Monetary Authority	Growers able to make timely purchase of high quality inputs appropriate to their needs.
	Formal provision of advice through workshops, correspondence, and attendance at meetings Reviewing plans of the input supply agencies Informal provision of advice through day-to-day working relationships		
Advice to extension agents and farmers on product grading, presentation, and packaging	Observation and identification of farmers' practices and problems	Horticulture Section staff in collaboration with FCB.	Growers adopt practices and gain income benefits

Contd.

Table 7.3: Contd.

Output	Activities	Responsibility	Success criteria
	Assessment of market and customer requirements for horticultural crops		
	Drafting of specification for regulations		Bhutan's horticulture exports improve in reputation and increase in volume
	Preparation of texts for advisory leaflets		
	Preparation for and running of workshops		

8

Development of Horticulture in the Mountain Regions of Pakistan: Progress, Potential and Constraints

Zahur Alam

Introduction

In the mountain areas of Pakistan, there is a comparative advantage in growing horticultural crops. However, the present situation with its traditional patterns of production, harvesting, handling and marketing has to be fully developed to a stage where a higher volume of quality products can compete in large markets and for higher prices. The present horticultural system is low input, low output. Technology has to be developed that is most suited to small landowners and producers. Climatically, the mountain areas of Pakistan offer unlimited development opportunity for selected horticultural crops which have excellent cash potential. Critics of subsistence farming must acknowledge that mountain farming, even in remote areas, does have the cash potential necessary for the survival and sustainability of small farms, provided this potential is properly harnessed and the present-day subsistence farming based on cereal crops is transformed into commercial farming.

The mountain areas examined in this report cover the following administrative sub-divisions:

- The federally administered Northern areas comprising the districts of Gilgit, Baltistan, and Diamer;
- the Malakand and Hazara divisions of the North West Frontier Province (NWFP); Hazara Division consists of Kohistan, Mansehra, and Abbottabad districts and the Malakand Division includes the

district of Chitral and Swat and the provincially administered Malakand Agency.

- the Murree Hills *tehsil* of the Rawalpindi district of the Punjab province; and
- the province of Baluchistan, a major part of which is mountainous.

The next section of this report presents the climate and ecological zoning of the mountain areas of Pakistan. This is followed by separate sections on fruit crop cultivation, vegetable crops cultivation, and potato cultivation. The two remaining sections deal with marketing and processing of fruits and vegetables and with strategies and recommendations for future development.

Climate and Ecological Zoning of Pakistan's Mountain Areas

The Northern Areas

The climate varies in each valley according to altitude. Each valley has its own microclimate so that plants respond not to an average situation, but to the immediate, proximal prevailing conditions of an area. However, generally speaking, most parts of the Northern areas are arid, rugged mountain desert. As it is a rain shadow area, the annual rainfall varies between 100–200 mm. The climate at lower elevations has two extremes, cold in winter and hot in summer, becoming temperate (continental Mediterranean) at about 2000 m above sea level. Most precipitation occurs during winter, mostly in the form of snow.

Due to aridity, vegetation is absent and there is nothing to insulate the bare rock. Solar radiation is absorbed and converted into a long heat wave. At 37° N latitude, days are long in summer, with virtually no cloud cover and nights are correspondingly short, causing considerable discomfort to people. On the other hand, the same process is important at high altitudes (3000 m), where it enables more heat to be accumulated during a shorter growing season which hastens the maturing of crops.

TEMPERATURE

Figure 8.1 represents a summary of the monthly mean average daily temperature for selected places in the Northern areas located at different elevations. The most striking features are the great similarity of the pattern of seasonal change and the very large variation in temperature during winter, which is a typical feature of temperate mountains. Thus, one can grow a wide variety of crops by choosing the correct altitude and those months which correspond to the required temperature regime.

Besides sunshine, fruit needs cool nights for flavour and sweetness to develop. Cherries mature early before temperatures get too hot, but

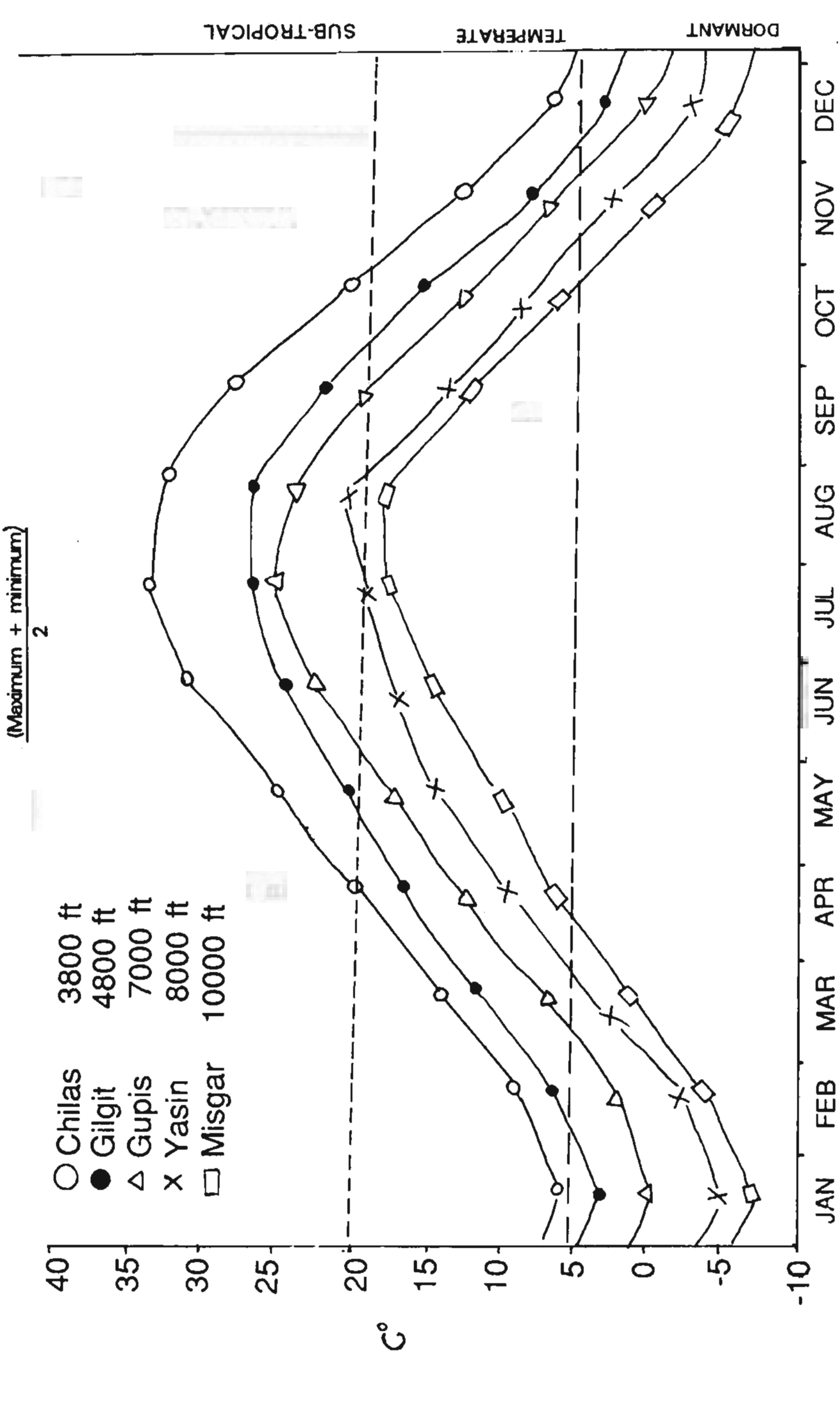


Figure 8.1: Monthly mean average daily temperature in the Northern areas of Pakistan

would not be an ideal crop below 1400 m. At these lower altitudes, almond would be excellent as its quality does not depend primarily on the sweetness or colour of succulent tissue.

RAINFALL

As a rain shadow area, the Northern areas receive the attenuated effect of both the summer monsoon and the winter westerly depression. The cut-off from the summer rains is almost complete, and only rarely does moist air penetrate to bring heavy rain that can cause considerable damage through torrents. In the high mountain mass areas, above 5000 m, there is much snowfall and the subsequent melting of this snow sustains human settlements in the area, which otherwise is a mountain desert.

Figure 8.2 represents a summary of monthly mean rainfall. The Northern areas being a rain shadow area, rainfall is 100–200 mm per year.

EFFECT OF ASPECT ON MATURITY

Shade is an important ecological factor, at the scale of topographical shade (it becomes a decisive factor preventing a second crop in marginal double-cropped areas), and within the field. Both the growing period and maturity of crops are modified by aspect, in addition to altitude and temperature. South-facing villages receive considerably more sunlight than north-facing villages. In north-facing fields, crops usually mature a week to 10 days later.

EFFECT OF RADIATION

Another important factor influencing habitats in mountainous areas is the radiation which affects photosynthetic potential, temperature, evaporation, and, therefore, water balance. The Northern areas have a high incident radiation level because of the rain shadow effect reducing cloud cover, especially in summer, when 70 per cent of the maximum possible sunshine hours occur.

The quality of radiation is intense at increasing altitudes, where the atmosphere is less dense with higher transmissivity and less water vapour and there is more ultraviolet radiation than at lower levels. Provided the temperature regime is suitable and with good crop management, very high yields of temperate crops can be obtained in the area. Apricots have the highest sugar content of any in the world and callus forms readily, facilitating propagation by cutting, budding, or grafting.

Mature trees when severely cut back readily sprout new shoots from epicormic buds. Shade has very little effect on field crops as the light

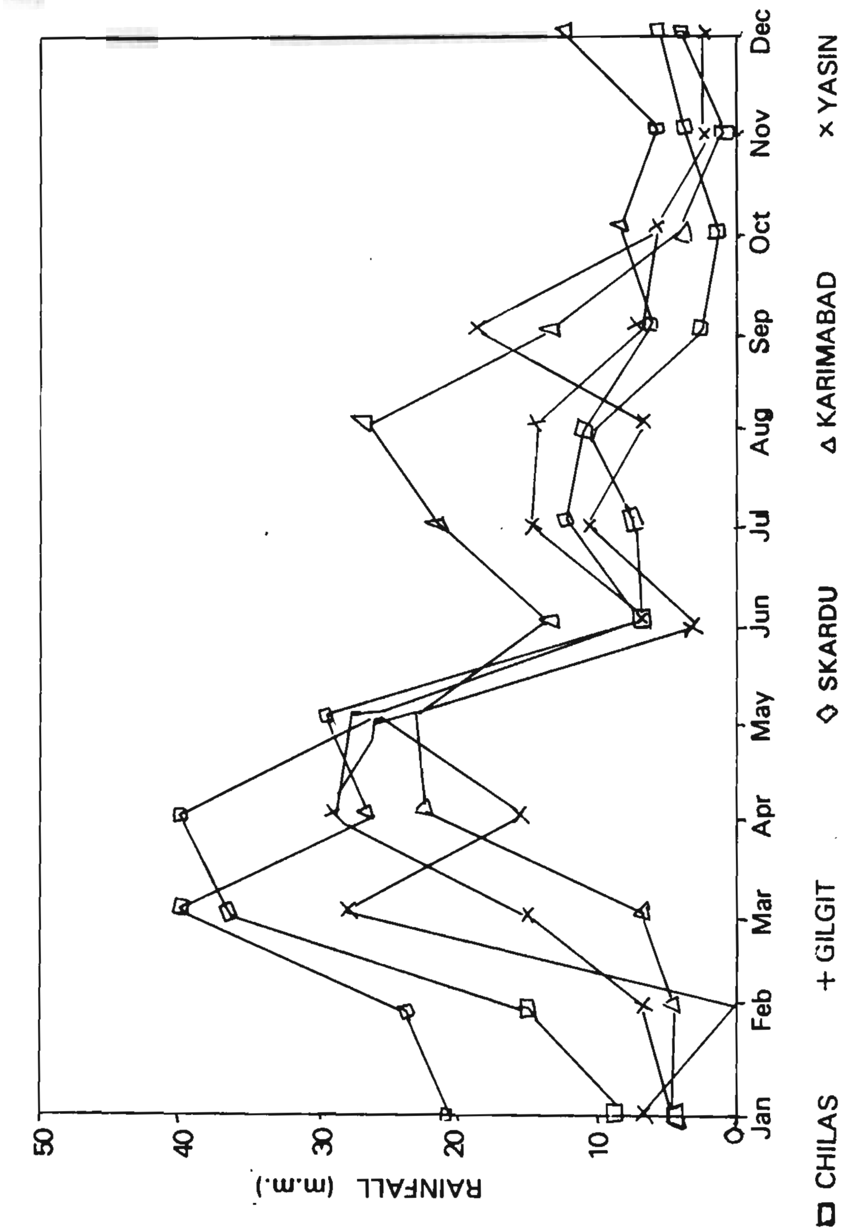


Figure 8.2: Mean monthly rainfall in the Northern regions of Pakistan

penetrates more deeply through tree canopies. Light intensity and radiation both affect some vegetable crops such as pepper, tomato, melon, and apple, causing severe sun-scald to exposed fruits.

Growing Period

In the Northern areas, the main limitation on the growing period is temperature, which is primarily a function of altitude. The growing period varies from 344 days at 1372 m to under 190 days in upper villages located at 3200 m. From the available climatic data, temperature profiles were produced for each 165 m interval, from 1372 to 3200 m height above sea level. These in turn were used to produce growing periods on the basis of the number of days estimated to be above 5° (Table 8.1).

TABLE 8.1

Growing periods for Gilgit District

Altitude		No. of growing days
ft	m	
4,500	1,372	344
5,000	1,524	331
5,500	1,676	314
6,000	1,829	303
6,500	1,981	277
7,000	2,134	264
7,500	2,286	254
8,000	2,438	241
8,500	2,591	232
9,000	2,743	222
9,500	2,896	210
10,000	3,048	199
10,500	3,200	187

Agro-Ecosystem Zoning

Since each valley has its own microclimate, agro-ecosystem zoning is considered to be extremely important for sustainable agricultural development in the Northern areas, providing: knowledge of natural resources that are available, their location, their potential role in development, and the limitations to their use; and information on the perspective breadth of applicability of proposed innovations and intervention.

In collaboration with the International Institute of Environmental Development, London, the zoning of Hunza valley was undertaken. Zones were drawn up primarily on the basis of the growing period, which is a function of temperature regime, altitude, and, to a lesser extent, aspect, radiation, and the predominant soil type and land form. Nine zones were established in Hunza valley. Similar zoning of other valleys is planned in the near future.

MALAKAND AND HAZARA DIVISION OF THE NWFP

In the district of Swat and Dir, November, December, January, and February are the coldest months in Swat and March is also cold in Dir, while June, July, and August are the hottest months with the maximum temperature not exceeding 40°C. Nights are comparatively cool. High seasonal temperatures allow the cultivation of most deciduous fruits and temperate types of vegetables.

Figure 8.3 provides annual rainfall figures for a range of areas. There is wide diversity in precipitation, but run-off from the higher rainfall zones ensures, in most instances, adequate water even in the rain shadow area. The valleys are narrow and the ratio of arable land to river flow is relatively small. In general, there is adequate irrigation water.

A feature of the monthly rainfall distribution is the double peak in early spring and the late summer. Obviously, the region is subject to monsoon rain when soil temperature is at its highest. Apples are, therefore, susceptible to crown rotting under such conditions. Also,extreme fluctuations in soil moisture levels during the growing season can favour the disease. The rainfall pattern leads to alternate periods of wet and dry. South of Mingora is basically too hot for apples at low altitudes, but suitable for plum, apricot, peach, and cherry cultivation with varieties that mature before the monsoon. This area is not suitable for vegetable seed production. Sooty mould is a problem for apples because of the heavy monsoon rain; besides, apples do not store well.

AGRO-ECOSYSTEM ZONING OF MALAKAND DIVISION

Given the different temperature and rainfall regions, Malakand Division has been divided into four distinct agro-ecological zone—Malakand Agency, Swat, Dir, and Chitral districts—for the purpose of possible fruit and vegetable production and innovative practices. Higher-altitude pastures and forests above the snow line have been left aside. The main agro-ecozones are:

Zone I: Hot and humid in summer, cold in winter, with frost occurring at night in December and January. Two crops are grown per year. This zone includes lower Swat, lower Dir, and lower Chitral districts and Malakand Agency, excluding Dargai.

Zone II: Warm and humid in summer with heavy frost and occasional light snow in certain areas during December and January. This zone is composed of middle Swat, Dir, and Chitral. Two crops are grown per year.

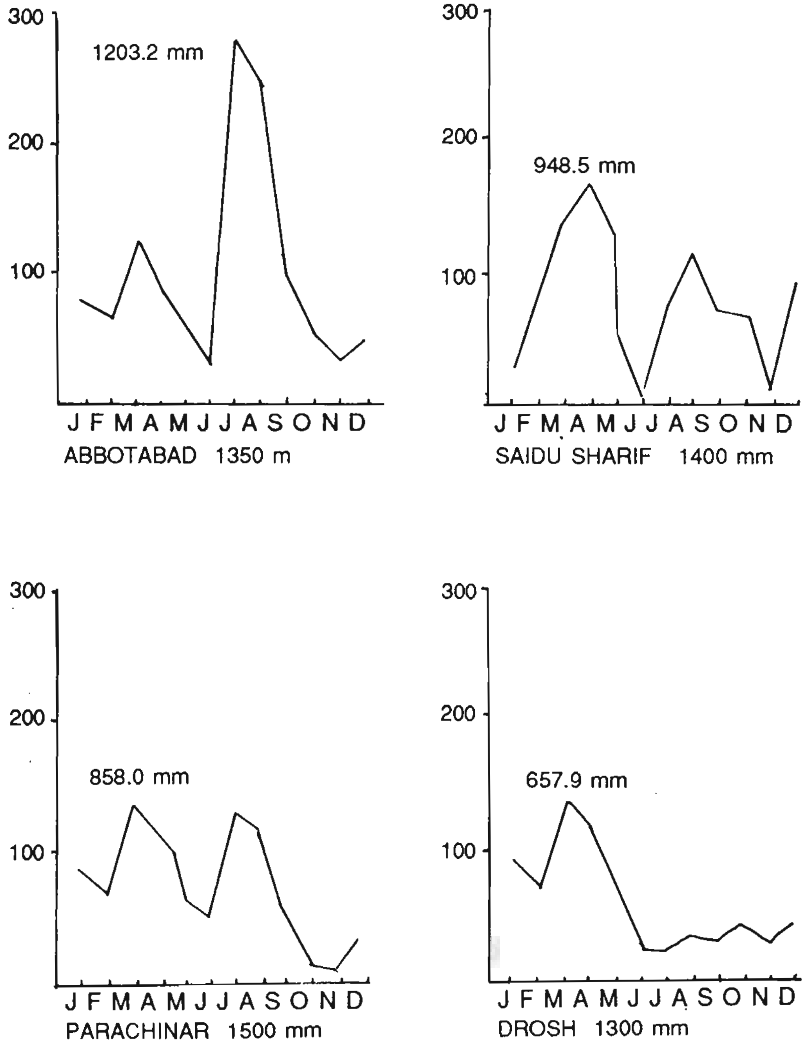


Figure 8.3: Mean monthly rainfall in Hazara and Malakand divisions of Pakistan

Zone III: High altitude areas with temperate climate where summers are comparatively mild and heavy snow falls during winter; only one crop is possible during the summer months after the snow melts. This zone includes upper Swat, upper Dir, and upper Chitral.

Zone IV: Lower part of Malakand Agency. This is a unique pocket where the winter is frost-free and the summer is hot and humid.

Cropping Patterns of the Zones and Their Potential

Zone I is a double-cropped zone where wheat and barley are planted in October and November, and harvested in May. Maize or rice crops follow. The following is the cropping pattern:

Wheat or Barley	—	Maize
Wheat or Barley	—	Rice

Among the fruit crops, some citrus and guava orchards exist. Vegetables are mainly grown for home consumption on small plots.

Buner area, where both irrigated and rainfed agriculture is in vogue, offers tremendous scope for fruit and vegetable development. Major food crops such as wheat, barley, and maize are grown along the natural water streams where water is readily available. Rice is also cultivated. The scarcity of water limits the cultivation of vegetable and fruit crops on a commercial basis. Tubewells are being sunk to harness ground water through a Dutch-assisted project. It should then be possible to develop horticultural crops commercially. The cost of sinking these tubewells can only be justified or recovered if high-value horticultural crops are grown on a large scale. These crops would require less water than field crops and a larger area could be brought under cultivation. In Buner, fruit production is not popular. However, great potential exists for late citrus and the blood-red variety of orange, early ripening plum, apricot, peach, and grape should adapt well to this area. Guava also has possibilities. In the cool season peas, carrot, cabbage, cauliflower, spinach, turnip, beet, and Brussels sprout could be cultivated and in the warm season cucurbits (pumpkin, melon, and other gourds). Beans, eggplant, and chilli could also be cultivated from March to August.

Zone II is also a double crop area and the cropping pattern is as follows:

Wheat, Barley, Onion — Maize, Rice, Tomato

Among the vegetable crops, tomato and onion are commercially grown in certain areas of Swat and Dir. In Chitral, olericulture is very poor. Only leafy vegetables such as spinach sonchal (*Malva* sp.) and Chinese spinach are grown. There is an acute shortage of vegetable when the Lowari Pass closes for November to the end of May.

Around Mingora and Saidu Sharif, other vegetables such as peas, cauliflower, spinach, radish, turnip, cucumber, okra, eggplant, and some beans are grown for the market. Cultivation of vegetables on rented land is also common. In these areas, a vegetable-based cropping system consists of companion and relay cropping. Small plants and quick-maturing crops are interplanted with slow-growing ones. The most intensive type of vegetable cultivation is practised on expensive land close to the cities.

Apple, plum, apricot, persimmon, and grape on a small-scale, as well as walnut and almond are grown.

Because of the favourable agroclimatic conditions, this area offers development of most types of fruits and vegetables. Among the vegetable crops, carrot, cabbage, and capsicum offer tremendous scope for development, but these are not grown at present. The climate is suitable for vegetable seed production of most crops.

Among fruits, cherries, which offer great potential, are not grown, but strawberry is cultivated in Mingora. This has great potential for further development when links with a processing industry are established. For fresh fruit supply to markets such as Islamabad and Peshawar, PIA may offer reduced air freight rates. New red types of pear not known in this area also have potential for local as well as distant markets.

In *Zone III*, only a single crop is possible during the summer, the cropping pattern being:

Maize, Wheat, Barley, Potato — Fallow, Potato

Vegetables are seldom grown, but apple, walnut, and some apricots are grown on the edges of crop fields.

These areas could take advantage of their production season to profitably market selected vegetables such as carrot, cabbage, peas, turnip, and radish at a time when there is a great dearth of these vegetables in areas of high consumption in the Punjab and NWFP plains and even in Sind. In the fruit category various kinds of berries appear to be suitable for commercial exploitation.

In *Zone IV*, winters are frost-free and farmers exploit this to the maximum extent by growing two crops of tomato. One crop is harvested in April-May and the second late crop in November, December, and January. During these months no other area produces tomato commercially. Tomato from Dargai is transported to most parts of Pakistan. The main cropping patterns are:

Wheat, Tomato — Maize, Tomato, Rice

Blood-red orange, guava, and plum are grown but there are relatively few regular orchards. Vegetables or fodder crops are intercropped in these orchards.

Frost-susceptible crops such as capsicum and eggplant, and off-season production of melon could be introduced and marketed from October to December in distant markets during lean periods of production in other areas.

However, the Northern areas of the NWFP are rapidly becoming the most important area for the production of various fruits and vegetables in the province. Heavy planting over the past 10 years is beginning to produce fruit which is increasing annually, and this is also true of certain vegetables such as tomato and onion.

Murree Hills in the Punjab Province

In the apple-growing areas (1500–2700 m) the average rainfall is between 875 and 1250 mm but, unfortunately, it is not evenly distributed. The bulk is received during the monsoon (July to September), while the early summer months (April to June) usually get little rainfall. Hailstorms are a great impediment to fruit and vegetable seed production. Hailing is more frequent in the months of March and April when it causes serious damage to blossom and newly set fruit and results in the wholesale laceration of foliage. To avert hail damage, the netting of apple orchards has been tried, but with very poor response from farmers because of its cost and cumbersomeness. Screening of late-blooming varieties and the use of growth regulators for delayed flowering would be obvious approaches to overcome this problem to some extent.

Baluchistan

TEMPERATURE AND RAINFALL

Baluchistan is the largest province in Pakistan. The temperature range is very great from the Kachi plain, where the maximum summer temperature reaches 50°C, with minimum night temperature around 30°C, to the high altitude areas of Kalat, Quetta, Ziarat, and Khan Mehterzai districts where the winter is very severe. Rainfall is the most erratic element here and the climate of the province is arid with an average annual precipitation of 375 mm.

ECOLOGICAL ZONES

On the basis of district characteristics of topography, climate, and soil, this province can be divided into five ecological zones.

1 *Plains*
2 *Lower valleys*: These two zones with elevation up to 600 m and rainfall below 150 mm annually are not suited to deciduous fruit tree cultivation.
3 *Medium valleys*: The elevation ranges from 600 to 1200 m above sea level and the rainfall varies annually from 200 to 350 mm. The summer is not very warm. Very little snowfall occurs in winter but severe frost is common. This zone includes Khuzdar, Panjgur, Zhob, Loralai, and Chaman, which are favourable to the growing of pomegranate, almond, grape, apricot, peach, and also dates and loquat.
4 *Higher valleys*: The elevation ranges from 1200 to 2000 m above seal level. This zone includes, Gulistan, Pishin, Killa Saifullah, Quetta Valley, Mustung, and Kalat. The climate is comparatively mild in summer,

up to 35°C, the winter is cold with snowfall and sub-zero temperatures. Annual rainfall ranges between 200 and 300 mm. This zone is favourable to the growing of deciduous fruits: grape, apple, apricot, pear, pistachio, pomegranate.

5 *High lands*: This zone includes Khan Mehterzai, Kawas, and Zindra in Ziarat Valley, as well as Toba Achakzai and Toba Kakri. Its elevation is more than 2000 m above sea level. The winters are very severe with heavy snowfall. Summers are relatively cool, the temperature seldom rising above 33°C. Because of the severity of the climate, only a few fruit trees are grown, mainly apples and cherries, but they produce fruit of good quality.

Fruit Crop Cultivation

Zonation of Fruit Species by Altitude Levels

In considering ways to improve the livelihood of small farmers in the mountain areas, policy makers commonly overlook the possibilities of fruit production. Although fruit trees produce well on the best land, they can also grow on land that is unused because it is steep, gravelly, low in fertility, or lacking adequate irrigation or water supply for cereal crops. Fruit trees in mountain areas are also well suited for mixing or intercropping with annual cereal crops, vegetables, or bulbous flowers which can be planted between widely spaced trees. Because of their extensive root system, trees control erosion and landslides, besides which, they are more stable than annual crops, producing despite rainfall fluctuations in some rainfed mountain areas. Typically, once established they require less intensive care. Consequently, a few fruit trees can provide a relatively steady income to small farmers, buffering them against fluctuations in income from annual crops, which are more sensitive to weather variations. With the construction of new highways, metalled and gravel link roads in mountain areas, and a readily available transport service, fruit production has great potential to develop into a major farming enterprise in these areas, namely Gilgit, Chitral, Baltistan, Hazara, Kohistan, Swat, Dir, Parachinar, north and south Waziristan, Murree Hills, and Azad Kashmir.

Fruits are a very rich source of carbohydrates, proteins, minerals, and vitamins, which are essential for human health and vigour. Pakistan is blessed with varied agroclimatic conditions that make it possible to grow all types of fruits. The seasonal temperature changes in conjunction with altitude are clues for the optimum location of fruits. The zoning of fruit crops at various altitudes is given in Table 8.2. In certain high rainfall mountain areas, the altitude may be the same as in arid and semiarid areas but it may not be possible to grow certain fruits such as pistachio,

TABLE 8.2

Zoning of deciduous fruit growing in the mountain areas of Pakistan

Altitude (m)	Fruit that can be grown profitably
1200	Almond, pomegranate, apricot, plum, persimmon, peach, grape, fig, pistachio, mulberry, strawberry, and other fruits
1500	Almond, pomegranate, apricot, plum, persimmon, peach, grape, fig, pistachio, cherry, pear, walnut, mulberry, and strawberry
1800	Almond, apple, apricot, plum, peach, grape, cherry, pear, walnut, mulberry, and strawberry
2100	Apricot, apple, peach, plum, pear, walnut, and strawberry
2400	Apricot, apple, pear, peach, and berry fruit
2700	Apricot, apple, berry fruits (gooseberry, currants, raspberry)
3000	Apricot, (early maturing cultivars only) and berry fruits (gooseberry, currants, raspberry)

almond, grape, cherry, or pomegranate. This aspect has to be taken into consideration when planting fruit crops.

The history of fruit culture in the mountain area is difficult to trace. However, it is presumed that the British who resided in these areas since the early part of the 19th century were instrumental in the introduction of apples and cherries, initially, and other deciduous fruits later, perhaps around 1915.

There are no regular fruit orchards in the mountain areas, except in Quetta, Kalat, Ziarat, and Swat valleys. In other places, only a few trees of each type are grown by individual households along terraced field boundaries to meet their own domestic needs. Surplus apricots, apples, and mulberries are dried for consumption in winter, as also apricot kernels and other fruit. Small surpluses are marketed in nearby areas by individual households.

Separate statistics of area and production of deciduous fruits for each mountain area are not available and in most places not even collected.

Area and Production of Fruits by Species and Location

Because of the varied agroclimatic conditions the production of almost all types of fruits is possible. Among the leading fruits produced in Pakistan is citrus, followed by mango, guava, dates and banana, all grown in the plains of Pakistan with tropical and sub-tropical climate. Area and production of deciduous fruits in Pakistan are given in Annex 1.

Punjab is by far the leading province, contributing 68.6 per cent of the national production, while Sind contributes 16.7 per cent, Baluchistan 9.11 per cent, and the NWFP 5.7 per cent.

Citrus, guava, mango, pomegranate, and dates are the main fruits of the Punjab; Sind contributes banana, mango, and dates; the NWFP contributes, pear, plum, apple, apricot, and persimmon. The province of Baluchistan contributes grape, almond, peach, apricot, apple, and dates.

Punjab's share in deciduous fruit is very meagre and Sind has almost none (Figure 8.4). In other mountain areas of Azad Kashmir, Gilgit, Diamer, and Baltistan, these fruits are grown, but their area and production are not reported.

Deciduous Fruit Growing Areas

About 97 per cent of the almond production comes from Baluchistan where the main production areas are the districts of Loralai and Zhob.

During the past 20 years, both the apple-growing areas and production have increased much more than for other deciduous fruits. Baluchistan is the leading province for apple production. The NWFP also has important production. Sizeable quantities are also produced in the Northern areas and in Azad Kashmir. In Baluchistan, the main production areas are Pishin, Ziarat, Quetta, and Kalat.

For apricot, 74 per cent of the growing area, giving 81 per cent of the production, is in Baluchistan. The other production areas in the NWFP are Peshawar and Malakand division. The Northern areas and Azad Kashmir also produce a sizeable amount. In Baluchistan, Loralai is the leading area, followed by Zhob, Pishin, Quetta, and then Kalat.

Approximately 98 per cent of grape is produced in Baluchistan province. The main districts of production are Pishin and Quetta.

The main growing areas for pomegranate are the Multan division of the Punjab, followed by Baluchistan.

Almost the entire production of cherry is from Baluchistan, mainly in the Ziarat valley. Some are produced in the Northern areas as well.

Peach is mainly produced in NWFP and Baluchistan and some in the Northern areas.

The major quantity of pear is produced in NWFP, some in Punjab, Baluchistan, Azad Kashmir, and Northern areas.

Plum is produced mainly in Peshawar district of NWFP with about 25 per cent from Baluchistan.

Pistachio is grown in a very small area of Baluchistan only.

Causes of Production Expansion

In Quetta and Kalat valleys of Baluchistan, the area under fruit has increased because of availability of electric power. Tubewells were sunk for irrigation water, which was an expensive operation as the rechargeable water-table is very low. Only horticultural crops could compensate for this expensive investment. New land has been created and is being created wherever electricity is available. Barren rocky land unsuit-

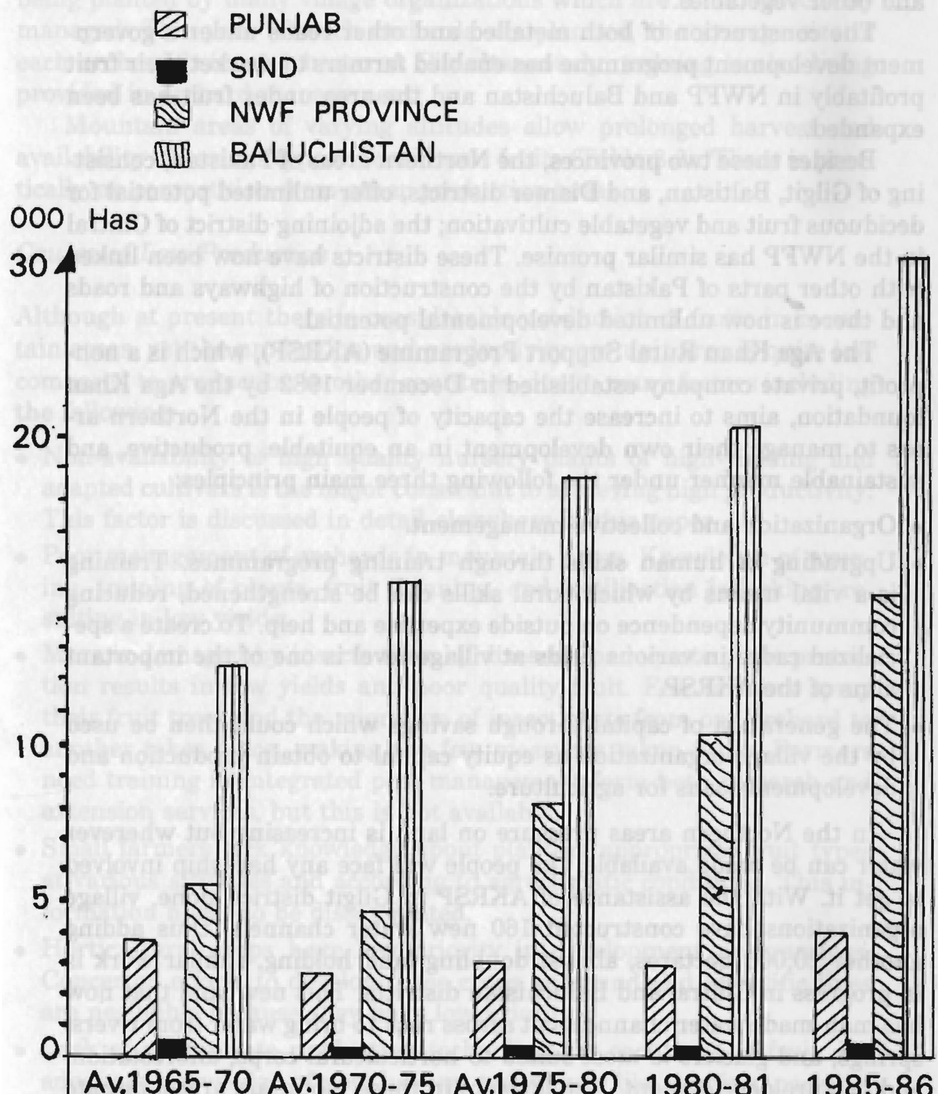


Figure 8.4: Deciduous fruit cultivation areas in Pakistan, 1965–1970 to 1985–1986

able for agriculture is being brought under horticultural crops wherever electric power and water are made available. Retention walls are being constructed, about 1 m high, which are then filled with river soil. Fruit orchards have been planted, which are intercropped with potato, onion, and other vegetables.

The construction of both metalled and other roads under a government development programme has enabled farmers to market their fruit profitably in NWFP and Baluchistan and the area under fruit has been expanded.

Besides these two provinces, the Northern areas of Pakistan, consisting of Gilgit, Baltistan, and Diamer districts, offer unlimited potential for deciduous fruit and vegetable cultivation; the adjoining district of Chitral in the NWFP has similar promise. These districts have now been linked with other parts of Pakistan by the construction of highways and roads and there is now unlimited developmental potential.

The Aga Khan Rural Support Programme (AKRSP), which is a non-profit, private company established in December 1982 by the Aga Khan foundation, aims to increase the capacity of people in the Northern areas to manage their own development in an equitable, productive, and sustainable manner under the following three main principles:

- Organization and collective management.
- Upgrading of human skills through training programmes. Training is a vital means by which rural skills can be strengthened, reducing community dependence on outside expertise and help. To create a specialized cadre in various fields at village level is one of the important aims of the AKRSP.
- The generation of capital through savings which could then be used by the village organization as equity capital to obtain production and development loans for agriculture.

In the Northern areas pressure on land is increasing but wherever water can be made available, the people will face any hardship involved to get it. With the assistance of AKRSP in Gilgit district alone, village organizations have constructed 160 new water channels, thus adding another 20,000 hectares, almost doubling land holding, similar work is in progress in Chitral and Baluchistan districts. This new land that now has man-made water channels cut across rock to bring water from rivers, springs, and glaciers is most suited to horticultural corps, afforestation, and pasture development. The farmers in these mountain areas, despite the arid nature of their terrain, are good farmers well versed in promoting fertility and conservation.

The AKRSP has also financed 131 link roads, the total length of these roads being 1210 km, enabling farmers to market their surplus produce. Similarly, 15 bridges have also been financed. These have been micro-projects but the government has under consideration macro-projects such as the construction of major roads, bridges, and hydel projects. There is great demand for fruit trees here. The AKRSP has supplied about 60,000 fruit trees in the last three years at cost. Mixed regular orchards are being planted by many village organizations which are to be collectively managed. This year 30 such orchards are planned, the average size of each orchard being 1.5 hectares. Simultaneously, training is also being provided in orchard management.

Mountain areas of varying altitudes allow prolonged harvest and availability of various types of deciduous fruits (Table 8.3). There is practically no competition from other production areas.

Causes of Low Production

Although at present there is considerable production of fruits in mountain areas, yet the production and productivity per unit area is quite low compared to production in other countries, due to many factors including the following:

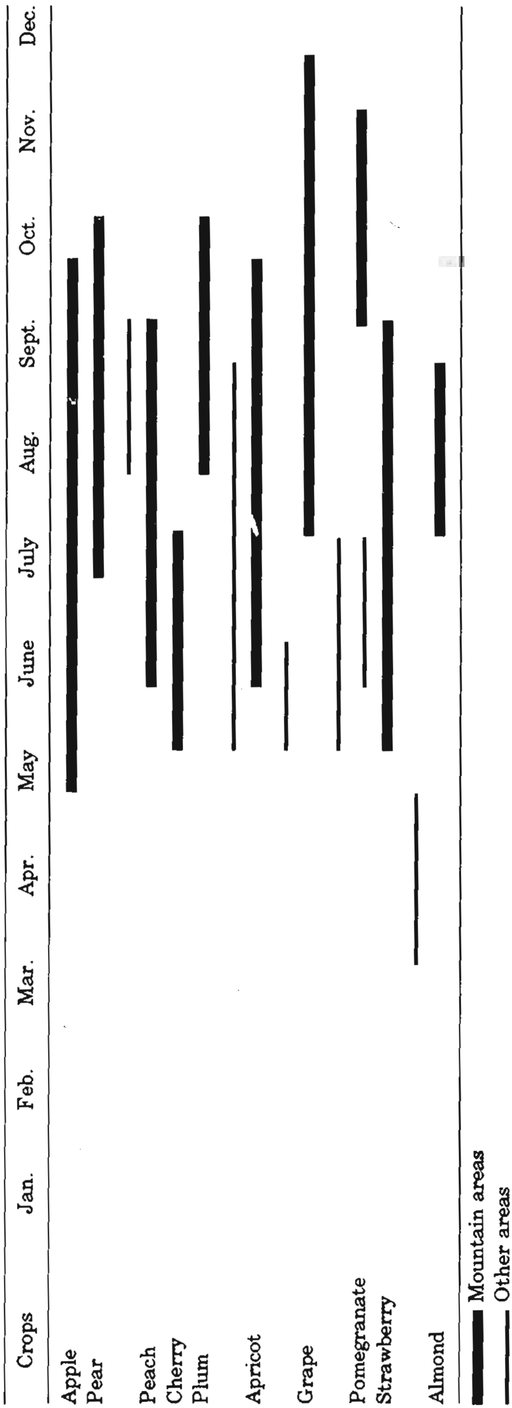
- Non-availability of high quality nursery plants of high-yielding and adapted cultivars is the major constraint to achieving high productivity. This factor is discussed in detail elsewhere in this paper.
- Poor management of orchards in mountain areas. Knowledge of pruning, training of plants, fruit thinning, and fertilization is lacking, resulting in low yields.
- More is damaged by insects than by disease. Inadequate plant protection results in low yields and poor quality fruit. Few farmers spray their fruit trees and the migration of insect pests from one orchard to another takes place, making the few measures taken futile. Farmers need training in integrated pest management form both research and extension services, but this is not available.
- Small farmers lack knowledge about planting appropriate fruit types at various altitudes and according to agroclimatic conditions. This information needs to be disseminated.
- Horticultural crops have low priority in development programmes. Concerted efforts to develop these crops on sound and scientific lines are negligible because they have low priority.
- Lack of appropriate production technology for each type of fruit. Inadequate knowledge of post-harvest techniques like grading, packing, storage, marketing, and transportation.
- Inadequately trained manpower at each point in the system.

Research of Fruit Crops

Each province has its own Agricultural Research Institute with research sub-stations in different agro-ecological locations for research into specific fruits. In addition to these provincial research institutes, there is

TABLE 8.3

Harvesting periods of major deciduous fruits in the mountains and other areas of Pakistan



the National Agricultural Research Centre at the federal level in Islamabad, which coordinates all provincial research and carries out basic research.

Some of the provincial research sub-stations have been upgraded to full-fledged research institutes. Through the concerted efforts of these institutes a large number of new varieties of different fruit species have been introduced successfully for large-scale cultivation.

Research into other aspects of fruit growing has also been carried out and recommendations made. These research endeavours included:

- Use of fertilizer and micro-nutrients
- Growth regulators
- Flood, drip, and sprinkler irrigation
- Integrated pest management
- Control of diseases
- Post-harvest physiology
- Evaluation of size controlling rootstocks
- Effect of pruning on yield
- Rootstock/scion compatibility studies, (Table 8.4 gives the stock-scion compatibility chart of some deciduous fruits.)

TABLE 8.4

Stock/scion compatibility of selected deciduous fruits in Pakistan

	Scion								
Stock	Apple	Cherry (sweet)	Cherry (sour)	Almond	Apricot	Peach	Plum	Pear	Quince
Apple	X								
Cherry (sweet)		X	X						
Cherry (sour)		X	X						
Almond				X		X			
Apricot					X	X			–
Peach				X	X	X			
Plum		X	X	X	X	–	X		
Pear						–		X	
Quince							–	–	X

Problems That Remain to Be Solved

- Mango malformation
- Screening of various rootstocks for salt tolerance
- Splitting of pomegranate
- Gumosis in stone fruit crops
- Alternate bearing in most fruit crops
- Stem borers in apple, shoot borer in peach
- Collar rot of apple
- Introduction and evaluation of new cultivars being continued

Excellent work in testing new rootstocks and varieties has been done and a number of suitable rootstocks and varieties with sequential maturity have been identified by various research institutes. These new rootstocks and varieties need dissemination through the development of fruit plant nurseries run on scientific lines.

Nursery Development and Management

The key element in expanding mountain area fruit production is the availability of good nursery stock at reasonable cost. Nurseries that produce quality trees are where a progressive fruit industry begins and, when nurseries are poorly run, then the industry often ends.

Comparison of tree crops with cereal crops will clarify why nursery stock is so critical. In the case of cereal crops which are grown in dense plantings, a few unproductive plants can be ignored. Fruit production, however, depends on fewer plants per unit of land, and a single unproductive or diseased plant can affect the farmer's income. Thus, the careful selection of individual trees is exceedingly important. Second, annual crops such as cereals occupy the land for only a season, while the fruit trees remain for many years. Therefore, fruit trees should be of the best possible quality if they are to provide a good cash return to the small farmer year after year. Third, fruit trees begin to bear some years after planting. A mistake made in producing or selecting nursery stock will reveal itself only after the farmer has spent time and money in growing the tree for several years.

Good quality fruit plants can be produced in nurseries if the right choice is made. The rootstock and the cultivar to propagate should be selected by a person experienced in fruit production and with knowledge of the area. Management of trees, grafting and budding techniques, and disease and pest control must be carefully discussed and implemented.

Nursery operations should ideally be supported by a properly staffed fruit research programme. Unfortunately, in most areas only poor quality nursery stock is available to fruit growers because of management failures in both government-operated and private nurseries. In areas such as Swat, Quetta, Kalat, Ziarat, and Hazara where there are private nurseries, there is little consciousness of quality. Standardized disease-free rootstock is not used. The supply from these nurseries is far lower than the demand. In all other mountain areas there are government department nurseries, but they run at about 25–30 per cent of their production capacity. Each canal (1/8th of an acre) should produce, after allowing for stoolbeds, green manure crops, and unbudded layers, 1000 trees per year for sale. This has not been the case because of lack of knowledge of intensive techniques. Therefore, the government and private nurseries, combined, cannot meet the ever-growing demand of farmers. The selection of proper rootstocks and more scion cultivars has to be considered. The scion is important because it is directly responsible for fruit production and quality. It is the carrier of genetic potential for high production and the chief determinant of quality.

PROBLEMS

Problems in fruit tree nurseries can be grouped into two categories: in efficiency that makes the operation of nurseries expensive and mistakes that affect the farmer. The responsible management of nurseries should prevent both kinds of problems.
The major causes of inefficiency are:

- Scarcity or lack of sources for the rootstocks most commonly used
- Lack of appropriate methods for soil disinfection
- Propagation techniques that are slow or that have low rates of success
- Poor weed and pest management
- Poor irrigation practices

The major problems in a nursery that penalize the farmer are:

- Poor selection of rootstock
- Poor selection of the scion
- Use of budwood and rootstock infected by virus disease. These viruses may not kill the tree, but they can drastically depress yields throughout its life. In areas where all the trees come from the same infected bud source, the low yield may escape notice simply because there are no healthy trees with which to make comparisons. When a farmer buys a tree from a nursery that has any of these problems, he is bound to lose money, waste labour, infect his land with new pathogens, and ultimately reject fruit trees as a way to increase income.
- Lack of progeny gardens in various agro-ecological zones to obtain healthy budwood

- No fruit plant nursery certification standards or control over private nurseries

Keeping all the aforementioned problems in view, it is the non-availability of quality, disease-free nursery plants at reasonable rates that has remained the most significant deterrent to the fast expansion of deciduous fruit culture in mountain areas. The small farmer has not been able to make his small holding a viable and sustainable economic unit.

The AKRSP after thorough analysis of the present fruit nursery situation in the three mountain districts, namely, Gilgit, Chitral, and Baltistan, and seeing that the villages in inaccessible areas at very high altitudes have no access to the few government nurseries, developed a package for fruit tree nursery development in selected villages in various agro-ecologies. This package has a very strong training component in all aspects of nursery management. Training is imparted to two or three women nominated by village orgaizations. These nursery specialists are paid through the sale of nursery plants. Nurseries are laid out under the guidance and supervision of AKRSP technical staff; stool beds are established, three budded mother plants of each variety of peach, pear, apple, cherry, etc. are established to obtain authentic budwood for budding and grafting. Similarly, the plants of each variety of recommended cultivars of grape and pomegranate are also established to obtain cuttings for further propagation. In 1988, seven nurseries in the villages were established. Each nursery has an area of 1/2 to 1 acre. The development of 30 nurseries is planned. These nurseries will not only meet the plant requirements of the villages, but will also generate substantial income through the sale of surplus plants to clusters of villages around it.

Recommendations

- Government departments should immediately establish deciduous fruit progeny gardens in various agro-ecological zones of all mountain areas.
- Adequate well-trained manpower should be developed exclusively in nursery management.
- Regular training courses should be held for private nursery men.
- Fruit nursery certification standards should be formed and implemented immediately.
- All nurseries should be made liable for inspection and certification.
- All private and government nurseries should get their plants certified before sale.
- It should be made mandatory for private nursery men to obtain certified rootstocks and budwoods from the progeny garden. All private nurseries should be licensed. The Pakistan Agricultural Research

Council could render an invaluable service to poor and disadvantaged small farmers of the Northern areas by establishing an excellent deciduous fruit plant nursery and progeny garden at its Juglote station. This nursery could also take advantage of the immense variety available in the local varieties of fruit grown from chance seedlings. These are of excellent quality and some of them are unique. They also need proper documentation and characterization.

Vegetable Crops

Vegetable production for consumption is of extreme importance from the economic and health point of view in the mountain areas. Vegetables constitute a group of foods that are essential to a well-balanced diet. They have the special advantage of being a cheap and easily available source of carbohydrates, proteins, minerals, and vitamins.

Vegetable growing is a highly specialized branch of horticulture, requiring special care and attention. Vegetable crops are normally delicate, fast growing and susceptible to pest, disease, and environmental stress. Vegetable culture, being generally intensive and having a short time from planting to harvest, is most suitable to increase the income of small farmers in the mountain areas.

Area of Production

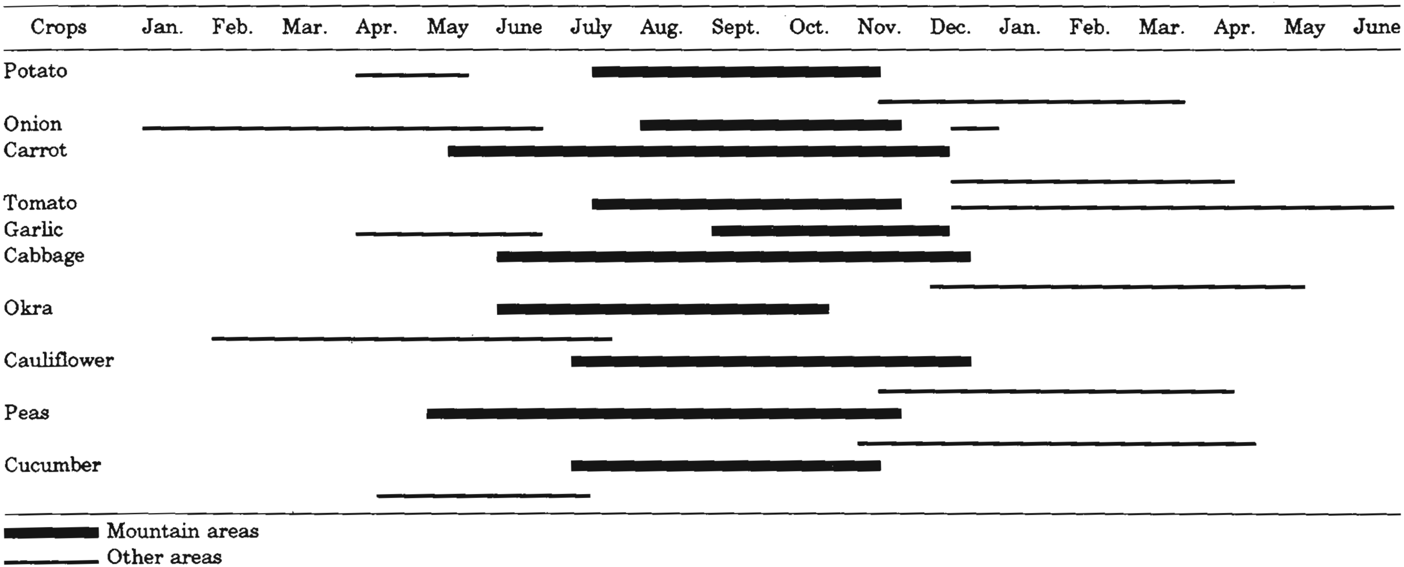
The area and production statistics of important vegetables from 1973/74 to 1985/86 are given in Annexes 3 and 4. Except for potato and onion, areas and production have remained almost static. Similarly, average yields per hectare from year to year have also remained static and low, being only 12 mt/hectare.

Unfortunately, separate area and production statistics for the mountain areas are not available. Small holdings, availability of irrigation water, link roads, and good markets in consumption areas offer great scope for expanded vegetable cultivation in mountain areas. Vegetables are grown mostly for home consumption in small patches or intercropped with other crops at present, but area like Quetta, Hazara hills, and Swat are being exploited to a limited extent.

Mountain areas have the advantage of seasonality of production. All types of vegetables can be produced during the summer season, both subtropical and temperate, when they cannot be grown in the plains. During this season prices are high and vegetables are marketed advantageously on a small scale. They do not have any competition during this season from other areas of production (Table 8.5).

TABLE 8.5

Harvesting periods of and major vegetables in mountain and other areas of Pakistan



Causes for Production Expansion

Vegetable farmers have been successful in highly intensive farming systems adapted to heavy population pressure and expensive land around cities and towns. Traditionally, they have been practising inter-cropping, mixed cropping, relay cropping, and sole cropping. There is no set pattern and crop combinations are too numerous to list. Vegetables are also inter-cropped in young fruit orchards. It is difficult to improve or to suggest what cropping pattern should be adopted.

The AKRSP, aware of the potential existing in Chitral, Baltistan, and Gilgit, has developed a production package for women, along with a strong training programme backed up by ample supply or quality seeds at cost. An integrated production package for vegetables, poultry, fish and fruit culture has also been developed to recycle waste and provide these essential commodities to local hotels to cater for the need of an ever increasing influx of tourists, both Pakistani and foreign. This type of production package gives about 8 to 10 times more income than merely growing wheat and maize on small land holdings can. For this production package, the AKRSP has also tested a number of vegetable cultivars in order to recommend suitable varieties to farmers in mountain areas. These high-yielding cultivars, suited to all agro-ecological conditions found in mountain areas from 1000 to 3000 m above sea level, are given in Table 8.6.

TABLE 8.6

Suitable vegetable varieties for mountain areas

Crop	Name of cultivar
Carrot	Nantes (first preference), Chanteney (second preference)
Cabbage	Golden acre (for early crop), Drum head (for late crop)
Cauliflower	Snow ball, Snow drift
Peas	Arkel, Green drift
Lettuce	Great lake
Beans	Contender
Tomato	Maglobe (first preference), Roma (second preference)
Okra	Perkinson spineless
Turnip	Purple top, Golden ball (for very high altitude)
Onion	Texas sweet grano, Shangshu
Radish	All season, Minnow
Pepper	Yellow wonder, California wonder
Table beet	Betroit dark red.
Chinese cabbage	Granat, Michihili
Squash	Petra, Caserta, Grey zucchini

Causes of Low Production

- Non-availability of quality seed
- Low plant population due to poor seed
- Considerable damage by insect pest and disease
- Inadequate use of fertilizer because farmers are not convinced of its efficacy
- Low priority in national development programmes
- Lack of a solid technical base and acute shortage of scientific manpower

There are other factors which have an indirect effect on production:

- Enormous post-harvest losses.
- Market gluts and low prices during peak production seasons.
- Lack of adequate cold storage facilities, poor market availability, and no stabilization of prices.
- There is no sound marketing and export policy. No market analysis is made of prospective importing countries for the preparation of a sound export programme. Thus, incentive for farmers to boost their productivity level and overall production is lacking.
- Processed and canned vegetables, being expensive, have limited demand within the country resulting in low in-take of surplus vegetables during the peak production season by the processing industry.

Vegetable Seed Situation and Prospects

In arid hill areas like Quetta, Gilgit, Baltistan, and Chitral, rainfall offers tremendous scope for the production of vegetable seeds of almost all types of vegetables, but more so the temperate type of vegetable, such as cabbage, Chinese cabbage, cauliflower, beetroot, carrot (European types), Swiss chard, and broccoli.

Vegetable seed production along scientific lines has remained a neglected field and non-availability of indigenously produced quality seed of high-yielding cultivars at reasonable cost is the major constraint restricting high productivity and the overall production of vegetables in the country. Seed quality is a vital factor for any crop improvement programme and to boost national production. All other inputs like fertilizer, water, pesticides, and labour applied to increase production cannot compensate for poor germplasm. Due to the poor quality of indigenous seed, plant population is low, resulting in reduced yields, specifically in directly seeded crops. It is, therefore, very important that farmers get pure and healthy seed of adaptive and recommended cultivars.

The Present Situation

At present there is no organized commercial vegetable seed production. In price it ranks very low compared to other inputs. However, non-availability of quality seed of higher-yielding cultivars is the major constraint restricting higher production.

Some farmers save their own seed, but a majority purchase it from the local market. The quality of this seed is unknown and farmers usually save their own seed for vegetables where this is feasible, as with eggplant, okra, tomato, beans, peas, chilli, carrot (local), and various types of cucurbit. Seeds of cabbage, Chinese cabbage, lettuce, cauliflower, onion, table beet, turnip, radish, carrot (European type), and broccoli are invariably purchased from commercial seed merchants every year. At present in the absence of a vegetable seed industry, the seeds of some economically important vegetables are multiplied on a very limited scale at various provincial research institutes by breeders who are simultaneously involved in research, seed production, and multiplication programmes. As a matter of policy, they should not be producing or multiplying seed for commercial sale, except the production of pre-basic or breeder's seed. They are not equipped to handle large amounts of seeds due to limitations of time and personnel and other infrastructure needed for seed production.

The present unsatisfactory seed situation has compelled the government to adopt a liberal policy for the import of vegetable seeds from India, Japan, the Netherlands, Denmark, the United States, and other countries, involving a substantial amount of precious foreign exchange. Seed worth millions of rupees has been imported from year to year, as shown in Table 8.7.

TABLE 8.7

Value and quantity of imported vegetable seeds

Year	Value of imported seed (millions Rs.)	Quantity (tons)
1983/84	20.4	885.8
1984/85	22.8	741.1
1985/86	37.5	1249.7
1986/87	61.2	2136.7

Seed merchants are free to import seeds of any type and of any cultivar, even though that cultivar may not have been tested and recommended for Pakistan. This is not a healthy situation and needs rectification immediately. Farmers are left with no other choice than to plant unadapted and untested cultivars, resulting in variable yields. The total vegetable seed requirement is about 2312 tons (Table 8.8), for a total area

TABLE 8.8

Seed requirements for various vegetable crops

Vegetable	Area (ha)	Seed rates (kg/ha)	Annual requirement (kg)
Kharif			
Melon	29,110	3.5	101,885
Squash	4,158	5.0	20,790
Gourd	2,890	5.0	14,450
B. gourd	2,228	9.0	20,052
Pumpkin	1,690	3.0	5,070
Okra	2,753	25.0	181,325
Brinjal	5,123	0.6	3,074
Tomato	5,026	0.6	3,016
Miscellaneous	20,158	6.1	122,393
Total			472,625
Rabi			
Turnip	8,355	4.0	33,420
Radish	3,941	10.0	39,410
Cauliflower	5,927	1.5	8,890
Cabbage	2,396	1.5	3,594
Carrot	6,374	20.0	127,480
Tomato	9,146	0.6	5,487
Pea	6,407	60.0	384,420
Spinach	4,498	25.0	112,450
Miscellaneous	18,700	15.2	284,240
Total			999,392
			1,472,017
Condiments			
Onion	48,200	10.0	482,000
Pepper	67,000	3.5	234,500
Coriander	6,200	20.0	124,000
Total			840,500
GRAND TOTAL			2,312,517

of 282,900 hectares under vegetable in Pakistan. No separate statistics are available for mountain areas.

So far, there have been no concerted efforts to alleviate the present problems of vegetable seed production, especially that of temperate (cool season) vegetables, which was a very rewarding business in the distant past in the hilly areas of Baluchistan, for example, Quetta. Baluchistan used to supply seed to south Asian countries, the Middle East, and some

African countries. During World War II, seed was also supplied to some European countries. However, with the passage of time and particularly after the creation of Pakistan, this industry died down due to lack of proper management and support from the government. To revive this industry the Government of Baluchistan initiated a pilot project with the help of the World Bank. A small seed processing plant with cleaning, grading, and packing units was established in 1976 at Quetta.

Vegetable Seed Production Prospects

The agroclimatic conditions in mountain areas offer unlimited scope for vegetable seed production of sub-tropical and especially temperate vegetables. The seed crop occupies the land for a considerably longer period than vegetables grown for marketing. Hence, it must fit into the traditional cropping pattern initially. Factors favouring seed production are:

- Low rainfall throughout the growing season and especially towards seed maturity.
- Warm days and cool nights during summer conducive to extensive flowering and formation of seed.
- Long cold winter fulfills requirement of temperate vegetables for bolting.
- Low natural incidence of disease and few insect pests.
- Great variation of climate at short distances due to range of altitude and temperature.
- No competition from other cash crops.
- Vegetable seeds are a high-value and low-volume commodity, easily grown in distant villages at any location, even those only connected by gravel or dirt roads.

Constraints to Vegetable Seed Production in Mountain Areas

The following are the major constraints to the development of a sound seed industry:

- Free grazing of animals in the fall and winter
- Very limited knowledge of crop and seed yield of various crops and cultivars (Annex 8)
- Low priority in national programmes
- Inadequate trained manpower
- Lack of knowledge of appropriate production technology
- High risk in investments
- Lack of marketing know-how vis-a-vis liberal government import policy

- Lack of proper processing, packaging, and storage facilities
- Conservative approach; traditionally vegetables are grown by women and presumably seed also produced by them.

Recommendations

Ways should be found to curtail free grazing. Problems associated with free grazing, such as winter feed shortage, should be solved through the introduction of cash crops such as vetch, rye, and turnips. The AKRSP has demonstrated this effectively.

Due to small land holdings, farmers cannot compete in seed production of some vegetables such as peas, cucurbits, okra, and radish, as these can be more economically produced in the plains than in mountain areas. Therefore, temperate-type crops (cabbage, cauliflower, pepper, onion, Swiss chard, beetroot, and carrot) should receive priority as their seed cannot be produced in the plains.

Vegetable seed production is a highly technical and specialized job for which a proper training programme for scientists as well as farmers should be drawn up. This is a prerequisite for seed production. Village level specialists, both men and women, need to be trained. It would be premature to initiate a vegetable seed production programme immediately; it may become a reality after five or six years. First, farmers have to become skilled in fresh vegetable production technology for marketing, backed up by a strong adaptive research and demonstration programme.

Seed potential for each crop and cultivar should be thoroughly investigated.

More studies are needed on disease and insect pests for each crop.

In a seed production programme the emphasis should be on quality and not quantity, because the seed has to compete with imported high quality seed which has already established its credibility with vegetable growers.

Any seed production programme should have a strong marketing component. Local seed requirements will remain small; therefore, national requirements need to be studied thoroughly.

The present liberal vegetable seed import policy of the government should be taken into account before initiating any programme.

Government departments and agencies should not become physically involved in the actual production and sale of commercial seed, but should organize seed growers' associations, or encourage private companies to take up this venture. Quality control and certification should remain with the government.

Village organizations should be used for any seed production or development programme and the services of the plant protection specialists trained by the AKRSP in each village should be effectively used at least in the Northern Areas (Gilgit, Chitral, and Baltistan districts).

Seed laws should be strictly enforced so that farmers gain confidence in locally produced seed.

Seed imports should be curtailed gradually to provide a much needed incentive for the development of a local vegetable seed industry.

Congenial climate conditions, isolated valleys, small farmers, and market demand provide an excellent opportunity to harness this potential for vegetable seed production at various elevations.

Research on Vegetable Crops

Vegetable crop research is the responsibility of the four provincial research institutes: located at Faisalabad (previously known as Lyallpur), in the Punjab, at Tarnab, Peshawar, in the NWFP; at Mirpur Khas, in Sind; and at Sariab, Quetta, in Baluchistan. Research includes the introduction and evaluation of cultivars and agronomic and crop protection trials. Universities and colleges are involved in some research, but these institutes work in isolation and have no coordination among themselves, resulting in duplication of work. In the past the meagre resources and the efforts of the few scientists available were being wasted. However, they have been able to identify high-yielding varieties of many crops.

Cooperative Vegetable Research Programme

In 1981, the Pakistan Agricultural Research Council, with its headquarters at Islamabad, taking cogizance of its situation, formulated a cooperative research programme on vegetable crops at the national level, and is also engaged in basic research at the National Agricultural Research Centre at Islamabad. This vegetable cooperative research programme now provides the necessary coordination among the provincial research institutes, as well as additional funds to strengthen their research capability. The overall objectives of the programme are to:

- Coordinate and integrate research activities to avoid wasteful duplication of research.
- Conduct uniform national cultivar trials of economically important vegetable crops.
- Introduce and evaluate germplasm to promote intensive breeding programmes to evolve desirable cultivars of peas, tomato, carrot, cucumber, okra, onion, melons, carrot, and other vegetables.
- Develop a package of production technology for each crop for different ecologies.

- Develop cropping (multiple, inter, and relay) systems to increase crop intensity and production.
- Develop a package of production technology for rainfed areas for various crops such as peas, radish, turnip, table beet, cucumber, and water melon.
- Develop appropriate low-cost technology such as solar drying.
- Develop or introduce low-cost farm tools and equipment which can be gainfully used on small holdings for intensive cultivation (in collaboration with the Agricultural Research Centre, Islamabad).
- Evolve suitable seed production technology.
- Study plant growth regulators to increase production.
- Study micro-nutrient requirements.
- Develop systems for year-round production of vegetables of economic importance under cover.
- Develop integrated pest control methods.
- Develop linkages with international research centres and agencies.
- Train scientific manpower, short-term as well as long-term.

The specific plan of work of the programme is:

- Screening of tomato material for heat tolerance, resistance to early blight, and bacterial wilt.
- Cross combination studies.
- Screening of exotic pea germplasm for powdery mildew and root-rot resistance. Hybridizing resistant material with local cultivars to evolve resistant cultivars.
- Screening of exotic cultivars for large root size, high yield, and late maturity.
- Collection of local and exotic germplasm of melon and screening for resistance to powdery and downy mildew.
- Uniform national cultivar trials on economically important vegetables such as peas, carrot, melon, water melon, onion, okra, cabbage, cauliflower, and beans.
- Screening of local and exotic germplasm of chilli for virus resistance and using resistant materials to breed high-yielding resistant cultivars.
- Screening of cabbage cultivars resistant to head cracking and head rot.
- Efficacy trials with various fungicides, insecticides, and herbicides to control disease, insects, and weeds respectively.
- Evaluation of low-cost seedling transplanter, garlic transplanter, seeders, fertilizer applicator, and diggers.
- Studies on pre-basic and basic seed production of promising material.

- Varietal testing in collaboration with Royal Sluis and Sluis and Groot, a Dutch vegetable seed company, in order to develop commercial seed production as a joint venture.

Achievements under the national cooperative research programme are listed below:

- Six lines of tomato tolerant to heat out of AVRDC material with fruiting ability have been identified at the National Agricultural Research Centre, Islamabad. Two of these lines have also performed well at Faisalabad and given double the yield of commercial cultivars.
- One line of cucumber resistant to powdery mildew with tremendous fruiting ability has been isolated.
- One late-maturing line of okra, red in colour, has been identified which is repellent to pod borers.
- One melon line has been isolated with excellent fruiting ability, having the characteristic of being able to ripen on the shelf without desiccation, with uniform fruit development and maturity.
- A couple of carrot cultivars have been identified which are late in maturity, with large root of good shape and colour.
- Four cabbage cultivars resistant to head cracking and rot have been screened.
- Two lettuce cultivars which form excellent, compact, large heads have been identified.

All the above material will be tested on a large scale in the field.

Marketing and Processing of Fruits and Vegetables

Main Marketing Channels

A majority of fruit and vegetable farmers have small holdings and usually grow more than one type of fruit and vegetable simultaneously. Fluctuations in prices and supply are typical patterns from year to year in the marketing of fresh fruits and vegetables because of very high prices during certain periods of the year when production is limited and very low prices at peak harvest time when there is a glut in the market.

The marketing of fruits and vegetables is a complex and complicated process in Pakistan. There are three different types of markets and many different people are involved in moving produce to and through these markets. The various market types include small rural markets, primary markets at the sub-divisional level, and wholesale markets at the district level. The three different marketing channels are: large-scale buyers for processing plants and some public sector institutions; regulated agricultural markets; and unregulated or weekly regulated private markets. Export marketing is covered in the next section.

Of the three types of domestic markets, small rural markets are the most numerous. They are located alongside roads leading to the larger towns and cities. They may have some improvised shops with temporary godowns and weighing scales. Transactions take place through private negotiations, with small farmers generally accepting whatever price is offered for their produce.

Primary and wholesale markets at the sub-divisional and district level are the most important places for fruit and vegetable marketing. Commission agents play a dominant role in these markets. Storage space in these markets is generally limited and usually confined to an area behind or in front of the commission agent's shop. In a few of the larger markets, cold storage facilities are available.

Current estimates are that Pakistan has about 650 markets, of which 200 are regulated under some sort of agricultural produce act. The Punjab accounts for 120 of these regulated markets and Sind another 87. Regulated markets are covered by the Agricultural Markets Ordinance of 1978 in the Punjab and by the Agricultural Produce Market Act Amendment Ordinance of 1980 in Sind. Regulated markets have a controlled schedule of fees and charges. They are under the control of market committees, elected bodies of growers and traders.

The three different marketing channels interact by supplying each other at different times, yet procedurally and organizationally they are distinct. Some large-scale buyers purchase for the needs of processors or public institutions. The government-owned Agricultural Marketing and Storage Limited, for example, has a mandate to intervene in the market when prices are considered to have fallen below the cost of production.

The commission agent, or arthi, is the kingpin in the regulated market. The arthi may advance loans to farmers who repay the principal and market their produce through him. The arthi's principal function is to auction produce on behalf of his farmer clients, or act as middleman between the farmer and the wholesale market. The buyer at the auction pays a fee to the market committee on each sale; the amount of the fee depends upon the type of produce bought and the extent to which the weight and value of the transaction is accurately reported. Commission fees range from 3 to 10 per cent depending on the product, the time of year, and other factors, such as the debt status of the farmer client. The arthi has a fixed place of business in the fruit and vegetable market from which he conducts auctions, packs and repacks produce, and maintains an office with bed, telephone, and safe. A market association of all arthis, anjuman arthi, serves as the medium for settling disputes and handling minor problems with government authorities.

Middlemen, or beoparis, are linked closely to arthis. There are two types of beopari: those who live and work in villages around a market and those who trade between markets. The village beopari bulk buys produce and arranges shipment to market. Normally, a beopari will attach himself to an arthi and sell his goods through him. In this arrangement, the arthi supplies working capital loans.

The market beopari works as a middleman between markets and between processors and markets. These middlemen also play an important role in the unregulated market. Sometimes a beopari will purchase directly from farmers and advance credit to pushcart operators who rent a cart, buy a lot of fruit, and sell it throughout the day. The push-cart operator repays the beopari the next day and the process begins again.

The largest amount of unregulated marketing occurs outside the towns at crossroads dividing village roads from trunk roads. There, beoparis set up shops where they buy produce from farmers and sell directly to government procurement centres or to processing plants. Since no market fee or sale commission is paid, growers frequently receive a higher unit price for their goods here than they would at the regulated market.

The marketing system for fruits and vegetables is similar, with only minor variations. Pre-harvest contractors, who buy entire orchards, are prevalent in fruit marketing. Similar intermediaries are not common in vegetable marketing. Secondly, cold storage appears to play a more important role in vegetable marketing. Figures 8.5 and 8.6 present the typical fruit and vegetable marketing systems in Pakistan.

Marketing Arrangements in Mountain Areas

However, in mountain areas where there is scattered production in distant valleys and where marketable surpluses are small, it becomes impossible for small farmers to market their low surplus volume individually and profitably. In these areas small farmers also lack market information and cash flow. The quality of available fruit and vegetables is highly variable. These are critical constraints that must be overcome.

Group operation in marketing can be a means by which poor mountain communities can be offered security and the opportunity to market their surplus crops at a fair price.

Marketing Promotion by Aga Khan Rural Support Programme

The AKRSP is fostering and supporting village organizations with the long-term aim that these cohesive socioeconomic groups will identify, implement, and manage on a continuous basis all the development activities pertaining to a village by optimal use of the resources available

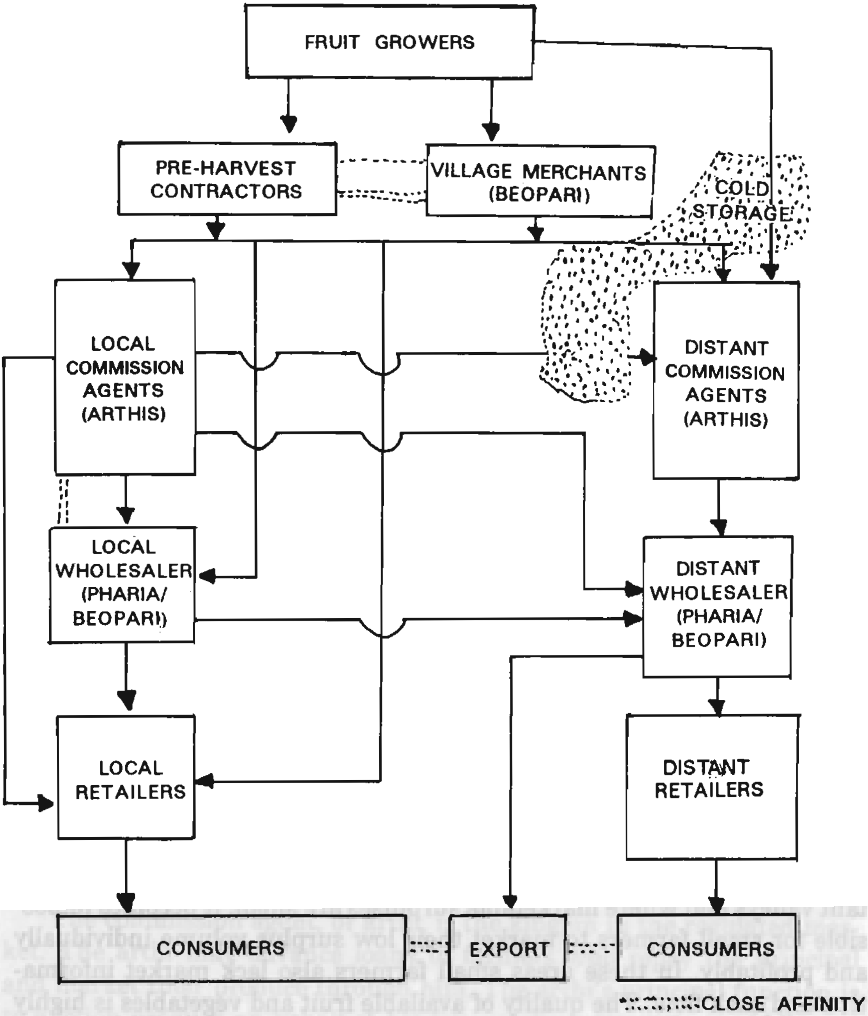


Figure 8.5: Generalized flow chart of fruit marketing in Pakistan

within and outside that village. In pursuit of these objectives, one of the major tasks ahead of a village organization is the establishment of vertically integrated marketing institutions. Such a system could be built on the cooperative collection of produce at the village level, and its subsequent marketing along the same principle.

The communication network in mountain areas such as Gilgit, Chitral, Baltistan, Dir, Parachinar, and similar valleys is extremely poor. The problem of transportation of produce is further compounded by the absence of proper harvesting of picking, grading, and packing skills among

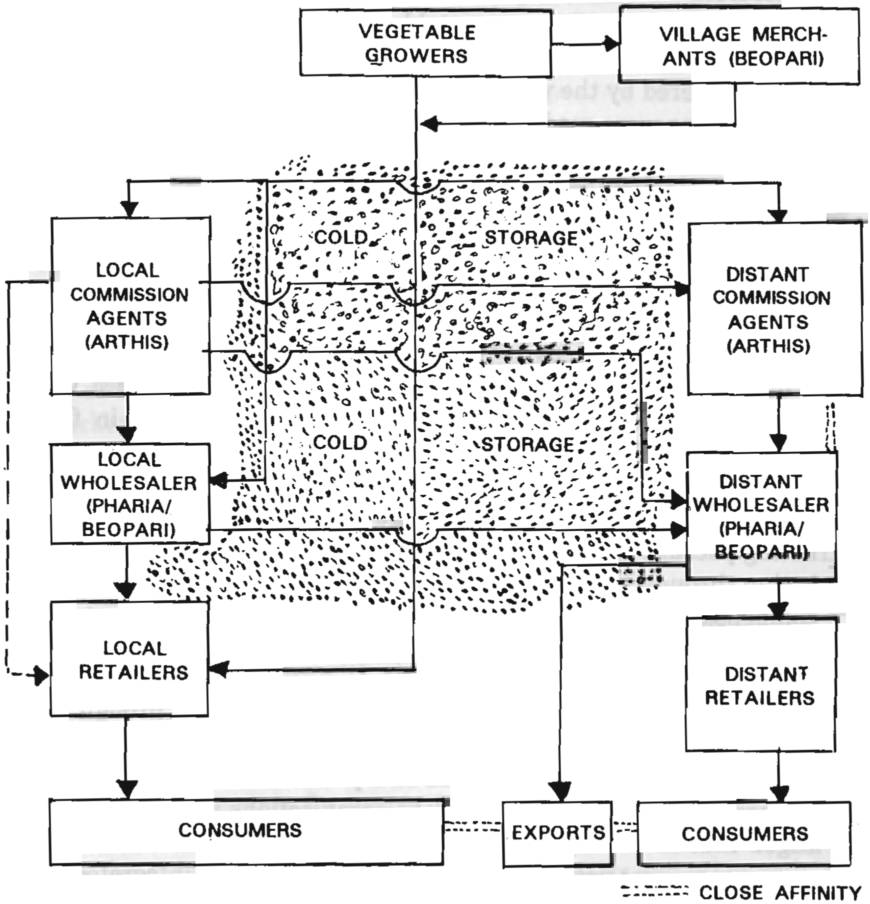


Figure 8.6: Generalized flow chart of vegetable marketing in Pakistan

the villagers and the non-availability of suitable and desirable packing material. The local markets in Gilgit, Chitral, and Skardu have been found to be relatively small, while distant urban markets are already being supplied by producers through well-established channels of communication.

Consequently, the basic marketing strategy that evolved responded to meeting these challenges. Training programmes were formulated to expose specialists from village organizations to bigger markets and to familiarize them with the actual mechanism that keeps these markets supplied.

Picking, grading, and packing techniques were demonstrated to the organizations to enable them to break into competitive markets. The processing of fresh fruit was taught to villagers so that they could transform produce into a more easily transportable commodity. Sulphuring and dehydration techniques were also demonstrated to improve the quality of the product offered by the village organizations. Interest-free, short-term production loans were made available to them to overcome their lack of ready cash. Meanwhile, the increased productivity package, which incorporated the successful prevention of losses in crops, was beginning to expand farm production. The productive physical infrastructure package (construction of link roads, irrigation water channels, bridges, etc) also made additional water and new land available. These programmes have increased the scope for commercial and industrial development.

The increased productivity package calls for greater vigour in identifying, developing, and marketing related items with the greatest value-added potential for a majority of farmers. Special attention in future must also be given to products that take advantage of seasonality and/or novelty value.

With continuous progress, the village organizations are adopting the marketing package with enthusiasm. They have undertaken cooperative marketing through their trained marketing specialists and their services are compensated through a commission or by an agreed amount as remuneration, in addition to transportation charges.

The marketing package being offered by AKRSP in the project areas is in different stages of diffusion and refinement. Through these endeavors, village organizations have clearly demonstrated their capacity to carry out commercial transactions in a profitable manner.

Regarding the future role of village organizations in marketing, it is envisaged that ultimately marketing collectives will federate into a central cooperative association and operate together as an integrated unit. The role of the central cooperative association would be to collect market information, plan marketing operations on behalf of its member marketing collectives, arrange for transport to distant commercial markets, impart the necessary managerial and technical skills to persons nominated by its members, and provide credit and other allied facilities to its members. Private entrepreneurship is also being established through training and the provision of loans.

Direct Sales

In a normal marketing process middlemen act as intermediaries between the supplier of goods and its consumer, as already explained. These middlemen invoice their functions. Often, but mainly during a time of economic difficulty, or when a producer does not receive fair payment, while the consumer estimates the price to be too high, one may think that middlemen should be suppressed. Some attempts in this direction have been made in Pakistan, involving horticultural perishable produce.

Juma Bazars

Launched in Pakistan in 1980, first in Islamabad, a *Juma Bazar* (Friday market) is an attempt to develop the sale of the agricultural product directly by growers to consumers. The idea of *Juma Bazars* has now spread to many cities all over the country. The basic idea was to lower the price of agricultural commodities by direct sale eliminating middlemen and their share of the profit.

