ICIMOD Manual 2017/7

ICIMOD

Package of Practices

for Climate Resilient Value Chain Development of Major Vegetables in Udayapur, Nepal

CEAPRED

About ICIMOD

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalaya – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

About CEAPRED

The Center for Environmental and Agricultural Policy Research, Extension and Development (CEAPRED) is a non-profit, non-political, and non-government organization established in April 23, 1991. It is registered at the District Administration Office, Lalitpur and has affiliation with the Social Welfare Council of Nepal. The Center is a value - based organization committed to human centered sustainable development.

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Package of Practices

for Climate Resilient Value Chain Development of Major Vegetables in Udayapur, Nepal

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Foreword

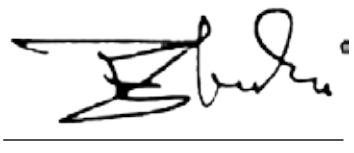
Nepal has a highly diverse physiography, ranging from tropical in the south to alpine in the north with three distinct eco-belts (mountain, mid-hills, and terai). Its hydrology is fed largely by the South Asian Monsoon System (SAMS). The dramatic variations in altitude over a short distance and different facing aspects of hills have resulted in pronounced geographic effects on precipitation dynamics and micro-climates in Nepal. The climatic diversity, with its multiple ecosystems and landscapes, also support a highly diverse array of cultures and livelihoods. Each of these specific micro-climates and localized ecosystems provides opportunities as well as poses constraints on livelihoods.

Due to its higher dependence on monsoon and weather, even slight alteration in temperature and precipitation has direct impacts on crop yield and food security. Smallholder and subsistence farmers in Nepal have also been suffering from climate change impacts. The impacts are sometimes localized and differ across regions and climatic zones. In many places erratic rainfall has resulted in a decline in crop production. The increasing temperatures have led to the emergence of new pests, posing new challenges to the entire farming system, ultimately increasing farm expenses. Over the last few decades, climate change has posed a big challenge in the production of agricultural crops including fresh vegetable, vegetable seed, cereal crops and legumes. This has affected the livelihoods of people. Farmers' perceptions of climate change on the ground suggest that precipitation has become more erratic, days are becoming hotter, the pattern of winds, fog and hailstorms have altered and farmers have become more vulnerable. Furthermore, rising temperatures have significant impact on the moisture and nutrient level of soil through rapid evapo-transpiration, soil erosion and landslides. Therefore, climate resilient technologies are the demand of the day.

Recent studies have helped enhance the understanding of adaptation to climate change. It is increasingly seen as adjustments in ecological, social, and economic systems in response to actual or expected climatic stimuli and their effects or impacts. Resilience is now recognized, much more than adaptation. In resilient systems, people actually 'do well' despite changing conditions, including in conditions attributable to climate change. Field studies in Kavre conducted under Resilient Mountain Village (RMV) by CEAPRED in partnership with ICIMOD have identified some climate resilient technologies that help people achieve wellbeing by building their resilience against vulnerabilities.

This Package of Practices (POP) for Climate Resilient Value Chain Development is based on lessons learned from Resilient Mountain Village piloted in Kavre, farmers' existing knowledge, and the experience of ICIMOD and CEAPRED in other districts and countries. The main objective of the document is to sensitize the community and concerned stakeholders and build their capacity to adapt and expand existing resilient practices and to adopt new technologies to tackle extreme events such as high temperature, erratic rain and floods, drought conditions, and natural disasters.

We would like to express our sincere appreciation and thanks to the authors and professionals who contributed to develop the POP, and to Dr Govinda P. Sharma (Program Director) and Mr Khem Raj Joshi (Sr. Horticulture Development Officer) from Vegetable Development Directorate for their review and inputs for POP finalization. We hope that this document will be useful to agriculture development professionals working at different levels. We welcome your valuable suggestions and constructive comments for addressing the shortcomings of the document.



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Director General
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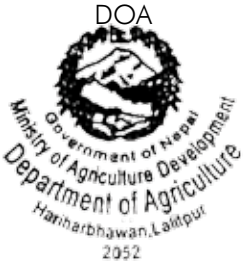

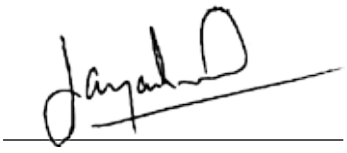

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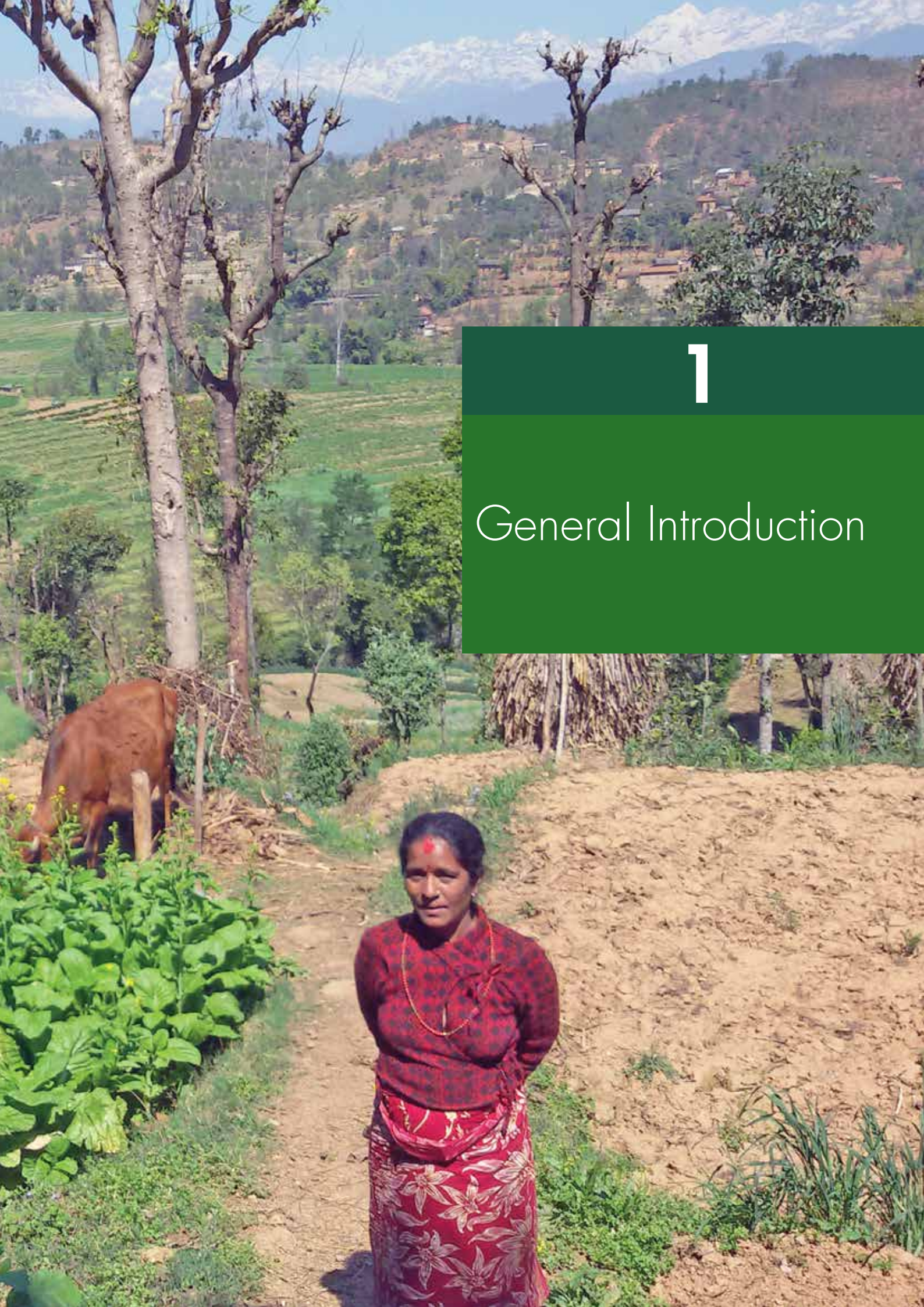
Acronyms and Abbreviations

AEC	Agro Enterprise Center
AEPC	Alternative Energy Promotion Centre
BCMV	Bean Common Mosaic Virus
CBO	Community Based Organization
CEAPRED	Center for Environmental and Agricultural Policy Research, Extension and Development
CRA	Climate Resilient Agricultural
CSV	Climate Smart Village
DADO	District Agriculture Development Office
DAP	Diammonium phosphate
DDC	District Development Committee
DoA	Department of Agriculture
EU	European Union
FNCCI	Federation of Nepalese Chambers of Commerce and Industries
FYM	Farm Yard Manure
GoN	Government of Nepal
HIMALICA	Rural Livelihoods and Climate Change Adaptation in the Himalayas
HKH	Hindu Kush Himalaya
ICIMOD	International Centre for Integrated Mountain Development
ICT	Information Communication Technology
IPM	Integrated Pest Management
NARC	Nepal Agricultural Research Council
NPK	Nitrogen, Phosphorus, and Potassium
NPR	Nepalese Rupee
POP	Package of Practices
RMV	Resilient Mountain Village



1

General Introduction

1: General Introduction

1.1 Background

Changes in global temperatures and rainfall patterns in the twentieth century serve as evidence of climate change. The impact of climate change has become more visible in recent decades. A number of reports indicate that climate change has adverse impacts on agricultural productivity and people's livelihoods (SANDEE, 2016). Hence it is important to take key components of climate change into consideration while designing programme/project interventions. The International Centre for Integrated Mountain Development (ICIMOD) has the mandate to support livelihood development and environmental conservation in the Hindu Kush Himalaya (HKH).

