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Horticultural Development in the Himalaya and the Hengduan Mountains, China

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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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