Being so successful the *Juma Bazars* are no longer restricted to the selling of fruits, vegetables, and poultry products, and have grown into big markets selling hundreds of articles meeting most requirements. All kinds of fruits and vegetables are available at reasonable prices, even those sold by stall holders, and fruit and vegetables grown around the town are brought for sale by the producers themselves.

Public Marketing and Storage Societies

The Agricultural Marketing and Storage Limited was set up in 1980 as a private limited company with shares. Its main objectives are:

- to support national policies designed to streamline production, storage, and marketing of perishable agricultural commodities;
- to take adequate steps for proper publicity of measures to further improve agricultural production, storage, and marketing.
- to adopt such means of making known the projects and other activities of the company as may seem expedient and, in particular, by undertaking demonstration programmes by advertising in the press, organizing seminars and exhibitions, issuing circulars, publishing literature, or through other media;
- to undertake research, surveys, and feasibility studies on the marketing of perishable agricultural commodities;
- to plan and implement projects deemed essential to improve the marketing of perishables and thereby to secure the interest of both producers and consumers;
- to involve both farmers' and consumers' cooperatives in the programme and facilitate their management of the exchange or marketing of perishables; and
- to provide fair competition at market levels and to help stabilize prices and check profiteering.

Agricultural Marketing and Storage Limited also owns and operates a citrus waxing and grading plant at Peshawar.

Post-harvest and Marketing Operations

Packing

There are some antiquated methods of packing for supply to the markets. Vegetables, by and large, are dumped in various carriers and vehicles and transported as such to the markets. Tomatoes are, however, packed in wooden crates and onions in bags. Fruits are packed in wooden crates of varying sizes. The high cost of improved packages and other packing material and limited demand for sophisticated packages in the present traditional markets are factors limiting the adoption of suitable containers for packing. Use of inappropriate and defective methods of packing result in substantial quantitative and qualitative losses. At present packing material is scarce in most mountain valleys.

Grading

Grading is almost non-existent. No efforts are made at the producer's level to classify different types of fruits and vegetables by quality. Uncertainty about the quality of produce has led to lower bids in the market and has consequently resulted in lower returns to producers. The absence of proper classification and grading has encouraged a number of malpractices. There is a tendency on the part of the producers to pack good quality fruits on top of the container and immature, damaged, and even rotten stuff at the bottom. Some loose selection and grading, done at the retailer's level, is, entirely based on personal conceptions of quality. Thus, there is a need to introduce grading and standardization on scientific lines in the interests of an improved marketing system and for the benefit of both producers and consumers.

Transportation

Transport and transport facilities are an integral link in the marketing chain and also have strategic implications for cost. The means of transport used to bring fruit and vegetables from farm to market vary according to location, type of roads, type and size of commodity, and the resources of the farmers. In mountain areas, farmers bear the sole responsibility for bringing their produce to collection points. All sorts of transportation are used; jeeps, pick-ups, animals (donkey, horses, oxen, and sometimes yak), tractor-trollies, and transport trucks where metalled roads and wider dirt roads are available. Air transport is seldom used. Cherries from Quetta are transported by PIA to Islamabad, Lahore, and Karachi. There is a need for PIA to provide more fruit and vegetable transport facilities at special rates from Gilgit, Chitral, Swat, Muzaffarabad, Skardu, and Quetta. Freight rates vary significantly within a given mountain area, depending upon season, road condition, type of transport available, and more so the distance from the central markets. Lack of link roads and non-availability of fast transport is still a big problem.

Storage

Vegetables are available in plenty during certain months of the year and are not available in other months. Even in season, the supply is uneven, being abundant in the peak months. This invariably results in wide fluctuations in prices. Therefore, in the interest of both the producers and the consumers, it is necessary that available supplies are spread over a longer period so as to maintain prices at a reasonable level. This objective can be achieved by carrying over the surplus production for distribution in the off-season by putting it in cold storage where possible.

In Pakistan, cold storage facilities for over 365,000 tons are available in consumption areas. This capacity is considered sufficient to meet the total requirements of all horticultural products. According to a study, out of the total quantity of various products put into cold storage, potatoes command the most important position in the country; about 50 per cent comprises potatoes, particularly seed potatoes. Onions are stored to a lesser extent. The rest of the capacity is used for fruit (citrus and apples) and poultry.

In mountain production areas, there are only two mechanically cooled storage facilities of 1000 mt capacity each, one in Quetta and the other in Swat. The condition and design of most cold stores are poor. They are not properly designed to store various commodities with different storage requirements. Fruits, potatoes, onions, vegetables, poultry, and fish are all stored in the same room though each has different temperature and humidity requirements. The present cold stores can be made more efficient with little extra expenditure. They should be divided into different rooms, each room having its own temperature and humidity control system. The storage of each type of commodity under ideal conditions would then become possible.

The production of horticultural crops is going to increase in mountain areas in the next few years. Therefore, there is a need to construct storage in production areas. These need not be sophisticated and expensive structures but can be simple and comparatively cheap to operate by taking advantage of cool air during the day and night. A humidity control system would have to be provided. These stores could be constructed in high mountain valleys, so that supplies from production areas to consumption areas could be regulated to the advantage of small farmers. These stores should be the property of farmers' cooperatives rather than of contractors or middlemen.

Scope for Fruit and Vegetable Processing

Another way of adding value to horticultural fresh products is by processing, especially during the production season, to avoid market gluts and keep prices at a level which benefits small farmers. There are about 55 processing and canning units in the country. Out of these, only about a dozen are comparatively large units and their products are of international standards. It is estimated that post-harvest losses are about 30 per cent due to improper handling and the highly perishable nature of these commodities. Most of the processing industry is in large cities. There are only two processing units in mountain areas, one in Quetta and the other in Swat. But their products are not of a very high standard.

Vegetables can be processed in different ways and the method differs from vegetable to vegetable. For instance, tomatoes can be preserved by conversion into tomato juice, sauce, and paste, and can be dehydrated into powdered form. Similarly, vegetables such as spinach, cauliflower, cabbage, carrot, peas, onion, garlic, butter gourd, and okra can be easily dehydrated. Mixed vegetable juice can also be prepared.

Mountain areas have the advantage of growing deciduous fruits which cannot be grown in other parts of the country. If processing units are established, these areas could have the monopoly of their produce, which is not generally processed in large quantities by other processing units. Mountain areas could take the lead in the production of apricot nectar or apricot-peach mixed nectar. Pure apple and grape juice could be marketed to great advantage. Apricot leather could also be produced and can be easily dehydrated. Cherries can be canned perfectly. Apricots, cherries, and peaches are extremely perishable by nature and cannot be marketed easily at long distances in the fresh form. In the Northern areas, about 40 per cent of the apricot production goes to waste. The greatest constraint in mountain areas for the development of a processing industry is the lack of electric power. Other constraints of capital availability and entrepreneurship can be overcome if power is provided.

Potato Cultivation and Seed Production

Role of Mountain Areas in Potato Production

Potatoes have adapted well to the mountain areas of Pakistan for a long time and now not only are the most important cash crop, but also provide food in winter. In mountain areas, potatoes are grown during summer due to the mild climate. The crop is generally planted from March to April and harvested from August to October. At this time of the year, it cannot be grown in other parts of the country due to very hot weather. Therefore, mountain areas have the advantage of off-season production. Potatoes are supplied to the city markets from September to November when the prices are high and the potato is in short supply. It also fits in well with a number of multiple cropping patterns with little competition from other important food and cash crops.

The important mountain areas of Pakistan where potatoes are successfully grown are Hazara and Murree hills, Azad Kashmir, Chitral, Baltistan, Kohistan, Swat, Kaghan, Dir, and Quetta. Mostly grown under controlled irrigation conditions, in Hazara, Murree Hills, and Azad Kashmir, potatoes are mainly grown under rainfed conditions.

At the time of Independence, there were hardly 3000 hectares under potatoes. The red-skinned cultivar Katwa Red and the white-skinned cultivar Phulwa were mainly grown. These cultivars took 150 to 160 days to mature and were low yielders. Furthermore, difficulties were experienced in procuring the seed of the cultivars from India. Therefore, the need to replace these varieties with early-maturing and high-yielding ones was strongly felt. In fact the genesis of potato improvement in Pakistan dates back to 1955/56. The first exotic high-yielding variety Ultimus (red-skinned) was identified and approved for general cultivation. Incidentally, this cultivar did very well in mountain areas and became very popular with the farmers. It is still being maintained and grown in hilly areas. With the passage of time and the introduction of high-yielding cultivars, the areas and production increased steadily (Annex 6). Out of the present 62,900 hectares, about 15 per cent is under summer crop in mountain areas. Separate statistics for area and production in hilly areas are not available.

There are three overlapping crops grown annually and as availability of cold storage space is not a serious problem, retail and wholesale prices do not fluctuate greatly. However, they are high in October and November. This is caused by the low total production of the small summer crops in mountain areas. It is estimated that most of the summer produce is stored as seed for the next spring crop in the plains and seed is also retained by the farmers for planting summer crops in mountain areas.

With the opening of the Karakorum Highway to Gilgit and Baltistan and the improvement of roads in other mountain areas, there is tremendous scope to increase area and production, which should be exploited. These are all truckable roads and there is no problem in hauling potatoes from the mountain areas to distant markets in the plains.

Potato Seed Situation and Prospects

SEED CYCLE IN PAKISTAN

The present movement of seed in Pakistan is depicted in Figure 8.7. It shows the planting of expensive imported certified seed as the spring crop, thus exposing it to high insect vector population due to favourable climatic conditions, causing considerable increase of the virus level in spring-produced potatoes. The spring season has not been eliminated as the first planting season to generate autumn-to-autumn seed cycle for producing quality seed. Similarly, seed produced in the high hills also has to pass one spring planting in the plains to enter the autumn-to-autumn seed cycle. During autumn, due to colder temperatures, insect vectors are less active and disease incidence is minimal.

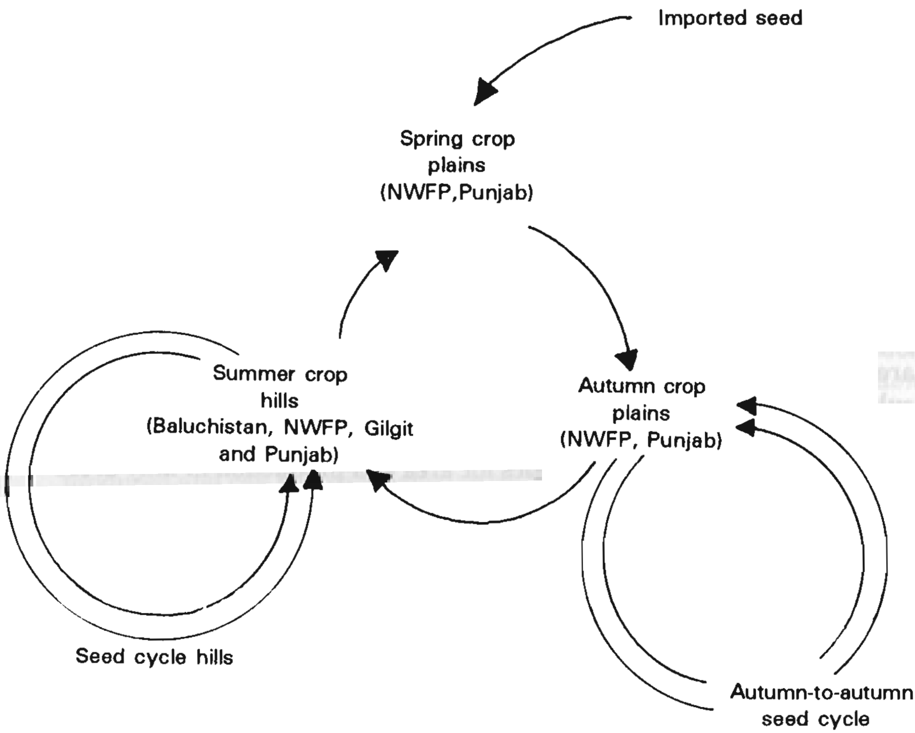


Figure 8.7: Present movement of seed potatoes in Pakistan

LOCAL SEED SUPPLY TO THE SPRING CROP

Seed for the NWFP is grown in the higher hills of Kaghan (Batakundi area) and Swat (Kalam area). The Punjab is supplied with seed from these areas as well as from Hazara hills, Azad Kashmir, and Baluchistan (Quetta, Kalat, Ziarat) areas. Kaghan seed is preferred as it is less degenerated and performs well.

Seed Supply for the Mountain Area Summer Crop

As described earlier, potatoes are grown in the mountain areas of Baluchistan where efforts are being made to establish some seed programmes, but farmers still practise their own seed production.

In early 1956, the Ministry of Food and Agriculture started a certified seed potato programme in the Quetta and Kalat valleys with cultivars, namely Bintje and Eighenheimer, with little success due to high insect vector population and the prevalence of fusarium in the soil. The higher hills of Swat and particularly of Kaghan appear to be very promising for setting up seed production programmes. More recently, Jaffer Brothers Private Ltd, have initiated seed production in upper Hunza and Gojal in the Northern areas and in Gilgit district on a contractual basis with farmers located along the Karakorum Highway, with resounding success. This programme could easily be expanded to surrounding valleys above 2500 m and also into Baltistan. These areas, being isolated, have been found to have very little insect vector population. The seed produced in Hunza and Gojal areas gave yields as high as those of the expensive imported seed from Holland. Thus, this opportunity should be exploited to the maximum and eventually it should become possible to stop the import of expensive seed which requires large foreign exchange outlays.

Seed Supply of the Autumn Crop

Seed for the autumn crop in the NWFP and the Punjab is partially met from the spring produce. Research in the Punjab during the late 1960s and early 1970s has established the autumn-to-autumn seed multiplication cycle, due to low aphid activity during this season. Efforts are under way to induct a high quality seed cycle by harvesting the immature crop in July or August. Chemicals are being tested to break the dormancy of seed so that it becomes possible to plant this seed in October-November in the plains. Once this is established, the spring crop could easily be eliminated for seed requirements.

Proposed Scheme for Quality Seed Production

Potato requires a very high investment per hectare of production. Seed is the most important item in potato production, constituting about 30 per cent of the total production cost. Seed is so important for this crop that production is directly correlated to the quality and health of the seed stock.

Lack of availability of high quality seed within the country is the single most important factor directly affecting productivity levels at present. The present low per hectare yield of 10 tons is mainly due to the inferior seed that farmers are planting. Till seed production and certification become a reality on a national basis, the present low productivity levels will prevail, and import of seed from abroad is inevitable. However, systems of potato seed production and seed certification are under way and probable improvement suggested. The objectives of this seed certification programme would be to:

- Supply high quality disease-free indigenous seed, reasonably priced, in large quantities to potato growers of all the three crops grown in Pakistan.
- Guarantee uniform standards throughout the country and free movement of seed stock among the four provinces.
- Stop import of expensive seed from abroad.

A scheme to link up the mountain area summer and autumn crops with imported seed and locally produced certified seed can be designed as shown in Figure 8.8.

Seed grown in Swat does not have a good reputation, mainly because of the all-weather accessibility to the valley. Farmers can purchase seed for their summer crop in the plains because of the comparatively low price of potatoes produced in autumn, although plains-produced seed is of poor quality. Consequently, Swat farmers produce seed of low quality and health. Therefore, a first step in a seed potato production programme should be a complete ban on the movement of seed from the plains to the hills.

Attempts to establish a basic seed programme in Batakundi area (Kaghan) with the technical assistance of GTZ of West Germany are under way. In Kalam (Swat), a seed potato pilot project is testing the feasibility of a viable certified seed programme in the high hills with the possibility of further expanded bulking of the seed stock in the mid-hills at the later stages. The seed for the central and south Punjab comes partly from Baluchistan and also some certified seed is imported annually from the Netherlands. However, the quality of Baluchistan seed is not very good. Recent success in producing quality seed in Gilgit will, it is hoped, become a major seed source for the Punjab.

Cultivation Practices

CROP PLANTING METHODS

All planting is done manually and farmers do not practise pre-sprouting of seed. Seed for the spring season is cut into pieces with at least two eyes per piece. This reduces the seed cost and stimulates sprouting, but

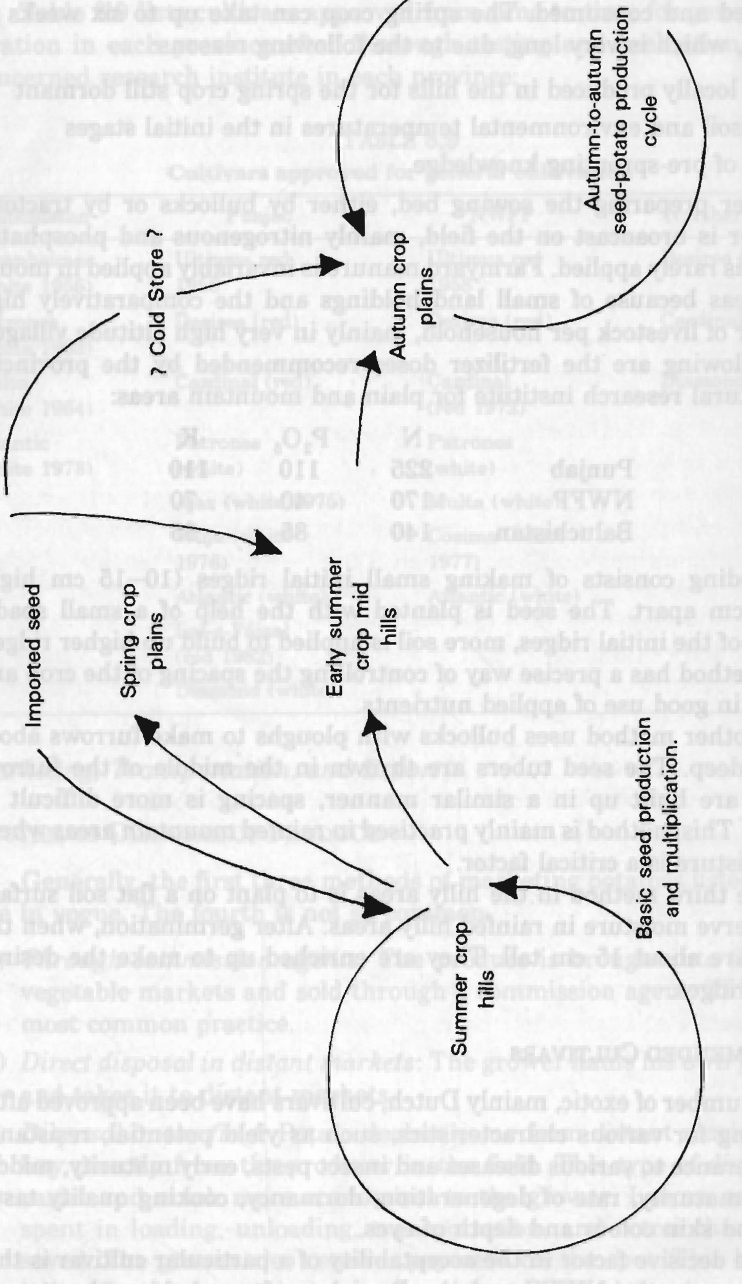


Figure 8.8: Probable pathways to link up summer and autumn crops with imported seed and locally produced certified seed

results in a very low stem density on an average of one stem per plant. In the Northern areas, only one eye per piece is taken out and planted, resulting in poor germination and patchy fields. The rest of the potato is cooked and consumed. The spring crop can take up to six weeks to emerge, which is very long, due to the following reasons:

- Seed locally produced in the hills for the spring crop still dormant
- Low soil and environmental temperatures in the initial stages
- Lack of pre-sprouting knowledge.

After preparing the sowing bed, either by bullocks or by tractors, fertilizer is broadcast on the field, mainly nitrogenous and phosphatic. Potash is rarely applied. Farmyard manure is invariably applied in mountain areas because of small land holdings and the comparatively high number of livestock per household, mainly in very high altitude villages. The following are the fertilizer doses recommended by the provincial agricultural research institute for plain and mountain areas:

	N	P_2O_5	K
Punjab	225	110	110
NWFP	170	40	70
Baluchistan	140	85	85

Seeding consists of making small initial ridges (10–15 cm high) 60–75 cm apart. The seed is planted with the help of a small spade. On top of the initial ridges, more soil is applied to build up higher ridges. This method has a precise way of controlling the spacing of the crop and results in good use of applied nutrients.

Another method uses bullocks with ploughs to make furrows about 10 cm deep. The seed tubers are thrown in the middle of the furrow. Ridges are built up in a similar manner, spacing is more difficult to control. This method is mainly practised in rainfed mountain areas where soil moisture is a critical factor.

The third method in the hilly areas is to plant on a flat soil surface to conserve moisture in rainfed hilly areas. After germination, when the plants are about 15 cm tall. They are enriched up to make the desired size of ridges.

Recommended Cultivars

A number of exotic, mainly Dutch, cultivars have been approved after screening for various characteristics, such as yield potential, resistance and tolerance to various diseases and insect pests, early maturity, middle or late maturity, rate of degeneration, dormancy, cooking quality taste, flesh and skin colour and depth of eyes.

One decisive factor in the acceptability of a particular cultivar is that consumers in the NWFP and the Punjab prefer red-skinned potatoes, whereas in Baluchistan and Sind, consumers prefer the white-skinned variety. Only white-skinned potatoes are exported to the Persian Gulf countries.

Table 8.9 lists cultivars approved from time to time for general cultivation in each province after thorough testing and evaluation by the concerned research institute in each province:

TABLE 8.9
Cultivars approved for general cultivation

Baluchistan	Punjab	NWFP	Northern Areas
Eigenheimer (white 1956)	Ultimus red 1958	Ultimus red 1958	Desiree (red)
Patrones (white 1963)	Desiree (red)	Desiree (red)	Cardinal (red)
Multa (white 1964)	Cardinal (red)	Cardinal (red 1972)	Diamond (white)
Atlantic (white 1978)	Patrones (white)	Patrones (white)	
	Ajax (white 1975)	Multa (white)	
	Wilja (white 1976)	Cosima (white 1977)	
	Atlantic (white)	Atlantic (white)	
	Lal-e-Faisal (red 1982)		
	Diamond (white)		

Marketing, Transportation, and Export

SYSTEM OF DISPOSAL OF PRODUCE

Generally, the first three methods of marketing potatoes listed below are in vogue. The fourth is not so common.

(1) *Through commission agents*: The produce is brought into the local vegetable markets and sold through a commission agent. This is the most common practice.

(2) *Direct disposal in distant markets*: The grower hauls his own produce and takes it to distant markets.

(3) *Disposal in the field*: Potato dealers come from distant markets and buy directly from the producer in the field. This type of disposal is easier and much more economical to the grower. Labour and time spent in loading, unloading, transportation, and octroi charges are saved. The grower also receives payment on the spot. This happens quite often in mountain areas when prices in the plains are very high

in the months of October and November. Potatoes at much higher prices were lifted in 1987 and 1988 from mountain areas.

(4) *Disposal as standing crop:* This method is not very common and is occasionally practised by the non-regular potato grower only, who once in a while cultivates potatoes in smaller areas. This saves harvesting, packing, and marketing charges, and avoids possible unfavourable changes in market prices.

Whatever the disposal system, potatoes normally pass though the grower, commission agent, intermediary, and retailer before reaching the consumer.

TRANSPORTATION

The means of transport and transport facilities are important in the marketing chain and have strategic implications for the cost. Efficient communication and transport help in minimizing transit losses and thus indirectly lower transport cost and increase the producer's share in the price paid by the consumer.

In the past, the primary means of transportation was in carts, by animals, and on tractor-driven trolleys. But the increased availability of trucks, improvement in the condition of highways, and extension of roads to many villages have improved the speed and reliability of short-haul movement, as well as long-distance movement by trucks, pick-ups, and jeeps, which are fast and efficient.

The most popular with growers and potato traders is the truck service. Though more expensive than other means it is preferred because:

- Potatoes are loaded within the field or in the market of origin and unloaded within the market of destination immediately after arrival.
- As soon as the truck is loaded, it is on the road moving towards its destination.
- There are no delays in transit and arrival; therefore, produce is mainly unaffected by price fluctuations.
- Service is readily available around the clock.

The expense of truck transportation does not affect the grower or the trader because the cost is naturally transferred to the consumer who pays a higher price.

EXPORT

Potatoes have been listed recently as an exportable commodity. Due to rising demand in nearby countries, export prospects have become bright. Potatoes were first exported in 1970/71. The export trade could not be expanded because of rising prices in the domestic market. In spite of great marketing constraints, the country exported 41,000 tons to the Gulf states in 1979/80. In fact, if better transport facilities and reasonable prices were ensured to the growers, Pakistan could easily export 100,000 tons of potatoes annually. The annual quantity of potatoes exported to nearby countries is given in Table 8.10.

TABLE 8.10

Potato exports of Pakistan, 1970/71–1985/86

Year	Quantity ('000 tons)	Value (million Rs.)
1970/71	1.1	0.3
1971/72	1.0	3.2
1972/73	3.2	2.5
1973/74	7.1	0.02
1974/75	—	—
1975/76	3.2	6.0
1976/77	12.5	23.0
1977/78	7.7	10.8
1978/79	23.3	25.5
1979/80	41.0	61.5
1980/81	6.0	8.8
1981/82	6.0	9.0
1982/83	7.4	14.0
1983/84	3.5	6.4
1984/85	25.1	36.6
1985/86	1.3	2.1

Potato exports were conducted without a proper study of the export market and the technical requirements of this commodity in terms of transport, storage, demand, price, grades, etc. The interests of the producers were not given full consideration. The conditions necessary to promote and establish an export business along sound lines are stated below:

- Production must be increased substantially, over and above domestic requirements, so that internal prices do not shoot up beyond the reach of the common man. Mountain areas could play a major role in boosting production.
- Proper arrangements for storage of surplus produce are needed so that export can be regulated and spread over a longer period to obtain better prices and control of the foreign market.
- Refrigerated transport is needed both on land and on sea.
- Packing and grading must be brought to international standards.
- The growers must receive a substantial profit of at least 60 per cent over their total investment.

- The potential in mountain areas must be exploited.

Apart from being a rich source of quality food, potatoes have the potential to bring great monetary benefits and prosperity to small growers in the mountain areas, and this is being exploited to some extent. Potatoes require an initial investment in seed, fertilizer, and pesticides which is higher than for other crops. At the same time, returns are also higher than on cereal crops as potatoes give three to four times more tonnage per unit area. Another important characteristic of this crop is that it takes 120 to 180 days to mature, whereas most cereals and other cash crops mature in 120 to 365 days. It is on account of these merits that potatoes are very popular as a cash crop with progressive and skilled growers who can afford to buy costly inputs and have the spirit of entrepreneurship.

Past Research Achievements and Future Strategies

PAST ACHIEVEMENTS

Earlier research endeavours were mainly confined to varietal introduction and evaluation at the four provincial research institutes and their sub-stations. Systematic investigation of other aspects of potatoes were lacking.

Since potatoes are grown in all the provinces and the production and marketing problems of the three crops (spring, summer, autumn) are interlinked, the Pakistan Agricultural Research Council put into operation a coordinated research programme at national level with the active involvement of the provinces and the US Department of Agriculture from September 1974. This programme focused on screening potato cultivars procured from various sources for their yield potential, resistance against disease, and tolerance to major environmental stresses, and to develop a practical package of technology for the production of ware and seed potatoes. This project, after its successful completion in 1981, generated very useful scientific results to provide a good empirical base to any potato improvement programme in Pakistan. The outstanding achievements of this coordinated research programme were:

- About 300 cultivars or clones procured from different sources have been screened for yield potential and environmental stresses. This knowledge will be used in developing a cultivar improvement programme.
- Cultivars Ajax, Atlantic, FB9003-2 (Lalai-Faisal), Cardinal, and Cosima have been released.
- Other agronomic practices were perfected and packages of production technology for each province were developed.

- The glyco-alkaloid level in selected cultivars was determined and found to be much below safe levels for human consumption.
- The studies carried out to develop seed production technology have revealed that it is possible to produce and multiply disease-free basic seed at higher elevations. The seed raised at 2200–2600 m altitude performed well and has given 50–60 per cent more yield than seed from the market from private growers in the plains. These findings have cleared the course for further improvement of the potato crop.
- Facilities for tissue culture have been established at the National Agricultural Research Centre, Islamabad and Ayub Agricultural Research Institute, Faisalabad, and are now being developed in Gilgit.

On the basis of current research and experience gained under varying agro-ecological environments, the following projects are operative in the country:

- Pilot seed production project financed by the World Bank,
- A research centre set up for production of basic and certified seed potato in the NWFP, with technical assistance from GTZ of West Germany,
- A cooperative programme for research, productivity improvement, and marketing of potatoes in Pakistan, with technical assistance from Switzerland.

Future Research Strategy

Keeping in view the rising economic importance of potatoes, the Pakistan Agricultural Research Council has identified the following research thrusts, with a more integrated approach at the national level and active participation by the provincial research institutes:

- Screening of germplasm to develop a sound varietal improvement programme
- Transfer of production technology to the farm level through on-farm trial and demonstration
- Study of consumption patterns and marketing systems to improve the present food situation and ensure outlets for the produce
- Investigation methods for increased consumption and industrial use of fresh potatoes
- Partial mechanization of farm operations
- In order to provide centralized facilities and a sound base for research and development, it is essential to establish a central potato research institute at the National Agricultural Research Centre with its outreach stations in the provinces on the lines of the Potato Research Centre at Shimla, India of ICAR. This institute can be linked up with

the US Department of Agriculture research centre at Beltsville, USA, and/or CIP (Peru) to promote potato production in the region.

TRAINED MANPOWER REQUIREMENTS

There is a great shortage of technical manpower at all levels. This needs special consideration. At present there are only three Ph.Ds in the whole country on vegetable and potato crops. The Pakistan Agricultural Research Council has developed a substantial programme for advanced studies abroad. It is envisaged that under this programme highly qualified scientists should be available in three to four years. There is also a great need for short-term practical training on seed production and certification, besides production technology.

Floricultural Development

Floriculture has been almost completely neglected by development and research programmes although it possesses tremendous development potential in the mountain areas because of suitable climatic conditions. In the past six to seven years, the formation of horticultural societies and the holding of seasonal flower shows have aroused great interest in the metropolitan cities of Lahore, Islamabad, Rawalpindi, and Karachi.

Due to increased demand for bulb and tuberous flowering plants, private seed merchants, nurserymen, and PIA have started imports from European counties which are very expensive. Policy makers seem to find it easier to import than to develop these crops in the mountain areas of Pakistan, which offer unlimited scope for the production of flowering bulbs and tubers. Among the most suitable arid and cooler areas are Quetta, Kalat, Gilgit, Chitral, and Baltistan.

A research-cum-production project is immediately needed in these areas to exploit this potential.

Coordination of Long-term Horticultural Development

Ongoing Horticultural Development Projects

To increase fruit and vegetable production and availability, and to train manpower, there are a number of ongoing developmental programmes with foreign financial and technical assistance as well as aid from non-government organizations. These programmes are:

- Pak-Swiss Potato Project with headquarters at Islamabad
- NWFP-German Potato Project operational in the NWFP
- Malakand-Swiss Horticultural Development Project with headquarters in Swat

- FAO/UNDP project in the Northern Areas of Pakistan with headquarters at Gilgit
- Pak-Italian Fruit and Vegetable Development Project with headquarters at Gilgit
- Aga Khan Rural Support Programme operational in Gilgit, Baluchistan, and Chitral districts, with headquarters at Gilgit
- World Bank Integrated Hill Farming Development Project in Azad Kashmir
- FAO/UNDP Fruit Development Project in Baluchistan with headquarters at Quetta.

Role of National Fruit and Vegetable Development Board

A National Fruit and Vegetable Development Board was established in 1983 to coordinate and formulate policy regarding all aspects of fruit, vegetable, and floricultural development. The Federal Minister for Food, Agriculture and Cooperatives is the Chairman of the Board. Other board members include provincial secretaries of agriculture, representatives of diverse federal institutions, an exporter, a processor, and a grower. The Board does not have a core staff, has yet to undertake major activities, and is more or less dormant. The government should recruit core staff immediately and make the board fully functional. The functions according to the notification of the board are:

- to advise on and coordinate policies for overall development and improvement of production, processing, storage, and marketing of fruits, vegetables, and flowers;
- to suggest a national programme for the production of fruits, flowers, and vegetables and to help and guide the provincial governments and other agencies concerned to develop concrete action-oriented schemes, projects, and plans within this programme;
- to suggest and advise on suitable annual production targets of fruits, vegetables, and flowers;
- to review measures to attain production targets, including supply of inputs vis-a-vis seed, plant seedlings, fertilizer, water supply, plant protection measures, and credit facilities;
- to review arrangements for the production, import, and distribution of seed, plants, and saplings, with a view to identifying seed required to meet the full requirement of the farmers;
- to coordinate research and development efforts, including the setting up of nurseries for accelerated production of fruits and flowers;
- to review the price trends of fruits, flowers, and vegetables;

- to suggest or review policy measures to develop the marketing of fresh and processed fruits, vegetables, and flowers;
- to oversee cost of production and the prices received by farmers, suggest measures for price support, and advise on steps required to ensure fair prices to growers;
- to recommend policy measures required to remove constraints or bottlenecks in the improvement of the efficiency of fruit and vegetable industries and the setting up of cold stores;
- to recommend measures to promote the export of fruits, vegetables and flowers;
- to collect and maintain statistics on any matter relating to fruits, vegetables, flowers, and the industries concerning them; and
- to advise the government on all allied matters.

Activation of Provincial Fruit and Vegetable Development Boards

In the NWFP, there is a provincial fruit and vegetable development board which became operational in 1986. In the Punjab, there is only a fruit development board, and vegetable crops need to be included. There is no fruit or vegetable development board in Baluchistan yet, where there is an urgent need for such a board. Once these boards are fully established, the National Fruit and Vegetable Development Board should coordinate all their activities and functions.

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Annex 1

Area and production of important deciduous fruit crops in Pakistan

Table 1. Cultivated area ('000 ha)

Fruit	1958/59	1973/74	1975/76	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
Apple	0.4	6.1	8.0	9.7	10.3	10.9	11.4	11.9	12.9	13.3	14.8	17.4
Apricot	0.5	2.0	2.6	2.8	2.9	3.1	3.2	3.5	3.7	4.2	4.7	4.9
Peach	0.8	1.2	1.2	1.3	1.4	0.9	1.0	1.1	1.1	1.2	1.4	1.4
Pear	1.2	2.5	3.1	3.3	3.3	2.5	3.1	3.1	3.1	2.8	2.9	2.9
Plum	0.8	2.4	2.4	2.6	2.6	2.7	3.3	3.4	3.6	3.9	4.0	4.1
Cherry	—	0.05	0.06	0.07	0.08	0.09	0.1	1.1	1.2	1.3	1.3	1.4
Grape	1.3	2.5	2.5	2.4	2.5	2.5	2.5	2.6	2.7	2.8	2.9	2.9
Almond	—	5.8	6.1	6.3	6.3	6.4	6.4	6.5	6.5	6.7	6.9	7.0
Walnut	—	0.8	1.1	1.4	1.5	1.5	1.5	1.6	1.7	1.7	1.7	1.8
Pomegranate	1.5	1.8	2.1	2.1	1.9	2.4	2.6	2.3	2.6	2.9	3.2	3.4

Source: Planning Unit, Food and Agriculture Division, Government of Pakistan.

Table 2. Production ('000 mt)

Fruit	1958/59	1973/74	1975/76	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
Apple	3.0	51.5	66.7	87.7	93.7	99.3	107.4	114.1	128.6	128.0	142.7	166.0
Apricot	3.0	22.6	25.7	30.3	31.3	34.0	35.1	37.1	43.7	46.5	52.2	53.4
Peach	6.0	10.2	9.8	10.3	10.9	9.7	10.1	10.3	11.2	11.4	11.7	12.2
Pear	10.0	32.0	29.6	33.6	33.3	27.7	33.5	33.2	33.8	33.5	34.1	33.9
Plum	6.0	42.4	26.6	29.6	30.5	32.0	38.2	38.3	40.4	42.8	43.8	44.3
Cherry	—	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.5
Grape	6.0	28.5	28.9	32.2	28.7	29.2	26.0	26.2	26.1	26.4	26.9	28.6
Almond	—	27.2	22.2	22.3	23.1	23.6	21.2	23.2	27.1	28.0	28.5	28.8
Walnut	—	11.9	15.1	14.7	15.4	15.3	16.0	16.9	17.5	17.9	18.1	18.3
Pomegranate	10.0	26.7	26.0	28.3	26.8	30.9	31.2	29.2	31.4	29.9	31.6	32.2

Source: Planning Unit, Food and Agriculture Division, Government of Pakistan.

Annex 2

Area and production of important vegetable crops in Pakistan

Table 1. Cultivated area ('000 ha)

Fruit	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
Potato	37.7	42.9	38.0	45.2	51.5	49.5	54.5	62.9
Onion	38.7	41.9	43.2	43.2	45.3	47.4	48.2	49.4
Carrot	5.3	4.9	4.8	4.6	5.2	5.8	6.3	6.6
Tomato	9.7	10.9	11.5	12.1	13.9	14.1	14.1	15.8
Garlic	2.3	2.3	2.4	2.5	2.6	2.6	2.5	2.6
Cabbage	1.2	2.3	2.2	2.9	2.6	3.1	2.4	2.4
Okra	4.8	5.0	4.8	5.6	6.3	7.2	7.2	8.2
Cauliflower	4.7	4.9	5.7	4.8	4.9	5.5	5.9	6.2
Peas	7.2	7.6	7.8	6.4	6.3	4.8	5.7	6.6

Source: Planning Unit, Food and Agriculture Division, Government of Pakistan.

Table 2. Production ('000 mt)

Fruit	1973/74	1975/76	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
Potato	238.0	320.7	293.5	392.4	448.6	394.3	476.6	518.1	509.8	543.4	618.3
Onion	239.4	322.7	325.4	389.7	434.0	447.6	451.8	474.8	503.3	514.6	524.7
Carrot	67.6	84.4	73.8	84.3	75.8	75.9	72.4	82.7	93.3	102.8	113.8
Tomato	56.0	53.7	63.4	79.3	86.5	92.1	99.1	118.4	127.2	130.0	150.0
Garlic	2.0	1.8	3.4	4.9	5.1	4.9	5.4	6.4	6.4	6.5	6.6
Cabbage	1.8	1.3	1.3	1.2	2.3	2.1	2.9	2.6	3.1	2.4	2.4
Okra	5.2	3.7	4.4	4.8	5.0	4.8	5.6	6.3	7.2	7.2	8.2
Cauliflower	2.2	3.4	3.4	4.8	4.9	5.7	4.8	4.9	5.5	5.9	6.2
Peas	2.5	4.4	6.3	7.3	7.6	7.8	6.4	6.3	4.9	5.7	6.6
Cucumber	Not available separately										

Source: Planning Unit, Food and Agriculture Division, Government of Pakistan.

Annex 3

Yield potential of some important vegetables in the Northern areas

Vegetables	Yield potential (tons/ha)
Cabbage	50.0
Tomato	90.0
Turnip	60.0
Radish	45.0
Carrot	40.0
Swiss chard	120.0
Cauliflower	30.0
Chinese cabbage	35.0
Eggplant (black beauty)	40.0
Okra	40.0
Onion	40.0
Pepper	40.0
Peas	17.0

Annex 4

Probable seed yield of some vegetable crops

Vegetable	Range of seed yield (kg/ha)
Cabbage	1600–1800
Carrot	1800–2000
Radish	540– 800
Swiss chard	2900–3000
Turnip	1060–1660

9

Horticultural Development in the Himalaya and the Hengduan Mountains, China

Zheng Du, Li Gaoshe, and Jiang Hong

Introduction

Situated in southwest China, the Himalaya and the Hengduan mountains are characterized by unique geo-ecological conditions and are sparsely populated, largely inaccessible, and generally underdeveloped.

In this area the pattern of land use depends chiefly upon the natural resources and the geo-ecological environment. The regional differences of the physical condition are reflected in the structure of land use. As a whole, the study area may be divided into three zones: the agro-pasture zone on the northern side of the Himalaya; the agro-forest zone on the southern side of the Himalaya and the southern section of the Hengduan mountains; and the agro-forest-pasture zone in the middle and northern sections of the Hengduan mountains.

With economic development, social progress, and improvement of communications, horticulture has been developed on a large scale since the 1950s. To develop horticulture is one of the strategies for rational use of renewable natural resources of mountainous areas.

In order to exchange experiences and recognize existing problems and future prospects, horticulture development in the study areas, including fruit, walnut, tea, potato, and vegetable cultivation, are dealt with.

General Characteristics of the Study Area

Geo-ecological Conditions

TOPOGRAPHY AND RIVERS

The topography on the northern and southern flanks of the Himalaya is fully asymmetrical, especially in the central Himalaya. In the south, the main ridges of the Great Himalaya rise abruptly to about 6000 m above the Ganges plain, forming steep slopes with strong fluvial erosion in the gorges. Owing to uplifting of the mountain system, the land form of valley may be found here and there in the region. Settlements and farmlands are—mainly located on the level shoulders, lying above the knick point in the transverse profiles.

By contrast, the topography of the northern flanks of the Himalaya is more gently undulating with a relative elevation of 1500–2000 m. The plateau proper of south Xizang (Tibet) stretches to the northern flanks of the Himalaya with broad basins and valleys, where piedmont deposits are very extensive. Under the cold and semiarid climate, a great many sand dunes and sand drifts lie along the river valleys.

The Hengduan mountains comprise a series of high mountain ridges sandwiched between deep river gorges. As a whole, the Hengduan mountains slope from northwest to southeast and from north to south, with altitudes from 4500 to less than 3000 m above sea level. The topography of the region is interlaced and separated by mountains, plateaux, valleys, and basins in distinct relief.

The northern section of the Hengduan mountains is a slightly dissected plateau with gentle slopes. In the middle section the plateau occurs with broad valleys and fluvial terraces, and flood lands may be seen in a number of broad valleys. The southern section of the region consists of basins, middle altitude mountains, and plateaux, with an elevation varying from 3000 to 2000 m above sea level. A number of basins with lower altitudes and gentle relief are suitable for crops and are an important area in this section.

Controlled by geological structure, the Himalayan ranges emerge in a series of drainage systems, cut through by very deep transverse gorges, such as the Indus, the Sutlej, the Pumqu (the upper reaches of the Arun river), the Yarlung Zangbo, and other tributaries of the Ganges and Brahmaputra, including the Zayu river.

In the Hengduan mountains occur the Nujiang river (upper reaches of the Salween river), the Lancang river (upper reaches of the Mekong river), the Jinsha river (upper reaches of the Changjiang river) and their numerous tributaries, such as the Yalong river, the Dadu river, and the Minjiang river. All of them cut deeply in parallel gorges with elevations of valley floors varying between 2000 and 4000 m above sea level.

Climate

Influenced by the Asian monsoon, both the Himalaya and Hengduan mountains are characterized by a monsoon climate with alternate wet and dry seasons. In winter, from November to April, the mountainous areas are under the control of the southern jet stream of westerlies. There is abundant sunshine and dry weather with rare precipitation, especially on the northern flanks of the Great Himalaya. The winter precipitation derived from the disturbed westerlies plays a significant role in the western Himalaya.

During the summer period, from May to October, the southern jet stream of westerlies withdraws northwards, and the southern moisture-laden monsoon from the Indian Ocean reaches up to the Himalaya and the Hengduan mountains. The monsoon brings heavy rainfall on the southern flanks of the Himalaya and most areas of the Hengduan mountains, while the southeastern monsoon prevails in the eastern and southeastern parts of the Hengduan mountains.

The southern flanks of the east Himalaya, with an annual rainfall of 2000–4000 mm, are the most humid section of the mountain system; decreasing westward, some 1000–2000 mm is received on the southern flanks of the central Himalaya and about 500–1000 mm by the west Himalaya. There is a rain shadow area with an annual precipitation of 200–300 mm on the northern flanks of the central Himalaya and further westward it is less than 200 mm; in the middle reaches of the Yarlung Zangbo river, the annual precipitation decreases from 600 mm in the east to 200 mm in the west.

On the peripheral region of the Hengduan mountains, annual precipitation of 1200–1600 mm has been recorded, but most of the area has a mean annual precipitation of about 500–900 mm. The bottom of the gorge section of the Hengduan mountains is climatically a centre of rare precipitation, forming a number of dry valleys with an annual precipitation of 300–500 mm only.

Because the mean temperature of the coldest month is less than 18°C, the base-belt on the southern side of the central and east Himalaya may be considered the northern fringe of the topics. At comparable altitudes, the temperature regimes of the southern section of the Hengduan mountains are similar to that of the southern flanks of the Himalaya, having a sub-tropical climate. Due to high elevation and unfavourable thermal conditions, the northern flanks of the Himalaya belong to the plateau temperate zone. Owing to various moisture regimes, temperature conditions in the northern and middle section of the Hengduan mountain, and the plateau temperate zone as well, are not as favourable as the northern flanks of the Himalaya for crop growing.

According to differences in the thermal regime, the dry valleys of the Hengduan mountains may be divided into four types: hot-dry valleys, warm-dry valleys, temperate-dry valleys, and cool-dry valleys, correlated to increasing elevation of the valley bottom.

ALTITUDINAL BELTS

In the mountainous region the altitudinal belt forms the background for rational use of renewable natural resources and the development of horticulture. The altitudinal belt signifies various temperature-moisture regimes from the valley bottom up to the mountain ridges, suitable for plantations of tea, orchards, and vegetable cultivation.

Based on the spectrum-structure the base-belt, dominant belt, and the pattern of the altitudinal belt may be identified: the monsoonal and the continental.

The monsoonal systems of the altitudinal belt prevail on the southern flanks of the Himalaya, the northern flanks of the east Himalaya, and the Hengduan mountains. It is characterized by dominant biochemical weathering, acid soil and mesophytic types of vegetation. The altitudinal differentiation is mainly dependent on the temperature. By contrast, the continental system is characterized by intense physical weathering, alkaline soil with coarse texture, and meso-xerophytic and xerophytic types of vegetation.

In the southern flanks of the Himalaya, the altitudinal belt consists chiefly of montane forest belts with the base-belt of tropical evergreen and semi-evergreen rainforest, accompanied by lateritic red earth and latosols as well as yellow and yellow-brown soil. In contrast, the base-belt of the altitudinal belt on the northern flanks of the Himalaya is montane shrubby steppe of the semiarid type in the middle, while the base-belt of the montane desert-steppe and desert of the arid type is found in the west.

The montane evergreen broad-leaved forest and the montane coniferous forest of *Pinus yunnanensis* with red earth comprise the base-belt of the altitudinal belt in the southern section of the Hengduan mountains, while the montane needle and broad-leaved mixed forest belt with brown earth is the base-belt in the middle section of the region. At the bottom of the dry valleys, the shrub grassland with reddish laterite soil occurs in the hot and warm dry valleys, while thorny shrub with montane drab soil appears in the temperate and cool dry valleys.

The altitudinal belts of the study areas with different thermal and moisture regimes could meet the requirements of various horticultural crops such as fruit trees, tea, potatoes, and vegetables. The upper limit of the major crops of horticulture in the study areas is quite different.

Physico-geographical Divisions

By integration of the thermal-moisture regimes and three-dimensional differentiation, four physico-geographical regions may be recognized in the study areas.

THE TROPICAL AND SUB-TROPICAL MONTANE MONSOON REGION WITH HUMID CLIMATE

The tropical and sub-tropical region, including the southern flanks of the Himalaya and Kangrigarbo mountain as well as the southern section of the Hengduan mountains, comprises Gyirong Nyalam, Yodong, Cona, Medog, Zayu counties in Xizang Autonomous Region, the Northwest Yunan, and West Sichuan.

In most of the valleys and hills with an elevation below 2500 m above sea level, the mean temperature of the warmest month varies from 18 to 25°C, and that of the coldest month from 2 to 16°C. There is an absolutely frost-free season below 1000–1200 m. Mean annual precipitation varies from 800 to 3000 mm in districts with altitudes below 2500–3000 m.

Tropical and sub-tropical fruit trees and cash crops, such as banana, orange, grape vines, tea, and sugar cane, grow at lower altitudes, while the temperate fruit trees, such as apple, pear, and peaches, can also be planted at higher elevations in the region. Vegetables that prefer a warm climate, such as tomato and pepper, grow very well.

THE TEMPERATE PLATEAU REGION WITH HUMID AND SUB-HUMID CLIMATE

The temperate plateau region, consisting chiefly of a series of high mountain ridges sandwiched between deep river gorges, comprises the middle and northern section of the Hengduan mountains as well as the northern flanks of the east Himalaya and Kangrigarbo mountain.

The temperature obviously varies in accordance with altitude. The mean temperature in the warmest month is 12(10) to 18°C in the valleys and basins with an altitude of 2500–4000 m above sea level and 6–10°C only in the high ridges or plateau surface with altitudes of 4000–4500 m above sea level. Annual precipitation totals 400 to 1000 mm, decreasing northwestward from the periphery to the interior. At the bottom of dry valleys, the mean temperature in the warmest month reaches 18–20°C or more with an annual precipitation of 250–400 mm.

The region abounds in forest resources. Native products include such medicinal commodities as the tuber of elevated gastrodia (*Gastrodia elata*), as well as mushroom. Tea may be planted at altitudes of less than 2500 m in the peripheral area under humid climate. Temperate fruit trees such as apple, pear, peach, and walnut grow well at altitudes of 2500–3500 m above sea level.

THE SOUTH XIZANG WITH PLATEAU TEMPERATE SEMIARID CLIMATE

The south Xizang lies between the Gangdise-Nyalinqentanglha ranges in the north and the Himalaya to the south. Its drainage is by means of the Yarlung Zangbo and Pumqu river systems.

Owing to the southerly latitude and a lower altitude of about 3500–4500 m, the mean temperature in the warmest month ranges from 10 to 16°C, that of coldest month, from 0 to 10°C. Average duration of a daily temperature of above 5°C varies from 100 to 220 days.

As a result of the climate barrier of the main Himalayan range, annual precipitation decreases from 500 mm in the east to 200 mm in the west with an aridity index from 1.5 to 3.0. In the valley along the middle reaches of the Yarlung Zangbo river, some 70 to 80 per cent of the precipitation occurs at night, resulting in abundant sunshine which is favourable for crop and vegetable growing.

The middle reaches of the Yarlung Zangbo river together with its larger tributaries, such as the Nyang Qu river and the Lhasa river, constitute one of the main farming areas with a number of towns and cities in Xizang. The farms are situated on terraces along the river and the lower part of alluvial-diluvial fans skirting the rims of the basins.

Temperate fruit trees such as apple and walnut can be grown in some plots at an altitude of less than 4000 m. The region is suitable for potato cultivation and for vegetable farming.

THE NGARI REGION WITH PLATEAU TEMPERATE ARID CLIMATE

The Ngari region, encircled by the West Himalaya, the Gangdisc and the Karakoram mountains, is composed of the upper reaches of the Indus river and the broad valley of the Banglong lake, with altitudes varying from 3800 to 4500 m.

The region is rather warm in summer, with a mean temperature in the warmest month ranging from 10 to 14°C and that of the coldest month from −10 to −14°C. Due to the climatic barrier of parallel ranges in the southwest, the annual precipitation is less than 50 mm with an aridity index of 6.1 to 15.0. Strong winds occur frequently in spring and winter. Most of the region is used for grazing sheep and goats, with the exception of valleys at a lower altitude in the southern part, where small areas of farmland have been opened with irrigation and vegetable farming areas have expanded.

Socioeconomic Background

The study areas are mainly populated by people of Tibetan origin and have sparse population. The mean density of population is low, with distinct regional differentiations. The density of population is one to three persons/km^2 in the basins of the northern flanks of the Himalaya; 14 persons/km^2 along the valley in the middle reaches of the Yarlung Zangbo river in the south Xizang; 40–50 persons/km^2 in the densely inhabited plains of Lhasa, Gyangze, and Zetang; less than one person/ km^2 in Ngari; and six to seven persons/km^2 in west Sichuan.

In 1986, only an estimated 21.4 per cent of the population in Xizang had completed primary school, while about 1.7 per cent of the population had an educational level of senior middle school.

The extensive management of agriculture in the study areas is inefficient with a low yield per unit area. Owing to poor techniques and dependence on the physical environment, only a small number of agricultural commodities are brought to market, the region being characterized by a self-supporting economy.

The Himalayan and Hengduan mountain region were remote and inaccessible areas before the 1950s. Now, highways with a total length of about 30,000 km connect every county town in the study areas. The mean density of highways is 18.1 km/1000 km^2 in Xizang and 33.1 km/1000 km^2 in the Hengduan mountains. However, due to poor quality of some roads and an inadequate number of vehicles, transportation facilities should be further increased and improved.

Because of the unfavourable physical environment and the socio-economic background, the study area is an underdeveloped region, where farming and animal husbandry predominate. For example, the output value of industry accounts for one-fifth of the total output value in Xizang. Of the total output value of agriculture, animal husbandry and plant cultivation each make up one-fifth, and forestry, horticulture, sideline, and other outputs amount to one-fifth.

In accordance with the dominant natural resources and their exploitation, animal husbandry is predominant, combined with plant cultivation and forestry. More attention should be paid to building up the infrastructure for energy resources and communication in order to develop processing industries (food, hides, and wool), mining, and tourism.

Horticulture has developed on a large scale in the study area since the 1950s. For example, to establish and enlarge fruit tree and tea plantations in the southeastern part of Xizang, to expand vegetable farming in the suburbs of the major cities and towns of south Xizang may, to a certain extent, meet the demand created by population growth, raised living standards, and economic development.

Horticultural Research

In 1951 to 1953 the Xizang working group, organized by the Central Commission for Culture and Education, carried out a study on horticulture in eastern and central Xizang.

A comprehensive scientific expedition to west Sichuan and north Yunnan, sponsored by CAS in 1959 to 1961, was engaged in studies on horticulture in these areas.

Experimental studies on horticulture, including the introduction and acclimatization of species and varieties of vegetables, potato and fruit cultivation measures, management techniques, as well as storage, were conducted in Lhasa during the 1950s.

Three major experimental stations of agriculture (including horticulture) were established at Lhasa, Xigaze, and Gyangze at the end of the 1950s and the beginning of the 1960s. A great deal of research into horticulture development has been made and abundant information and experimental results have been obtained since the 1960s.

Investigation of horticultural development in Xizang, including the conduct of surveys of varieties and species resources of fruit trees, tea, and walnut, their bio-ecological characteristics, plantation management measures, diseases, pests, and pest control, were carried out by the Integrated Scientific Expedition to the Qinghai-Xizang Plateau, CAS, in the 1970s.

Studies on varieties of fruit trees and their potential development in the Hengduan mountain region, especially in the dry valley, were made by the Chengdu Institute of Biology, CAS, in the 1970s and 1980s. The Xizang Institute of '*plateau biology*' in Lasha is carrying out research into horticulture, such as cultivation of medicinal plants and agronomical aspects of other crops.

Fruit Crops

The history of fruit cultivation in the region is short and the area under cultivation is small compared to other regions. As far as we know from recorded information, there were no orchards in Tibet until 1924 when about 10 species of fruit trees were introduced from India and were mainly planted in Yadong county and other border areas; but due to various conditions, especially low socioeconomic status and backward cultivation techniques, progress was slow. Since the establishment of the Tibet Autonomous Region in 1960 fruit growing has made good progress. The government introduced a great number of fruit saplings from the provinces of Hebei, Liaoning, Sichuan, and Shangong, and a series of large-scale plant experiments have been done in Qamdo prefecture. Because of the weak basis for fruit cultivation and lack of management experience of the local people, the orchards in the region are almost all state-owned plantations at present, and household fruit trees are sporadically planted around the villages. Therefore, most of the plantations are on a small scale. Investigation has revealed that only 10 orchards have more than 1,000 fruit trees in Tibet.

In the Himalayan-Hengduan mountain region, most of the cultivated fruit trees are planted on terraces along the valley and gentle slopes which have suitable temperature and rainfall, together with plentiful sunlight and rich soil for tree growing.

In the Himalayan area, fruit trees began to fruit about 1968. Since then, fruit production has increased very fast. Based on statistical data, in 1971 fruit production in the area was only 150 tons, but it reached 2000 tons in 1974, then 3258 tons (1981). By the end of 1986, the fruit plantation area was 666 hectares and the yield was 4373 tons with apple 3637 tons (about 83 per cent of the total), pear 326 tons (about 7.5 per cent of total), and other fruit 410 tons (9.3 per cent of total).

Species of Fruit Trees

In the Himalayan-Hengduan mountain region, there are various types of vegetation and crops among which fruit trees are abundant, due to the very complex natural conditions. There are about 100 species of fruit trees in this region, which can be roughly divided into two categories: (1) tropical and sub-tropical fruits, such as oranges (*Citrus* sp.), bajiao banana (*Musa basjoo*), lemon (*Citrus limon*), pomegranate (*Punica granatum*), yangtao (*Actinidia chinensis*), and chinese flowering quince (*Chaenomeles sinensis*); and (2) temperate fruits, such as apple (*Malus pumila*), pear (*Pyrus*), peach (*Prunus persica*), plum (*P. salicina*), cherry (*P. pseudocerasus*), walnut (*Juglans regia*), grape (*Vitis vinifera*), Chinese pear-shaped crab-apple (*Malus asiatica*).

Chinese flowering quince is generally scattered along river valley areas at elevations below 3000 m. It is an important fruit to use as rootstock for apple. Through experiments in recent years, horticulturists have found that it can make apple trees flower and bear fruit early. Now more studies on this rootstock are in progress.

In the Himalayan mountain area, there are about 60 cultivars of apple, 20 of pear, 6 of peach, and 4 of grape vines. Most of these cultivated fruit trees were introduced from the interior of China and can produce high and stable yields, as well as maintain the good characteristics of cultivars grown in their native place when transplanted to suitable areas in Tibet. However, in certain cultivars introduced, fruiting period has changed and quality has deteriorated.

In Tibet, only apple and pear have important commercial significance; other fruits, such as orange, peach, and grape, are not produced in sufficient quantity to be commercially viable. A brief introduction to the apple cultivars is given in Table 9.1.

TABLE 9.1

Characteristic features of apple cultivars

Species name	Bearing age (year)	Fruit quality	Harvest time	Storage property (day)
American Summer Pearmain	4–5	very good	first 10 days of Sept.	
Golden Delicious	4–5	very good	middle or late October	150
Starking	5	very good	middle 10 days of October	150
Jonathan	5	very good	middle 10 days of October	150
White Winter Pearmain	4–5	excellent	middle 10 days of October	120
Rall's	6	good	last 10 days of October	150
Huanong No. 1	4	good	middle 10 days of October	150
Yellow Transparent	3–4	average	first 10 days of August	15
Red Transparent	3–4	average	early or middle August	15
Mcintosh	4–5	good	middle 10 days of September	100
Cravenstein	5	good	middle 10 days of September	20
Ben Daris	4–5	good	middle 10 days of September	90

Distribution of Cultivated Fruit Crops

With an area of 800,000 square m, the Himalayan-Hengduan mountain region has a wide range of ecological conditions from north to south and from east to west. Because the natural conditions are extremely complex, with vertical variation of land form and temperature and varying degrees of influence by the monsoon, this region can be divided into three areas, excluding the northwest part of the region, which has no fruit crops.

HOT HUMID AREA IN THE SOUTH

All the area, except Zayu county, is located to the south of the Himalayas. Mountains, valleys, and canyons have developed because of serious down-cutting of the river. Influenced by the warm, damp air current from the Indian Ocean, with high temperature and abundant annual rainfall (usually more than 1500 mm), this area, at elevations lower than 1000 m, is suited to tropical and sub-tropical fruit crops such as banana, mango, litchi, longan, orange, papaya, and jackfruit.

TEMPERATE SEMIARID AND SUB-HUMID AREA IN THE MIDDLE

The middle and lower reaches of the Yarlung Zangbo river with an elevation of over 3000 m is mostly located in the sub-humid and semiarid zone with annual rainfall of 700 to 400 mm from east to west, heat (> 10° C, accumulated temperature is 2000–6000° C), abundant sunlight (annual sunshine 1500–2500 hours), large daily temperature differences (9–17° C) and lower humidity (relative humidity below 70 per cent). The natural conditions here are suitable for temperate fruit crops especially apple, pear, grape and peach. With the favourable climate, fruit trees in the area bear earlier, with high and stable yields and good quality fruit with good flavour. Besides the cultivated fruit trees, there are also many wild fruit trees, such as walnut, in this area.

HOT ARID RIVER VALLEYS IN THE EAST

Located south of the Sichuan-Xizang highway and east of the Himalayas, this area belongs to the Hengduan mountain region and includes the valleys of the Jinsha, Lancang, and Nujiang rivers. Due to its topography, cultivated fruit crops are limited to the valleys and gentle slopes. The broad valley bottoms and basins, where the climatic condition is hot and dry, are suitable to develop deciduous fruit trees such as pomegranate, grape, and walnut. At high elevations and long, gentle slopes, where the climate is temperate, peach, pear, and apple are grown. Although there are some sub-tropical cultivated fruit crops, such as orange, on the south valley bottoms of the Hengduan mountain region, the transplanting of fruit trees has been restricted because of low yield and poor quality.

Resource Assessment of Leading Fruit Crops

APPLE

Apple, a temperate fruit, of which the native habitat is the inland area of Eurasia, is suitable to these natural conditions: mild temperature (average annual temperature is 7.5–1.4° C,) appropriate rainfall (about 550 mm), abundant sunshine (annual sunshine 1600–1800 hours), and sunny, gently sloping land on the lee side with deep rich soil.

With favourable climatic conditions, most valleys in the Himalayan-Hengduan mountain region, especially in Nyingchi, Mainling, Bomi, and Nangxian of the Tibet Autonomous Region and Maowen, Xiaojin, Yanyuan, Batang, etc. of Sichuan province, are suitable for apple growing (Table 9.2). In these counties, the average annual temperature of 8.5–13° C and sunshine time of more than 2000 hours can meet the needs of various varieties (i.e., early-middle and late-maturing varieties); with appropriately lower temperatures in winter, the apple tree can

TABLE 9.2

Comparison of climate data of apple growing areas between arid valleys in the Himalaya–Hengduan mountains and other selected locations

Growing area	Average annual temperature °C	Average temperature in January °C	Extreme lowest temperature °C	Average temperature in July °C	Annual rainfall (mm)	Annual sunshine (hours)	Relative humidity (%)
Nyingchi	8.7	0.4	−11.4	15.8	587.7	2053.5	63
Bomi	8.6	0.2	−13.3	16.5	792.7	1596.9	72
Maowen	11.2	0.4	−11.6	20.8	492.7	1565.9	72
Xiaojin	11.9	2.0	−11.7	19.9	617.2	2188.7	52
Yanyuan	12.6	5.3	− 9.7	18.4	490.0	2600.1	59
Batang	12.4	3.6	−12.8	19.5	516.8	2437.7	47
Yantai*	12.6	− 1.9	−15.0	25.8	623.2	2624.5	65
Xiongyue**	9.2	−9.2	−30.4	22.4	657.7	2777.5	65
New York	10.2	−0.9	−23.3	22.3	1065.0	—	66
Yakima***	9.9	−2.5	—	21.7	199.0	—	50

* Yantai is in Shandong province, eastern China

** Xiangyue in Liaoning province, northeastern China

*** Yakima is in Washington state, USA.

pass its dormant period normally; apple trees can be kept from freezing although the extreme lowest temperature is −12°C; annual rainfall of 500–800 mm, mainly occurring in April to October, can satisfy the demands of apple growing and bearing on the whole; it is favourable to the sugar accumulation in apples because of the high elevation (usually above 2500 m in this region and in other apple growing places lower than 500 m) and because of large daily temperature differences. In most arid valleys of the region, the sugar content is high (usually 10–20 per cent) and acid content is lower (less than 0.5 per cent) in apple fruits (Table 9.3). Apple production of some valley counties in the Hengduan mountainous region is shown in Table 9.4.

TABLE 9.3

Sugar and acid content in apples grown in arid valleys of Hengduan mountain region

County	Variety	Inducing sugar (per cent)	Invert sugar (per cent)	Total sugar (per cent)	Total acidity (per cent)
Xiaojin	Starking	13.05	2.70	15.75	0.22
Maowen	Starking	12.18	0.99	13.17	0.16
Xiaojin	Richard-a-Red	11.66	3.39	15.05	0.16
Xiaojin	Golden Delicious	10.15	2.76	12.9	0.20
Batang	Golden Delicious	8.32	4.58	12.90	0.23
Xiangcheng	Golden Delicious	6.90	4.84	11.7	0.37

TABLE 9.4

Apple production of some counties in Hengduan mountainous region (1985)

County	Production (tons)	County	Production (tons)	County	Production (tons)
Lixian	2061	Wenchian	905	Maowen	6208
Heishui	948	Jinchuan	706	Xiaojin	2318
Maerkang	609	Kangding	663	Luding	787
Danba	377	Jiulong	24	Yajiang	44
Daofu	93	Ganzi	1	Baiyu	25
Derong	20	Daocheng	218	Xiangcheng	91
Batang	349	Huili	38	Mianning	191
Yanyuan	2253	Muli	251	Hanyuan	4978

PEAR

Not strictly limited by natural conditions, pear trees can grow in any place where the elevation is lower than 2500 m. In the Himalayan-Hengduan mountain region, pear trees are mainly distributed in the warm arid and temperate arid valleys, especially concentrated in areas such as Xiaojin, Jinchuan, Danba, Hanyuan, counties in the basin of Dadu river. There are about 140 cultivars of pear, which belong to three kinds of species system: *Pyrus bretschneideri* Rehd, *P. pyrifolia* (Burm) Nakai (*P. serotina* Rehd), and *P. communis* L (*P. sativa* DG), in this area.

Growing at altitudes of 1900–2500 m in the belt along the Jinsha river, Jinchuan white snow pear is very famous for its size, appearance, and spicy and juicy taste. According to incomplete statistics, there are about 733 hectares of pear in this region with a production of about 6300 tons. Of this, about 330 tons is produced in the Himalaya and rest in the Hengduan mountainous regions (Table 9.5).

TABLE 9.5

Cultivated area and production of pears in Hengduan mountainous region (1985)

County	Area (ha)	Production (tons)	County	Area (ha)	Production (tons)
Hanyuan	205	6735	Jinchuan	340	5619
Xiaojin	6	113	Markam	32	105
Kangding	4	694	Luding	—	—
Danba	48	880	Jiulong	—	473
Xiangcheng	20	75	Huili	93	1673
Mianning	76	2019	Yanyuan	86	807

ORANGE

The orange is an important sub-tropical cultivated fruit crop and is mainly distributed in the southeast. There are also some scattered orange trees in the counties of Yadong, Zayu, etc., south of the Himalayas. Usually, these trees are planted on alluvial terraces, on mountain slopes, terraced fields, and in the valley basins, along the river. In this region, the vertical distribution of orange trees is 500–1800 m, but its upper limit can reach 2100 m in the counties of Huili and Xichang. According to incomplete statistics, the area under orange cultivation is about 238 hectares and orange production is 760 tons (Table 9.6).

Major Fruit Crop Pests and Diseases

PLANT DISEASES AND THEIR CONTROL

There are about seven major types of fruit plant diseases. A brief description follows.

Selerotium rolfsii *Sacc.* occurs mainly in the orchards of Zhamu, Danqia, Zhalong, and Yigong in Bomi county. The incidence of the disease is 30 per cent in the orchard of Zhamu Forest Station and 36 per cent in

TABLE 9.6

Cultivated area and production of oranges in some counties in the Himalayan-Hengduan mountain region (1985)

County	Area (ha)	Production (tons)	County	Area (ha)	Production (tons)
Hanyuan	53	366	Kangding	–	22
Luding	46	200	Danba	1	3
Jiulong	–	26	Derong	4	18
Huili	27	87	Xichang	8	39
			Total	173	761

Zhamu Orchard. Almost all fruit species are affected by this disease and most of the infected trees die.

Selerotium rolfsii Sacc. appears first on the root collar of the tree and makes the root cortex soft and rotten, then it infects the leaves and makes them wither, and afterwards, the fruits stop developing and at the same time, white fungus hypha appear on the cortex and the tree can fall with a little push.

The reason for the spread of the disease is the cultivation of fruit trees under the sclerophyllous oak trees. In order to control this disease, the following two points should be observed: (1) avoid cultivation of fruit trees in sclerophyllous oak forests and (2) regularly inspect fruit trees. When a diseased tree is discovered, it should immediately be taken out. The treatment to contain the disease includes cutting off the rotten roots, changing the soil around diseased roots, and coating with solution of 2.5 per cent phenyl mercuric acetate (1:300).

Apple scald and canker can harm any part of the fruit, leaf, or branch of both apple and pear. The incidence of the disease is about 46.7 per cent in the orchards of Nyingchi county, and because of the disease, about 5000 kg of apple is lost every year in Danqia Orchard in Bomi county.

Control measures are: to spray every 10 days with lime-sulphur mixture during florescence (from late April to late May in the region), about four to five times every year; to trim the tree rationally for the sake of air ventilation and light transparency in the canopy; to apply fertilizer and to inter-till and weed to enhance disease resistance.

Apple mildew is found mainly in the counties of Bomi, Nyingchi, Mainling, and Luokong, and infected varieties are Jonathan, Ralls, American Summer Pearmain, and Huanong No. 1. It is very harmful to inflorescence, new growth of phyllotaxy, and fruit. The disease usually occurs from the middle of April to the first 10 days of June and the harmful process lasts for about 50 days.

Control measures are: removal of wild Chinese flowering crab-apple, which is the source of the disease; cutting off disease-infected branches and buds; spraying with lime-sulphur mixture (0.5 degree) four to five (once every day); improving orchard management; applying phosphate and potash fertilizer to ameliorate the soil.

Apple leaf spot may occur anywhere in the Himalayan Mountain Region, but the most seriously affected areas are Zayu county and Bomi county. The leaves will fall 30 to 45 days earlier than normal if the fruit tree is infected by this disease. Among the various varieties, Ralls, Jonathan, and Golden Delicious are the cultivars most susceptible to the disease.

Control measures are to put prevention first: clearing away the source of disease; cutting the disease-infected leaves and branches; improving water and fertilizer management; taking plant quarantine; spraying with pesticide 10 days before the disease occurs and then spraying once every 10 days. The commonly used pesticides are Bordeaux mixture (1:2–4:200) and 50 per cent thiophanate methyl (1:800).

Taphrina deformans (Berk.) Tul. occurs in the orchards of Bomi county and Nyingchi county and mainly harms leaves, new growth, and branches. When a tree is affected, its leaves crumple and the colour turns from green to pink, even to crimson, after which the leaves will be coated with a layer of white-grey powder.

Control measures are: spraying with Bordeaux mixture (1:100) to eliminate the source of the disease in early spring; sprinkling leaves with lime-sulphur mixture (0.5 degree) once every 10–15 days after the tree blooms; cutting off disease-infected branches in winter and burn diseased leaves when they are discovered.

Rotten disease can cause two major types of symptom: one is ulcerous and the other shows withered branches.

Control measures are: improving cultivation management; ameliorating the soil by improving soil water conservation; applying phosphate and potash fertilizer to enhance disease resistance and drought resistance; coating the stock with white powder to decrease radiation intensity.

Sun heat scathing generally, occurs in the high mountain valleys with an elevation of above 3000 m such as Lhasa, Xigaze, Gyangze, and Qamdo. It harms the inner part of the trunk stem and makes trunk, canopy, and branches wither. Trunk rot often takes place in the damaged parts of the tree.

Trunk rot results from intense sun radiation and physiological drought in spring. Germs (pathogenic bacteria) intrude into the trunk through the infected parts, while the bark is burnt and injured, when brown disease spots will appear on the trunk surface. The controlling measures for this disease are the same as for *rotten disease*. The tree will wither and die when the disease spots encircle the trunk.

Fruit Pests and Their Control

Red mite is a very prevalent pest in the area of semiarid valleys of Lhasa and Xigaze. Red mite mainly attacks old orchards.

This pest is always seen around the main veins on the backs of leaves. It spins a type of cobweb that directly influences the flowering and fruit setting of fruit trees.

Control measures are: binding grass on the crotch of a tree, the surviving place of the pest during winter, and burning it to kill the mite; spraying high concentration liquid of dichlorvos to kill pest; clearing away the source of the pest; spraying lime-sulphur mixture (0.6 degree) or 45 per cent Rogor liquid (1:2000) just before flowering.

Eye-spotted bud moth mainly occurs in the counties of Nyingchi, Bomi, Mainling, and Lhasa. The affected part is leaf and blossom but young fruits are also harmed to some extent.

Control measures are: spraying with a mixture of DDT emulsion and wettable benzene hexachloride powder once every 10–12 days at fruit forming stage.

Excepting the two main types mentioned above, other pests and their countermeasures are listed in Table 9.7.

TABLE 9.7

Some pests and their countermeasures in orchards of the Himalaya-Hengduan mountain region

Pest	Distributed area	Countermeasures
Apple longicorn beetle	Qamdo	Pour BHC liquid into pest holes
Peach fruit borer	Yadong	Spray sulphur-phosphorus mixture and dust with BCG powder
Apple aphid	Lhasa, Nyingchi	Spray BHC liquid (1:200)
Cocoid (scale louse)	Lhasa, Nyingchi	Spray diesel oil emulsion (1:100) or to sprinkle DDT
Clearing moth	Zayu	Scrape warped bark and kill the pests
Green yellow eggar (lappet moth)	Yigong	Sprinkle 50 per cent dichlorvos liquid (1:1000)
Greenish brown hawk-moth	Nyingchi, Bomi	Spray DDT liquid (1:200)
Peach aphid	Nyingchi, Bomi	Spray wettable benzene hexachloride (1:200)

Fruit Harvesting and Post-harvest Operations

The fruit harvesting season is dependent on the biological characteristics of fruit species and varieties concerned, but is also influenced by climate, soil conditions, management levels, and cultivation techniques, as well as by relevant fruit use. Take apple as an example; in the Himalayas, the picking season for most varieties is middle or late October, excepting Yellow Transparent and Red Transparent, for which the picking season is early or middle August.

The fruit should be kept free from any form of damage such as by hails, rough handling, rub-wounds, and pressure injury at the time of harvesting. Different picking methods should be adopted for different kinds of fruit and their biological characteristics. For example, apple and pear can be picked by hand because it is very easy to remove carpopodium from the branch, but grapes should be cut with shears to separate them from its branch.

When harvesting, the picking order should be lower fruits first, then the upper, and the outer fruits before the inner.

It is necessary for safe transportation to pack fruits suitably. But in Xizang, very little fruit packing is done except when the fruit is put on long-distance transport. Even when fruit is packed, the packing containers are very simple and crude, and mainly made from wicker.

Packing methods vary with different kinds of containers. For round containers, fruit should be circularly arranged. For example, apple is circularly arranged layer upon layer in baskets. For rectangular containers, such as pear boxes, fruit is usually placed in rows.

In Tibet, fruit transport mainly depends on highway transportation. According to available data, there are about 15 arterial highways and 315 feeder highways with a total length of 21,551 km. But most of these highways are rudimentary, often jeopardized by glaciers, frozen earth, landslides, and mud-rock flow. So even now, pack animals are used for fruit transport in many places.

In Tibet, the main, kind of fruit preservation is natural cold storage for the relatively small quantity of fruit, rather than artifical refrigeration. The early-maturing varieties such as Red Transparent and Yellow Transparent can be stored for shorter periods than middle or late-maturing such as Jonathan, Delicious, and White Winter Pearmain, which can be kept for a long time.

There is little or no surplus fruit available in Tibet. Much of the fruit production is sold in Lhasa and a very small amount is marketed at local county towns.

There is no fruit processing industry in Tibet at present because of lack of transportation, the non-availability of raw materials such as glass and tin plate, and lack of equipment for processing which is difficult to buy and to transport; the other reasons are the backwardness in science and technology and the lack of technical personnel in Tibet. These are major drawbacks for fruit production in Tibet and more attention should be paid to them immediately through suitable measures to improve conditions and by overall planning.

Measures to Increase Fruit Production

Better transport services and stronger technical advice and management in areas such as Bomi, Nyingchi, NanXian, Jiacha, and Mainling should enlarge orchard area, improve management, and solve the problems of processing and storage of fruits and thus become the bases for fruit supply. The government should positively create factors to support the development of collective orchards, and also encourage individual cultivation, so as to ameliorate the present situation of produce supplied by only a few places. This would not only enliven the economy of the mountain area, but also improve the people's nutrition conditions.

In order to guarantee a longer period of fruit supply every year, advantage should be taken of the fact that Tibet ranges widely from south to north and its topography undulates. For variety selection, attention should be paid to having an appropriate mixture of early, medium, and late varieties to regulate the market supply.

The management of orchards should be strengthened, raising the output and quality of fruit produce. This includes cutting tree branches, increasing applications of manure and irrigation, preventing plant diseases and insect pests, and timely harvesting of the fruits.

Agricultural production is mainly carried out by peasant families. For this reason, the production and management of fruit trees must encourage peasant families to grow fruit trees. The government should implement a protective policy for the development of horticulture. There should be proper arrangements for training and guidance in cultivation and management, and essential inputs should be provided.

Introduction of Imported Plant Material

In the initial stages of fruit production it is essential to import a large number of fruit plants. However, there are also cultivated and wild varieties of fruit trees in Tibet which should be collected. Trials should be carried out on the imported plant material before introducing it on a commercial scale. Cultivars should be of good quality with high productivity suitable to local conditions resistant to frost, drought, plant diseases, and pests.

A professional study should be established on production and problems of the fruit sector to solve the various problems that occur. The breeding, planting, and popularizing of good varieties are needed to accelerate development.

The dwarf tree has the advantage of maximum use of solar energy, manure, and water, is convenient to manage, has feasibility for mechanization, and is reasonable in land use. Having begun with wild Chinese flowering quince as apple stock, Tibet should now continue to experiment and cooperate with other areas for exchange of information and plant material.

Walnut

Level and Distribution of Production

Walnut, an important oil-bearing and timber-producing tree, is widely distributed throughout the dry valleys of the Hengduan mountains to Jilong area in the east, Tibet in the west, and from mountains of medium height in the south to the southern edge of the northern Tibetan Plateau in the north. At present, over 700,000 walnut trees have been planted, and 1000 tons of walnut is produced annually.

The counties of Jiacha and Nangxian are the areas where walnut trees are most widely distributed. The quantity sold annually was 75 tons in the 1970s. Next come Bomi, Markam and Zogang in Qamdo area with yearly sales amounting to 60 tons. In Lhasa area, the annual quantity sold is less than 30 tons, with Nyingchi and Mainling as the main distribution places.

Geomorphologically, walnut trees are widely planted at elevations of 1500–4000 m, with the highest going up to 4300 m which has surpassed the upper limit for walnut growing not only in the northern temperate zone, but also in eastern areas with the same latitude. For example, the upper limit for walnut distribution is 1000 m in China's mountains, and 2000–3000 m in Yunnan and Sichuan provinces in the same latitude. The height of the vertical distribution relates mainly to land form and climate, especially the thermal conditions. According to the record, at the upper boundary of walnut distribution, the average annual temperature is 2–4°C, the average temperature in January −7°C, and the minimum temperature −16°C. It has been observed that when anti-cold measures are taken, walnut trees can survive winters with the minimum temperature at −25°C.

The water regime for walnut cultivation is flexible. The trees can grow in semiarid and sub-humid areas with an annual precipitation of over 400 mm, and a relative moisture of 40–60 per cent. They are also widely adaptable to soil; for example, provided the climate is suitable, yellow-brown soil, steppe soil, as well as meadow soil with pH value around 7.0, will be acceptable in mountain as well as valley locations. However, deep, well-drained, sandy soil on sunny slopes is the most favourable.

The varieties of walnut in Tibet are varied, with thin-carpodermis, and thick-carpodermis being common, of which Jiamian walnut is the most widely distributed. Table 9.8 shows their growth properties,

TABLE 9.8

Growth properties of the Tibetan walnut

Variety	Diameter length (mm)	Size width (mm)	Fruit weight (g)	Kernel weight (g)	Shell thickness (mm)	Kernel producing ratio	Oil bearing (per cent)	Protein content (per cent)
Kernel naked	4.0	3.0	6.90	3.70	0.6	53.6	61.6	—
Thin carpodermis	3.3–3.9	3.0–3.5	10–12	4–6	1–15	40–53	65	15–20
Jiamian walnut	3.4–4.1	2.9–3.5	10–14	4.2–6.1	1.5–2.0	35–40	60–68	15–19
Thick carpodermis	3.5–4.2	2.7–3.5	7.5–12	3–5	2.2–6	30–37	60–62	20–25

revealing the good quality of the Tibetan walnut's kernel-producing percentage and oil-bearing ratio. Walnut samples from the Markam area showed that 45 per cent or even over 50 per cent of the kernels produce 65 per cent or even 72 per cent oil.