Under its regional programme Adaptation to Climate Change, ICIMOD, together with its partners, strives to enhance adaptive capacity, reduce risks and build the resilience of women, men, and children of the HKH region who are facing socioeconomic and environmental change, including climate change.

The Rural Livelihoods and Climate Change Adaptation in the Himalayas – Himalica – is a demand-driven programme financed by the European Union (EU) and managed by ICIMOD. The programme aims at supporting vulnerable mountain communities in the HKH region in mitigating and adapting to climate and socioeconomic change.

The ultimate beneficiaries of the programme are hill and mountain communities. These people are in most cases economically active or can potentially become so with access to appropriate technical support. Women and the young stand out as especially vulnerable groups.

The expected results of the Himalica programme are as follows:

- The capacity of national and regional stakeholders in dealing with livelihood development, more sustainable and efficient use of natural resources and the protection of the environment enhanced; and
- Poverty among mountain people reduced through increased resilience and the unlocking of new livelihood opportunities, and through the promotion of more equitable approaches.

Pilot projects and capacity building are the two main areas that address the second expected result: the reduction of mountain poverty. The pilot project may include (but is not limited to) the following topics:

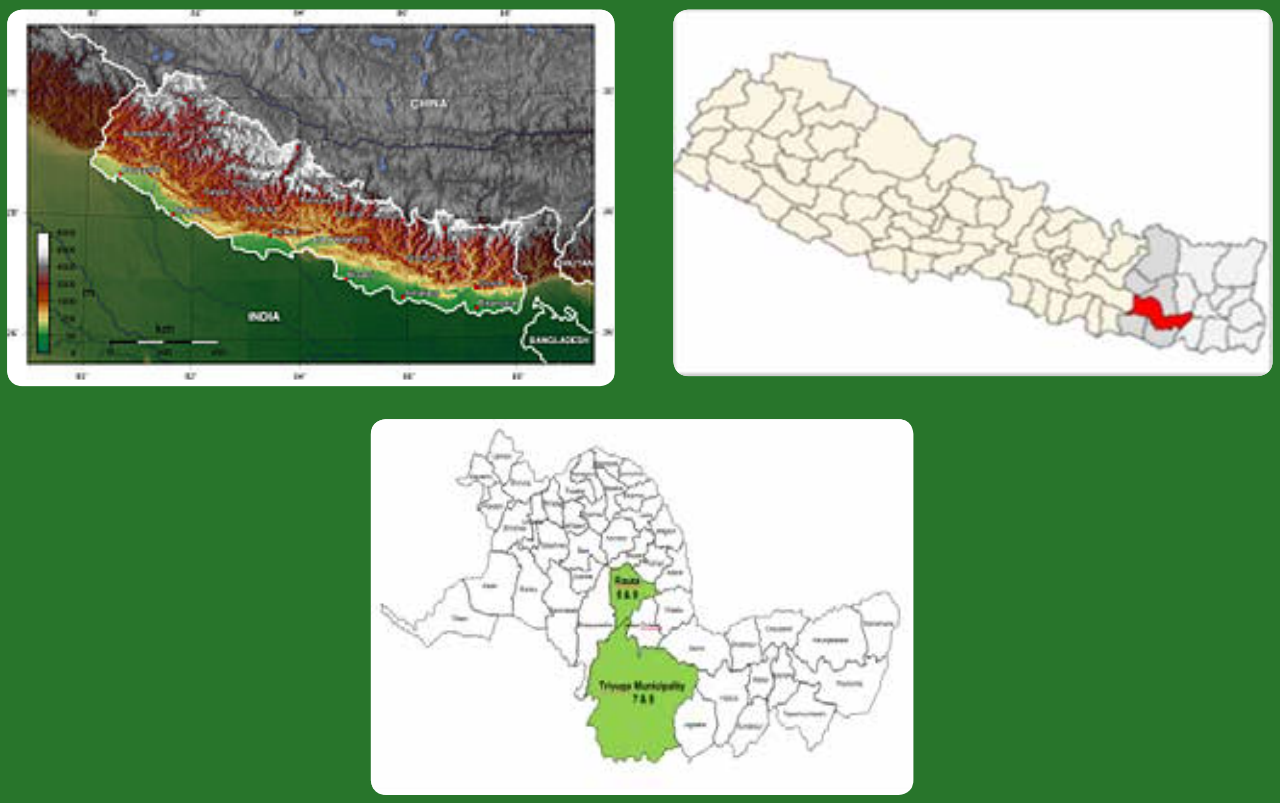
- Promote and develop pro-poor value chains of mountain niche products and services as an adaptation strategy, ensuring sustainable and equitable management of natural resources with strong cooperation between the community and the private sector.
- Promote and diversify livelihood opportunities through the identification of new and risk reducing income and employment opportunities in pilot areas (e.g., linking value chain development to investment and employment generating activities; market-oriented services such as access to information, financial services and micro-finance).
- Support the use of ecosystem services such as landscape management and biodiversity protection/ conservation for recreational activities with direct community involvement and benefits.
- Enhance sustainable practices in the management of natural resources and identification of alternatives at the local level (e.g., use of fallow or degraded lands and forests, improved farming and water management systems, including improved planning capacity).

1. 2 HIMALICA Pilot Project in Udayapur, Nepal

1.2.1 Objectives and approach of HIMALICA Pilot in Udayapur

The Himalica pilot project in Udayapur is jointly implemented by ICIMOD and the Centre for Environmental and Agricultural Policy Research, Extension and Development (CEAPRED). The overall objective of the pilot project is to increase community resilience, reduce risks and improve livelihoods by supporting target beneficiaries to produce

Figure 1: **Maps showing Udayapur district (Red) in Nepal and HIMALICA Project (Green) in Udayapur**



more food with less water and other CRA practices, and value chain upgrading. To achieve these goals and objectives sustainable use of natural resources enhancing the capacity of local people in environment protection and to adopt coping mechanism against natural disaster and climate change calamities.

This pilot project intends to showcase the results of improved resilience of mountain women and men in selected clusters through designing and implementing context/target community specific interventions. The project is based on the principles of value chain development, drawing on appropriate upgrading strategies – products, processes and/or functions to broaden options for income enhancement and diversification. Under this intervention, vegetable crops have been identified as major commodities for income generation and for improving livelihoods and food security.

The outcomes expected from the pilot project:

- **Increased income** of target households through improving productivity and production, strengthening linkages (both horizontal and vertical) among value chain actors, and reducing post-harvest losses thereby promoting activities that add value to vegetables and spices. Finally, 50% of selected beneficiaries (minimum 250 households) will be able to increase their income by 30% by the end of the project life.
- **Better resilience** of local stakeholders for dealing with the effects of climate change and other risks associated with livelihood sources. This will include unlocking livelihood opportunities, community-based micro planning with a focus on climate change adaptation and management, private sector engagement and improving access to market information and business services.

The pilot project has adopted the following strategic approaches to achieve the goal and objective of the project:

- Showcase and demonstrate the production and marketing of commercial vegetables that can adapt to local climatic conditions and resources;
- Facilitate production and marketing in close collaboration with government CBOs and private sector;
- Promote low risk production system through promoting climate resilient practices as a model (e.g., smart water use, soil nutrient management, efficient use of energy, crop management according to weather trends and knowledge exchange among value chain actors);

- Facilitate and promote the collaboration and coordination between concerned stakeholders in vegetable production and marketing; and
- Develop technology packages based on practical knowledge and publish these in Nepali and English languages.

1.2.2 Situation of Udayapur in Space Geometry

Udayapur is a mid-hill district in Sagarmatha Zone of the Eastern Development Region of Nepal. It is situated at 26°.56' N latitude and 86° 31' East longitudes. (It falls in Province No. 1 in the proposed new map of Nepal.)