When the walnut ripens, the involucres turn from dark green to light yellow, some of which split or even detach from the kernel. This is a suitable period for harvesting. If this harvesting period is missed, the walnut quality will be affected adversely.

Post-harvest Processing

Post-harvest processing also influences walnut quality. If half the involucres have split, they become easily detached from the walnut after several days' lying about in houses. Frequently, turning over is necessary to prevent the involucres from becoming rotten and then polluting the walnut. After the involucres are detached the wet walnut should be bleached with water every three hours, otherwise, the conducting bundles on the base of the walnut will contract, allowing the bleaching water to penetrate and make the kernel discoloured or even rotten.

Generally, walnuts are not further processed in Tibet. Traditionally, Tibetan people do not like walnut oil. Therefore, after primitive processing, the walnuts will be sold to the government or kept for guests.

Insect Pests and Plant Diseases

Insect pests and plant diseases rarely existed in the wild walnut trees of the Himalayas, but they often occur in introduced varieties. Some of these are very harmful. The two most common pests are *Lebeda nobilis* Walker and *Batocera horfieldi* Hope.

Lebeda nobilis Walker is very harmful to walnut cultivation. It eats the leaves and thus affects the growth of the plant. Usually, this pest occurs in trees which were introduced from Xinjiang Uygur Autonomous Region, in the counties of Bomi and Yigong.

Control measures are: killing the ova or pupa in winter and autumn; and luring the pest with light traps. Spraying 6 per cent wettable benzene hexachloride suspension (1:400) before July is often helpful.

Batocera horfieldi Hope is a kind of large moth and mainly harms the introduced walnut planted in or near oak forests. Among the affected trees, 20 per cent of them die due to withering.

The affected dead wood should be removed. Spraying with 50 per cent phosphamidon or 50 per cent fenitrothion (1:40) is effective for the control of the pest.

Recommendations for Development

Walnut cultivation is not well developed in Tibet. Before 1956, walnut production was practically left to its natural state without human intervention. Since the 1970s, increasing attention has been paid. Some walnut cultivars were introduced from Xinjiang and have been cultivated successfully in Tibet.

At present, however, many problems remain unsolved. The most serious is the lack of proper management. Walnut orchards have not been formed and production is low and increases only slowly. In some places, the walnut trees have even been cut down for crop planting.

To develop walnut production in Tibet, attention should focus on several aspects.

The significance of walnut development should be made known to the local Tibetan population and, at the same time, guidance and planning should be strengthened. Walnut production is more labour-saving and money-saving than any other kind of cultivation. For example, one walnut tree can produce 40 kg walnut, going up to 75 kg, and as much oil as rape, but with only five to seven man-days. This is particularly important for the middle, southern, and eastern parts of Tibet, where there are vast mountainous areas but very little manpower. As shown from the statistics for Yunnan province, in the total agricultural production, walnut accounts for 0.7 per cent of the investment and 5.4 per cent of the labour power, while it is as high as 30.9 per cent of the total gross agricultural production. Moreover, walnut trees are also an important factor in soil and water conservation.

In the development of walnut production, both good local and improved imported varieties should be promoted. Scientific study should focus more on local varieties which are best suited to the local environment, more resistant, and continuously productive. Acclimatization studies are needed for imported varieties, because the environment is different from the original habitat. The experiments conducted on imported Xinjiang walnut in Lhasa and Xigaze showed that it can grow normally although some young shoots may wither in the first two years; it blossoms and bears fruit after only four to five years, which is a very good sign that it is productive. In Yunnan province it was found that the introduced Xinjiang walnut grew slowly with small nut and low production. This must be taken into consideration in Tibet.

The study of walnut cultivation should be strengthened. Due to unique land form, walnut trees are commonly planted at elevations of over 1300 m, where cold winter and dry spring may cause young trees to be damaged. Studies should be carried out to identify the best conditions for walnut trees to survive the cold winter and to discover the best measures to prevent damage from frost and excessive cold.

Walnut processing should be developed, which includes the adoption of proper methods for walnut detaching and desiccation, and methods to further process the kernels.

In Tibet there are many old walnut trees. Old branches should be cut to permit new ones to develop. The walnut tree will then recover and bear several years later.

Walnut orchards should be developed where conditions permit. Intensive management will raise the quality and commercial value of walnut production.

Tea

Tea, a species of *Camellia* genus, is a typical plant of the sub-tropical evergreen broad leaved forest. It originated in southeast Asia, and is found in China in the sub-tropical mountains of Yunnan, Guizhou, and Sichuan provinces.

China has a long history of tea use and cultivation. However, the history of tea cultivation is relatively short in the Hengduan mountains and even shorter in the Himalaya of southern Tibet.

History of Tea Cultivation in the Himalaya

Tea is in great demand in Tibet, where there is a tradition of tea drinking. Before 1956, tea was imported from faraway Yunnan and Sichuan provinces through the long, rugged mountain terrain and was too expensive for ordinary people to consume. The demand increased quickly with the improvement of transportation and living standards after 1956, and the Chinese government decided to introduce and plant tea on the southern flank of the Himalaya and southeast Tibet, originally regarded as an unfavourable area for tea cultivation.

There were two stages for tea introduction and plantation. The first was an experimental period of small plantations before 1970. Because of mismanagement, tea planted in 1956 was put into production as late as 1964. However, success was achieved in Zayu, Bomi, Cona, and Nyingchi counties, which are now important centres for tea cultivation. Different methods of tea leaf processing, such as Maofeng, Meicha, Longjing, and Biluochun, were also successively applied.

The second stage was large-scale plantation after 1971. Tea plantations have now spread to 28 counties among which Zayu, Bomi, Nyingchi, and Cona counties, have shown very good results. By 1986, the area under tea had reached over 133 hectares and tea leaf production stood at 47,600 kg.

Species and Varieties

There are many species of wild tea. Through introduction, domestication, and cultivation, many cultivars, mutations, and cross breeds have been developed and planted.

Tea is more abundant in the Hengduan mountains than in the Himalaya. For example, in Miaoxi tea garden, cut across Tiangquan, Lushan, and Baoxing counties in Sichuan province northeast of the Hengduan mountains, there are cultivars for green tea making like Sci No. 21 and those for black tea such as Shu-Yong No. 3, No. 307, and No. 808. Among these cultivars, Shu-Yong No. 3, No. 307, and No. 808 have proved to be cold-resistant and productive. In the southern Hengduan mountains, the 400-year-old Fengqing tea garden in Yunnan province has five main species in cultivation: reddish-bracted, small-clustered, rape-flowered, large-leaved, and small-leaved teas.

In the Himalaya, tea species and varieties were mainly introduced from Sichuan and Yunnan provinces. Now both large-leaved and small-leaved species are cultivated. The two species are biologically and ecologically dissimilar. The small-leaved tea has a significant tree structure of strong trunk, high ramification, and condensed tree crown. The internodal length in the new shoot is short and the attached new leaves dense; the old leaves are dark green, leathery, and small. Its white flowers blossom early in the year. It is more cold resistant than the large-leaved species, therefore, more widely adaptable and distributed. The large-leaved tea has a typical tree structure of great size with open crown. The new shoots are thick with long internodal length and large, fleshy new leaves. The leaf is well shaped, tipped, and of pure flavour. It blossoms and bears late. Vulnerable to cold weather, it is not suited to all conditions.

Ecological Suitability and Distribution

Climatically, the tea bush requires high temperature and high humidity, with an average annual temperature of above 10°C, an accumulative temperature of over 3000°C, annual precipitation of above 1000 mm and average relative moisture about 80 per cent. Tea begins to germinate at temperatures over 10°C and put out new shoots if adequate water is provided. The most suitable temperature for tea growth ranges from 20°C to 25°C, and it is unfavourable outside that range. A temperature of over 35°C may cause damage, preventing growth and withering the shoots; lower than −15°C will cause most of the above-ground parts to die. Its water requirement is at least 800 mm annual precipitation. Generally, the whole tea plant contains as much water as 50–60 per cent, and the tender leaves as much as 70–80 per cent. Rainfall of 100 mm/m and 80 per cent relative moisture will make the tea leaves of high quality.

The tea plant prefers well-drained acid soils of pH 4.5–5.6; when the pH is over 7 or less than 4, the tea plant does not grow well.

Generally, the environment in the Himalaya and Hengduan mountains can meet the needs of tea growth as described above. In the northeastern and southern Hengduan mountains, the conditions are very suitable. The yellow forest soil has pH values of 5.5–6.5. This may be seen from Table 9.9.

TABLE 9.9

Climatic conditions in the Hengduan tea cultivation area

Location	Elevation (m)	Temperature (°C)					> 10°C	Rainfall (mm)	Relative moisture (%)
		average	Jan.	July	Min.	Max.			
Yaan (NE)	800	16.2	6.1	25.4	−1.9	3.5	5058	1750	79
Miaoxi (NE)	1100	13.7	—	—	−5.5	34.6	—	1448	86
Fengqing (S)	1950	16.5	10.3	20.8	−0.9	32.7	—	1322	73

NE: Northeast Hengduan. S: Southern Hengduan

In the Himalaya, the growing areas are heterogeneous. Thermal conditions vary greatly, as shown in Table 9.10. In the low elevation of Medog and Zayu areas, thermal conditions are within the most suitable range. In the areas lower than Zayu and south of Medog, conditions are even better, with rich precipitation. For instance, in Beibeng village at 600 m above sea level, the average annual temperature can be 21°C, > 10°C accumulative temperature over 7000°C, the mean temperature in the coldest month nearly 15°C, and the minimum temperature 4°C. Thermal conditions decline with the increase in elevation, though an elevation of 2500 m is acceptable for tea cultivation, e.g. in Dongjiu tea garden, tea grows normally. The introduced tea varieties are so cold-resistant as to endure temperatures of −5°C to −16°C; and the small-leaved breed can even tolerate up to 10 continuous days at temperature of −1°C to −16°C provided the more cold-resistant breeds are selected for cultivation, and with the adoption of anti-cold measures, tea can be grown even higher. Obviously, tea has reached its highest elevation here, compared with other areas in the same latitude.

The moisture regime for tea-growing areas in the Himalaya is also varied with annual precipitation ranging from 700 to 2000 mm, and relative moisture between 60 and 80 per cent. In some areas, moisture conditions are lower than the normal requirement and this restricts the development of tea cultivation, its growth, and its quality as shown in Table 9.11.

Soil factors in the Himalaya are also favourable for the cultivation of tea. The yellow and reddish-yellow soil is similar to that of sub-tropical evergreen broad-leaved forest and tropical evergreen rainforest at eleva-

TABLE 9.10

Thermal conditions for tea gardens in the Himalaya

Location	Elevation (m)	Temperature (°C)					10°C	Frost-free days/year
		average	Jan.	Min.	July	Max.		
Medog	1100	18.6	11.6	− 0.2	24.6	33.8	5898.7	300
Lower zayu	1590	51.3	8.3	− 0.5	21.6	33.3	4729.9	284
Zayu	2328	11.6	3.9	− 4.5	18.8	30.9	3140.4	205
Yigong	2250	11.4	3.3	−10.7	18.1	32.8	3109.6	210
Dongjiu	2500	11.9	4.4	−12.4	17.5	25.9	3080.9	—
Zhamu	2750	8.5	− 0.4	−20.3	16.5	31.0	2286.9	161

TABLE 9.11

Water regime of tea gardens in the Himalaya

Location	Elevation (%)	Annual rainfall (m)	Relative moisture (mm)	Aridity (%)
Medong	1100	2357.6	80	—
Lower Zayu	1500	998.6	69	1.26
Yigong	2250	960.4	73	0.59
Dongjiu	2500	703.1	77	—
Zhamu	2750	935.8	69	0.56
Zayu	2327	764.7	67	0.84

tions lower than 1800 m. The whole soil profile presents acid reaction; the pH value of the upper soil is 4–5, and deeper down it is 5.5–6.0. The humus layer is thick and the necessary plant nutrients are sufficiently available. This is the most suitable type of soil for tea cultivation. On the impoverished soil of coniferous forest, where the pH value is nearly 7, tea is not widely suitable, except for some areas with deep soil horizon and relatively high humic composition accompanied by acid fertilization. On the shaded slopes at an elevation of 1800 m in the evergreen and deciduous broad-leaved mixed forest, yellow-brown soil dominates, which should be selected for tea cultivation.

On the whole, in the Hengduan mountains, tea can be planted at elevations of 800–1500 m in the northeast, and at around 2000 m in the south, while in the Himalaya, tea plantations are distributed at elevations 1000–2500 m on the southern flanks.

Growth, Management, Production, and Quality

GROWTH

Tea grown in the Himalaya has the following characteristics:

- Elevation is the most important decisive factor for tea growth. For example, tea can grow in one year to 25 cm height at an elevation of

1800 m while it grows to 10 cm at 2500 m.

- The area is not continuous or large. Instead, it is scattered as a result of the uneven land form and varied environment. Different distribution areas obviously differ.
- The number of terminal buds per unit area is 450–650 every square metre, far less than production in east China. However, the weight per shoot is rather high; according to research done in Dongjiu garden, the shoot of one terminal bud and one leaf weighs 0.387 g, and that of one bud and three leaves 0.577 g, with the highest being 1.2 g, which surpasses the level found in east China.
- Tea roots are distributed underground according to character. Nearly 80 per cent of the roots are distributed on the soil layer of the upper 30 cm, which indicates the focused part in fertilization.

The growing properties in different tea gardens are shown in Table 9.12.

MANAGEMENT

In the Hengduan mountains, tea gardens are well managed by a set of measures.

- *Fertilizing system*: Suitable proportions of different fertilizers have been recognized according to the soil condition, comprising 1500 kg organic manure, 100 kg oil residue, 5 kg nitrogenous fertilizer, and some phosphoric fertilizer. Organic manure has to be added in the spring, accompanied by small amounts of nitrogenous and phosphoric fertilizers.
- *Plucking system*: In the spring, the terminal bud and two or three leaves should be plucked leaving the stipules; in the summer, the terminal bud and two leaves should be plucked, leaving on leaf; in the autumn, the terminal bud and two leaves must be plucked leaving the stipules. Increasing leaf tenderness is done by starting to pluck early when only 10 per cent of the shoots are fit. Every year, after harvesting and pruning, there should be a thorough check of the productivity properties of the tea plants.
- *Selection and cultivation of good varieties*: Since 1983, eight varieties have been introduced, and three of them have been selected as productive and resistant to both cold and disease.

In the Himalaya, management is rather poor. Generally, tea leaves should be plucked about 25 times per year. But in the Himalayas, plucking is too light. In many gardens, tea leaves are plucked only three or four times. In Yigong area, as a result of labour shortage, plucking is done only five or six times. Even in the relatively well-managed Dongfeng tea garden in Nyingchi County, plucking is done only seven or eight times:

TABLE 9.12

Inventory of tea growth in the Himalaya

Location	Elevation	Age	Plot (cm)	Height (cm)	Ground diameter (cm)	Leaf number	Shoot length (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm)	Crown diameter (cm)
Xinchun	1800	1	38 × 150	17	0.18	—	17	2.9	4.8	8.2	—
Dongjiu	2500	1	30 × 50	9.9	0.08	4.6	9.9	2.7	4.6	7.4	—
Dongjiu	2500	2	30 × 150	10.3	0.27	10.8	6.5	2.7	4.9	7.8	15.2
Xinchun	1800	2	30 × 150	53.5	0.06	—	36.5	2.2	3.6	4.6	16.1
Dongjiu	2500	3	30 × 150	60.0	0.06	76.0	33.5	3.5	6.9	14.4	16.1
Dongjiu	2500	6	30 × 150	85.3	1.8	—	27.3	2.8	7.0	11.8	95.0
Dongjiu	2500	10	30 × 150	103.3	2.4	—	24.0	2.4	6.5	9.4	133.0

Xinchun is in Zayu county, and Dongjiu is in Nyingchi county.

twice in the spring beginning from mid-May at intervals of one month, three or four times in summer beginning in July at an interval of 10 to 15 days, and an autumn pruning of leaves for coarse tea. Too many leaves will have been left growing, which is not good for production: the leaf area index is 6.6, 2.5 times higher than that of east China's Hangzhou tea gardens. The other problem of tea garden management in the Himalaya is the insufficiency of fertilization.

Production

In the Hengduan mountains, relatively high production has been achieved and there is a long history of tea cultivation. In the northeast, there are altogether 9440 hectares of tea gardens, and the average production is 525 kg/hectare in the productive area. From Miaoxi tea gardens, fine processed tea leaves can yield as much as 1170 kg/hectare.

However, in the Himalaya, production is very low. On an average in the lower elevations, tea can be put into production within three years, while at higher altitudes it takes five to six years. But mismanagement hampers production. For example, in Yigong area, one of the advanced areas for tea introduction, only 315 kg fine tea and 1125 kg coarse tea per hectare was produced in 1983. Even in the well-managed Dongfeng tea garden, the highest production recorded was only 375 kg fine tea and 1875 kg coarse tea per hectare. Production is increasing very slowly; for instance, based on the total tea garden area of Tibet, the yield was 315 kg/hectare from the total 45 hectares in 1981, and was only 375 kg/hectare from the total 133 hectares in 1986.

Tea Leaf Quality

In the Hengduan mountains, due to good management and high processing, good quality tea leaves have been produced. In Miaoxi tea garden, advanced processing methods were adopted for black tea, a promising tea product for export.

In the Himalaya, the tea processing techniques and mechanism are backward and do not produce quality tea. However, with good processing some good quality teas are now being produced. Maofeng tea and black tea made in Zayu were identified as possessing the properties of size, tenderness, and aroma. Because of the unique spectrum composition and intense radiation in mountain areas, the Himalaya tea has plenty of water extracts and soluble tannic acid.

Diseases

The common diseases are described.

Leaf-speck disease is caused by *Phyllosticta theicola, Colletotrichum camelliae,* and *Gloeosporium theaesinensis*. The tender leaves and new shoots are damaged, and white specks of about 0.1–0.2 mm with brown edges appear.

Black blight occurs widely in the tea gardens of the Himalaya. In Yigong area, black blight is so serious that it may last four to five years and cause production to decrease by one-third. The general causes are *Neocapnodium theae* and *Zukalia nanoensis*.

In areas with rich precipitation or near forests, the environment is so humid that many lichens and mosses develop, attaching themselves to tea bushes, slowing their growth, withering their shoots, and making their leaves small and withered and, therefore, unfit for tea making.

To control leaf-speck and black blight, refer to the measures used to control leaf-speck disease. As for lichens and mosses, the best method may be removal of infected portions of the bush.

Potato (*Solanum Tuberosum*)

General Situation

The potato, alongside rice, wheat, maize, and highland barley, is one of the major crops in the Himalaya and Hengduan mountain region.

Originally from the South American Andes, between 10°N and 20°S at altitudes above 300 m above sea level, potatoes are mainly cultivated in temperate zones. Potato contains high-value protein, various vitamins, especially vitamins B and C, carbohydrates, enzymes, and other substances necessary for human nutrition.

Before the 1950s the potato was mainly cultivated in Yadong, Nyalam, and Gyirong on the southern flanks of the Himalaya, Nyingchi, Bomi, in the forest area on the northern side of the eastern Himalaya, as well as at Aba, Garze, Lijiang, and Xichang Prefectures in the Hengduan mountain region, mostly at altitudes of 2000–3000 m above sea level, while in the middle reaches of the Yarlung Zangbo river, the potato was fragmentarily cultivated on the manor.

The area under potato cultivation has been expanded to the middle reaches of the Yarlung Zangbo river and the broad valleys and basins on the northern flanks of the Himalaya. Various units and institutions of local government and the barracks of the *PLA* grow potato to resolve the shortage of vegetables in the high mountainous regions.

The upper limit for potato cultivation is at Saga with an elevation of 4650 m above sea level in the upper reaches of the Yarlung Zangbo river with semiarid climate; at 4300 m in the southeastern part of areas with sub-humid climate; and at 4300 m at Gar in the Ngari region with an arid climate.

Ecological Characteristics

Despite its wide distribution, the potato is a typical plant of a temperate climate, characterized by a short growing season and high, stable yield.

Potato tubers begin germinating at 3–5°C; 5°C daily mean temperature is considered the lowest possible for plant growing at the seedling stage, and 10°C daily mean temperature is the lowest limit for blossom and tuberization. A soil temperature of 16–18°C is regarded as the most favourable for tuberization, which approximately corresponds to an air temperature of 10–14°C at night and 20°C at daytime. Cool nights (10–14°) are essential for the best yields. Potato tubers are retarded in growth if the optimal temperature is either lowered or raised. The potato will not tolerate frost. It is subject to freeze injury at a temperature of −2 to −3°C, and dies at a temperature of below −4°C.

In the middle reaches of the Yarlung Zangbo river, the temperature regimes in July and August, with a mean temperature of 15–20°C in the daytime, 8–10°C at night, and a ground temperature of 18–20°C at 10 cm below the surface are favourable for high yield of potato tubers. The middle- and late-maturing varieties with a growing season of 150–180 days can be widely used in this area.

On the northern flanks of the Himalaya with an elevation of above 4000 m above sea level the mean temperature of 10–15°C at daytime, 4–8°C at night, and a ground temperature of 14–18°C at 10 cm below the surface in the warm season, the early-maturing variety with a growing season of 100–120 days is suitable.

At the initial stages the potato does not require much moisture. Its requirements for moisture reach a maximum during the period of flowering and the plant develops well only if the soil moisture reaches 60–80 per cent of the field water capacity.

The potato, being a light-preferring plant, forms its flowers and tubers at any day length, but with shorter days the development is considerably increased. Long, warm days with moderate sunshine prove to be favourable for haulm growing, while short days are necessary for the growth of tubers.

Deep, well-drained, aerated, light-textured, fertile loam is preferred for potato cultivation; the pH may range from 4.8 to 7.8. Because the tuberization zone is mainly located 10–15 cm underneath, porous soils well aerated are favourable for root development and tuber growth.

Sandy soil is suitable for sprouting tubers with a good quality and high yield, as well as resistance to disease; while clay soil, located at wet lowlands, is unfavourable to tuberization of the potato because of drainage difficulty. Most of the soils in the study area are suitable for potato cultivation.

The potato must be, primarily, resistant to disease degeneration and drought. Early-ripening varieties of potato, because they produce tubers in short growing periods (usually three months, maximum four), have been frequently used in the Himalayan and Hengduan mountain regions.

Present Extent of Cultivation

In the Hengduan mountain region, the area under potato cultivation made up 1/10th of the total cultivated area of cereal crops in the 1960s. Of this area, Liangshan and Xichang account respectively for 27.1 per cent and 24.6 per cent, Li-jiang 20.3 per cent, Aba 14 per cent; Garze, Diqing, and Nujiang together account for the remaining 14 per cent.

According to a study made on the altitudinal variation of farming types in central Yunling, located in the middle section of the Hengduan mountains, the area under potato cultivation accounted for the following shares in total cultivated areas (including buckwheat and oats) of the different farming types:

- Crop farming dominant in broad valley basins: 14 per cent
- Forestry and agriculture combinations on slopes and piedmont of hills and mountains: 41 per cent
- Forestry, agriculture, and animal husbandry combinations on mountain slopes and intermontane basins: 58 per cent.

It can be seen that the proportion of area under potato cultivation dominates the higher elevations. This is because the geo-ecological conditions do not suit the major cereal crops.

In Lhasa prefecture a moderate estimate puts the total area under cultivation of potato at 1120 hectares in 1985, when it made up 2.96 per cent of the total area under cultivation.

It can be seen that the area under potato cultivation made up a much higher proportion of the total cultivated area in Lhasa city and the adjacent counties (Table 9.13).

Based on incomplete statistics in 1981, the total area under potato cultivation in Lhasa and Xigaze accounted for 120 hectares, the tuber production amounting to 215 tons; of which about 72 per cent of the total area (under potato cultivation), and 73 per cent of the total potato production are respectively planted and produced by farmers, both cooperatives and individuals. (Table 9.14)

On the basis of experiments in Lhasa, the yield of potato tubers could reach 23–38 tons/hectare. The statistics show that yields (Table 9.13) are much lower than the potential productivity, resulting possibly from the normal mixed cultivation of potato and rape in the region.

TABLE 9.13

The area under potato cultivation in proportion to the cultivated area of cereals, Lhasa prefecture, 1985

County	(A) Total cultivated area (ha)	(B) Area of cereal crops	(C) Area under potatoes (ha)	(D) Proportion of C/B (per cent)	(E) Total production of potato (tons)
Nyingchi	2,600	2,160	7	0.31	150
Gongbogyanda	3,400	2,647	47	1.76	156
Maizhokunggar	5,733	4,607	113	2.46	304
Dagze	4,533	4,320	193	4.48	373
Lhasa	2,400	2,280	120	5.26	286
Doilungdeqen	6,400	6,100	273	4.48	517
Quxu	4,267	3,967	133	3.36	250
Nyemo	2,933	2,747	60	2.18	96
DamXung	—	—	—	—	—
Lhunzhub	6,467	5,580	147	2.63	171
Medog	1,133	940	—	—	—
Mainling	2,933	2,433	27	1.10	53
Total	42,799	37,781	1,120	2.96	2,356

TABLE 9.14

Cultivated area and production of potato in Lhasa and Xigaze (1981)

Responsibility system	Total	State farming	Collective enterprise	Institutions and individual barracks	Cooperatives, individual farmers and others
Area (ha)	120	7	7	20	87
Yield (ton)	215	7	13	38	157

Cultivation Techniques

PLANTING

The successful cultivation of potatoes in the study area depends primarily on the proper timing of cultivation activities.

In the Hengduan mountain region two planting times have been accepted, early spring and summer, depending chiefly on geo-ecological conditions and cultivation habits. Early spring potatoes depend on the temperature regimes of the initial growth period and the early spring potatoes are mainly planted in the plateau and upper mountain areas. Planting takes place from the middle of February to mid-April, and harvesting from the end of June to the end of September. The summer potatoes are planted after the harvesting of early maize and wheat, from the end of June to the middle of July, and are harvested in October. The early-maturing varieties should be selected for their short growing season. Winter potatoes, planted mainly in the river valley at low altitude on the southern section, are planted from the end of October to the middle of November, and harvested in May in the following year.

The middle- and late-maturing varieties of potatoes are widely planted in the middle reaches of Yarlung Zangbo; planting starts when the soil is warmed up to 6–7°C at 10 cm below ground in March and April, e.g., at the end of March to beginning of April in Lhasa district (3600–3700 m), and the beginning and middle of April in Xigaze district (3800–3900 m). Harvesting takes place in August and September with a growing season of 150–180 days. On the north side of the Himalaya, the potatoes are chiefly early-maturing varieties; the planting begins at the beginning and middle of May and harvesting from the end of August to the middle of September, with a growing season of 100–120 days.

The planting pattern depends chiefly on the soil and climate conditions. Ridge planting is preferable, particularly under irrigation, because the ridge raises the temperature of the soil, improves aeration for tuberization, and favours irrigation and drainage.

Level planting of potato is more feasible in semiarid regions with insufficient moisture; the embedding depth depends on soil and climatic conditions. The plants are usually covered with 7–8 cm thick soil, earthed up after they grow to a height of 20–30 cm. The optimum density of potato plants is usually 75,000–90,000 per hectare.

Management

Soil and plant management includes tillage of row spaces before rows contact, regular weeding, irrigation, fertilization, and the application of herbicides. Owing to the long period before shoots emerge and the impermeability of the soil, the soil should be harrowed lightly before the plants sprout.

After sprouting, the row spaces are usually tilled. The first loosening with slight hilling to a depth of 8–10 cm is made when the plants reach 6–8 cm in height, then in 10–15 days the second tilling and hilling follow. The row space may be slightly hilled to facilitate tuber development.

Irrigation

In the early stages of growth, the water consumption is less owing to the small leaf surface; at the later stages, when the tuber is expanding, it needs aerated soil and the leaves gradually turn yellow, and transpiration is also less. But at the budding stages, the water requirement reaches its maximum for the formation and development of tubers.

According to the experience in Namling county, the first irrigation with sufficient water supply starts one month after sprouting, the second begins when tubers are in formation. The timing of irrigation and its volume depends on the moisture regimes and plant growing status.

FERTILIZERS

Potatoes demand soil fertility and respond well to mineral and organic fertilizers. Mineral fertilization of potatoes on all kinds of soil facilitates high yields.

Various fertilizing systems are applied to potato cultivation. The basic application of organic and mineral fertilization during ploughing is necessary for potato growth and tuberization. Top dressing with quick-action fertilizer is usually accompanied by irrigation and hilling, especially during tuberization. Potassium and phosphorus fertilizers are suggested, such as potassium sulphate, plant ashes which contain 13.8 per cent of potassium oxide and are quick-acting, and calcium superphosphate.

Potatoes can be sensitive to the type of fertilizers applied; for example, if mineral fertilizers with chloride components are applied, it decreases the tuber starch content and its quality. Therefore, ammonium and potassium chloride should be avoided as potato fertilizers.

DISEASES AND PESTS

Two kinds of potato diseases are reported—late blight (*Phytophthora infestans*) and early blight (*Alternaria solani*)—occurring especially in the southeastern part of Tibet and the mid-southern section of the Hengduan mountains under humid and sub-humid conditions. On the northern flanks of the Himalaya and the Yarlung Zangbo river, the blight is characterized by diseases of the kind due to low temperature and humidity in a temperate semiarid climate.

The main pests of potatoes include *Polyphylla sikkimensis, Anomala* sp., *Amethes cnigrum, Euxoa segetum*, and *Cicadulla virdis*, which occur in eastern Tibet, the Hengduan mountains, and Lhasa district.

Insect control in Tibet is mainly dependent on insecticides and artificial control. Dipterex is one of the important insecticides applied to control pests there. The measures to control grubs of *Polyphylla sikkimensis* include agricultural control measures such as autumn ploughing, artificial catching, and insecticide control methods such as earth mixing, sprays, and irrigation. An integrated method of control is expected to come into use in future.

To establish and improve quarantine measures is very important to control damage by other pests that occur in adjacent areas.

SIGNIFICANCE OF RATIONAL ROTATION

Continuous cultivation of potatoes can give rise to severe damage by disease and degeneration. Potatoes cannot be alternated with other crops of the Solanaceae family, such as tomatoes, because of their poor resistance to the diseases of the Solanaceae crops. The best way is to let the land be fallow before commencing potato planting and to follow it with legumes and cereals. To efficiently control damage by disease, potatoes should be rotated for at least three years.

Vegetables

Before the 1950s, only a few Tibetans could afford to eat vegetables in the Tibetan Plateau. *Brassica rapa*, Chinese cabbage, rape, radish (*Raphanus sativus*), and broad bean (*Vicia faba*) were commonly grown in the study area, but the Tibetan people were not accustomed to eating vegetables.

Because of the introduction of vegetable species from other regions, especially eastern China, since the 1950s, the area under vegetables has expanded, and the total production has increased. The demand for vegetables has also increased due to population growth and dietary changes by some Tibetans.

Most of the vegetables are cultivated in broad valleys and basins on the northern side of the Himalaya, the middle reaches of the Yarlung Zangbo river, and dry valleys and broad basins in the Hengduan mountains, as well as on the southern flanks of the Himalaya and in Zayu district. Lhasa, Xigaze, Gyangze, Gonggar, Zetang, and Nyingchi, located in the middle reaches of the Yarlung Zangbo river and its tributaries, are the major cities and towns. Owing to the increasing demand for vegetables, the cultivated area has expanded and now abounds in vegetable varieties. The vegetable area and its proportion to the respective prefectures are shown in Table 9.15.

TABLE 9.15

Vegetable cultivation area and relative importance by prefecture (1985)

Place	Area cultivated (ha)	Relative proportion (%)
Lhasa prefecture	400	
Lhasa	100	25.0
Nyingchi	107	26.7
Shannan Prefecture	727	
Gonggar	307	42.2
Nedong	240	33.0
Xigaze Prefecture	633	
Gyangze	327	51.6
Namling	80	12.6

The area distributed under various management systems is shown in Table 9.16.

TABLE 9.16

Vegetable area under various management systems, 1981 (ha)

Area	Total	State	Collective	Enterprise	Individual
Tibet total	7594	53	5020	127	2393
Lhasa prefecture	1087	7	173	80	827
Shannan prefecture	1193	—	107	13	1073
Qamdo prefecture	4613	7	4287	—	320

Vegetable Crops

The species distribution of vegetables depends mainly upon the ecological requirements and the physical environment, such as temperature. A number of vegetables with cool temperature resistance are extensively distributed in the study area.

The important cultivated vegetables are listed in Table 9.17, together with their distribution limits.

TABLE 9.17

Principal vegetables and their upper elevation limits of cultivation

Common name	Principal species	Upper limit of elevation (m)
Cole crop	*Bassica oleracea*	
Chinese cabbage	*Brassica pekinensis*	4700
Radish	*Raphanus sativus*	4700
Turnip	*Brassica rapa*	4700
Carrot	*Daucus carota*	4150
Spinach	*Spinacia oleracea*	4700
Lettuce	*Lectuca sativa*	4150
Celery	*Apium graveolens*	3900
Tomato	*Lycopersicon esculentum*	4000
Eggplant	*Solanum melongena*	4000
Garlic	*Allium sativum*	4600
Welsh onion	*Allium fistulosum*	4260
Chinese chive	*Allium tuberosum*	3900
Pepper	*Caspicum annum*	4000
Bottle gourd	*Lagnaria siceraria*	3900
String bean	*Vigna sinensis*	3900
Lablab bean	*Dolichos lablab*	4150

TURNIP (*BRASSICA RAPA*)

Turnip is extensively distributed on the northern side of the Himalaya with its higher limit in Tibet. It is a cold-resistant crop with a short growing period and a high yield even when subjected to low temperatures and freezing. Owing to its lower economic value, the area under turnip cultivation accounts for 4567 hectares with a total yield of 3505 tons according to a rough estimate in 1981. Turnip cultivation area accounted for some 3 per cent of the total cultivated area in the 1960s, while in 1984 it was 2.4 per cent.

In Tibet the turnip is usually used as food and fodder.

RAPE

Rape, a cruciferous oil plant, is cold-resistant. It begins to germinate at 2°C, and its shoots can tolerate early frost of −3 to −5°C. The optimum temperature for good germination is 20°C. Good yield of rape can be achieved on fertile soil with a permeable top layer. The moisture requirement varies between different species and different growing stages; for example, winter rape requires higher moisture, and the need is especially great during the blossoming and seed formation periods.

In Tibet, the physical environment is suitable in many areas for rape cultivation. From Medog, at an elevation of several hundred metres, to Gyangze 4630 m high, rape cultivation is widely found. Though not as cold-resistant as naked barley and wheat, it has a short growing season (100–150 days); therefore, it is most commonly sown in the valleys of the Yarlung Zangbo river and its tributaries, the valleys of the Hengduan mountains, and the southern flank of the Himalaya.

Due to the high content of protein, rape oil is nutritious. However, it is not in great demand by Tibetan people, who are unused to it. The cultivation area, therefore, did not expand very fast, its proportion in the total cultivation area remaining at about 4–5 per cent.

Rape is good for rotation and to enrich the soil, so it is often mixed with naked barley, wheat, and broad bean. As a green manure crop with short nutrient growing period and high biomass of green herbage, it is also widely planted. The advantage of rape manure cultivation lies in that the seeds can be provided locally, and that it is more easily planted in rotation than perennials because it is a short-season crop.

In Tibet, over 10,700 hectares of rape is cultivated, with an average production of 1200 kg/hectare in 1985. On experimental fields in Gyangze farm, the yield in 1978 reached 5088 kg/hectare, and an even higher production of 6167 kg/hectare was achieved in 1979 in experiments done by the Agricultural Research Institute of the Autonomous Region. These facts indicate that rape has great production potential in Tibet, and a rape production base is likely to be set up in the future.

Field preparation is strictly required for rape cultivation because of the smallness of rape seeds and the depth of penetration by rape roots. For example, the tillage layer should be made thicker, and the soil texture finer.

Rape has a high requirement for fertilizers, the most necessary being the nitrogenous type followed by phosphoric and potassium fertilizers. In the early growing stages, a small amount of fertilizer is demanded due to the slow growth, while in the following budding and flowering period, much more fertilizer is needed to promote ramifying, bearing, and maturing. Because of the low speed of nutrients discharged under the low temperatures, in order to make the fertilizers available in time, basal dressing is recommended, accompanied by additional fertilizing with quick-acting fertilizers before the flowering season.

The main rape varieties in Tibet are Nianhe No. 1 and Qushui bigseed, which are middle or late maturing. Early planting is suitable from late March to early April. The seed planted should be about 15 kg/hectare when spraying, and less than 7.5 kg/hectare when strip-planting or pit-planting. The local people usually mix cultivation of rape with broad beans because rape can raise not only its own production but also that of the accompanying broad bean, due to its nitrogen-fixing capacity.

Rape planting density should be 75,000 per hectare in mixed planting, 225,000 in single planting on fertile soil, and 300,000–450,000 in single planting on infertile soil. Thinning should be started when three to four euphylla have stretched out, and final thinning done when five to six euphylla are out. Earthing should also be followed after thinning the crops.

Optimum harvesting is important for rape production. Harvesting too early will result in immature seeds and low oil content, while late harvest would cause the seeds do drop off. The optimum harvesting time is indicated by 70–80 per cent of the plants and fruits turning yellow. Harvesting should be done in the early morning and evening, when moisture is relatively high, in order to reduce cracking of fruit and seeds dropping off.

The Management of Vegetable Farming

Conservatory cultivation of vegetables such as greenhouse, breeding ground, plastic film cover, and seedling transplant, are recommended to improve ecological conditions by increasing temperature, shortening the growing period, and expanding the distribution of vegetables.

In the plateau, basins, and broad valleys on the northern flanks of the Himalaya with an elevation of more than 3500–4000 m above sea level, sunshine abounds for more than 36 hours. The effects of raising temperature in the conservatory are very obvious. Therefore, conservatory cultivation and transplanting the seedlings are key measures to enrich the species and varieties of vegetables, to expand their distribution, and meet the demands of population growth and economic development.

Lhasa and Xigaze are located in the valleys of the Yarlung Zangbo river, and Tingri and Saga on the plateau region with an altitude of 4650 m above sea level. Many vegetables which prefer warmer temperatures, such as tomato, cucumber, and pepper are grown in greenhouses. In Lhasa district, fresh vegetables can be produced in greenhouses all year round without heating; cucumbers, for example, can be grown twice a year with yields reaching 30–60 tons/hectare. In Yanbajing area, by using the thermal energy of the thermal power station, vegetable farming can be developed at an elevation of 4200 m.

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PART 2

Horticulture Research and Diversification by Ancillary Horticulture Programmes

10

Horticultural Research in the Himalayan Hill Region of India

K.L. Chadha

Introduction

The Himalayan hill region covers more than one-eighth of the total land area of India and makes up the entire northern boundary running from Jammu and Kashmir in the west to Arunachal Pradesh in the east. The economic condition of the people inhabiting this region is poor. Land holdings are small, scattered, and uneconomic. Irrigation facilities are limited and there is serious land degradation due to overgrazing, deforestation, and inappropriate land use. However, the agroclimatic conditions prevailing in this region are most suitable for the production of a number of horticultural crops on a commercial scale. These crops are more profitable per unit area and are also labour intensive, which generates more employment and can improve the economic condition of the people of the region. Horticulture is, therefore, considered the best way to exploit the region's natural resources, increase farm income, generate employment, and conserve land resources.

In the post-partition period, great strides were made in temperate fruit production in the hilly areas of the country, particularly in the northwest hill region comprising the states of Jammu and Kashmir, Himachal Pradesh, and the hill districts of Uttar Pradesh, located between latitudes 28° and 36°N. Simultaneously, efforts have also been made by both the Indian Council of Agricultural Research (ICAR) and the state governments to create a sound research infrastructure which has yielded several useful introductions, new cultivars, and agro-technology for improved productivity. This paper describes the infrastructural facilities available and achievements made in growing fruits and vegetables, including potato, with special reference to the northwestern Himalayan region of India.

Fruit Research Infrastructure

The ICAR has been the premier agency to pioneer systematic temperate fruit research in the country. Research stations started with the initial help of the ICAR now form the nucleus of research in various states of the country. Notable among these in Uttar Pradesh has been the government Hill Fruit Research Station at Chaubattia, which was established as early as 1932 and was the first of its kind in southeast Asia. During the last two decades or so, work on temperate fruit research has also been initiated at the Fruit Research Station, Chakrata, in Uttar Pradesh. Some research on temperate fruits is also being conducted by the G.B. Pant University of Agriculture and Technology. The mid-hill zone is served by a research station at Majhera and the high zone by the Zonal Research Station at Ranichauri.

In Jammu and Kashmir, research on temperate fruits was initiated at the Fruit Research Station, Shalimar, Srinagar, in April 1945 with the introduction of a Survey of Deciduous Fruits by the ICAR. Subsequently, another scheme, Research on Fruits in Kashmir, was started in Collaboration with ICAR in June, 1955. This scheme was subsequently merged in August 1959 with the Establishment of Regional Fruit Research Station for Intensification of Research on Temperate Fruits in Kashmir. In 1972/73, a sub-station at Balapora, Shopian, was added to cater for the needs of high elevation fruit growing. Recently, the entire horticulture research in the state has been brought under the purview of the Sher-e-Kashmir University of Agriculture and Technology established at Srinagar in 1982.

With a view to exploit the fruit-growing potential in Himachal Pradesh, a comprehensive Fruit Research Scheme funded by ICAR was started at Mashobra during 1954 for temperate fruits. This station was elevated to the status of a Regional Fruit Research Station for temperate fruits during 1959. Later, a National Hortorium was established at Kotkhai during 1961 by the ICAR for the collection, maintenance, and evaluation of temperate fruit germplasm. A raisin research centre was also started at Sharbo during 1959 with the objective of evaluating the performance of grape varieties under arid conditions in Himachal Pradesh. Similarly, a research station was started at Boktu in Kinnaur district in 1960 to carry out research on drying varieties of apricot, almond, and walnut. Fruit research stations were also established at Khadrala and Bagthan in 1965 with funds provided by ICAR, to solve the problems of fruit cultivation in high altitude and low altitude zones respectively. Similarly, research work on olive and pomegranate is under way at the Fruit Research Station, Kothipura, Bilaspur. Work on these fruits is also conducted at the Fruit Research Station, Borlaugh. Under the Himachal Agricultural University, work was started at Stokes Campus, Nauni, Solan, in 1971. The entire research work on fruit crops in Himachal Pradesh is now under the purview of the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan.

A Horticultural Research Station was also established in 1950 at Kulu, erstwhile Punjab, to develop the fruit industry in Kulu valley. The station made a good start, but later functioned primarily as a development centre. During the late 1950, a vegetable production farm, started at Kandaghat in the year 1921, was converted into a research station for stone fruits. The ICAR funded this station during 1960/61. The ICAR, New Delhi, sanctioned a project entitled Centre of Advanced Studies in Temperate Horticulture with UNDP/FAO assistance under the Himachal Pradesh Agricultural University, Solan, in 1979 to improve research and the quality of post-graduate education in temperate horticulture. On December 1, 1985 the Dr. Y.S. Parmar University of Horticulture and Forestry was established in Solan in Himachal Pradesh to boost horticultural research and development in the state and the entire horticulture research in Himachal Pradesh has been transferred to this university.

In the eastern region, a project was initiated during 1975 which grew into a full-fledged institute with regional stations in all the northeastern states. The institute, known as ICAR Research Complex for the northeast region, is located in Shillong.

The Indian Agricultural Research Institute (IARI) is also conducting work on temperate fruits through its Division of Horticulture at its Regional Station at Shimla, which came into existence in October 1965 for the collection, maintenance, and use of wild germplasm in pome and stone fruits. Work on virus aspects is also being carried out at IARI substation at Flowerdale and on plant introduction by the National Bureau of Plant Genetic Resources Regional Station at Phagli.

Temperate fruit research got a further fillip with the start of the All India Co-ordinated Fruit Improvement Project under the aegis of the ICAR during the Fourth Five-year Plan in 1968. Several ad hoc schemes are also under way to study specific problems of these fruits. A full-fledged Central Institute for Temperate Horticulture has been approved, to be established by the ICAR near Srinagar in Jammu and Kashmir during the current plan. The efforts of universities in the northwest region are also being further strengthened in different agroclimatic zones under the National Agriculture Research Project.

The research stations in the different states have been working on important problems of temperate fruits, including varietal evaluation and improvement, propagation and rootstock, training and pruning, orchard management, nutrition, use of growth regulators, pest and disease control, and, lately, post-harvest management.

Fruit Research Achievements

Crop Improvement

Collection and Evaluation of Genetic Resources

The earliest record of varieties of fruits growing in Kashmir is found in the Gazetteer of Kashmir and Ladakh published in 1890. It lists Ambri as the leading apple variety. During the 20th century, great emphasis has been laid on the introduction and evaluation of the genetic resources of various fruits. While significant contribution in this regard were made at the beginning of the 20th century by missionaries, planned introductions have been made during the last three decades, mainly from Argentina, Australia, Bulgaria, Canada, Germany, Greece, Iran, Israel, Italy, Japan, Kenya, the Netherlands, Syria, the United Kingdom, the United States and the U.S.S.R.

As a result, a good collection of germplasm of pome, stone, and nut fruits has been made at 19 research centres, 11 of which are located in the northwest Himalayan region. Recently, an inventory of germplasm collection of pome, stone, and nut fruits has been compiled (Yadav, 1988) which lists species and varieties available in India. Accordingly, the number of varieties now existing in germplasm collection in India is apple 849, pear 165, apricot 98, cherry 11, peach 215, plum 280, almond 154, filbert 2, hazelnut 16, pecan 7, hecan 1, walnut 63, and other nuts 4.

India also has a wealth of wild germplasm collected from within and outside the country which offers an opportunity to breed suitable rootstock as a source of resistance and in several other ways. These include various genera, namely, *Amygdalus* (1), *Cary* (2), *Corrylus* (2), *Cotoneaster* (7), *Crataegus* (2), *Cytonia* (1), *Docynia* (1), *Juglans* (8), *Pyrus* (7), and *Sorbus* (3). The performance of various cultivars has been studied both in the collection blocks and through systematic varietal trials and suitable cultivars have been recommended for different areas in various states. A list of promising cultivars identified in Himachal Pradesh is given in Annex 1. Besides this, a number of promising apple cultivars have been identified by the evaluation of introductions. These are listed in Table 10.1.

Similarly, in peach, on the basis of tree growth, yield, and fruit quality, two exotic cultivars, Kanto 5 and Shimizu Hakuto, were found better than the existing recommended cultivars (Gautam *et al.*, 1986).

TABLE 10.1
Important categories of apple germplasm

Categories	Important cultivars
Non-spur type	Tydeman's Worcester, Stark Red Rome, Skymine Supreme, Red Delicious, Red Baron, Akane, Lalla Delicious, Lord Lambourne, Rose Red Delicious
Spur type	Starkrimson, Sky Spur, McSpur, Spur Type Golden Delicious, Bisbee Spur, Silver Spur, Gold Spur, Red Delicious
Low-chilling type	Vered, Michal, Maayan, Schlomit, Hybrid I, Tropical Beauty, Rome Beauty, Anna, Kidd's Orange Red
Scab-Resistant	Star Prize, Prima, Priscilla, Quinte, Liberty

COLLECTION AND EVALUATION OF INDIGENOUS WILD GERMPLASM OF POME AND STONE FRUITS

Several wild relatives of temperate fruits occur in the Himalaya. Surveys were conducted from 1966 to 1970 in several areas of Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh, and even Sikkim, Meghalaya, and Darjeeling district of West Bengal. As a result, 56 different species, varieties, and types of different genera covering pome, stone, and nut fruits were collected and conserved at IARI Regional Station, Amartara, Shimla: *Malus* (29), *Pyrus* (7), *Prunus* (15), *Crataegus* (2), *Cotoneaster* (7), *Docynia* (1), *Myrica* (1), *Cydonia* (1), *Sorbus* (3), *Fragaria* (1), and *Actinida* (1). The salient findings were reported by Randhawa (1987) and are given below:

- Seven different types of *Malus baccata* and one *Malus* sp. were studied. *Malus baccata* from Shillong and Khrot were as dwarfed as M-9. These two types have, therefore, potential as a dwarfing rootstock for apple.
- *Pyrus pyrifolia* has shown resistance to powdery mildew, fire blight, and collar rot and should be preferred over *pashia* and *pashia* var. *Kumaoni* as a rootstock for pear.
- Fourteen different species of *Prunus* were evaluated. *Prunus cornuta* was considered to be a better rootstock for cherry than *P. cerasoides*. *Prunus cornuta* and *P. persica* are susceptible to powdery mildew while *P. salicina* is resistant.
- *Crataegus*, *Cotoneaster*, and *Docynia* were found incompatible as rootstocks for both apple and pear.

DEVELOPMENT OF NEW VARIETIES

Hybridization work to evolve better varieties has been in progress in different states since 1960. In Himachal Pradesh and Jammu and Kashmir, efforts have been made to combine the dessert quality of the delicious group with the good keeping quality of Ambri. As a result, two promising hybrids, namely, Lal Ambri (Red Delicious Ambri) and Sunehri (Ambri Golden Delicious), were released from Jammu and Kashmir during 1973. These have already gained popularity with farmers. Lal Ambri has a red-striped colour, whereas Sunehri has a sulphur yellow skin. Both varieties store well at room temperature and are considered an improvement over both the parents. In addition, eight newly synthesized hybrids are in the pipeline or under evaluation. Some scab-resistant varieties have also been crossed with commercially important varieties and are being evaluated at various locations in the Kashmir valley.

Similarly, from Mashobra, hybrid seedlings from crosses between Starking Delicious and Ambri gave four promising hybrids: Ambstarking, Ambroyal, Ambrich, and Ambred. While all these hybrids are late in maturing, Ambred has good fruit quality and better shelf life. Ambrich is a semi-spur type

In Uttar Pradesh, the apple breeding programme was initiated to evolve an early, red, sweet variety with good keeping quality. For this purpose, Early Shanberry, Fanny, and Benoni varieties were crossed with Red Delicious. Two hybrids of Early Shanberry and Red Delicious, namely, Chaubattia Princess and Chaubattia Anupam, are early ripening with an edible quality close to that of Red Delicious. Their keeping quality is better than that of either parent.

Introduction of New Crops

Efforts have also been made to domesticate new fruits in the temperate regions. Two important examples are olive and the Chinese gooseberry.

In northwestern Himalaya, the possibility of commercial cultivation of olive is provided by the presence of wild species, locally known as Kahu (*Olea cuspidata*) in concentrated belts at elevations ranging from 1000 to 1300 m above mean sea level. Systematic introductions of olive varieties were made under an Indo-Italian Project on the Development of Temperate Climate Fruit Crops in Jammu and Kashmir, Himachal Pradesh, and Uttar Pradesh. Nearly 1983, 2399, and 1202 trees have been planted in these states so far. The performance of six olive cultivars (*Olea europea* L.) studied in Nauni, Solan, has revealed that the cultivars Ascoiterana and Frantouo gave better yield and higher oil content than other cultivars (Singh *et al.*, 1986). Ripening of different varieties started in the first week of September and continued till the third week of December. The oil content ranged from 16.20 to 25.87 per cent.

The Chinese gooseberry is a promising fruit for lower hills. Four Chinese gooseberry cultivars introduced from the United States and New Zealand were evaluated at Phagli, Shimla, for 10 years. Among the four cultivars, Abbott, Allison, Bruno and Hayward, Allison was the best for its earliness, yield, and total solid content (Rathore, 1987).

Pollination, Flowering, and Fruit Set

Several temperate fruit cultivars need pollinizers to raise commercial crops. Studies have been under way at different centres to find suitable pollinizers.

Among apple cultivars, Red Gold and Tydeman's Worcester have been found to be good pollinizers for cultivars McIntosh, Red Delicious, Richared, and Royal Delicious at Mashobra. These pollinizer cultivars are, however, themselves partially or fully self-fruitful. At Chaubattia, good fruit setting was reported in Red Delicious with Jonathan, Buckingham, and Esopus Spitzenberg. Of these, however, Buckingham is preferred commercially. For Early Shanberry, cultivars Fanny, Winter Banana, and Rome Beauty were found to be better pollinizers.

Studies on the varying proportion and distribution of pollinizer trees indicated that where the proportion of pollinizer trees was 33.33 per cent, the percentage of fruit set in open pollination was fairly high. Fruit set reduced when pollinizer trees were fewer than 12.5 per cent.

In plum, the cultivar Beauty, which flowers profusely, has been recommended as the best pollinizer for commercial adaptability in Santa Rosa orchards in Himachal Pradesh. At Chaubattia, however, New Plum proved to be a good pollinizer for all the European plums, while Santa Rosa was best for all Japanese plums.

In almonds, the cultivars Thin Shelled, Nonpareil, and Ne Plus Ultra were found to be self-incompatible and Drake to be self-fruitful in Himachal Pradesh. Nonpareil was reported to be the best pollinizer for all varieties except Ne Plus Ultra. Therefore, no single almond cultivar should be planted in a compact block and a combination of two or more is a must for successful almond cultivation. A combination of Nonpareil, Thin Shelled, and Drake has been finally recommended for commercial cultivation in Himachal Pradesh.

Pollination studies have also been undertaken with identified varieties and local selections in Jammu and Kashmir. HS-2, a local selection, is a good pollinizer for HS-8, HS-1, and Primorskij. Nonpareil and Nikitskij have been found to be good inter-pollinizers. HS-15 and Afghanistan seedlings are incompatible with each other and with HS-15.

Observation by Awasthi *et al.* (1986) at Mashobra for a period of 13 years has revealed that climatic conditions during flowering in March-April greatly influence the time of flowering, fruit set, and yield of Royal Delicious apple. During the pre-bloom period in March a maximum temperature around 10°C delayed flowering, whereas above 15°C enhanced it. Average maximum and minimum temperatures around 20°C and

10°C respectively during flowering in April produced good fruit set. High relative humidity above 50 per cent in March delayed flowering, without affecting fruit set. Rainfall during flowering in April adversely affected fruit set.

In Himachal Pradesh, SADH,at concentrations ranging from 2000 to 8000 ppm, was effective in delaying the time of flowering of Royal Delicious while succinic acid at 600 to 800 ppm sprayed one month before bud burst was effective in delaying the blooming period of almond.

Physiological studies of Royal Delicious variety revealed that erratic and irregular flowering under Solan conditions was due to temperature fluctuations in spring and the problem was solved by the application of PP333 at 500 ppm or GA at 50 ppm after cessation of growth. Similarly, under high hill conditions increased fruit set was achieved in Royal Delicious by the application of 100 ppm GA plus 40 ppm NAA at pink bud stage.

In strawberry, the application of 100 ppm CCC 15 days before flowering in Himachal Pradesh improved growth, flowering, fruit set, and quality of Senga Sengana, Tioga, and Missionary cultivars.

Crop Production Technology

PROPAGATION TECHNIQUES

While vegetative propagation techniques in pome and stone fruits are well known, propagation has been difficult and techniques known in certain nut crops. Constant efforts have, therefore, been made to improve known techniques in pome and stone fruits and to standardize new propagation techniques for nut crops. The results obtained for various crops are summarized below.

In apple, success up to 70 per cent has been achieved in rooting hard wood cuttings of crab under glasshouse conditions at Chaubattia. Treatment with 2500 ppm IBA improved rooting (Pathak and Pandey, 1984). With the use of IBA 2500 ppm, rooting was increased by stooling in M 109 and M7 rootstocks (Srivastava and Joshi, 1984). Provision of bottom heat (21 + 2°C) was essential for root initiation during the dormant season. Chip budding during August-September and tongue grafting during February-March 10–15 cm above collar has been recommended to save plants from root rot and collar rot (Chadha, 1978). In Uttar Pradesh, up to 80 per cent success in rooting of crab-apple stool layers was achieved by the application of 2500 ppm IBA in a lanolin paste. Similarly, 84 per cent success in rooting of stool layers of MM 106 was achieved by the application of 2000 ppm of IBA in lanolin paste (Chauhan, 1987).

In Himachal Pradesh, the stooling performance of nine clonal rootstocks—M2, M7, M9, M25, MM 104, MM 106, MM 108, MM 110, and

MM 111—was studied at Fruit Research Station, Kotkhai. Rootstocks MM 110 and MM 106 produced more rooted suckers. Other rootstocks produced medium or low suckers. Rootstock MM 110 produced the most vigorous suckers. A good root system was recorded in Malling Merton Series of clonal rootstocks under study (Rana *et al.*, 1986).

Air-layering was tried in cultivars Fanny, Early Shanberry, and Rymer. Air-layers treated with 5000 ppm IBA gave best results (60 per cent rooting) in Fanny. A rooting percentage of 60 to 70 was found in Early Shanberry and Rymer respectively with the application of 7500 ppm of IBA (Chauhan, 1987).

In pear, some success has been reported in shoot layering by the application of 500 ppm of IBA after ringing in Uttar Pradesh at Chaubattia; however, 2500 ppm of IBA induced maximum rooting in the cultivars Patharanakh and Gola, with provision of bottom heat (Chadha, 1978).

Plum cultivars Santa Rosa, Mariposa, and Greengage, bench grafted on five different rootstocks—wild peach wild apricot (*Behmi*—a natural hybrid of almond and wild peach), bitter almond (*Prunus amygdalus*, and Myrobalan B (*P. cerasifera*)—gave varying drafting success from zero to 100 per cent. Wild peach and Myrobalan gave the best results and bitter almond and Behmi the poorest. Among scions, Mariposa was most successful on a greater range of rootstocks (Sharma and Sharma, 1986).

At Chaubattia, IBA 1000 ppm was found to promote the rooting of cuttings in plum. Mist was favourable for rooting and success was greater in December (Chauhan and Reddy, 1978).

Stratification of cherry stones in a sand + soil (3:1) medium from May onwards gave the highest germination. Also, stooling of cherry seedlings has been induced with and without application of IBA.

For the vegetative propagation of persimmon, veneer grafting done during the second half of September at Nauni, Solan gave 97.67 per cent success and proved to be an excellent method of vegetative propagation (Chauhan and Gautam, 1986).

Concerted efforts to vegetatively propagate walnut have been made in Himachal Pradesh, Uttar Pradesh, and Jammu and Kashmir. In Himachal Pradesh patch budding gave up to 72 per cent success in 1961. Later, during 1967, a modified forkert method of budding done from mid-June to the first week of July was found to be the best in Kinnaur area of Himachal Pradesh. Further, veneer grafting was reported to be the best method at Kandaghat during 1968. During 1975, however, at Solan, storage of cleft and tongue grafts in an incubator at $25 \pm 1°C$ for weeks prior to planting gave a high percentage of successful grafts.

From Chaubattia, a maximum success rate of 80 per cent was reported by cleft grafting during 1971. Alkathene of 400 gauge was found to be the best tying material. Later, during 1975, modified patch budding with the help of a double-bladed knife was successful between mid-

June and mid-August. Vegetative buds showed better success and are recommended to be used as scions. For best results, budding should be performed as early as possible after collecting the scion (Chadha, 1978). In walnut, stooling was attempted in Jammu and Kashmir by Rashid (1978) using growth regulators. A combination of 10,000 ppm of IBA and 5000 ppm of NAA was most effective in increasing the rooting of walnut stools.

In Jammu and Kashmir, three methods of budding and two methods of grafting have been tried at different times. Budding was found to be more successful, especially patch budding.

In pecan, maximum rooting was obtained in the semi-hard wood of juvenile cuttings, treated with 500 ppm IBA and planted when misty during summer.

Standardization of Rootstocks

Since there is a lack of uniformity in tree size and cropping of plants propagated on seedling rootstocks, clonal rootstocks of Malling and Malling Merton series were introduced from East Malling Research Station, England to Mashobra and Kotkhai in Himachal Pradesh; Chaubattia in Uttar Pradesh, and Shalimar in Jammu and Kashmir. These rootstocks offered the possibility of having trees of the desired size from dwarf to very tall, besides which, the MM rootstocks are resistant to woolly aphid. Varietal and rootstock trials have been in progress at Mashobra (1967), Kotkhai (1968), Chaubattia (1969), and several locations in Jammu and Kashmir. Simultaneously, commercial usage started in the early 1950s in India. Until then, the nurseries in Kashmir, Kumaon hills, Kulu valley, and other hill regions have been using crab-apple as a rootstock for apple. Similarly, in pear, the common rootstock has been *Pyrus pashia*, called Kainth or Shiara. Quince was occasionally used to produce dwarf pear plants. For peach and plum, apricot and plum were used.

Among the Malling series, M 9 and the Malling Merton series MM 110 and MM 111 were considered to be most dwarfing, based on stomatal density (Jindal and Rana, 1984). Randhawa and Kishore (1984) observed Malus baccata Shillong, a native type, to be as dwarfing as the M9 rootstock.

Rootstock trials conducted in the Uttar Pradesh hills have shown that M9 rootstock is not suitable for this area because soil depth is low; the shallow root system of M9 stock results in heavy casualties under drought conditions. Among vigorous rootstock, MM 104 has shown better results. Studies also indicate that M9 exerts a dwarfing effect as an intermediate stock (Chauhan, 1987). However, growth as well as yield are higher in vigorous rootstock. Srivastava (1966) recommended Merton 779 rootstock for apple in Chaubattia and on a commercial scale for Kumaon hills considering its overall performance. Rootstock trials conducted at Chaubattia also showed M25 to be the most promising in the dwarfing of apple trees.

The performance of commercially important varieties of apple on Malling and Merton rootstock is being assessed under various agro-climatic conditions in Jammu and Kashmir. Results indicate promising performance by M2, M4, M7, and M9. Further, Ambri apples on seedling rootstock came into bearing after 10–12 years of plantation. Precocity has been successfully induced through use of M9 and M26 rootstock/interstock (Kabu 1975). Studies conducted to evaluate different scion varieties of apple on *M. baccata* Khrot revealed that these rootstocks are as dwarfed as M9, are easy to propagate through mound layering, and have good graft compatibility with apple cultivar Golden Delicious (Randhawa and Kishore, 1986). Further screening of *Malus* species revealed that *M. sieboldii* (Sanashi 62) requires the least the chilling (Kishore and Randhawa, 1986).

Practically no work has been done on the standardization of rootstock for stone fruits. However, wild peach for peach and plum, wild apricot and bitter almond and wild peach for almond have been recommended from Chaubattia.

Three scions—Santa Rosa, Mariposa, and Greengage—were grafted on three rootstocks—wild peach, wild apricot, and Myrobalan rootstock. Wild peach was generally poor rootstock (Sharma and Sharma, 1986).

In Himachal Pradesh, rootstock studies conducted have resulted in the identification of promising rootstock for various fruits as under:

Apple	Dwarfing:	M9, M26
	Semi-dwarfing:	M7 and MM 106
	Semi-vigorous:	MM 111
Plum	Clonal:	Myrobalan B
	Seedling:	Wild apricot
Peach:		Wild peach seedling
Almond	Mid-hills:	Wild peach seedling
	High-hills:	Bitter almond seedling
Apricot:		Wild apricot (Chuli) seedling

NUTRITIONAL NEEDS

Nutrition of temperate fruits has not received enough attention in the past. The prevailing manurial practices were based on the experience of growers and there was considerable variation from orchard to orchard for the same variety and under similar agroclimatic regions. No serious attempts have so far been made to ascertain the validity of the prevailing practices nor to evolve suitable manurial schedules. Systematic and long-range fertilizer trials on apple were initiated in 1970 at Chaubattia (Uttar

Pradesh) and in 1975 at Mashobra (Himachal Pradesh). Work on other temperate fruit crops were started much later.

Salient results obtained are discussed below.

Apple

Seasonal variations in NPK content of Royal Delicious were studied by Verma and Singh (1986). Nitrogen content declined sharply in the active growth period from May to July and was stable during July. Phosphorus content showed no consistent seasonal trend, but K content generally decreased from May to August. After fruit harvest, increase in NPK, content was registered. The best time for collecting leaf samples was found to be July for N and P and August for K.

On the basis of fertilizer trials conducted in Uttar Pradesh, 25 g of N, 20 g of P205, and 25 g of K20 per year of age increasing up to 15 years is recommended. These doses are expected to give a yield of 9.5 tons/hectare. For apples on the dwarf rootstock M9, the recommended doses are 20 g of N, 10 g of P205, and 8 g of K20 per year of age, increasing up to seven years. These doses relate to the Delicious group of apple.

Under the conditions of Jammu and Kashmir, a fertilizer doze consisting of 600 g N and 900 g K20 was recommended for the White Dotted Red variety (Gani and Raina, 1984). Under Mashobra (Himachal Pradesh) conditions, application for NPK at 350:175:175 g respectively per tree was found to be adequate.

Foliar sprays of NPK have also been attempted. Foliar sprays of N and K increase the N and K content of apple leaves. With spray there was no response in P content of foliage. Fruit yield was not affected significantly, but fruit colour was improved by K and reduced by urea spray. Further urea spray improved weight and size of fruit and K spray increased T.S.S and acidity.

The leaf sampling technique in apple has also been standardized. Leaf sampling in the month of August is the best in order to study the nutrient status. It has also been found that 2.744 per cent P205 and 2.775 per cent K20 indicates abundant content, 1.685 per cent N, 0.228 per cent P205, and 2.234 per cent K30 optimal content, and below 1.685 per cent N, 0.171 per cent P205, and 1.693 per cent K20 a deficient level (Chauhan, 1987).

A study on the nutrient status of apple orchards in Himachal Pradesh has revealed that deficiency of NPK is fairly widespread in Himachal Pradesh. Out of the three fertilizer elements, phosphorus was the most limiting factor in apple production (Rana *et al.*, 1976). However, there was no response to phosphorus application in Jammu and Kashmir (Gani and Raina, 1984). Studies conducted by Karkara *et al.* (1986) have revealed that nutrient uptake is not affected by the source of N but with increased N levels, the K and Mn content increased and the leaf P content decreased. Broadcasting the fertilizer was found to be convenient and as effective as pocket placement or trench application (Awasthi *et al*., 1984). Application of 225 g N in soil and 75 g to the foliage was found optimum for Red Delicious under Mashobra (Himachal Pradesh) conditions (Awasthi *et al*., 1976). Foliar application of potassium sulphate was found to be effective in increasing the yield (Divakar, 1976).

Micronutrient disorders have become widespread in Himachal Pradesh due to zinc, copper, and boron deficiencies. Tomar *et al*. (1970) reported moderate to acute zinc deficiency in Kulu valley, Himachal Pradesh. Boron deficiency in Rymer apple was reported in Himachal Pradesh by Dune *et al*. (1969). Pre-harvest fruit cracking in Cox's Orange Pippin variety occurring in Himachal Pradesh during the monsoon has been attributed to a combined deficiency of copper and boron by Pant (1969) and Pant *et al*. (1971).

Nutrient surveys carried out by Rana *et al*. (1976) in Himachal Pradesh as part of the All India Co-ordinated Fruit Improvement Project revealed the deficiency of all nutrients, except magnesium and iron.

Control of micronutrient deficiencies of various elements has also been studied. Zinc deficiency in apple can be corrected either by foliar sprays of 0.5 per cent $ZnSO_4$ or the application of zinc sulphate in the soil at 100 g/tree. Boron deficiency is best controlled by twice spraying with 0.4 per cent boric acid, once at petal fall and again within a month of the first spray. Pre-harvest cracking due to copper and boron deficiency can be tackled by combined sprays of 0.4 per cent borax and 0.05 per cent copper sulphate, once at fruit set and twice at fortnightly intervals after the first spray. Apple measles, caused by toxicity of manganese, can be controlled by the application of lime to the soil at the rate of 1 kg/tree. Zinc deficiency resulting in little leaf can be controlled by foliar spray with zinc sulphate, 0.4 per cent combined with 0.2 per cent lime (Chauhan, 1987).

Foliar application of borax at 70 ppm or application to the soil at 100 gm after harvest, but before leaf fall followed by another spray at pink bud, was effective in controlling boron deficiency (Bhat and Singh, 1984).

Plum

It is recommended that 36 kg of farmyard manure, 720 g calcium ammonium nitrate, 570 g of superphosphate, and 360 g of muriate of potash be applied to a full bearing plum tree. Foliar feeding of plum trees with 0.5 per cent urea was found to increase the efficiency of nitrogen fertilizers. The entire quantity of nitrogen at 1.044 kg., when applied in a single dose in February, was effective for fruit retention and yield, whereas application in two doses, once each in February and April, increased fruit size. Foliar application of 0.6 per cent zinc sulphate, together with 0.2 per cent copper sulphate, increased fruit retention and eventually the yield per tree (Mann *et al.*, 1984).

Studies on leaf nutrient standards in plum revealed that the period from June 20 to July 15 is the most suitable for leaf sampling.

Apricot

Applications of nitrogenous fertilizers were found to increase the apricot yield in Uttar Pradesh. When nitrogen was applied along with phosphorus and potash, fruit yield as well as individual fruit size was found to increase. Individually, nitrogen at 450 g/tree was found to be optimum. The yield maximizing combination of N, P_2O_5, and K_2O was observed to be 56.7, 28.35, and 68.04 g respectively for each year age of the tree; while 500 g N was optimum for New Castle apricot, 300 g was adequate for Shipley's Early cultivar.

Almond

In Kashmir, nut weight and kernel weight was found increased with fertilizer application of NPK but fruit maturity was delayed.

Training and Pruning

Comprehensive training trials have been under way at various centres under the All India Co-ordinated Fruit Improvement Project. Modified central leader or open central leader system has been found to be good for apple cultivar Red Delicious on M7 rootstock, and the espalier system of training proved best for Red Delicious with respect to dwarfing, yield, and quality of fruit (Anon., 1984).

Studies conducted to determine the intensity of pruning in the apple variety Royal Delicious revealed that moderate pruning involving 40 per cent growth was good while light pruning (20 per cent) and no pruning control impaired tree health and reduced the yield (Ram Kumar and Srivastava, 1982).

Summer pruning of apple has also been tried to enhance colour development. The removal of current year twigs and one metre long current-year wood gave 37 per cent more fruits conforming to A grade (80–100 per cent colour) compared to 23 per cent in controlled conditions.

Very little research on pruning of stone fruits has been done in India. Some pruning trials have been conducted on Elberta peach at Palampur (Himachal Pradesh) which have indicated that light pruning increased fruit yield, while severe pruning improved the quality. Therefore, it was recommended that 75 per cent of the previous year's growth be retained (Badiyala and Bhutani, 1984).

ORCHARD MANAGEMENT

Since apple is grown on light soil under rainfed and moisture stress conditions in Uttar Pradesh, attempts have been made to conserve soil moisture and control weeds through mulching. Experiments conducted with various mulches on Royal Delicious cultivar with MM 106 rootstock have shown that all the mulches have been able to conserve more moisture and reduce weeds, thereby increasing growth of apple grafts. The percentage of saleable plants increased from 50.5 per cent in control to 64.3 per cent in a black polythene mulch (Chauhan, 1987).

In Jammu and Kashmir, perennial fodder, especially red clover, can be grown successfully in the open spaces of young orchards beyond the canopies of fruit trees. Red clover successfully establishes itself, even in old orchards under the canopy of fully grown trees, but due care needs to be taken of the problems associated with it (Kaul et. al., 1978).

In Himachal Pradesh, black polythene was observed to be good mulching material for apple in the high hill region, but unsatisfactory as a mulch in the lower and mid-hill areas, because of its deleterious effects. Mulching with grass or hay or without herbicides like Simazine at 5 kg/hectare plus glyphos at 2.5 kg/hectare is highly effective in maintaining a higher moisture level and lower temperature in the soil throughout the growing season, resulting in better growth and higher yield of some fruits.

Experiments on the use of herbicides for the control of weeds in orchards and nurseries have been under way at several places. At Mashobra, Gramaxone spray at 3.75 hectare controlled annual grass and broad-leaved weeds for a period of two to three months in apple orchards. Summer spraying was found more effective than spraying in spring or autumn. A mixture of 2, 4, 5-T at 1000 ppm and Gramaxone at 500 ppm showed a long-lasting effect in controlling weeds Atrazine (at 5, 10, 15 kg/hectare) gave better results than Simazine at the same rate. Each herbicide at 4.5 kg/hectare gave 84–89 per cent control, compared to 74 per cent with hand weeding.

In plum, both Diuron and Razine at 4 kg/hectare proved effective in controlling weeds but Diuron maintained its superiority to Atrazine during both the years. No phytotoxic effects were noticed (Khodhar *et al.* 1986). Diuron and Atrazine at 4 kg/hectare each were found to stimulate the activities of amylase and invertase, whereas cellulose activity remained unaffected (Khokhar *et al.* 1986).

Regardless of herbicidal treatment, different levels on N improved markedly the nitrogen, calcium and magnesium content, while phosphorus and potassium remained unaltered. Simazine and Terbacil may partly substitute for nitrogen fertilizer in Santa Rosa plum (Bhutani and Bhatia, 1986).

CROP REGULATION

Significant achievements have been made in crop regulation of temperate fruits, particularly with the use of chemicals and plant growth regulators. These are described below.

Application of SADH at concentrations ranging from 2000 to 8000 ppm was effective in delaying flowering of Royal Delicious apple (Singh and Jindal, 1986). Thiourea at 5000 ppm delayed bud break in Royal Delicious apple (Jindal and Singh, 1986). Kinetin at 12.5 ppm advanced flower opening. In almond, succinic acid at 600 to 800 ppm, sprayed one month before bud burst, was effective in delaying blossom.

A critical analysis of the problem of overbearing in many temperate fruits reveals that judicious thinning, suitably employed at the proper stage of fruit development, can regularize cropping with good-sized, well-developed, and superb quality fruit. Considerable work on this aspect has been done in the case of apple, plum, and apricot.

In apple, carbaryl (Sevin) at 750 ppm, sprayed 7–10 days after the petal fall stage, proved to be most effective for fruit thinning. NAA 30 ppm and Hexavin (85 per cent W.P.) at 1000 pm were also rated good thinners. At Chaubattia, carbaryl at 1000 ppm induced maximum thinning and had an appreciable effect on quality (Chadha, 1978). Post-bloom spray with Ethephon at 100 and 200 ppm concentration was found to be effective for fruit thinning in apple and increased the superior yield of grade fruit by 40 per cent in Red Delicious (Wazir *et al.*, 1984).

In plum, hand thinning, keeping fruits 5–7 cm apart, and chemical sprays with DNOC and Sevin at 2000–2500 ppm at full bloom and a week after fruit set resulted in large fruits of Santa Rosa at Kandaghat. In recent years, Ethephon at 100 ppm sprayed 10 days after full bloom was found to be effective for fruit thinning and improving fruit quality in Beauty plum.

In apricot, NAA at 100 ppm at petal fall stage has been reported to give good thinning results.

Several studies have been made to control pre-harvest drop, particularly in apple. Spraying with Planofix containing 10 ppm of NAA three weeks before harvest or 7–10 days before actual drop, has been found to be highly effective in checking pre-harvest fruit drop and improving fruit size in Delicious apples in Himachal Pradesh. In late-maturing cultivars like Granny Smith, spraying with CCC at 200–300 ppm three weeks before harvest was found to be most effective.

Planofix sprays have also been found to check drop when apple harvesting was delayed by about a fortnight to avoid a glut in the market. NAA and 2, 4, 5-T each at 20 ppm sprayed two weeks prior to normal harvesting significantly decreased pre-harvest drop. In Golden Delicious, 2, 4, 5-T at 20 or 40 ppm applied a month prior to plucking had a beneficial effect. 2, 4, 5-T at 10 ppm checked drop in Red Delicious apple (Chadha, 1978).

In apricot, sprays of 2, 4, 5-T at 80 ppm have given best results for the New Castle variety (Chadha and Bajwa, 1968). GA 75 ppm, NAA 30 ppm, and 2, 4, 5-T ppm were other treatments found effective in controlling fruit drop.

The development of pigment in red apple cultivars is greatly inhibited in some areas situated at elevations of 1400–1700 m above mean sea level in the mid-hills of Himachal Pradesh. Spraying Ethephan at 100–1200 ppm in combination with 25 ppm NAA three weeks before harvest has been found very effective in enhancing red colour development and inducing uniform fruit maturity in such warm areas. Application of 3000 ppm of CEPA, combined with 2000 ppm of SADH 12 weeks after full bloom, was found to be the best for colouring Red Delicious apple and improving its quality.

In Jammu and Kashmir, experiments over a four-year period have shown that dipping Red Delicious fruit in 4 per cent calcium chloride solution for five minutes increased the calcium content of the fruit from 4.25 mg/100 g to 5.70 mg/100 g on a fresh weight basis.

Sprays with DNOC, at the rate of 2000–2500 ppm at full bloom and a week after fruit set, improved fruit size in Santa Rosa plum. Three applications of Ethephon 300 ppm at 10-day intervals commencing from 45 days before the normal date of harvesting hastened ripening in Santa Rosa plum. Concentrations above 100 ppm resulted in a dark purple colour. The application of Ethephon to advance ripening should be done 15 days before the normal harvesting time. Similarly, to induce ripening in plum, a post-harvest dip for one minute in 1500–2000 ppm Ethephon containing 0.05 per cent Teepol was found to be the best treatment at Solan.

TIBA at 10–25 ppm and SADH at 500 ppm has been found to significantly increase fruit firmness of Santa Rosa plum (Jindal and Mehta, 1986). The combination of $Ca\ (NO_3)_2$ with 10 ppm TIBA increased the anthocyanin content of fruit (Jindal and Sharma, 1986).

Crop Protection

PESTS

More than 150 species of insect pests have been found to cause damage to temperate fruit in India. Work on bionomics and the control of some important pests is under way.

San Jose scale, *Quadraspisiotus perniciosus*, is a most destructive pest in Kashmir, Himachal Pradesh, the Uttar Pradesh hills and other eastern Himalayan regions of India. It is also reported as a serious pest of pear, peach, plum, cherry, and apricot. Biological control of this pest has been tried. A Russian strain of *Prospartella perniciosi* gave as high as 9 per cent mortality of the pest. At Chaubattia, after release of American and Chinese strains, the pest population decreased by 95.73 and 94.78 per cent respectively. However, in commercial orchards control by parasites and predators is seldom sufficient to provide effective population suppression; consequently, one or two annual sprays are applied (Masoodi and Amin, 1978). Experiments have shown that oil emulsion sprays are more efficacious than organophosphoric insecticides and that dormant season application is better that summer spraying (Dar *et al.*, 1976). Work done in Himachal Pradesh revealed that 2 per cent miscible oil impregnated with organophosphatic insecticides like methyl parathion or fenitrothion 1 g for 1 hectare gives effective results (Sharma and Bhalla 1965).

The woolly aphid, *Erisoma lanigerum* (Hausman), is another serious pest of apple found in the northwestern hill region and the Nilgiris in Tamil Nadu. Successful biological control of the aphid has been achieved in the Kulu valley (Himachal Pradesh) by the introduction of an Aphelinid parasite *Aphlenus mali* Hald. Control was partly successful in Uttar Pradesh. *Coccinella septumpunctata* was also found feeding on all stages of the pest and giving almost complete control during summer in some Uttar Pradesh orchards. Work done on aphid-resistant rootstock has revealed that Golden Delicious, Northern Spy, and Stocks M-21, M-779, M-793, MM-111, MM-114, MM-115, and crab-apple (*M. baccata* L. var. Himalica) have been found highly resistant (Chauhan, 1987). The aerial population of the aphid can be controlled effectively by foliar sprays with fenitrothion, diazinon, dichlorvos as 0.05 per cent methyl demeton or thiometon 0.025 per cent and dimethoate 0.03 per cent in summer. Diazinon and methyl demeton are found less toxic to the parasite, *Aphelinuls mali*. For root infestation, the application of granules of demethoate, phorate, or disulfatan at 1 kg a.i./hectare is recommended (Chadha, 1978).

The codling moth, *Cydia pomonella*, is a serious pest of temperate fruit, mainly apple, in the Ladakh region of Jammu and Kashmir. It is absent in other parts of the state. The moth is active from May to July. The new hatched caterpillars bore into developing fruit causing the young fruits to fall off. The variety Thakush is most susceptible, while Karkitchu is least susceptible. Destruction of the fallen fruit and spraying with Dichlorvos are effective control measures.

Peach leaf curling aphid *Brachycaudus helichrysi* Kalt, is the most serious pest of peach and also attacks almond, apricot, and plum. Damage is caused by the nymphs and adults which suck sap from leaves, petioles, blossom, and fruit. The affected leaves turn pale and curl up, blossoms wither, and fruits do not develop to their normal size and drop prematurely. To control this aphid, 0.03 per cent dimethoate, oxydemeton, methyl phosphamidon, or quinalphos is sprayed before flowering (pink bud stage), followed by one or two sprays when the fruit is pea-sized (Sharma *et al*. 1968).

Four species of fruitfly, namely *Dacus dorsalus, D. zonatus, D. ciliatus*, and *D. cucurbiatae*, have been found to infest peach fruits seriously in Himachal Pradesh and Uttar Pradesh. For their control, bait sprays with yeast hydrolysate + sugar + malathion 0.1 per cent are recommended. Sharma *et al*. (1973) suggested two sprays of fenthion or fenitrothion 2.5 ml a.i. per tree four and two weeks before harvest. Growing of early-maturing cultivars like 16–23 and Florida Sun are also recommended because they escape damage (Deol *et al*., 1977).

Walnut weevil causes the premature dropping of fruit during June-July. During April, trees should be sprayed with 0.04 per cent quinalphos or 0.05 per cent dichlozvos.

Diseases

Systematic work on diseases of temperate fruits has been under way for the last three decades and work on epidemiology and control has been carried out.

Among various diseases which attack apple, the most destructive one is scab incited by a fungus *Venturia inaequalis*. This is particularly severe in areas with high rainfall and relative humidity. Losses from scab are greater than from any other disease or insect of apple. The apple scab fungus is only confined to apples (cultivated and crab) with the genus *Malus* and does not affect almond, apricot, peach, pear, plum, and other plants. Most of the apple varieties which are commonly grown in India are susceptible to scab. However, the locally evolved apple hybrids, Ambroyal, Ambred, and Ambstarking, were found to be fairly resistant to apple scab. Versified, popularly known as Maharaji, used to be free from scab but in recent years it has proved less resistant, a mild infection of the fruit having been noticed (Gupta and Lele, 1980).

The most striking symptoms of scab are commonly observed on leaves and fruit, but rarely on one-to three-year-old shoots (Gupta and Lele, 1976). The scab fungus consists of many strains which differ in their morphological, physiological, cultural, and pathogenic reactions.

Three main criteria—quantity and relative maturation of pseudothecia as a source of primary inoculum, phenology of the tree, and the occurrence of infection periods—form the basis of apple scab prediction in Himachal Pradesh which makes known the occurrence of infection before symptoms appear in the spring and helps growers to spray efficiently.

Adoption of certain means, e.g., 5 per cent urea spray at leaf fall (Gupta, 1979) to enhance the decomposition of leaves and keeping the orchard floor clean of fallen leaves, can help to reduce fungicidal application in the next season. A recommended spay schedule for the control of apple scab is given in Annex 2.

Hulling of Walnuts

The conventional method of walnut harvest, which consists of heaping up the walnuts so as to allow fermentation of hulls, is cumbersome and time consuming. It also stains the shells and hands of the huller and in some cases the kernel as well. Chemical hulling is more efficient.. This method also enables walnuts to be harvested earlier, keeping the kernels an attractive colour (Qureshi *et al.*, 1986).

Ethrel in various concentrations has been sprayed on trees and on nuts on the ground after harvest. Application of ethrel at the time of normal harvest in general resulted in a higher percentage of hulled walnuts in comparison to those treated one and two weeks before normal harvest (Qureshi *et al.*, 1986). Dipping the nuts in 2000 ppm ethrel resulted in great ease in hulling; the hulls either split on their own or could be removed easily. No staining was noticed on treated nuts. Even though spraying the nuts on the trees gave better results, trees of seedling origin being giant-sized, the operation is not practicable with the commonly used spraying equipment (Kabu, 1975).

Storage

Studies on apple storage carried out by Maini *et al.* (1985) revealed that firmness of the fruit decreased in storage. Dry matter, acidity, fibre, and tannin did not show any particular trend. Fruits showing a firmness of 7.5 lb or less should not be stored but should be disposed of immediately. In Jammu and Kashmir, studies on prolonging the storage life of Red Delicious apple by use of various wrappings have shown a definite advantage in the use of polythene 1 mm bags over the use of waxed paper, oiled tissue paper, or no wrapping at all. It resulted in minimum loss in fruit weight and maintained taste and crispness for a longer time (Bhat and Kabu, 1972). Apples placed in the controlled atmosphere storage at Srinagar remained fresh after nine months (Sharma, 1987).

Maini *et al.* (1983) reported that treatment of Red Delicious apple with calcium chloride 4 per cent for 15 minutes enhanced storage life. Further, the incidence of bitter fruit was reduced from 38.2 per cent in control to 22.4 per cent with post-harvest dip in $Ca(NO_3)_2$ and 20.1 per cent in 4000 ppm daminozide. Waxol coating improved fruit quality and was more effective when combined with alar for storage life improvement up to 60 days, as compared to 30 days under control (Chauhan, 1987).

The poor storage life of scabbed apples and of healthy fruit from infected trees reflect the need to send such fruits to the market for immediate consumption (Gupta and Verma, 1986).

Santa Rosa plum, given a post-harvest dip in 4 per cent calcium chloride for two minutes, recorded the highest colour development and minimum loss in flesh firmness during storage (Chopra *et al.*, 1986).

Packing

Studies conducted on the suitability of different types of packing have shown that the traditional wooden boxes are unsuitable due to the high percentage of bruising (16.6 per cent) and rotting (16.9 per cent) in comparison to imported cartons, which cause bruising and rotting of only 8.5 and 3.5 per cent respectively (Chauhan, 1978).

According to Maini *et al.* (1987), considerable reduction in bruising damage was observed in tray-packed apples during transportation compared with traditional packs. Bruising was reduced from 36 per cent in conventionally packed wooden boxes to 5 per cent in tray packs in wooden or corrugated fibre board cartons (Maini *et al.*, 1984). They further concluded that tray packing is better as it avoids wrapping individual fruits, provides cushioning material, prevents suffocation of the fruit by the proper circulation of air, and dispenses with the services of trained packers to repack these boxes for marketing. The trays can also be recycled.

Processing

Research on processing of apple is very meagre. Technology for apple cider production has been developed at IARI, New Delhi (Ambadan, 1978), while varietal screening has been done by Ambadan (1978) and Nagi Singh and Manjrekar (1976). Methods have been standardized for clarification of juice at CFTRI, Mysore and de-acidification of the juice at RRL, Jammu (Bhatia *et al.* 1979).

Some varieties of apple have been evaluated for processing qualities. Three low-chilling varieties, namely Sharp's Early, Gallia Beauty, and Parlin's Beauty, were found to be more juicy, with a juice content of more than 60 per cent. Pomace of Tropical Beauty registered the maximum pectin content of 9.1 per cent. On the basis of this study, cultivars Tropical Beauty, Sharp's Early, Royal Delicious, and Golden Delicious have been found to be the best for juice processing and pectin extraction from pomace (Gautam *et al.*, 1986).

The technology to develop fermented beverages from apple, plum, peach, and apricot is under standardization. Technology to prepare chuli (wild apricot) wine consists of dilution of the pulp in 1:2 ratio, the addition of DAHP 0.1 per cent, blending clarified wine to give a TSS of 11.5—12 per cent, and maturation in bottles for six months.

Vegetable Research Infrastructure

Research into the improvement of vegetable crops in the region started in 1947–48 in Uttar Pradesh, Himachal Pradesh, and Jammu and Kashmir under ad hoc schemes sponsored by the ICAR. In 1949, the Government of India started the Vegetable Breeding Station at Katrain, located in the heart of the Kulu valley in Himachal Pradesh where a small unit of the Government of Punjab was already operating since 1943. However, systematic research work on seed production and the development of new varieties of temperate vegetable crops was initiated when the Katrain station was transferred to IARI in 1955. At present, work on vegetable research is being carried out by the following organizations:

Himachal Pradesh:	Dr. Y.S. Parmar University of Horticulture and Forestry, Solan Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur
Jammu and Kashmir:	Sher-E-Kashmir University of Agriculture and Technology, Srinagar
Uttar Pradesh:	G.B. Pant University of Agriculture and Technology, Pantnagar Vivekananda Laboratory for Hill Agriculture, Almora Horticultural Research Station, Chaubattia, Almora
Northeast region:	ICAR Research Complex, Shillong

The programme of these institutions is supplemented by the Project Directorate on Vegetable Crops, which has its centres operating at Katrain, Solan, and Srinagar.

In addition, an ad hoc scheme on the control of black rot disease complex of cauliflower is functioning at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan.

Vegetable Research Achievement

Crop Improvement

The germplasm of cabbage and late cauliflower is being maintained at Katrain and Solan. A limited collection of germplasm of garden beet, radish, turnip, and carrot is being maintained at Katrain and Srinagar.

The IARI Regional Station at Katrain has done good work on the standardization of techniques for seed production of different temperate vegetable crops. Subsequently, the priorities changed and emphasis shifted to the breeding of new varieties with varying periods of maturity and better adaptation to agroclimatic situations. On the basis of these efforts at Katrain and other places, a number of new temperate vegetable varieties have been identified or bred. The important ones are listed in Annex 3.

Crop Production

Temperate vegetables are grown during the winter months in the Indian plains. However, in some pockets, i.e., the hills of Himachal Pradesh, Jammu and Kashmir, and the Uttar Pradesh hills, temperate vegetables are grown during the summer months because of favourable climate and to cater for markets in the plains and increased demand from local markets due to tourist influx. During recent years, off-season vegetable growing has picked up in a big way because of the high value of the produce. In the plains these vegetables are usually the last to come on the market and stay in the field for a considerably longer period of time because they do not throw off their seed stalks as quickly as their tropical and sub-tropical counterparts. The agro-techniques developed for different crops are given below.

CABBAGE

For off-season crops in the hills, successive nursery sowing is recommended from March to July for continuous supply. Delay in planting the variety Golden Acre beyond the end of September may result in reduction of the number of marketable heads (Tewari *et al.*, 1977, Awasthi *et al.*, 1976). The choice of varieties for off-season crops is crucial. Golden Acre and Sel-8 have been found to perform well in this season.

Spacing is dependent upon the cultivars. For early varieties, like Golden Acre, Sel-8, and Pride of India, a spacing of 45× 45 cm between rows and plants is recommended, while for late cultivars where head size is bigger, a wider spacing of 60× 60 cm is desirable. Different NPK doses have been recommended by various workers. Choudhury (1967) recommended 40 to 50 tons of farmyard manure, 325 kg of ammonium sulphate, 270 kg of single superphosphate, and 75 kg of muriate of potash per hectare. Thakur and Gill (1976) reported that 150 kg N, 125 kg P, and 100 kg K is the optimum dose for cabbage. Sharma and Lal (1986) believed that increasing the N level from 60 to 120 kg/hectare results in increased yield.

Seedlings should be watered immediately after transplanting. Thereafter, irrigation at an interval of 7 to 15 days is recommended, depending upon the season, soil, and rainfall. At the time of maturity, watering should be avoided to avoid splitting of the heads. Gautam *et al.* (1976) found that pre-plant application either of Trifulralion (0.51/hectare) or

Basaline (0.51/hectare) ensured excellent control of both dicot and monocot weed species and enhanced yield.

LATE CAULIFLOWER

To get a fresh supply of cauliflower during summer and autumn months, periodical sowing of Pusa Himjyoti is recommended, starting from March to June. This has done exceedingly well in areas located at 1000 m above mean sea level (Gill *et al.*, 1987). The raising of the nursery is similar to cabbage. Setbacks even at the nursery stage may result in buttoning. For the main season crop, a spacing of 45× 45 cm between rows and plants is recommended. However, for off-season crops a spacing of 45× 45 cm give better results. From July onwards the sowing of Pure snowball and Pure Snowball k-1 is recommended.

Cauliflower requires very high manuring as it takes large quantities of major nutrients from the soil. For best results, 15 to 20 tons of farm yard manure should be applied three to four weeks before planting. Sixty kg N, 80 kg P, and 40 kg K should be applied just before planting. Another dose of 50–60 kg N may be top-dressed six weeks after planting; 500 kg ammonium sulphate + 187 kg superphosphate is reported to be the optimum dose for the highest yield in Himachal Pradesh. Cauliflower is prone to boron and molybdenum deficiency, for which 10–15 kg/hectare of borax and 1–1.5 kg of sodium molybdate is recommended. Two sprays with 0.3 per cent boric acid before curd formation can also help to correct boron deficiency.

The cauliflower curd should be harvested immediately after it reaches its prime. Late harvesting results in loose, ricey, yellow, and fuzzy curds. Late cauliflower is more susceptible to fluctuations in day and night temperature, which results in a pinkish tinge on the curd.

KNOL-KHOL

Knol-khol is one of the most popular vegetables in Kashmir and can be grown throughout the year by making successive sowings and plantings. For an early crop in the northern hills, sowing is done in March-April according to the altitude, with some protection at night. For an off-season crop, spacing of 30 × 15 to 20 cm is recommended, while in the main season (winter sowing), the spacing should be more. Knol-khol requires steady growth and any check in growth will make the knobs fibrous. Best yields are obtained with 75 to 100 kg N and 60 kg P.

CARROT

Temperate variety carrots are more popular in the hills as these contain much higher carotene content than their asiatic counterpart. In the higher hills (1200 m above mean sea level), carrot can be grown throughout the year barring a few winter months (November to March). However, in the foothills, carrots are grown from August to November. The seeds are sown on ridges about 15 cm deep.

Well-rotted farmyard manure should be applied at the rate of about 30 tons/hectare, which should be supplemented with 60 kg N and 50 kg each of P and K (Choudhary, 1976).

RADISH

Radish is very useful for intercrop or companion planting between rows of crops of slower growth. By choosing the appropriate varieties, radish can be grown throughout the year in the hills as well as the plains. For the higher hills, Pusa Himani is most successful for growing from March to June, Japanese White from July to September, and Pusa Rashmi from October to November. For table purposes, Rapid Red, White Tipped, and White Icicle are the best varieties.

TURNIP

Turnip is grown on a very limited area during the main season. It is sown from August to November, depending upon the altitude. In the higher hills, sowing from March to May gives the best results, while in the lower hills, the best sowing time is from August to September. In heavy soil, sowing on ridges at a distance of 40 cm from each other is recommended. However, in sandy loam soil, flat sowing gives an equally good result. The fertilizer dose recommended is 20 to 25 tons of well-rotted farmyard manure, which should be supplemented with 60–70 kg N and 50 kg each of P and K per hectare (Choudhary, 1967).

OTHER VEGETABLES

Brussels sprouts and heading broccoli, which also belong to the cole group of crops, are not commonly grown in India. However, their cultivation is slowly picking up due to increased demand from large hotels catering to foreign tourists. The cultivation of brussels sprouts is similar to cabbage. No research has been done in India on this crop because of its minor importance.

Seed Production in Different Vegetable Crops

The Kashmir valley specializes in the seed production of cabbage, knolkhol, turnip, carrot, and garden beet, while Saproon valley and other adjoining areas of Solan in Himachal Pradesh concentrate on seed production of late cauliflower and some radish varieties. Seed production in the western Uttar Pradesh hills has also picked up quite recently. In these regions, most of the crops are planted for seed in August-September, passing through the vegetative phase during the snowy winter months of December-February, and flower after overwintering late in spring, producing seeds from April to June. Seed production in cabbage, cauliflower, and turnip is described below:

There are three main methods of seed raising in cabbage, namely, seed to seed, head to seed and late planting. Head to seed method is most suited for seed production of cabbage. To maintain the genetic purity of the crop roguing is essential, which should be accomplished before plants are stripped for their outer leaves in the months of November and December. An isolation distance of 1 km, between two varieties or sub-species of *B. oleracea* for certified seed is recommended. However, for breeder's seed, the distance should be more, preferably 1600 metres.

Most of the cultivated types of cabbage are biennial in nature. So far no variety has been bred which can produce satisfactory seeds in the plains.

The sowing and transplanting of the varieties should be so adjusted that head formation is complete before the onset of winter (November), by which time the temperature falls below 10°C, which causes wintering of mature heads. It has been seen that the Drum Head type should be sown in a nursery in the third week of June and transplanted by the first week of August. In a late-sown crop, head formation will take place after winter with no seed stalk formation. A mean temperature of 22°C, 20°C, and 15°C during the months of August, September, and October respectively is best for growth and head formation. Early varieties, like Golden Acre and Pride of India, should be sown from 10 to 25 July and transplanted during the second fortnight of August.

The highest seed yield can be realized by applying 250 kg each of N and P_2O_5 and 100 kg of P per hectare (Thakur and Gill, 1976). In case the growth of the crop is below normal, 2 per cent urea spray at 10-day intervals is very helpful to boost growth.

Crop Protection

PESTS

Among insect pests, cabbage white butterfly (*Pieris brassicae*) and aphids (*Brevicoryne brassicae*) are the two major pests of cabbage. Cabbage butterfly makes its appearance during the month of March when bright yellow eggs are laid usually in clusters on the leaves. On hatching, the young green caterpillar feeds on the surface of the leaves and skeletonizes them, but as the pests grow they crawl to all parts of the plant. In case of heavy infestation all the plant parts, including the pods of the seed crop, are completely destroyed, drying the attacked shoots. The pest remains active up to June and reappears in August-September. Spraying with 0.2 per cent Sevin gives some control. The attack by cabbage aphid and mustard aphid persists throughout the year in brassica crops, even during winter when covered with snow. The cloudy season accompanied by high humidity from March onward is very favourable to pest multiplication. Aphids can be successfully controlled by 0.03 per cent spray of dimecron in the vegetative stage and 0.2 per cent spray with thiodan or sumithion in the flowering stage, as they are safe insecticides for bees, which visit the flowers and help in pollination.

Besides the cabbage caterpillar and aphid, thrips (*Thrip tabaci*) cause considerable damage to turnip and radish crops. The presence of thrips in small numbers helps in pollination, but in case of heavy infestation, the flowers become sickly and setting is affected. Spraying with thiodan (0.2 per cent) or sumithion will help to keep the thrip population in check. Besides controlling thrip, these sprays will also help to control caterpillars and aphids, which can be quite serious at this stage.

Radish may be attacked by aphid at the seedling stage and can be checked by 0.2 per cent spray with malathion or any other insecticide. Sometimes, leaves are attacked by cabbage caterpillars, which can also be controlled by 0.2 per cent spray with malathion.

Diseases

The most serious disease of cole crops at the nursery stage is damping off caused by *Pythium* and *Rhizoctonia* sp. To get rid of these soil-borne diseases, the nursery beds should be treated with 2–3 per cent formaldehyde (1 part in 48 parts of water). Well-prepared nursery beds should be thoroughly drenched and covered with a sheet of alkathene to prevent escape of the fumes for 96 hours. Before sowing the seeds, the nursery beds should be kept open for at least 48 hours. Seed treatment with 0.3 per cent Bavistin or Difolatan or Captan will help to get rid of seed-borne fungal diseases. Five litres of solution is sufficient for one sq.m.

Rhizoctonia is caused by *Rhizoctonia solani* and may attack at different stages of plant growth. Young, transplanted seedlings of cole crops suffer the most. Drenching the soil around the plants with 0.3 per cent Brassiocol or Captan is helpful to combat this disease. High temperature accompanied by high soil moisture favours the spread of infection.

Black rot is a bacterial disease caused by *Xanthomonas campestris*. The disease is very common in off-season crops of cabbage and cauliflower in the northern hills.

Late Cauliflower

Techniques for seed production of late cauliflower have been standardized at Katrain. The seeds of early varieties of cauliflower have been produced in the country for a long time, but it has been possible to produce the seeds of late cauliflower since 1958 (Singh *et al.* 1960). The seed production of late cauliflower is limited to temperate regions, like Kulu valley and Saproon Valley of Himachal Pradesh, U.P. hills and Jammu region of J & K. The late cauliflower differs from other temperate vegetables in that it requires no wintering to break its dormancy. The success or failure of the late cauliflower seed crop depends mainly upon the time of transplanting which should be so adjusted that curd formation takes place when there is no danger of frost or snow. Experiments conducted at Katrain have revealed that the last week of August is the best time to sow the nursery and the first and second weeks of October for transplanting under Kulu and Saproon Valley (Solan) conditions where the bulk of cauliflower seeds are produced. Cauliflower is a very sensitive crop and even a little fluctuation in environmental factors can affect the crop seriously.

Heavy rainfall and even a little snowfall in the month of February are very harmful. However, better and assured seed yield can be obtained at a slightly lower elevation (1200 to 1450 m) where temperature fluctuations are not so wide. Relative humidity was not found to play any part in cauliflower seed production (Gill and Singh 1974).

Turnip

There are two distinct groups of turnip from the seed production point of view, namely asiatic and temperate. Asiatic types easily set seed in the plains. Therefore, the seeds of asiatic varieties can more profitably be produced in the plains. The seeds of temperate types are produced in the temperate hilly regions of the country, Kashmir Valley, Kulu Valley and Kalpa district of Himachal Pradesh. The crop is biennial in nature. For the temperate type seed sowing is done by the end of August or beginning of September and roots are ready by November. There are two methods of raising the seed of turnip i.e., seed to seed and root to seed. In the seed to seed method, the selection of roots is not possible and if the stock seeds are not of very high quality there are chances of great deterioration of the variety. Therefore, the root to seed method is advisable, although the yield of seed obtained by the seed to seed method is much higher. To raise stock seed the root to seed method is always followed. For certified seed production, an isolation distance of 1000 metres between any two varieties is necessary. However, for the production of foundation seed the distance should be more, preferably 1600 metres. Turnip should also be equally well isolated from mustard, Chinese cabbage, rutabaga and rape.

The seed crop usually ripens in the second fortnight of May. Due to easy dehiscence, turnip pods when fully dried shatter very easily. It is, therefore, advisable to cut the turnip crop when 60 to 70 per cent of the pods have turned yellowish brown. Harvesting in the early hours is recommended to avoid shattering. There are no control measures except to breed and grow resistant varieties. Two resistant varieties, one each in cabbage (Pusa Mukta) and cauliflower (Pusa Shubra), have been released by IARI. Some precautionary measures are also helpful in containing the disease, which is normally soil as well as seed-borne. Three-year rotations with non-cruciferous crops and hot water treatment of seed at 50°C for 30 minutes before sowing have been recommended as control measures.

Potato Research Infrastructure

Potato research is being carried out exclusively by two organizations, the Central Potato Research Institute, Shimla (CPRI), and the All India Co-ordinated Potato Improvement Project (AICPIP). Both organizations are under the ICAR and have their headquarters at Shimla (Himachal Pradesh). Whereas CPRI is primarily engaged in developing crop production, the AICPIP is engaged in testing newly developed varieties and techniques at various locations and assessing their suitability for adoption. The AICPIP centres are located at the state agriculture universities, which provide infrastructural facilities for conducting research work. The region has the following CPRI stations and AICPIP centres:

- CPRI, Shimla; established 1935/1945
- CPRI Research Station, Kufri-Fagu (Himachal Pradesh), established 1935/1968
- CPRI Research Station, Mukteswar (Uttar Pradesh), established 1975
- AICPIP headquarters, CPRI, Shimla, established 1971
- AICPIP Sub-centre, HPKVV, Palampur (Himachal Pradesh), established 1975
- AICPIP Main centre, SKUAST, Shalimar, Srinagar (Jammu and Kashmir), established 1972

Of these, the stations at Kufri-Fagu and Mukteswar are potato seed-producing centres, whereas the CPRI, Shimla and AICPIP centres at Palampur and Srinagar are involved in conducting research on potato.

Potato Research Achievements

Crop Improvement

GERMPLASM COLLECTION

Efforts have been made to collect the old potato varieties being cultivated in the region. The first collections were made in the early 1940s through the Department of Agriculture and Marketing Department. As many as 50 samples were collected from Himachal Pradesh (Pushkarnath, 1969). Among the varieties collected were Magnum bonum, Sathoo, Up-to-Date, and Darjeeling Red Round from Himachal Pradesh, Italian White Round, Up-to-Date, Chamba Red, Sathoo, Gola C, Phulwa, and Darjeeling Red Round from Jammu and Kashmir and Magnum bonum, Gola, Majestic, Up-to-Date, Dunbar Cavalier, Darjeeling Red Round, and President from the Uttar Pradesh hills. Since 1985, CPRI has undertaken a systematic survey of remote areas to collect old potato varieties. The details of these surveys are given here under in Table 10.2: This material forms a part of the potato germplasm collection at CPRI and is being used in variety improvement programmes. More surveys to collect additional indigenous varieties from the north western Himalayan region have been planned in the next few years.

TABLE 10.2

Potato varieties cultivated in the northwest Himalaya region

Date of collection	State	District	No. of samples collected
November 20–24, 1985	UP	Uttarkashi	16
August 25 to September 5, 1986	HP	Shimla	41
October 16 to November 6, 1988	HP	Shimla	12
		Kinnaur	37
	UP	Uttarkashi	6

VARIETY IMPROVEMENT

Work on potato variety improvement began in 1935 with the establishment of the Potato Breeding Station at Shimla. In 1949, a disease-free clone of Up-to-Date from Northern Ireland was released by the CPRI in Himachal Pradesh. Subsequently, the variety Craigs Defiance was introduced from the United Kingdom. Later, three potato varieties, Kufri Kumar, Kufri Kundan, and Kufri Jyoti, bred at CPRI were released during 1958 and 1968.

Ever since its release, Kufri Jyoti has continued to be the most popular variety in the region, because of its high yielding ability and resistance to late blight. However, in the last few years this variety has started getting late blight infection due to a change in the racial pattern of *Phytophthora infestans*, the organism that causes late blight. Efforts are, therefore, being made to select a culture possessing a high degree of field resistance to late blight and good yield. A large number of such cultures are being tried at Shimla/Kufri, Palampur, Ranichauri (Uttar Pradesh), and Srinagar centres of CPRI and AICPIP.

Crop Production

A large number of experiments have been conducted on various aspects of crop production in this region. Some of the data have been published and a lot more is available in the annual progress reports of CPRI and AICPIP. The major findings are given below:

NUTRITION

Fertilizer application is needed to meet the nutrient requirements of potato in most of the soils of the region. The optimum fertilizer dose varies with soil type, variety, climate, cropping pattern, composition of fertilizers, and the time and method of application.

A good crop of potato removes about 120 kg N per hectare from the acidic brown hill soil. The peak period of N uptake is from 60 to 80 days in the hills. The economic potato response to hill soil in Himachal Pradesh and Jammu and Kashmir is up to 92 kg N/ha (Grewal and Sharma, 1980). The dose of nitrogen in valleys may vary from 100-150 kg/ha. Economy in the dose of N can be affected if farm yard manure is applied 25-30 t/ha (Grewal and Sharma, 1981). Urea as source of N is comparatively less efficient than ammonium sulphate, ammonium chloride and calcium ammonium nitrate. A dose of urea higher than 40 kg N/ha adversely affects germination (Sharma and Grewal, 1978). The broadcasting of N fertilizer does not ensure its proper utilization by the potato plant. Grewal *et al.* (1979) reported that the placement of N fertilizer either in furrows or in side bands is significantly superior to 104 and 120 kg N/ha for furrow placement, band placement and broadcasting methods respectively. Split applications of N dose is recommended to avoid the deleterious effect a higher N dose has on seed tuber emergence. Thus, half the N dose should be given before planting and the rest by spraying around the time of tuber initiation (Sharma and Grewal, 1978) or 2/3 at the time of planting and 1/3 at earthing up (Grewal *et al.* 1979). If the second dose of N is to be given as a spray application of urea, the concentration of urea in the spray solution should not exceed 2.0 per cent and the biuret in urea should be less than 0.5 per cent (Sharma *et al.* 1975).

The deficiency of phosphorus is more pronounced in acidic hill soil as this is characterized by high P fixation capacity. The optimum P dose for this soil is 57 kg/ha. A number of phosphatic fertilizers have been tested for their efficacy. In the acidic soil of Kangra (HP) the relative efficiency of superphosphate, multiphosphate, defluorinated phosphate, fused magnesium phosphate, rock phosphate and a mixture of rock phosphate and superphosphate was 100,83.3, 88.7, 74.6, 61.6, to 83.9 and 95.3 respectively (Randhawa *et al.* 1968). Water soluble P fertilizers, particularly superphosphate, is the most suitable for potato in the hill soil of Shimla region (Sharma *et al.* 1976 a). P fertilizer should be placed near the active root zone of the plant. Verma and Grewal (1978) and Grewal and Verma (1982) reported that the placement of P fertilizer in furrows is better than broadcasting and band placement. The optimum P dose was calculated to be 52 kg/ha through broadcasting and band placement and 41 kg/ha through furrow placement. For the efficient use of P fertilizer, potato seed tubers should be soaked in 1.5 per cent single superphosphate solution. This treatment economises P use by 22 kg/ha (Sharma *et al.*, 1984).

The potato's need for potassium is high. On average, it removes about 190 kg/ha from acidic brown hill soil (Sharma *et al.* 1978). The peak period of K uptake is generally 60—80 days under the long day conditions in the hills which coincide with the tuber development phase (Sharma *et al.*, 1978). K application generally increases the size of the tubers which results in higher tuber yield. The optimum K dose for hill soil is 93 kg/ha (Grewal and Sharma, 1980). Potato varieties differ greatly in their response with K application. Among the various sources of K, potassium sulphate is found to be more efficient than potassium chloride and schoenite (K_2SO_4 + $MgSO_4$) in acidic hill soil (Sharma *et al.*, 1976). Furrow placement of K is the most efficient and economical method of application to potato (Grewal and Verma, 1982). Application of farm yard manure 30 t/ha can meet the P&K requirement of potato crop and can also economize on N dosage.

Positive response to copper, iron, boron and molybdenum has been observed in experiments conducted at Shopian (J&K) and to zinc at Shimla (Grewal and Trehan, 1979). Field experiments conducted at Shimla (Trehan and Grewal, 1981), revealed that soaking seed tubers in 0.05 per cent zinc sulphate solution for 3 hours or dip treatment of seed tubers in 2 per cent zinc oxide suspension were efficient and economical methods to meet the zinc requirement of potato.

Irrigation

The potato crop grown in the hills is mostly rainfed. Although the total annual precipitation in the hill regions may exceed evapotranspiration, there is moisture deficiency in early summer and excess water in the monsoon season. The use of a vegetative mulch in the pre-monsoon period conserves soil moisture and increases the tuber yield (Singh *et al.* 1975). Water harvesting within the field is also a good practice in areas receiving some pre-monsoon showers.

WEED CONTROL

The dominant weeds found in potato fields in the northwestern hills are *Oxalis latifolia, Galinsoga parviflora, Echinochloa colonum,* and *Setaria glauca*. Nankar and Singh (1982) reported that the nutrient losses caused by weeds at Shimla amounted to 42.6 kg N, 8.24 kg P, and 48.5 kg K/hectare. In an experiment with weed control through cultural practices and weedicides, the cultural treatment (hand weeding 50 days after planting) was found to be the best. It saved the nutrients by 33.5 kg N, 6.3 kg P, and 37.6 kg K/hectare. Among the weedicides, treatment with EPTC (3.75 kg ai per hectare, pre-planting) + Linuron (0.25 kg ai per hectare, pre-emergence) + Propanil (0.87 kg ai per hectare, post-emergence) was the best in controlling weed flora.

SEED PRODUCTION

Traditional potato seed production involves identification of virus-free seeds and its multiplication (usually in three years) to produce breeder's seed stocks. To date, the detection of viruses in tubers was done by serological techniques. However, a more efficient technique, ELISA (enzyme-linked immuno sorband assay), has recently been introduced into the Indian potato seed production programme for the detection of viruses PVX, PVS, and PVY. Virus detection with this technique is nearly 20 times more efficient than by serological testing. The virus-free or indexed tubers are subsequently multiplied by tuber cutting and also by sprouts.

Efforts are also being made to micropropagate indexed tubers to produce *in vitro* microtuberlets.

Crop Protection

PESTS

The soil pests commonly infesting potato are cutworms and white grubs, but the former are more destructive. Five species of cutworms—*Agrotis ipsilon, A. interacta, A. flammatra, A. spinnifera,* and *A. segetum,*—damage crops in India (Saxena, 1977). Of these, *A. segetum* and *A. ipsilon* are more important in the hills.

Cutworms occur regularly in the early period of crop growth (May-June) when the weather remains dry. Control of cutworms is possible by drenching the ridges with chlorpyriphos 20 EC at 2.5 l/hectare in 1000–1250 l when water 75 per cent of plants have emerged.

White grubs are usually present in all types of soil throughout the year in hilly tracts. They are, however, serious only occasionally and only in pockets. They feed on the underground tubers, making them unsuitable for marketing. This can be controlled by the application of Phorate 10 G or Carbofuran/3 G at 2.5 kg ai./hectare at earthing up (Anon., 1988).

Aphids (*Myzus persicae*) are important mainly because they are vectors of potato virus diseases which cause degeneration of seed stocks. In the northwestern hills, the aphid population generally remains below the critical level during the summer crop season. The critical limit is crossed only by the end of July. In the Uttar Pradesh hills, aphids generally cross the critical limit by early June. Insecticides like phorate (Thimet 10, G) at 10–15 kg/hectare in the furrows at the time of planting supplemented by foliar spray with oxydementon-methyl (Metasystox 25 EC) or dimethoate (Rogor 30 EC) at 1.2 l and 800 ml respectively, in 1125 l water for one hectare, provide good protection to the crop (Misra and Raj, 1977).

DISEASES

A total of 24 diseases of potato have been recorded (Shekhawat, 1988) in the hills of Himachal Pradesh. Several of these are found in the hill districts of Uttar Pradesh and Jammu and Kashmir.

Late blight is the most important disease in the entire northwestern hill region. The disease generally appears during the first week of July and kills susceptible varieties by mid-August. Losses due to the disease range from 21 to 74 per cent.

Several fungicides—mancozeb, copper oxychloride, oxadixyl, and matalaxyl formulations—are available for the control of the disease. Of these, mancozeb at 2 kg/hectare is commonly used. Continuous use of a single fungicide can result in selective depletion of beneficial soil microflora (Shekhawat, 1988). It is, therefore, desirable to use alternative or sequential sprays of one or more fungicides. To enable the farmer to prepare for timely spray of fungicides, a late blight forecasting system has been developed (Bhattacharyya *et al.*, 1982).

The main source of inoculum for disease development is the infected seed tuber. Proper earthing up of tubers and preventing the build-up of foliar inoculum by fungicidal spray and by haulm cutting when 20 per cent of the foliar infection is observed helps to reduce tuber infection.

The soil- and tuber-borne diseases—common scab, black scurf, and powdery scab—do not reduce yield but lower the market value of the produce. These diseases are increasing in many areas because of monoculture of potato. (Singh and Nand, 1988). Control measures for these diseases include: treatment of seed tubers to eradicate seed-borne inoculum by dipping tubers in 0.5 per cent organomercurial compound or in 3 per cent boric acid (pharmaceutical grade) for 30 minutes within 45 days of harvest; crop rotation with cereals, millet, or maize; and ploughing the land immediately after harvest so that it is exposed to low winter temperatures.

Brown rot of potato is a widespread disease in Kumaon hills (Singh, 1977) and several districts of Himachal Pradesh (Shekhawat, 1988). The disease is primarily seed-borne and the pathogen may remain viable in infested fields for two or three years. There are no resistant varieties available for commercial cultivation in India. Hence, cultural practices have been developed to contain this disease: use of disease-free seed; application of stable bleaching powder at 12 kg/hectare along with fertilizer in furrows at the time of planting; and growing potato in three-year rotations with maize, cereals and onion (Shekhawat, 1988).

Future Thrusts

The above review clearly indicates that systematic efforts have been made to create suitable infrastructure for research on temperate fruits and vegetables, including potato, in the Himalayan region of India. Further sound research programmes have already been initiated to tackle various aspects of crop improvement, crop production, crop protection, and to a lesser extent post-harvest management by various institutes and universities. This has resulted in building up valuable indigenous and exotic germplasm, identification of varieties for different regions, and the release of new varieties particularly of apple, vegetables, and potato. Several long-range trials to standardize agro-techniques have been laid out, particularly in fruit crops. However, the problems facing the fruit and vegetable industry are diverse and require concerted efforts to solve them. Some of the areas identified for this purpose are given below:

Fruit Crops

Emphasis needs to be given to the introduction of new germplasm, particularly new spur-bearing scion cultivars of apple, mutant selections of Delicious which develop better red fruit colour even in conditions of shade within the tree canopy, and new apple rootstock and new cultivars of cherry, peach, almond, and walnut developed in the United States and Europe.

Selections of the apple cultivar Delicious are notoriously unstable and mutate quite frequently. Efforts should be made to select improved, possibly compact 'sports' from existing orchards. Similarly, clonal selection may be made of walnut and almond having adaptability to particular environments and ease of propagation. Selection of suitable clonal rootstock out of different *Malus* species with semi-dwarfing vigour, tolerance to drought or adverse soil and moisture conditions, and resistance to root rot, collar rot, and woolly aphid may be made.

Cultivars resistant or tolerant to apple scab, powdery mildew, and woolly aphid need to be evolved through breeding.

The role of pollinizers and pollinators, including honey bees and other insects, needs to be fully assessed to improve fruit set. This should also take into consideration the female sterility prevailing in the Delicious group of apples.

In vitro micropropagation technique may be employed for the distribution of new and/or virus-free germplasm. Efforts should be to supply virus-free planting material from elite nurseries in large quantity.

For flat areas the optimum density for high-density planting needs to be determined and suitable systems of training and pruning defined.

Standardization of macro- and micro-nutrient requirements for young and bearing trees, doses of fertilizer for trees with different crop loads, and time and method of application need to be standardized.

Drip irrigation has high potential to increase fruit production through conservation and management of scarce water resources in rainfed areas. This system of irrigation may be tried for cultivation of temperate fruits.

Productivity of apple (tons/hectare) in Himachal Pradesh, Jammu and Kashmir, and Uttar Pradesh is significantly lower than in Europe or the Unites States. The best production figures noted in Jammu and Kashmir were only 50 per cent of those expected in most parts of northern Europe. Orchard productivity can only be maximized if an efficient tree spacing, pruning and training system is adopted. This involves optimal integration between tree spacing and appropriate techniques of branch and central leader pruning and training.

Suitable areas for apple and other temperate fruits need to be delineated on the basis of chilling hours, freedom from spring frost, hail, rainfall, and other factors.

A system of orchard soil management suitable for slopes and level areas needs to be worked out to conserve soil moisture and nutrients. Studies should also be conducted on replanting problems or soil sickness in apple orchards.

Intensive research into the effect of spring frost, hailstorms, and fluctuating temperature at the time of flowering and fruit set needs to be undertaken under different agroclimatic conditions. This should also include the use of growth regulators to delay flowering in order to escape frost damage and to ensure better fruit set under adverse weather conditions.

The extent of alternative bearing by different cultivars should be assessed and suitable remedial measures, including blossom thinning during the 'on year' with the help of growth regulators, should be worked out.

Economical methods of control need to be worked out against apple scab, powdery mildew, root rot, collar rot, canker complex, San Jose scale, woolly aphid, defoliating beetles, and other pests and diseases. An apple scab disease prediction control system with the minimum number of sprays needs to be based on weather and inoculum parameters.

Integrated pest management employing biological control agents for temperate fruits, particularly apple, should be standardized.

The problem of codling moth in the Ladakh area of Jammu and Kashmir should be taken up on a priority basis. Quarantine measures should be introduced to check its spread to other areas.

Reliable maturity standards for apple need to be worked out for the fresh market and for fruit to be stored or processed. Grading by quality and colour needs to be improved and standardized. Packing methods must be improved to avoid bruising and injury during handling and transport. Alternative packing cases other than wood have to be developed and their suitability and economics determined.

On-farm air cool storage and cold storage is necessary in the production areas to regulate supply and avoid gluts.

Suitable cold storage, controlled atmosphere storage, and hypobaric storage needs to be tried on an experimental scale and the optimum temperature and relative humidity for storage of different cultivars determined to ensure their availability to the consumer in good condition over a prolonged period.

At present, only apple juice is manufactured in the country. Some diversification in processed products is required like apple chips or crisps, alcoholic beverages such as cider, or cherry, apricot, peach, or strawberry nectar. In Europe and the United States, fruit-based carbonated drinks are becoming very popular and they should be introduced in India.

Some basic research should be carried out on crop and growth manipulation, including plant growth regulators.

Apple is currently the dominant temperate fruit crop produced in the country. There is a need to diversify into pear, cherry, peach, apricot, nectarine, olive, hops, saffron, figs, and plum. More emphasis should be given to the cultivation of nuts, particularly almond, walnut, pecan, and pistachio. The economics of apple farming alone and with pear, cherry, almond, or vegetables needs to be worked out to find suitable combinations.

The wide gap between the technology now available and its actual application by farmers should be bridged immediately through reorganization and strengthening of the departments of horticulture in hill states, so that they can provide competent professional horticultural extension services.

For quick adoption of horticultural technologies at the farmer's level, demonstrations should be arranged on orchard management, tree canopy management, density of plantation, moisture conservation, *in situ* tree nutrition, integrated pest and disease management, and other such aspects in accordance with the requirements of the area.

A national variety foundation (elite progeny orchard) should be established as a repository of all commercially grown varieties in the three hill states to serve as a scion bank.

The data base of horticultural crops is inadequate and, in some cases, not reliable. The data base, particularly area, production, and yield of different crops, should be regularly compiled. Crop cutting experiments on important tree crops should be initiated. The impact of tree crops on ecology and the environment must also be quantified.

Vegetable Crops

There are several constraints to the production of vegetables in the northwestern hills. These include moisture stress, acidic soil, and nutrient fixation, besides some major diseases and insect pests. The major diseases of cole crops are damping off caused by *Pythium* and *Rhizoctonia* spp., downy mildew caused by *Paranospora parasitica,* black rot (*Xanthomonas campestris*) in commercial crops, and cabbage yellowing (*Fusarium oxysporum f. conglutinans*), bacterial soft rot (*Erwinia carptovora*) in seed crops. In the root crops, root rot (*Fusarium oxysporum*), white rust (*Cystopus*), and Phyllody are important diseases. Among the insect pests, cabbage white butterfly (*Pieris brassicae*), aphids, and thrips are serious. Only limited information on the management of acidic soil, water management practices, and nutrient fixation is available. Ways to resist most of the diseases of these crops, except black rot in cauliflower and cabbage, are not known.

The following objectives have been identified to improve vegetable production in the region:

- Development of varieties possessing resistance to major diseases and insect pests, particularly curd rot and alternaris blight of cauliflower, adaptable to wider areas
- Development of F_1 hybrids in cabbage, cauliflower, radish, and turnip
- Intensification of research on seed production and location of new disease-free seed production areas
- Vegetable-based cropping systems and a package of agro-techniques for improved varieties
- Development of varieties for stress environment (e.g., drought, acid soil)
- Integrated management of common diseases and insect pests.

In addition, timely supply of essential inputs such as, quality seed, balanced mixtures of fertilizers, and plant protection chemicals and the organization of efficient marketing of the produce will go a long way towards boosting the production of vegetables in this region.

There are several major constraints to potato cultivation in the northwestern hills. These include moisture stress during the early phase of crop growth and excess moisture during the tuberization phase, high fixation of nutrients in acidic hill soil, and incidence of late blight and, to some extent, bacterial wilt or brown rot diseases. However, there are several constraints to tackling these problems, namely, inadequate information on water and soil management practices; insufficient information on reducing nutrient fixation, especially P and K in acidic hill soil; and the non-availability of sources of resistance to brown rot so as to develop resistant varieties.

The following objectives have been identified to improve potato production in the region:

- Development of late blight-resistant varieties to replace the new susceptible variety Kufri Jyoti
- Evaluation and development of soil management practices for water optimization and conservation in relation to potato crop
- Development of a potato-based cropping system for efficient use of nutrients and to reduce the incidence of soil for tuber-borne diseases
- Management of brown rot.

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Annex 1

Promising cultivars of fruits identified in Himachal Pradesh

Apple Spur Type:	Red Spur, Golden Spur, Stark Spur, Orgon Spur, Miller Sturdy Spur, Starkrimson
Colour mutants:	Top Red, Royal Red, Vance Delicious, Hardeman
Low-chilling:	Tropical Beauty, Parlin's early Worcester
Peach, for mid-hills:	Shimizu Hakuto, Kanto-5, and Dawne
For valley areas:	Early Amber
Plum:	Greenage, Simmon, Frontier, Queen Ann Nubiana, Friar
Apricot:	Farming Dale, Local selection
Almond:	Merced, White Brandis, Kashmir Seedling, Star Basin
Kiwi fruit:	Allision, Hayward
Olive, pickle type:	Aglandeau, Frantoio, Ascoiternana, Leccino, Coratina
Oil type:	Ascolano, Grosseune, Cornicobra, Itrana, Mission

Annex 2

Recommended spray schedule for the control of apple scab disease (Agrawala 1985)

Tree stage	Schedule	Amount (chemical/100 l water)
Silver tip to green tip	Difolatan (SALT),	300 g
	Difolatan,	200 g
	Captan 75 WP, or	300 g
	Dithane M-45	400 g
Pink bud or after 15 days	Dithane M-45,	300 g
	Captan 50 WP, or	300 g
	Captan 75 WP	200 g
Petal fall	Carbendazim (Bavistin, B-stein, MBC-JK-stein, or Agrozim)	50 g
Fruit set (10 days after petal fall)	Dithane M-45,	300 g
	Captan 75 WP,	200 g
	Captan 50 WP, or	300 g
	Mixture of Carbendazim and Dithane M-45	250 g
Fruit development (14 days after fruit set)	Dithane M-45,	300 g
	Delan,	50 g
	Captan 50 WP, or	300 g
	Difolatan	150 g
14 days later	Repeat only Dithane M-45, or Delan or Captan 50 WP	
Pre-harvest	Repeat Dithane M-45, Delan, Captan 50 WP	
Pre-leaf fall	Urea	5 kg

Annex 3

Important Vegetable varieties identified or bred in the hill region

Crop	Name of variety	Institution	Remarks
Cabbage	Golden Acre	IARI research Station, Katrain	Introduction
	Pusa Mukta (Sel - 8)	IARI research Station, Katrain	By hybridization. Resistant to black rot.
	Pusa Drum Head	IARI research Station, Katrain	Selection field-resistant to black leg.
	Pride of India	Dr. Y.S. Parmar University of Horticulture and Forestry	Introduction.
	September	Tamil Nadu Agricultural University	Introduction suitable for Nilgiris.
Late cauliflower	Pusa Snowball-I	IARI Regional Station, Katrain	Hybridization.
	Pusa Snowball-I	IARI Research Station, Katrain	Selection.
	Pusa Snowball-I	IARI Research Station, Katrain	By inbreeding and selection.
	Pusa Himjyoti	IARI Research Station, Katrain	Selection from III maturity group.
Knol-khol	White Vienna	IARI Research Station, Katrain	Introduction.
	Purple Vienna	IARI Research Station, Katrain	Introduction.
Brussels sprout	Held Ideals	IARI Research Station, Katrain	Selection.
Garden beet	Detroit Dark Red	IARI Research Station, Katrain	Introduction.
	Crimson Globe	IARI Research Station, Katrain	Introduction.
Carrot	Nantes	IARI Research Station, Katrain	Introduction.
	Pusa Yamdagni	IARI Research Station, Katrain	Selection.
	Zeno	Tamil Nadu Agricultural University	Suitable for Nilgiri hills.

11

Genetic Resource Issues in Horticultural Developmental Approaches of the Hindu Kush-Himalayan Countries

Tej Partap

Introduction

The contribution of genetic resources to horticulture has been the most important application of the new science. Taking famous examples from history (Lamb and Aldwinckle, 1981), French grapes relied heavily on rootstock developed from wild American vines. Strawberries and several minor fruits have drawn extensively on wild germplasm and banana breeders have turned to wild stock for disease resistance. Apple breeders have used several *Malus* species for disease resistance and to widen the adaptations of the cultivated apple. New scab-resistant cultivars of apple have been developed using genes from the Japanese crab-apple *M. floribunda*, which is otherwise domesticated as a flowering plant (Lamb and Aldwinckle, 1981).

In the USSR and China, breeders have used the cold tolerance of *M. baccata* to extend the northward range of apple growing (Cummins and Aldwinckle, 1979). A review of other fruit reveals that wild genetic resources have had a major impact on strawberry, raspberry, and currants, while others that have benefited to a lesser degree include peach, plum, apricot, almond, walnut, chestnut, and pistachio (Robert and Prescott-Allen, 1988).

What can be expected from genetic resources in the future is also largely based on past trends. A look at past achievements shows that genetic resources have been successfully used to our advantage in the following ways:

- Domestication of new crops
- Disease resistance
- Pest resistance
- High yield
- Vigour
- Environmental adaptations
- High food value (vitamins, proteins)
- Cytoplasmic male sterility
- Petaloid male sterility
- Harvest and transport adaptations (such as post-harvest adaptations and quality).

The use of these resources can be expected to continue and will probably increase. It will be necessitated by the need to cope with new ecological conditions, more virulent diseases, peskier pests, unforeseen fluctuations in climate, and changing economic demands. Changes in technology and social expectations also encourage the greater use of genetic resources.

More genetic resources may be screened for potential biochemical crops and those yielding latex (e.g., *Euphorbia* sp.,), waxes (e.g., *Calthea* sp.) and oils (e.g., *Prinsepia* sp., and *Bassia butyraceae*) may be in great demand.

Broadly, the potential of genetic resources is seen to be in the culture of biochemicals, the development of new domesticates, and the improvement of existing domesticates. Thousands of species could be used in improvement of existing domesticates alone (Robert and Prescott-Allen, 1988). However, the factor that will determine the degree of their use in the future largely depends on the availability of suitable germplasm. Breeders and genetic engineers can devise more and more ingenious ways of using available genes but they cannot create new ones. Although genetic resources are a relatively brand new resource and their utility is growing dramatically, the lack of progress in conserving them is casting a shadow over their future.

Loss of habitat, overexploitation, and competition and predation by introduced species are the main threats to genetic resources today. The possibilities of finding new species of potential genetic value diminishes as the areas of greatest ecological diversity, such as the mountains, face deforestation, habitat shrinking, encroachment, and agricultural expansion. The wild gene pools of many fruit and nut crops are being reduced throughout the world by habitat destruction, cutting for fuel, and overgrazing and overbrowsing by animals (Robert and Prescott-Allen, 1988).

A standing example is that of the wild pear in Japan. The wild Japanese forms of *Pyrus usuriensis* and *P. pyrifolia* and the species *P. dimorphophylla* are of great importance as genetic resources for the improvement of pears of China, Japan, and other countries. However, Iizuka (1975) reported that these species were already near extinction and could be classified as rare species.

The reasons for conserving variations within species are: first, genetic variation is essential for species to adapt and survive, and second, genetic variation is the new material of domestication and of the continued survival and improvement of the domesticate. Both reasons are equally valid and each requires different approaches to conservation. But so far, conservationists have usually thought only of the first while the second has been largely ignored. New ways of maintaining and using these newest resources are high on the international agenda today (Jacobs and Munro, 1987). It has been realized that development that is inflexible and too little influenced by ecological considerations is unlikely to make the best use of the available genetic resources. When ecological damage occurs, economic and social damage are also likely. The most effective way society can avoid such problems is to integrate every stage of conservation and development processes, from the initial setting of policies to their eventual implementation and operation (IUCN, 1980; Swaminathan, 1986).

In the farming sector, after decades of considerable debate on sustainability and the wisdom of expanding industrialized agriculture to marginal lands, it is now realized that the time has come for an assessment of agricultural development vis-a-vis sustainability (Dover and Talbot, 1987). A region-by-region agro-ecological audit covering the use pattern of energy, physical, and biological resources and preservation of biological diversity along with environment is suggested to identify principal problem areas in terms of sustainability. It is intended to provide a basis for developing coordinated comprehensive research and development programmes and policy changes.

Selected Genetic Resources Issues in Mountain Horticultural Development

Objectives and Strategies of Horticulture Development in the Hindu Kush-Himalayan Region

Horticulture advocated as a dominant activity for mountain areas has the basic intention of taking advantage of varied climatic conditions to provide better sources of income to mountain people, improve their lifestyle, and stabilize fragile mountain land.

However, the objective of rational use and conservation of available genetic resources and their biological diversity are peculiarly missing from the basic approach so far. The results of this neglect become clear when analysing various programme strategies and their impact.

The horticulture development strategies of the Region are intended to be a three-way effort—special emphasis on self-sufficiency in horticulture items currently imported; promotion of those crops which could be exported to gain foreign exchange (especially crops which are highly developed and largely cultivated elsewhere, with proven market value); and a low priority effort to improve the nutritional status of undernourished mountain communities through encouraging cultivation of fruits and vegetables for family use. Horticulture policy planning and research institutions are making earnest efforts to bring several other activities, also called ancillary activities, under the scope of horticulture.

In following this approach the financial gains from horticulture have been impressive in selected areas of the Hindu Kush-Himalayan region.

Genetic Resources and Biological Diversity

Several factors have dictated the choice of horticultural species in this region. Some are stated in objectives and programmes, others are not. Biological diversity was never the main focus of this activity whether for use or for conservation. The chief objective of programmes in the Hindu Kush-Himalayan Region is the introduction of well-developed crops with high marketing potential. Table 11.1 illustrates how little use of the genetic resources of the region has been made to develop new domesticates to diversify horticulture in the ecological context.

An example of the valuable gene pools that exist in these mountain areas is the vast gene pools of several horticultural plant species in the northeastern Indian Himalaya. Rich diversity in this region has been reported for citrus, mango, and banana (Arora and Nayar, 1984; Kaul, 1981). A citrus sanctuary is being established in this region for the preservation of wild forms (Singh, 1977). These indigenous species include *Citrus lemon, C. medica, C. jambhiri, C. ichengensis, C. latipes, C. macroptera, C. assamensis, C. indica, C. aurantium, C. lamonica, C. karna*, and *C. aurantifolia*. The Indian wild orange, *C. indica*, is found in the Naga hills near Dimapur, Garo hills of Meghalaya, and Kaziranga forest of Assam. In mango, the wild forms of *Mangifera indica* and its allied species *M. sylvestris* occur in the forests of this region. Rich diversity occurs for *Musa, Pyrus, Rubus, Ribes*, and *Prunus* as well. The Shillong plateau of Khasi hills in Meghalaya accounts for many *Prunus* species such as *P. nepalensis, P. undulata*, and *P. cerasoides* (Kaul, 1988). In vegetables and tuber crops good variability occurs in *Alocacia, Abelmoschus, Amorphophyllus, Colocasia, Dioscorea, Luffa, Cucumis*, and *Trichosanthes* in different parts of this region. In spices and condiments,

TABLE 11.1

An overview of diversity of horticultural resources within the Hindu Kush-Himalayan Region and their utilization

Crop type	Number of species promoted for cultivation		Approximate number of species locally used
	Major	Minor	
Fruit trees	5	18	150–200
Fruit shrubs	2	5	80–120
Vegetables	8	20	230
Tuber vegetables	1	6	15
Spices	3	8	40
Mushrooms	1	6	280
Medicinal and aromatic plants	10	50	500
Other plant resources, e.g., fibres, insecticides	?	7	50

Alpinia speciosa, *A. galanga*, *Amomum aromaticum*, *Curcuma zeodooria*, *C. amada*, *Piper longum*, and *P. peepuloides* are the major species. The region is considered a home of several species of medicinal plants such as *Berberis*, *Cassia*, *Coptis*, *Gynocardia*, *Litsea*, *Paedera*, and *Solenum* (Kaul, 1988).

These examples are given to show that if only we explore it, there is no dearth of valuable indigenous plant material in the Hindu-Kush Himalayan Region. In other parts of the Himalaya there is vast genetic diversity within various fruit plants which remains underexploited or threatened by extinction, by habitat destruction, and by displacement by new exotic crops.

Tables 11.4, 11.5, 11.6, and 11.7 further prove that everywhere the focus has been on a limited number of similar crops leading to problems of monoculture. The objectives, programme priorities, and horticulture crops choice pattern in Bhutan (DOA, RGB, 1989) seem more judicious (Table 11.8).

The data also show that there is an ongoing attempt at identifying distinct climates, comparing them with the agro-ecological requirements of known exotic species, or cultivars, evaluating their suitability, and suggesting their introduction into those specific mountain microclimates. So only the variations in climate have been considered and not the whole agro-ecosystem which develops under the sum total of all the conditions.

To further illustrate the state of genetic resources in horticulture development policies, an examination of the strategies and programmes of Himachal Pradesh, recognized as the fruit or apple state of India, is

TABLE 11.2

Genetic resource diversity in pear in mountain areas of Pakistan

Vernacular name of variety	Distinguishing features as reasons of folk varietal selection (excluding agroclimatic adaptations)
Parao	Large size, pear shape
Sur Tango	Small, round
Shin Kulay	Medium, apple shape
Spin Tango	Small, round
Mamusay	Small to medium, round, early
Shakar Tango	Sweet, medium size
Nashpati	Medium to large, sweet
Tang	Large, pear shape
Khan Tango	Small, round
Batang	Large, pear shape, sweet
Nag Tango	Large, apple shape, hard
Nar	oblong to pear shape
Shal Tango	—
Khar Nak	Large, hard
Gadaray Tango	—
Bap Tango	Early
Khawaga maiwa	Small, round, sweet
Khapa	Sour

These 18 varieties have 13 distinct characters in different combinations. Their agroclimatic specificities are unreported here and will be additional features.

Source: Rashid Anwar and Sadiq Bhatti (unpublished). ICIMOD-commissioned paper on genetic resources of Pakistan.

presented here. Many of the programmes listed below were initiated with financial support from external agencies, both national and international. A brief appraisal of the programmes follows (Azad, 1986):

A programme for *production and supply of fruit plant material* facilitates plantations of hybrid varieties, mostly apple. In the 10 years up to 1985, 24 million plants were distributed.

Under an apple cultivation support programme, financial support is given to farmers to purchase plant material, pesticides, and fertilizers. Also, there are projects supported by international aid agencies on apple crop development and promotion.

In programme on top-working wild fruit trees, wild relatives of fruit crops are being top-worked, *in situ*. The total target for the Sixth and Seventh Plan periods was 11 million plants to be rechristened. The means converting jungles into orchards. Although the intentions behind the programme are good, the implications are dangerous on several counts in general and specifically for maintaining diversity of wild genetic resources.

Diversification of horticulture, enlarging its scope to include mush-

TABLE 11.3

Genetic resource diversity in apricot existing in mountain areas of Pakistan

Vernacular name of variety	Distinguishing features as reasons of folk varietal selection
Skardu area	
Marpho choli	Red apricot
Karfoo choli	White apricot
Warfo choli	Pith used for oil
Bro choli	Late maturing
Khakas choli	Kernel partly split
Cho choli	Juicy
Apo choli	Large size
Beru choli	Small size
Blafo choli	Small, red
Odumar choli	Partially red
Chun choli	Sweet pith
Yakar choli	Reddish
Gurdaalo choli	Like peach
Pharang choli	Dry apricot
Kartaksha	Early, juicy
Sara choli	—
Kacha choli	Hard, good to keep
Halman choli	Best quality
Kazangi choli	Sweet
Khashanda choli	Good taste
Kho choli	Bad taste, sour
Shakanda choli	Sticky
Tacho choli	—
Marghlam choli	Early, good quality
Shanda choli	Small size, early
Stun choli	Late maturing
Mamoor choli	—
Ghom choli	—
Sara karfo choli	Early
Stun kuban choli	—
Khustar choli	—
Sapastan choli	Sour, kernel used for oil
Miting choli	Sour, kernel used for oil
Shakar choli	Sweet
Hongool choli	—
Brook choli	—
Halwar choli	—
Duspaong choli Yakab yak choli Snair choli	Selections due to specific agro-ecological characters
Shikanda joo	—
Brum joo	White
Surasune joo	Good quality

Contd.

Table 11.3 Contd.

Duda-sanag joo	—
Koropiam joo	—
Ali Shan Kakas joo	Late
Habi joo	Very late
Khanemish joo	—
Kartach joo	Very early, white
Dudar joo	—
Ghulam joo	—
Rashikin joo	Early
Alman joo	Good quality
Koropian joo	Early
Gakateen joo	—
Kaka shikanda joo	—
Moen joo	—
Ghaka joo	—
Mamoor joo	—
Brun joo	—
Gario joo	—

Source: Rashid Anwar and Sadiq Bhatti (unpublished). ICIMOD-commissioned paper on genetic resources of Pakistan.

TABLE 11.4

Fruit crops selected for Nepal Himalaya on the basis of agroclimatic suitability

Fruits	Zonation system (districts)
Citrus	Dhankuta, Bhojpur, Terhathem, Sankhuwasabha, Panchthar, Ilam, Sindhuli, Ramechhap, Dhading, Kavrepalanchok, Gorkha, Lamjung, Tanahu, Syangja, Kaski, Palpa, Gulmi, Salyan Dailekh, Dadeldhura
Apple	Solukhumbu, Sindhupalchok, Rasuwa, Mustang, Jumla, Kalikot, Dolpa, Rukum, Doti, Baitadi, Darchula
Banana	Kavre, Dhading, Nuwakot, Sarlahi, Dhanusha, Mahotari, Chitwan
Pineapple	Dhading, Nuwakot, Sarlahi, Chitwan
Mango	Bare, Parsa, Rautahat, Sarlahi, Mahotari, Dhanusha, Sunsari, Sirha, Saptari, Chitwan, Kapilbastu, Nawalparasi, Rupandehi, Surkhet, Dang
Walnut	Jumla, Kalikot, Bajhang, Darchula, Baitadi, Dolpa, Rukum
Pear	Dhankuta, Bhaktapur, Lalitpur, Kavre, Dhading, Makwanpur, Sindhupalchok, Nuwakot, Rasuwa, Palpa
Grape	Banke, Bardiya, Manang, Mustang

Source: Seventh Five-year Plan (1985–1990), National Planning Commission, HMG, Nepal.

room culture, olericulture, cultivation of medicinal plants, and other activities is under way.

Special crops such as hops, sarda melon, ad pistachio are being introduced in high mountain areas with a temperate climate.

TABLE 11.5

Fruit crops of various agroclimatic zones of Pakistan mountains

Zonation system by altitude (m)	Fruit crops
1200	Almond, pomegranate, apricot, plum, persimmon, peach, grape, fig, pistachio, mulberry, strawberry
1500	Almond, pomegranate, apricot, plum, persimmon, peach, grape, fig, pistachio, cherry, pear, walnut, mulberry, strawberry
1800	Apple, peach, grape, cherry, pear, walnut, mulberry, strawberry*
2100	Apricot, apple, peach, plum, pear, walnut, strawberry
2400	Apricot, apple, pear, peach, berry fruits*
2700	Apricot, apple, berry fruits* (gooseberry, currants, raspberry)
3000	Apricot (early-maturing cultivars), berry fruits* (gooseberry, currants, raspberry)

* Prospects for cultivation exist

Source: Alam (1989).

TABLE 11.6

Fruit crops of various agroclimatic zones of Indian Himalaya (Himachal Pradesh)

Agroclimatic zones	Approx. elevation (m above sea level)	Rainfall (cm)	Fruit crops
Low hills' and areas near the plains	365–914	60–100	Mango, litchi, valley loquat, citrus, papaya, ber, fig, low-chilling varieties of pear, early variety of grape
Mid-hills (sub-temperate)	914–1523	90–100	Peach, plum, apricot, almond, persimmon, pear, pomegranate, pecan
High hills into interiors	1523–2742	90–100	Apple, pear (soft and valleys type), cherry, walnut, almond, chestnut
Cold and dry zone	1523–3656	25–40	Grape, prune, drying variety of apricot, almond, chilgoza, sarda melon, pistachio, hops, apple

Source: Azad (1986).

TABLE 11.7

Fruit crops of various agroclimatic zones of Chinese Himalaya (Hengduan mountains)

Agroclimatic zones	Areas of interest	Fruit crops
Hot arid zone: Av. annual temp. > 20° C Winter, 7–12° Summer, 24–28° C	a. Yuanjiang river valley, Shangjiang river valley	a. Coffee, mango, banana, papaya, common
	b. Jinshanjing river valley, Ninnan, Qiaojia	b. Citrus, banana, guava, longan, litchi, > 1900 m apple, pear, peach, grape
Humidity conditions in sub-zones a. 0.67–0.50 b. 0.5–0.29		
Warm arid zone: Av. annual temp. > 14° C Winter, –5–7° C Summer, 22–24° C	a. Dadu river valley, Lhasa river valley, Yalong river, reaches of Lanchangjiang river	a. apple, pear, peach, plum, apricot, cherry, persimmon, grape, walnut, chestnut, loquat, pomegranate, orange, tangerine
Humidity conditions in sub-zones	b. Jinchuan-Luomo in Dadu river valley	b. Snow pear of Hanyuan Sweet-smelling peach of Luding
a. 0.67–0.50 b. 0.50–0.29	Binchuan Basin in Yunnan	Nave orange of Shimian and Dechang, Xing peach of Xichang, green skin pomegranate of hills, apple, pear, pomegranate, walnut in Jinchuan Danba, tangerine in Binchuan basin
Temperate arid zone: Av. annual temp. > 710° C Winter, 0° C Summer, 18° C	a. Zagunou river valley, higher reaches of Mingjiang river	a. Concentrated areas for pear and apple
	b. Songpau in Minjiang valley, higher reaches of Dadu river and its tributaries	b. Snow pear Best quality apple
Humidity conditions in sub-zones a. 0.67–0.50 b. 0.5–0.29 c 0.29.–0.2	c. Batau Shangiatou area of Jinshajiang river, higher inaccessible areas or lesser areas of Nujiang river valley	c. Pear, apple

Contd.

Table 11.7: Contd.

Cold arid zone: Av. annual temp. > 74° C a. 0.67–0.50 b. 0.50–0.29	Baiyu-Batan area of Jinshajianj river valley, Changdu	Wild domesticates of: Flowering crab-apple (*Malus toringoides*); Chinese crab-apple (*Malus asiatica*); Hawthorn (*Crataegus scabrifolia*); and Japanese apricot (*Armeniaca mume*) Many other important wild fruit genetic resources
Winter, −70° C Summer, 12° C	Manhan of Lanchangjiang river valley, Bangda-Zougong of Nujiang river	
Humidity 0.5–0.29	All high altitude areas	

TABLE 11.8

Horticulture crops of various agro-climatic zones of Bhutan Himalaya

Agroclimatic zones	Important areas	Horticulture crops
Northern 30 km wide. Alt. above 4000 m. Cold climate, perpetual snow, glaciers, barren rocks.	High mountain areas	No farming practices or horticulture activity
Central		Apple, potatoes
70 km wide. Alt. 2000–4000 m. Temperate climate, major forest areas, horticulturally suitable.	Thimpu, Paro, Ha, Bhumthang, Wangdiphodrang	Scope (trails): Asparagus, apricot, peach, plum, cherry, walnut
		Scope (planned): Currants, blackberry, gooseberry, raspberry, loganberry
Southern		
50 km wide. Alt. foothills to 2000 m. Tropical to sub-tropical warm climate, horticulturally suitable.	Samchi, Gaylephug, Chirang, Samdrup	Cardamom (low volume, high value), lemon grass oil (wild resource, low volume, high value), orange, ginger, chillies, potato scope (planned): Mango, guava, litchi, banana, kiwi fruit, figs, black pepper

An Indo-Italian project aims to introduce olive cultivation in the state. Other introductions being executed under this project include rootstock for various temperate fruits such as apple, peach, plum, and cherry.

There are quite a few projects assisted by UNDP, FAO, and the Dutch government to promote the cultivation of mushrooms. Under these projects some strains of *Agaricus*, essentially introductions, are being promoted for cultivation.

Introductions, Monoculture and the Issue of Unsustainability and Environmental Degradation

Too much dependence on introductions is illustrated here by an example of temperate fruit promotion in the Indian Himalaya and its consequences.

Temperate fruits (apple, pear, peach, apricot, cherry, plum, almond, walnut, pomegranate, and persimmon) have been instrumental in transforming the farming economy of several hilly areas of the Indian Himalaya. But this success is largely based on introductions of varieties and rootstock of several of these crops. The focus of horticultural research in the institutions of the region has been mainly directed to introducing developed genetic material at convenience (Table 11.9) and its evaluation for key features (Chadha, 1986). Higher yields through introductions are to be further pursued. Such large-scale introductions into a region may cause several unforeseen problems. And one of the first to be realized is the introduction of new diseases into a region. These diseases are inadvertently caused by genetic material which might have been infected and have escaped detection. The discovery of this category of diseases in the region shows that they came with crops in which large-scale genetic material introductions were made (Table 11.10).

Though technologies are being perfected to avoid the transfer of such diseases, yet the dangers persist, especially in poor developing countries where the application of these technologies depends on the availability and development of infrastructure facilities.

Apple has emerged as the number one crop of this region in terms of both area and production (Teoatia 1986; Rongsen, 1988; Chaudhry, 1989; Pandey, 1989). Indicators of the unsustainability of apple monoculture are already coming to light. A two-way loss is reported. First, expenditure on plant protection measures is increasing due to large-scale incidence of diseases, upsetting the cost-benefit ratio to a considerable degree. In some areas it has increased to levels where it is no longer economical to grow apples and a serious search for alternatives has started. For example, reports from the Hengduan mountains of China (Rongsen, 1988) speak of increasing disease incidence in the apple crop, reducing production by 30—60 per cent. Pesticides are being used extensively and with up to eight sprays a season pests are becoming resistant and chemical control proving ineffective. The natural ecological community of apple orchards has already been damaged and the environment affected. At the same

TABLE 11.9

Scale of introductions of horticulture genetic resources: Temperate fruits of Indian Himalaya

Apple	• All commercial cultivars introduced over time.
	• Latest trend is for introduction of genetic material for dwarfing and disease resistance from Europe.
	• The cultivars introduced are several spur types.
	• Present promising rootstock introductions from Malling Merton series, like M 26, M 7, M 25, MM 106.
Pears	• Main introduced commercial cultivar being promoted for cultivation is Bartlett.
	• Among other recent introductions are Megness, Devoc, Starkrimson.
Cherry	• Many introduced cultivars like Sletta, Merton, Bigarreau, Sunburst, Lapins, Sam, Van.
	• Some new hybrid selections from Canada under evaluation.
	• Non-availability of a suitable rootstock and heavy virus infection in existing plant material are major constraints of the crop.
Peach	• Introduced cultivars are Kanto-5, Shimizu from Japan, Red haven, Sun haven, three of the Prairie series and Veteran, all from the United States and under evaluation.
	• Rootstock Brompton and St. Julian K are under evaluation.
Plum	• Santa Rosa a known cultivar.
	• Recent introductions in plums are Starking Delicious, Late Santa Rosa, Queen Ann, Nubiana, Burmosa, Laroda, Stanley, Cacenska Rana, Ruth Gersttater, all from the United States.
	• Introduced Myrobalan has been found to be a promising clonal rootstock.
Apricot	• Newcastle cultivar for mid-hills introduced.
	• Some native varieties for high hills are known
	• Recent introductions under evaluation include Hargraud, Reliable, Forming, Dale, Alfred, and many others from Bulgaria.
	• No clonal rootstock available yet.
Almond	• Introduced cultivars are Non-pareil, Ne Plus Ultra, Drake.
	• Other introductions under evaluations are Wonder, Bruce, Mercett.

time more area is being brought under apple crop. A similar situation has developed in the Indian Himalaya also.

The second loss ascribed to apple monoculture is in the degradation of the environment. Huge amounts of poisonous chemicals are being used as pesticides. The Chinese example described above and another example from Himachal Pradesh (India), revealed that 2300 tons of pesticide were sprayed over 425,000 hectares of apple crop up to last year to control diseases. To meet the future needs of the farmers of this state, plans to install plants to formulate several of these pesticides in the state itself are under way (Azad, 1986). By the year 2000, Himachal will have been

TABLE 11.10

Exotic diseases and pests of horticultural and vegetable crops introduced along with genetic resources into the Himalayan Region of India

Diseases/pests	Host	Region/country of origin	First recorded
Hairy root	Apple, pear	Sri Lanka	1940
Crown gall	Apple, pear	Sri Lanka	1940
Canker	Apple,	Australia	1953
Woolly aphid	Apple, pear	England	—
Downy mildew	Grape	Europe	1980
Fluted scale	Citrus, Guava	Australia	—
Fluted scale	Mango	Australia	—
Mosaic	Banana	Not known	—
Rust	Chrysanthemum	Europe, Japan	1984
Late blight	Potato, Tomato	Europe	1983
Wart	Potato	Netherlands	1953
Golden nematode	Potato	Europe (UK)	1961
Potato tuber moth	Potato	Italy	—
Downy mildew	Onion	Not known	—
Smut	Onion	Not known	—

Source: Paroda *et al.* (1987).

sprayed with thousands of tons of these non-degradable lethal chemicals. By 2000 these pesticides will have entered most of the food chains of ecosystems to a considerable degree, poisoning most biological organisms, including humans. Similar practices are under way on an even higher scale in olericulture. The issue does not attract much attention because of lack of information and the tendency to ignore it for as long as possible.

The question that arises here is whether we can find solutions to these problems by using genetic resources. If yes, what constraints prevent such as exercise?

Rootstock–Exploration and Easy Alternatives

The use of wild genetic resources as rootstock in horticulture crops does more than develop new crops. One of the significant needs of fruit crops is good rootstock to achieve any of the following main objectives:

- Manipulating plant size, such as creating dwarf varieties
- Disease resistance
- Manipulating phenological calendars and fruiting cycles, so important for mountain areas

The problem of rootstock is aptly described to Alam (1989) quoting the example of Pakistan. He has reported poor selection of rootstock as well as insufficient availability of selected rootstock resources as the number one problem of horticulture in the mountain areas of that country. Using poor rootstock means lower yields. In areas where all trees have the same rootstock it is difficult to account for poor yields and disease, discouraging farmers from cultivation of a particular fruit crop because they mistakenly believe environmental unsuitability to be the cause. He has further stated that non-availability of nursery plants raised on healthy rootstock is a major deterrent today in expanding horticulture successfully in these mountain areas. The scenario describes, in fact, the general situation prevailing in almost all the Hindu Kush-Himalayan Region countries today.

At present, the general practice is to depend heavily on introduced rootstock for fruit trees, such as the Malling Merton rootstock series of apple. It has been introduced on a large scale in almost all countries of the Region. The present use of and future plans showing heavy dependence on introduced rootstock resources, with no programme to explore indigenous materials in the case of temperate fruit crops throughout the Indian Himalaya (Chadha, 1986, Table 11.9), is an example of the unwise trend.

The idea here is not to oppose introductions but to discuss its other implications such as the cost of introductions, their consequences, and indigenously available better material.

There are examples to show that promising rootstock genetic material is available within the Hindu Kush-Himalayan Region to improve many of our fruit crops but that there is lack of interest and efforts to explore and use it (Table 11.11). In China, flowering quince is in use as apple rootstock to bring on dwarfing and early fruiting (three to four years). In Swat valley of Pakistan, local people have gained experience in using incompatible species as rootstock to cope with soil-borne diseases of apple. They use *Crataegus* (hawthorn) as rootstock, by first grafting *Sorbus* on it and then later grafting apple on *Sorbus*, which is compatible. These examples are only the tip of the iceberg as far as available indigenous genetic resources and knowledge of their potential uses are concerned. Lack of information and its exchange seems to be another reason for low use of indigenously available genetic resources.

Medicinal Plant Resources: Underutilization and Reckless Exploitation of Resources Coupled with Ill-conceived Strategies

Available information shows that a vast amount of medicinal plant resources are available within the Hindu Kush-Himalayan Region with high potential to provide economic benefits to mountain people

TABLE 11.11

Diversity of underexploited rootstock and crop genetic resources of fruits in the Himalayan region (an example)

Species	Local name	Use
Pyrus pashia	Kainth	Rootstock for pear
Pyrus lanata	Kainthee	Rootstock for pear
Prunus puddum	Wild cherry	Cherry and fruit crop
Prunus padus	Bird cherry	Cherry and fruit crop
Prunus cerasus	Arid cherry	
Fragaria vesca, indica	Strawberry	Fruit and root breeding material
Cydonia vulgaris	Quince	Fruit, rootstock
Pyrus baccata	Siberian crab	Fruit, rootstock
Ribes grossularia	Gooseberry	Presently all imported stock is used for berry cultivation
Ribes glaciale	Red currant	Native genetic material as rootstock, for breeding and development of currants
Ribes nigrum	Black currant	Native genetic material as rootstock, for breeding and development of currants, introduced
Ribes rubrum	Red currant 5000–12,000 ft., new fruit better than *R. glaciale*	New fruit crop, rootstock, introduced
Corylus colurna	Hazelnut . 5000–10,000 ft	Dry fruit

Source: Atkinson (1860, reprint 1980).

(Dhiman, 1976; PFRI 1984; Teoatia, 1986; DMP, HMG, 1982; Ayensu, 1986). Their use in household medicine has only secondary importance. The main focus is on using the medicinal plant resources of mountain areas to enhance that income of the people, be it through collection from natural habitats or by cultivation. As the institutional efforts in horticulture are to encourage farmers, research efforts are directed to identifying promising drug plants and attempting their domestication. Some examples of medicinal plants being farmed on a commercial scale are found in Tibet, the northwest Himalaya in India and medicinal plant farming cooperatives in Nepal. Compared to farming, the collection of medicinal plants from their natural habitat is on a much larger scale. This two-way harnessing of medicinal plants falls under two kinds of farming activity. One is their cultivation and the second the generation of off-farm employment.

Two important issues emerge in the context of medicinal plants.

One concerns those few species known for their high economic potential. Increasing demand for these scarce plant resources by drug and pharmaceutical industries is resulting in their collection beyond their productivity levels. So far, no effective institutional methods have been devised in any of the countries to contain the threat of genetic erosion of these species. This has led to a situation where many of these species are now listed as endangered species in national and international records (Ayensu, 1983; see Table 11.12). The International Union for Conservation of Nature and Natural Resources (IUCN) and UNESCO, through its Man and Biosphere (MAB) programme, have highlighted this impending danger and cautioned governments and other agencies to take effective steps.

TABLE 11.12

Overexploited medicinal and aromatic plants of Himachal Pradesh, Indian Himalaya, listed as threatened plants

Name	Agroclimatic zone of collection
Aconitum spp.	Alpine zone, high mountain areas
Dioscorea spp.	Alpine zone, high mountain areas
Picrorrhiza kurrooa	Alpine zone, high mountain areas
Podophyllum	Alpine zone, high mountain areas
Orchis sp.	Alpine zone, high mountain areas
Jurinea sp.	Alpine zone, high mountain areas
Banium sp.	Trans-Himalayan high mountain areas
Berberis spp.	Foothills to high mountain areas
Artemisia sp.	Trans-Himalayan high mountain areas
Arnebia sp.	Trans-Himalayan high mountain areas
Atropa sp.	Trans-Himalayan high mountain areas
Gentiana spp.	Trans-Himalayan high mountain areas
Nardostachys sp.	Trans-Himalayan high mountain areas
Rheum sp.	Rocky high mountains
Rannolfia serpentina	Foothills sub-tropics

Source: Chauhan (1988); Lakhanpal (unpublished), commissioned paper by ICIMOD

The second issue is the cultivation of medicinal plants. One school of thought takes the view that encouraging the cultivation of these medicinal plant will save them from extinction and also ensure regular income. Such an approach gives rise to new problems. For example, Hindu Kush-Himalayan mountain farmers have, on average, 0.5 hectare land holding and it could be less than this in high mountain areas where these resources occur. Here the emphasis is on growing food crops on all available cultivable land and, even then, production barely meets the farmers' needs. In such a situation it is highly unlikely that the ordinary farmer will accept cultivation of non-food crops. Moreover, land holdings are too small to give the farmer adequate economic benefit from non-food crop cultivation. There is a danger that scientific and institutional support and efforts may unwittingly help an outside enterprising wealthier class to initiate large-scale medicinal farming, reaping the benefits at the expense of the native cultivator. It will also destroy the off-farm income opportunities generated by these medicinal plants so far.

Mushrooms: A Complex Case of Underutilized Resources

Like medicinal plants, mushrooms fall both under farming and forestry sectors. Throughout the Himalayan region people have been reported as collecting and eating more than 283 species of mushrooms (Lakhanpal, 1988), a vast edible mushroom bastion by any standard. Mushroom, in fact, is used as a vegetable during distress periods. In March-April when there is only a small stock of pulses left with subsistence mountain farmers and when there are not enough green vegetables, poor farmers depend on local forest supply of mushrooms as a vegetable. Also, they often sell any excess collection in local markets to meet petty cash needs.

On the other hand, the strategy in mushroom cultivation is directed to the cultivation of the world-renowned species *Agaricus* in a major way and other species such as *Pleurotus*, *Volvariella*, and *Lentinus* on a minor regional basis. *Agaricus* is, by all standards, a world mushroom crop (Table 11.13). It has been introduced in a highly developed form and the transfer of technology and technology development in this region is mostly related to composting and spawning (Lakhanpal, 1988). The small concern for the diverse underexplored mushroom genetic resources indigenously available is explicit.