The elevation varies from 200 metres in the Terai to 3,000 metres in the high hills. It has 2,063 square kilometre (206,169 ha) land area with three topographical regions namely, mid mountain (87,394 ha), Siwalik (108,627 ha), and Terai (7,148 ha). The district has 35,065 ha of cultivated land. Udayapur has one municipality and 45 Village District Commiittees. Based on the elevation, the district is divided into three distinct agro-climatic zones.

i) Hill and mountain region

The elevation of the hill and mountain region varies from 1,000–2,310 metres. This region expands from the Sunkoshi River in the north to the upper range of the Mahabhara in the south. High hill areas such as Lekhani, Majhkharka (Nametar), Rauta and Pokhari VDCs occupy nearly 20% of the land area of the district.

ii) Midland Tars and basins

Midland Tars and basin areas expand from 550–1,100 metres between the central Mahabharat Range and the region near the Terai. About 46% of the land of Udayapur falls in this range. The major VDCs include valleys and basins like Nepal Tar, Murkuchi, Mainatar Bahunitar, Bhuttar, Hardeni, etc.

iii) Inner Terai

The elevation ranging from 260–550 metres including Triyuga Municipality is also known as inner Terai (Bhitri Madesh). Inner Terai (Bhitri Madesh) occupies about 34% of the total land area of the district. The Triyuga Municipality and other VDCs like Katari, Beltar, etc. are in this part of the district. The areas situated at the banks of the River Triyuga and Tawa Khola has south border.

1.2.3 Pilot clusters of HIMALICA in Udayapur

Three pilot sites representing all the three physiographic zones of the district have been selected for the demonstration of POP for climate resilient value chain development for major vegetables. The pilot intervention is implemented in ward no 7 and 8 of Bagaha in Truyuga municipality; ward no 5 and 9 of Rauta VDC and wards 1, 3, 5 and 7 of Saune VDC. The project will demonstrate proven/best practices that lead to income growth and a resilient production system. All three pilot sites have particular advantages for seasonal production and for upstream-downstream market linkages. They are described below:

- Bagaha is in a low-elevation plains area where crops like tomato, beans, eggplant and cole crops can be grown during autumn through winter. The products can be supplied to hill and mountain regions. Since the Sagarmatha highway (under construction) links the plains with the mountain area including Everest Base Camp, the upstream markets along the road corridor can be easily tapped for the supply of vegetables.
- Rauta has both sub-tropical and warm temperate climate, the altitude ranging from 350 to 1,000 masl. This site falls along the road corridor linking Gaighat with hill districts Okhaldhunga and Khotang via Katari. This creates opportunity for upstream marketing of fresh vegetables and spices produced in Rauta. Similarly, vegetables produced during the main season in the higher altitudes can be sold in the downstream markets like Lahan, Janakpur and Biratnagar as off-season products.
- Saune VDC area ranging from 700 to 1,100 masl falls along the Sagarmatha road corridor. It has been identified as a natural off-season vegetable production site for both upstream and downstream markets. The seasonal vegetables grown during summer through the rainy season e.g., cole crops like cauliflower, cabbage, radish, broad leaf mustard can be supplied to downstream markets of Gaighat and other areas in the Terai as well as to upstream markets including Salleri and Sagarmatha base camp as off-season vegetables.

2

Climate in Udayapur and Its Impacts

2: Climate in Udayapur and Its Impact

2.1 Climate in Udayapur

Udayapur district falls in the 'very high' category for temperature and precipitation risk (0.580–1.000) (MoEST, 2010). The 20 year average of Udaypur's weather recorded at the Gadi station (26.560°N, 86.310°E), which is located at about 1,000 masl altitude, shows that the mean daily temperature ranges between 8–31°C (Figure 2). Similarly, the mean total monthly precipitation is mostly confined to the wet summer months (May to October) with the highest mean monthly precipitation being recorded in July (Figure 3).

The average annual total precipitation of Udayapur district of the last 20 years is 1,390 mm. Records show that the maximum amount of precipitation is received from May to October; further analysis shows that excessive rain (about 75% of annual total) occurs from June to September. During these months, floods and landslide hazards troubled the farmers. From November to April/ May, people suffer mostly from drought and this trend is increasing every year. The intensity and duration of drought is increasing. Most natural water resources are being exhausted, and this will lead to even more dramatic water scarcity.

Figure 2: **District average temperature in Udayapur, Nepal (1999-2013)**

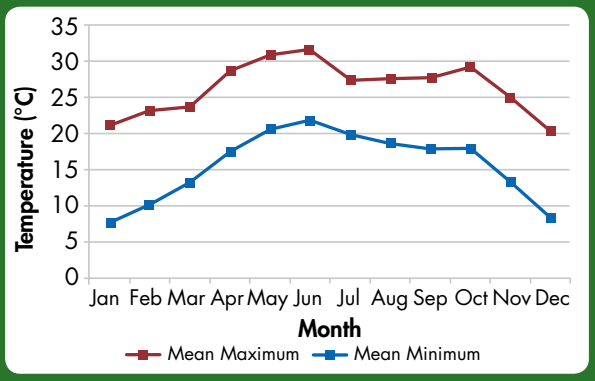
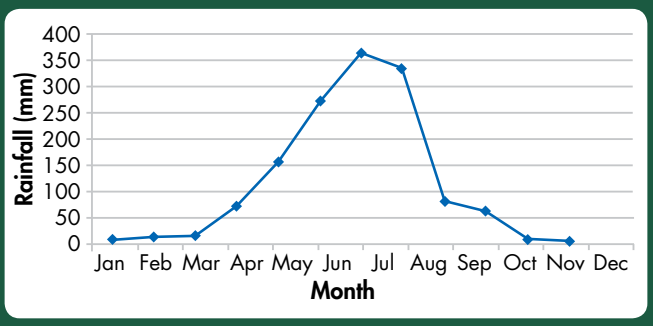


Figure 3: **District average rainfall in Udayapur, Nepal (1999-2013)**



Source: Climate change vulnerability assessment report, HIMALICA Pilot Project Udayapur District Nepal by ICIMOD in January 2016

2.2 Climate Change Impacts on Livelihoods in Pilot Sites

Both hills and plains ecosystems in Udayapur are vulnerable to climatic hazards like rising temperature, erratic precipitation and unpredicted floods. These hazards have impact on the agricultural system and this is manifested in the shifting planting time, changing cropping pattern and the impact on livelihoods. The vulnerability assessment (January 2016, CEAPRED) for Bagaha 7 & 8 of Triyuga Municipality and ward no. 5 & 9 of Rauta showed incidence of pest/diseases and drought as the major problems in most of the crops including vegetables. Impacts in specficic sites are described below:

2.2.1 Bagaha 7, Triyuga Municipality of Udayapur

An historical timelines shows the range and frequency of different climate-induced hazards and disasters in Bagaha 7, Triyuga Municipality of Udayapur district based on historical timeline. Unexpected flood of 2047 and 2052 BS killed five people and washed off about 100 bigha (68 ha) of land. Likewise, severe drought forced people to leave more than 100 bigha of cultivable land fallow in 2056 BS.

The frequency of rainfall has decreased gradually whereas the incidence of drought and plant disease and insects, which occurred rarely in the past, has been increasing during recent years. Major crops like rice, wheat, maize, potato, mustard and cauliflower are grown in Bagaha 7. However, a slight change in the cropping time was noticed for almost all the crops. Vegetables like tomato, pea, bottle gourd, cucumber, etc. are affected by hazards such as drought, flood, and windstorm.

2.2.2 Bagaha 8, Triyuga Municipality of Udayapur

In Bagaha 8, drought, plant diseases and insects and cold waves have affected almost all the crops, the most affected being paddy and vegetables.

In Bagaha 8, drought has been the most severe hazard, followed by plant diseases and insects and cold waves for vegetable crops.

2.2.3 Rauta VDC 5

Rauta VDC was affected by drought and smoke and dust pollution. People faced water scarcity and water sources became unsuitable for irrigation. Plant diseases and insects that weren't seen in the past have become frequent in recent years. Some households were also affected by forest fire and wind during the dry season. Cereal, potato and other vegetable crops were affected by frost and cold waves. Drought has been a frequent occurrence in recent years. Frost, which was absent in the past, is now occurring in the months of December to February. Vegetables are mainly affected by cold waves and plant diseases and insects. Wheat and buckwheat were least affected. Vegetables like cucumber, bitter gourd, pumpkin, cowpea, etc. have been affected by hazards such as drought, plant disease and insects. This has reduced the yield of major crops and affected agrarian livelihoods.

2.2.4 Rauta VDC

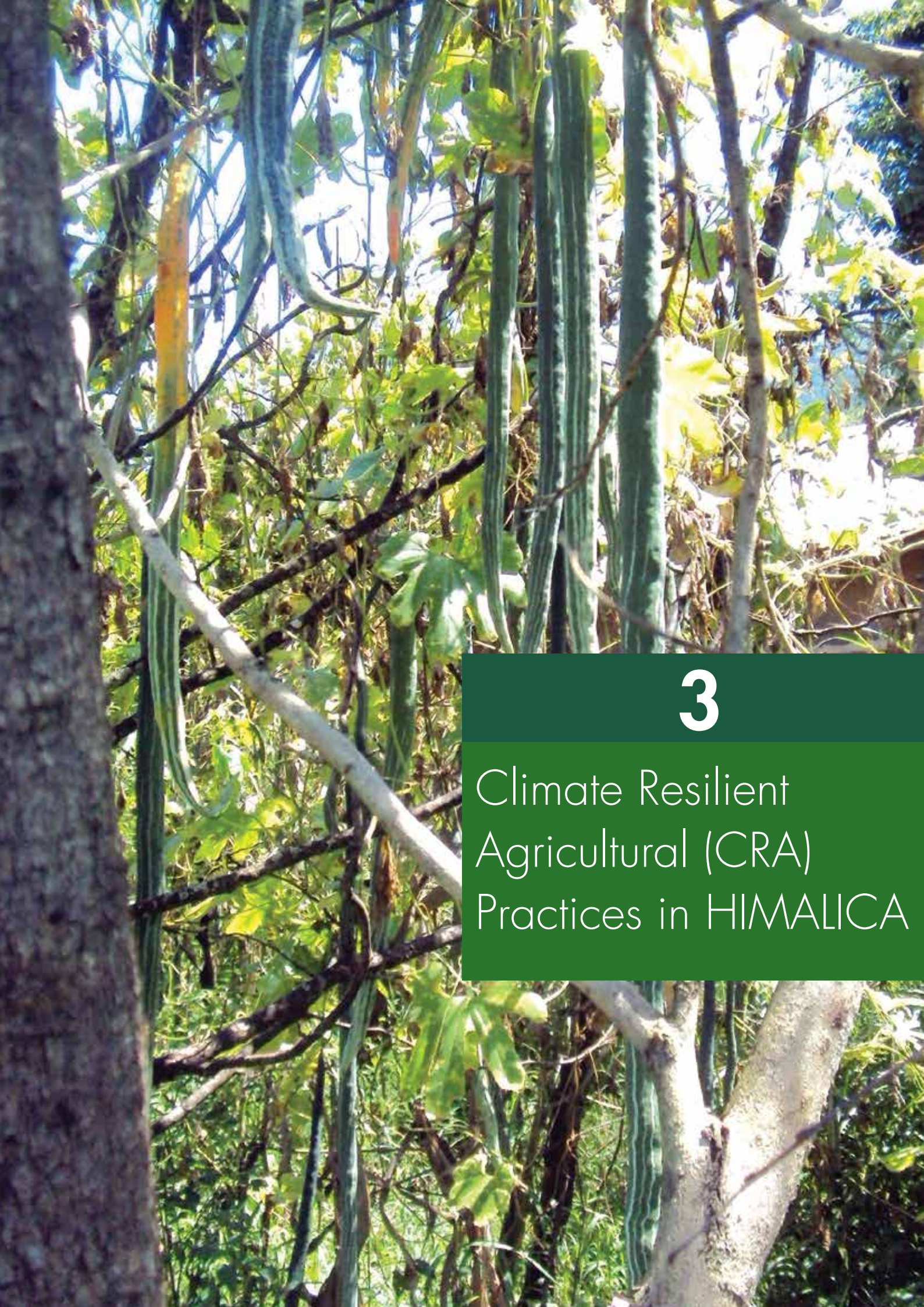
The frequency of rainfall, flood, and wind/storm has decreased whereas the incidence of drought and plant disease and insects has increased gradually. Cold waves did not occur in the past but have been observed in recent years. Landslide occurred in 2057 BS, killing 10 people and many domestic animals in Murkuchhi Bazaar. Another landslide in 2067/68 BS damaged the water tank of Guranse. Drought has been affecting all the farmers since 2061 BS. Crops like rice, maize and vegetables are mainly affected by plant diseases and pests. Vegetables like cucumber, bitter gourd, pumpkin, cowpea, etc. have been seriously affected by hazards such as drought, plant disease and insects.

2.2.5 Saune VDC

Saune VDC has faced the same impacts of climate change. However, as the area lies at a higher elevation, farmers reported more frequent thunderstorm and rain. Prolonged summer and drought have affected water resources, and the planting time for crops including vegetables has shifted as a result. Disease and insect infestation in crops and vegetables has increased in recent years. The problem is more serious during the dry season.

Effects of climate change such as drought and plant diseases and insects were serious in all the project sites. However the adaptive capacity of the community people was low in all the sites. There is lack of economic resources, human resources and institutional capacity to address the hazards. Various climatic and non-climatic factors have increased people's vulnerability, and different tiers of the value chain (input supply, productivity and marketing) have suffered as a result. To maintain the different tiers of the value chain, the HIMALICA project should seek to reduce people's vulnerability associated with climatic hazards like drought, plant disease and insects. This would allow people to produce more vegetables and enhance their economic well-being, thus increasing the efficiency of the value chain and improving livelihoods.


रमेश
जा घर



3

Climate Resilient Agricultural (CRA) Practices in HIMALICA

3: Climate Resilient Agricultural (CRA) Practices in HIMALICA

3.1 Introduction

Nepal ranks fourth in the list of countries most vulnerable to climate change (Maple Croft, 2011). As farming in Nepal heavily depends on the weather, especially monsoon rains, Nepalese agriculture is particularly sensitive to climate change. Alteration in temperature and precipitation has direct impacts on crop yield and food security. Smallholder and subsistence farmers in developing countries have been suffering the most from climate change impacts. This holds true for traditional smallholder farmers in Nepal as well. The impacts of climate change on small landholders are localized and vary according to the region and climatic zone. Besides the physical factors, geographical remoteness and social factors also contribute to farmers' vulnerability. When it comes to climate change related issues, the high dependence of small farmers on monsoon has increased their vulnerability. In many places, erratic rainfall has led to a decline in crop production. There are also evidences of agricultural pattern shifting due to water scarcity. The higher surface temperatures have led to the emergence of new weeds and pests, increasing farm expenses and posing new challenges to the entire farming system. Over the last few decades, climate change has posed a big threat to the production of crops, vegetables, vegetable seeds, and legumes. This has affected the quality and quantity of the produce. As rising temperatures and the effects of climate change are felt more intensely, food insecurity in Nepal is expected to become more acute. Therefore, CRA practices are the need of the day.

CRA practices are an applied set of farming principles and practices that increase productivity in an environmentally friendly and socially sustainable way (*adaptation*). It strengthens farmers' capacity to cope with the effects of climate change (*resilience*); conserves the natural resource base through maintaining and recycling organic matter in soils and increasing water use efficiency. The CRA practices include proven technologies and practices, such as water management, intercropping, conservation agriculture, crop rotation, mulching, and integrated crop-pest management. Furthermore, CRA practices should deliver a high rate of production and adaptive capacity with the same amount of greenhouse gases (GHGs) emission and consumption of labour as well as farm equipment. Hence it should mainly focus on three dimensions: i) sustainably increasing agricultural productivity and incomes, ii) adapting and building resilience to climate change, and iii) reducing greenhouse gases. The climate resilent package of practices for major vegetable crops in Himalica project areas in Udayapur is based on lessons learned from another project – Resilient Mountain Village (RMV) – jointly implemented in Kavre by ICIMOD and CEAPRED. The RMV has proved to be water smart, nutrient smart, crop smart, energy smart, ICT smart as well as adopted future smart technologies. The techniques are summarized here and recommended for adoption in the HIMALICA project in Udayapur.

3.2 Basic Pillars of Climate Resilient Agriculture

The CRA practices were designed based on the vulnerability assessment carried out in Udaypur. The main issues identified during the vulnerability assessment included prolonged drought, unexpected floods, incidence of increased diseases and pest attack. To achieve climate resilient agriculture, climate smart and efficient farming of crops (also includes livestock and fisheries) has to be promoted at all levels along with the enhancement of resilient technologies in the sector. The basic pillars of climate resilient agriculture practices and some of the successful smart practices recommended for implementation in the Himalica project in Udayapur are as follows:

3.2.1 Water smart

It includes aquifer recharge, rainwater harvesting, and community management of water and efficient use of water. Household level water harvesting and judicial and efficient use of water are also water smart approaches.



The 3Rs (Recharge, Retention and Reuse) is a holistic approach to water management. The approach focuses on water buffering to better manage natural recharge, and to extend the chain of water use. When water is abundant, a large portion is commonly lost through floods, surface runoff and evaporation (Mekdaschi et al., 2013). Water smart technologies store and efficiently utilize stored water for productive uses. Water can be stored above and below ground with various techniques such as ponds, tanks, pits, bunds and terraces. Stored water is used with water efficient micro irrigation techniques. Some important water smart technologies are as follows:

i) Plastic lined water harvesting pond

Building a plastic lined pond for wastewater, rainwater collection is a practical way of increasing water use at household and community level. Plastic lined ponds are used for storing wastewater, runoff water, and water from other sources such as taps, spring spouts or wells for later use.

Small ponds are useful for irrigating crops grown in the kitchen garden of individual households. About 2 metres long, 1.5 metres wide and 1 metre deep pit is built to harvest rain and runoff water. Each household can harvest 500–1,000 litres of water per week on a regular basis. The pond should be built at an appropriate location where wastewater from kitchen and bathroom sinks, shower and laundry can be collected.