There is yet another significant point worth highlighting which concerns the choice of species for cultivation, e.g., the unique case of morel, *Morchella esculenta*, and other species of the genus. It is a highly valued mushroom (US$ 80–100 per kg) found in the forests of several areas within the Himalayan region, namely, Nepal, India, Pakistan, and Bhutan. Viewed from the household angle it is an important cash income source for poor mountain folk, vital because its habitat forests are in inaccessible areas. Poor farmers can earn income from morels at a time when there are few other income sources and little work on the farm (March-April). A morel-ethnobotanical study conducted by Lakhanpal and his associates (1988) in Himachal Himalaya lends further support to this statement. Also it is a source of income to all sections of the family, i.e. children, women, shepherds, and cowboys. Official records, however, do not show very impressive production of morels, for example, 25 tons from the northwest Himalaya of India (Lakhanpal, 1988). That may just equal the income from an apple orchard of a few thousand trees. But the fact remains that the money becomes available to the most underprivileged class at a crucial time and from non-agricultural land. It is available without any investment inputs to the section of society which

TABLE 11.13

History of world production of *Agaricus bisporus*, white button mushroom

Country	Production (tons)				
	1939	1960	1970	1980	1983/84
USA	17,000	50,000	88,000	213,000	255,000
UK	6,800	21,000	40,000	61,800	84,000
France	20,000	35,000	68,000	131,700	—
Hungary	800	1,000	2,000	—	—
Denmark	400	2,500	6,500	6,600	—
West Germany	300	3,000	20,000	35,000	34,200
Italy	—	2,000	20,000	44,000	—
The Netherlands	—	3,000	29,500	60,000	80,000
China	—	—	2,000	66,800	—
India	—	—	—	1,500 (est)	2,000 (est)
Japan	—	2,000	4,800	5,500	—
Taiwan	—	700	39,000	64,400	—
South Korea	—	—	6,000	25,600	—
Total world production	46,000	136,000	381,100	812,200	455,200

Note: Compiled figures are from Lakhanpal (unpublished), commissioned paper by ICIMOD.

can least afford to invest. The only effort needed is to devise sound policies to preserve the habitat conditions which, unfortunately, are being degraded, shrinking the gene pool of this valued genetic resource. Dangers in the cultivation of morels lie in snatching a sustenance income source of the poor disadvantaged mountain people which may pass on to a comparatively wealthy farmer enterprising class. Though some may argue that total production of morels will increase through cultivation and that there will be overall state or national income gains, actually the benefits will move from those who had it as a vital resource to those who will have it as a new accessory resource. As the morel is not a medicinal plant but merely a scarce delicacy, the arguments in favour of necessary increases in availability to large sections of society cannot be convincing.

These lengthy explanations have been given to bring home the point that we must understand these linkages and the implications of ignoring them in our development strategies. We should be aware of the implications of already limited options of cash income to remote mountain people. Further depriving them of these options will lead them to desperately find alternative ways, such as increasing cultivation of unwanted crops like hemp (*Cannabis*), which is coming up as one of the new sources of income in several remote mountain areas of the Himalayan region.

Floriculture: Plant Resources for Comparative Advantage

Floriculture, a relatively new ancillary activity of horticulture, offers much potential in the mountains. Several hundred species of beautiful mountain flowers are listed in *Flowers of the Himalaya* by Polunin and Stainton (1987). The northeastern Himalaya of India and southeastern provinces of China are centres of diversity and evolution of several ornamental plant species such as *Rhododendron, Magnolia, Primulas, Camelia, Iris* and *Jasminum*. It is also home to hundreds of species of orchids (Table 11.14), notably *Dendrobium* spp., *Paphiopedilum* spp., *Cymbipidium* spp., *Phalaenoosus* spp., and *Vanda* spp. Many of these orchids are highly valued for floriculture.

TABLE 11.14
Orchid diversity in the Indian Himalaya

Important areas of diversity	Approximate no. species found
Northeast Himalaya	
Assam: Rani, Kaki, Garampani, Orang, Digboi	150
Meghalaya: Kawphlong, Jarain, Cherrapunji	300
Arunachal Pradesh: Rupa Valley, Kameng, Subansiri, Siang, Tirap	368
Manipur hills	250
Nagaland hills	150
Tripura hills	100
Sikkim: Rabongola, Margan, Tsunythang, Gangtok	275
Northwest Himalaya	
Himachal Pradesh	
Uttar Pradesh: Garhwal and Kumaon hills	200
Jammu and Kashmir mountain ranges	

Source: Swarup 1989.

Several pockets of the Indian Himalaya are engaged in the flower trade. The practice is based on raising hybrids of known varieties and cut flowers are sent to the cities in the plains during the off-season. The cut flowers of rose, gladiolus, lily, narcissus, daffodil, carnation, chrysanthemum, etc. are supplied from the northwestern Indian Himalaya to Delhi and Bombay; similarly, Kumaon hills of Uttar Pradesh, Kalimpong, and Gangtok in Sikkim supply gladiolus, orchids, gerbera, magnolia, camellia, iris, geranium, and other temperate species to Bombay, Delhi, Calcutta, and other cities of the Indian plains. The economic benefits of flowers with comparative advantage of mountain habitat could be tremendous. The price of a sample spray of orchid, for example, is about US$ 1–2 in the markets of Delhi and Bombay (Swarup, 1989). Rose (*Rosa* spp.) offers vast scope for farming due to its tremendous genetic diversity in the Himalayan region. Existence of races with high potential for rose oil brighten the chances of increasing yields to economically acceptable levels.

The current emphasis in floriculture is on research and development to evolve improved varieties of mostly exotic species known for their market value and to evaluate their climatic suitability. Except for some attention given to orchids, few attempts have been made to harness mountain floral resources as a cut flower crop and for the production of essential oils of high value, and as garden or potted plants. Instead, the programmes under way are pushing cultivation of hybrid exotic flower varieties, with little effort to harness the floral diversity potential of the mountains.

Further, as with mushrooms and medicinal plants there is always a chance of transferring resource gains, after technology application, from the most needy, the custodians of underutilized genetic material, to an enterprising, resource-exploiting class from outside.

Alleviating Malnutrition through Horticulture Crops

One of the objectives of a horticulture development policy is to improve the nutritional standards of people facing malnutrition. Although malnutrition is recognized, the objective is relegated to a low priority programme.

Most people assume that increasing the cash income of households automatically helps to increase nutrition levels. The point is particularly argued with reference to horticulture development programmes. Although no data are available to substantiate or contradict this assumption for the mountain areas of the Hindu Kush-Himalayan region, several studies on this issue have been made elsewhere to explain this relationship. (Tinker, 1979; Kumar, 1977; Acharya and Bennett, 1983; Tripp, 1982). A review of these studies reveals several facts which question this assumption.

A recurring theme in all cash crop promotion programmes or technologies is that while the cash income of the people increases, its effects on household food consumption and nutrition are mixed, i.e. positive, neutral, or negative. The disturbing fact is that more often they tend to be negative, as pointed out by Braun and Kennedy (1986). These experts further argue that the actual outcome depends on several factors such as the actual increase in real income, income composition, change in who controls income (men or women), effects on the allocation of time of household individuals, especially mothers, nutritional knowledge, and health and sanitary factors.

Cash cropping influences nutrition in two ways. First, land and other resources are shifted from food crops to cash crops. Secondly, the diet transformation may not necessarily be nutritionally better than the past subsistence diets containing indigenous foods.

Promoting cash cropping to the extent of substituting food crops and thus depending on total or some food imports for a region has the danger of food being used as a political tool. Also, in importing food, the main objective shifts to checking hunger or undernutrition while malnutrition is ignored. Situations can be visualized where price levels and availability of food become important factors in maintaining political stability. Under such conditions food distribution may actually be targeted only toward the social groups relevant for political stability.

Understanding the nutritional consequences of cash cropping depends on what kind of indicator is chosen, such as household food expenditure, caloric intake of family, protein intake of family, or growth, mortality, and morbidity.

Income is one of the major determinants of a family's food consumption pattern. The marginal propensity to spend on food may be significant but the propensity to consume calories and proteins out of additional income may actually be low.

The form in which income is received is another factor that can affect consumption and nutritional status. There is evidence from India that income in kind is more likely to be used for family consumption than cash income (Braun and Kennedy, 1986). Studies in India and Nepal suggest that the children of families practising mixed farming of cash and food crops are better nourished than those switching over to total cash crops. Lastly, home or kitchen garden produce is more likely to meet nutrition demands of households in an effective way.

Selecting Horticulture Resources for Remote Mountain Areas

Inaccessibility, harsh climatic conditions, poor socioeconomic environment, and the availability of several kinds of indigenous crop resources in their traditional farming systems, are notable features of remote mountain areas. Inaccessibility is paramount and varies from a day's walk to a journey of several weeks. Some areas in Nepal are outstanding examples.

The imperatives for horticulture development under such conditions are certainly different from those of other mountain areas. Here the priority focus has to be on horticulture crops which help to make these areas self-sufficient in food needs. Under a traditional system, knowledge exists about perennial plants which can help to supplement the diet.

From several local examples, we learn that any food habit, so long as it provides a nutritious diet, is worthy enough to be protected from unnecessary transformation and its primary sources should be given due care. It also explicitly explains the ways in which horticulture can contribute to supplementing food. Helping reduce dependence on outside food supplies and reduce human drudgery of transporting it over long distances will be significant contributions. Efforts are needed to base the cash income of these remote mountain communities necessarily on non-agricultural land because of scarcity of agricultural land and primary importance of food crops. Moreover, the products need to be of high value and low volume and non-perishable, e.g., medicinal plants.

Mountain Perspective in Horticulture Development and Genetic Resources

The important conditions characterizing mountain areas, which for operational purposes separate mountain habitats from other areas, are termed 'mountain specificities' (Jodha, 1989). The first four specificities, inaccessibility, fragility, marginality, and diversity or heterogeneity, may be called 'first order specificities'. Natural suitability or niche for some activities or products in which mountains have comparative advantage over plains and human adaptation to mountain habitats are the two second order specificities. The latter are responses or adaptations to the first order specificities.

A development initiative designed with full sensitivity to these mountain specificities will reflect the Mountain Perspective. This perspective is a complex of varying degrees of these mountain characteristics, their multiple dimensionality, and their interrelationships, providing a contextual perspective to decisions and actions in mountain areas.

Sensitivity to such a mountain perspective would determine the relevance and effectiveness of any approach to horticulture development in mountain areas (Table 11.16). Biological resources fall under several categories and the possible range of contributions and benefits they offer to the development of horticulture with a mountain perspective are listed in Table 11.17. Efforts to identify and inventory such plant resources are very much needed for these mountain areas, specially because there is a dearth of any up-to-date information. The following two examples of plant resources are being quoted here to emphasize and illustrate the kind of potential contributions these genetic resources can make. In addition, using them in a sustainable way should also help in their conservation in several ways.

Seabuckthorn: Promising Horticulture Plant for High Mountain Farming Condition

The unsuitability of conventional horticulture crops to remote high mountains areas is well known because of several constraints. *Hyppophae*

TABLE 11.15

Relationship between prevalence of malnutrition in children and income flow periodicity

Functional group	Percentage of malnourished children
Horticulturists	25.1
Diversified small farmers	29.1
Maize and rice producers	25.1
Agricultural workers	21.4
Salaried urban class	15.5
Self-employed workers	13.4
Government employees	12.8
Professionals	11.2

Source: Braun and Kennedy (1986).

is one of the few species native to such environment. It can offer multiple benefits to the people living in the high mountains and also help to improve the environment. Rongsen (1988) while citing an example of proper harnessing of *Hyppophae* in west Sichuan mountain areas of China, has discussed how promising this plant resource could be to horticulture and agro-forestry practices of mountain areas with harsh climates and marginal lands. Some of the noteworthy points he made follow.

Seabuckthorn (*Hyppophae*) is equipped with several outstanding features. Most important is its ability to fix nitrogen. Nitrogen-fixing bacteria live in symbiotic relationship, in abundance in its root nodules. So great is its capacity to fix nitrogen that a 1 hectare plantation of seabuckthorn would fix more than half a quintal (50 kg) of nitrogen. It is better than the nitrogen-fixing capacity of soybean, the standard example quoted worldwide. More investigations on its genetic races may reveal still higher potential.

It can resist cold temperatures up to minus 60° C and can tolerate hot summer temperatures up to 40° C. The plant also tolerates alkaline soils (pH 9.5) and salts (1.1 per cent). It has an extensive root system which probably also helps in controlling soil erosion. While secreting acids from roots, it in fact helps improve alkaline soils.

Other features of the plant are its excellent fuelwood in areas where fuel is a scarce commodity (caloric value 4000 kcal/kg). It is most adapted to cold, dry conditions and marginal, infertile soils. High mountain farmers do not have to put fertile agricultural land under it. Rather it will grow on barren slopes and flat lands, making them more fertile and suitable for agriculture. Intercropping with seabuckthorn would forgo the need for additional fertilizer supply. It is also traditionally used as a common hedge plant in trans-Himalayan high mountain areas of Nepal and the Indian Himalaya.

TABLE 11.16

Mountain perspective in horticulture development: Issues for consideration

Dimension Mountain Specificities	Physical	Biological	Economic	Social
Inaccessibility	Remoteness, transportation problems	Underexplored genetic resources	Subsistence systems, poverty	Ethnically unique, isolated mountain communities
Fragility	Fragile environment, soil erosion on slopes	Endangered species, over exploitation, reckless exploitation	Dependence on limited horticultural crops of plant resources	Danger of losing beneficial social values of these ethnic communities (cooperation, resource sharing)
Marginality	Less fertile, barren land	Neglected, underexploited genetic resources	Neglected non-profitable practices	Socio politically neglected mountain people (societies)
Diversity	Agro-ecological zones, several microclimates	Management of overall biological diversity	Varied choices of income generation (horticulture with several options)	Countless kinds of ethnic mountain communities with their own social organizations
Niche or comparative advantage	Exclusive agro-ecosystem suited to horticulture activities or mixed farming	Horticulture-related endemic species for exclusive agro-ecosystems	Advantage of producing specialized products	Peculiarities of each social organization
Adaptation experiences	Adjustments of skills to local environment	Harnessing skills for indigenous plant resources	Mountain societies traditional activities income generation	Traditional systems of cooperation, help, resource sharing

TABLE 11.17

Range of possible contribution of genetic resource diversity to horticulture development with mountain perspective

Horticulture genetic resources

Inaccessibility

- Genetic resource for high-value, low weight products
- Low input centred
- Low crucial dependence
- Long keeping quality
- Non-perishable products
- Suited to local processing
- Developing self-sufficient farming in remote areas
- Nutritional needs

Fragility/marginality

- Facilitate stability
- Reduce fragility
- Adapt to marginality
- Improve marginal soils
- Strengthen sustenance capacities of mountain societies
- Management of fragile resources

Diversity

- Facilitate expansion of horticulture to wide range of environmental conditions
- With more options and external inputs
- Help develop horticulture in a sustainable way
- Provide material for crop protection system
- Open scope for biological control
- Help develop exclusive, specialized horticulture production based on farming system

Niche (comparative advantage)

- Harnessing ecological niches in a complimentary way (honey bees)
- Help reduce dependence on few resources and their over exploitation
- Reduce monocultures
- Help develop exclusive product-oriented farming
- Provide opportunities for better terms of trade for the exclusive products

Adaptation experiences

- Use of local knowledge and experience of resource management and processing
- Local skills available
- Low dependence on external advice and input
- Support existing social systems for cooperation, mutual benefit, and rational use of resources

The plant bears small juicy berries which are rich in nutrients. Of special significance is its vitamin C content of up to 100 times more than any other fruit known so far (Table 11.18). Its significance as a very good source of vitamins further increases when we take into account the fact that in these high mountain areas vitamin sources are always scarce. In addition, fruit pulp and seed contain a high quality oil for use in food and industry.

TABLE 11.18

Fruit characters and nutritional value of products of seabuckthorn

Parameter	Average (Percentage)	Range (Percentage)	Remarks
Weight of 100 berries	24.9	4.5–405	
Percentage of juice in berries	71.76	33–82.5	
Soluble sugars	6.4	6.1–8.9	
Free amino acids (mg/100 ml)	130	76–264	
Vitamin C (mg/100 ml)	952	471–1709	Vitamin C highest of all plants
Vitamin E	93.2	60–120	Vitamins present in the juice, syrup, and wine of seabuckthorn
Vitamin A (mg/100 g)	11	7.75–14.5	Processed dry powder prepared by Chinese and marketed for preparing drinks
Vitamin B (B_1, B_2 (mg/100 g)	0.6	0.35–0.75	
Vitamin (mg/100 g)	1000	700–1400	

Source: Rongsen (1989), commissioned paper by ICIMOD, unpublished.

The plant has its centre of origin and maximum diversity in the Himalayan region itself. At present, four species and nine sub-species are identified and hopes of more genetic diversity within *Hyppophae* which could be of much ecological and economic significance are not ruled out.

In India, Nepal, and Pakistan, although the plant extensively grows in mountains, it is an unexplored species for horticulture and agroforestry purposes. It is only in China that there have been major efforts by scientists, planners, and farmers to explore, develop and draw benefits from *Hyppophae* in an effective way. Surveys revealed that around 670,000 hectares are under *Hyppophae* in China. It is capable of producing 22,000 tons of berries. By 1987 three major seabuckthorn berry processing and product making factories were installed and products like juice, syrup, soft drinks and wine marketed to earn a total profit of 50,000 yuan (US$ 12,000) per year. Several micro juice-extracting plants have been installed in remote areas at the base of the source and only concentrated juice transported to factory points.

The available information speaks of high economic gains to farmers and vegetation rehabilitation of bare, arid regions. In the mountain area of west Sichuan in China, a large amount of marginal land is available. It is infertile and remains without much vegetation; farmers of this region have small land holdings because of non-availability of fertile land. The Chinese government leased this marginal land to households for putting up *Hyppophae* plantations. The households got the right to pick the fruits and land improved in fertility, giving way to diverse, stable plant cover. In this way, shelterbelt plantations of *Hyppophae* are slowly appearing over large areas.

In October 1989 scientists and other professionals from the USSR, Finland, Norway, Hungary, Czechoslovakia, West Germany, Romania, and Japan gathered in China to exchange information and discuss ways to harness the full potential of *Hyppophae* at an international symposium on seabuckthorn.

The major constraint in other countries of the Hindu Kush-Himalayan Region to using *Hyppophae* is lack of information. An agency like ICIMOD has the mandate and resources to fill in this gap. The plant species is most appropriate even for initiating a limited pilot action programme. There may be several other plants waiting for explorations to make known their promising potential.

Scarcities, New Crops and Unconventional Land Use:
The Example of Prinsepia sp.

Among the plant resources of these mountain areas some have the potential to help solve chronic scarcities. Let us examine the case of edible oils. There is a general scarcity of oilseeds in this region. For example, a technology mission on oilseeds, was set up by the Government of India. The kind of initiative made under the programme, in terms of crop choice, are reflected by the following statement on the oilseed programme of a Himalayan state in India:

'A well-planned programme with the help of national agencies, i.e. a technology mission on oil seeds, has been launched. It emphasizes the increasing production of soybean, toria type of mustard, and flowers. To achieve this, the area under toria mustard would be increased to about 35,000 hectares from that of 5000 hectares at present. At present Himachal grows mustard, sesame, rape, groundnut, linseed, castor, and other minor oilseed crops on 20,000 hectares, and overall production is just over 5000 tons. The total annual production is expected to be increased from 5000 tons to 16,000 tons by implementing these schemes'.

Indigenous oilseed plants with no ecological backlash, growing in harmony with nature and acceptable to the agro-ecosystems, already exist and can be perfected for wider use with little scientific effort. One such example is *Prinsepia* spp., a thorny multipurpose bush of this region.

Prinsepia is a promising oilseed plant with unconventional land use. It is a multipurpose shrub and makes it possible to plan unconventional land use for boosting oilseed production, without putting pressures on existing agricultural land. The thorny shrub acts as a live fence and gives excellent fuelwood and oilseeds. Its purple fruits are food for birds and other wild animals. As a hedge plant it is an excellent habitat for birds. In winter (November to March), when bee flora is scarce, it provides valuable forage for honey bees, and the honey produced is of excellent quality. The plant commonly grows between the altitudes of 800 and 2500 m on wastelands, road sides, and forest, and around agricultural fields and orchards. The plant is widely distributed throughout the Hindu Kush-Himalayan Region.

Prinsepia oil is edible and can be used in medicines, soaps, and varnishes. Its oilseed cake is a good source of animal feed. In the past, oil from its seeds was widely used by several mountain households for cooking purposes but the practice is now vanishing. It still holds value for medicine, massage, and fuel.

The potential benefit of harnessing *Prinsepia* as an oilseed shrub, taking the case of Himachal Pradesh, is illustrated in Table 11.19.

Conclusions

Today, the foundations of horticulture development in the Hindu Kush-Himalayan Region are largely based on the adoption of uniform cultivars of fewer crops than desirable. Both the technology and crop choice are for high input varieties which are less dependable when grown under traditional horticulture management. Also, the practice of planting vast areas with monocultures of genetically uniform cultivars has made productivity extremely vulnerable to yield-limiting factors. This is illustrated by the apple diseases that occur in the Hengduan mountains and Indian Himalaya. Further, this approach faces several constraints on the large-scale expansion of horticulture to all mountain areas. Moreover, one can discern little concern for conservation in this approach to horticulture and there appears to be little value placed on the diversity of the genetic resources available.

From the technical standpoint, the capability of scientific institutions to work on the new concept requires an interdisciplinary approach and infrastructure facilities. The existing research and development institutions are engaged in working mostly in areas focusing on increasing yield

TABLE 11.19

Estimation of oilseed potentials of *Prinsepia* under unconventional land use (Himachal Pradesh)

Average seed production of the plant[1]: 1 kg per year, 0.5–5 kg range. Oil content in seeds: 30–40 per cent.

Assuming no agricultural land is available for *Prinsepia* cultivation in Himachal:

> Area under apple orchards in Himachal[2]: 55,000 hectares up to 1988–89, but 75,000 hectares by 2000 (estimated target).
>
> Assuming one hectare as an average size of orchard,[3] fencing area of this size of field: 400 m.
>
> A *Prinsepia* plant, maintained agronomically, would need around 1 m space and if planted closely the fencing area would provide enough space for 400 plants.
>
> Total fencing area available for plantations around apple orchards in Himachal: 55,000 × 400 = 22,000,000 m.
>
> Number of plants supported in the area: 22,000,000.
>
> Estimated oilseed production from *Prinsepia*: 22,000,000 kg
>
> Alternately, it would yield 66,000 tons oil (at 30 per cent), and 15,400 tons oilcake.

Comparison of *Prinsepia* and other oilseeds of Himachal Pradesh.

Total annual oilseed production from 20,000 hectares of oilseed cultivation in Himachal (1980–1985 average): 5000 tons.

Future plans are to increase toria cultivation from 6000 to 35,000 hectares to enhance total oilseed production. It would raise total oilseed area to 50,000 hectares for an estimated production target of 16,000 tons.

In contrast, 2200 km fencing strip 1 m wide is available around apple orchards only and it would produce approximately 22,000 tons of oilseeds, four times the present oilseed production of the state.

Also, there is scope to increase area under *Prinsepia* by 10 times as more fencing area under crops, wastelands, and roadside common property is also available. Production estimates then will increase to 220,000 tons.

[1] Estimates of seed and oil yields are author's own experimental observations.

[2] Keeping in view 1.5 hectures as average size of land holdings and several smaller land parcels of households in Himachal Pradesh.

[3] Keeping in view 1.5 heactores average size of land holdings and several smaller land parcels of households in Himachal Pradesh.

and quick economic gains. They need further reorientation to incorporate the approach based on genetic and biological diversity to horticulture development.

Horticultural development approaches and strategies of the governments of most of the Hindu Kush-Himalayan Region countries seem designed to keep quick economic gains to farmers and the state paramount. Lack of understanding of the mountain environment and its specificities is visible in most cases. International aid has also contributed to this. The goal of international development assistance both technical and financial has so far been, in horticultural development of agriculture, to help countries to enhance their human, social, and economic conditions. Environment and conservation ethics did not come into it. Interestingly, at present these ethics seem to prosper in traditional cultures as well as in highly developed nations. The rest of human society is in transition between old cultures and a more economically developed state.

There are also examples which show some kind of confusion between development investment, and conservation measures. Many programmes supported by international development agencies do not conform to conservation principles, while these same agencies are willingly spending on genetic resource conservation elsewhere.

The changing conditions dealt with below are creating a demand for new products from previously underexploited resources and many more will emerge in the future as pressure grows for the increased exploitation of renewable resources:

- Technical innovations and improved scientific knowledge on the use of biological diversity, such as biodegradable from plants.
- New demand for speciality items and the heightened desire for new products, such as rare species, rare fruits and fragrances. A source of comparative advantage to mountain people.
- The pressures of increasing population and poverty call for survival plants which can be grown in unusable marginal lands, e.g., *Hyppophae*.

However, faced with an area like the Hindu Kush-Himalayan Region, home to thousands of species of plants, many of which are yet to be discovered by scientists, is it not impractical to screen each species for its potential as a new resource. The concept of using plants which are already known for their ability to aid the local human population should have wider appeal than exploring species totally unknown for their value. The adoption of known plant resources as new crops is also supported by new knowledge on the components of sustainable farming systems. Several workers (Altieri and Merrick, 1987; Harwood, 1979) have reported on the vital role of these underexploited genetic resources in traditional agriculture for its stability and sustainability. These workers strongly argue for incorporating these genetic resources into the design of sustainable farming, stable food production, and the economic well-being of people within the agro-ecosystems.

Plant resources user agencies and genetic resource conservationists often talk about plants, their exploitation patterns, and the risk of extinction. They have seldom recognized the value of folk knowledge about these species, which is disappearing at a much faster rate than the species themselves. The present-day custodians of this knowledge in the mountains are isolated, remote mountain communities and culturally distinct tribes. All the lesser-known species of these underexploited genetic resources are extensively used by them. The need is to document the complete ethnobotanical knowledge of these communities of plant resources of horticultural value. An example of the value of ethnobotanical knowledge is the information on the use of apricot as staple food by Hunza villagers (Jeddy, 1989).

The need for such a study is becoming clearer with each passing year. For as we feel the need for more and more plant species, the folk knowledge, about them is shrinking, partly through extinction of the custodians of this knowledge and partly because of their acculturation. Each time a medicine man dies it is as if a library has burned down (Plotkin, 1988), and we may have been deprived of knowledge about some promising medicinal plants.

Such research, combined with expanded programmes, will help to bring some of the more promising species into cultivation, or may be useful in identifying varieties and wild forms for use in horticulture crop improvements, or reveal ecological information on how best to develop horticultural-dominated mountain farming systems.

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12

Seabuckthorn Resources and Its Underexploited Potential in the Himalayan Region

Lu Rong-sen

Economic Significance and Ecological Value of Seabuckthorn

Seabuckthorn (*Hippophae* spp.), a deciduous shrub or tree which belongs to Elaeagnaceae, is widely distributed in the temperate zones of Asia and Europe and at high altitudes of the sub-tropical zone of Asia. The berries of seabuckthorn are rich in nutrients and bio-active substances such as sugar, organic acid, amino acid, vitamins (B, C, E, K and P), carotene, and flavone (see Table 12.1). The vitamin C content is 5 to 100 times higher than in fruits and vegetables. The pulp and seeds of seabuckthorn have a high content of oil also (see Table 12.2). Therefore, seabuckthorn is being used as food and in the medicine industries.

In the 19th century, Russians began using seabuckthorn berries for making wine, jam, and other food. At the beginning of the 20th century, interest in this plant obviously increased. Horticulturists began to introduce it into orchards as a fruit tree. In the 1940s, especially after the World War II, nutritionists and pharmacologists analysed the vitamin composition and found that seabuckthorn could be used not only as food, but also as medicine. Many countries, such as the USSR, Mongolia, Poland, West Germany, Finland, Italy, Norway, Hungary, Canada, the United States, and Japan have been studying this wonderful plant.

Growing at altitudes between 60 and 5200 m, *Hippophae* is distributed widely in various geographical areas of the world. *Hippophae* can resist low temperature of $-60°C$ and does not wither in the summer

TABLE 12.1

Comparison of the vitamin content of seabuckthorn and fruits and vegetables (mg/100 g)

	A	B_1	B_2	P	K	C
Seabuckthorn	11.00	0.04	0.56	1000.0	100–200	300–1600
Cili (*Rosa roxburghii*)	4.83	0.05	0.03	2909.0	–	1000–3000
Hawthorn	0.82	0.02	0.05	–	–	100–150
Kiwi fruit	–	–	–	–	–	100–470
Orange	0.55	0.08	0.03	–	–	50
Tomato	0.31	0.03	0.02	–	–	11.8
Carrot	4.00	0.02	0.05	–	–	8.0

Source: Xu Zhonglu, 1956; Tian Houmou, Wang Guoli, 1987; Luo Dengyi, 1983.

TABLE 12.2

Comparison of the composition of fatty acid, Vitamin E, and Vitamin A of seabuckthorn oil and other nutrient oils

	Fatty acid components(%)			Vitamin E (mg/100 g)	Vitamin A (mg/100 g)
	Saturated acid	Unsaturated acid	Linoleic and linolenic acid		
Seabuckthorn oil	13.7	86.0	64.6	93.2	4.35
Wheat embryo oil	–	–	–	33.8	–
Safflower oil	8.0	92.0	81.4	3.3	–
Maize oil	15.2	84.8	48.3	34.0	0.81
Soybean oil	14.8	83.7	62.8	7.5	0.11

Source: Wang Gouli, 1987; Lu Rongsen, 1989.

heat of 40°C. Some species can grow well in regions with only 300 mm precipitation and others can endure inundation. Some species even grow in soil with pH 9.5 and soil which contains 1.1 per cent salts.

Hippophae shows high ability to fix atmospheric nitrogen. A six-year-old seabuckthorn plant has 180 g of root nodules or 100–140 nodules/m^3 of soil. A hectare of seabuckthorn can fix 45 kg nitrogen or more, which is twice that of soybean in the same area.

The farmers in the loess plateau of China often dig out seabuckthorn instead of planting potato. Because seabuckthorn bushes make the soil more fertile, the yield of potato is much greater than in a field without any seabuckthorn bushes.

The root system of seabuckthorn can secrete certain acid compounds which improve alkaline soil.

In many cases, by sexual and asexual propagation, Seabuckthorn often forms mass bushes in hillslopes or along riverbanks. With its luxuriant foliage and strong root system, it can retain surface run-off and prevent soil erosion by wind and water. Moreover, the massed bushes can increase the content of organic matter in the soil and improve the physical and chemical properties of the soil. For example, in Youyu country, Shanxi province of China, 15 years ago, there was no vegetative covering along the Changtou river and thousands of tons of soil were washed into the Yellow river. Then on the banks of the Changtou river dense bushes of seabuckthorn were planted, and three to five million tons of soil were saved from being washed into the Yellow river every year. With the planting of seabuckthorn bushes, more than 80 per cent of surface run-off was decreased and erosion by surface water decreased by 75 per cent.

Seabuckthorn is a good resource for firewood. The calorific value of the wood is more than 4000 large calories/kg.

An Appraisal of *Hippophae* Resources in the Himalayan Region

Hippophae plants can be found in all countries of the Hindu Kush-Himalaya, the distribution extending over 3500 km from east to west of this vast mountainous area and the plants growing abundantly. *Hippophae* has four species and nine sub-species, of which four species and four sub-species are in the Himalaya and the other five sub-species are in the other part of Eurasia. It is believed that the Hindu Kush-Himalaya and the Qinghai-Tibetan Plateau are the main centres of distribution and origin of this genus.

Tables 12.3 and 12.4 contain data on the uses of *Hippophae* in the Hindu Kush-Himalaya, and its use and potential are discussed.

Hippophae rhamnoides L. ssp. *sinensis* Rousi occupies the largest area, and is distributed in Shanxi, Shaanxi, Gansu, Qinghai, Sichuan, Nei Mongol, Hebei, and Liaoning at 60–3800 m above sea level. Because it is most widely distributed in China, the plants are commonly found bearing berries which vary in shape, size, and colour, indicating that it is a typical diverse sub-species. The data in Table 12.3 indicate that this sub-species is rich in Vitamin C and organic acid, very suitable for making soft drinks. From the data in Table 12.4 it may be seen that the pulp and seeds are rich in oil and the linoleic and linolenic acid in total fatty acids account for more than 60 per cent. Therefore, this sub-species is most valuable for comprehensive use. Nowadays, seabuckthorn products

TABLE 12.3

Chief chemical composition of the juice of seabuckthorn in the Himalaya (China)

Species	Collecting places	Weight per 100 fruit (gm)	Rate of juice (fresh weight %)	Soluble sugar (%)	Organic acid (%)	Vitamin C (mg/100 g)	Free amino acid (mg/100 g)
H. rhamnoides L. ssp. *gyantsensis* Rousi	Zedang, Xizang	6.5	33.5	3.7	2.2	23.4	65.7
H. rhamnoides L. ssp. *turkestanica* Rousi	Huocheng, Xinjiang	19.5	80.8	7.2	3.5	471.5	122.0
H. rhamnoides L. ssp. *yunnanensis* Rousi	Zhongdian, Yunnan	16.5	78.1	6.1	4.6	1129.0	108.0
H. rhamnoides L. ssp. *sinensis* Rousi	Xiaojin, Sichuan	18.3	79.1	6.8	6.2	1289.5	83.6
H. salicifolia D. Don	Chuona, Xizang	19.0	76.6	10.3	8.3	1709.5	264.0
H. thibetana Schlechtend	Hongyuan, Sichuan	40.0	82.5	8.9	3.0	159.8	76.4
H. neurocarpa S.W. Liu et T.N. He	Daocheng, Sichuan	4.5	trace	2.1	1.6	3.5	666.6

Source: Author.

TABLE 12.4

Chemical composition of fatty acid in seabuckthorn in the Himalaya (China)

Species	Collecting Place	Fruit part analysed	Oil content (%)	Fatty acid Component (%)		
				Saturated	Unsaturated	Linoleic and linolenic acid
H. rhamnoides	Xiaojin, Sichuan	seed	9.87	13.7	86.6	64.6
L. ssp.		Pulp	2.02	27.3	71.2	11.4
Sinensis Rousi						
H. rhamnoides L. ssp.	Huocheng, Xinjiang	Seed	12.86	11.1	88.9	74.2
turkestanica Rousi		Pulp	2.03	31.7	64.8	15.4
H. rhamnoides L. ssp.	Zhongdian, Yunnan	Seed	10.21	16.9	83.0	62.3
yunnanensis Rousi		Pulp	2.59	25.1	74.9	17.9
H. rhamnoides L. ssp.	Zedang, Xizang	Seed	9.82	16.0	83.9	60.0
gyantsensis Rousi		Pulp	4.03	27.7	72.3	44.4
H. salicifolia	Chuona, Xizang	Seed	10.85	17.3	82.7	63.0
D. Don		Pulp	1.58	26.3	73.7	8.2
H. thibetana	Hongyuan, Sichuan	Seed	19.51	11.7	88.2	64.9
Schlechtend		Pulp	3.50	16.1	81.3	8.0
H. neurocarpa	Daocheng, Sichuan	Seed	16.12	14.0	85.9	65.5
S.W. Liu et T.N. He		pulp	8.60	24.1	75.8	47.7

Source: Author.

are mainly made from natural groves. However, these natural groves being very scattered, the yield is unstable. It is necessary to collect good seedlings with properties such as big berries, high content of vitamin C, dwarf size, and no thorns from these natural groves. These seedlings should then be propagated through asexual reproduction. In order to raise the commercial value of *H. rhamnoides* L. ssp. *sinensis*, artificial plantations should be established.

Hippophae rhamnoides L. ssp. *turkestanica* Rousi is grown on the terraces of river valleys, open slopes, and riverbanks at altitudes of 800–3000 m in western Xinjiang, Tibet, the USSR, Afghanistan, northern Pakistan, and northwestern India. It is grown in the arid regions of Xinjiang and central Asia. From Table 12.3 it can be seen that Vitamin C content of this sub-species is much lower than that of *H. rhamnoides* L. ssp. *sinensis,* so it is not so good for making soft drinks. But the seed oil content is 12.86 per cent, which is higher than in other sub-species. The arid climate of Xinjiang, abundant sunshine, and wide temperature range are advantageous for oil formation.

Hippophae rhamnoides L. ssp. *Yunnanensis* Rousi is distributed in the gorges and along riverbanks in northwestern Yunnan, southwestern Sichuan, eastern Tibet, and northern Burma. Its characteristics are very similar to those of *H. rhamnoides* L. ssp. *sinensis.* It is often found that the two sub-species are mixed in the southern part of Sichuan and the eastern part of Tibet and it is difficult to identify them by plant morphology. From Tables 12.3 and 12.4 it may be seen that there are no distinct differences in berry quality between the two sub-species. Both are used to make soft drinks.

Hippophae rhamnoides L. ssp. *gyantsensis* Rousi is grown on terraces and riverbanks at 3200–3800 m along the Yalu Tsangpo river in Tibet and Sikkim. The berries have several ridges. Table 12.3 shows that the rate of juice is only 33.5 per cent, which is just half that of other sub-species. The vitamin C content is much lower so it is not suitable for making juice, but the pulp and seed oil can be used. This sub-species is distributed in the arid region of Tibet and grows well in river valleys where the precipitation is below 300 m. It is believed that it can be introduced to other arid or semiarid regions. It is quite different from other sub-species in morphology, biological features, geographic distribution, and chemical composition. A. Rousi identified it as a sub-species under *H. rhamnoides.* The author of this paper considers that it needs to be studied again.

Hippophae salicifolia D. Don is found in gorges and the edges of forests in alpine mountains with altitudes 2800–3700 m in southern Tibet, northwestern India, Nepal, Sikkim, and Bhutan. It is an endemic species in the Himalayan region with vigorous growth and few thorns. The quality and content of vitamin C, total sugar, organic acid, and free amino acid is higher than that of *H. rhamnoides* L. ssp. *sinensis*. The content of vitamin C amounts to 1700 mg/100 ml, which is higher than in any of the others. This species is now distributed in the southern Himalaya. It is necessary to introduce it to other seabuckthorn production regions and it is good material for breeding.

Hippophae thibetana Schlechtend is distributed in grassland, meadow, and riverbanks in Qinghai, Gansu, Tibet, Sichuan (China), Sikkim, Nepal, and northern India at altitudes of 3000–5200 m. It is a short species with a height of 8–60 cm and few thorns. The plant can withstand cold and grows well in grassland with an annual average temperature of 0°C. From Tables 12.3 and 12.4 *H. thibetana* can be seen to have, the largest berry and the richest juice. Although the content of vitamin C is lower than in *H. rhamnoides* L. ssp. *sinensis*, the content of pulp and seed oil is higher, so it is useful for producing oil. It is convenient to pick and suitable for close planting. In alpine mountains and plateau grassland this species has both economic and ecological significance and is a precious resource for cultivation and breeding.

Hippophae neurocarpa S.W. Liu et T.N. He is grown in the river valleys or plateau at altitudes 2800–4300 m in Qinghai, Gansu, Sichuan, and Tibet. Tables 12.3 and 12.4 illustrate that this species has the smallest berries, little juice, and a low content of sugar, organic acid, and vitamin C. The pulp and seed, however, contain oil of which the unsaturated fatty acids account for more than 75 per cent. Its pulp oil content of linoleic and linolenic acid is higher than that of other species. In areas above 3500 m, where it is difficult to find trees other than the willow, *H. neurocarpa* can grow well to a height of 3 m. Moreover, it can resist strong wind and forms mass natural groves, so it has important ecological value.

All the seven species and sub-species have their own advantages and are a precious resource for introduction and breeding. Because of the rich juice and vitamin content, *H. rhamnoides* L. ssp. *sinensis* and L. ssp. *yunnanensis* and *H. salicifolia* are suitable for making soft drinks and other products. With their high content of oil, *H. rhamnoides* L. ssp. *turkestanica* and *H. thibetana* are suitable for oil production, as are *H. rhamnoides* L. ssp. *gyantsensis* and *neurocarpa*. Each has different ecological adaptability and can be grown in quite different natural conditions in the Hindu Kush-Himalaya.

The Present Situation and Prospect of Seabuckthorn Exploitation

China was the first country to use seabuckthorn berries. In ancient times under the Tang Dynasty, a book named *Si Bu Yi Dian* described seabuckthorn berries as a medicine. Similar descriptions are to be found in ancient Mongolian medicine and Tibetan medicine.

Present Situation

Since 1983, some provinces and autonomous regions of north, northwest, and southwest China, such as Shanxi, Shaanxi, Neimeng, Gansu, Qinghai, Sichuan, and Xinjiang, have begun to exploit seabuckthorn with good results. Now, the exploitation of seabuckthorn is not only a way to develop the mountain region economy, but also a promising integrated enterprise.

According to statistics, the total natural seabuckthorn area in China is 670,000 hectares and 49,000 hectares are scattered in the east Himalaya (including east Tibet, west Sichuan, northwest Sichuan, and northwest Yunnan). A recent survey shows that about 22,000 tons of seabuckthorn berries lie hidden and undeveloped in the east Himalaya.

By the end of 1987, 150 seabuckthorn processing plants were built in China. The primary processing (such as the crushing and concentration of juice) is done in the places of origin. The product is then transported to big cities for further processing. For example, in western Sichuan, three primary processing plants (located in Xiaojin, Jinchuan, and Muli counties) produce raw products and sell them to Chengdu, Chongqing, Wuhan, and other cities where products such as soft drinks, wine, jam, juice and medicine are made and sold in the market.

Economic and Ecological Benefits

Seabuckthorn exploitation has made farmers who live in the mountain regions richer and the many processing factories bring in income. From 1985 to 1987, along the middle reaches of the Yellow river, farmers earned an annual income of more than five million yuan by picking seabuckthorn berries. For example, there is a small village with 42 farmer households in Fangshan county, Shanxi province. In the autumn of 1984, each household got an income of 160 yuan by selling seabuckthorn berries. In Qingshui county, Gansu province, there is an alcohol distillery which was running at a loss until it turned in 1983 to the production of seabuckthorn products. In 1985 it met the deficit and by 1987 had made a profit of 164,900 yuan. In Sichuan province seabuckthorn exploitation came later but still did well. Table 12.5 gives the statistics.

Besides profitability, the ecological benefit is very important. China now has a vast programme of shelter forest in northeast, north and northwestern China. After many years of practical experiments, forestry experts believe that shrubs must be planted first in the shelter forest system, of which seabuckthorn is the most important. The main step in harnessing the mountains and rivers of Youyu county, Shanxi province, has been to plant seabuckthorn shrub on a large scale. Since the 1950s

TABLE 12.5

Seabuckthorn processing in Sichuan province, China

Name of factory	Annual capacity of production	Varieties of production	Annual value of output (yuan)	Annual profit (yuan)
Xiaojin Seabuckthorn Beverage Factory	Processed 100 tons berries	Crushed Juice, Condensed juice Solid juice, wine	135,000	20,000
Jinchuan Seabuckthorn Beverage Factory	Processed 100 tons berries	Crushed juice, Solid juice	135,000	18,000
Muli Seabuckthorn Beverage Factory	Processed 100 tons berries	Crushed juice, Syrup	130,000	15,000
Chengdu Fruits Processing Factory	Processed 250 tons	Crushed juice, Condensed juice, Syrup, Soft drinks	1,000,00	150,000
Chongquing Jiangbei Beverage Factory	Processed 50 tons berries	Crushed juice, Syrup, Soft drinks	150,000	50,000

Source: Author.

Note: There were 4.73 yuan to the dollar in 1989.

more than 15,000 hectares of seabuckthorn shrub have been established in the county and water and soil has been controlled to a high degree.

Problems

At present, seabuckthorn berries are collected from natural forest shrubs. It is difficult to pick the berries from trees because of the many thorns on the stems and branches. Some farmers fell the trees in order to pick the berries. Such a method damages the seabuckthorn resources.

Seabuckthorn plant is a dioecious plant. In the natural forest, the ratio of male to female is not equal. The quantity of males is often higher and the female plants are scattered and difficult to harvest.

In the east Himalaya, specially in east Tibet and western Sichuan, most of the seabuckthorn resources are far away from transportation and cities, making it difficult to exploit seabuckthorn resources fully.

In order to best use these resources the Chinese government has formulated a policy to protect resources and set up new plantations. The main belongs to the state, which is collectively or individually owned; protect seabuckthorn groves; give hill forest and wasteland to orchards and farmer households and contract with them; grant benefits to whoever reforests, and this cannot be changed for 50 years; forbid felling of seabuckthorn trees or digging it out for cultivation; and strictly enforce, the forest law and water and soil conservation regulations.

Through the efforts of the last five years more than 150,000 hectares of seabuckthorn groves have been set up in north and northwest China.

Seabuckthorn is a new horticultural crop with tremendous potential. It is and will be playing an important role in making mountain farmers richer and sustaining the stable development of mountain regions. There are rich resources of *Hippophae* in the Hindu Kush-Himalaya Region. It is suggested that the countries of this region work out a programme to survey their resources and exploit them.

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13

The Role of Beekeeping in the Development of Horticulture in the Himalayan Mountains of India

L.R. Verma

At present, several countries of the Hindu Kush-Himalaya are making desperate efforts to achieve self-sufficiency in food production by physical expansion of the area under cultivation and better management of resources. This includes use of better quality seeds and animals, bringing more waste land under cultivation, the use of fertilizers and pesticides, and more irrigation. However, in the past decade or so, food production has come to a point of stagnation for some cultivated crops. Emphasis in the future, therefore, should be on the full use of underused resources. One resource which concerns us here is an increase in the yield of various cultivated crops through cross-pollination by honey bees. The vital role which honey bees play in the pollination of large numbers of agricultural and horticultural crops is often underestimated. As a matter of fact, the main significance of honey bees and beekeeping is pollination; hive products, such as honey and beeswax, are of secondary value. This is evidenced by the fact that income from agriculture by the use of honey bees for crop-pollination is many times greater than their value as honey and beeswax producers. Many cultivated crops do not yield seeds or fruits without cross-pollination of their flowers by honey bees and other wild insects. Cross-pollination of entomophilous crops by honey bees is one of the most effective and cheap methods of increasing their yield. Other agronomic practices such as the use of manure, fertilizers, pesticides, and irrigation are cost-effective, but they may not yield the desired results without the use of honey bees to enhance the productivity levels of different cultivated crops through pollination. It is not only the self-sterile varieties or cultivars which require cross-pollination, but also the self-fertile forms, which produce more and better quality seeds and fruits if pollinated by honey bees and other insects.

Despite the great economic and biological significance of honey bees as pollinators of agricultural crops, they have not yet been made an integral part of agricultural and horticultural management technology, particularly in the developing countries of the Hindu Kush-Himalaya.

In recent years, a number of techniques have been developed to increase the productivity of certain agricultural crops through cross-pollination by honey bees. These include the use of pollen dispensers, pollen bombs, scent training of bees, development of high and low preference strains of honey bees through selective breeding for pollination of specific crops, domestication and use of non-*Apis* pollinators, and safeguarding bees against pesticides. All these techniques are at present used only in developed countries; however, there is now growing awareness in the developing countries of the fact that agricultural crops give better yield and higher financial returns if honey bees are used for optimal pollination. For example, Verma (1984) made the following observation in a report submitted to FAO Expert Consultation on Beekeeping:

'In view of the importance of bees in increasing the yield of cross-pollinated crops different species of honeybees and solitary bees are being utilized in North India. Himachal Pradesh, Uttar Pradesh and Kashmir are the principal temperate fruit-growing regions of the country. In Himachal Pradesh, more than 75,000 hectares of land are under temperate fruit cultivation and they require more than 2,00,000 colonies of honeybees against the present number of 10,000. The population of non-*Apis* pollinators is declining at an alarming rate owing to growing deforestation, the clearance of waste land for cultivation and increased use of pesticides. This makes domesticated hive bees essential for pollination. In addition to pollinating temperate fruits, both species (*Apis cerena* and *Apis mellifera*) are also being utilized for the pollination of vegetables, oil seed crops and clovers. Himachal Pradesh has taken the lead in renting *A. cerana* colonies to orchardists for the pollination of apple crops. This programme has helped to create awareness among the orchard owners about the importance of honeybees for pollination.'

Advantages of Bee Pollination

Honey bees are the most efficient pollinators of several cultivated and wild plants because:

- Their bodies are specially adapted to pick up pollen grains.
- They show flower fidelity and constancy.
- They have long working hours.

- They micro-manipulate flowers.
- They maintain high populations when and where needed.
- They are adaptable to different climates and niches.

As a result of cross-pollination by bees, somatic, reproductive, and adaptive heterosis or hybrid effects occur in plant progeny, either singly or in different combinations. Such hybrid effects bring the following qualitative and quantitative changes in the economic and biological character of plants:

- stimulate germination of pollen on stigmas of flowers and improve selectivity in fertilization
- increase viability of seeds, embryos, and plants
- form more nutritious and aromatic fruits
- increase vegetative mass and stimulate faster growth of plants
- increase number and size of seeds and yield of crops
- enhance resistance to diseases and other adverse environmental conditions
- increase nectar production
- increase oil content in oilseed crops
- increase fruit set and reduce fruit drop

Deodikar and Suryanarayanan (1977) have reported the following increase (in percentage) is seed or fruit yield in various crops due to bee pollination:

Oilseeds (seed yield)	
Linseed	2–49
Mustard	13–222
Niger	17
Safflower	4–114
Sunflower	21–3400
Fodder and grain legumes (seed yield)	
Alfalfa	23–19,733
Beans	3–1000
Bird's foot trefoil	900
Clovers	40–3315
Sainfoin	2815
Vetches	39–20,000
Vegetables (seed yield)	
Asparagus	12,405
Cabbage	100–300
Carrot	9–135
Onion	354–9878
Radish	22–100
Turnip	100–125
Orchard crop (fruit yield)	
Apple	180–6950
Black currant	81–2200

Contd.

Blueberry	11–9800
Cherry	56–1000
Citrus	7–233
Cranberry	19–2153
Cucumber and squash	21–6700
Gooseberry	29–300
Grape	23–54
Guava	12
Litchi	4538–10,246
Peach	7–3788
Pear	244–6014
Persimmon	21
Plum	536–1655
Raspberry	291–463
Strawberry	17–92
Buckwheat	63

Principles of Bee Pollination

Most of the investigations of crop pollination have been carried out in developed countries where the European honey bee, *Apis mellifera*, has been extensively used to increase the yield of different cultivated crops. However, there is very little information available on the role of the Asian hive bee, *A. cerana*, in pollinating agriculture crops in the developing countries of south and southeast Asia. Both these species of honey bee, however, show remarkable similarities in foraging behaviour, thus, the basic principles involved in crop pollination by them should not differ significantly. The efficiency of a bee colony as pollinator would depend upon the following factors:

Colony Strength

Larger and stronger colonies are four to five times better pollinators than smaller and weaker ones because the former have a higher percentage of older bees as foragers. Good honey-yielding colonies are better and more efficient pollinators also. It has been estimated that one colony of *A. mellifera* with 60,000 worker bees produces one and a half times more honey than four colonies with 1500 bees each. The same is true for pollination activity also. The strength of a colony depends upon the honey bee breed, the availability of nectar and pollen plants as food resources, and the management practices employed, and also upon the season. In the Hindu Kush-Himalayan countries, during winter the colony strength is poor because of low temperatures and dearth of bee flora. In early spring, when honey bee colonies are required for the cross-pollination of apple blossom in this region, these colonies do not build up enough strength for effective pollination. Keeping in view this constraint, apple growers in Himachal Pradesh move their colonies to lower altitudes, where winters are warmer and there is no dearth of bee flora, so that in spring, at the time of apple blossom, they are available in adequate strength for effective pollination.

Number and Time of Placement of Colonies for Pollination

The number of colonies required for pollination of different cultivated crops depends upon the following factors:

- density of plant stand
- total number of flowers in inflorescence of one plant
- number of flowers over an area of one hectare of land
- duration of flowering
- strength of bee colonies.

In general, two colonies of *A. mellifera* per hectare of crop in blossom are recommended for sufficient and efficient pollination. Keeping in view the smaller colony size of *A. cerana* and also its shorter flight range, three colonies per hectare are recommended.

Distribution of Colonies in the Field or Orchard

Honey bees, as a rule, primarily visit those sources of nectar flow which are within 0.3 to 0.5 km radius from the apiary. At a distance of more than 0.5 km, pollination activity diminishes significantly. In the Hindu Kush-Himalayan countries, because of the small size of farm holdings and also due to the practice of mixed cropping, spacing of colonies and their optimum arrangement do not pose a serious problem as in developed countries, where monoculture in farming systems is a common practice. For effective pollination, *Apis cerana* hives should be placed singly instead of in groups. Honey bees always tend to forage in the area closest to the hive, particularly when the weather is not favourable.

Time of Placement of Colonies in the Field or Orchard

Bee colonies should be placed in the field or orchard when 5 to 10 per cent crop is in bloom. Earlier placement of colonies would result in foraging of the bees on other weeds and wild plants present in the vicinity of the orchard and their ignoring the crop in bloom. If the bees are moved late, they only pollinate the late and less vigorous flowers.

Weather Conditions

Weather plays an important role in determining the success or failure of pollination programmes, as it affects bee activities as well as seed or fruit setting. For example, in the temperate climate of the Hindu Kush-Himalaya, apple trees are in bloom in early spring when the temperature is low. Flower buds may be killed by frost injury and also adversely affect the foraging activities of bees. As reported earlier, native hive bee *A. cerana* can forage at lower temperatures than its European counterpart, *A. mellifera.* Wind velocity of 15 miles per hour or more also adversely affects the foraging behaviour of bees. It is, therefore, recommended that a wind break around the crop field or orchard should be provided.

Attracting Bees to a Crop in Bloom

Russian bee scientists have strongly advocated the theory that bees should be fed a flavoured syrup of the flowers required to be pollinated in order to attract large numbers of them for effective pollination. This seems to be a logical approach, but in practice does not always yield the desired results. In Sweden, Canada, and the United States, various research workers have also tried essential oils or flavours, especially from apple flowers, and their results are inconclusive.

Another method of attracting bees to a particular crop in bloom is by sowing a high nectar-yielding crop among other crops that are poor in nectar secretion. For example, sweet clover requires cross-pollination by bees for good seed yield. But this crop is not very attractive to bees due to poor or very low quantity of nectar. However, if other nectariferious plants such as buckwheat are sown nearby, a larger number of bees are attracted to sweet clover. A crop to be pollinated can also be made more attractive to honey bees if nectar production is increased by breeding techniques or by improving other agronomic practices such as addition of fertilizers and manure or better irrigation facilities.

Apple Pollination in Hindu Kush-Himalaya

Apple is the most important of the temperate fruit cultivated in the Hindu Kush-Himalayan countries. Of the total land in this region under fruit cultivation, more than two-thirds is under apple cultivation. The areas under this crop in different parts of the Hindu Kush-Himalaya are as follows:

	Area ('000 hectares)	Production ('000 mt)
Arunachal Pradesh	4.821	3.373
Himachal Pradesh	52.380	259.320
Kashmir	65.107	723.826
Uttar Pradesh	52.00	170.00
North West Frontier Province (Pakistan)	19	212.000
Bhutan	3.656	4.6
Nepal	5.00	50.000

These figures show that in 1986/87, more than 200,000 hectares of land of Hindu Kush-Himalayan region was under apple cultivation. Every year approximately 10 per cent of the total area already under apple cultivation is being added and according to this estimate, about 250,000 hectares of land should be under this crop in the entire region of the Hindu Kush-Himalaya.

With such a drastic increase in the area coming under apple cultivation, some management problems inevitably have arisen. The major problem has been found to be in pollination. The Delicious and other commercial varieties of apple are self-incompatible and require cross-pollination by honey bees. The population of non-*Apis* pollinators is declining at an alarming rate due to growing deforestation, vast clearance of wasteland, and increasing use of pesticides. The most effective way of assuring adequate pollination is through the introduction of honey bees into the orchard at the time of blossoming, a practice well developed for apples in Canada, Europe, Japan, and elsewhere.

Most of the orchards of the Hindu Kush-Himalayan region are small (about 1 hectare or less) and owned by local farmers. Thus, each orchard requires about three hives of bees (this figure is only an educated guess). A conservative estimate of the number of beehives needed exclusively for pollination of the apple crop in the entire region of the Hindu Kush-Himalaya is more than one million. In the temperate mountainous region of the Hindu Kush-Himalaya, the bee species available for beekeeping is not *A. mellifera*, but the native Asiatic honey bee, *A. cerana*. At present, there are only a few thousand colonies of *A. cerana* kept in modern hives by farmers and orchardists. A major problem, therefore, is that the present large-scale expansion of the horticultural industry in the region has not been accompanied by corresponding increase in pollination resources and technology through availability of appropriately managed beehives. It is not surprising that it has been noticed that many orchards do not bear sufficient fruit because the population of bees is too small. Moreover, with the increased use of pesticides for the control of apple pests, the population of pollinators as represented by various species of naturally occurring solitary ground nesting bees is decreasing at an alarming rate. This makes the domesticated hive bee essential for pollination and beekeeping an essential part of fruit production.

A large horticulture undertaking such as that of the Hindu Kush-Himalayan region cannot flourish in the long run without the large-scale development of scientific beekeeping. Nevertheless, there are problems to be addressed and overcome. The wealth contributed by beekeeping as a cottage industry would run into several millions of dollars spent on hive rental, pollination, and honey production.

Distribution, Abundance and Diversity of Insect Pollinators in the Shimla Apple Orchards

According to Verma and Chauhan (1985), insects visiting apple blossom comprised 44 species belonging to 14 families and 5 orders. Of these, 16 species belonged to Hymenoptera, 11 to Diptera, 9 to Lepidoptera, 7 to Coleoptra and 1 to Hemiptera (Table 13.1).

Data on the relative abundance of different insect pollinators in the Shimla hills indicated that *A. cerana* constituted 24.01 to 43.03 per cent of the total pollinator population.

Besides honey bees and bumble bees, *Halictus dasygaster* was predominant in one experimental orchard at Thanadhar (Shimla District of Himachal Pradesh). Besides hymenopterous insects, dipterns were other visitors to crop in the Shimla hills. These were *Eristalis tenax, E. angustimarginalis, Eristalis* sp., Mucids (*Musca* sp., and *Orthelia* sp.), *Syrphids* (*Epilobium* sp., *Scava* sp., *Metasyrphus* sp., and *Macrosyrphus* sp.).

The relative abundance of all the insects varied from place to place. Differences in the environmental conditions, location and altitude of orchards are possible reasons for such variation (Verma and Chauhan, 1985).

Role of Honey Bees in Yield and Quality of Apple in Shimla Hills

Most of the commercial varieties of apple give good yields only after cross-pollination. Cross-pollination is done mostly by insects, the role of wind in cross-pollination of apple bloom being negligible because of the heavy and sticky nature of apple pollen. Honey bees are the most efficient pollinators among insects because they can be managed in sufficient numbers and show flower constancy (Free, 1970). Although self-compatible varieties of apple do not need as many insect visits as self-incompatible varieties to give an adequate fruit set, yet some visits are essential. A lot of work has been done regarding the role of honey bees in the pollination of apple bloom in many developed countries (McGregor, 1976), but very little has been done in the temperate region of the Hindu Kush-Himalaya. Dulta and Verma (1987) studied the role of honey bees on fruit set, fruit drop, and fruit quality of apple in the Shimla hills of Himachal Pradesh.

The following experiments were conducted in three different apple orchards of 0.8 hectare each, located in Kotkhai and Jubbal area of Himachal Pradesh (India) at heights of 1350, 1875, and 2400 m above sea level, to study the effect of honey bee pollination on fruit set, fruit drop, and quality of apple:

- No insect pollinator
- Open-pollinated flowers (natural insect pollinators)

TABLE 13.1

Insect species visiting apple flowers with their taxonomic status in Northwest Himalaya

Order				
HYMENOPTERA	DIPTERA	LEPIDOPTERA	COLEOPTERA	HEMIPTERA
Family and Species				
APIDAE	DIPTERA	NOCTUIDAE	COCCINELLIDAE	PENTATOMIDAE
Apis cerana	*Musca* sp.	*Plusia onchaicea*	*Cocinella*	*Apodiphus* sp.
Apis mellifera	*Orthelia* sp.	*Heliothis armigera*	*septumpunctata*	
Bombus tunicatus		*Agrotis flammantra*		
Bombus sp.	SYRPHIDAE	*Agrotis ipsilon*	CHRYSOMELIDAE	
Bombus sp.	*Melanosatma*		*Altica* sp.	
	Eristalis tenax	NUMPHALIDAE	*Alticinae* sp.	
NANTHOPHORIDAE	*Eristalis angustimarginalis*	*Neptis* sp.	*Nonartha variabilis*	
Anthophora sp.	*Eristalis arvorum*	*Vanessa cashmirensis*	*Minastra cymura*	
	Eristalis sp.			
HALICTIDAE	*Epilobium bolteatus*	PIERIDAE	SCARABAEIDAE	
Nomodo sp.	*Scaeva pyrastri*	*Pieris canidia*	*Protaetia neglecta*	
Halictus dasygaster	*Metasyrphus corollae*	*Delias belladona*	*Brahmina crinicolis*	
Halictus sp.	*Macrosyrphus* sp.			
Halictus sp.		LYCAENIDAE		
Xylocopa sp.		*Heodes* sp.		
VESPIDAE				
Polistes maculipennis				
Vespa magnifica				
Vespa auraria				
Vespa flaviceps				
ICHNEUMONIDAE				
Netalia tatra				

Source: Verma and Chauhan (1985).

- Honey bee-pollinated flowers

The results are summarized in the following paragraphs:

Effect of Insect Pollinator on Fruit Set

In self-compatible varieties such as Golden Delicious, the percentages of fruit set in control, open, and honey bee-pollinated flowers were not significantly different. Similarly, in another self-compatible variety, Red Gold, the percentage of fruit set in control, open and honey bee-pollinated flowers did not differ significantly. These small differences in fruit set for Golden Delicious and Red Gold under different conditions could be due to the self-compatibility of these varieties. In self-incompatible varieties like Royal Delicious and Red Delicious, there was no fruit set in the absence of insect pollinators, but the fruit set was significantly higher in honey bee-pollinated flowers of Royal Delicious (23.33 per cent) and Red Delicious (19.69 per cent) than inopen-pollinated flowers of Royal Delicious (13.21 per cent) and Red Delicious (11.42). No fruit set in the absence of any insect pollinator in self-incompatible varieties clearly indicated that there was no pollen transfer from pollinizer to pollinated varieties without an insect pollinator (Table 13.2). The higher fruit set in honey bee-pollinated flowers than in open-pollinated flowers suggested that the degree of cross-pollination by honey bees was certainly higher than that of other natural insect pollinators.

TABLE 13.2

Percentage of fruit set and fruit drop in three experimental conditions

Varieties	Honey bee-pollinated flowers (H)	Open-pollinated flowers (O)	No insect pollinator (C)
Golden Delicious	34.53 (25.22)	30.73 (27.62)	24.57 (38.45)
Red Gold	22.45 (25.02)	18.34 (28.38)	15.76 (38.07)
Royal Delicious	23.33 (25.50)	13.21 (28.69)	0.00 (0.00)
Red Delicious	19.69 (25.73)	11.42 (28.86)	0.00 (0.00)

Data in parentheses pertain to fruit drop.
For fruit set in Royal Delicious and Red Delicious: H > O > C ($P > 0.01$).
For fruit drop in Golden Delicious and Red Gold: C > O, H ($P < 0.01$).
$P < 0.01$ = Highly significant.
Source: Dulta and Verma (1987)

Effect of Insect Pollinators on Fruit Drop

The fruit drop in self-compatible varieties of apple was significantly higher from flowers under controlled conditions then for fruits from open and honey bee-pollinated flowers. For example, in Golden Delicious and Red Gold, the fruit drop was maximum (38.45 and 38.07 per cent respectively) under control, and minimum (25.22 and 25.02 per cent respectively) in honey bee-pollinated flowers. In open-pollinated flowers of Golden Delicious and Red Gold, the fruit drop was 27.62 and 28.38 per cent respectively, with no significant difference. In self-incompatible varieties like Royal Delicious, the fruit drops in open-pollinated and honey bee-pollinated flowers were 28.69 and 25.50 per cent respectively, without any significant difference. The same trend was observed in the other self-incompatible variety, Red Delicious, where the fruit drop in open and honey bee-pollinated flowers was 28.86 and 25.73 per cent respectively with no significant difference. The high percentage of fruit drop in controlled experiments was due to poor pollination whereby the number of ovules fertilized was less (Table 13.2).

Effect on Fruit Quality

In Golden Delicious, there was an increase in the weight, length, breadth, volume, and number of seeds per fruit by 22, 9, 7, and 17 per cent respectively in the fruits which developed from flowers exclusively pollinated by honey bees as compared to open-pollinated flowers; in Red Gold, the weight, length, breadth, volume, and number of seeds per fruit increased to 18, 9, 9, 9, and 32 per cent respectively. In these two self-compatible varieties, fruits from honey bee-pollinated flowers were greater in number than fruits from open pollinated flowers, which were greater in number than fruits from control ($P > 0.01$).

In Royal Delicious, the increase in weight, length, breadth, volume, and number of seeds per fruit was 33, 15, 10, 51 and 49 per cent respectively, in fruits which developed from flowers exclusively pollinated by honey bees as compared to open-pollinated flowers. Similarly, in Red Delicious, the increase in weight, length, breadth, volume, and number of seeds per fruit which developed from flowers exclusively pollinated by honey bees was 19, 9, 10, 16, and 30 per cent respectively as compared to fruits developed from open-pollinated flowers. In these self-incompatible varieties, the quality of fruits from honey bee-pollinated flowers was significantly better ($P < 0.010$) than that of fruits from open-pollinated flowers. The improvement in the quality of fruits due to cross-pollination by honey bees (also other natural insect pollinators) might be a result of heterosis. The increase in weight, size, and volume of the fruits which developed from honey bee-pollinated flowers might be due to a greater number of seeds per fruit (mean number of seeds 8.92, 9.22, 7.31, and 6.78 in Golden Delicious, Red Gold, Royal Delicious, and Red Delicious respectively, Table 13.3). The better pollinating efficiency of the honey bee helps in the fertilization of the maximum number of ovules and thereby more seeds are formed. In this way, the maximum amount of auxin, a growth hormone, is produced, which results in larger fruit.

Comparative Foraging Behaviour of A. cerana and A. mellifera on Apple Bloom

Verma and Dulta (1986) studied the comparative foraging behaviour of *A. mellifera* and *A. cerana* on apple bloom and the results of their investigations are reviewed. Worker bees of *A. cerana* started their foraging activities earlier in the morning (mean time, 0603 hours) than *A. mellifera* (mean time, 0627 hours). In the evening, *A. mellifera* ceased its foraging activity earlier (mean time, 1855 hours) than *A. cerana* (mean time, 1913 hours). Thus, average duration of foraging activity in *A. cerana* was 13.10 hours and in *A. mellifera*, 12.28 hours (Table 13.4).

The mean duration of a foraging trip by *Apis cerana* and *Apis mellifera* was 11.85 and 17.92 minutes respectively. Thus the duration of a foraging trip was significantly longer for *Apis mellifera* ($P < 0.01$) than for *Apis cerana* (Table 13.4).

Observation at three different times of the day (0.900, 1200 and 1500 hours) during apple flowering in order to study the nature of food (nectar, pollen or both) collected by worker bees of *Apis cerana* and *Apis mellifera*, revealed that in both the species, nectar collectors were significantly more (P < 0.0.) than pollen collectors (Table 13.5).

In *Apis cerana*, no pollen plus nectar collectors were observed, whereas, in *Apis mellifera*, the percentage of such worker bees varied from 6 to 11 during different hours (Table 13.5). However, in *Apis mellifera* the number of nectar collectors was significantly higher than pollen collectors (41 and 20 per cent respectively). For *Apis mellifera*, the number of nectar collectors was significantly higher at 0900 and 1500 hours (73 and 70 per cent respectively) than pollen collectors (48 and 22 per cent respectively). At 1200 hours, no significant difference was observed in the proportion of pollen and nectar collectors.

At 0900 hours, the number of pollen collectors of *Apis cerana* was significantly higher ($P > 0.01$) than *Apis mellifera* whereas, at 1200 and 1500 hours, there was no significant difference ($P < 0.01$) in the number of pollen collectors of *Apis cerana* and *Apis mellifera* (Table 13.5). Nectar gatherers of *Apis mellifera* were significantly more ($P < 0.01$) than that of *Apis cerana* at 0900 hours, whereas at 1200 hours, the trend was significantly more ($P < 0.01$) than that of *Apis mellifera*. At 1500 hours, there was no significant different ($P < 0.01$) in the number of nectar collectors of both the species (Table 13.5). Pollen plus nectar collectors of *Apis mellifera* were maximum at 1200 hours (Table 13.5).

Observations made on hourly fluctuations in the number of bees leaving the hive per five minutes showed that peak activity of *Apis cer-*

TABLE 13.3

Effect of insect pollinators on quality of apple fruit in different cultivars grown in Northwest Himalaya

Variety	Honey bee-pollinated flowers (H)				Open-pollinated flowers (I)				No insect pollinator (control I)			
	Weight	Length	Breadth	Seeds (no.)	Weight	Length	Breadth	Seeds (no.)	Weight	Length	Breadth	Seeds (no.)
A. Golden Delicious	208.88	7.34	7.74	8.92	188.00	6.76	7.26	8.11	104.44	5.58	6.12	6.00
B. Red Gold	152.67	5.97	7.00	9.11	135.53	5.81	6.85	7.77	82.00	4.94	5.75	7.00
C. Royal Delicious	266.55	7.88	8.13	6.78	201.16	6.87	7.41	6.20	No fruit set			
D. Red Delicious	217.67	7.21	7.69	6.78	183.80	6.61	7.00	5.33	No fruit set			

$A^{WH} > A^{WI} > A^{WJ}$ $(P < 0.01)$ $A^{LH} > A^{LI} > A^{LJ}$ $(P < 0.01)$ $A^{BH} > A^{BI} > A^{BJ}$ $(P < 0.01)$ $A^{VH} > A^{VI} > A^{VJ}$ $(P < 0.01)$ $A^{SH} > A^{SI} > A^{SJ}$ $(P < 0.01)$

$B^{WH} > B^{WI} > B^{WJ}$ $(P < 0.01)$ $B^{LH} > B^{LI} > B^{LJ}$ $(P < 0.01)$ $B^{BH} > B^{BI} > B^{BJ}$ $(P < 0.01)$ $B^{VH} > B^{VI} > B^{VJ}$ $(P < 0.01)$ $B^{SH} > B^{SI} > B^{SJ}$ $(P < 0.01)$

$C^{WH} > C^{WI} >$ $(P < 0.01)$ $C^{LH} > C^{LI} >$ $(P < 0.01)$ $C^{BH} > C^{BI} >$ $(P < 0.01)$ $C^{VH} > C^{VI} >$ $(P < 0.01)$ $C^{SH} > C^{SI} >$ $(P < 0.01)$

$D^{WH} > D^{WI} >$ $(P < 0.01)$ $D^{LH} > D^{LI} >$ $(P < 0.01)$ $D^{BH} > D^{BI} >$ $(P < 0.01)$ $D^{VH} > D^{VI} >$ $(P < 0.01)$ $D^{SH} > D^{SI} >$ $(P < 0.01)$

TABLE 13.4

Foraging data for *A. cerana* and *A. mellifera* on apple flowers at 1350 m in the Northwest Himalaya in April-May

Parameter		*A. cerena*	*A. mellifera*
Initiation of foraging (time of day)		06.03 ± 0.01	06.27 ± 0.02
Cessation of foraging (time of day)		19.13 ± 0.01	18.55 ± 0.01
Duration of foraging activity (min.)		13.10 ± 0.002	12.28 ± 0.003
Duration of foraging trip (hours)		11.85 ± 0.36	17.92 ± 0.36
Peak foraging hours (time of day)		09.00 –11.30	11.00–13.20
Weight of pollen load (mg)	09.00	09.06 ± 0.02	9.24 ± 0.04
	12.00	9.26 ± 0.02	12.22 ± 0.04
	15.00	8.64 ± 0.06	11.12 ± 0.03
No. stigmas touched/flower		3.09 ± 0.39	3.33 ± 0.32
Time on flower (min.)		5.90 ± 0.22	6.63 ± 0.23

Each mean (± SE) is for eight observations, for times of initiation, cessation, and duration of daily foraging activity, duration of a foraging trip, and weights of pollen load, differences between species are significant ($P < 0.01$); for number of stigmas touched per flower and time spent on flower, $P > 0.01$.

Source: Verma and Dulta (1986).

TABLE 13.5

Percentage of *A. cerana* and *A. mellifera* collecting pollen, nectar, or both from apple at different hours of the day in April-May at 1350 m in the Northwest Himalaya

Forage	0900 hours		1200 hours		1500 hours	
	A. cerana	*A. mellifera*	*A. cerana*	*A. mellifera*	*A. cerana*	*A. mellifera*
P	46.0	18.0	41.0	40.0	20.0	22.0
N	51.0	73.0	55.0	44.0	76.0	70.0
PN	0	6.0	0	11.0	–	7.0
P:N	1:1.11	1:4.05	1:1.34	1:1.10	1:3.80	1:3.18

Percentages are based on eight observations.

P = pollen collectors
N = nectar collectors
PN = pollen and nectar collectors

At 1200 hours Nc > Pc ($P < 0.05$) for *A. cerana*, at 1500 hours Nc > Pc ($P < 0.01$) for *A. cerana*.

At 0900 and 1500 hours Nc > pc ($P < 0.01$) for *A. mellifera*; at 0900 hours P *A. cerana* > Pc *A. mellifera* ($P < 0.01$) and Nc *A. mellifera* > Nc *A. cerana* ($P < 0.01$); at 1200 hours, Nc *A. cerana* > Nc *A. mellifera*; at 1200 hours Pc + Nc *A. mellifera* > Pc + Nc *A. mellifera* at 09:00 or 15:00 ($P < 0.05$). Depending on the hour, 1–5 per cent of bees might collect water.

Source: Verma and Dulta (1986).

ana was between 0900 to 1100 hours (mean 132 bees/5 minutes) when the temperature ranged from 13.5 to 21.0 degrees C, and that of *Apis mellifera* was between 1100 to 1300 hours (mean 118 bees/5 minutes) when the temperature ranged from 21–25° during the months of March and April in Shimla Hills (Table 13.4, Fig. 1).

Pollen loads carried by *Apis mellifera* 0900, 1200 and 1500 hours of the day were 9.24 mg, 12.22 mg and 11.12 mg respectively, whereas these values for *Apis cerana* were 9.06 mg+, 9.26+ and 8.64 mg+ at 0900, 1200 and 1500 hours respectively. A worker bee of *Apis mellifera* carried significantly heavier ($P < 0.01$) pollen than *Apis cerana* throughout the day (Table 13.4).

While foraging apple blossom, *Apis cerana* contacted on an average 3.09 stigmas (2.65 to 3.60) per visit to flowers, whereas *Apis mellifera* touched 3.33 stigmas (3.20 to 3.45) per visit at 1350 metres a.s.l.

Apis cerana spent an average of 5.90 seconds per flower, whereas *Apis mellifera* spent 6.63 seconds on a single visit to an apple flower at a height of 1350 metres a.s.l. (Table 13.4).

Foraging studies also showed that at 0.900, 1200 and 1500 hours, *Apis mellifera* visited significantly ($P > 0.01$) more apple trees in the same rather than in different rows. However, for *Apis cerana*, the number was significantly ($P < 0.01$) more in the same than in different rows at 1500 hours only. No significant difference ($P < .05$) was observed between *Apis cerana* and *Apis mellifera* with regard to their visits to the same or different rows of apple trees. There was no significant difference between *Apis cerana* and *Apis mellifera* in the number of flowers visited per apple tree except at 0900 hours. However, *Apis mellifera* visited significantly more apple trees at 0900, 1200 ($P < 0.01$) and 1500 hours ($P < 0.05$) than the *Apis cerana* (Table 13.5).

The ratio of top and side worker bees on apple bloom at particular times of the day did not differ significantly in *Apis mellifera* and *Apis cerana*. However, the percentage of side and top worker bees varied according to the time of day in both. For example, at 0.900 hours top workers outnumber side workers in both species but at 1500 hours, the reverse was true. At 1200 hours, the percentage of side worker bees was greater than top workers for *A. cerena*. The time spent by top and side workers of both species on each flower did not differ significantly. However, at 1200 and 1500 hours, the time spent per flower by side workers of *A. cerana* was significantly greater than for top workers, (Verma, unpublished results).

Effects of Altitude on the Foraging Behaviour of A. cerana and A. mellifera

Studies on the foraging behaviour of *A. cerana* and *A. mellifera* at three different altitudes, 1350, 1975 and 2400 m, showed that worker bees of

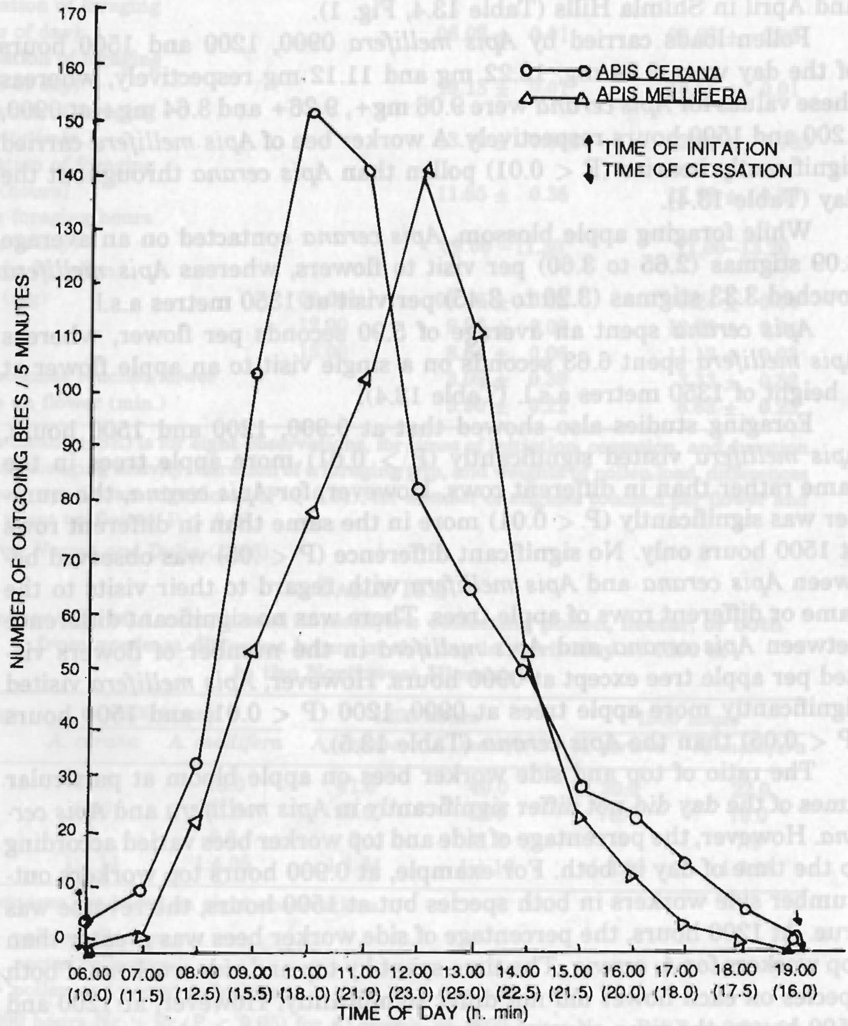

Figure 13.1: Peak hours of foraging activity (number of outgoing bees/5 min.) of *A. cerana indica* and *A. mellifera* on apple flowers in the northwest Himalayas. Temperatures are indicated in parentheses (° C).

Source: Verma and Dulta (1986).

the former species started their foraging activities earlier in the morning and ceased later in the evening at all three altitudes. Initiation of foraging activity by both species was delayed with increasing altitude. For example, times of initiation by *A. cerana* were 0603, 0606, and 0618 hours at 1350, 1875, and 2400 m, whereas for *A. mellifera* the times to initiation at 1350, 1875, and 2400 m were 0627, 0641, and 0648 hours, respectively. Foraging by both species ceased earlier with increased altitudes. *A. cerana* ceased its foraging activity at 1913, 1902, and 1825 hours at 1350, 1875, and 2400 m and *A. mellifera* ceased activity at 1855, 1838, and 1804 hours at 1350, 1875, and 2400 m. Thus, the duration of foraging activity per day of *A. cerana* and *A. mellifera* bees on apple bloom decreased with increase in altitude (mean duration, 13.10, 12.56, and 11.76 hours for *A. cerana* and 12.28, 11.57, and 11.16 hours for *A. mellifera* at 1350, 1875, and 2400 m (Verma and Dulta, 1986).

The duration of each foraging trip for both species of honey bee increased with increase in altitude of orchard location and it was found to be maximum (mean time, 17.83 minutes and 22.67 minutes in *A. cerana* and *A. mellifera*, respectively) at 2400 m, followed by 17.58 minutes and 22.25 minutes at 1875 m and 11.85 minutes and 17.92 minutes at 1350 m.

Altitude had no significant effect ($P > 0.01$) on other parameters such as bee preference for pollen or nectar or both during a visit, peak hours of foraging activity, pollen load, number of stigmas touched per visit, and time spent per flower (Table 13.6).

The above data on comparative foraging behaviour of *A. mellifera* and *A. cerana* suggest that both species of honey bee are complementary to each other for sufficient and efficient pollination of horticultural and agricultural crops. Instead of providing two colonies of the same species per hectare of crop in bloom, one strong colony of each should be kept to ensure efficient pollination. During low temperatures, *A. cerana* should be preferred to *A. mellifera*. Additional research on comparative foraging behaviour of *A. cerana* and *A. mellifera* on other agricultural and horticultural crops in the Hindu Kush-Himalayan Region should be carried out to augment the present data.

Renting of Beehives for Pollination in Himachal Pradesh

The state horticulture department and a few private beekeepers rent *A. cerana* and *A. mellifera* colonies to fruit growers at the time of apple bloom for pollination. Generally, at the onset of winter (November-December), colonies of both species are brought from the temperate hilly region to sub-tropical plain areas where brood rearing usually starts in the first or second week of February. By the middle of March, the colony strength reaches its maximum and this is also the time when flowering begins in apple orchards. These colonies are transported in trucks directly to the apple-growing belt of the state and distributed to fruit growers at

TABLE 13.6

Effect of altitude on foraging of *A. cerana* and *A. mellifera* on apple flowers at different altitudes in the Northwest Himalaya in April-May

Parameter	Annu orchard		Penghunas orchard		Amin orchard	
	A. cerana	*A. mellifera*	*A. cerana*	*A. mellifera*	*A. cerana*	*A. mellifera*
IF	06.03 ± 0.01	06.27 ± 0.02	06.06 ± 0.01	06.41 ± 0.01	06.18 ± 0.01	06.48 ± 0.01
CF	19.13 ± 0.01	18.55 ± 0.01	19.02 ± 0.01	18.36 ± 0.01	18.25 ± 0.01	18.04 ± 0.01
DF	13.10 ± 0.002	12.28 ± 0.003	12.56 ± 0.003	11.57 ± 0.004	12.07 ± 0.004	11.16 ± 0.003
DT	11.85 ± 0.36	17.92 ± 0.36	17.85 ± 0.25	22.25 ± 0.39	17.83 ± 0.41	22.67 ± 0.32

Annu orchard is at 1350 m, Penghumas at 1375 m, and Amin at 2400 m above sea level. Means (± SE) are for eight observations. Times of initiation and cessation and duration of daily foraging activity in an orchard were not affected significantly by altitude. Duration of a foraging trip by either species at 2400 or 1875 m > duration at 1350 m ($P < 0.01$).

IF = initiation (time) of daily foraging activity

CF = cessation (time) of daily foraging activity

DF = duration (hours) of daily foraging activity

DT = duration (min,) of an individual trip

Source: Verma and Dulta (1986).

the rate of Rs. 25 per colony for one flowering season. However, private beekeepers charge higher rental fees than state government-owned apiaries. At present, such colonies are distributed to about 1000 fruit growers and each gets about two to five colonies, irrespective of the size of his orchard. Although the number of colonies distributed for pollination is perhaps too small, keeping in view the large areas of land under fruit cultivation in Himachal Pradesh, it has, nevertheless, created awareness among apple growers of the important role honey bees play in apple pollination. Fruit growers now maintain their own colonies of bees for the purpose of pollination and honey production.

Bee Management Practices in Relation to Apple Pollination

It is now well documented that bee pollination improves the size, shape, colour, storage capacity, and taste of apples. Inadequate pollination in an apple orchard may be due to the following reasons:

- lack of pollinizer varieties suitable for cross-pollination
- non-overlapping of blooming period of main cultivar and the pollinizer variety
- inadequate pollinator force in the orchard
- unfavourable weather conditions
- production of non-functional pollen or ovules
- irregularities in the development of embryo sacs.

Some of these problems of orchard management can be overcome by adopting the following pollination practices:

- When planning a new apple orchard, the planting pattern should be such that every third tree in every third row is a pollinizer.
- The flowering period of a pollinizer variety should overlap with the flowering period of the main cultivar to be cross-pollinated.
- The pollinizer variety, besides helping in cross-pollination of the main cultivar, should also have commercial value.

Changes recommended for good pollination in an established orchard are:

- Replacing the whole tree.
- Top working or grafting the pollinizer cultivar.
- Providing cut flowering branches of the pollinizer cultivar to the main cultivar.
- Using pollen dispenser.

- Keeping in view the shorter flight range of *A. cerana*, the beehives should be spread throughout the orchard, or possibly around the perimeter, rather than kept in groups.

Two beehives of *A. mellifera* per hectare of apple orchard provide adequate pollinator force. Due to the smaller colony size of *A. cerana*, three colonies per hectare are recommended for this species.

If the weather is good, honey bees should not be kept in the apple orchard for more than two days because of the adverse effect of pesticides.

To obtain good economic yield of apple, 5 per cent of flowers or approximately 55,000 flowers per 0.4 hectare of orchard must set and mature.

Bees scrabbing for pollen set a greater percentage of flowers than those collecting nectar.

Trees should be planted around the orchard which act as good wind breaks.

The strength of bee colonies to be used for pollination can be increased by: feeding of sugar syrup; introduction of a prolific queen; and increasing the amount of brood by adding combs of unsealed brood.

Combs containing stored pollen should be removed to create a pollen dearth in the colony.

Colonies should be placed in the orchard when 10–15 per cent of the crop is in bloom.

Shifting colonies from one site to another, or even interchanging them, will broaden the search areas of bees, which is helpful in pollination.

Mowing of orchards in bloom will keep the bees away from flowering weeds.

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14

Potential of Floriculture in the Hindu-Kush Mountains

Vishnu Swarup

Introduction

The beauty of the Hindu-Kush mountains, including the Himalaya and the neighbouring hills, lies in its woods where exquisite wildflowers of every conceivable colour and hue occur. These mountains have a wide range of altitudes from the foothills to the alpine region, and a variety of climates varying from tropical and sub-tropical at the foothills with mostly deciduous species, to temperate evergreen forests, to the alpine belt with extremely low temperatures and stress conditions.

Of the 6700 endemic plant species and 134 genera comprising 61 per cent of the total Indian flora, approximately 3000 species occur in the Himalaya and the Khasi hills in the northeastern regions. The northeastern Himalaya and the southeastern provinces of Yunnan and Szechuan in China are the centres for the evolution of several important ornamental plants, such as *Rhododendron, Camellia, Magnolia, Maconopsis, Buddleia, Prunus, Primula denticulata, Primula roses, Sorbus, Viburnum, Paeonia, Eremerus himalaicus, Clematis montana, Iris nepalensis, Jasminum,* rose species and many species of orchid—(*Aerides rosea, Coelogyne cristata, Cymbidium* sp. *Dendrobium aggregatum D. chrysotoxium, D. nobile, Paphiopedilum insigne, P. villosum; Phalaennoosus* sp. *Pleione maculata, Spathoglottis plicata,* and *Vanda coerulea*

The Himalaya mountains have attracted many plant collectors from various parts of the world. An important collector was Frank Kingdom-Ward from Great Britain who visited Assam and Burma about five to seven times from 1938 to 1956. He discovered the blue poppy (*Meconop-*

sis aculeta) for the first time. Ludlow and Sheriff, also from England, explored the Kashmir area during the years 1939–1941, as also Tibet and Bhutan. There were similar expeditions to the northeastern Himalayas, Nepal, Sikkim, and Bhutan, from the United Kingdom, other European countries, the United States, and Japan. Many species of orchid and rhododendron of the Himalayan region have been extensively used to breed new varieties and hybrids in the United Kingdom, Europe, the United States and other countries. Unfortunately, many species of *Rhododendron, Meconopsis*, orchid, *Magnolia*, and *Primula* have either become extinct or are considered rare and endangered. The conservation of these endangered species and other useful flora has become a matter of great concern to all the countries of this region. To protect the endangered species, some countries have established biosphere reserves, plant or gene sanctuaries, and germplasm banks. There is also a ban or control on the movement of wild species from one country to another by the Convention on International Trade in Endangered Species (CITES, 1973), which has been ratified by 43 countries of the world.

Research and Development of Floriculture in India

For the last two decades there has been an awareness of the potential of floriculture in India. In the year 1960, some ad hoc research projects were started by the Indian Council of Agricultural Research (ICAR), New Delhi. Later, with the establishment of the Indian Institute of Horticultural Research (IIHR) at Bangalore in 1968, research on floriculture was intensified in its newly started Division of Floriculture and Landscaping. From 1970/71 onwards, multidisciplinary research on floriculture at several locations, representing different agroclimatic conditions, was taken up at the agricultural universities in various states and the central research institutes of ICAR. The National Botanical Research Institute (NBRI) in Lucknow (Uttar Pradesh) and the complex at Palampur (Himachal Pradesh) of the Council of Scientific and Industrial Research are also engaged in research on ornamentals. The expenditure on floriculture research is approximately Rs. 30 million annually.

The main emphasis is on evolving improved varieties by breeding, improvement of agro-techniques, including control of diseases and insect pests, and post-harvest technology. Research is concentrated on the rose, carnation, chrysanthemum, orchid, gladiolus, tuberose, jasmine, bougainvillaea, and a few other seasonal flowers. Varietal testing and selection, standardization of agro-techniques of cut flower crops, pretreatment, handling, and packaging of cut flowers for export are receiving special attention. The important research centres for rose are located at Delhi (IARI) and Pune, for gladiolus at Bangalore (IIHR), Delhi (IARI), and Lucknow (NBRI), for jasmine at Coimbatore, for chrysanthemum at Lucknow (NBRI), for carnation at Ludhiana (Punjab), for orchid at Bangalore (IIHR) and Kalimpong (West Bengal), and for bougainvillaea at Delhi (IARI), Bangalore (IIHR), and Lucknow (NBRI).

More than 300 varieties of rose have been evolved in India by research scientists, nurserymen, and amateur rose breeders. The agrotechniques of growing roses in the open for cut flowers and their packaging for export have been standardized. Similarly, several varieties of chrysanthemum were developed for garden display, for cut flowers and also for flowering in the off-season (summer and rainy season). Dwarf and compact chrysanthemum varieties which do not require pinching have been developed for pot culture. Both standard and spray type of carnation varieties have been selected for cut flowers, bedding, and pot culture. At IIHR, Bangalore, orchid species and hybrids are being multiplied by meristem culture and a few hybrids have also been evolved. Many attractive varieties of gladiolus suitable for cut flowers were developed at IIHR (Bangalore), IARI (New Delhi), and NBRI (Lucknow). Several bougainvillaea varieties have been developed at NBRI (Lucknow), IIHR (Bangalore), and IARI (New Delhi), and by private nurserymen and amateurs. Commendable work has been done on improvement and agro-techniques of jasmine at Coimbatore. High plant density was recommended for commercial cut flower crops of roses (62,000 plants per hectare), gladiolus (60 plants per sq/m.), and carnation (4,40,000 plants per hectare for standard and 330,000 per hectare for spray types).

The contribution of private nurserymen and amateurs to the improvement of rose, orchid, bougainvillaea, croton, hibiscus, chrysanthemum, dahlia, and other ornamentals is also praiseworthy. A couple of nurseries in Kalimpong propagate orchid species and hybrids by meristem culture and by seeds in flasks in the laboratory. The production of quality plants, particularly indoor plants, is a speciality of nurseries at Bangalore, Calcutta, Trivandrum, and Cochin. Kalimpong and Sikkim are famous for cacti and succulents, gerbera, and corms or bulbs of gladiolus, amaryllis, crinum, sucharis, hemerocallis, haemanthes, zephyranthes, and lilies. Srinagar, Nainital, and Almora are other good sources for gladiolus corms. Srinagar is also important for bulbs of temperate flowers like narcissus, daffodil, hyacinth, and lily. A leading nursery, Indo-American Hybrid Seeds in Bangalore, produces hybrid seeds of flowers for domestic sale and export. It has also started propagation of ornamental plants by tissue culture for both export and local markets. Another company, A.V. Thomas at Cochin, also produces tissue-cultured plants of ornamentals, cashewnut, cardamom, banana, and other kinds of plants for export and domestic markets.

Floriculture Industry in India

The domestic floriculture trade comprises cut flowers and its products, such as vani, floral ornaments, garlands, bouquets, floral baskets, live plants, bulbs, corms, tubers, and seeds. There are two kinds of flower markets: the traditional market dealing with loose and destalked flowers of jasmine, fragrant rose, small chrysanthemum, crossandra, marigold, aster, and tuberose, and florist shops selling long-stalked and better quality of rose, carnation, chrysanthemum, gladiolus, tuberose, lily, narcissus, daffodil, peony, gypsophila, goldenrod, orchid, and other seasonal flowers, bouquets, and flower baskets.

It is estimated that about 34,000 hectares are under flowers and ornamental plants, including 24,000 hectares for traditional flowers and 10,000 hectares under modern cut flowers. At the retail level the floriculture industry is worth Rs. 205 crores, comprising traditional flower sales valued at Rs. 105 crores and florists' cut flowers valued at Rs. 100 crores. About Rs. 15 million worth of seeds, bulbs, and live plants are traded in the domestic market.

The hilly areas are important sources for the supply of cut flowers, bulbs, and plants to the plains. Cut flowers are sent to the plains during the off-season. Cut flowers of rose, gladiolus, lily, narcissus, daffodil, peony, carnation, and chrysanthemum are supplied regularly from Srinagar to Delhi and Bombay markets during the summer months. Gladiolus comes to Delhi from the Kumaon hills (Nainital and Almora district, Uttar Pradesh). Similarly, Kalimpong and Gangtok (Sikkim) send gladiolus, gerbera, and orchids to Calcutta. Gladiolus, rose, and other flowers are supplied from the Ooty hills to Bangalore, Madras, and Bombay markets. Carnation and chrysanthemum in small pots are transported from the Shimla hills to Delhi and Bombay. Orchids from Kalimpong, Darjeeling, and Gangtok are supplied to Calcutta and Delhi markets. The plants of gerbera, geranium, fuchsia, azalea, camellia, magnolia, juniper, begonia, iris, and other temperate species are available from Srinagar, Darjeeling, Gangtok, and Kalimpong.

Potential of Floriculture in the Hills

Floriculture is a promising enterprise in the hilly regions. There is potential to develop floriculture dealing with cut flowers, cut foliage, bulbs, tubers, corms, seeds, live plants, dry flowers and foliage, and perfumes. Flowers are high-value crops with a higher income per unit of growing area than other horticultural crops (14.1).

TABLE 14.1
Income from flowers per unit growing area

Flower	Cost of production (Rs.)	Profitability (Rs.)	Return % of cost (Rs.)
Orchid	2,16,000	88,000	41
Gladiolus	85,000	34,000	40
Carnation	38,000	12,000	33
Chrysanthemum	23,000	8,000	34
Rose	58,000	20,400	33

Cut Flowers

For cut flowers, orchid, gladiolus, carnation, chrysanthemum, rose, tulip, hyacinth, iris, daffodil, narcissus, gerbera, amaryllis, tuberose, peony and lily are the most important plants grown in the hills. There is a great demand from the florists in the big cities. Some of these flowers are described here:

ORCHID

Among flowers, the orchid is one of the most fascinating, long lasting and expensive, both in domestic and in foreign markets. The price of a single spray of orchid is Rs. 20–30 in Delhi and Bombay markets. In Kalimpong the price ranges from Rs. 36 to Rs. 360 for a dozen, depending upon species. An orchid plant in a small pot costs Rs. 18–20. The Himalayan region is the natural habitat of the orchid species. It is estimated that in India there are about 1300 orchid species, of which 800 species occur wild in the northeastern Himalaya, 200 species in the northwestern Himalaya, and 300 species in the Western Ghats and Deccan peninsula. (Tables 14.2 and 14.3).

The important wild orchids of the northeastern Himalaya are *Cymbidium, Paphiopedilum, Dendrobium, Vanda, Pleione,* and *Phaleonopsis.* These have attractive flowers and many hybrids have been evolved using them in hybridization with other genera and species by orchid breeders of the world. It is not difficult to produce plants and cut flowers of *Cymbidium* and *Paphiopedilum* in the northeastern Himalayan region. Plantlets of species and also hybrids raised from seeds in flasks and by merciloning in a tissue culture laboratory are already being produced successfully by nurserymen in Kalimpong. At present, production is limited, but it can be increased by providing assistance to the nurseries in the form of bank loans on lower rates of interest with longer period of repayment, improving infrastructural facilities, and giving subsidies on agro-inputs. Financial assistance will be helpful in the export of orchids. The important

TABLE 14.2

Distribution of orchid species

Region	No. of species
Northeastern region	
Assam	150
Arunachal Pradesh	368
Meghalaya	300
Manipur	250
Nagaland	150
Tripura	100
Southern region	
Western Ghats, Deccan peninsula	300
Karnataka	170
Tamil Nadu, Andhra Pradesh	200
Maharashtra	130
Bihar, Orissa, West Bengal	200
Andaman and Nicobar	70
Northwestern Region	
Jammu and Kashmir, Haryana, Himachal Pradesh, Punjab, Uttar Pradesh hills	200

TABLE 14.3

Important natural habitats of orchids

Assam	Rani, Kaki, Garampani, Orang, Digdoi
Meghalaya	Kawphlong, Cherrapunji, Jarain
Arunachal Pradesh	Rupa valley, Salbeli Kameng, Subansiri, Sian, Tirap
Sikkim	Rabongola, Mangan, Tsunythang, Gangtok
Uttar Pradesh	Kumaon hills, Valley of flowers and Govind Ghat, Chamoli district, Thaiaskot, Pithoragarh district
Nilgiri ranges	Kodaikanal, Papanasam, Kannikaddi and Yercaud hills, Western Ghats

commercial orchid-growing areas are located in Kalimpong, Darjeeling, Sikkim, Shillong, Arunachal Pradesh, Calcutta, Bangalore, Pune, Bombay, and Trivandrum.

GLADIOLUS

Gladiolus is very popular in the cut flower industry in India. It has a majestic spike with a dozen or more florets of attractive colours and varying shapes and sizes and good keeping quality. The gladiolus spikes are commonly used in flower arrangements and bouquets. It is grown both in the plains and the hills. The important commercial gladiolus-growing areas are located in Srinagar (Jammu and Kashmir), Delhi, Ludhiana and Chandigarh (Punjab), Pune and Nasik (Maharashtra), Bangalore (Karnataka), Lucknow, Ghaziabad, and Muradnagar (Uttar Pradesh), Baga (Haryana), Kumaon and Garhwal hills in Uttar Pradesh (Nainital, Almora, Dehra Dun, Mussoorie, Haldwani, Srinagar), Gangtok (Sikkim), Darjeeling and Kalimpong (West Bengal). In the plains it flowers from October to March, while in the hills it flowers during May-June and August-September. Gladiolus flowers from Shimla, Nainital, and Srinagar are supplied to florists in the big cities in the plains during the off-season (June to September), when local production is not available. The price ranges from Rs. 12.48 for a dozen spikes, depending upon variety, season, and market.

The popular gladiolus varieties are White Friendship, Oscar, Ratna Butterfly, Carmine, Mary Housley, Apple Blossom, Friendship, Sylvia, George Mazure, Happy End, Fay, Garland, Patricia, Geoff Whitemen, Yellow Stone, Sancere, Jo Wagneaar, G.G. Porter, Nobel, Snow Princess, Peter Pears, Hunting Song, Vinks' Glory, Eurovision, and Rose Supreme (Table 14.4). Corm production is also remunerative in the hills where the rate of corm multiplication is higher and faster than in the plains. The price of a corn varies from Rs. 1 to Rs. 5 or more according to its size and variety. The gladiolus crop gives a higher percentage of return than rose, carnation, and chrysanthemum.

CARNATION

Although carnation is one of the three most important cut flowers in the international market, ranking second to roses, it has not become popular in India yet. It is grown on a small scale in northern and western areas of the country. In northern India it is cultivated for cut flowers in and around Delhi, Chandigarh, Ludhiana, Lucknow, Calcutta, and the hills of Srinagar and Shimla (Dochi). It is also grown in Bangalore, Pune, and Nasik. Flowering in Bangalore and Nasik is from September to April and from February to September respectively.

The two types of carnation used for cut flowers are the standard and the spray. The commonly grown standard carnations are William Sim, Arthur Sim, Lena Scania, Dusty Sim, Laddie, White Sim, Clear Yellow Sim, Harvest Moon, Shocking Pink, Alec Red, Dusty Yellow, Tangerine, Dusty Pink, and New Arthur Sim. The popular spray types include orange Elf, Goldilocks, Scarlet Eleganca, Nero, Exquisite, Silvery Pink, and Madonna (Table 14.5). Standard and other perpetual flowering carnations are propagated mainly by cuttings and other varieties from seed.

TABLE 14.4
Gladiolus varieties

Domestic market	Export market
Friendship	Vink's Glory
Oscar	Hunting Song
Ratna Butterfly	Carmine
Sylvia	Spic and Span
Carmine	Happy End
Mayur	Peter pears
Mary Housley	Friendship
Apple Blossom	White Friendship
George Mazure	Yellow Stone
Happy End	Sancere
Fay	Oscar
Garland	Eurovision
Patricia	Rose Supreme
Geoff Whiteman	
Snow Princess	
Jo Wagneaar	
G.S. Porter	
Nobel	

However, in the northern plains it is difficult to propagate carnation from cuttings as the rate of mortality is quite high. It is more economical to propagate it from cuttings in the hills, which could be brought to the plains to raise plants for cut flowers. A few florists in Delhi have adopted this procedure for the multiplication of carnation plants.

TABLE 14.5
Carnation varieties for export market

Standard type (Sim's varieties)	Spray types
White Sim (white)	Sam's Pride (deep pink)
Scania Red	Scarlet Elegance
Arthur Sim	Silvery Pink
William Sim	Mini Star (yellow with red streaks)
	Tony (yellow)
	Red Baron (red)
	Gold Star (yellow)
	White Lily Ann (white)

ROSE

In both domestic and international markets, the rose is one of the three top-ranking cut flowers in the floriculture trade. It is also one of the most popular plants grown in the garden. Its use is very common in bouquets, floral baskets, garlands, and flower arrangements. Loose flowers of fragrant roses like Edouard, Damask de Hollande, Crimson Glory, and Gruss en Teplitz are used to make garlands and for religious offerings and floral decorations. The damask rose (*Rosa damascena*) is cultivated for extraction of rose oil or rose attar and concentrates from its flowers for perfume. Rose water and gulkand are prepared from the flowers of the Eduoard rose (*Rosa bourboniana*).

It is estimated that about 2280 hectares are under commercial roses of which Karnataka has 841 hectares, Maharashtra 620 hectares, Tamil Nadu 419 hectares, West Bengal 400 hectares and Delhi 60 hectares. The production is about 875 million cut flowers annually, while the sale of loose flowers is 7200 tons each year. The rose varieties commonly grown for cut flowers (Table 14.6) include Mr. Lincoln (red), Happiness (red), Christian Dior (red), Angelique (orange), Montezuma (orange-scarlet), Golden Giant (yellow), Landora (yellow), Gladiator (red), Century Two (pink), Peter Frankenfeld (deep pink), Queen Elizabeth (light pink), Sea Pearl (light pink), Sonia Meilland (salmon-pink), and White Masterpiece (white).

Rose oil extracted from the damask rose is the most expensive essential oil. Both rose and jasmine oils are a principal ingredient in all high quality perfumes. Rose oil is used extensively by the cosmetics and food flavour industry.

The fragrant rose is cultivated in an area of about 600 hectares in Uttar Pradesh, Tamil Nadu, Karnataka, Punjab, and Rajasthan. The damask rose can be profitably grown for essential oil in Kashmir valley and other similar areas of the Himalayas which have the most suitable climate for its growth, high yield and the quality of its essential oil.

CHRYSANTHEMUM

In India, chrysanthemum flowers are sold both in traditional markets and in florists' shops. Stalkless, the flowers are used for decoration, religious offerings, garlands, and 'venis'. The long-stemmed flowers required for bouquets and flower arrangements are marketed by florists. The dwarf and compact plants commonly known as pot mums are sold by florists. Commercially, the chrysanthemum is cultivated in Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh, Rajasthan, Bihar, and West Bengal. Cut flowers for florists are grown in Calcutta, Delhi, Lucknow, Chandigarh, Ludhiana, Bangalore, Pune, and other places. A private firm in Dochi, near Shimla (Himachal Pradesh), produces pot mums in polythene houses for marketing during summer months in Delhi, Chandigarh, Bombay, and other cities. The chrysanthemum is grown in an area of about 2000 hectares with a total annual production of more than 12000 tons. There is not much scope to develop the cut flower trade in chrysanthemum in the hills as it can be

TABLE 14.6
Rose varieties

Domestic Market	Export Market	
	Large Flowered	Small Flowered
Mr. Lincoln (red)	Sonia (salmon-pink)	Mercedes (red)
Happiness (red)	Ilona (red)	Red Garnette (red)
Super Star (orange)	Red Success (red)	Belinda (orange)
Montezuma (Orange-scarlet)	Diana (yellow)	Carol (pink)
	Carlita (pink)	
Golden Giant (Yellow)	Whilte Masterpiece (white)	Golden Times (deep yellow)
Landora (yellow)	Motrea (red)	Jack Frost (white)
Gladiator (red)	Prive (red)	
Century two (pink)	Madelon (orange)	
Peter Frankenfeld (deep pink)		
Eiffel Tower (light pink)		
Royal Highness (light pink)		
Blue Moon (lavender)		
Lady X (lavender or mauve)		
Paradise (deep mauve)		
Queen Elizabeth (light pink)		

easily grown in the plains where it is possible to produce flowers almost throughout the year by growing different varieties under different agroclimatic conditions.

OTHER FLOWERS

The mountainous regions are ideally suited to growing temperate flowers, such as daffodil, narcissus, lily (Easter lily, Tiger lily), iris, peoni, hyacinth, and tulip. Unfortunately, tulips have not become popular in the Indian hilly regions, perhaps because of lack of availability of varieties suitable for these areas. Selection of suitable sites and varieties and the standardization of agro-techniques for growing tulips in the hills should receive priority in floriculture development projects.

Lavender (*Lavendula angustifolia* ssp. *angustifolia*), which grows successfully on slopes in Jammu and Kashmir, produces lavender oil used by the cosmetic industry. It is also an important crop for the Himalayan region.

Exports

There is an increasing demand for floricultural products in the world. Cut flowers and live plants are important items of import and export in present-day international trade. The consumption of flowers and plants per caput is highest in Switzerland, followed by Holland and the Federal Republic of Germany (Table 14.7). Nevertheless, this consumption is considered to be low and is expected to continue to rise in future. The production of cut flowers and plants in most of the European and North American countries cannot meet the domestic demand, which has to be met by imports. In all the European markets, the demand for cut flowers is at its peak during the winter months (November to May), particularly during Christmas, Valentine's Day, Mother's Day, All Saint's Day, and Easter. In the cold season, when production is in glasshouses, the limitation of space and high cost of labour and energy result in limited production and higher cost of production than in the summer. A few developing countries of the tropical and sub-tropical areas have taken up the export of flowers during winter when it is possible for them to produce flowers at lower cost than in Europe. Unfortunately, the share of developing countries in this export is very low. The Federal Republic of Germany is the biggest consumer of cut flowers and the Netherlands ranks the highest in exports, its share being as high as 66 per cent in cut flowers and 45 per cent in plants. The total world imports of floricultural products, including cut flowers, cut foliage, and live plants in 1985 was US$ 2488.17 million and the total exports were $ 2269.20 million (Table 14.8). The total world imports and exports of cut flowers in 1985 were $ 1297.10 million, and $ 1149.59 million respectively. Live plants valued at $ 1035.29 million were imported in 1985, while exports amounted to $ 989.31 million.

TABLE 14.7
Per caput consumption, 1984 (in US$)

Country	Cut flowers	Plants	Total
Switzerland	32	32	64
Holland	39	21	60
West Germany	35	23	58
Austria	23	22	45
France	19	17	36
United states	20	15	35
United Kingdom	9	6	15

TABLE 14.8

World imports and exports of floricultural products, 1985

Product	Imports	Exports
Cut flowers	1297.10	1149.59
Cut foliage	155.78	130.30
Live plants	1035.29	989.31
Total	2488.17	2269.20

CUT FLOWERS

Among the top three cut flowers in the international market, carnation ranks first (U.S.$ 212.7 million), followed by rose ($ 178.6 million) and chrysanthemum ($ 126.3 million). The Netherlands is the leading exporter of roses ($ 102.8 million), followed by Colombia ($ 36.6 million) and Israel ($ 15.0 million). The four largest exporters of carnation are Colombia ($ 70.6 million), the Netherlands ($ 65.7 million) Israel ($ 27.0 million), and Italy ($ 18.3 million). Chrysanthemums are supplied mainly by the Netherlands ($ 74.7 million) and Colombia ($ 42.1 million). Colombia sends its supplies mostly to the United States and to some European countries. The maximum import is by West Germany, about 36 per cent of the total world imports, while the United States, France, the United Kingdom, Netherlands, having 65 per cent share in the total world exports. The other leading supplier is Colombia (12 per cent), which exports mainly carnation, rose, gypsophyla, and other flowers like lily, gladiolus, gerbera, and statice. Among the main orchid suppliers, Thailand is next to the Netherlands and it exports mainly Dendrobiums. Recently, it has started diversifying by growing carnation and rose for export in the cooler areas of the northern part of the country. Kenya ranks eighth among the exporting countries and its exports include rose, carnation, chrysanthemum, alstroemeria, and statice. The other developing countries which supply cut flowers are Taiwan, Singapore, Peru, Mexico, Costa Rica, Brazil, Ethiopia, Zimbabwe, Mauritius, and Malaysia. Both Singapore and Malaysia export orchids and Mauritius supplies anthurium. The South American countries (Peru, Mexico, Costa Rica, and Brazil) export rose, carnation, chrysanthemum, and other flowers. The Netherlands obtains roses and gladioli from Zimbabwe during winter and gladioli from Ethiopia in winter.

While analysing the market opportunities of cut flowers in foreign markets, it has been observed that carnation, orchids, and chrysanthemum from developing countries may have favourable markets in Europe. France is a good market for exporting rose, spray carnations, chrysanthemum in winter and orchids, particularly new varieties and species. The long-distance shipment of cut flowers to the United States from Asian and African countries may not be competitive with supplies from the South American countries.

Live Plants

The world imports and exports include a large variety of plants, both ornamental foliage and flowering. Among the foliage plants the most important ones are dieffenbachia, dracaena, ficus, philodendron, aglaonema, maranta, croton, yucca, begonia, saintpaulis kalanchoe, pelargonium, cordyline, scindapsus, syngonium, ananas, schefflera, bromeliads, palmas, spathiphylum.

The total world imports and exports of live plants are US$ 1035.29 million and $ 989.31 million respectively. The largest buyer is the Federal Republic of Germany (23.6 per cent), followed by France, the United Kingdom, Italy, and the Netherlands. The leading exporter (44.3 per cent) is the Netherlands and the other large exporters are Denmark, Belgium, West Germany, France, and the United States.

The live plants exported to Europe include rooted and unrooted cuttings, large 'finished' plants, and 'semi-finished' plants. During the last five or six years, large-scale propagation of foliage plants by tissue culture has been taken up in the Netherlands, the United states, and Belgium. The tissue-cultured plants with better rooting, superior quality, uniformity, and freedom from disease have proved advantageous, in spite of higher prices than of those propagated by conventional methods.

Exports from India

The export of floriculture products from India is not substantial. It amounted to Rs. 2.4 million in the first year, 1976/77, and 5.4 million in 1985/86. It reached as high as Rs. 8.0 million in 1978/79 and Rs. 8.4 million in 1980/81 but decreased in later days (Table 14.9). About 50 per cent of the exports are of live ornamental plants, 35 per cent of cut flowers, and 15 per cent of seeds and bulbs. The live plants, are sent mainly to the Gulf countries United Arab Emirates and Oman and cut flowers to the Federal Republic, Holland, Italy, and the United States (Table 14.10). A few nurseries in Kalimpong export orchid plants propagated from seeds or meristem culture in flasks worth about Rs. 0.5 million and bulbs valued at Rs. 2.5 million annually.

Packaging of Cut Flowers and Live Plants

The packaging of cut flowers and live plants should be lightweight, sturdy, and functional. The type and quality of packaging adopted in India is poor and results in post-harvest losses, during transport and storage adversely affecting the keeping quality of cut flowers and plants. Traditional

TABLE 14.9

Export of floriculture items from India

Year	Value (Rs. million)
1976/77	2.4
1978/79	8.0
1979/80	5.6
1980/81	8.4
1981/82	6.0
1982/83	6.0
1983/84	5.8
1984/85	5.8
1985/86	5.4

TABLE 14.10

Commodity-wise export of floriculture products and fruit plants from India, 1981/82

Items	Value (Rs. '000)
Cut flowers	588.3
Flowering plants	425.9
Other live plants	3276.8
Bulbs	731.7
Cactus	139.3
Cut foliage	310.4
Fruit plants	133.6

flowers, small-flowered chrysanthemum, jasmine, marigold, crossandra, stalkless rose, and loose rose petals are packed in gunny bags or baskets with a gunny cover. Long-stemmed, non-traditional flowers for the florist trade are sent to distant markets in cardboard cartons or rectangular bamboo or palmleaf boxes with lids. Live plants have their earthballs wrapped in polythene and/or old newspaper and are packed in baskets with gunny cover and are supported along the edges by long, vertical, slit-bamboo stakes which are criss-crossed at the top and tied with hessian string rope. Corrugated cardboard cartons are also used to pack live plants.

The Indo-American Hybrid Seeds Co. has pioneered in India the standardized packaging of live plants for export, as well as for long-distance transport within the country. The dimensions of the telescopic boxes made of corrugated cardboard used for packaging of live plants are $90 \times 45 \times 25$ cm and 60×45 cm $\times 25$ cm. First, a layer of paper is placed at the bottom of the box with its sides overhanging the edges of the box. Each plant, grown in a plastic pot, is carefully packed individually with a sleeve of newspaper or thin paper over the top, covering the foliage up to the base of the stem. The soil or peat in the pot is covered with thick rolls of wet newspaper and the pot is then wrapped in polythene up to the stem end, the top of which is fastened with rubber bands or thread. The packed plants are placed inside the box horizontally, keeping the pot end towards the edge of the box. On the opposite side also the plants are arranged in a similar way. More than one layer of plants can be packed depending upon the size of plants and pots. A sheet of newspaper is spread between layers of plants.

Care must be taken to ensure that the packing is not loose and gaps should be tightly filled with newspaper or shredded paper so as to avoid movement of the plant or flower bundles inside the box during transport. Finally, the flap of the bottom layer of newspaper left hanging outside the box is folded inside to cover the top of the packed plants. The box is then covered with the lid. The carton is fastened tightly with plastic straps using a strapping machine. The address label is pasted at the top of box and other shipping and product details are also marked on the box, such as name and address of despatcher, nature of product minimum stem lengths, and number or net weight. Each box is marked perishable in bold capital letters.

Packaging Requirements of Cut Flowers in European Markets

Flowers are harvested in the early morning or late in the afternoon. The stage of development or opening at which the flower is harvested depends upon the species and variety. However, the stage of opening should be such that a cut flower can continue developing without any treatment. Soon after harvesting the flowers are placed in a clean bucket filled with clean water and kept in the shade. The bucket, when full of flowers, is taken to the grading hall. Flowers such as rose, carnation, gladiolus and chrysanthemum, which require pre-cooling, can be cooled in an hour by suction, unlike the normal cold treatment of 12–24 hours. The optimum pre-cooling temperature varies with different kinds of flowers, but generally it is between 2° and 4°C. In many cases, a flower preservative (silver thiosulphate or any other proprietary product) is put in the bucket of water in which cut flowers are kept in cold store. Grading is done on a grading table that has graduations marked on it. More expensive automatic grading tables are also available. On the grading table, the flowers are graded for stem length, and defective, damaged, or bruised flowers are rejected. The graded flowers are generally bunched with 5 or 10 stems in each bunch depending upon the kind of flower and market preference.

In many cases, the bunches are sleeved in paper or plastic film, with or without perforation according to the requirement of the importing country. The bunches are then packed in telescopic boxes of specific sizes made of corrugated cardboard. Usually the flowers are packed dry, but during summer exporters in some countries use ice packs kept in sealed polythene bags, wrapped in paper, or deep-frozen liquid packs which are placed in the box to keep the flowers fresh during transport.

Packaging requirements vary with the kind of cut flowers and market. The commonly adopted packing practices for different kinds of cut flowers are mentioned in Annex 1. The product must confirm to market requirements of quality, stem length, and packaging. The produce should be cut or picked at an appropriate stage of growth and meet the requirements of a specific class. Class II may have slight malformation, bruising, damage by disease or insects, weaker stems, and small pesticide residues and the quality tolerance may not exceed 10 per cent from the requirements of the class. In Class I, not more than five per cent of cut flowers may have slight defects. There may be an Extra Class which qualifies for Class I without any quality tolerance.

The stem length of cut flowers (including flower head) is coded from 0 to 120 at intervals of five each, designating the stem length of each code. In code 0 the stem length is less than 5 cm, or flowers that are marketed without stems; code 5 has 5–10 cm stem length, code 10 has 10–15 cm, code 15 has 15–20 cm, and so on. Code 120 is for stems longer than 120 cm. The maximum and minimum lengths of flowers in each unit may not exceed 2.5 cm in codes 15 and below, 5.0 cm in codes 20 to 50, and 10.0 cm in codes 60 and above.

The packaging and presentation are also specified. A unit of presentation, either bunch or box, must contain 5, 10 or a multiple of 10 pieces. However, this does not apply to flowers sold singly or by weight. There must be uniformity of the product in each box with regard to species, variety, quality, and stage of development. The packaging should protect the produce adequately and all packages must be marked carefully, giving all the particulars required by the market. All consignments must be accompanied by phytosanitary certificate, CITES (Convention of International Trade in Endangered Species) certificate, Forest Department certificate, and other relevant customs and forwarding documents. As soon as the air cargo booking is confirmed, the importer or importing agency must be informed by telex or fax of the details of shipping, such as date, airline and flight number, flight route, scheduled arrival date, time, number and weight of boxes, contents (cut flowers, live plants, seeds, bulbs) and airway bill number. Such information and documents will enable the importer take the consignment without delay.

Conclusion

The Hindu-Kush mountains have immense potential to develop a floriculture industry. Cut flowers, cut foliage, dried flowers and foliage, live plants, bulbs, corms, tubers, and seeds can be produced profitably for supply to domestic markets. In the case of cut flowers, priority may be given to orchid, rose, carnation, chrysanthemum, tuberoses, tulips, iris, gladiolus, and peonies. Multiplication of the corms of gladiolus and the bulbs of amaryllis, crinum, hyacinth, tulip, narcissus, daffodil, iris, begonia, lily (Easter lily, Tiger lily), and tuberoses can also be remunerative. Rooted cuttings of carnation, chrysanthemum, and geranium and plants of orchid, African violet, fuchsia, and azalea, are in great demand in big cities. The cultivation of the damask rose and lavender for rose and lavender oil may also be taken up in the valleys.

There is also good scope to develop an export trade in floricultural products, like the cut flowers of orchids, carnation, chrysanthemum, and rose, and live orchid plants propagated by tissue culture. The bulbs of tropical flowers, amaryllis, crinum, eucharis, haemerocallis, haemanthes, and zephyranthes can also find markets abroad. These bulbs can be multiplied in the open at a comparatively low cost of production and are easily transported to distant markets. However, good quality and consistent supply at scheduled dates are essential to the export trade.

Annex 1

Packaging requirements of cut flowers in European markets

Flower	Colour preference	Stem length	Bunch	Pre-treatment	Box size
Rose	Varying with country and season	60–90 or 100 cm (top grade)	10–20	Pre-cooling and preservative	105 × 45 cm (200–300 stems, stem length 40–50 cm)
	Pink and red	40–60 cm	Sleeved with thick paper or plastic film		135 × 35 × 20 cm (200–300 stems, stem length 60–100 cm)
Carnation (Standard)	Pink, white, red	70–75 cm (top grade)	10–20	Pre-cooling and preservative (silver thiosulphate)	105 m × 95 m × 80 cm (20 bunches, 400 flowers)
		40–60 cm (at least half open)	Sleeved with perforated thick paper or plastic film		
Carnation (Spray)		40–60 cm (a minimum of 3 buds showing colour)	5–10	Pre-cooling and preservative	105 × 45 × 25 cm
Chrysanthemum (Spray)	White, yellow, pink	75–90 cm, Bottom 10 cm without foliage	5–10	Pre-cooling, No preservative	100 × 40 × 20 cm
Chrysanthemum (Standard)	White, yellow	75–90 cm	10	Pre-cooling, no preservative	100 × 40 × 20 cm
Gladiolus	Red, peach	90–150 cm	10	Pre-cooling and preservative	135 × 35 × 20 cm
Orchid	Nil	No specific stem length	Generally not bunched	Flower conditioned in water at 27°C,	As per requirement

		Each stem and kept in a vial filled with water or preservative or a wad of wet cotton wool at the stem end	Sometimes spray types are bunched and sleeved	24 hours before shipping. Storage temperature between 8° and 15°C	of the importer
Gerbera	3 distinct types: single, double, black-centred	At least 40 cm Uniform flower size, maximum deviation 10%	Not required	Pre-cooling and preservative	100 × 30 cm × 10 cm or 12 cm (50–60 flowers/box, large flowers 12 cm and above 40 flowers/box)
Lily (Asiatic hybrids)	Yellow, orange	Not specific. Variation not more than 10% Bottom 10 cm without leaves. Graded on number of buds. One flower must show colour and be fully developed or opened	10	Flower preservative	100 × 40 × 20 cm or 100 × 35 × 23 cm
Lily (Large-flowered)	White, yellow	50 cm (minimum)	20	Flower preservative	120 × 33 × 25 cm or 100 × 35 × 23 cm
Anthurium	Red, orange	45–60 cm	No bunching	A piece of tissue paper or shredded tissue paper placed in between spathe and spadix. Each stalk and wrapped with a wad of wet cotton and covered with polythene	70 × 35 × 15 cm (30–50 stems/box)

15

Role of Prices and Markets in the Development of Horticulture

R.L.N. Nasol

Introduction

As an economy develops, marketing usually becomes more important in order to bring food products to people in the non-agricultural sector who are employed in the urban-industrial areas. The more differentiated the producing areas are from the consuming areas, the greater the role played by agricultural marketing. In a purely subsistence economy marketing has very little role to play, if any.

Prices are the signals which regulate production and consumption of agricultural products. High prices tend to stimulate production but decrease consumption and vice versa. It is said that demand implies control and, hence, prices are established at the retail level by consumers through their power to accept or reject (in part or total) products for sale offered at different prices.

Prices are sensitive to many factors and change often at the wholesale level. Wholesalers are in the most strategic position to appraise the interaction of supply and demand forces. Good market intelligence, therefore, provides producers and marketing agents with information to judge the true market values and enables both to direct their output to the best markets.

An effective and efficient marketing system reflects the demand of consumers in terms of prices and, hence, directs the flow of commodities. This task is performed best by market information that is properly assembled and distributed to buyers and sellers.

Markets are centres of trade where assembly and distribution of farm products take place. In a country there may be a whole hierarchy of market centres, from the biggest to the smallest. Thus there may be national, regional, district, and village markets, which may or may not be a fully articulated system or functionally interconnected systems.

Price and Market Information

Many countries have found that the market mechanism offers the least costly scheme to provide incentives to increase agricultural production and productivity, as well as to move surplus efficiently from producing to consuming areas. Timely and relevant price and market information are important in the production and marketing decisions of farmers, traders, dealers, and processors. Its importance is widely recognized as critical in the overall agricultural development strategy.

Most agricultural market information systems which have been set up and operated in developing countries primarily consist of the collection and dissemination of market prices, especially wholesale prices. One reason for this is that prices are easy to monitor and they are supposed to reflect the supply and demand situation of a commodity in a particular market.

It is recognized that supply statistics are equally important market information. Traders, processors, distributors, and even government market regulators benefit from such information in making their procurement, sales, and storage management decisions. It facilitates movement of supplies from surplus or producing areas to deficit or consuming areas. Such movement of supplies increases demand in surplus areas, thus increasing prices. On the other hand, the increase in supplies to the consuming areas decreases the price. Thus, knowledge of supply levels and availability benefits both producers and consumers by enabling the marketing system to function effectively and efficiently.

Design of Improved Market Information Systems

Under a technical assistance project, FAO/UNDP with His Majesty's Government of Nepal is aiming at expanding the public or audience of the market information system being implemented by DFAMS. The system includes farmers, traders and consumers and aims to attain greater market transparency and improved marketing efficiency of agricultural products.

The improved market information system design is presented in Figure 15.1. The main features of the improved design are:

- Better data collection through training and use of a standard data collection manual.

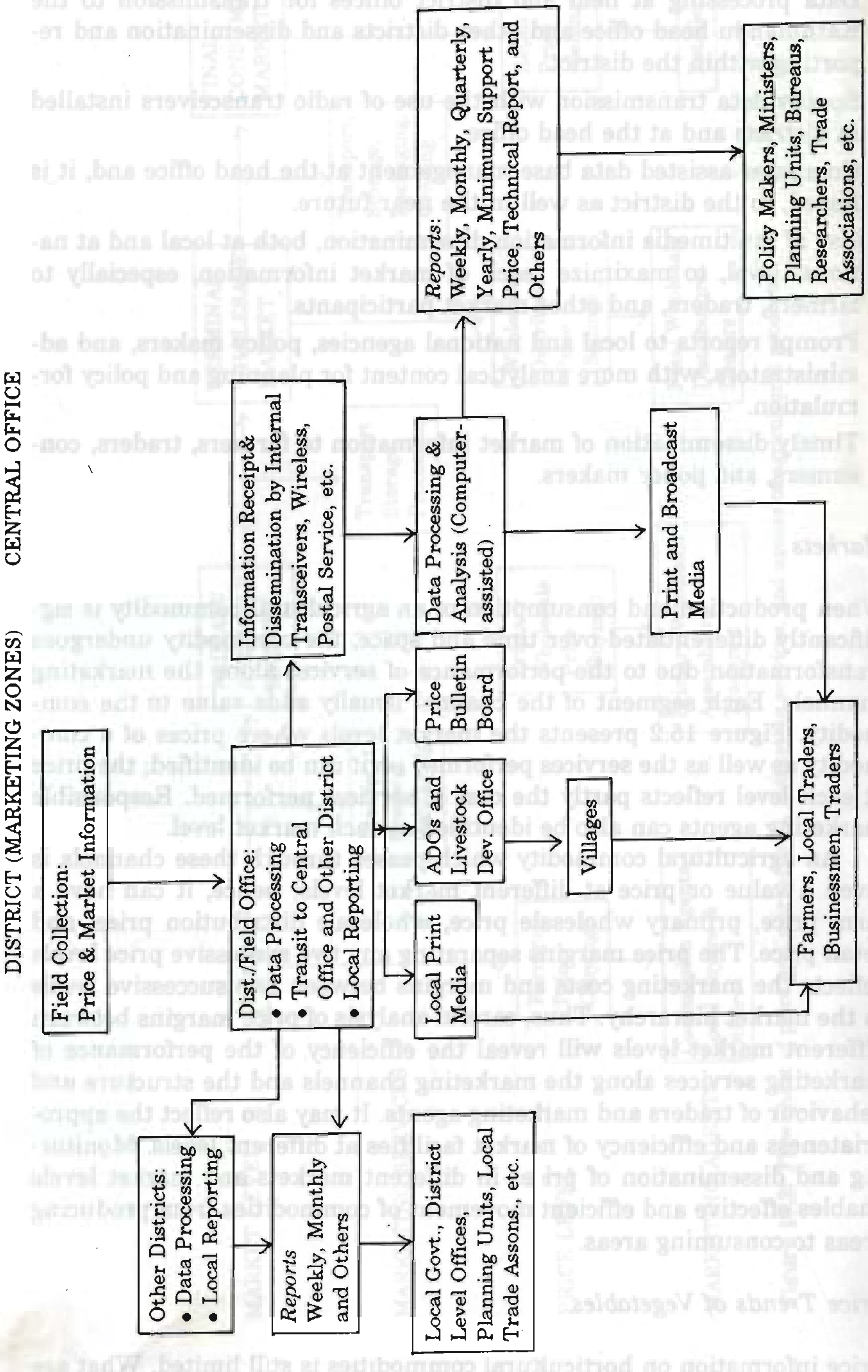


Figure 15.1: The design of an improved agricultural market information system

- Data processing at field and district offices for transmission to the Kathmandu head office and other districts and dissemination and reporting within the district.
- Speedy data transmission with the use of radio transceivers installed in districts and at the head office.
- Computer-assisted data base management at the head office and, it is hoped, in the district as well in the near future.
- Use of multimedia information dissemination, both at local and at national level, to maximize reach of market information, especially to farmers, traders, and other market participants.
- Prompt reports to local and national agencies, policy makers, and administrators, with more analytical content for planning and policy formulation.
- Timely dissemination of market information to farmers, traders, consumers, and policy makers.

Markets

When production and consumption of an agricultural commodity is significantly differentiated over time and space, the commodity undergoes transformation due to the performance of services along the marketing channels. Each segment of the channel usually adds value to the commodity. Figure 15.2 presents the market levels where prices of a commodity as well as the services performed on it can be identified; the price at each level reflects partly the cost of services performed. Responsible marketing agents can also be identified at each market level.

An agricultural commodity which passes through these channels is given a value or price at different market levels; hence, it can have a farm price, primary wholesale price, wholesale distribution price, and retail price. The price margins separating any two successive price levels reflects the marketing costs and margins between two successive levels in the market hierarchy. Thus, careful analysis of price margins between different market levels will reveal the efficiency of the performance of marketing services along the marketing channels and the structure and behaviour of traders and marketing agents. It may also reflect the appropriateness and efficiency of market facilities at different levels. Monitoring and dissemination of prices in different markets and market levels enables effective and efficient movement of commodities from producing areas to consuming areas.

Price Trends of Vegetables

Price information on horticultural commodities is still limited. What are

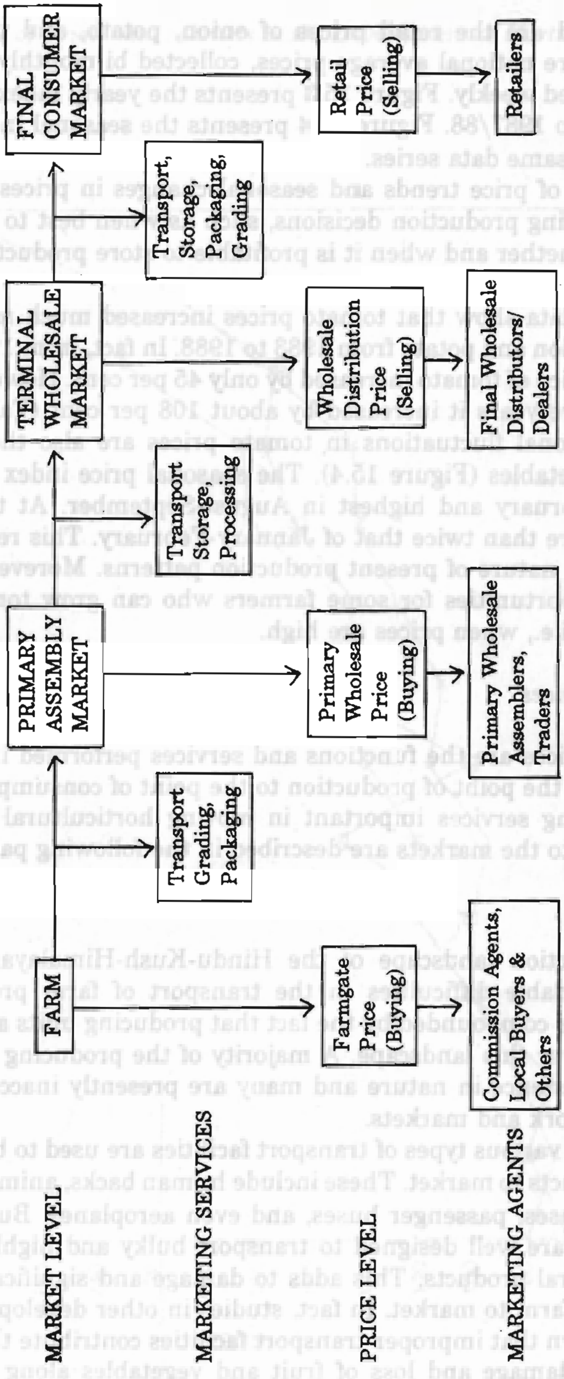


Figure 15.2: Flow chart of price and market level, marketing services, and agents of agricultural products

being presented are the retail prices of onion, potato, and tomato in Nepal. These are national average prices, collected bi-monthly initially, but now collected weekly. Figure 15.3 presents the yearly index of prices from 1974/75 to 1987/88. Figure 15.4 presents the seasonal indexes derived from the same data series.

Knowledge of price trends and seasonal changes in prices provides a basis for making production decisions, such as when best to sell or in determining whether and when it is profitable to store products for sale at a later date.

The price data show that tomato prices increased much more than the prices of onion and potato from 1983 to 1988. In fact, from 1977/78 to 1982/83, the price of tomato increased by only 45 per cent. However, during the next five years it increased by about 108 per cent (Table 15.1). Moreover, seasonal fluctuations in tomato prices are also the highest among the vegetables (Figure 15.4). The seasonal price index is lowest in January-February and highest in August-September. At this time, the price is more than twice that of January-February. This reflects the highly seasonal nature of present production patterns. Morever, it indicates profit opportunities for some farmers who can grow tomatoes in the off-season, i.e., when prices are high.

Marketing Services

Marketing services are the functions and services performed in moving a product from the point of production to the point of consumption. The major marketing services important in moving horticultural products from the farm to the markets are described in the following paragraphs.

TRANSPORT

The production landscape of the Hindu-Kush-Himalayan Region presents formidable difficulties in the transport of farm products to markets. This is compounded by the fact that producing units are widely dispersed all over this landscape. A majority of the producing units are primarily subsistence in nature and many are presently inaccessible to transport network and markets.

At present, various types of transport facilities are used to bring horticultural products to market. These include human backs, animals, carts, traders, minibuses, passenger buses, and even aeroplanes. But none of these facilities are well designed to transport bulky and highly perishable horticultural products. This adds to damage and significant losses en route from farm to market. In fact, studies in other developing countries have shown that improper transport facilities contribute the largest proportion to damage and loss of fruit and vegetables along the marketing chain. Changes in design of transport equipment and facilities

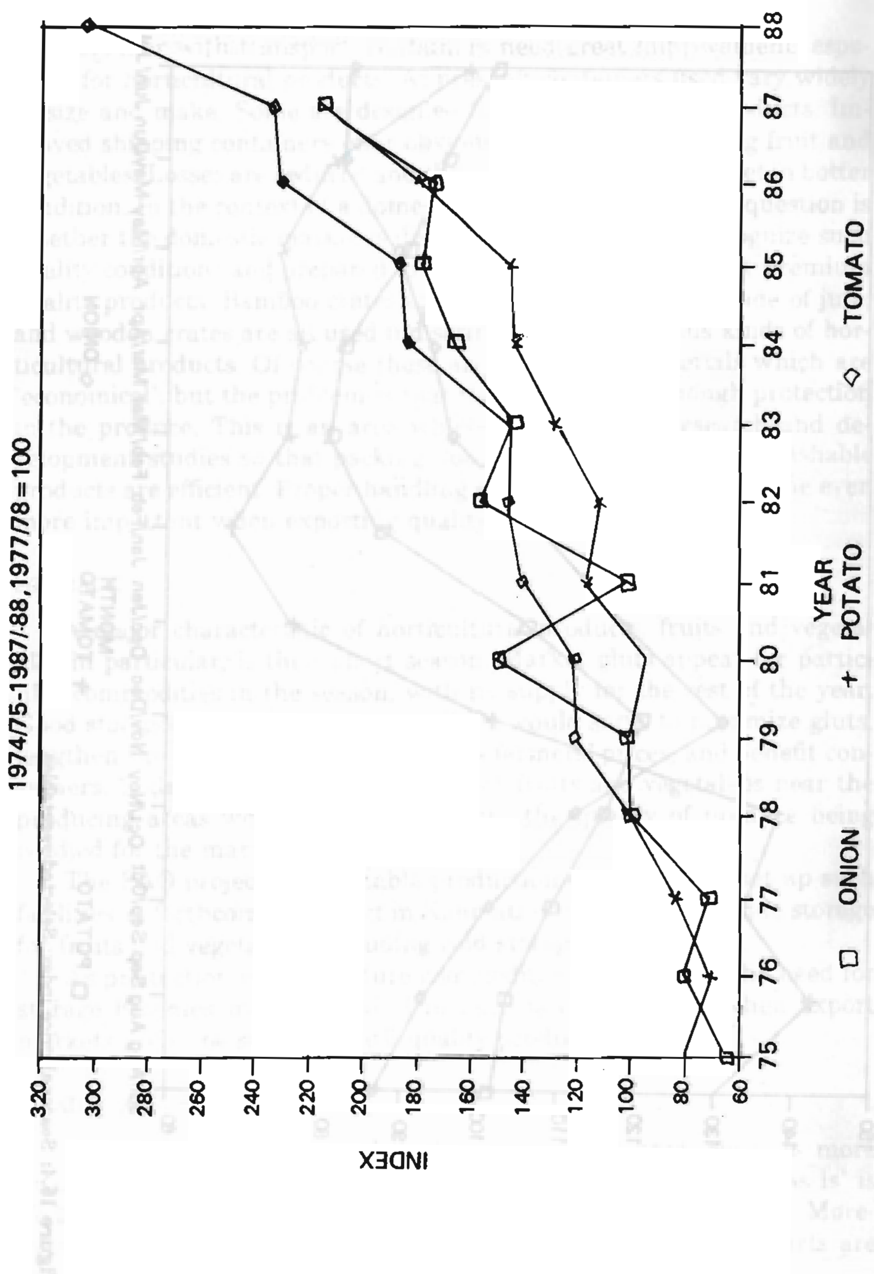


Figure 15.3: Retail price index: Selected vegetables

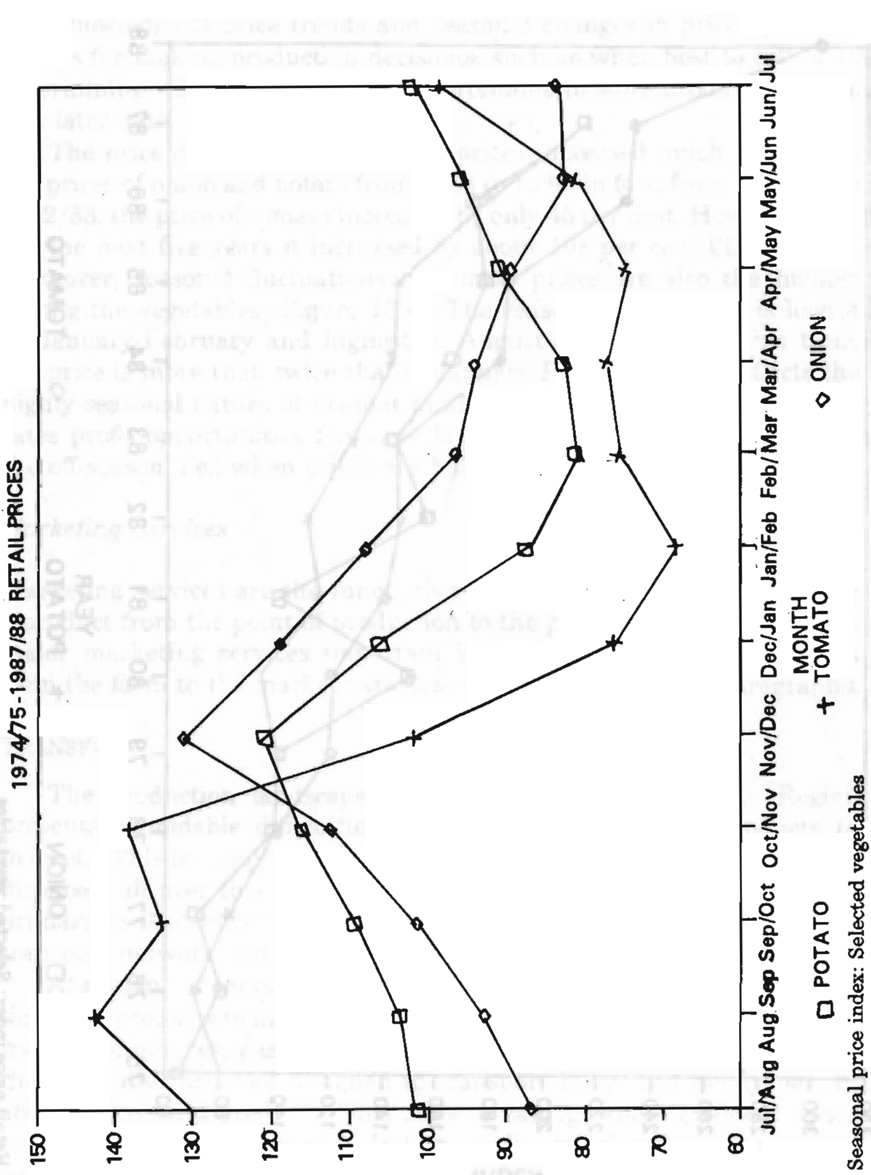


Figure 15.4: Seasonal price index: Selected vegetables

to minimize damage and loss would go a long way towards improving horticultural marketing.

Containers

Together with transport, containers need great improvement, especially for horticultural products. At present, containers used vary widely in size and make. Some are designed for specific types of products. Improved shipping containers offer obvious benefits in marketing fruit and vegetables. Losses are reduced and the products arrive at market in better condition. In the context of a domestic market like Nepal, the question is whether the domestic market is discriminating enough to recognize such quality conditions and prepared to pay the price differential for premium quality products. Bamboo crates and baskets, gunny sacks made of jute, and wooden crates are all used indiscriminately for various kinds of horticultural products. Of course these are indigenous materials which are 'economical'; but the problem is that they do not give enough protection to the produce. This is an area which requires both research and development studies so that packing, loading, and transport of perishable products are efficient. Proper handling and containerization become even more important when exporting quality products.

Storage

A major characteristic of horticultural products, fruits and vegetables in particular, is their short season. Market gluts appear for particular commodities in the season, with no supply for the rest of the year. Good storage for perishable commodities would serve to minimize gluts, lengthen the marketing period, improve farmers' prices, and benefit consumers. Collection and packing sheds for fruits and vegetables near the producing areas would help to maintain the quality of produce being readied for the market.

The FAO project on vegetable production is expected to set up such facilities. A forthcoming project in Kalimati is expected to provide storage for fruits and vegetables, including cold storage facilities.

As production of horticulture commodities is increased, the need for storage becomes more critical. The need is even greater when export markets are to be supplied with quality products.

Grades and Standards

As output rises and markets become sophisticated, there is more quality consciousness among buyers. The sale of commodities 'as is' is no longer possible when catering to more discriminating markets. Moreover, in the absence of grading, producers of high quality products are penalized while those producing inferior goods benefit.

In Nepal there is only a small domestic market for quality grade horticultural products, but there is large potential in export markets. Penetrating such markets requires, among other things, competitive, quality products.

The maintenance of standard quality products starts on the farm. The problem of quality control is compounded by the existence of numerous small farm units in Nepal and in the whole Hindu Kush-Himalaya Region. Under this production structure the maintenance of uniform quality standards for produce requires close supervision of the production system. The question is, can small, independently operating units be regimented so that they produce the quality grades that domestic or export markets demand?

PACKAGING

Delicate horticulture products require suitable packaging, especially while being transported to far destinations. Damage due to improper handling, packaging, and transport can result in inferior quality as well as significant losses. This loss has been found to be high in some developing countries. Not only is there loss of volume and value but also there are losses of nutrients. Experience in the Philippines has shown that proper packaging of vegetables reduced weight losses from 29 to only 2.5 per cent. The difficult terrain for transporting goods in the Hindu Kush-Himalayan Region makes packaging and handling critical in preserving the quality of marketed horticultural products. At the moment the domestic market is simple and less discriminating, except for a small segment of the total market. Proper packaging will become extremely important when produce is to be sold to more discriminating domestic consumers and export markets.

PROCESSING

Highly perishable products are presently sold in fresh form as they have been for ages past. Marketing seasons are short; supply is heavy for a period, then non-existent for the rest of the year. Prices drop sharply as the marketed volume reaches its peak, then rise sharply. On the one hand, farmers receive low prices when they market the bulk of their produce. On the other hand, consumers use the product heavily during the season and little, if at all, for the rest of the year.

WHOLESALE MARKETS

As the economy develops and there is more articulation of markets and spatial differentiation for production and consuming areas of food products, wholesalers become critically important in the assembly and distribution of food products, especially of perishable horticultural produce.

Wholesalers are usually located in major markets and often in a major transport nexus where they or their agents undertake the primary assembly of horticultural produce. Often it is here that products are graded, packaged, and distributed to local markets, or shipped to distant markets, both domestic and export. In Nepal there are no formally organized wholesale markets for fruit and vegetables, except the Kalimati wholesale market in Kathmandu.

The Kathmandu city area is the largest urban market for fruits and vegetables in the country. The Kalimati wholesale market has been in existence, informally, for some years. It has been the natural area for unloading of fruits and vegetables from the terai and neighbouring districts. The government has found it necessary to organize the market along more modern lines by providing facilities for wholesale, storage, and other services.

The volume of arrival in Kalimati is one important indication of the seasonal nature of horticultural production. In 1988/89, of the total volume of 17.5 million metric tons, 26 per cent was registered in the first quarter, 24 per cent in the second quarter, and 34 and 14 per cent in the third and fourth quarters respectively (Figure 15.5). In fact, the two months of October-November and November-December account for 26 per cent of the total arrivals. Figures 15.6 and 15.7 show the value of sales conducted at the wholesale market.

Marketing of vegetables and fruits showed a significant difference between the six months of 1988/89 and the corresponding period of 1987/88. The tremendous jump in the volume handled reflects not only increased arrivals in Kathmandu from supplying areas, but also more patronage by producers, suppliers, and traders (Figures 15.7 and 15.8). When a facility like this is set up, it provides a convenient and reliable place to buy and sell vegetables. While farmers and assemblers are sure to be able to unload their produce in the market knowing that buyers will come to that place, the distributors, retailers, institutional buyers, and their agents expect to buy and procure the commodities they want from this market.

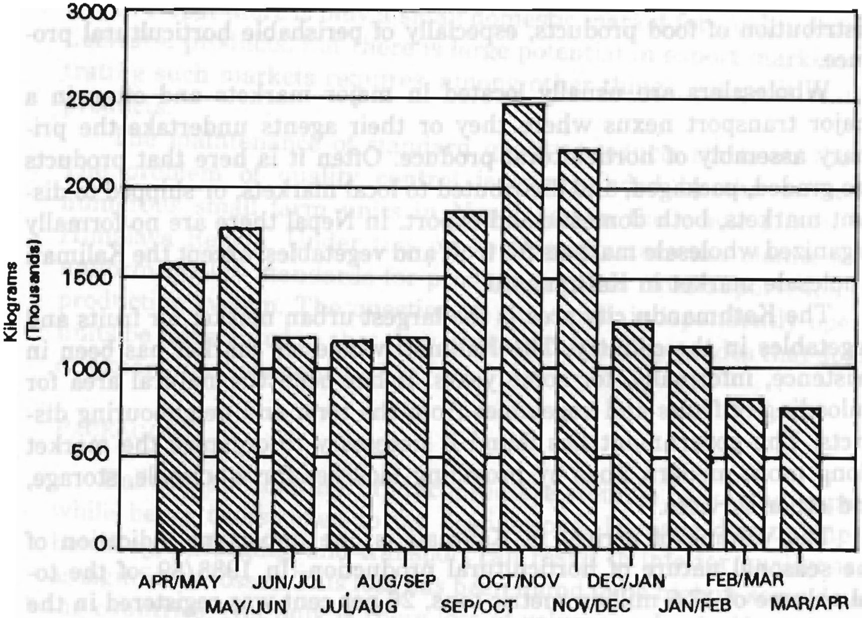


Figure 15.5: Total volume of vegetable and fruit arrival at Kalimati wholesale market, 1988/89

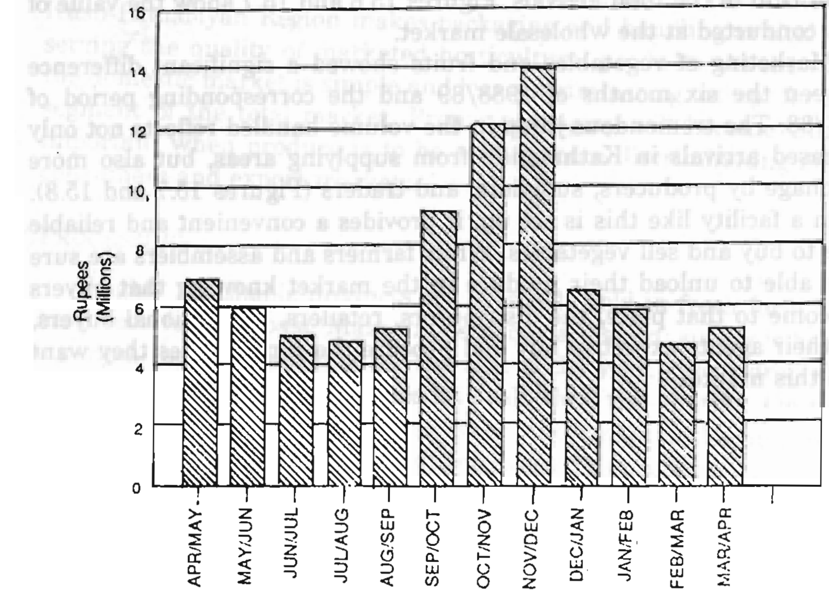


Figure 15.6: Total value of vegetable and fruits sold at Kalimati wholesale market, 1988/89

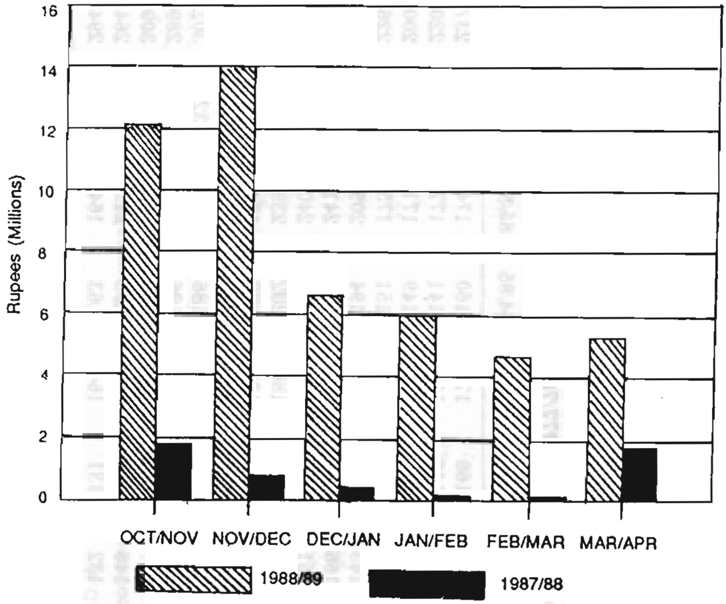


Figure 15.7: Comparison of total value of vegetable and fruit arrivals at Kalimati wholesale market, October-November to March-April, 1987/88 and 1988/89

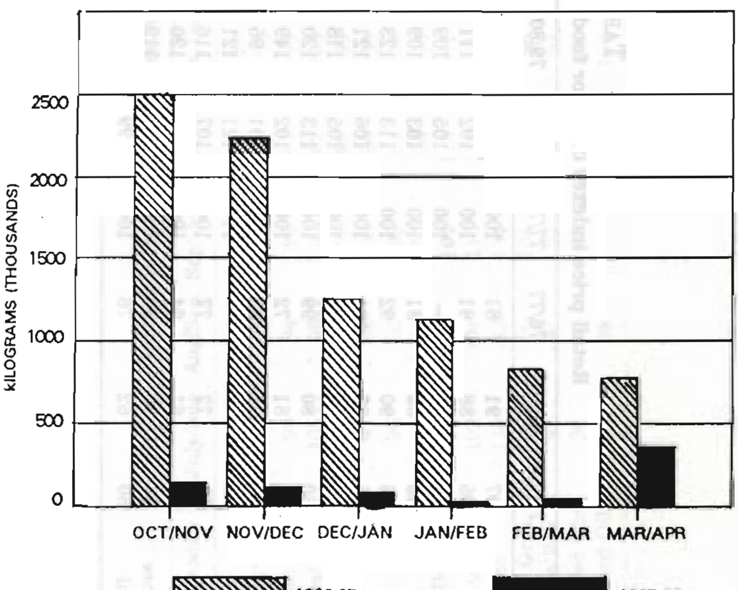


Figure 15.8: Comparison of total volume of vegetables and fruits sold at Kalimati wholesale market, October-November to March-April, 1987/88 and 1988/89

TABLE 15.1

Retail price indexes of major food items, 1974/75–1987/88, 1977/78 = 100

Commodity	74/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88
Rice	97	91	81	100	105	109	117	127	166	174	160	174	208	237
Maize	95	88	81	100	102	111	114	122	146	153	141	177	179	220
Wheat Flour	—	—	—	100	105	109	125	122	156	158	149	171	181	200
Cereal	96	89	81	100	103	109	116	124	158	163	151	175	195	226
Chicken	86	90	92	100	113	123	134	143	172	182	194	209	250	280
Buff	85	97	101	100	106	121	132	166	191	222	221	241	285	326
Mutton	83	90	94	100	105	118	137	151	168	187	209	240	295	286
Fish	80	80	99	100	113	120	136	146	169	186	202	239	273	305
Onion	65	81	72	100	102	149	101	156	143	165	177	174	214	308
Potato	80	71	83	100	101	95	117	112	129	143	145	179	215	187
Tomato	—	—	—	100	121	121	141	146	145	183	186	230	232	302
Black Gram	77	77	77	100	107	116	131	132	144	165	196	221	228	289
Pigeon Pea	86	61	64	100	114	120	125	137	149	167	178	188	215	309
Purified Ghee	84	90	93	100	108	119	121	148	156	172	205	219	242	264
Mustard Oil	80	62	76	100	99	11	140	132	131	164	163	164	213	294

TABLE 15.2

Seasonal retail price indexes: Major food commodities 1974/75–1987/88 average

Commodity	July/Aug	Aug/Sep	Sep/Oct	Oct/Nov	Nov/Dec	Dec/Jan	Jan/Feb	Feb/March	March/April	April/May	May/June	June/July
Rice	105	103	102	100	92	96	97	96	97	100	102	109
Maize	101	95	91	92	93	95	97	105	106	107	108	109
Wheat Flour	98	94	96	101	95	105	108	106	105	95	95	102
Cereal	105	95	97	102	103	93	96	97	103	98	100	111
Chicken	98	97	98	99	99	99	99	101	102	100	102	105
Buff	97	96	98	100	98	99	99	99	100	103	103	108
Mutton	96	95	98	98	98	98	100	100	103	103	105	106
Fish	95	98	97	96	96	97	99	105	106	100	103	107
Onion	87	93	101	113	131	119	108	97	94	90	83	84
Potato	102	104	110	116	121	106	88	81	83	91	96	102
Tomato	130	143	134	138	102	76	69	76	77	75	81	98
Black Gram	100	100	104	100	96	96	97	98	99	101	103	106
Pigeon Pea	97	98	97	96	99	100	103	101	102	100	101	107
Purified Ghee	98	97	98	99	102	97	99	100	100	101	103	106
Mustard Oil	96	98	99	99	100	102	102	99	99	100	101	105

16

Post-harvest Practices as Affecting Marketing of Fruits and Vegetables in Himalayan Mountain Regions in India

J.C. Anand and O.P. Grover

The Indian Himalayan mountain region, as considered in this paper, runs from Jammu and Kashmir in the west to Arunachal Pradesh and Mizoram in the east. This region covers more than one-eighth of the total land area of the country and makes up the entire northern boundary. The two important mountainous belts of the Himalaya in India include: the Northwest hill region (NWHR), comprising the states of Jammu and Kashmir, Himachal Pradesh, and hill districts of Uttar Pradesh and located between latitudes 28° and 37° N; and the Northeast hill region (NEHR), which consists of the states of Sikkim, Arunachal Pradesh, Assam, Manipur, Tripura, Meghalaya, Mizoram, and Nagaland and is located between 20° and 29° N. Due to higher latitudes and elevation the NWHR falls mostly in the temperate zone, whereas, the NEHR is mainly sub-tropical with a small temperate part. The entire area consists of high, medium, and low rugged mountains with valleys enjoying varying agroclimatic conditions. Rainfall is low to moderate in the west but heavy to very heavy in the east. Only a small area of these mountainous regions is under cultivation.

The importance of horticultural crops to the economic development of the hilly region cannot be overemphasized. It is only through more intensive horticultural production, improved orchard and land management techniques, and appropriate post-harvest marketing technologies that we can increase farm income, generate employment, and conserve land resources.

Production Pattern of Fruits and Vegetables

The suitability of different tree crops to specific areas is governed primarily by the climate. In the NWHR, this can change within short distances, caused by abrupt changes in elevation or proximity to the plains or snow-clad peaks. These changes are not so marked in the NEHR where most of the area is located in the sub-tropics.

Apple is the dominant fruit grown in the NWHR. Other temperate fruits include plum, apricot, pear, cherry, peach, grape, and nuts such as walnut, almond, and chestnut. Sub-tropical fruits include mango, citrus, guava, fig, and grape. Among the vegetables, the important ones are potato, capsicum, cauliflower, cabbage, ginger, and chilli. The production of fruits and nuts in the NWHR is given in Table 16.1

TABLE 16.1
Approximate production of fruits and nuts in NWHR

Commodity	Production ('000 tons)			
	J&K	HP	UP	NWHR
Apple	760(96)	175(84)	165(47)	1100(81)
Other temperate fruits	4(1)	24(10)	32(15)	60(6)
Nuts and dried fruits	16(2)	2(1)	8(2)	26(2)
Sub-tropical fruits	10(1)	10(5)	126(36)	146(11)
Total	790	211	331	1332

Figures in parentheses are percentage of total.
Source: World Bank Review of Horticulture in North West Hill Region, January 1987.

In the NEHR, the major fruits grown include pineapple, citrus, banana, apple, pear, stone fruits, papaya, mango, guava, and coconut. The vegetable list includes potato, tapioca, sweet potato, cole crops, ginger, turmeric, and chillies. The approximate production of different fruits and vegetables in the region is given in Table 16.2.

Horticultural crops are extremely important and provide a useful avenue for the economic development of mountainous regions. This is especially so when the land holdings in these areas are small and becoming further fragmented with each generation. They are a rich source of vitamins and minerals and are essential for proper physical and mental growth. Fruits and vegetables are, further, a good source of income and employment for the farming community. Vegetables are extremely labour intensive in nature with high-pay-off crops.

TABLE 16.2
Approximate production of fruits and vegetables in NEHR

Fruits	Production ('000 tons)	Vegetables	Production ('000 tons)
Apple	6.7	Chilli	10.9
Banana	327.2	Ginger	23.2
Citrus	119.7	Potato	270.7
Coconut	32.1	Sweet potato	54.8
Guava	0.5	Tapioca	17.2
Mango	0.4	Turmeric	6.0
Papaya	47.3		
Pear	12.5		
Pineapple	167.5		
Stone fruits	7.4		
Total	721.3		382.8

Source: State Profile of Area and Production of Fruits and Vegetables in India, National Horticulture Board, Gurgaon (1988).

Besides production, related areas such as grading, packing, transport, marketing and processing are essential to proper management of horticultural crops and provide business and employment wherever these crops are marketed.