At the community level, to ensure water security for vegetable production, bigger plastic lined pond for rainwater harvesting are useful. Sources of water for community level plastic line ponds are taps, spring spouts and wells. Dimensions of community level ponds are, generally, 8–10 metres long, 6 metres wide and 1 meter deep with maximum capacity about 25,000–30,000 litres. Community members can use harvested water for irrigation by setting rules for themselves.

During the construction of plastic lined pond, surface of the pond should be made smooth and level by pressing and patting to ensure safety of the plastic sheet. Generally, thicker (more than 90 gsm) and multi-layered UV protective plastic is used in both HH and community level ponds. Embankment breaches and pond wall failure may unintentionally deliver unanticipated hazards. This is more critical in big ponds. Therefore, maintenance of the embankment and walls should be carried out regularly. A fence is constructed around the pond to prevent animals and humans (particularly children) from entering the pond.

The harvested water should be efficiently utilized using a micro irrigation system such as the drip irrigation system as explained in the following section.



ii) Straw or plastic mulching to retain soil moisture and prevent weeds

Mulching entails layering the soil surface with organic or inorganic material, creating a favourable environment for plant growth. This is a temporary measure for providing protective cover for plant establishment. In rainfed agriculture, mulching with straw, plastic or leaves can prevent soil moisture loss during the dry season. Mulch improves the water holding capacity of soil, stabilizes soil temperature, creates a rough surface to reduce runoff velocity of water, suppresses weeds, and adds organic material to the soil.

Grass, straw, leaves, food by-products, wood product, animal manure and compost organic mulch materials. Plastic, geo fabric, rubber tire, brick chips and stones are inorganic mulch materials.

There are two main methods of mulching:

- Mulching around individual plants: Apply 5–10cm thick mulch around the plant, leaving a space of 5–15 cm. The mulch should form a circle around the plant. This type of mulching helps to keep the soil cool and moist, enhancing the growth and early establishment of shrub and tree seedlings.
- Mulching to treat the entire area: Mulch is laid across the slope to form a surface cover of 5 cm thickness. It is normally used to aid the establishment of grass seed, and therefore it is a temporary form of surface armoring.

Some pictures of mulch material and methods used to retain soil moisture and prevent weeds:

The following precautions should be taken while applying mulch:

- On steep slopes >40°, hold the mulch with a large mesh jute net.
- Do not use the part of the plant carrying seeds.
- Extra heavy mulch layers are often a shelter for rodents and may lead to the girdling of some plants.
- Do not apply mulch directly on the plant. Leave a space of 5–15 cm to help prevent disease that may result from excessive humidity.
- Remove weeds before spreading mulch.

iv) Drip irrigation for smart and efficient use of water



Drip irrigation is also known as trickle irrigation or micro irrigation. In this irrigation method, water is applied uniformly (2–2.5 litres/hour) on the root zone of plants through a network of pipes, and emitters. This technology is suitable for distantly planted crops e.g., vegetables like bitter gourd and cauliflower, fruit trees, and vine crops.

Drip irrigation is a proven technology. The Resilient Mountain Village (RMV) project has demonstrated the use of drip irrigation for tomato production inside a plastic tunnel. Farmers have successfully grown tomatoes for more than eight months in a year. Even in open fields, drip irrigation can be used in row-planted crops for efficient water management.

Drip irrigation saves a considerable amount of water compared to flood, furrow and bucket irrigation because this method involves less water loss from evaporation, infiltration and percolation. It enables early fruiting and production of dry season (off-season) vegetables; provides opportunity for cultivating fallow land in water scarce areas; and allows agricultural chemicals to be applied efficiently. It also reduces the drudgery of women, who are traditionally responsible for managing irrigation water for cash crop production.

The establishment activities are generally done in February and March for pre-monsoon vegetables and in September and October for winter vegetables. The major steps include:

- Level and prepare land.
- Build a wooden platform for a storage tank and place the tank on it (tank is generally raised 1 m above the surface).
- Lay down lateral pipes; the dripping holes of the lateral pipes and plants should correspond to one another.
- Connect the lateral pipes to the main pipes and the main pipes to the storage tank.
- Run the system by opening and closing the gate valves.
- Identify the location of the pit holes by running the system.
- Plant vegetable seedlings in the pits.



Maintenance activities include maintenance against leakage by replacing spare parts, cleaning of dripping holes with water and pin, and application of chlorine through a drip tube to help prevent the growth of microorganisms like algae and bacteria from clogging up the pipe.

v) Rainwater harvesting in the field

Rainwater harvesting is important for providing supplementary irrigation for vegetables during water scarce periods. Rainwater can be harvested in situ by constructing bunds, terraces, pits, trenches, furrows; vegetables are planted in or around these structures. Rainwater can also be harvested from roofs, courtyards, footpaths and roads and collected in ponds, jars and tanks and later applied to crops using efficient irrigation methods.

Much of the rainwater is lost through quick runoff. The basic purpose of water harvesting is to capture rainfall/runoff and promote the retention of rainfall runoff within fields. Some of the rainwater harvesting techniques are:

- Rainfall runoffs collected in the sunken beds of onion and garlic fields.
- During the dry season, crops (e.g. potato) are planted in deep furrows and mulching is done and surface evaporation is reduced.
- Crops like cucurbits are transplanted or sown in deep pits to conserve moisture and collect rainwater.
- The basin areas are covered with locally available mulch to further retain soil moisture.
- A Thai jar may be constructed in the field to store rainwater for the dry months.

Water harvested and stored in jars, ponds, tanks are available for crop, fodder, fruit or vegetable production. In-field rain water harvesting is considered a climate resilient approach because it increases the availability of water and reduces the risk of crop failure. This technique conserves rainwater for longer periods, allowing farmers to grow crops despite low and erratic rainfall.



3.2.2 Soil nutrient smart

It includes maintenance of soil health through retaining organic matters in soil and low and efficient use of fertilizers, such as site specific nutrient management, optimum use of fertilizers (mainly, nitrogen, phosphorus and potash), green manuring, etc. It further includes activities that control soil erosion and enhance carbon sequestration through promoting the agro-forestry system, conservation of tillage and other land use system.

Organic farming and bio-fertilizer have become the catchwords of our times. Till 1955/56, Nepal was a completely organic agricultural country. The use of chemical fertilizer and pesticide began with the advent of modern agriculture, such as the projects initiated through Tribhuwan Gram Bikash in 1956. Nepal is now trying to revert to organic agriculture, which is not completely possible in large-scale commercial farming. However, balanced use of chemical fertilizer, bio-fertilizer and botanical or organic pesticide and safe use of chemical pesticide might be the midway in vegetable farming. Organic manure or bio-fertilizer derived from plant and animal sources are also valued as a nutrient smart product in the context of climate change.

The major organic manures include farmyard manure, rural and town compost, night soil (which is not available now), green manure, vermin-compost, poultry manure, bone meal, oilcake, azolla, and different kinds of Jholmal.

Nutrient smart agriculture involves applying balanced doses of manures and fertilizers based on soil testing. It also includes practices that are beneficial for sustainable soil management and increase soil resilience. Such practices use technologies based on locally available resources. Using Jholmal and improved farmyard manure (FYM) is one of the best ways to reduce the use of chemical fertilizer and increase soil resilience. Three types of Jholmal have been demonstrated in RMV and recommended for use in Himalica project areas. Jholmal is an organic liquid based fertilizer and also a pesticide for repelling and preventing insects and minimizing diseases. Jholmal is prepared by mixing animal urine, well-decomposed manure, botanical herbs, spices, Jeevatu (a package of beneficial microbes) and water. Jholmal has been extensively used in climate-smart practices as a liquid manure and bio-pesticide. Farmers are preparing and using three types of Jholmal for cereal and vegetable production, with minimal use of synthetic fertilizers and chemical pesticides. The methods of preparing and applying different organic manures and Jholmal are briefly described below:

i) Farm Yard Manure (FYM)

This is traditional organic manure and is bulky in nature, but supplies plenty of plant nutrients in small quantities and steadily improves soil quality. This is the most readily available organic manure in the subsistence farming system in rural Nepal, where livestock is an integral part of agriculture. To make FYM, liquid and solid excreta of livestock are allowed to decompose and then stored in the farm along with varying amounts of straw or other litter used as bedding for animals. For improved FYM, animal sheds have to be improved so as to use dung and urine efficiently. Dung and urine should be mixed properly and well decomposed. The mixture should turned and covered to prevent nutrient loss through volatization. Urine may be collected separately and can be applied directly to the crop mixed with five parts water. This will protect the crop from insects like aphids and caterpillars. In the improved method of FYM preparation, urine is collected in a tank and later used to prepare Jholmal, liquid manure and bio-pesticide. The manure is also enriched using various nitrogen-fixing bacteria and phosphate solublizing microbes obtained from a solution called Jivatu. Improved FYM is prepared by mixing Jivatu in the manure heap and then preventing the nutrients from evaporating or from leaching by rain.