Increasing Importance of Post-harvest Handling

Deterioration in fruits and vegetables sets in soon after harvest, depending upon the nature of the fruits, their ambient conditions, and the mode of handling. The increased attention afforded to post-harvest horticulture has mainly been due to the realization that faulty handling practices after harvest can result in large loss of produce. There is increasing awareness now that more emphasis must be given to conservation after harvest, rather than in endeavouring only to increase crop production.

Various authorities have estimated that 50–80 per cent of fresh fruits and vegetables are lost after harvest, although a recent FAO survey serves only to indicate how vague and incomplete many of these estimates are. In tropical regions which include a large proportion of the developing countries, these losses can assume considerable economic and social importance. In India, out of an estimated production of 50 million tons of fruit and vegetables, 20 to 40 per cent, valued at Rs. 5000–7000 crores, is lost annually (Swaminathan, 1981). These losses further escalate when we include the cost of transportation from the farm to the retailer, including cost of preparation, packaging, transport, marketing, and control system. These overheads cost five to nine times the production cost (Greenhalgh, 1974).

Post-harvest loss of fruits and vegetables depends on whether the fruit is hard or soft, handling during picking, grading, packaging, mode of transport, the condition of roads, proximity to the terminal market, and above all, the temperature and humidity experienced between harvesting and final sale. Once harvested, each type of fruit and vegetable has its own post-harvest requirements and varying degrees of perishability, depending on a host of physical, physiological, and environmental parameters.

The basic parameters in the integrated distribution system depend upon:

- harvesting and preparation
- packaging
- transport
- marketing and storage
- retailing.

Great strides have been made in apple production in India, especially in the NWHR during the last 20 years. Production rose from less than 100,000 tons in 1966/67 to over 1 million tons in 1986/87 (Table 16.1). The basic parameters and their implications for the marketing process (mainly in terms of apples and other important perishables grown in the Indian Himalayan region) will be dealt with here. Solutions to overcome some of the constraints based on advances made in other countries have also been addressed where appropriate.

Harvesting and Preparation

The harvesting of fruits and vegetables and their sizing and grading form the first step in the marketing chain. Fruits and vegetables should be harvested when they are at their prime. Immature or overripe fruits and vegetables tend to deteriorate quickly in quality and bring depleted returns. Important criteria for harvesting and grading apples are discussed in the following paragraphs.

Harvest Maturity

Apples are picked by hand. The time to pick the fruit is judged on the basis of several physical, chemical, and physiological parameters, keeping in view the end use of the apples. It has to be seen whether the apple, once picked is to be consumed locally, sent to near or distant markets, put in cold stores, or be processed (Table 16.3). Flesh, colour, firmness, total soluble solids, and days from full bloom can prove valuable guides. Mechanical gadgets such as a pressure tester and hand refractometer have been found very valuable because they provide immediate results.

TABLE 16.3
Firmness of apple indicating maturity vs. destinations/use

Destination/use	Firmness of flesh (pounds per square inch)
Nearby markets (Shimla, Chandigarh)	14.5–15.0
Distant markets (Bombay, Calcutta, Madras)	18.0–20.0
Export	18.0–22.0
Local market	13.0–14.0
Cold storage	18.0–20.0
Minimum for cold store fruits	12.0

Source: K.C. Azad, National Workshop on Temperate Horticulture in NWHR of India, p. 274, 1987.

Field Containers for Harvesting

Apples are usually picked and transported from farm to packaging sheds in conical containers called 'Kilta' made from bamboo, which can hold about 25 kg of fruits. Studies on replacing the Kilta with rigid plastic crates (55 × 35 × 30 cm) which can carry 30 kg revealed that bruising of Red Delicious could be cut by half due to the design and smooth inside surface of plastic crates. Labourers, however, still prefer to use Kilta because it can be carried easily on the back.

Grading

Standardization of size, grade, and packaging is important to post-harvest quality and the reduction of post-harvest loss. It also reduces marketing cost, establishes trade language, and brings increased returns. In apple, apart from size, colour and, freedom from blemishes or defects are also important criteria (Table 16.4).

Though the commercial grading practised in Himachal Pradesh is of a fairly high standard, buyers feel that grading is often subjective. There is not much difference between 'Agmark' and this form of grading. Agmark was introduced in 1970. The Market Planning and Design Centre, Directorate of Marketing and Inspection, in collaboration with Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh, took up an Apple Trade Development Project during 1980/81 to develop uniform

TABLE 16.4
Size grades of Himachal apples

Grade	Diameter of fruit at broadest point (mm)	No. of fingers placed between left hand thumb & middle finger
Super large	87 ± 3	4 and thumb
Extra large	81 ± 3	4 and some extra space
Large	75 ± 3	3–4
Medium	69 ± 3	2–3
Small	63 ± 3	1–2
Extra small	57	0–1
Pitto	Less than 51	None

This is mixed with C Grade apples and sold as culls for processing.

Quality Grades of Himachal Apples

A grade:	Fruits must have more than 50 per cent of the colour characteristics of the variety, be of normal shape, clean, bright, and free from blemish or defects. The fruit should have reached that stage of maturity which will permit subsequent completion of ripening in the ordinary course of transport and marketing.
B grade:	Fruits with less than 50 per cent colour characteristics of the variety, with slightly abnormal shape and two to three healed spots, say up to 0.5 cm.
C grade:	Fruit with flesh bruising and spots which are likely to rot immediately in transit and fruit very irregular in shape. Fruits in this grade are not fit for the fresh market.

Source: Harbans Singh and H.L. Kochhar, *Grading and Packing of Apples*, Horticultural Bulletin No. 2, Shimla, 1974.

grade and size standards for the Delicious group, including Golden and Maharaji varieties. Unfortunately, the project could not be implemented. Efforts are now being made to do this and the National Horticultural Board of the Ministry of Agriculture, Department of Agriculture and Cooperation, convened a meeting of relevant agencies to work out standards for varieties from the three states. Use of the grading standards is voluntary, therefore, intensive extension efforts will have to be made to achieve these standards and to see that only A and B grade fruits reach the terminal market.

In the future, the marketing of NWHR fruits, especially apple, is to be size graded for better market returns. Currently, the only mechanical fruit sizing machines in NWHR belong to the two marketing corporations of HPMC and JK-HPMC, set up with World Bank assistance. The 11 HPMC and 17 JK-HPMC pack houses contain 45 sizing machines, each capable of grading 1000 cartons per day with a total capacity of 4.5 million cartons (90,000 tons) in 100 days. Besides, there is a very large size grader installed by JK-HPMC at Sopore with assistance from the Australian Government. To date, there has been little demand from growers for these facilities because grade standards are not enforced. If these circumstances change in the future, the present grading capacity in the existing packing houses, which can handle only 10 per cent of the apple crop, can be considerably expanded by holding loose fruits in cold storage and expanding the existing capacity of grading centres in the production areas.

Packaging of Fruits and Vegetables

The whole aim of packaging fresh produce is to enable it to be moved from the producer to the consumer at the lowest cost, with minimum loss of quality. Several types of conventional packaging such as wooden boxes, bamboo and reed baskets, jute bags, and even earthen pitchers have been used depending upon the nature of the commodity, its intrinsic value and the ready availability of the packaging materials. More recently, corrugated fibreboard (CFB) cartons and rigid plastic crates have also been used. Due to the shortage of timber and alternative packing materials and their high cost, fruits such as raw mango, banana, and pineapple are marketed without any protective packaging. Increasing the production of fruit and vegetables in the country in general and in the mountains in particular depends to a large extent on the supply of wood for making wooden boxes from forest resources in the hills.

Wood Requirements

Fortunately, in the Himalayan mountain region there is an abundant supply of silver fir and pine-chir and, till recently, the Forest Department in Himachal Pradesh was committed to supply wood at subsidized rates for packaging of hill produce. The estimated supply of wood required in 1990 for packaging of apples has been drawn up (Table 16.5). These calculations are based on the assumption that nearly one-third of the standing volume of wood is wasted, only two-thirds of it being used for cases. Further, 60 packing cases of 18 kg capacity are made from each cubic metre of standing volume.

As may be observed the demand for wood for the manufacture of packing cases for Himachal apples alone would be about 2,00,000 (Negi, 1989). The considerably larger production of apples in Jammu and Kashmir and the demand of Uttar Pradesh will require much more wood. This figure can multiply if we take into consideration housing, furniture, and other uses of timbers. Massive deforestation of the Himalaya has become a source of great anxiety to environmentalists, causing as it does imbalance in the ecology, erratic rainfall, increased soil erosion, and faster

TABLE 16.5

Projected quantity of apple requiring packing and wood required for the purpose in Himachal Pradesh

Year	Production ('000 tons)	Net quantity to be boxed (84 per cent, of production) ('000 tons)	No. of boxes needed ('000 boxes)	Wood required for packing cases ('000 m^3)
1985	174.6	145.7	8069	134.5
1986	191.0	160.4	8822	147.0
1987	209.0	175.6	9658	161.0
1988	228.7	192.1	10566	176.1
1989	250.3	210.3	11567	192.8
1990	273.9	230.1	12656	210.9

Source: R. Swaroop, Director, Agro-Economic Research Centre, Shimla (Himachal Pradesh).

silting of dams and riverbeds. Restrictions have now been imposed on the indiscriminate felling of forest and alternative sources of wood for the packaging of fruits and vegetables are being looked into.

Wooden Packing Cases

Unlike in the advanced countries, in India wooden packing cases have not been properly standardized for the same or different commodities. In the case of apple, the standard size of packing case is 18 kg in Himachal Pradesh as against about 20 kg in Kashmir. There are also half standard cases in Himachal Pradesh, Jammu and Kashmir, and Uttar Pradesh (Table 16.6)

To pack and market stone fruits (plum, apricot, peach, and almond) and for vegetables such as tomato and capsicum, the capacity of the box is less than that used for apples (Table 16.7).

Substitutes for Wooden Boxes

With the timber crisis, its rising cost, and the recognition of the forests' role in preserving the ecological balance, every effort is being made to minimize the felling of trees. Efforts are therefore being made to develop substitute containers which consume less wood but are comparable in performance. Great success has been achieved in developing CFB cartons, alternative packing using little or no wood, and rigid plastic containers.

Corrugated fibreboard cartons with paper pulp trays have long been used for packing and transport of fruits and vegetables in many developed countries. They offer several advantages over wooden boxes:

- A CFB carton consumes only 30 to 40 per cent of the wood used for a

TABLE 16.6

Details of wooden boxes in use for packing and marketing of apple in Himachal Pradesh

Size grade	Fruit size (+ 2.5 mm)	Fruit count	Box size (inner dimensions, cm)	Capacity (kg)
Super large	85	54–57	45.72 × 30.48 × 27.94	18–20
Extra large	80	60–63	45.72 × 30.48 × 25.45	18–20
Large	75	96	45.72 × 30.48 × 30.48	18–20
Medium	70	112	45.72 × 30.48 × 27.94	18–20
Small	65	128–132	45.72 × 30.48 × 25.45	18–20
Extra small	60	160	45.72 × 30.48 × 25.45	18–20
Pitto	55	—	45.72 × 30.48 × 24.45	18–20
Kullu dabba (for different sizes)	—	—	48.70 × 20.50 × 22.50	10

The price for an empty box is Rs. 12–13 for all sizes except Kullu dabba, which costs Rs. 8

Source: B.B. Lal, Horticulture Technologist, Y.S. Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh (personal communication), 1989.

TABLE 16.7

Details of wooden boxes in use for packing of stone fruits and vegetables in Himachal Pradesh

Fruit	Inner dimensions (cm) Length	Width	Capacity Height	Wood (kg)	Box (Cost Rs.)
Plum, apricot, fresh almond	37.5	20.5	15.5	5–6	5
Peach	42.5	27.5	19.5	12	8
Tomato small	43.2	25.4	20.3	13	8–10
Tomato large	45.7	27.9	20.3	15	8–11
Capsicum small	50.8	33.0	20.3	12–13	12
Capsicum large	55.9	38.1	27.9	15–16	14

Source: B.B. Lal, Horticulture Technologist, Y.S. Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh (personal communication), 1989.

wooden box of the same capacity. The change over to CFB cartons will thus considerably increase the total output of cartons from the same timber resources. These cartons can also be made from other materials like biomass, bamboo, bagasse, and wheat and rice straw.

- Their corrugation helps to minimize the bruising of fruits.
- They are easier to handle and stack, their weight being only one-fifth that of wooden boxes.
- They can be punched and ventilated.

- They are internationally acceptable.
- They are pilfer-proof and any tampering is seen at a glance.
- They can be printed artistically at low cost.
- Their telescopic form imparts a high degree of stacking strength.
- They can be fabricated and turned out quickly in highly precise and accurate sizes.
- They are totally recyclable into pulp, unlike wooden boxes which are invariably used as fuel.

The only disadvantage of the CFB carton is that, together with its paper tray, it costs more at present than the wooden box. This could be partially overcome by increasing production and bringing in better technology for production. The price difference could also be neutralized by higher prices fetched by apples packed in CFB cartons than in wooden boxes.

To promote the use of CFB cartons in India, the Market Planning and Design Centre of Marketing and Inspection took up an apple trade development project in 1980/81 under the auspices of UNDP/FAO, using the services of foreign consultants. Telescopic cartons and pulp trays were imported from New Zealand and distributed to apple-growing states for experimental purposes.

From 1983 onwards, the Himachal Pradesh Government took up promotional efforts for the extensive use of corrugated telescopic tray-pack cartons by appropriately subsidizing them to keep their price lower than that of standard wooden cartons. In 1986, these were sold at the rate of Rs. 9 per carton including pulp trays, straps, and gum tape, as against the prevailing price of Rs. 10 for standard wooden boxes. There is an increasing use of CFB cartons for packing apples in Himachal Pradesh:

Year	*No. of CFB cartons used*
1983	21,000
1984	16,000
1985	179,000
1986	1,665,000
1987	6,000,000

A company under the name of Agro Industrial Packaging India Ltd. has been incorporated by the Himachal Pradesh government at a cost of Rs. 240 million to manufacture 45 million sq.m of corrugated liner board and 30 million cartons for the packaging of fruits and vegetables in the first phase. The plant will have the most modern heavy duty technology and use high strength, water-resistant craft paper with a burst factor above 30. At present, the country is short of soft wood with long fibre and will have to develop long fibre resources in order to manufacture a liner and fluting medium with the necessary physical properties.

The CFB cartons used in apple packaging have the inner dimension of 50.8 × 30.8 × 28.0 cm and are assembled by fitting two standard telescopic pieces of five ply into each other, thus giving 10-ply thickness to the carton on the sides and five ply on the top and bottom. Fruits are packed in paper pulp-moulded trays with appropriate size cavities. Altogether, six trays, five trays carrying fruit and the sixth one as the topper, are stacked one above the other, carrying 120 fruits altogether. Each tray is arranged in the opposite direction to hold the weight of the fruit on the projections of tray cavities rather than on the fruit.

Details of CFB cartons used for packaging of different fruits like apple, plum, apricot and almond are given in Table 16.8.

So far, only Himachal Pradesh has been able to promote the use of CFB cartons for apple packing. This has been made possible because government subsidies on these cartons keep their price slightly lower than that of wooden boxes. In Jammu and Kashmir and Uttar Pradesh, apples are still being packed in wooden boxes. A part of the plum, apricot, and almond crop in Himachal Pradesh is packed in CFB cartons. The change-over to CFB cartons is complete in Jammu and Kashmir, where cherries are packed in these cartons. This is because of the lighter weight of these cartons for transporting cherries by air from Srinagar to Delhi and Bombay.

TABLE 16.8

Details of CFB carton used for apple, plum, apricot, and almond packaging

Type	Size	Approx. capacity (kg)	Subsidized price (Rs.)
Telescopic CFB carton with 6 trays for apple	50.8 × 30.8 × 28.0	20	11.50
Universal CFB carton	45.0 × 30.0 × 27.5	18	8.00
Universal Kullu dabba	48.7 × 20.5 × 22.5	10	6.00
Universal CFB carton for plum, apricot, and almond	37.0 × 18.0 × 15.0	5–6	4.5

Source: B.B. Lal, Horticulture Technologist, Y.S. Parmar University of Horticulture and Forestry, Himachal Pradesh (personal communication), 1989.

ALTERNATIVE PACKAGING USING LITTLE OR NO WOOD

In the Himalayan region, jute bags are extensively used to pack cabbage, beans, radish, turmeric, carrot, eggplant and cucurbits. Bamboo and wooden baskets are used to pack tomato, peas, capsicum, and cauliflower. Jute bags and bamboo baskets have extremely poor holding capacity and stacking strength. They offer no physical support or protection to the product, resulting in unusually heavy losses and damage.

The Himachal Pradesh State Forest Corporation has set up a plant to manufacture pine-needle hardboard with a capacity to turn out 400,000 standard size boxes. Trials conducted with pine-needle packs reveal that the boxes absorb moisture and tend to loosen up during transit. Also, the printing of stencils on its body and its handling was difficult. These cartons may prove useful to pack apples in the interior areas not linked by roads.

Other innovations in alternative packaging, using cheaper and less wood, have also been tried. The Forest Research Institute, Dehra Dun, has devised five types of 18 kg standard size (30 × 30 × 45 cm) boxes: plywood boxes, fir veneer box, toon veneer box, chir box, and poplar box. Some of these boxes have proved as good as the conventional wooden Shimla box as far as bruising damage was concerned during the transit of fruit from the production centre near Shimla to Delhi in trucks (Table 16.9).

TABLE 16.9

Bruising damage in Royal Delicious apple during transit

Type of packaging	Bruising percentage
Shimla box	36.0
Chir Box	35.2
Toon veneer	26.2
Fir veneer	20.0
Thin plywood	39.0
Poplar	23.3

Source: Maini et al. *Trials on Substitute Boxes for Packing of Apples,* National Workshop on Apple Industry, New Delhi, 1983

USE OF PLASTIC CONTAINERS

Substitution of CFB cartons for wooden boxes for the packing of apple has been encouraged and large-scale production of these cartons is in hand. During the rainy season, however, the handling of CFB cartons becomes problematic as they are not totally moisture-proof. The Indian petrochemical industry has introduced two types of plastic containers: corrugated polypropylene co-polymer (PPCP) boxes; and moulded PPCP crates. The former is a prototype of the CFB carton made with plastic sheeting instead of craft paper and is being manufactured by Caprihans at Bombay. These cartons proved useful in rainy weather but are still not commercially used. The latter is the rigid plastic container. As they are made from petrochemical-based polymers, these containers are prohibitive by PPCP box costs 2.5 times and a PPCP rigid plastic crate costs about 7 times the cost of a CFB carton. Compared with the wooden box, however, the rigid plastic crate offers the following advantages:

- It is 1/5th to 1/10th lighter.
- It does not absorb moisture.
- It is easy to handle and stack.
- Bruising damage is minimal.
- It provides better aeration.
- It can be easily washed and does not attract fungus or bacteria.
- It is excellent in removing field-heat from packed fruits and more economical to maintain at low temperature in cool storage.

Initial tests carried out on these PPCP cartons by IPCL show that they can be used 18 times, while other containers are used once. The economy of these cartons lies in recycling them through a close network of distribution and in standardizing their design. The material required for making crates is now indigenously available at the IPCL plant at Vadodara.

TABLE 16.10
Crate introduction plan

Year	No. of crates	Equivalent (M.T.)	Equivalent wooden boxes replaced
1987	100,000	220	18
1988	200,000	440	38
1989	600,000	1320	108
1990	2,400,000	5280	432
2000	2,400,000	5280	432

Source: Plastic in Packaging of Horticultural Produce, Proceedings of National Seminar on Use of Plastics in Agriculture, Vigyan Bhavan, New Delhi, p. 39, 1987.

With a view to introducing standardization, a compromise has been made in the common dimension of 60 × 40 cm. These rigid plastic crates have replaced the conventional wooden box for carrying apples from the orchard to the grading and packing house or nearby market. At present, HPMC uses about 50,000 plastic crates as field boxes. Mother Dairy of the National Dairy Development Board has used these crates successfully for the last two years for transportation and storage of fruits and vegetables in Delhi. Other user organizations include the Horticultural Producers' Cooperative Marketing and Processing Society Ltd., Bangalore. Both in economy and in performance, these crates were found satisfactory.

For plastic crates to become the generally used container for transportation and marketing of fruits and vegetables to distant markets, certain information besides size standardization and distribution mechanism is desirable:

- size and type of crate and capacity, advantage of collapsible crates
- technical specifications
- capacity for faster transportation and recycling
- price factor and economic feasibility
- mode of investment in crates, guaranteed security
- alternative use of these crates in cold stores and institutional supply
- overhaul and repair for maximum utility.

A scheme has been jointly launched by IPCL and HPMC using 20,000 crates on a trial basis to generate data on their performance. The HPMC is to be supplied 20,000 crates free of cost by IPCL for use by the apple trade. It is to generate all the data on these crates and to ensure lending and retrieval of them. It is to charge Rs. 5 and Rs. 8 per crate trip to apple growers. It is to meet total expenses on fruit, packaging, transportation, and washing and storage of crates.

Bulk Bins

The increased cost of apple packaging in India seems inevitable, but mid- to long-term bulk movement of fruits may have good potential. This can be done by the use of bulk bins. Initially, the concept may apply only to B grade apples which invariably bring lower prices in the market and thus not warrant the additional cost of a tray pack or carton operation.

Truck-loads of apples have also been moved by some orchardists using wooden planks as tiers, supported on the sides of the truck by hooks. Three tiers are used and the planks are padded with paddy straw to avoid bruising. On arrival at Delhi, these apples are graded again and stored in boxes in cold storage. This operation has shown promise and, if proved profitable, will gain momentum in future.

Packing Houses

After harvest, most horticulture crops are cleaned, sorted, graded, and usually packed if they are to be sold in the fresh produce markets. All these procedures usually take place in packing houses of different types, a small thatched shelter on the edge of a field or a more permanent packing house with various facilities. The packing house design and the facilities needed depend very much on the local infrastructure, quantity of the produce, the markets being served, and budgetary provisions. The operation carried out by a packing house may include: receipt, checking, loading and unloading; packaging, including washing, waxing, grading; despatch, checking, and loading; and storage, ripening, and cooling.

Packing houses should be near production areas and have easy access to the market through good highways or railways or other transit facilities. Services such as water, electricity, and labour should be easily available. In the mountainous regions of the Himalaya, the grading and packing operation was usually done by individual farmers, while private contractors who buy the produce at pre-harvest stage from the individual grower arranged their own sheds to sort, grade, and pack the produce.

The HPMC was created in 1975 to set up an efficient marketing and processing organization with infrastructure to market horticultural produce (mainly apples), under a Rs. 160 million World Bank-assisted project. It was to set up packing houses with a capacity of 14,000 tons. Similarly, JK-MPMC, established in 1979 with Rs. 240 million as part of a World Bank-assisted project on marketing and processing horticultural produce, was asked to set up 17 packing houses with 34,000 tons capacity. All 17 packing houses have not yet been fully commissioned due to lack of response from the growers.

Storage of Fruits and Vegetables

Fruits and vegetables remain alive even after harvest, inhaling oxygen and exhaling carbon dioxide, water, and heat. If not managed properly, they tend to wither and may soon start rotting. Their shelf life can be considerably extended from a few days to several months if stored properly at low temperatures with high humidity. Cold storage of fruits and vegetables is helpful to avoid gluts in the market and to regulate the supply of these perishables over longer periods, to the advantage of both the producer and the consumer.

The Himalayan regions produce all types of temperate and subtropical fruits and vegetable. Their maximum storage life depends upon their maturity, variety, quality, and other factors. Currently, two of the important crops grown in this region, apple and potato, are stored at low temperature in cold stores for up to 12 months, thus being available throughout the year. It is not worthwhile to store all types of fresh produce if the ultimate price realized for them is not enough to cover the cost of storage. Low temperature management of post-harvest fruits and vegetables during grading, packing, transport, and marketing is of great advantage to retain their freshness and bring better economic returns to the growers. The recommended environmental conditions and approximate storage life of important fruits and vegetables is given in Table 16.11.

TABLE 16.11

Recommended temperature for storage of Himalayan region fruits and vegetables

Fruits	Temp °F (°C)	Life (weeks)	Vegetables	Temp °F (°C)	Life (weeks)
Extremely perishable					
(0–4 weeks)	RH 90–95			RH 90–95	
Apricot	31 (–0.5)	2	Asparagus	32 (0)	2–4
Banana (green)	55 (12.5)	2–3	Brussels sprouts	32 (0)	2–4
Cherry	32 (0)	2–4	Cauliflower	32 (0)	2–4
Guava	45–50 (7–10)		Green peas	31 (–0.5)	1–3
Mango	50–55 (10–12)	2–3	Melon	40–45 (5–7)	2–3
Papaya	45 (7)	7	Capsicum	45 (7)	2–3
			Radish	32 (0)	2–3
			Spinach	32 (0)	1–2
			Tomato (red)	45–50 (7–10)	1–2
			Mushroom	32 (0)	1–2
Perishable (4–8 weeks)					
Grape	31 (–0.5)	4–6	Cabbage	32 (0)	4–6
Mandarin	40–45 (5–7)	3–6	Tomato (green)	55 (12)	3–6
Peach	31 (–0.5)	2–6			
Pineapple	50 (10)	2–4			
Plum	31 (–0.5)	2–7			
Slightly perishable* (6–12 weeks)					
Grape	30 (–1)	7–12	Cabbage	32 (0)	6–12
Lime	50 (10)	6–8			
Orange	40–45 (5–7)	6–12			
Non-perishable (12 weeks)					
Apple	30–38 (–1–3)	8–28	Beetroot	32 (0)	12–20
Nuts	30 (–1)	up to 50	Carrot	32 (0)	12–20
Pear	30 (–1)	8–28	Potato	45 (7)	16–20
Quince	30 (0)	8–16	Sweet potato	55 (12)	16–24
			Turnip	32 (0)	10–24

*The longer-keeping produce which can be safely stored for correspondingly shorter periods at temperatures higher than the optimum temperature for best keeping are listed above.

Source: E.G. Hall, Mixed Storage of Food Stuffs, Cir. 9, CSIRO, Australia, 1973.

Cold Stores

In India there are 2522 cold stores with a storage capacity of 5.1 million tons, out of which 1588 stores with a capacity of 4.5 million tons (88.2 per cent) are used for storage of potato only (Directory of Cold Storage in India 1985, Directorate of Marketing and Inspection, Faridabad). With World Bank assistance, five cold stores with a capacity of 5000 tons were set up in Himachal Pradesh and seven cold stores with a capacity of

6400 tons, ultimately to increase to 12,000 tons, are to be constructed in the state of Jammu and Kashmir exclusively for apple storage.

With the increasing volume of apples coming into the market each year, the provision of adequate fruit storage facilities becomes increasingly imperative, if market gluts and reduced prices are to be prevented. In fact, to gain full benefits from the cold stores, a cold chain strategy in production, transshipment, and consumption areas has to be effectively adopted for the proper care of over 1 million tons of apple. The crop being harvested early in Uttar Pradesh, efforts should be made also to market it, avoiding investment in the establishment of cold stores. In Jammu and Kashmir and Himachal Pradesh, however, cold storage is inevitable for the Delicious variety, which does not have a long shelf life.

The scale of storage required is enormous when long-term management and the existing facilities are considered. Estimates drawn for Jammu and Kashmir by the Indo-Australia Apple Technology Extension Project proposed about 30 per cent of apples be cold stored in the Kashmir valley, 15 per cent in transshipment centres at Jammu, and 15 per cent at terminal markets, which would require a storage capacity in Jammu and Kashmir for 350,000 tons by 1990 (total production estimated 800,000 tons in 1990), compared with an existing facility for 12,000 tons. Similarly, additional cold storage capacity will have to be provided for Himachal Pradesh where the existing capcaity is only 6400 tons. Most of the cold stores were set up in India either in potato production areas or in large cities where potato is sold. Half of their capacity is used for potato seed. Some of the stores in terminal markets are also used to store apples during the off-season.

The construction and operation of cold stores for the NWHR's fruit crop is, therefore, likely to involve major investment in coming years. An addition of 4000 tons capacity will cost about Rs. 8 million. Keeping this in view, alongside the energy crisis and its rising cost, it becomes a matter needing serious and detailed planning to ensure that appropriately sized and equipped units are established at optimum locations in the hills, near production centres, or in terminal markets, in a phased manner matching the needs of growers, commission agents, and wholesalers.

Pre-cooling

Prompt cooling of apples in the production area, whether meant for direct marketing or destined for storage, is a key factor in retaining quality. Leaving Delicious apples outside at 70°F (21°C) for a week will reduce their storage life approximately nine weeks. The storage life of the apple is closely related to ambient temperature.

Pre-cooling can be achieved by picking fruit pre-chilled by night air and/or by watering down and forcing air over the stacked fruit (evaporative cooling). Other methods like vacuum cooling and the more recent technique called ice-bank cooling are also used.

TABLE 16.12

Life of apple at various temperatures

Temperature (°F) °C	Storage Life
(30) –1	7 months
(32) 0	6 1/4 months
(36) 2	3 months
(40) 4	2 months
(50) 10	1 1/4 months
(60) 16	23 days
(70) 21	20 days

Source: US Department of Agriculture Bull. No. 1406 (1926)

Evaporative Cooling

Hot and dry weather prevails over much of India for a significant part of the year. Exposure to such weather causes rapid deterioration of perishables, particularly those more liable to water loss by evaporation. In hot and dry weather use of the evaporative cooling system can considerably reduce dry bulb temperatures and raise the humidity of the air, which is conducive to preservation of fresh fruit and vegetables after harvest.

With energy shortage and its rising cost, refrigerated cooling is becoming extremely expensive. Desert coolers are now fast replacing air conditioners to provide coolness in homes in the northern plains of the country. These coolers consume only one-fifth the energy per unit drop in temperature that air conditioners consume and create a desirable humidity of around 80 to 90 per cent which is difficult to obtain in the refrigerated system. If the air is drier, the evaporation is greater and so is the drop in temperature.

Several evaporative cooling models based on simple, natural convective ventilation without the use of energy and others using forced draft ventilation (FDV) with the use of energy have been tried and found useful. A simple fruit cooler using a draft of air forced by an exhaust fan through wet, porous walls has been used with success in Australia (Figure 16.1). This relatively cheaply constructed room has been found very suitable for the cooling and short-term holding of citrus fruits and grapes with negligible wilting and weight loss. It should be possible to maintain the room at a temperature of 65–70°F even on the hottest day.

Where electricity is **not available,** a thatched roof structure (Figure 16.2) can be kept cool by periodically flooding the gravel base. Maximum cooling is obtained by converting the wall facing the prevailing wind direction into a large evaporating surface. This can be done by packing porous material between supporting studs held together by wire netting. A drip system for water is also provided at the top. The structure has been used with great success in Kenya.

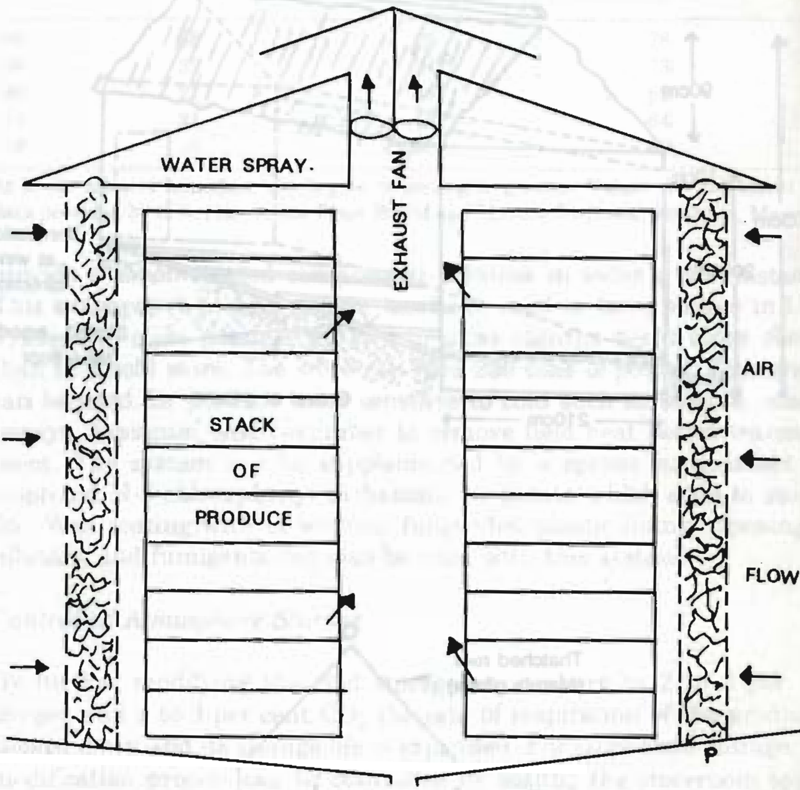
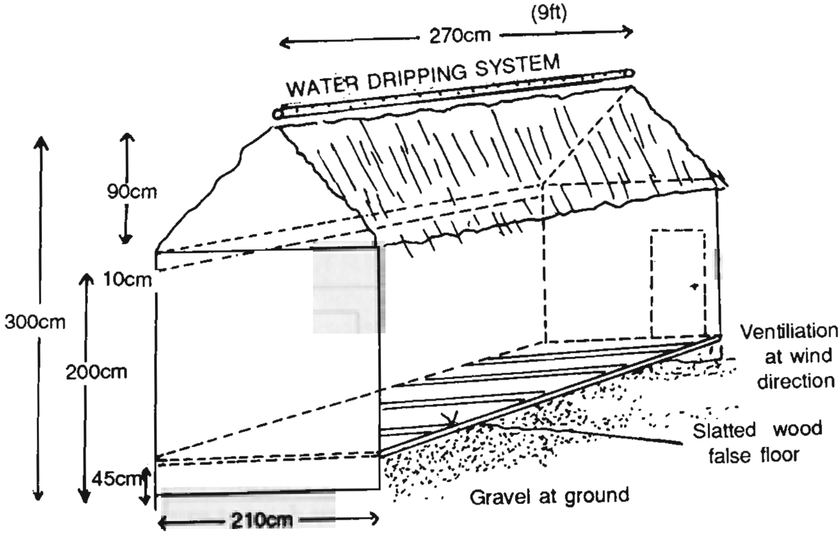


Figure 16.1: A simple evaporation-cooled fruit cooler (Australia)

P: Porous wall 15 cm thick on a timber frame with 1.25 cm wire netting, either side filled with 3–5 cm coke or charcoal pieces.

Source: E.G. Hall, *Evaporative Coolers* ASCA Seminar Proceedings, North Ryde, Australia.

Another cold godown working satisfactorily for the short-term storage of potatoes is made of mud wall with bamboo frame structure and thatched roof standing on a false bamboo bottom. The ground below is kept wet with sand and water. The thatched roof is also periodically sprinkled with water. This low-cost, energy-saving cooling system can be used with success on the farm in packing sheds and for pre-cooling purposes. It cannot be expected to do all that the cold store can but it can



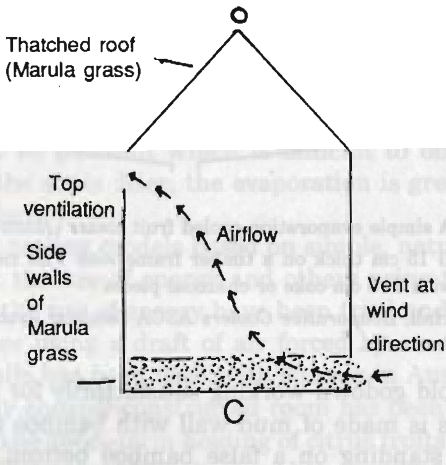


Figure 16.2: Low-cost ventilated store cooled by evaporation (Kenya)
Source: International Trade Forum UNCTAD/GATT, January-March 1981.

TABLE 16.13

Air temperature obtained by single-stage evaporative cooling

Ambient temperature		Ambient relative humidity (Percentage; 80 per cent RH)	Temperature of air ex-cooler at	
°F	°C		°F	°C
100	38	25	78	26
90	32	34	73	23
80	27	46	69	21
70	21	64	64	18
60	16	90	59	15

At lower relative humidity, the degree of cooling is greater. Values are calculated from data provided by E.G. Hall in the Fruit World and Market Growers, Australia, May 1972.

provide a much needed compromise solution in today's circumstances. This evaporative cooling system has been used in farm houses in Uttar Pradesh to store potatoes for two to three months much more cheaply than in a cold store. The store can hold 250 tons of potato. This system can be used for produce most sensitive to cold such as banana, mango, papaya, capsicum, and cucumber to remove field heat before transshipment. The system can be supplemented by a sprout suppressant like Isopropyl N-3-chlorophenyl carbamate for potato which adds to storage life. Wax coating with or without fungicides, plastic lining, ripening inhibitors, and fumigants can also be used with this system.

Controlled Atmosphere Storage

By further modifying the cold storage atmosphere to 2 to 3 per cent oxygen and 2 to 3 per cent CO_2 the rate of respiration of the produce is slowed down and its storage life is expanded. For large-scale storage, this modification process can be controlled by sealing the storeroom to gas-tightness and by incorporating equipment for the addition or removal of oxygen and carbon dioxide. The use of polythene bags of a specific thickness and gas permeability, combined with refrigeration, could be profitably used to extend post-harvest life because of the repressive effect on respiration and transpiration. This controlled atmosphere storage is in widespread use in many developed countries for the storage of apples and pears. Making a cold store gas-tight increases the capital cost by about 10 per cent and is thus not practicable in India. An experimental controlled atmosphere store has been used for the past three to four years for the storage of apples by JK-HPMC at Srinagar. Commercial controlled at atmosphere storage of apples should come into use only after normal air storage is widely practised to the greatest advantage.

Air-cooled Stores

In areas where night temperatures are low and the day temperature is high, air-cooled stores are used to house perishables on the farm. The temperature in an air-cooled storage room is reduced by opening air intakes and vents near the floor and the exhaust opening near the ceiling in the opposite wall to admit cool air at night. The vents and intakes are closed when the outside temperature rises above the storage-room temperature. The efficiency of these stores can be improved by using evaporative coolers in areas which experience high temperature and low humidity. Stacking of produce inside the store must allow for free movement of air. Humidification of incoming air can be done to restrict water loss from the produce. One such store with a capacity to stack 100 standard apple boxes is functioning satisfactorily at the Regional Fruit Research Station at Mashobra in Himachal Pradesh.

Transportation of Fresh Produce

Fruits are grown in the Himalaya on the slopes, ridges, and valleys of far-flung and remote areas. Improvised tracks and dirt roads provide the only linkages with roadheads. The fruit from these areas is first carried on human backs or heads or by mules to the roadhead. At these assembly points, fruit is stored, packed, and arranged to be transported by forwarding agencies to markets outside the states, mainly by truck. It is not usual for trucks to carry a load all the way to the terminal markets. In the case of apples in NWHR, local trucks are used to ply between the production centres and the transshipment centres established at Jammu and Kashmir, Parwanoo and Keratsahib (Himachal Pradesh), and Haldwani and Kathgodam (Uttar Pradesh). Local trucks carry about 400 boxes of 20 kg each but the truck from transshipment centres to the terminal markets carry an increased load of 500 to 550 boxes. Jammu, Parwanoo, and Haldwani are also connected by rail to different parts of the country, but railways are rarely used to transport fruit. Potato and some other vegetables are sometimes transported from these transshipment centres by rail.

Temperature is a major problem in the marketing of fruits, especially in the NWHR and NEHR. Fruits from both these areas have to travel long distances to reach the consuming markets. Srinagar is 800 km from Delhi and over 2000 km from Bombay and Calcutta. In the case of apples from Srinagar, the transport time in the hot humid plains may be about three days to Delhi and up to 10-days to distant markets. During this long haul at high ambient temperatures the fruit quality suffers. Pineapple, banana, and citrus grown in the NEHR has to reach the sale points by circuitous routes via Assam.

Road versus Rail Transport

For carrying fruits and vegetables there is a pronounced preference for road transport in this country. One of the basic reasons for preference is shorter transit time and the advantage of door-to-door service. Road transport, however, is two to three times more expensive. With the energy crisis there will undoubtedly be a switch back to the railway. It is estimated that rail transport is about 8 to 10 times more efficient in the use of energy than road transport to move a ton of produce. The railway system has thus to be improved and made more service-oriented to attract more traffic in perishables. Rail transport is handicapped in that fruit and vegetables have to be carried in general-purpose, all-steel, unventilated wagons which literally carry everything. In these wagons damage is bound to result because accumulated heat and solar radiation is unavoidable.

Temperature in Transit

Both refrigerated and insulated rail wagons and trucks are now in use in advanced countries to carry perishable produce from the production centres to the consuming markets. Although these would be ideal, understandably such specialized vehicles are not only costly to build, but also unreasonably expensive to operate in the Indian economy.

How best to maintain low temperatures in both trucks and wagons to preserve the quality of fruits and vegetables and to reduce loss during transit needs close attention. There is an urgent need to improve the design and ventilation of rail wagons. Fruits and vegetables need to be pre-cooled before loading. During movement by train, the fruit undergoes evaporative cooling and its temperature, instead of rising, remains close to the ambient temperature. Ventilation at night will help to cool the produce by cold air from outside. In the closed wagons, Dr. Swaminathan's committee (1981) recommended the use of dry ice inside the wagons to maintain low temperature. Dry ice can also be used in trucks for the local distribution of fruits. Painting the roofs of rail wagons white will further reduce the absorption of radiant heat to the advantage of the fruit.

There is a need to improvise small changes in the design of existing trucks to allow the passage of air through a wet surface connected by a drip system from an overhead tank. Water in the tank can be replenished during the journey.

Furthermore, trucks should travel at night to avoid the sun's heat and be made to park in the shade during halts. There is also suggestion to sprinkle powdered ice on the fruit boxes in the truck to keep them cool during transit. In the case of properly pre-cooled fruits, the use of insulated trucks would be an advantage. When grapes were cooled to 4°C before loading in insulated trucks for transport from Bombay to Delhi in April, only 1°C rise in temperature per hour was observed.

Improvement in Transport Strategy

If India is to attain a marked improvement in the horticulture sector, a bold policy with massive financial inputs, as was done in the case of cereals and milk, has to be evolved to create a proper infrastructure for the post-harvest management of fruit and vegetables. Transportation forms the most important link in the distribution chain and is estimated to cost 30–35 per cent of the sale price. An action plan needs to be evolved and properly executed, based on the introduction of mechanical or gravity ropeways in difficult hilly terrain, designing of modified trucks and railway wagons, and subsidization of their rates to encourage their use. For long-distance NEHR export markets, links to the local airport should be developed. The cost of air transportation can be neutralized by appropriate subsidies to make the transported commodities competitive. Further, inland navigation needs to be developed through Bangladesh to market produce from the NEHR Calcutta. Priority clearance should be given to trucks carrying fruit and vegetables at sales tax barriers in the states.

Fruit and Vegetable Processing

Important fruits in the NWHR include apple, pear, plum, apricot, and cherry, and in the NEHR banana, pineapple, and citrus. The vegetables most common in both regions include potato, tomato, cabbage, cauliflower, pea, and capsicum. Jammu and Kashmir and Himachal Pradesh also grow nuts, (walnut, chestnut, pistachio, almond, pecan). The wild pomegranate is abundantly available in Himachal Pradesh and Jammu and Kashmir and wild mango in the NEHR.

Apple constitutes about 80 per cent of the total production of the NWHR amounting to over 1 million tons. Out of the total production of apples, about 200,000 tons are culls which are available for processing each year, 60 per cent of which comes from Jammu and Kashmir.

Several large-scale units for apple, pineapple, and orange juice concentrates have already been commissioned or are to be commissioned in the NWHR and NEHR (Table 16.14).

The apple juice concentrate unit at Sopore, Jammu and Kashmir, with a capacity of 12,000 tons was initially set up by Cadbury and sold later to JK-HPMC in 1985. The Parwanoo unit in Himachal Pradesh of 18,000 tons was built by HPMC while the second unit of 2000 tons at Jarol was built with German bilateral aid and is now run by HPMC. Thus, the total crushing capacity of apples in these units is 32,000 tons

TABLE 16.14

Units for concentrates in the NWHR and NEHR

State	Concentrates Produced	Location
Jammu and Kashmir	Apple	Sopore
Himachal Pradesh	Apple	Parwanoo and Jarol
Tripura	Pineapple	Kumarghat
Assam	Pineapple	Silchar
Arunachal	Orange	Tinsukhia*

*Unit to be commissioned shortly.

with several other small units crushing another 500 tons. The total number of units processing fruit and vegetables in the states of the Himalayan region are given in Table 16.15. Most of these units are very small when compared with fruit juice concentrate plants.

TABLE 16.15

Number of fruit and vegetable processing units in the Himalayan region (1988)

State	No. of units
Jammu and Kashmir	58
Himachal Pradesh	55
Uttar Pradesh	164
Assam	19
Arunachal Pradesh	02
Mizoram	03
Meghalaya	05
Manipur	04
Nagaland	03
Sikkim	01

Source: Ministry of Food Processing Industries, New Delhi.

Apple Juice

None of the apple juice concentrate plants have run to full capacity since their inception. In spite of great efforts made by HPMC for the promotion and sale of apple juice through juice vending machines set up at important centres, the sale of apple juice lags far behind mango, pineapple, and citrus juices. This is also reflected in the poor sale of apple juice compared with other juices packed in new packaging material like the tetra-pack. Public apathy to apple juice is said to be due to its lack of body and aroma. Blending apple juice with fruit pulp can give excellent nectar (see Table 16.16). Blending with other fruits like mango, citrus, pineapple, and guava could also be tried.

TABLE 16.16

Recommended apple juice blends

Fruit blend	Other fruit (percentage)	Apple juice (percentage)	Added sugar (percentage)	PH malic	Acidity (acid gm/100 ml)	Brix 17.5°C
Plum-apple	63	37	1.5	3.40	0.98	18.50
Cherry-apple	55	45	3.0	3.22	1.14	17.75
Apple-raspberry	25	75	2.0	3.32	0.72	16.50
Apple-strawberry	53	47	5.0	–	–	–
Apple-grape	50	50	None	–	–	–
Apple-cranberry	22.6	77.4	2.5	3.10	–	13.00
Apple-elderberry	22.6	79.7	3.3	–	–	–

Source: Luh B.S. Nectars, Pulpy Juices and Fruit Juice Blends in Fruit and Vegetable Juice Processing Technology, 2nd ed. D.K. Tressler and M.A. Josylyn. AVU Publishing Company, INC, West Port, Connecticut, 1971.

Stone Fruit Pulp

Peach, plum, and apricot are rated very high on account of their attractive colour and flavour. Because they are highly perishable and because of the rising overheads on packaging, transport, and marketing them, growers are slowly becoming disenchanted. For better realization from these crops it may be more appropriate to preserve them as pulp at their optimum ripeness in the field, with simple technology like heat treatment or the addition of chemical additives. The pulp can be stored in plastic carboys or steel drums with plastic lining and used at convenience to convert into juice, nectar, or jam. These containers can be used again and again.

Appropriate Processing Technology for Hill Fruits

Large proportions of undersized, hail-damaged, and misshapen fruits which otherwise go to waste or are left in the field can be profitably used. Similarly, vegetables which grow abundantly during the summer months can be preserved for the lean winter months. Canning, freezing, freeze-drying, and vacuum concentration based on expensive equipment and cost by packaging have only a limited use in the techno-economic conditions in India. Alternative preservation technology based on sun-drying, pickling, chemical preservation, and fermentation, which are already being applied to some extent in the countryside, needs to be upgraded and supported. Technology in commercial use includes sun-dry of wild pomegranate seeds into 'Anar Dana' in Himachal Pradesh and Jammu and Kashmir; drying of ginger rhizomes into dry ginger 'sunthi' in Arunachal Pradesh and Himachal Pradesh; drying of seedling varieties of mango into powder in Uttar Pradesh; preparation of wines and brandies from various fruits in some remote hilly areas; drying of wild apricots and the extraction of edible oil from their kernels in Kargil area of Jammu and Kashmir; and drying of *Morchella* mushroom (Guchhi) in Jammu and Kashmir. Upgrading the existing preservation techniques like the blanching of vegetables and sulphitation of fruits before drying can go a long way towards improving the quality of dried products and their shelf life. Further, the packing of dried products in plastic pouches for storage can help to improve their keeping quality. Some new areas in fruit processing which could be profitably exploited are:

(1) *Apple in cattle and poultry feeds*: Apple culls and windfalls can be cut into slices, dipped in sulphur dioxide solution or sulphur-fumigated, and sun-dried. Dried apple could be compressed into blocks of suitable size and finally coated outside with molten wax to prevent insect and microbial attack. During the winter months when cattle feed is scarce, these slices could be used as feed. The wax coating can be chipped off and used again and again.

(2) *Home preservation of fruit juices and pulps*: Fruit juices and pulp can be easily preserved in glass bottles with sulphur dioxide and the bottles tightly lidded.

(3) *Apple vinegar*: Vinegar making from apple has not yet been initiated. The setting up of home vinegar generators evolved at CFTRI, Mysore, could help to provide additional income to growers. Other fruits can also be used for this purpose.

(4) *Preservation of tomato concentrate*: Tomato as slices are sun-dried extensively on wooden planks or stones in the hilly areas for use in the off-season. Most of the juice from these tomatoes is dried away or absorbed by the wood. Tomatoes could be preserved by cutting them into slices, crushing these slices, and concentrating the mashed tomatoes three-fold on slow heat. A paste-like concentrate from tomatoes with seeds and skins can be preserved with acetic acid (vinegar), sulphur dioxide, and sodium benzoate in air-tight jars. The concentrate can be used during the off-season to add to vegetable curries.

(5) *Preservation of cabbage*: Cabbage shreds with the addition of 2.5 per cent salt and 0.5 per cent mustard powder are allowed to undergo lactic fermentation which helps to preserve them for the off-season. Other vegetables can also be preserved in glass or glazed jars in the same way.

The adoption of some of these simple, low cost, and practicable methods in the remote hill areas could go a long way towards the full use of hill produce and by making these fruit and vegetable products available in the lean season can upgrade the nutritional level of the rural population. These techniques can also take on industrial overtones and develop into a fruit processing industry in the rural areas.

In order to achieve this, extension efforts along with preservation kits (glass jars, plastic pouches, chemical preservatives) need to be made freely available at reasonable cost as has been done in the case of fertilizers, pesticides, and other agricultural inputs.

Marketing of Horticultural Produce

Existing practices and infrastructural facilities in handling, packaging, transport, storage, and processing of horticulture produce grown in the NWHR and NEHR have already been highlighted. These are closely related to their efficient marketing. A well-organized marketing system is absolutely essential to help the producer to get remunerative prices for his produce and the consumer quality material for his money. Fruits and vegetables in India are primarily consumed by the urban population, especially in the metropolitan cities Delhi, Bombay, Calcutta, Madras, Bangalore, and Hyderabad. In recent years, this trade has also spread into smaller townships.

Role of Delhi Market

The Delhi wholesale fruit and vegetable market is located at Azadpur and has a unique role, being a major distribution centre, the biggest in Asia and the second biggest in the world. The total annual arrival of fresh fruit in this market is around 1,377,225 tons and of vegetables 1,135,777 tons; the total value is around Rs. 800 crores. Potatoes and onions account for 63 per cent of the total vegetables sold in Delhi. Among fruits, apple constitutes 37 per cent of the total sales.

According to a review of horticulture in the NWHR conducted by the World Bank, Delhi is the biggest apple distribution market in the country, receiving about 70 per cent from Jammu and Kashmir, 60 per cent from Himachal Pradesh, and a part of the apple produce from Uttar Pradesh. About 85 per cent of the fruit delivered at Delhi is sold, then repacked and shipped to other parts of India. It reaches the retailer and the consumer after passing through several intermediaries.

Delhi has always played a dynamic role in apple marketing not only because of its proximity to apple-growing areas, but also on account of its enterprising apple merchants who maintain a close link with the industry and retain their hold on the market by way of financing through pre-harvest contractors, as also supplying inputs such as packaging material through them. Market functionaries involved in the trade are forwarding agents, commission agents, wholesalers, and retailers. The forwarding agent arranges the transportation of consignments from the producing areas to the terminal market mainly by road, prepares the forwarding note, and usually arranges for the payment of labour charges. All the expenses incurred along with forwarding commission charges are debited to the consignee from the gross sale proceeds of the commission agent in the terminal market. The commission agent then sells the produce to the wholesalers or sub-wholesalers who consign the fruits to other markets after regrading. Some commission agents also work as wholesalers.

Market Channels

Two types of marketing channels exist in apple marketing:

(1) Producer to forwarding agent to commission agent to wholesaler to retailer to consumer; and
(2) Producer to co-operative organization to forwarding agent to commission agent to wholesaler to retailer to consumer.

The usual market channels for fruit and vegetables are shown in Figure 16.3.

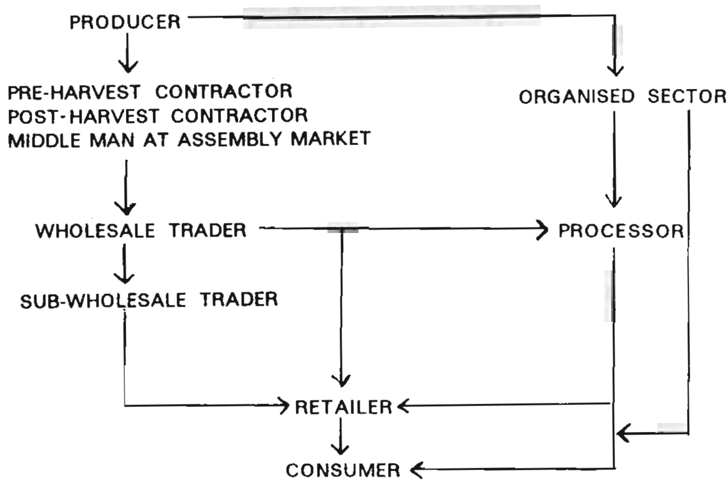
According to a Market Planning and Design Centre report (1987), the share of the producer in the two marketing channels amounted to 50 and 52 per cent respectively in Himachal Pradesh. Institutional channels in Jammu and Kashmir also bought 52 per cent from the producers as against 42 per cent through private channels. The packaging cost ranged from 7.3 to 9.4 per cent of the consumer price and transport charges ranged from 5.7 to 6.8 per cent in all cases. JK-HPMC charged lower commission at the rate of 4 per cent, as against 6 per cent charged by HPMC. Most of the existing sales of fruit and vegetables are regulated or being regulated to safeguard against the exploitation of producers.

Market Facilities

The marketing of fresh fruit and vegetables today faces a number of problems. The condition of the market, both wholesale and retail, is perhaps the most critical. The conditions under which markets operate and the facilities or services available in the markets are far from satisfactory, which is reflected the down-grading of produce. Most of the terminal markets are antiquated, improperly designed, and ill-equipped to handle the increasing load. Basic requirements for an up-to-date terminal market include:

- Appropriate location, well connected by road and rail.
- Appropriate design with wide platforms for auctions, loading and unloading, grading, packing of produce. These structures should be simple, functionally convenient, and cost-effective.
- Facilities for cold-storage.

Vegetable



Fruit

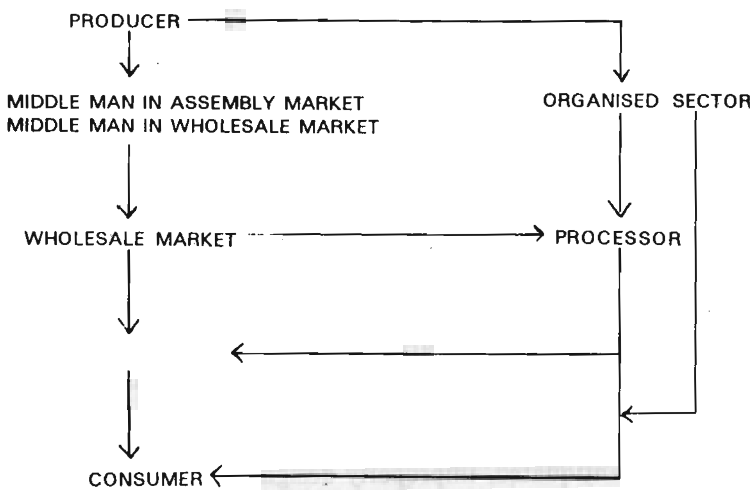


Figure 16.3: Marketing channels of fruits and vegetables at Delhi

- Amenities such as public conveniences, adequate water and power supply.
- Facilities such as banks, telecommunication system, canteen, dormitory, and rest rooms.
- Wide roads for free movement of traffic.

- Strict sanitation control through quick garbage disposal, proper drainage, and trained sanitarians.
- Effective monitoring of entry and exits.
- Provision of extra space for expansion.
- Development of an effective market information service for growers, traders, and consumers.

To increase the producer's share in the consumer price, government has encouraged growers' co-operatives and agro-industrial corporations to participate in the marketing of perishables. Karnataka was the first state to interlink producers directly with the consumers through the Horticultural Producers' Co-operative Marketing and Processing Society, which at present operates 150 outlets in four cities. The National Dairy Development Board in Delhi organizes marketing of fruit and vegetables through over 170 booths with modern grading, packing and storage infrastructure. The 'FRESH' Cooperative Society at Hyderabad has also adopted a similar approach in Andhra Pradesh under a project assigned by the National Co-operative Development Corporation.

The National Horticultural Board has also recently initiated a National Project on Post-harvest Management of Horticultural Crops, under which 50 per cent financial assistance is offered as a subsidy to strengthen the entire post-harvest infrastructure.

Marketing Information

Market information service is essential not only for the formulation of a proper price policy and its successful implementation at macro-level, but also for farmers to improve their marketing performance. The timely dissemination of market information, especially on prices, would help policy makers, administrators, traders, and farmers to take appropriate decisions regarding choice of time, place, and amount for the sale of perishable commodities.

Besides the data on price trends, data on market arrivals and despatches should be collected. Any surplus depresses the price critically. There should be regular dissemination of such data through the mass media for the benefit of relevant agencies.

The National Horticulture Board is in the process of setting up a national grid of market information centres at 21 important fruit and vegetable terminal markets in the country. All the market centres are to be provided with a computerized telex, interlinked to Delhi, where a central computer is interfaced with the main computer at the headquarters of the Board at Gurgaon. The rates in all markets are to be compiled and disseminated the very same day.

Post-harvest Loss Control Measures

The marketing of fruits and vegetables from the Himalayan mountain region in India results in huge quantitative and qualitative loss amounting approximately to one-third of the total production. Losses of this magnitude represent significant food wastage and a considerable economic loss to the producers.

In recent years, great concern has been shown by both state and central governments, as well as other organizations in the trade, about these losses. Sophisticated techniques adopted in the developed world like mechanical harvesting, appropriate packaging, efficient and fast-moving transport, proper storage and marketing, all operated under a cool chain umbrella, have paid rich dividends to minimize losses in perishables and to improve their quality. This is of no relevance to Indian conditions, where the climate is mostly tropical and humid, and where there is no infrastructure for proper management. To augment the basic infrastructure, the IDA World Bank is embarking on an Integrated Horticulture Development Project in the NWHR with an investment of around Rs. 300 crores containing a foreign component of 13 per cent in this investment. This project when initiated will help both producers and consumers.

Loss Assessment and Its Reduction

Most of the post-harvest loss is due to mismanagement in the field (pest attack, mechanical injury, temperature fluctuations, and respiratory disorders). Secondary causes like inadequate packaging, transportation, storage, and marketing also add to the loss. Because post-harvest losses occur throughout the marketing process, it is worthwhile to learn the origin and level of this loss, which in turn, will indicate the scope and means to overcome it.

Loss assessment is a major goal in the reduction of losses. Because of the complex diversity of fresh produce and the lack of handling and marketing operations of the appropriate type, much more attention needs to be given to determine an acceptable method for loss assessment. The steps include:

- identifying the stages in the marketing process where important losses occur
- further probing at identified spots to make detailed assessments of the magnitude of the loss
- devising strategy to reduce these losses
- implementation of remedial measures
- training manpower to execute programmes
- creation of research and development facilities

All the measures mentioned above need the preparation of a comprehensive proposal at national level.

Efforts at National Level

Several steps have been taken to reduce post-harvest losses in fruit and vegetables in India. These include:

- Formation of a national Horticulture Board as an apex agency under the Ministry of Agriculture to provide the needed coordination and monitoring of production and marketing of horticultural crops. The Board also provides financial, technical, and organizational assistance to organizations connected with the horticulture industry.
- A research infrastructure has been created under an All India Coordinated Research Project on Post-harvest Technology of Horticultural Crops at more than one dozen ICAR institutes and agricultural universities.
- A collaborative INDO-USAID project on post-harvest technology of fruit and vegetables has been in operation since 1985 at four centres in the country. This project is meant to strengthen the existing facilities by way of staff and additional infrastructure such as works, equipment, and advanced training.
- The Y.S. Parmar University of Horticulture and Forestry has been set up in Himachal Pradesh for research and training in temperate horticultural crops.
- A National Centre on Temperate Fruits and Vegetables has been proposed under the auspices of ICAR in the next Plan.

Besides the above, several national institutes, the Central Food Technological Research Institute at Mysore, the Indian Agricultural Research Institute, New Delhi, the Indian Institute of Horticulture Research at Bangalore, the Indian Institute of Packaging at Bombay, the Market Planning and Design Centre at Nagpur under the Directorate of Marketing and Inspection, the Indian Council of Agricultural Research's National Centres on citrus, mango, potato, tuber crops, etc, agricultural universities, and several state directorates of horticulture, are assisting in developing appropriate technology to reduce post-harvest loss, besides generating trained manpower to handle this stupendous task. The Bureau of Indian Standards has proposed several national standards on individual fruits as well as their containers. Processed fruit and vegetables are also covered under central laws, the Fruit Products Order, and the Prevention of Food Adulteration Act.

The limitations, such as the remoteness of fruit-growing areas, poor connecting roads, inadequate containers, insufficient systems, and ill-equipped transport, storage, and marketing, have been outlined along with proposed remedial measures including improved handling and packaging practices, the use of an evaporative cooling system, and selection of appropriate varieties. Massive national efforts monetary and human resources are needed to increase the availability of fruit and vegetables, a valuable source of food, and to improve the present position of food shortages and malnutrition prevailing in the country.

Recommendations

The Indian Himalayan mountain region, west and east, offers great scope to diversify agriculture into horticulture in order to get an additional source of nutritious food supplies and to provide avenues of employment. For this purpose, an action plan has to be framed keeping the following guidelines in view:

- Surveying the area under individual horticultural crops and the actual potential for their extension.
- Screening existing plant material not only for quality, productivity, and disease resistance, but also for amenability to better packaging, transportation, storage, and marketing.
- Encouraging nuts and vegetable seed production in remote and inaccessible areas.
- Development of on-farm and refrigerated storage at production centres, assembly stations, and in the foothills to regulate supply.
- Making available appropriate packaging material like wooden boxes, rigid plastic containers, or CFB cartons at subsidized rates or in easy instalments.
- Development of a fleet of improvised trucks for cheap and efficient transport of perishables.
- Introduction of rigid grading of fruits so that only A and B grade fruits go into the market.
- Processing of fruit culls and undersized fruits into pulp at the production centres for subsequent use as fruit beverages and for fuller use of their by-products.
- Introduction of returnable steel and plastic containers for transport and the supply of fruit pulp to processing units in the plains.
- Subsidizing fruit and vegetable transport in the NEHR to make them more competitive with crops grown in the plains.
- Finding alternative outlets like defence establishments for the disposal of fresh and processed produce in these areas.
- Arranging a regular and reliable market information service.

- Arranging training programmes at different levels to acquaint farmers with scientific methods for grading, packaging, transport, and storage of perishable produce.
- Providing suitable outlets to farmers in the terminal markets for proper sale and better prices for their produce.

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17

Role of the Himachal Pradesh Horticulture Produce Marketing and Processing Corporation in the Development of Horticulture in Himachal Pradesh

R.S. Rana

Introduction

The state of Himachal Pradesh with a geographical area of 55,657 km^2 and a population of 4.28 million lies in the foothills of the Himalaya. It is situated in the extreme northwest of India and bordered by Jammu and Kashmir to the north, the Punjab to the west and southwest, Haryana to the South, Uttar Pradesh to the southeast, and Tibet to the east.

Himachal Pradesh was created from one of the 30 princely states in 1948 and, later in 1951, was enlarged by the merger of one more state, Bilaspur. The adjoining hills areas of the Punjab were also merged with Himachal Pradesh in 1966 during the bifurcation of the Punjab. At present, the state has 12 districts: Bilaspur, Chamba, Hamirpur, Kullu, Kangra, Mandi, Kinnaur, Solan, Sirmour, Shimla, Lahul and Spiti, and Una.

The state is by and large mountainous, the height of its hills increasing from south to north; the Shivaliks, the lower foothills, ascend from 610 to 1220 m above sea level. The inner ranges vary from 1220 to 3660 m and the northernmost Piranjal Range soars up to about 6710 m. Correspondingly, the state is endowed with diverse agroclimatic conditions. Broadly, the entire state can be divided into three different zones:

the outer Himalaya, the inner Himalaya, and the alpine zone. The average rainfall is 1600 mm per annum and the climate varies from cool to cold, depending on the season and elevation of the terrain.

The total population of the state was 4.28 million as per the 1981 census, out of which 90 per cent live in villages, depending on agriculture as their main source of livelihood. Out of the total geographical area of 55,675 km^2, only about 11 per cent is being cultivated. Among the farming community, small and marginal farmers dominate; more than 77 per cent of holdings are less than 2 hectares, accounting for only 34 per cent of the total cultivated areas. Agriculture, including horticulture, is the most important sector of the state economy as it contributes about 50 per cent of the state domestic product.

Himachal Pradesh, a vast complex of hills and valleys, not only nourishes agriculture, horticulture, forestry, and animal husbandry, but is also rich in mineral and other natural resources. The melting snows and glaciers feed the numerous rivers which sustain life in the Indian plains. There is a vast hydroelectric power potential which is gradually being exploited in a systematic and planned manner. It is paradoxical that in a region with such rich natural resources the people have remained in abject poverty for so long. With a view to improve the living standard of the people, various development programmes were initiated by the state government during post-Independence era, the main emphasis being laid on the development of horticulture in this area.

The Horticultural Sector of Himachal Pradesh

Rationale for Horticultural Development

Land is one of the most important natural resources in the hills and its rational use assumes the utmost significance for the economic upliftment of the rural masses. It is obvious that the land use pattern in hilly areas is bound to be different from that in the other parts of the country, because of the type of terrain and unique climatic conditions. The continuous cultivation of agricultural crops has been responsible for the deterioration of the land resource base over the years. Besides, increasing population pressures and the adverse topography have forced farmers to expand cultivation to steep slopes which are not inherently capable of sustained and intensive agricultural use without loss of soil productivity as a result of soil erosion. Apart from this, even from land physically fit for cultivation, the yields are lower than those obtained in the plains. The possibilities of expanding irrigation for agriculture in the hilly areas are also limited. The slopes and land aspect also limit the availability of sunlight to a great extent. Difficult access from farms to markets is yet another factor inhibiting the remunerative sale of crops other than high-value crops.

The only choice open to the hill farmers is to take advantage of climatic conditions by growing high-value crops. The wide range of altitude, temperature, and precipitation found in Himachal Pradesh in fact creates conditions for growing a large number of temperate and subtropical fruits such as apple, pear, peach, plum, almond, walnut, citrus fruit, mango, grape, guava, and litchi. The cultivation of these perennial horticultural crops enjoys certain advantages over other crops: it yields higher returns; it generates more employment opportunities; it conserves soil and reduces land degradation, besides avoiding silting of dams; it helps to maintain proper ecological balance; and it provides raw material for the development of fruit-based processing industries. Therefore, it is clear that the cultivation of perennial fruit crops in hilly areas can improve the income of the rural masses without disturbing the soil and destroying the ecology of the areas.

With this in mind, the state government formulated policies and programmes to induce farmers to take up horticulture on a commercial basis. Owing to the persistent efforts of the state government during the last three decades, horticulture has emerged as an important sector of the state economy, intimately linked to the economic uplift of the farming community.

The progress achieved on this front is evident from the fact that, whereas in the 1950s only about 800 hectares of land was devoted to fruit cultivation, this increased to 134,985 hectares in 1987 with an annual production potential of about 0.5 million tons.

Among the fruits, apples occupy the top position, claiming over 38 per cent of the area and 58 per cent of the total fruit production. Himachal Pradesh is now known as the 'apple state in India'. With a view to developing all the areas of the state simultaneously, efforts are also being made to induce farmers in the lower belts of the state to take up horticulture as an ongoing occupation to supplement their income. The results achieved so far reveal that there has been a rapid expansion of the area under sub-tropical fruit.

Trends in Apple Production and Prices

The phenomenal expansion of the apple industry in the state has been due to both an expansion of apple orchards and a rise in productivity, as is shown in Table 17.1.

AREA EXPANSION

At present, the total area under apples is recorded at 53,999 hectares, or about 10 per cent of the net cultivated area of the state. The area under

TABLE 17.1

Compound growth rates of area, production, productivity, and prices of apples

Period	Area	Production	Productivity	Prices
1961–1965	35.34	21.47	–8.62	1.37
1965–1968	15.78	32.22	16.27	2.60
1968–1973	8.06	5.19	– 18.28	0.08
1961–1974	15.20	21.40	2.30	0.90
1974–1978	4.95	18.12	11.55	0.25
1979–1985	3.60	8.10	0.80	11.50
1974–1985	4.10	9.60	4.50	7.30
1961–1985	8.10	10.00	3.10	3.50

Source: HPMC

apples increased at a compound growth rate of over 8 per cent per annum from 1961 to 1985. However, period-wise analysis indicated higher growth rates in the initial plan periods which subsequently declined. On average, about 2000 hectares of land was brought under apple cultivation each year from 1961 to 1985. The compound growth rate of the area declined to 4 per cent in 1974–1985, as against 15 per cent for the period 1961–1974. Apple cultivation in the state picked up momentum only in the post-Independence era.

PRODUCTION

Expansion of the area under apples was accompanied by an increase in production which registered a compound growth rate of over 10 per cent per annum against 8 per cent in the case of area. A glance at the production figures reveals that the production pattern has been erratic during the period under study. It further reveals that the extent of fluctuation in production was high before 1975, whereas, during the later period, fluctuations were contained to some extent. The lowest growth rate was observed from 1968 to 1973 and the highest from 1965 to 1968. This can be attributed mainly to the climatic conditions prevailing during those periods.

PRODUCTIVITY

Interestingly, in the initial years, the negative growth rate in productivity was perhaps due to the method adopted to estimate growth rates. These were obtained by dividing production by total area (bearing and non-bearing). Although this method has some inherent deficiencies, because of lack of data a suitable alternative could not be developed to estimate productivity more accurately. The productivity figures indicate an improvement of 2.3 per cent during the period 1961–1974 and 4.5 per cent during the period 1975–1986, as against negative figures in the early 1950s.

PRICES

The wholesale price of apples (Delhi market) increased at a compound growth rate of 3.5 per cent per annum. A sharp difference in the price behaviour for the periods 1961–74 and 1975–85 is rather interesting. The growth rate was very low, i.e. 0.90 per cent, particularly before 1974, but this improved to 7.30 per cent later, showing a very positive achievement in this period. The positive effect on prices in the post-1975 period is attributed to the implementation of an International Development Agency-aided Himachal Pradesh Processing and Marketing Project which helped to build up the necessary marketing infrastructure, on the one hand, and created desirable competition in the fruit market on the other, consequently completely avoiding price crashes in main markets, a recurring phenomenon observed in earlier years. Period-wise comparison indicates that the period 1979–1985 registered the highest compound growth rate of over 11 per cent in the price of apples. It is worthwhile to mention that this was the period during which most of the Horticultural Produce Marketing and Processing Corporation's activities and infrastructural facilities were placed on a commercial basis.

Conventional Marketing Arrangements

MAIN FEATURE OF THE SYSTEM

The apple crop is normally ready for picking in the second or third week of July, particularly in lower areas, and continues until October. August and September are the peak harvesting periods, when 60–80 per cent of the crop is despatched to various markets. The growers are required to make advance arrangements for procurement and packing material so that the fruit can be marketed immediately after picking, sorting, and packing. Generally, the fruit is picked by hand, placed in a basket (or Kilta) and brought to a common place for grading and packing. Conventionally, apples are classified into various homogeneous lots based on their size and quality. The quality specifications followed in the state are A, B, and C. The A grade should have over 50 per cent of the colour characteristics of the variety, should appear clean and bright, be free from blemishes, and be of typical shape. Fruit of B grade may have less than 50 per cent of the colour characteristics of the variety and may have a slightly abnormal shape also. C category fruits include those which are not fit for competitive marketing, for example, fruit with fresh injuries, spots, or an irregular shape. The A and B categories are again classified on the basis of size, such as super large, extra large, large, medium, small, extra small, and pittoo. Size grading is generally done by hand.

After grading, the fruits are wrapped in old newspaper and packed in wooden boxes. The size specification of wooden boxes varies; however, there are two types more commonly in use: the Shimla box and the Kullu dabba. The former can hold about 18 kg. The packed boxes are marked with specifications such as name and variety, size and quality, grade, and name of orchard. After packing, the produce is hauled to the nearest roadhead and despatched to the market. The produce is generally despatched through forwarding agents who operate in large numbers during the season. These forwarding agents make arrangements for transport to the markets and charge a fee for this service. Sometimes the forwarding agent also makes arrangements for the supply of packing material and labour for local transportation.

Although there are about eight identified channels used by growers to market their produce, the most popular is through a forwarding agency to a commission agent of wholesaler to the retailer in the market. This channel alone accounts for over 60 per cent of the total marketed produce. Delhi is the nearest traditional market for Himachal apples and earlier accounted for over 80 per cent of the total fruit sent from the state.

After the arrival of the fruit in the market, it is auctioned to determine the price for specific sizes and grades. The most common method of selling fruit in the Delhi market is the Hatha system. It is often classified as an auction but is more in the form of a closed tender. Buyers and sellers clasp their hands under a piece of cloth and the prices are determined by feeling each other's fingers. Other participants, including the owner of the lot, do not know the price offered or accepted.

After the sale is conducted, a sale memo is prepared by the commission agent indicating the price per box, gross sale, and expenditure incurred, inclusive of freight, commission, and other charges and the net amount is remitted to the growers.

Deficiencies of the Conventional Marketing System

With the big increase in apple production, marketing has developed in importance and complexity. The traditional marketing system could not keep pace with the problems that emerged as it had numerous deficiencies. The major deficiencies observed are discussed in the following paragraphs.

Grades and standards constitute an agreed market language which can greatly simplify the marketing process and reduce marketing costs. Product grades and standards also furnish an ethical basis for buying and selling. Without the development of such standards, the principal of caveat emptor would prevail along with confusion and unfairness. Although grades for apple have been developed conventionally, they have not been followed strictly in the actual grading of produce as this is performed manually on individual farms. This allowed for subjective classification of produce, leading to variations in quality even from box to box, let alone from orchard to orchard. Thus buyers had to inspect several boxes from each lot, a time-consuming process, besides providing scope for commission agents to manipulate and exploit the growers.

There were almost no cold storage facilities in the producing areas, and these are essential to pre-cool the fruit soon after picking to prolong shelf life, avoid gluts, and reduce pressure on transportation during the peak harvesting season. Cold storage also facilitates the sale of fruit in the off-season. Thus far, due to the absence of such facilities in the producing areas, growers have had no option but to sell their entire stock immediately after harvesting, often causing market gluts and frequent price crashes, thereby reducing their returns.

The absence of adequate processing facilities to use available cull fruit was another stumbling block in the conventional marketing system. The availability of fruit for processing was estimated at 15–20 per cent of the total production, and this used to go to waste in the absence of any alternative use or value. Some of this fruit used to be sent to the market, thereby adversely affecting the sale of the good fruits, causing a loss to farmers.

The apple harvesting season in Himachal Pradesh coincides with the rainy season. Roads in the producing areas were not built to all-weather standards and were subjected to wash-outs and frequent blockades. The terrain in the apple-growing areas is so steep that it necessitates porterage to the nearest roadhead. Lack of suitable link roads in the apple-producing areas inhibited the quick transportation of produce to markets, resulting in the spoilage of fruit during transit.

The apple marketing system was based on the monopoly of private traders, placing the fruit growers at the mercy of commission agents. The profiteering tendencies of these private traders deprived the growers of competitive prices. One of the peculiar and dominant features of the selling proces was the Hatha system mentioned earlier.

The higher marketing cost was another dominant feature of the conventional apple marketing system in Himachal Pradesh. Studies conducted by the Agro-Economic Research Centre, Himachal Pradesh University, revealed that the producer's share was as low as 50 per cent of the consumer's rupee. The main components of the marketing cost were the cost of packing material, labour, and freight and service charges paid to intermediaries.

Delhi was the major market for Himachal apples, receiving over 80 per cent of the state's total apple produce, and there was no horizontal expansion of markets. This sole dependence on one market was risky, as there were frequent manipulated gluts.

The marketing of perishables like apples poses yet another problem. After harvesting, these fruits remain alive, their rate of metabolism mainly depending on temperature, and they are likely to be damaged by heat or cold. Besides, these fruits are bulky and easily damaged by rough handling. Therefore, special attention and expertise is required in post-harvest management to ensure the delivery of quality fruit to the consumers. This special expertise has hitherto been lacking and not enough attention has been paid to the improvement of post-harvest handling.

Government Policies

GOVERNMENT INSTITUTIONS

The main responsibility for the development of horticulture rests with the state government. However, of late, in order to provide proper direction and financial assistance for various related programmes, a separate horitcultural division has recently been established in the Central Ministry of Agriculture. Earlier, no separate long-term strategies were formulated for fruit crops at the national level because, until recently, horticulture was only a part of the Crop Division of the Ministry of Agriculture and practically no attention was paid to its development. Recognizing the importance of horticulture at state and national level and in order to support this activity through long-term strategies, the Government of India recently set up a National Horticultural Board.

The state government recognized that fruit production should no longer be a minor adjunct of the daily activities of farmers, particularly where ideal location and climate offer vast potential for its expansion. Therefore, the essential components of fruit production have been built into the state's overall strategy of economic development.

PLANTING MATERIAL AND OTHER INPUTS

The state government policy, with regard to the establishment of nurseries for fruit tree seedlings, is to develop fruit plant multiplication facilities, in the public and private sector, backed by nursery certification regulations. The government has also adopted a unique growth centre approach by establishing a chain of progeny-cum-demonstration orchards and nurseries in all potential fruit-growing areas with the objectives of; stocking progeny trees of outstanding merit for the supply of budwood; multiplying pedigree and disease-free planting materials; and serving as a nucleus for the development of horticulture in this zone. With a view to inducing farmers to adopt horticulture as a vocation, a wide range of economic incentives in the form of institutional credit facilities and liberal subsidies for production inputs are now available from the government.

The state government is also extending help to fruit growers to control fruit diseases, a 50 per cent subsidy being made available for essential pesticides and plant protection equipment. Credit support facilities, both short-term and long-term, are easily available from commercial banks for the development and maintenance of fruit plantations under special schemes refinanced by the National Bank for Agriculture and Rural Development (NABARD).

Research and Extension

In order to ensure an effective delivery system and the implementation of horticultural programmes, the state government established a separate Directorate of Horticulture in 1970, charged exclusively with the responsibility to formulate and implement horticultural development plans. Research and development support to the fruit industry is provided by the universities in the state. Earlier, the state had only one agricultural university, but a new university concentrating mainly on horticulture and forestry has recently been set up.

Support Prices

With a view to ensure remunerative prices to fruit growers, the state government has introduced price stabilization measures by announcing support prices for various fruits grown in the state. It has been observed that the timely announcement of support prices avoids the otherwise recurring phenomenon of price crashes. Himachal Pradesh is the first state in India to fix support prices for horticultural produce. The fruits covered by this scheme are: apple, hill lemon, orange, kinnow, guava, and lime. The support prices announced particularly favour small orchardists as a special price is given to them. The implementation of the scheme has been assigned to the Horticultural Produce Marketing and Processing Corporation (HPMC) by the state government.

Packing Materials

Another important state policy is to replace the conventional timber-based wooden containers by corrugated fibre board (CFB) cartons to conserve its fast-depleting natural forest wealth. The state government proposes to switch over to the use of CFB cartons in a phased manner, and there would be a complete ban on the use of wood-based packing by 1990. In order to popularize the cartons, the state government has fixed the sale price of cartons lower than that of wooden boxes. These cartons are at present heavily subsidized by the government. Arrangements for their purchase and sale are assigned to HPMC. A state-owned company has been incorporated for the manufacture of the cartons which would likely to go into production in 1990.

The Himachal Pradesh Apple Processing and Marketing Project

With a view to bring about improvements in the existing marketing system and keeping pace with technological advances in the post-harvest handling of fruit, as introduced in the horticulturally advanced countries of the world, in the late 1960 the state government introduced the idea of an integrated marketing project financed by external sources.