On an average, well-rotted FYM contains 0.5% nitrogen, 0.2% P_2O_5 and 0.5% K_2O. Based on this composition, adding an average of 25 tonnes of FYM per hectare supplies 120 kg of nitrogen, 56 kg of P_2O_5 and 112 kg of K_2O. In addition, FYM also adds humus and other micronutrients to the soil and improves soil properties. The crop doesn't utilize all the available nutrients in FYM during the year or season of application. Nitrogen from FYM acts very slowly and less than 30% of it is available to the first crop. Some % of remaining N is either leached or available to the next season crop. About 60 to 70% of phosphate and about 75% of the potash becomes available to the immediate crop and the rest is available to the subsequent crop. This phenomenon of availability of plant nutrients is known as residual effect/availability.

ii) Compost

Compost manure includes decayed refuse like leaves, twigs, roots, stubbles, straw, crop residue, weeds and other decomposable organic waste. Water hyacinth and banmara (*Ageratina adenophora*) are also used to make good compost. The decomposition process is accelerated by adding nitrogenous materials like cow dung, nightsoil, and urine. A large number of soil microorganisms feed on these waste materials and convert them into well



decomposed manure; the final product is known as compost. FYM and compost possess the same characteristics. The application process is also the same.

iii) Sheep and goat manure

Droppings of sheep and goat make very good manure. Panning is therefore a common practice of collecting and using sheep and goat droppings in the field.

iv) Poultry manure

This is rich organic manure, as chickens expel liquid and solid excreta together, resulting in no urine loss. Poultry manure ferments very quickly. If left exposed it may lose up to 50% of its nitrogen within 30 days. Poultry manure should be applied to the soil directly as soon as possible. Two types of poultry manure (fresh and floor litter) are available for agricultural use.

v) Oilcakes

Oilcakes are rich in nitrogen, phosphorus and potash. Edible oilcakes are used as animal feed and non-edible cakes are used as manure. However, in Nepal edible oilcakes are also used as manure and they help control fungal diseases like clubroot in crucifers. Oilcakes need to be well powdered before use so that they can be applied evenly. They can be applied before sowing. Oilcakes are more effective in moist soil. They also have pesticidal properties.

vi) Jholmal: Preparation and application

a) Jholmal-1 preparation:

- Dig a pit about 1 ft deep with a 2 ft diameter.
- Place a 50-litre plastic drum inside the pit.
- Pour 17 litres of cow or buffalo urine into the drum.
- Add 16 litres of water into it.
- Add 16 kg of well-rotted dust compost into it.
- Add 1 litre of JIWATU into it and stir properly and close the lid tightly.
- Stir it daily or at 2–3 day intervals depending on the situation.
- Jholmal is ready in 15 days (two weeks) in summer and in 21 days (Three Weeks) in winter.

When it is ready, the colour changes to green and the urine odor is gone. When you stir it, you can find green bubbles in it.

b) Jholmal-2 Preparation:

- Dig a pit about 1 ft. deep in a shade.
- Place a 50-litre drum inside the pit.
- Add 24.5 litres of cow/buffalo urine straining with a muscling cloth.
- Add 24.5 litres of water into it.
- Add 1 bottle of Jiwatu in it, stir manually and put the lid on.
- In this process, we don't need to add compost fertilizer.
- After 2–3 days, open the lid and stir the contents thoroughly.
- Generally Jholmal is ready within 15 days in summer and around 30 days in winter.
- When it is ready, the surface of the liquid is green and the urine odor is gone.

c) Application of Jholmal 1 and 2

- Filter Jholmal with a cloth or a fine strainer before applying it using a sprayer.
- To prevent insect pests, mix 1 litre of Jholmal in 3 litres of water and spray twice a week.
- If pests have already infested the plants, increase the concentration – mix 1 litre of Jholmal and 2 litres of water – and spray on the infested plants.
- If the infestation is severe, use a mixture of 1 litre of jholmal and 1 litre of water.
- To get rid of cutworms and insects that hide under the soil, spray around the base of the plants.
- While spraying Jholmal, the plants and the plant base must be thoroughly be wetted.
- Jholmal provides plant nutrients and also protects plants from pests.
- While spraying Jiwatu or Jholmal, no other chemical pesticides should be sprayed.
- If the sprayer has been used to spray chemical pesticide, it should be washed properly before spraying Jholmal.

d) Jholmal-3 Preparation

Production of fresh vegetables is often hampered by pests. This may reduce production, ultimately reducing farmers' incomes. Chemical pesticides are available and used, sometimes excessively, to combat these pests in commercial vegetable production in Nepal. Botanical pesticides prepared from a variety of plant ingredients soaked and fermented in cattle urine provide a suitable alternative to chemical pesticides. This is useful especially for subsistence and semi-commercial vegetable producers. These pesticides are based on farmers' traditional knowledge and scientifically valid. They are emerging as alternatives to chemical pesticides.

All the ingredients of these pesticides are available locally. In some cases, plants considered to be weeds serve as sources of nutrients and bio-pesticide. Crofton weed or cat weed (banmara) grows in abundance along roads and paths and on forest floors, and suppresses the growth of other more valuable species. It is believed to have pesticidal effects and often used in botanical pesticides. The Nepali names of other plants commonly used in tonics are Asuro (Malabar tree), Titepati (mugwort), Bakaino (Persian lilac), Timur (Sichuan pepper), Pudina (field mint), Tulsi (sweet basil), Neem, Sisnu (stinging nettle), Ketuke (century plant), and Khirro (tallow tree). In general it is said that herbs and plants that are sour, pungent, bitter, and tart or 'hot', or that produce a strong odor are effective in botanical pesticides.

Bio-liquid fertilizer is the original product of rural Nepal. It is prepared by using available vegetation and other organic matter. It is called 'Gitimal' or 'Jholmal' in Nepali. It is used to manage and control different insects and diseases in plants both in nurseries and in the fields. It also provides micronutrients to crop plants. The ingredients should have four different properties a. bitter, b. pungent, c. tartaric and d. sour.

e) Common ingredients of Jhomal-3 or Gitimal include:

- Bojho (*Acorus calamus*) sweet flag leaves ½ kg;
- Timur (*Zanthoxylum* sp) Sichuan pepper seed and leaves 1.5 kg;
- Asuro (*Adhatoda vatic*) Vaasa twigs ½ kg;
- Bakainu (*Melia azedarachta*) Chinaberry or Neem twigs ½ kg;
- Tobacco leaves and twigs ½ kg;
- Banmara (*Ageratum* sp) cat weed leaves and twigs ½ kg;
- Sisno (*Urtica dioica*) stinging nettle leaves and twigs ½ kg;
- Mustard cake 200 gm;
- Garlic cloves 250 gm;
- Chilli pepper 250 gm;
- Some of the above-mentioned vegetation may be replaced with other plants depending on availability. Alternatives include peach leaves, tomato leaves and twigs, angeri dude (*Lyoniao valifolia*, *Pierson valifolia*), Simali (*Vitex negundo*), khirro (*Wrightia arboreas*), Sajiwan (*Jatropa cureas*), physic nut, Agave clade (*Century plant*), papaya leaves, etc.

f) Preparation method of Jholmal-3

- Cut the botanical ingredients into 5–10 cm pieces and mix them well.
- Put the mixed materials in a 50 litre (or larger) plastic drum.

- Add 15 litres of water and 25 litres of cattle /buffalo urine.
- Urine may be collected in a drum a few days in advance or added 2–3 days after mixing the ingredients.
- Tightly close the lid of the drum and keep it in the sun for 18–20 days.
- After 3–5 days, stir the contents with a stick to ensure they mix properly and ferment well.

The well-fermented material is then strained through a fine mesh. The solid residue obtained thus is put aside for compost making. The liquid is Gitimal/Jholmal. It can be stored in a non-staining bottle or pot and used as and when needed over the next two months.

g) Application method and effect of Jholmal-3

Gitimal has an unpleasant odor and pungency that can drive away some insects. It also kills aphids and caterpillars. While applying Gitimal, 1 part gitimal is mixed in 4 parts water and sprayed over the plants. The same solution can be applied around the root zone of the plant at the rate of 200 ml per plant. The method of application depends on the type of crop and attacking pest.

Gitimal contains different micronutrients and helps the plant to overcome micronutrient deficiency. Depending on the severity of the aphids and other chewing insects, Gitimal can be applied 2–3 times at weekly intervals. Various ingredients can be used to prepare Jholmal depending on the locality and availability of vegetation with insecticidal properties.



vii) Use of green manure

Green manure is created by leaving uprooted or sown crop parts to wither on a field so that they serve as a mulch and soil amendment. The plants used for green manure are ploughed under and incorporated into the soil while green or shortly after flowering. Leguminous green manures such as Dhaincha, Sunn hemp, Berseem clover are popular as they supply nitrogen to soil by root nodulation.

Dhaincha (*Sesbania rostrata*) – Dhaincha is planted when there is no crop in the field. Trials on green manure with Dhaincha have been conducted in RMV project in Kavre. Results have been encouraging at the initial phase. Farmers appreciated the technology and understood that Dhaincha supplies nitrogen supplement to plants. This technology improves soil fertility and can be an alternative to synthetic fertilizer.

Sunn Hemp (*Crotalaria juncea* L.) - Sunn hemp is another popular legume that is used to increase organic matter and provide nitrogen. Results have been very encouraging, particularly during summer, it can produce over 5,000 pounds of biomass and over 100 pounds of nitrogen per acre. Farmers only need 8 to 12 weeks of frost-free growth conditions to receive these results. As it grows in low fertility sandy soils and does not harbor nematodes, Sunn hemp can be excellent alternative to Dhaincha. During rainy season when there is no vegetable in the field, Sunn hemp may be turned into soil after 45 days of sowing for decomposition before planting of the succeeding vegetable crop.

Berseem clover (*Trifolium Alexandrinum*)- Berseem grows fast and produces large amounts of forage and nitrogen. It is a multi-purpose plant, and used for green manure, forage production, and honey production.

a) Importance/role of organic manure and key nutrients

Organic manure is the natural food of crop plants. It can supply almost all types of nutrients required by the plants. It also adds humus and organic matter to the soil and improves the soil characteristics. Organic manure provides the following additional benefits:

- It improves soil texture and structure.
- Increases soil aeration, water holding capacity and micro-organism activities.
- Compost preparation helps clean the environment as it makes use of waste materials.
- FYM/compost helps reduce farmers' dependency on chemical fertilizer to some extent.
- The demand for organic products has grown worldwide. Vegetables produced with Integrated Pest Management (IPM) and with the use of organic manure fetch better prices.
- Biogas/gobar gas and organic agriculture help contribute to a healthier environment.

The main nutrients in some important types of organic manure are presented in the table below:

Table 1: **Nutrient contents of different types of organic manures**

Names/Types	Nitrogen %	Phosphorus %	Potassium %
Farmyard manure	0.5	0.2	0.5
Farm compost	0.5	0.2	0.5
Water hyacinth	2.0	1.0	2.3
Town compost	1.5	1.0	1.5
Sheep and goat manure	3.0	1.0	2.0
Poultry manure (Fresh)	1.47	1.15	0.48
Poultry manure (floor litter)	3.03	2.63	1.40
Cakes	2.5–7.9	0.8–3.0	1.2–2.2
Vermi-compost	0.73–1.0	0.8–0.9	4.38

viii) Soil solarization for crop protection

a) Introduction

Soil solarization is a non-chemical method for controlling soil borne pests using high temperatures produced by capturing radiant energy from the sun. The method involves heating the soil by covering it with a clear plastic sheet for 4 to 6 weeks during the hot period of the year when the soil will receive the most direct sunlight. When properly done, the top 6 inches of the soil will heat up to as high as 60°C depending on the location. The plastic sheets allow the sun's radiant energy to be trapped in the soil, heating the top 30 to 45 cm and killing a wide range of soil borne pests, such as weeds, pathogens, nematodes, and insects.

Solarization leaves no chemical residues and is a simple method appropriate for nursery owners, home gardeners and even large-scale farmers. It can improve soil structure by increasing the availability of nitrogen and other essential nutrients for growing healthy plants, as well as by controlling a range of pests.

b) Benefits

Solarization during the hot summer months can increase soil temperature to levels that kill many disease-causing organisms (pathogens), nematodes, and weed seeds and seedlings. It leaves no toxic residues and can be easily used on a small or large scale garden or farm. Soil solarization also speeds up the breakdown of organic material in the soil, often resulting in the added benefit of releasing of soluble nutrients such as nitrogen, calcium, magnesium, potassium, etc., making them more available to plants. Plants often grow faster and produce both higher and better quality yields when grown in solarized soil. This can be attributed to improved disease and weed control, the increase in soluble nutrients, and relatively greater proportions of helpful soil microorganisms.

c) Effectiveness on Various Pests

The degree to which various pests can be controlled is related to the intensity, depth, and duration of the elevated soil temperatures. Although some pests may be killed within a few days, others will need 4 to 6 weeks of full exposure to the sun during the summer.

Fungi and Bacteria: Solarization controls many important soil borne fungal and bacterial plant pathogens, including those that cause Verticillium wilt, Fusarium wilt, Phytophthora root rot, damping off, crown gall disease, tomato-canker, potato scab, and many others.

Nematodes: Soil solarization can be used to control many species of nematodes. Solarization for nematode control is particularly useful for organic and home gardeners. However, soil solarization is not always as effective against nematodes as it is against fungal disease and weeds, because nematodes are relatively mobile and can recolonize soil and plant roots rapidly. Control of nematodes by solarization is greatest in the upper 12 inches of the soil. Nematodes living deeper in the soil may survive solarization and damage plants with deep root systems.

Weeds: Soil solarization controls many of the weeds. While some weed species seeds or plant parts are very sensitive to soil solarization, others are moderately resistant and require optimum conditions for control (good soil moisture, tight-fitting plastic and high solar radiation). Solarization generally does not control perennial weeds as well as annual weeds because perennials often have deeply buried underground vegetative structures such as roots and rhizomes that may re-sprout.

Beneficial Soil Organisms: Although many soil pests are killed by soil solarization, many beneficial soil organisms are able to either survive solarization or recolonize the soil very quickly afterwards. Important among these beneficial organisms are mycorrhizal fungi and fungi and bacteria that parasitize plant pathogens and aid plant growth. Increased populations of these beneficial organisms can make solarized soils more resistant to pathogens than non-solarized or fumigated soil. Earthworms are generally thought to burrow deeper into the soil to escape the heat.

d) Months of soil solarization

Soil solarization is most effective in warm, sunny locations. It has also been used successfully in the cooler areas during periods of high temperature and no fog. Solarization is effective when the days are long, air temperatures are high, skies are clear, and there is no wind. The soil heating effect is not as great on cloudy days. Wind will disperse the trapped heat and may loosen or damage the plastic sheets. Shady areas may not be suitable for effective treatment. Solarization is most effective when done during the hottest weeks of the year. The best time for solarization of soil in Nepal is from March to June, although good results may be obtained starting as early as late May. Soil can also be solarized during September after the rainy season. Winter is not a suitable season. There are several steps involved in soil solarization:

Soil preparation: A smooth bed with no clods and litter is best because the plastic will lie tightly against the soil and have fewer air pockets. Air pockets between the plastic and the soil can greatly reduce soil heating and promote 'sailing' of the plastic in the wind. Solarization can be done on flat areas or raised beds. For future nurseries, raised beds of 1–1.5 metres width and convenient length are made. A trench should be made on all sides of the bed for draining water. If possible, when using raised beds, lay them out going north to south rather than from east to west to improve the uniformity of heating.

Soil irrigation: Before placing the plastic tarp on the preformed beds, moisten/irrigate the beds, ensuring that the water seeps up to 30 cm into the beds. Wet soil conducts heat better than dry soil and makes soil organisms more vulnerable to being killed by heat. In larger areas it is easiest to do this prior to laying the plastic.

Choice of plastic tarp: In general, transparent or clear plastic is most effective for solarization, as the heating rays from the sun will pass through the sheet and get trapped to heat the soil below. Usually, black plastic is less effective because it absorbs and deflects part of the heat rather than trapping it as clear plastic does. However, in cooler areas, black plastic is sometimes better than clear. The use of clear plastic produces higher temperatures faster because the sunlight passes through the clear plastic to heat the soil. In a cooler climate or a cooler time of the year, black plastic works just as well because it absorbs the heat making it quite hot. The gauge of plastic should be from 250–300. The plasic sheets should not overlap and should have no holes in it.

Plastic tarp placement on flat beds: The plastic must be held as tight as possible against the soil. One way to hold it down is to dig a trench 10–15 cm deep around the area that is going to be solarized:



Spread the plastic over the selected area with one edge in the trench.

- Cover that edge with soil to hold it down.
- Pull the plastic tightly from the other side and bury that edge in the corresponding trench.
- Do the same with the other sides and then walk around the perimeter of the trenched area to pack the soil down around the edges of the plastic. The closer to the soil surface the plastic is, the better the heating.