PROJECT FORMULATION

The project was first proposed by the Department of Horticulture. However, a World Bank mission was later invited to study the prospects of modernizing the states apple trade. The mission concluded that the immediate need was to concentrate on improving the marketing system rather than on production. Project preparation was further assigned to experts from the FAO Co-operative Programme in 1972. The project prepared and by the FAO experts included the construction of link roads, packing houses, collection centres, cold storage, and transshipment centres, consulting services, technical assistance and training.

PROJECT COMPONENTS

The World Bank appraised the project in September 1972. It recommended additional items such as an apple processing plant and the construction of cable lines to and from more inaccessible orchards. Further improvements were incorporated in the project by the follow-up appraisal mission in 1973, and these included the establishment of a new state enterprise to administer the marketing and processing of apples. The final project consisted of the following components:

- 12 packing houses;
- three collection centres;
- a transshipment centre;
- four cold stores;
- a juice concentration plant;
- construction of 97 km of new roads and improvements;
- training and technical assistance; and
- project evaluation studies.

The project was broadly divided into two components: (1) commercial buildings, cold storage, an apple processing plant, and a transshipment centre and (2) non-commercial components such as the construction of roads, procurement of road maintenance equipment, and training and technical assistance. The earlier components were to be implemented by the newly set up state-owned HPMC, whereas the latter were to be taken up by the respective state departments. The total project cost was estimated at US $ 21.7 million (Rs. 325 million) with US $ 13 million as IDA credit to cover the entire foreign exchange and 35 per cent of local costs. Funds for the commercial components were channelled by the Government of India through NABARD and participating commercial banks to HPMC and, for non-commercial components, through the State Plans and the Department of Horticulture and the Public Works Department.

Project Benefits

The major financial and economic benefits anticipated from the project at the time of appraisal were: (1) surplus funds to be generated by HPMC; (2) incremental income to fruit growers using the HPMC marketing system; (3) incremental income on account of the sale of processed grade fruit which otherwise had no alternative use or value; and (4) incremental income to other farmers in the project area and road user benefits which were expected to be generated by the road development component. The economic rate of return of the project, at the time of appraisal, was estimated at 23 per cent, which was quite attractive. It was, therefore, considered desirable to take up the project for the overall welfare of fruit growers in the state.

Organizational Structure

The IDA agreement envisaged the formation of a marketing institution in the public sector to take up the implementation of the commercial components of the Himachal Pradesh Apple Processing and Marketing Project. Accordingly, HPMC was incorporated in 1974 under the Companies Act, 1956. It is governed by a panel of 14 directors, giving due representation to the fruit growers of the state by nominating them to the board. The managing director of the corporation is also one of the directors. In order to conduct day-to-day administration of the company's business, the Board has delegated power to the managing director.

With a view to initiate effective steps for the implementation of the project components, HPMC was equipped with qualified and competent manpower as per the recommendations of the World Bank. There are five functional divisions: Marketing, Finance, Research and Planning, Engineering, and Personnel and Company Affairs. Each division is looked after by a divisional head reporting to the managing director. The divisional heads are responsible for the efficient functioning of their divisions.

Physical Infrastructure

The HPMC set up the following facilities:

- six packing houses, each with a capacity to grade and pack 5000 tons of apple per season;
- four grading houses, each with a capacity to grade and pack 1500 tons of apple per season;
- five cold stores in the apple producing areas, each with a capacity to store 1000 tons of fruit;
- one apple processing plant with a capacity to process 18,000 tons of apples and 400 tons of peaches per season; and
- one transit warehouse.

Apart from the facilities created under the project, the HPMC operates various other units transferred to it by the state government at the time of its incorporation or developed subsequently. These include one apple processing unit with a capacity to process 2000 tons of apples per season, two cold stores in terminal markets, two transit warehouses located at a strategic locations, and two grading houses set up in the tribal areas. A network of sales offices has been developed, within the state as well as in the major markets of the country, to undertake the marketing of fresh and processed fruit products. With a view to making apple juice the common man's drink, over 400 juice vending machines have been installed at inter-state bus terminals, railway stations, airports, busy shopping complexes, and other important institutions. Chilled, reconstituted, ready-to-serve apple juice is available at these kiosks at a nominal price.

Activities and Functions

From 1974 to 1982, the HPMC devoted itself primarily to the development of essential infrastructure for the post-harvest handling of fruit. However, with the limited facilities available, some of the marketing activities were taken up right from the beginning. A brief description of each activity is given in the following paragraphs.

GRADING AND PACKING

With a view to introduce a system of centralized grading and packing, 12 packing sheds were set up. These packing sheds are equipped with mechanical graders. Rather primitive schemes have been introduced and at some places even facilities for washing and brushing have been provided. This system rids the fruit of possible fungus and chemical residues, besides improving its shine.

The HPMC extends the facilities for grading and packing to fruit growers on a fee basis. However, special concessions are admissible to those growers who patronize the marketing channels of HPMC. The packing shed staff visit the fruit growers well before the harvesting season to book their produce, and open plastic field boxes are delivered to the growers to bring their produce to the packing sheds. Each packing shed is also provided with a truck or tractor to facilitate the timely transportation of fruit from the orchards. The fruit so received is graded as per the grades and standards developed by the HPMC in consultation with the state Horticultural Department and the Government of India.

Grading and packing being a highly seasonal activity, steps have been taken to diversify the activities of the packing sheds. Now the packing sheds also undertake the procurement and sale of various inputs such as fertilizers, insecticides, pesticides, fungicides, and tools and implements and the sale of processed products. Another important activity is the popularization and sale of (CFB) cartons in place of the conventional timber-based boxes. The state government has now entrusted the HPMC with the procurement of fruit at support prices. The packing sheds play an important role in the procurement of fruit. Payment to fruit growers against the purchase of fruit or the sale of fruit through the HPMC network is also made from these centres.

Cold Stores

A cold storage facility close to the fruit production areas in an integral component in the post-harvest handling of fruit. Five cold stores have been established in the apple producing areas. Each cold store consists of four chambers of equal capacity, operated with ammonia refrigerant to maintain the desired level of temperature and humidity. These cold stores are also equipped with modern methods of handling fruit such as palletization and fork-lifts. The facility for the cold storage of fruit is extended to growers for a monthly fee. The HPMC also stores good quality fruit, sorted from fruit purchased at support prices.

Transit Warehouses

With a view to protect the fruit from sun and rain during transit, three transit warehouses have been set up at strategic locations from where the fruit is sent to various distant markets. These warehouses are scientifically constructed for unloading and reloading, and provide suitable shelter and storage to fruit arriving from the producing areas. A nominal fee is charged from the consignor which is realized after the sale of the fruits.

Sale of Fruits on a Consignment Basis

To ensure competitive prices, the HPMC has made arrangements for the sale of fruit in the major markets of the country by introducing healthy competition with private trade.

Fruit Processing

Another important activity is the manufacture of a wide range of processed fruit products. The HPMC has two modern and highly sophisticated fruit processing plants, the first of their kind in the country. The total crushing capacity of these plants is over 20,000 tons per annum. Earlier, there was no use of the processing grade apples other than to sell them at throw-away prices, to use them as cattle feed, or to destroy them as it was uneconomical to sell. With the development of processing facilities, sizeable quantities of these apples are being processed annually, ensuring remunerative prices to the fruit growers and converting them into value-added and nutritious products. Other fruits grown in the state are also processed. Apple juice concentrate is the major product manufactured at these plants, accounting for over 80 per cent of the total value of products manufactured. Other products are natural apple juice, mixed fruit jam, apple jam, canned potatoes, orange and lemon squashes, ginger appetizer, canned peaches, pears in syrup, canned mushrooms, fruit punch, ginger drink, fruit sauce, and pickles.

Sale of Processed Products

The sale of processed products is organized through sales offices of the HPMC located all over the country. The efforts of these branches have been further intensified by distributors and sub-distributors and retailers in various cities.

At present, the most important channel for the sale of apple juice concentrate is the HPMC's juice-vending machines, numbering over 400, where other fruit products manufactured by the HPMC are also available for sale. Through these vending machines, chilled reconstituted apple juice is made available. This system of dispensing the juice has enabled HPMC to transport apple juice concentrates in bulk barrels, thus avoiding excess expenditure.

CFB Cartons.

The HPMC has developed CFB cartons for the packing of apples and other fruits as a substitute for conventional wooden boxes. The procurement and sale of the cartons has also been assigned to HPMC by the state government. The complete switch-over to CFB cartons will help to save over 200,000 cubic metres of forest wealth annually.

PURCHASE AND MARKETING OF FRUIT AT GOVERNMENT SUPPORT PRICES

The HPMC is the organization appointed by the government for the purchase and marketing of various fruits at support prices. Prior to implementation of this scheme, the marketing of fruits was faced with the problem of frequent price crashes and government intervention was considered necessary to protect growers from price uncertainties. However, the timely announcement of support prices had a very positive effect on the market prices of fruits and has helped fruit growers to improve their returns and to solve the problems of marketing their produce.

Achievements to Date

PHYSICAL

The most notable achievement of the HPMC has been the experience gained in the post-harvest management of fruit. The performance details of HPMC's main activities, marketing, forwarding, grading and packing, cold storage, processing, and sale of processed products are given in Annex 2. The table reveals that there has been a gradual increase in HPMC's activities, reflecting overall growth. The activity-wise review indicates that the capacity utilization of grading and packing houses is abnormally low. Even after a lapse of five years only 300,000 boxes could be graded and packed against a rated capacity of 1,800,000 boxes. The reasons for the low capacity utilization are discussed under the heading Deficiencies Experienced and Lessons Learned below. Similarly, the achievements of cold storage facilities are low. However, the processing plants achieved over 70 per cent of their installed capacity.

FINANCIAL

The sales and income of the HPMC have shown significant improvement, particularly 1987–1989. The major source of its income is the sale proceeds of processed products, commission from forwarding and sale on a consignment basis, rentals from cold stores, grading and packing charges, and sale of packing material and other items such as fertilizers, fungicides, tools and implements. The income was expected to increase substantially after the completion of the project facilities, but this could not be achieved to the extent expected, mainly due to low capacity utilization, particularly in the initial years. During 1987–1990, a significant improvement was observed and the turnover rose to Rs. 94.2 million against a turnover of Rs. 28.1 million in previous years. This is likely to increase further as more and more fruit growers come into the fold of the marketing organization introduced by the HPMC.

The profit and loss position reveals that the HPMC has been incurring losses continuously right from the beginning, except for one year.

The total accumulated losses as of March 1987 were Rs. 106,800,000 against a paid-up capital of Rs. 35,800,000. As the losses have exceeded the equity and reserves, the net worth has been negative.

An analysis of accumulated losses revealed that depreciation and interest alone accounted for over 80 per cent of the total losses. The losses started increasing steeply from 1981/82 when the project facilities were put into operation, and the trend continued until 1983/84. Thereafter, a declining trend has been observed. The losses were reduced to Rs. 13,100,000 in 1986/87, against Rs. 24,300,000 annual loss in 1983/84. The operating losses (before depreciation and interest) also declined from Rs. 3,789,000 in 1982/83 to Rs. 1,500,000 in 1984/85. During 1985/86, the HPMC generated profits of Rs. 2,400,000 before depreciation and interest and, in 1986/87, the operating profits further increased to Rs. 7,700,000 indicating a continuous improvement in financial performance.

The financial position of the HPMC did not enable it to discharge the due debt-service liability which was to commence in 1985/86. The NABARD has appointed a task force to suggest ways to rehabilitate the HPMC so as to make it financially viable.

Benefits to Producers

Although the performance under this project was not very encouraging in the beginning, the outstanding results now being achieved will give this project a new impetus for trade and the development of horticulture, encompassing a successful approach in all the hilly areas. The HPMC has now become a leading industrial institution at the national level. It is known at national and international levels for the production of quality fruit products and for helping growers to organize the marketing of their produce in a scientific manner. The benefits accruing to fruit growers are briefly described in the following passages.

The immediate benefits to fruit growers have been in the form of remunerative prices ensured to their low grade fruit which otherwise had no use or value. The HPMC directly purchases fruit from the growers to meet the requirements of its processing plants. During 1989/90, it purchased sizeable quantities of various fruits at support prices from the growers.

The fruit purchased by the HPMC at support prices is properly sorted and graded and good quality fruit is cold-stored in open plastic field boxes. The balance, unsuitable for storage, is used by the fruit processing plants and excess quantities are diverted to various non-traditional markets. This avoids reduction prices in the traditional markets where over 80 per cent of the fruit is normally sold. Thus, fruit growers benefit not only from the sale of their horticultural produce to the HPMC, but also by the regulation of the flow of produce in an orderly manner resulting in the creation of favourable market situations.

The presence of HPMC in the terminal markets, providing improved services for the sale of farm produce, has not only provided an alternative to the unregulated marketing system, but has also helped to curb the profiteering tendencies of private traders, ensuring competitive prices to the growers. This is evident from the fact that the compound growth rate of the wholesale price of apples was 7.30 per cent per annum for the period 1974 to 1985 against 0.90 per cent per annum before the formation of HPMCs.

Another significant benefit accruing to fruit growers is the construction of roads in the project areas. This has increased commercial activities as well as saved time and transportation costs.

The introduction of CFB cartons as a substitute for traditional wooden boxes for the packaging of fruits is yet another significant contribution to the conservation of the fast depleting natural forest wealth of the state. Table 17.2 indicates the number of cartons used by growers and their percentage in the total export of apples from the state in all types of containers.

TABLE 17.2

Cartons supplied to growers and export of apples from Himachal Pradesh

	1986	1987
Total no. of boxes of apples exported (100,000)	158	105
Fruit exported in cartons	14.34	8.48
Percentage of cartons to total exports	9	8

Source: HPMC.

The complete switch-over to the use of CFB cartons for the packaging of fruits in a phased manner would save over 200,000 cubic metres of wood per annum. Besides the ecological improvement, fruit packed in cartons commands a premium in the market as bruising and quality deterioration is insignificant. The comparative analysis of prices for comparable varieties and grades is given in Table 17.3. The prices are based on the sales through HPMC in the Delhi market in 1986/87.

The HPMC has also been instrumental in introducing plastics to horticulture. Earlier, fruit was brought to grading and packing sheds in wooden field boxes which were cumbersome and unsafe. These have now been completely replaced by light weight, smooth, hygienic plastic field boxes. The HPMC has already introduced 50,000 plastic field boxes which are returnable, thus saving wood.

TABLE 17.3

Prices realized from sale of different categories of boxes of apples (Rs. per carton or box)

Month	Carton	Wooden box
July	112	109
August	75	68
September	46	42
October	50	48
Average	71	65

Another contribution to the reduction in the amount of wood used for packing has been the purchase of sizeable quantities of fruit at support prices and use of the same either for processing or for marketing in gunny bags or plastic field boxes. The HPMC procured over 25,000 tons of fruit in 1986 and 22,000 tons in 1987, equivalent to 1,375,000 and 1,210,000 standard boxes respectively. These figures clearly indicate that the HPMC has played an important role in minimizing the use of wood for the packaging of fruits. More importantly it has saved Rs. 46.5 million on account of the subsidy that would have been paid had this fruit been sold in cartons by the growers.

Another intangible benefit accruing to society is the improvement in calorie intake from nutritious juice at reasonable prices, manufactured from fruit which was unused in the absence of processing facilities in the state.

Unemployment is a serious problem in developing countries. This project has contributed immensely towards the generation of employment opportunities. There are about 415 personnel employed on a regular basis by the HPMC, generating 72,000 man-days annually for seasonal employment at fruit processing plants, grading and packing sheds, and transit warehouses. The expenditure on salaries and wages is about Rs. 9 million per annum.

The outstanding contribution made by the HPMC to the farming economy in the state has been recognized, at both national and international levels. It won the International Asia Award in 1983, 1984, and 1985, the International Food Award, the Udhyog Rattan Award in 1985, and the Marketing Man of the Year Award in 1988. The HPMC has also won the first prize for apple juice concentrate in the All India Apple Show organized by the Government of India in 1975 and 1981.

Deficiencies Experienced and Lessons Learned

In the beginning HPMC could not achieve the anticipated targets because of the volatile nature of the apple industry, dictated primarily by the climatic conditions and poor responses of growers towards alien technology. Apart from this, there have been certain inherent deficiencies in project preparation as well as project implementation. This being the first project of its kind both for IDA and India, it was obvious that certain deficiencies would exist.

PROJECT FORMULATION APPRAISAL

One of the major drawbacks at the time of project appraisal was the classification of grading and packing sheds, fruit processing plants, and cold storage as commercial components; consequently, the HPMC had to pay 12.5 per cent as cost of capital, and this proved detrimental to its financial status.

The capacity utilization assumed at the time of project appraisal, 85 and 100 per cent in the first and second year respectively, was unrealistic and over optimistic. It had not been taken into account that such a project requires a considerable gestation period for growers to become accustomed to alternative methods and innovations.

Centralized grading and packing similar to that adopted in Europe, the United States, Australia, and other horticulturally advanced countries is unsuitable for this hill state, where terrain, size of holdings, accessibility, and other conditions are altogether different. In developed countries, large orchards are situated close to the road and the collection of fruit is not a problem. However, under Indian conditions this is a great constraint. Unfortunately, neither were collection centres provided nor proper arrangements made for haulage of crops from orchards to packing sheds. Alternatively, there should have been a network of ropeways connecting the packing sheds from all sides. However, there being paucity of technology, know-how, and financial resources, this work was not attended to and consequently it has reflected adversely on the working of those packing sheds and cold stores established in the producing areas.

The project envisaged the installation of sizing machines (mechanical graders) only. Essential equipment for washing, brushing, and waxing were not provided for in the project. The installation of additional equipment could have encouraged more fruit growers to use mechanical grading and packing as these improve the presentation of the fruit and its quality so that it commands a premium in the market.

The project had no provision for a publicity campaign for apple juice concentrate, a non-traditional item for consumers in India. As a result, the demand for apple juice concentrate did not match the production, resulting in the carrying over of stocks.

TECHNICAL

Technical deficiencies have also been observed in various components of the project.

The installed capacities of grading and packing sheds are not feasible. This is evident from the fact that only two workers have access to the grading section for first quality apples and they are unable to pack these apples as quickly as they come from the graders. As a consequence, first grade apples have to be bulked thus suffering bruising and quality loss. The lay-out of existing facilities does not permit even the addition of a conveyor belt so that more packers could be put to work. Another factor affecting capacity is the frequent discontinuity of fruit for grading and packing. It was overlooked at the time of appraisal that a large number of growers would bring their produce in small lots and that the system would have to be discontinued after the grading of one lot so that it could be properly packed. Apart from this, the installed capacity is based on the assumption that the fruit will be available for a period of 60 days in a season, whereas, in practice, the fruit is not available for more than 30 to 40 days in a particular belt location, thus reducing the working period of the packing houses. It appears that these aspects were not critically examined at the time of project formulation or technical appraisal. These limitations reduced the financial viability of these units considerably. The per hour capacity of machines should have been of a much higher order.

The capacity of the fruit processing plant at Parwanu is based on 180 working days per year. This is not realistic as the fruit is available for a period of 90–120 days a season only. The storage of apples is not economically feasible, hence it is not possible to achieve the installed capacity. This disturbs the financial viability of the plant considerably. Had the capacity of machinery been of a higher order, the targets would have been achieved in a shorter period.

FINANCIAL

The highly unbalanced debt-equity ratio of the HPMC is one of the major reasons for its accumulated losses. It even achieved a debt-equity ratio of 73:27 against a recommended norm of 40:60 for agro-based projects. Had the HPMC maintained at least a 50:50 debt-equity ratio, losses could have been reduced by over Rs. 30 million and its viability would have improved.

Lack of working capital from the very beginning has, however, been another financial snag in operating at the desired level. Although the project envisaged a provision towards the working capital, the HPMC faced severe resource constraints on the completion of the project facilities. As a result, it had to depend heavily upon the commercial banks to meet its daily financial requirements. This situation forced the HPMC to pay Rs. 2,500,000–3,500,000 annually as interest to banks. This could have been saved had there been adequate provision or availability of working capital. The HPMC has so far paid Rs.1,300,000 to the banks as interest on working capital alone. The working capital required would have been even more than envisaged in the project had the HPMC resorted to outright purchase of fruit as per the project concept. Lack of resources, therefore, not only adversely affected capacity utilization, but also prevented realization of the project concept. Adequate working capital support has recently been extended by the state government under a rehabilitation package.

Managerial

The composition of the board of directors also needs to be examined closely as all important decisions are taken at board level. Since the state is the sole owner and shareholder of the HPMC, the board is predominantly made up of government officials. There is a near absence of professionally or commercially competent personnel on the board. As a consequence, the decision-making process lacks the basic element of profit-oriented business ethics.

Autonomy is another aspect which requires attention. The basic reason for public sector undertakings was to release them from the rigid rules and regulations prevalent in government and allow them enough initiative and autonomy. It has, however, been observed that all crucial decisions regarding employment, promotions, and transfer are taken at the government level.

The HPMC inherited a government style of working rather than one suited to the business environment. This is mainly attributed to the fact that at the time of inception most of the staff was taken on deputation from the government.

The HPMC could not introduce modern management concepts, such as management by objectives, performance appraisal, participative culture, career planning, reward, and succession planning, and promotions are based on seniority and merit.

Training

Training is an important input which contributes to the efficiency of the total productivity exercise. It has two important components: building up new skills and updating or upgrading existing skills. Since the HPMC introduced an alien technology, it was imperative to impart training to build up new skills to operate the plant and machinery efficiently. This aspect was given due importance in the project by providing training for senior and middle managers in the horticulturally advanced countries of the world where such facilities exist; but the most important aspect, which did not receive attention, was the on-the-job training of lower functionaries who primarily operate the plants. Similarly, there are no in-house arrangements for conducting training regularly to update and upgrade existing skills so as to meet the ever-growing techno-managerial requirements.

OTHER PROBLEMS

An inadequate number of field boxes inhibited the uninterrupted flow of fruit to the packing and grading sheds. This adversely affected the capacity utilization of these units. The procurement of field boxes should have been matched with installed capacity.

The high cost of setting up packing and grading sheds, cold stores, and processing plants makes them financially non-viable. The cost of a packing house with cold storage facilities is as high as Rs. 6,000,000 and these are almost entirely financed by a commercial bank loan.

Conclusions and Recommendations

Regardless of the various drawbacks observed, projects of this type are desirable for state profitability and should not be neglected. The concept of integrated marketing, introduced nearly one and half decades ago in Himachal Pradesh, has proved successful in augmenting the income of thousands of small and marginal fruit growers through the scientific and profitable disposal of their horticultural produce. This has sustained the entire fruit industry in the state on a viable basis. Realizing their benefits, such projects should be replicated elsewhere with suitable modifications in the light of experience gained from this project. Some of the major points which should be considered when formulating an integrated market project are given below.

One important experience gained from this project concerns the response of fruit growers to new technology. It was found that their response was very slow. It took five to eight years to motivate growers to adopt the new system, which, in this case, was responsible for upsetting the entire commercial character of the organization. The situation deteriorated to the extent that the organization developed symptoms of sickness. In order to avoid such situations, it is recommended that these institutions should be classified as horticultural development corporations, with the primary responsibility of developing suitable infrastructural facilities and operating them until they become commercially viable. If such an enterprise is to be classified as commercial, the well-established financial norms of debt-equity ratio should be strictly followed besides providing adequate financial support for working capital. If these norms are not followed projects are bound to fail.

Selection of technology is of vital importance and local conditions should be studied in detail for the successful introduction of technology. From the experience gained so far, it is apparent that a large, centralized system of grading and packing does not suit the terrain or conditions in the state. It is, therefore, recommended that medium-sized packing sheds at village or panchayat level are more appropriate for the hilly regions.

When formulating such projects, each packing shed should be provided with an adequate number of collection centres, so that the desired quantity of fruit can be regulated and procured by the packing sheds for grading and packing.

Packing sheds should not be equipped only with mechanical graders, but should have a complete system with chemical washing, brushing, waxing, and packing installed so that growers can enjoy all the benefits of increased value.

To operate packing sheds along commercial lines, the investment cost should be kept as low as possible. It has been observed that in hilly areas the cost of civil works is high, thereby making the entire system uneconomical. Therefore, steps should be taken to minimize the cost of civil works by constructing sheds rather than concrete buildings.

The activities of packing sheds should not be confined only to packing and grading fruit; efforts should also be made to develop backward linkages by taking up the sale of fertilizers, fungicides, pesticides, insecticides, power sprayers, and other orchard management equipment. This will help to develop a close liaison with the fruit growers and improve the financial position.

The concept of setting up cold storage facilities nearer to the fruit producing areas needs rethinking for places where the majority of fruit growers are small and marginal and cannot afford to store their produce. Therefore, a system of making advance payments against stored boxes is imperative for the success of cold storage. Apart from this, the construction of cold storage is highly capital intensive. In addition, the factors of seasonal work and low capacity utilization in the initial periods together inhibit the functioning of cold storage facilities on commercial lines. The viability, however, can be improved if the organization undertakes the outright purchase of good quality fruit, storing the same in bulk-bins and undertaking the packing and grading in the off-season. The introduction of this concept would require adequate finances for the purchase of sizeable quantities of fruit. This would help to make full use of available cold storage facilities as well as of the benefits of off-season sales.

The construction of small air-cooled stores at farm or village level may also be considered, as these are economical.

Cold stores in the producing areas will be of little importance unless refrigerated vans are provided to transport the fruit to terminal markets. It has been observed that the transportation of apples in ordinary trucks causes fruit deterioration, because of high temperatures in the months from March to June in the plains. Therefore, the provision of refrigerated vans is imperative for the success of cold storage in the producing areas.

The cold storage of processing grade apples to prolong the processing season is not economically feasible. Therefore, while designing processing plants, the per hour capacity should be more relevant so as to undertake the entire processing of fruits within the season.

A detailed market potential survey should be undertaken as well as the designing of suitable marketing strategies at the project preparation stage. This assumes assigning more importance to items that are non-traditional in nature and appropriate marketing strategies need to be designed to educate the masses regarding the nutritional value of fruit-based processed products. Necessary financial support to undertake publicity and other promotional campaigns should invariably form part of the project cost.

Such institutions should be equipped with a full-fledged technical division with a multidisciplinary team of experts in quality control, plant protection, post-harvest management, and other fields to impart necessary training to fruit growers as well as to the various functionaries of the HPMC.

Annex 1

Area and production of apples and other fruits in Himachal Pradesh

Year	Area (ha)			Production (metric tons)		
	Apples	Other fruits	Total	Apples	Other fruits	Total
1950/51	400	392	792	—	—	1,200
1955/56	1,023	1,007	2,030	—	—	—
1960/61	3,250	2,979	6,229	12,000	6,710	18,710
1965/66	12,711	9,647	22,358	24,000	12,910	36,910
1966/67	15,146	11,114	26,260	28,900	16,470	45,370
1967/68	17,588	12,717	30,305	39,344	23,852	63,196
1968/69	20,230	14,347	34,577	50,524	30,557	81,081
1969/70	23,482	15,968	39,450	72,250	37,319	109,569
1970/71	26,735	17,594	44,329	103,120	45,460	148,580
1971/72	28,308	19,261	47,569	125,060	53,270	178,330
1972/73	31,003	20,452	51,455	29,800	50,020	52,020
1973/74	32,127	23,412	55,539	118,676	67,510	186,186
1974/75	33,628	25,895	59,523	43,299	33,140	76,439
1975/76	35,076	28,309	63,385	200,000	45,882	245,882
1976/77	3,734	32,016	68,750	121,896	15,331	137,227
1977/78	38,925	35,979	74,909	131,617	18,936	150,553
1978/79	40,655	39,688	80,343	121,896	15,331	137,227
1979/80	41,947	43,986	85,933	135,475	24,586	160,061
1980/81	43,356	49,111	92,467	118,013	21,815	139,828
1981/82	45,360	54,724	100,084	306,798	35,145	341,943
1982/83	47,379	61,322	108,701	139,086	38,768	177,854
1983/84	48,292	65,759	114,051	257,913	46,362	304,275
1984/85	49,840	70,740	120,580	170,629	45,291	215,920
1985/86	51,103	77,667	128,770	17,461	33,124	207,742
1986/87	—	—	134,985	359,321	41,187	400,508

Source: HPMC

Annex 2

Physical performance, 1983/84 to 1987/88

Activities	Units	1983/84	1984/85	1985/86	1986/87	1987/88 (targets)
Sale of fresh fruit on consignment basis						
No. of boxes	(No., lakh)	1.76	1.54	1.17	3.41	3.70
Gross billing made	(Rs., lakh)	—	78.61	64.83	202.39	245.50
Commission earned	(Rs., lakh)	3.84	4.14	4.64	8.96	10.78
Forwarding of boxes						
No. of boxes	(No., lakh)	10.92	6.92	8.62	17.45	14.50
Gross turnover	(Rs., lakh)	—	—	68.56	156.14	125.05
Commission earned	(Rs., lakh)	4.02	3.05	3.56	7.02	8.30
Boxes graded/packed	(No., lakh)	1.01	1.95	1.67	2.93	5.90
Boxes cold stored	(No., lakh)	0.35	0.19	0.53	0.94	1.25
Cold storage revenue from terminal markets	(Rs., lakh)	38.58	43.74	62.63	66.16	65.00
Outright sale of fresh fruit and vegetables	(Rs., lakh)	—	—	—	48.84	65.00
Processing of fruit						
Apples	(Tons)	5007	1034	8307	13.391	12.00
Other fruits	(Tons)	75	121	1181	754	800
Sale of processed products	(Rs., lakh)	122.22	152.81	137.37	180.12	428
Gross turnover	(Rs., lakh)	355.11	526.90	372.73	942.93	

A lakh is 100,000.

Source: HPMC.

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Marketing Development and High Value Hill Agriculture: Some Observations on the Experience in the Bagmati Zone, Nepal

Mahesh Banskota

Introduction

The term 'marketing' assumes the integration of many different activities. It suggests that smooth linkages exist between producers, processors, and consumers. With the development of marketing there should also be a greater degree of mutual support between agriculture, industry, and services. It is important to examine linkages between different areas, especially in the context of agricultural marketing. Successful marketing development is, therefore, an important reflection of the process of economic transformation itself but as long as subsistence production prevails, none of these linkages between sectors and areas manifests itself.

Marketing development is also important from the point of view of entrepreneurial activity, as it involves producing for other consumers, an assessment of demand, prices and the allocation of resources among different economic opportunities. There is an important element of risk as prices are largely influenced by non-local factors. Consequently, this aspect of entrepreneurial development is very critical in any process away from subsistence agriculture.

From the point of view of mountain development, marketing development and entrepreneurial innovations have been very important for horticultural development in Himachal Pradesh, India, and to tourism development in Nepal.

While the government of Nepal has played an important supportive role through investments in infrastructure and the implementation of suitable economic policies, it has been primarily private sector entrepreneurs who have taken the leading role in the development of these sectors. In the context of horticultural development in Nepal, some of the experiences, both within and outside Nepal, should be more carefully evaluated. Tourism, as compared to horticulture, appears to be more capital intensive, urban-based, and dependent on high technology and has limited domestic multipliers. On the other hand, high value agriculture such as horticulture, being more rural-based, has relatively greater employment and income potential for rural areas but also favours those who own land. Issues like these must be very systematically evaluated in order to understand why some activities are sustainable in some areas while others are not.

This paper is divided into two parts. The first part discusses the general problems and potentials in marketing development in hill agriculture, where without market integration subsistence hill agriculture is unlikely to be very productive. It also discusses potential areas based upon comparative advantages where market integration could play a positive role. The second part of the paper discusses the experience of the Bagmati zone in Nepal in general terms.

Market Integration of Hill Agriculture

In order to use scarce land resources more efficiently so as to provide gainful employment and increased incomes to the labour force in the hills, development of market-oriented multiple cropping systems presents a major potential. Potentials for improvement in productivity of traditional subsistence hill agriculture are becoming increasingly difficult. Without access to economically superior cropping systems using improved technology and high-pay-off inputs, subsistence farming in the hills will generate even greater problems of poverty and environmental pressures in future. A poor hill farmer is less capable of properly managing the hill environment.

Market-oriented multiple cropping systems have played a major role in the transformation of small-holder, family-based agriculture in many countries of southeast Asia. And more recently this has been evidenced in hill areas such as Himachal Pradesh in India. Disadvantages of extremely small land holdings, comparable to those of the hills of Nepal, have been offset by the development of very high cropping intensity, which has successfully absorbed the rural labour force. Increased flow into the market of many non-cereal agricultural products has sustained the development of a diverse range of agro-processing industries, and has made it economically viable to expand services and physical infrastructure deep into the rural areas. The major precondition has been the existence of a technically sound research and extension system that is able and willing to work closely with the farmers to help them increase their productivity. The fact that large groups of small farmers were able to organize themselves and work together was closely related with the existence of a fairly equitable landholding distribution. Unlike in many countries where the agriculture sector has either lagged behind the industrial sector or where only large-holder agriculture has expanded, transformation of small-holder agriculture has provided a very sound basis for sustained all-round development (Oshima, 1983).

Multiple cropping systems that are very well suited to conditions with high labour-land ratios, as in the middle hills, cannot develop without availability of improved crops varieties and related cultural practices. Farmers will not give up their subsistence crops completely. Under special conditions of the monsoon climate, many areas in the hills have no alternative to rice and maize cultivation in the summer. In many cases, hill farmers may also take a second crop of cereals. However, there are periods when land is fallow, or when land is being used for non-high-value crops. In some cases, it may even be possible to convince hill farmers that high value crops would perform better than the crops currently being raised by the farmer, even under conditions of existing resource endowments. Alternatively, it may also be feasible to profitably exploit tree crops with other seasonal crops as is being increasingly practised in many hill areas in China and India.

Another important aspect of multiple cropping is the assumption that there is a demand for higher-value crops raised by the farmer. It assumes the existence of a market. As additional varieties of crops and increasing quantities of products are added to the supply, the market becomes the most powerful factor for inducing changes in the farming systems.

Similarly, multiple cropping development cannot succeed without: (1) strong agricultural institutions to guarantee fair returns from the efforts and risks undertaken by the farmer; (2) responsiveness through appropriate research and education institutions by developing new products, technology, and productivity; and (3) encouragement of strong local farmer responsibility that increasingly undertakes management of inputs and primary marketing activities (Huang, 1975:64–76). The last point is particularly important as agricultural development programmes cannot be designed on the needs of the individual farmer. The need to develop specialized crop production or, more appropriately, specialized systems of multiple cropping based upon demand, local factor endowments, and available technology, requires that we seek to develop the potentials in larger areas. The individual farmer still operates as the owner and manager of his farm, but he does so under a planned system with institutions and organizations to assist him in his production, input supply, marketing, and other activities. Thus, while individual family farms are still the basic operating units, they are organized to change or engage in various planned farming activities on a group basis over a larger area.

Multiple Cropping and Marketing Orientation in the Hills

Having made out a case for market-oriented multiple cropping systems, it is useful to examine this issue more carefully in the current context of hill agriculture. It becomes immediately apparent that there is already a very high degree of multiple cropping in the hills, and that some marketing of agricultural products already exists (Calkins, 1976; Jones and Innes, 1981).

Multiple cropping in the hills is generally more common in upland fields than in lowlands because the soil moisture and other conditions seem to be more favourable (Calkins, 1976). Over time, with increases in population pressure, cropping intensity of hill agriculture has increased (Schroder, 1985). These increases in cropping intensity are accompanied by decreasing labour productivity, contributing less to both subsistence needs and net incomes. It has been argued that in many cases, reducing the number of crops with focus on only some that have good yield and marketing potentials would increase farmer incomes quite substantially (Calkins, 1976). These changes towards greater specialization on selected crops could be undertaken without affecting the cultivation of major cereal grains in appropriate seasons.

Regarding market orientation of hill agriculture, the sale of agricultural products is one major source of cash income for the hill farmer. Obviously, sale of agricultural products alone is insufficient to meet all the cash needs of the household and needs to be supplemented with off-farm work. (Banskota, 1986). The balance between subsistence and sale of crops is, therefore, a very critical decision for the hill farmer as it affects the choices of crops and use of limited resources. At present, market sales are mainly from surplus of larger farms located in lowlands, using high-yielding seeds and irrigation. Sale of livestock products has declined, as a higher priority has been given to subsistence crops due to increasing population pressure. There has also been a marked decline in the sale of forest products with extensive deforestation across the hills.

Ecozone Specialization

One alternative to predominantly subsistence farming in the hills is part or full specialization of agriculture production. As opposed to the current 'inward looking' strategy of the hill farmer, ecozone specialization calls for some degree of 'outward orientation'. Underlying such a strategy are a number of important assumptions. First, there are potentials for meaningful specialization in hill farming activities. If there were none, the current pattern of resource allocation by hill farmers would clearly be the most optimal. Second, there are economic advantages to specialization through economically superior systems in the use of scarce resources in the hills. Third, specialization automatically assumes trading and marketing beyond those already being undertaken by hill farmers. In other words, it also assumes both potential local and non-local demand for specialized agricultural products produced by the hill farmers.

At the regional level (in terms of the plains and hills) the idea of specialization in agriculture has been well known for a long time. It started in Nepal's Fourth Plan, when the concept of regional development based on a regional focus on specific types of agricultural activities was expounded. It was argued that the plains should focus on cereal crops, while the hills should develop livestock and horticultural activities. (Gurung, 1970:1–17). Efforts to implement this strategy did not go very far, however, as it failed to develop the understanding or the plans and activities that were necessary for regional development. It remained a good idea without the support of adequate research and careful planning necessary for implementing such an approach. It was bound to face many problems as it meant many changes for hill farmers and related development institutions. For the hill farmers, it meant a switch from subsistence to greater dependence on trade and the outside environment, and development of more effective farmer cooperation to implement carefully designed production plans for which hill farmers had no resources, relevant knowledge, or strong institutional support. For development institutions, it meant facing up to obstacles inherent in such shifts in policies and programmes. For national planning, it meant a greater degree of close-to-ground, barefoot thinking necessary for translating a good idea into meaningful practice, which was a far cry from harmless exercises of manipulating capital output ratios. Such radical changes in development planning are seldom self-generating or self-inspired. They often require careful national direction and extensive resources. This is where Nepal's regional development strategy has floundered.

Furthermore, this approach also overlooked a number of critical stages in regional development. First, it did not start from the farm to work its way upward, integrating homogeneous units by cropping zones, resources, settlement clusters, market accessibility, similar investment packages, and support services required. Second, in a predominantly subsistence economy, trade and marketing developments in the initial stages are better stimulated in smaller spatial units than in the larger regional context. Farmers are more comfortable trading with people they know and in markets more familiar to them. Later on, as development expands to higher levels and more experience is gained in market-oriented production, regional trade becomes more feasible. Another important constraint with the development of inter-regional trade has been the cost of transportation.

If it is somewhat premature to expect promotion of inter-regional trade within the current levels of development in the hills, how should specialization in hill agriculture proceed? Our attention naturally turns to the environmental diversity of the hills and the extent to which this could be a basis for agricultural specialization. To some extent this is already evident in hill farming. Crops raised in lowland valley areas differ from upland fields. Similarly, as one moves northwards, crops change to some extent. Focus on specialization in the hills should have three major thrusts. The first, is to increase productivity of existing crops that are best suited to the local environment, for example, paddy in lowlands where irrigation is feasible. In view of the monsoon conditions, very few crops perform as well as paddy in low-lying fields. Second, there is substantial scope for off-season production. Third, high-value tree crop specialization potentials are greater in the hills and thus likely to be highly desirable from environmental considerations.

Ecozone specialization has meant to simply identify horticulture and livestock in the hills and cereal grains in the plains. This approach has not worked because of the lack of carefully designed plans for specific agroclimatic zones starting with what the hill farmer is already doing, and focusing on providing high-pay-off inputs and services to the most beneficial combinations of crops, within the existing cropping system. At present, for example, one finds little qualitative difference in the agricultural development plans for the various hill districts and sub-regions even for an area like the Bagmati zone where there are better institutions. Some crops out-yield others over a wide range of soil, microclimate, and factor combinations. Identification of these crops, including the demonstration of their benefits, is the surest way to convince hill farmers of progressive specialization in hill agriculture.

The extent of current research work on the economic and environmental aspects of ecozones is very limited. Based upon changes observed in different parts of the hills further agronomic, economic, and environmental analysis is required for specific directions that ecozone specialization in the hills may follow.

PRODUCTS MOST APPROPRIATE TO DIFFERENT ALTITUDINAL BELTS

It is by now well established that crop performance varies with different altitudinal belts. Hill farmers themselves have evolved a wide choice of crops through experience over the years. There is need for research, in terms of which of these are likely to have greatest comparative advantage in local conditions and after the development of market potentials. Some examples from Nuwakot will help to clarify the argument (Calkins, 1976). For the tropical zone farm located at 2500 ft, or less, net income through specialization increased in each cropping season. In lowland fields during winter, farmers raised as many as four crops. But it was found to be more advantageous to concentrate on potato. Similarly, in upland fields during the winter it was found more profitable to increase area of ginger cultivation from the 2 per cent allocated by the farmer to almost 85 per cent of the area. Similar examples can be identified for farms in different altitudes. There are also some crops that out-yield others over a wide range of soil, microclimate, and factor ratios, such as potato and rapeseed. Unless research to identify and analyse these influencing factors is undertaken, it will be difficult to recommend improvements to systems being used by the farmer.

Focus on Seed Production

Many types of seeds produced in higher elevations perform relatively better in lowland conditions. In some areas, farmers have already started seed production of potatoes and other vegetables. The scope for expanding seed production is very large indeed. If proper quality control can be maintained, market potentials are very large.

Off-season Products

The harvest periods of similar agricultural products vary under different altitudinal conditions. For instance, if vegetables like cauliflower, chilli, and sweet pepper are harvested during January and February in the terai, they can be harvested in the hills from November onwards, while in still higher altitudes they can be harvested from July onwards. Proper planning of crops in different altitudes in the hills can ensure a steady flow of products to the urban and terai markets especially when there is no production in the terai. This aspect of agricultural production in the hills holds a major potential for development. The only major precondition is proper transport and handling of these products as they need to be transported over long distances in order to exploit off-season advantages.

Development of Livestock Products

Despite many potentials, current livestock conditions in the hills are shocking. As one of the most seriously mismanaged sectors of the agricultural system, it is characterized by shortages of feed, heavy parasitic infestation in a generally very inferior breed, and low livestock productivity (LRMP, 1986:5–6). Furthermore, its effect upon the environment is a very serious issue. 'While ruminants are a key link in the vital chain connecting cultivation of crops and forestry, they are also the weakest links. Virtually all of the environmental degradation so common is directly attributable to the management of the livestock sector' (LRMP 1986:14).

The potential for livestock development lies in improving the productivity of livestock. Demand for livestock products is very strong even in the hills. Fresh milk is always in short supply though there are well-known techniques for processing milk into ghee and cheese. For hill farmers with little land, productive livestock can be a major source of income. If managed properly it can even exceed contributions from the land. It is a sector of immense potential that has been grossly neglected so far.

Trade and Marketing Development

There are a number of possibilities for developments in trade and marketing in the hills. With specialization, intra-hill trade is likely to develop a strong interdependence between different ecozones in the hills. Following specialization based on comparative advantages, each farmer group is likely to be better off through trading than with prevailing subsistence production. Rural demand structure for agricultural products is also not uniform in the hills. It varies by income groups as much as in other areas. The demand structure between upper and lower income groups varies. This difference in demand structure has been identified as a source of promoting rural growth linkages for other areas and there are no reasons to believe that this would not be applicable in the hills (Mellor, 1983).

The second and more exciting possibility lies in the development of rural-urban trade and marketing linkages. With increasing pace of urbanization across the hills, urban centres represent an important potential for increased momentum of hill development. The traditional isolation of rural hill areas is rapidly breaking down with the development of infrastructure, urbanization, and other socioeconomic changes. Rural areas are quickly being swept into the vortex of urban influence. If this is not properly managed and directed, the hill economy will not be in a position to take advantage of the opportunities afforded by urban development in the hills.

Experience with mountain area development generally suggests that the potential contribution of urban areas has not been fully exploited. Rural-urban developmental linkages in the hills have been relatively weak. If these rural hinterlands could be made more responsive to the opportunities created by a growing and diversified urban demand structure for agricultural products, the impact upon rural income and employment would be substantial.

The comparative advantage of rural hill areas in horticulture, livestock, and vegetable products clearly suggests major possibilities for gains from specialization and exchange to rural hill households. An agrarian economy, isolated from trade, is inhibited by the lack of market opportunities to diversify production and expand income and employment opportunities. Once trading opportunities are developed, and rural areas begin responding favourably to urban demand, there are other important production and consumption linkages that will emerge in the urban economy as well. The process of agrarian specialization based upon strong urban linkages is likely to lead to improved productivity of hill agriculture, through adoption of improved technology and increased rural consumption of intermediate raw materials and capital goods supplied by urban areas. Thus the reduction of market barriers and expansion of trading opportunities between rural and urban areas provides a major opportunity for transformation of the hill economy. An appropriate investment package should be designed to help rural hill economies respond to these increased opportunities for trade and exchange. Incentives and support systems are necessary to encourage rural hill households to reallocate their resources to meet a growing and diversified urban demand for various agricultural products. In the past a good deal of emphasis has been laid on increasing rural food production per se, without any attention to urban demand structure, marketing, and enhancement of trading opportunities. Without major improvements in these areas, emphasis on food supply alone is unlikely to generate sustained improvements in rural incomes, as the comparative advantage of many hill areas might lie in the production of non-grain crops.

Market areas in the hills are limited in number, far apart, poorly organized, and relatively undeveloped in scope and types of marketing functions. In many instances, inaccessibility has limited the development of markets, but in many other cases improved access has not resulted in any significant improvement. Markets, on account of transport improvements, have undoubtedly grown, but have not really developed. Transport is just one among a whole host of factors that have hindered the development of these markets. Other factors include lack of marketing knowledge, weak research and extension institutions, and total absence of promotional activities.

This issue of marketing development is emerging as a very significant factor in the transformation of rural hill economies. Rural development activities that have carefully developed and organized a marketing approach as a critical component have made some significant economic impacts upon rural households. In others, where marketing has not been given attention, even innovative farmers have been unable to dispose of their produce or 'receive' fair prices for a variety of reasons to do with pre- and post-harvest operations.

The lack of a market-oriented approach in the hills has clearly demonstrated the persistence of many anomalies. Hill demand for many commodities is being met through imports when they could very well be supplied from the hills. Many hill products fetch significantly low prices due to their inability to compete with similar products entering the market from the plains. Because of the lack of regular markets and reliable marketing, hill farmers find it too risky to switch to more lucrative high-value crops, and continue with subsistence farming. In many hill markets producers try to maintain direct contact with the consumers, increasing the cost of marketing. This is prevalent even in areas with good access because of lack of market intermediaries.

On the other hand, the potentials of marketing in hill development can be seen in terms of: stimulating market oriented higher-value cash crop production; generating higher levels of cash incomes for hill farmers; generating more off-farm employment in post-harvest and marketing activities; more effective use of costly transport and energy infrastructure in the hills in areas where these are available; and, in the long run, the development of more environmentally and economically sound land-use practices.

Organization and Management Aspects

The task of organizing thousands of small hill farmers to participate in the development of specialized production systems is not easy by any account. Many good programmes and policies have been wrecked because inadequate attention has been paid to organization and management. After all these years of poor plans and programmes, it is now necessary to examine the appropriateness of the existing organizational and management set-up. With strong institutions, even weak programmes are likely to become stronger, though the same does not hold true in the reverse situation. The experience of countries like Nepal is increasingly beginning to suggest that the biggest weakness in development has been the lack of organizations and institutions capable of bringing desired changes on a sustained basis. Complex developmental programmes are casually dumped upon organizations that expand programmes and area coverage without efforts to consolidate existing activities. Many organizations have become so susceptible to outside pressures and influence that there is constant 'fine-tuning' of programmes. No good is ever likely to come out of such organizations. Development is to a large extent the process of creating opportunities for the emergence of more productive forces. As we learn more about the process of development, readiness to organize necessary changes, particularly through sustained improvements in organization and management, become a critical condition for the success of development programmes. Thus, one important aspect of development is a process of creative destruction of institutional arrangements, organizational structures, and management systems. The extent to which subsistence hill farming can make a reasonable transition towards greater market integration depends on the effectiveness of organization and management and the demands made are neither simple nor limited.

Establishment of Specialized Production Ecozones

Establishment of specialized production ecozones in different altitudinal belts is the first major task. The objective behind it is to enlarge the scale of farm operation of specialized agricultural production activities so that management can be organized on an area basis. It is far too complex to deal with diverse activities of the individual farmers. In fact, the continuation of a diversified pattern of family subsistence farming in the hills is a response to the lack of effective organizations for integrating and managing hill farming on a larger area basis. Operation on a larger area basis provides many advantages. It is easier to improve basic production facilities and provide commercial-scale handling and marketing, and cost of services to the farmers can be substantially lowered. While individual family farms are still retained as the basic units, they now operate on a planned basis under different systems of price guarantee, supply of improved packages, and contract growing and marketing. The most appropriate mix of incentives and support services will vary from area to area and crop to crop. Some of the advantages of group activities have already been well established under the SFDP in Nepal, particularly risk sharing, access to credit, and dealing with outside organizations. All of these advantages need to be fully exploited under specialized production zones. The big question is who will manage them?

Decisions on what should be produced will require a careful evaluation of alternative land uses in the hills. Specialization cannot ignore the limitation of environmental sustainability. Areas of comparative advantage have to be meticulously identified. A beginning towards specialized production zones is already evident in Nepal through identification of special crop areas for tea, cardamom, apples, and other products. In areas where such potentials have been identified, they need to be developed intensively, while for other areas, such opportunities for specialization have to be carefully identified.

Development of Infrastructure

Physical infrastructures like roads, electrical supply and provision of water are very limited in the hills and are in the rudimentary stages of development. Slow development of infrastructure has, in part, been due to high costs of providing and maintaining these facilities. Assumptions underlying these high cost investments that they would quickly transform the areas brought under infrastructural development have not been validated. Consequently, there have recently been strong economic reservations expressed about further high cost infrastructural investments in the hills, while large parts are still lacking in any type of modern infrastructure.

One basic premise regarding infrastructures like road and power supply is that they only become economic when they are used for productive purposes. Under major constraints such as subsistence agriculture, it is difficult to use infrastructure productively. High costs are not the only implications but also the lack of profitable alternatives. It is therefore very important that use of infrastructure be carefully planned and integrated with other productive activities. Infrastructure investments alone are insufficient to generate their productive use. While they offer many opportunities, their development requires additional investments, appropriate technology, availability of support services, and marketing outlets.

The development of specialized production zones cannot take place without basic infrastructure. Movement of goods and services in and out of these zones will require reliable and relatively cheap transport services. Availability of power will help reduce the burden of human drudgery and enhance labour productivity. It is clearly inappropriate to attempt development of specialized production areas without the basic infrastructure. There are many important choices of technology and phasing possibilities that need to be examined, within the specific possibilities of each specialized production zone.

Research, Education and Extension

Research and educational institutions have played a major role in agricultural development whenever they have been properly organized and managed. The successful propagation of high-yielding seeds in paddy, wheat, and maize has been possible mainly because of effective research and education programmes. However, much of this development has occurred outside national systems in places such as IIRI and CIMMYT. In spite of the high pay-off from such research and education programmes, countries like Nepal have failed to develop a strong domestic research capability (Yadav, 1987). This sharply contrasts with agricultural developments in countries like Japan, Taiwan, and South Korea where, because of the strong support provided for agricultural research in a wide variety of fields, agricultural development has been largely internally induced and has provided valuable surplus resources for development of non-agriculture in the initial stages of development. Agricultural research institutions in these countries have enjoyed strong support from the government for a considerably long time (Oshima, 1983). They cover many activities from research and experimentation to establishment of research centres, experimental stations, improvement stations, multiplication centres, breeding stations, and very specialized farms. Many improved varieties and new agriculture production techniques have been developed by these institutions. Closely related to these organizations are vocational schools in almost every major district or county. These schools have played a very important role in training a large number of agricultural workers and technicians and have become an effective mechanism for agricultural development because of the quality of research work and linkages. The conditions in countries like Nepal are quite the reverse, with undue concentration of resources, technicians, and organization at the top. Basic facilities for research work are lacking in most field stations. In a bureaucratic system, resources are often used for purposes other than activities benefitting the farmer. The entire agricultural development system needs to be reorganized to respond to the needs of the farmer.

The development of sustainable hill agriculture that balances economic and environmental factors will not progress without strong research institutions capable of dealing with specific problems, for instance, developing seed varieties that are not damaged by hail.

It will be almost impossible to improve hill agricultural productivity without the support of strong research institutions. This means major investments in manpower to provide adequate research facilities and reasonable motivation for individuals to undertake research activities in hill agriculture. Extension services are equally critical as vital links between the hill farmer and researcher. While various alternative models exist for organizing hill agricultural research and extension based on the concept of specialized production ecozones, the fact that prevailing systems have not been effective underscores the need for a thorough evaluation of the prevailing research and extension system in the hills.

Market Functions and Pricing

Development of marketing is particularly critical as specialization progress. In many cases weak marketing activities have resulted in serious consequences to farmers. Marketing must include the identification of suitable products and pass on this information to research and extension. Alternatively, it must also identify suitable markets for different products. It should support the development of processing, storage, transport, and packaging and provide farmers with some reasonable estimates of prices, and advise the agencies concerned on appropriate pricing policies.

Given the increasing competition in generally perishable agricultural products, the role of marketing activities cannot be underestimated. Many products will lose their off-season advantages if they fail to reach the market on time. The problem of finding ready markets cannot be left to the hill farmer.

ORGANIZING THE FARMERS

Without effective local change agents to implement programmes, new technologies or development programmes are unlikely to have far-reaching impact. Experience all over the world has clearly shown that strong grassroots organizations are vital for the sustainability of development programmes. Financially induced changes invariably wither away, unless supported and managed by strong grassroots institutions. Thus, in the specific domain of agricultural programmes, deliberate promotion of a strong local organizational base is as important as financial resources and improved technology. Unfortunately, this has been overlooked for a long time at great cost to otherwise good agricultural development programmes.

An example of effective management at the grassroots level is the farmers' association in Taiwan, which has had a very good track record, (Huang, 1975). It has existed in almost every community, providing various services needed by farmers such as credit, marketing, and extension services. Credit has been the heart of the association as it both mobilizes deposits and disburses credit. If therefore must compete with local banks for deposit mobilization and that farmers are members of the association has been very important too. This alone would have been insufficient if it had not at same the time provided good returns on the farmers' deposits. Capital needed by the farmers has come mainly from this source. To support its banking functions, the association has organized effective extension systems so that farmers can take advantage of the latest technology. It has encouraged joint cultivation in order to take advantage of economies of scale in mechanized farm operation, bulk marketing, and setting up of agro-processing units. It has been argued that the success of this organization lies mainly in its organization structure and particularly its links with the farmers. Most of the management staff are farmers themselves. The government has also tried to help the association with necessary organizational, technical, and even financial assistance. A well-organized and responsive agriculture research system providing improved technology and farming practices was also very essential for the farmer's association to succeed in developing effective support services and organizing the farmers.

Many other examples can be cited where the formation of effective local organization with strong support from the government has provided opportunities for unprecedented changes in rural areas. There are successful cases of dairy development, afforestation programmes, cash crop development, and even agro-processing, organized on a group basis by farmers. Working together in groups has been a major factor in overcoming many constraints related to capital shortages, marketing, quality of extension work, etc. The critical element in the development of specialized production ecozones in the hills is the extent to which hill farmers can be organized and mobilized to work jointly in improved production systems and management of limited hill resources.

Experience of the Bagmati Zone

The Bagmati zone in Nepal comprises eight districts and the greater Kathmandu valley region, with the largest urban area in the country (see Figure 18.1). Over the years a good deal of development investment has been made in this zone in road construction, establishment of agricultural support services, and other development investments, but the transformation from subsistence agriculture has been relatively slow and many anomalies continue to persist. There is an increasing urban demand for fruit and vegetables and much of this is met through imports while opportunities for local production remain untapped. The prices of many hill products are very low because they compete directly with those from the terai. The obvious problem here is the absence of off-season advantage in what is being produced. The bulk of agricultural marketing in the zone is still directly carried out by individual farmers and is not organized so as to improve the bargaining capacity of farmers or enhance marketing investments. The hill farmer faces the problem of how much of his land and other resources should be allocated to market-oriented production, because he has no guarantees of long-term purchases or off-farm employment opportunities. Many of the smaller farmers still find the production of commercial crops far too risky and continue to produce paddy or maize.

In spite of all these problems at the farmer's level the opportunities are large. The production of a large variety of easily marketable crops would provide good returns to farmers. It is also quite obvious that some cash crops perform relatively well across different altitudes and emphasis on these would encourage marketing development.

Some changes are, however, evident along the major transport corridors which clearly indicate that inaccessibility and choice of products (especially produced for markets) are critical (Figures 18.2 and 18.3).

Sub-regional Specialization and Development of Marketing

The construction of an extensive network of roads in this zone has led to the emergence of a number of sub-regions that are showing signs of agricultural specialization and market integration (Figure 18.3). Not only are various parts of the hinterland responding favourably, the greater Kathmandu valley (GKV) region is also indicating some positive changes in response to the development activities in the hinterland. There are signs of increasing economic integration although very little of this has been deliberately planned or, for that matter, even been recognized as a

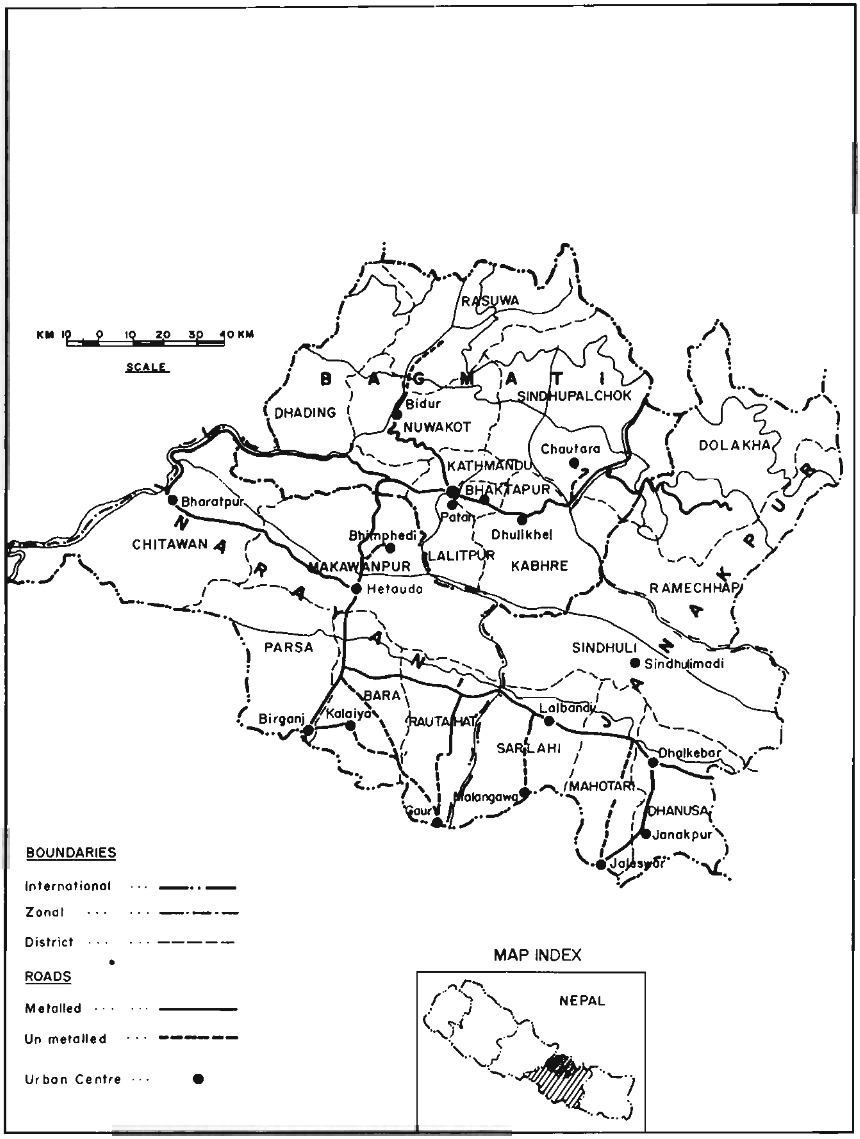

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Figure 18.1: Nuwakot district and Bagmati zone in the central development region

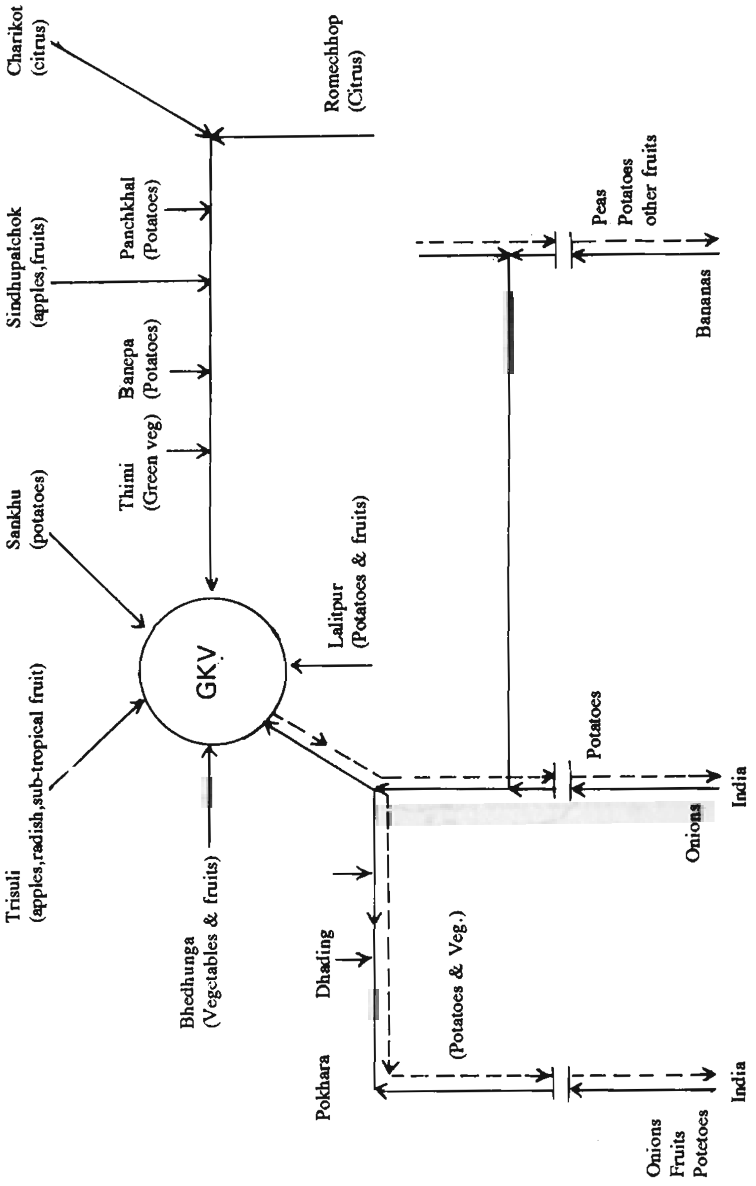

Figure 18.2: Exports and imports of horticultural products

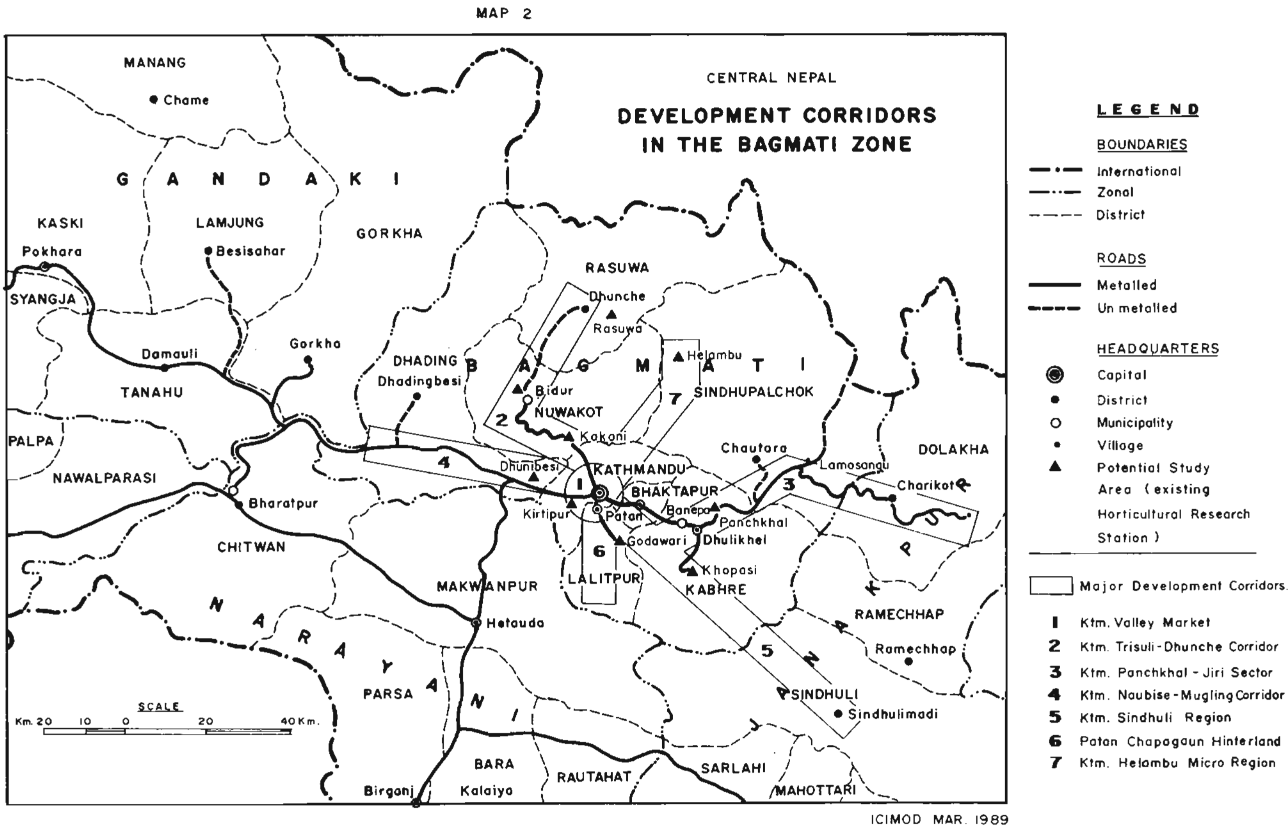

Figure 18.3: Major development corridors in the Bagmati zone

major regional force. Many programmes are still haphazardly scattered across different districts. Different agencies are engaged in a wide range of district-level programmes that neither support the forces of market integration and specialization nor exploit economies of scale.

The first sub-region is the valley area itself, where major changes can be seen in the agricultural activities. Farmers in the valley are realizing lucrative returns from vegetables production. Wherever irrigation is available, more land is being brought under vegetable cultivation. In Kathmandu vegetable cultivation covers as much as 65 per cent of the agricultural area. It is somewhat lower in Lalitpur and Bhaktapur, but nevertheless increasing.

To the east of the GKV region lies the Kathmandu-Dhulikhel sub-region extending to Chautara, Jiri, Dolakha, and southern Kavre. Major exports of the GKV region are paddy, potatoes, livestock, and some horticultural products. More recently, opportunities for agricultural trade with Lhasa in the north have expanded considerably in Panchkal valley and a number of other areas are beginning to export agricultural products. Development in specialization and trade are, however, not to the extent that would be possible on the basis of existing factor endowments and environmental conditions. The case of potatoes illustrates difficulties associated with changes. Potatoes, which have higher per hectare net income, higher return to labour, and higher return to capital cost, are found to be an extremely attractive crop, but only a small per cent of the potential area has been allocated to potatoes. Potato is a market crop rather than a subsistence crop in this area. It has not been an important part of the staple diet of the population. It must be sent to Kathmandu as it is difficult to store and cannot all be consumed locally. If marketed immediately, it fetches good off-season prices. The greater the delay, the lower the price, as supplies from other areas start arriving. Farmers complain of major transport, storage, and price problems. Although there are no local marketing organizations, some efforts are being made to form farmer groups for marketing (Pachico, 1980).

To the southwest lies the Kathmandu-Mugling corridor with large parts of Dhading district serving as the hinterland of the GKV. Recently, some major changes have been seen in agricultural specialization with focus on vegetable crops in selected areas. Commercialization of agriculture decreases markedly as one moves further away from the region. Farmer awarness of improved agricultural practices has increased considerably, but agricultural production for the market has been restricted among larger farmers.

To the north west of the GKV lies the Kathmandu-Trishuli corridor, with the two districts of Nuwakot and Rasuwa. This region also exports paddy and horticultural and livestock products to Kathmandu valley. Some efforts have been made to promote apple farming in Rasuwa district, though progress has not been encouraging. Lack of transport has been the major complaint so far, but this situation should change with the opening of the new road link to the north.

Although changes are being seen here and there, the major regions of the GKV hinterland are largely similar with a predominantly subsistence focus. Though changes are discernible in some areas in response to specific opportunities, these changes are at most sporadic and location-specific. Furthermore, they do not form part of a larger organized strategy for regional agricultural development

Demand for Agricultural Products

Demand conditions exercise a significant influence upon specialization and trade in agriculture. Obviously, supply conditions are also important, but without favourable demand, farmers are not easily motivated to produce for the market. In the context of the GKV region, demand for specialized agricultural products comes from a number of sources. First is the urban household sector. With increases in incomes, households with higher incomes consume greater amounts of products such as milk, meat and eggs, vegetables, and fruits. The Nepal Rastra Bank Household Survey indicates that consumption of these products has more than doubled over the past 10 years. Changes in income levels also show significant differences in expenditure for the these products, with the upper income groups spending thrice as much (NRB, 1987).

Another important element of demand for various types of agricultural products has come from tourist demand. With rapid growth in tourism, expenditures in agricultural products are likely to grow quite rapidly. There has been a growing import substitution in these products, but supply is still very erratic, product choices are limited, and quality control is lacking. Figure 18.2 shows the extensive import and export linkages of the GKV region.

Demand is also likely to come from other sources if careful off-season supply planning is organized. Many areas in southern Nepal and in India are important markets for off-season products. Prices for vegetables and fruits have been rising very rapidly in recent times. This is a good indicator that price conditions are very favourable for inducing positive supply responses. While data are sketchy, the indication is clearly towards very favourable demand conditions for specialized agricultural products, particularly vegetables, meat, and fruits.

Changes in Fruit and Vegetable Marketing in Urban Kathmandu

During the past 10 years, there have been major changes in the organization of fruit and vegetable marketing in urban Kathmandu. The most notable changes have been the emergence of Kalimati as the major wholesale fruit and vegetable centre in the valley, superseding other traditional centres of Asson, Ranamukteshwor, and Indrachowk.

The Kalimati wholesale market has 40 to 50 wholesalers, with agents operating on commission basis in different parts of Nepal and India. Connections extend as far as Delhi and Assam. These wholesalers organize direct shipment of seasonal fruits from different parts of India and Nepal with minimum transshipment costs. Discussions with different wholesalers revealed a fairly competitive situation. Another important characteristic of this wholesale market has been the integration with mobile retailers. Every morning, one can see hordes of retailers either on their bicycles or on foot, collecting fruits and vegetables for retail distribution in the valley.

Interestingly, the development of organized marketing started mainly with fruits and is still dominated by fruits. However, it has also attracted other groups to organize wholesale and retail purchase and sale of tomatoes, potatoes, cabbages, and other vegetables. There are groups dealing with vegetables for Bhaktapur, Dhading, and a number of other areas.

In spite of these developments, there are many serious problems with the ad hoc manner in which marketing has developed. First, farmers outside the valley face major transport problems. The limited number of vehicles causes a heavy rush. In Dhading, for example, farmers have complained of having to load their products by three in the morning so as to reach the market on time in the morning. Another problem related with transportation is the difficulty of access into the valley after six in the morning. There are some restrictions on the entry of heavy vehicles in the morning. There are also problems of unloading because of the lack of suitable places. Lack of proper marketing sheds, absence of control over weights and measures, very poor sorting and grading of produce, and lack of skilled labour to load and unload delicate fruits and vegetables are all major problems in the organization and development of fruit and vegetable marketing. It is also important to point out that farmers' preferences in the choice of convenient market points vary largely. For instance, farmers from Nuwakot and Panchkhal find it very inconvenient to have to go to Kalimati or other locations that require moving through the city with their produce. It is, therefore, important that separate marketing outlets be located to suit the conveniences of farmers from different areas.

Without stronger farmer marketing organizations, the development of the present marketing system will not operate to the advantage of the farmer. So long as farmers have to sell to urban wholesalers, they will always be price takers and not price setters. At present, large numbers of farmers still deal with the market on an individual basis, which is unlikely to improve their bargaining capacity. Also, it severely limits the level of investment that have to be made for reducing distress sales of farm produce.

Thus, while important developments are under way, there is still a long way to go. Many improvements in marketing are critical for major thrusts in agricultural specialization and trading in the Bagmati zone. To date, public investment in marketing development in the GKV region has been minimal and the bulk of the investments have come from the private sector. In the future, it is important for the public sector to make marketing investments and carefully coordinate them with specific, area-wise plans for agriculture development.

From the point of view of both farmers and marketing development, a number of general conclusions can be made.

Demand Conditions

Demand conditions are likely to become more and more favourable for high value agricultural products like fruits, vegetables, and livestock products. Apart from possibilities for import substitution, there is also some scope for export promotion to the Lhasa market and off-season markets in the terai towns and neighbouring parts of India and, in terms of high quality seed production, even exports to more distant markets. Capturing these markets will not be an easy job especially on account of high competition and costs. Careful planning and effective organization support are necessary for integration of different operations from producing to marketing of various crops.

Production Conditions

From the farmer's side, a number of problems in production conditions are evident. First, knowledge of markets for various products, their prices, and necessary marketing arrangements are lacking. Second, farmers face problems of sales and reasonable prices in cases where they are already producing for a market. There is strong reluctance to commit land to these crops as there are no long-term guarantees of purchases. Third, post-harvest losses are very high. Farmer-level processing to preserve product quality is virtually non-existent. Some simple processing steps could enhance product quality and shelf life of products.

Marketing Organization and Support Services

Marketing organization and support services are clearly the weakest link and the most difficult constraint in the process of agricultural specialization in the Bagmati zone. At the present, quality control and central marketing facilities are very poor. There is a complete lack of specialized marketing boards or commodity trading houses or even effective marketing cooperatives. Among line agencies, there is lack of clarity as to who should be doing what. It is fairly clear from the experience of many countries that without demonstration of effective institutional co-ordination and support, farmers will be reluctant to change.

The Development of an Agro-processing Industry

In the early stages of economic development, the role of an agro-processing industry is very obvious. In a predominantly agricultural country, this is the only type of industry that will be economically feasible for a long time. Agro-processing industries have very strong forward linkages with the agricultural sector and in many countries it has been those industries and entrepreneurs willing to undertake such activities that have brought about long-lasting changes in traditional agriculture.

FRUIT PROCESSING

Some of the major characteristics of the fruit processing sector are:

- A wide variety of fruits are being grown and the harvest period indicate that raw material could be available throughout the year.
- Because the raw materials are dispersed among three climatic regions, combining them would be very difficult because of inaccessibility and perishability of produce.
- There is no plantation-scale production of fruits yet.
- Of 11 fruit processing units, 8 are cottage scale, in the eastern terai two processing units exist in collaboration with Indian and Bhutan parent companies. Tomato production is estimated to be in excess of demand.
- In the high hills apple production is increasing, but because of transport problems it is being processed into alcoholic beverages. As electricity becomes available, prospects for dehydration and production of concentrated apple juice should be explored.
- Total fruit production at the end of the Sixth Plan (1980–1985) stood at an estimated figure of 343,204 mt and was expected to reach 461,743 mt by 1990.
- There is already sufficient processing capacity for the production of squash, juice, jelly, jams, and slices.

NUT PROCESSING

Walnuts and chestnuts are being promoted. Hazel, almond, brazil, pistachio, pecan, macadamia, betel, and other nuts also have potential. Cashew is not doing well. Nuts have excellent prospects. As tree crops, they are important from the point of view of afforestation in hill areas. They can provide useful timber and fuelwood. Nuts are not easily perishable and also have a high value-to-weight ratio. Markets are not a problem.

VEGETABLE PROCESSING

Vegetables are mostly traded in their fresh state and there is good year-round supply. The major market is Kathmandu. At present, per caput consumption is still very low. Production is very price-responsive with frequent mid-season gluts and low prices. Some off-season imports from India also exist and are a reflection of poor storage development and a lack of coordination in planting times and areas of production. This problem exists for potatoes; Nepal exports potatoes to India, but re-imports almost 10 times the amount.

There is excellent potential for marketing vegetables both within the country and outside. Constraints to this development have been a lack of knowledge of export markets, poorly developed air links, lack of facilities for temporary storage, grading, and packing, and the low entrepreneurial level in food processing.

The system of marketing and storage of vegetables is poorly developed in Nepal. Cold storage space is sold on a contract basis and the producer is responsible for his own quality and grading. Vegetables are not stored at present. Economies of scale are important in the freezing industry and these need to be vertically integrated with contract growers producing the right varieties.

HERB PROCESSING

A wide range of herbs for medicinal and aromatic purposes is available in Nepal. At present, ginger and cardamom are grown on a large scale.

Institutional Aspects

There are at least 13 different agencies at the national level that exercise some influence on the food processing sector (Table 18.1). There is thus considerable duplication and lack of coordination which can easily frustrate the efforts of the private sector to undertake new business activities.

At the district level, the institutional set-up is equally weak. Private sector marketing is active in cereals, but is relatively weak in other crops. The public sector institutions are also stronger in cereal-related support activities. There is a strong locational rigidity on the part of these institutions and the farmer has to move from one agency to another. The research and extension aspects are singularly unable to solve problems in the field and are devoted entirely to propagating stereotyped

TABLE 18.1

Institutional influence on agro-processing

Institutions	*Functions*
Finance	Takes, foreign investments, eights
Industry	Licensing, location, quality
Agriculture	Raw materials, food research, storage
Water	Electricity, water
Transport	Infrastructure
Panchayat and Local Development	Local raw material
Forest and Soil Conservation	Forests, watershed management
Commerce	Export promotion
Supplies	Import of raw materials
Education and Culture	Manpower
Labour and Social Welfare	Labour laws
National Planning	Statistics, planning
Land Reform	Land acquisition

programmes. There is continuing evidence of a major supply constraint with regard to agricultural credit.

It is becoming more and more obvious that the appropriateness of the institutional model that has been developed is very questionable. The fact that this framework has been implemented to promote cereal grains does not make it relevant to more commercial crops, where marketing, research extension, and credit, including pricing policy, must be far more effectively integrated. Given the very limited period of off-season advantage, weaknesses in institutional structure are likely to make changes much more difficult. Another important factor is the need for agro-processing activities to play a more dynamic role in bringing about these changes in subsistence hill agriculture. The time has, therefore, come to study and identify alternative institutional models that focus on: agro-specialization based on environmental and off-season advantages; mobilization of small farm households in production of agricultural support services; integration of agricultural support services through factor-based agro-processing; export-oriented agriculture, encouraging trade between ecozones, rural and urban areas, and other markets; and development of basic infrastructure strictly on the basis of production potential.

In the Nepalese hills, the absence of an appropriate institutional mechanism seems to be the strongest factor in the failure to bring about a basic transformation of hill agriculture.

Conclusion

The growing conflict between short-run needs for food, fodder, and fuel and long-run environmental sustainability, under conditions of subsistence agriculture in the hills, is apparent. The overall economic and environmental scenario for the hills appears to be extremely bleak if demand conditions continue to overload the carrying capacity of the hill resources. And yet, for all their fragility, the hills also possess substantial economic and environmental development potentials. These potentials remain largely untapped and will continue if the existing problems associated with hill agriculture are not realistically examined and some bold decisions taken to alter radically its basic structure.

The case for commercialization of hill agriculture has already been made. While there are many examples of successful integration of hill agriculture with the wider market economy, the heterogeneity of the hills means that each area and ecozone requires very careful examination in terms of local environmental conditions, access and marketability, local food conditions, and necessary investments. Unless a deliberate search is made to identify areas of comparative advantage, the hill farmer is likely to continue struggling with subsistence production systems. This is undesirable for both the hill farmer and the hill environment. Efforts to marginally improve subsistence production systems are likely to be unsustainable. This is because the hill farmers lack resources to pay for these services and inputs and government cannot continue to subsidize them indefinitely.

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