Plastic tarp placement on raised beds: As with flat beds, the plastic must be held close to the soil. Multiple beds can be covered with a single sheet of plastic, but this might reduce the amount of heat the soil receives and the plastic may 'sail' when it is windy. If only single beds are covered, the furrows between the beds are left uncovered. Each bed is covered with a strip of plastic tarp that is wide enough to cover the entire bed width and have enough plastic material left over to bury the edges to hold it down. Avoid moving soil from the untreated furrows to the beds because this may re-infest the treated beds with pests. Plastic tarp may be pressed against the bed with long wooden planks so that it is held tightly in place.



e) Solarizing soil in containers

Soil solarization has been shown to be effective for disinfesting small amounts of moist, containerized soil and soil in cold frames. Soil can be solarized either in bags, pots, plastic buckets, or flats. These containers are placed on an elevated surface such as wooden pallets and covered with a "double-tent" of transparent plastic. Soil temperatures should be monitored closely in this planting media to assure that temperatures are high enough to control pests. For example, in warmer areas, soil inside black plastic bags can gain more than 70°C during solarization. This is equal to target temperatures suggested for commercial soil disinfestations that use aerated steam. At these temperatures, all soil pests can be killed within one hour. Soil temperatures can be monitored using simple soil thermometers inserted into the centre of the soil mass.

f) Solarizing period

The duration of solarization depends on the season and soil temperature. The cooler the soil temperature, the longer the plastic needs to remain in place to raise the temperature to desired levels. In general, 4 to 6 weeks of soil heating during the warmest time of the year is sufficient to control most soil pests. In some cases, such as in cooler, windier, or cloudier locations, or if there are pests that are harder to control, it may be necessary to leave the plastic in place for 6 to 8 weeks. On the other hand, in persistent hot weather, some pests can be controlled with solarization lasting a shorter period. Soil in the Terai and lower basin regions can be solarized for 4 weeks anytime between April and June. The temperature inside the plastic reaches 50°–60°C and sometimes even up to 70°C.

g) Advantages of soil solarization

One of the best non-chemical ways to get rid of weeds, and some diseases and pests, is to solarize soil. While this technique is normally used in areas with lots of sun and high temperature, it can be modified and carried out in containers and pots also. The results may not be as long lasting or effective, but it can definitely help the plant battle against pathogen.

Solarization is a simple non-chemical technique that captures the radiant heat and energy from the sun and causes physical, chemical, and biological changes in the soil. These changes lead to control, or suppression of soil borne plant pathogens such as fungi, bacteria, nematodes, and pests along with weed seeds and seedlings. Solarization kills a wide range of soil inhabiting pests such as wilt and root rot fungi, root knot nematodes and noxious weed seed. In addition, solarization stimulates the release of nutrients from organic matter present in the soil. It is especially effective for treating garden soils where vegetables, herbs, and flowers are to be grown. The advantages can be summarized as follows:

- Soil is sterilized and protected from diseases and insects.
- It can control/drive away nematodes.
- Once solarization is done, it may be effective for six months.
- Seed germinates well and no damping off occurs.
- The number of healthy seedlings per square metre increases and seedlings become healthy.
- Productivity increases by 20–30 percent in solarized soil.

h) Post-solarization

After solarization, the plastic may be removed, taking care not to disturb the underlying soil so as to avoid bringing up new organisms in it and viable weed seed. The area can be planted with seeds or transplants. Alternatively, the plastic may be left on the soil as mulch by cutting holes and transplanting plants through the plastic. If cultivation is needed for planting, the planting must be shallow, about 5–10 cm, to avoid bringing viable weed seeds and pathogens to the surface.

3.2.3 Crop and weather smart

In a broad sense, this entails managing crop on the basis of seasonal weather forecasts, information communication technology based agro-advisories and index-based insurance. At the farm level, it includes alteration in production and harvesting time to escape extreme weather (e.g., farmers started planting potatoes 15 days later in the mid-hills of western Nepal to escape frost during the peak growing period), introduction of new varieties (e.g., cauliflower and cabbage varieties are available in regional markets suitable for the rainy season), changes in farming practices (e.g., plastic house technology for rainy season tomato production in the hills), etc.

i) Crop rotation, inter cropping and mixed cropping

Crop rotation combined with mixed cropping and nitrogen fixation through intercropping is another smart technology to employ. Different crop types are available for efficient use of soil nutrients at different depths of soil. Deep rooted crops after shallow rooted crops, leguminous crops after non-leguminous crops are the examples of crop smart technology. Different combinations have been tested in multiple locations to assess their suitability for variable rainfall patterns and climatic conditions, as well as home gardening and integrated pest management.

ii) Varietal selection

The varieties of different crops are tested in certain agro-ecological conditions at the research station and recommended for ideal conditions similar to the research stations. Besides, the varieties are tested and recommended several years in advance, thus anticipating changes already taking place in rainfall patterns, humidity, and temperature. These differences in geographical location and changes in climatic conditions demand both on-farm verification of the varieties to check performance of the varieties under the given conditions.
In collaboration with the District Agriculture Development Office, the crop varieties are identified and their performance (yield, pest/disease resistance, drought tolerance, etc.) compared with that of the farmers' variety. This creates opportunity for the farmers to make the right decision.

3.2.4 Knowledge smart technology

Agricultural development of a country requires wider dissemination of information, skills and knowledge to the farmers so that they can adopt these practices to improve their production system, outputs and income. Knowledge smart practices encompass everything that farmers needs to make decisions. These may include farmer-to-farmer learning, knowledge networks and platforms, electronic media, different kinds of publications, etc. that impart knowledge on the input supply, production related matters and marketing information.

i) Farmer-to-farmer learning

Innovative farmers who are already adopting climate-smart practices are the best source of information, as they can share their knowledge and experience with other farmers in their community. Exposure visits are very effective for scaling up the technologies.

ii) Learning centres

The pilot sites where smart technologies are demonstrated and adopted by farmers could be used as learning centres for development actors and extension workers.

iii) Networks and platforms

The formal as well as infromal networks like coordination committees, advisory committees, etc. established to support the operation of the intervention help influence policy and scale up the results through other value chain actors.

iv) Information and communication technology (ICT)

Use of ICT is fast and effective means for dissemination of knowledge is fast and effective. The weather information, market information and production technologies are readily available on the websites and can be accessed easily. The information can also be broadcast quickly through radio and television or disseminated through mobile phones using SMS. Websites such as www.accuweather.com and www.worldweatheronline.com have satellite connections at more than 100 locations in Nepal and forcast weather information for 14 days. Similarly, Agro Enterprise Center (AEC) http://www.aec-fncci.org/ under the Federation of Nepalese Chambers of Commerce and Industries (FNCCI) has been supporting the establishment and management of market information websites where market prices are collected daily from about 40 major markets of Nepal and stored for public use, e.g., the website of the Kalimati market: http://agribiz.gov.np/dailyprice/pricelist/kalimati.app/ and the website for all markets in Nepal: http://www.agripricenepal.com/. The HIMALICA project has been using the SMS system to provide farmers information on weather forcasting for three days, daily market price in the district and regional markets, and messages on improved technologies based on the cropping calendar.

v) Publications

Brochures, flyers, leaflets, bulletins, manuals, posters and other forms of written documents provide varied levels of information, some summarizing it for quick reading and others providing substantial details on the subject matter. Some of the publications of HIMALICA are: i) HIMALICA project brochure, ii) Package of Practices for Climate Resilient Value Chain Development of Major Vegetables in Udaypur, Nepal (English), iii) Farmers' Booklet on Major Vegetables (Nepali), iv) Flyer on Jholmal Preparation and Application (Nepali). These publications could be used as reference materials for disseminating and scaling up the technologies.

vi) Business to business linkages

Understanding how market function and how to engage in the marketplace is the key to ensure sustainability of the chain. Strengthening horizontal linkages helps farmers to achieve economy of scale and enhance bargaining powers. Establishing cooperative/associations, providing them adequate information and knowledge about market, and facilitating buyer-seller meets and participation in trade fairs are some of the ways to strengthen relationship and networks among actors working at different nodes of the chain.

3.2.5 Energy smart technology

i) Incorporation of crop residue

Incorporating succulent crop residue of previous crops like rice and wheat in soil helps increase humus and nutrient in soil. Crop residue of rice is applied in late winter and spring vegetable production. Similarly wheat residue is applied in rainy season vegetable production. During rice and wheat harvest, farmers are asked to leave behind one foot of the plant in the field. The remnant is ploughed into the soil and incorporated in the field during field preparation for the subsequent crop.

ii) Plastic tunnels for off-season vegetable production

Small and large plastic houses are energy smart techniques for growing off-season seedlings and crops that can be marketed earlier or later than in-season crops. Similarly combining environmentally sustainable energy like bio-gas and bio-gas slurry and using it for vegetable production is another energy smart technology. In collaboration with and support from the Alternative Energy Promotion Centre (AEPC), biogas plants can be installed with provision of technical support for regular maintenance. Hot bed preparation and double digging techniques are other energy smart techniques for increasing crop productivity.

iii) Solar lift irrigation

Solar power is one of the energy efficient power source used for lifting water for irrigation purpose. The direct use of solar power is attractive for the small-scale pumping of irrigation water. The technical feasibility of solar powered pumping has been demonstrated in Udayapur using AC pumps. The initial investment is slightly higher when compared with conventional alternatives, such as diesel or mains electric pumps. But the operation cost is nominal and maintenance cost is reasonable as the panels have 20 years warranty and pump can be repaired locally. It is observed that 1.5 HP pump can lift water at vertical height of 70 meters @ 0.5 lit water per second. The area to be irrigated per day depends upon method of irrigation used.

iv) Solar dryer

Solar dryers are used to dry the vegetables and spices to prepare semi processed or processed products. These devices are more useful when the production area is away from the road head. In case of Nepal, the solar dryers can be used for drying spices like turmeric, chilly, ginger and vegetables like cauliflower, radish etc. The devices are affordable by the small holder farmers because they are assembled by local promoters using low cost materials.

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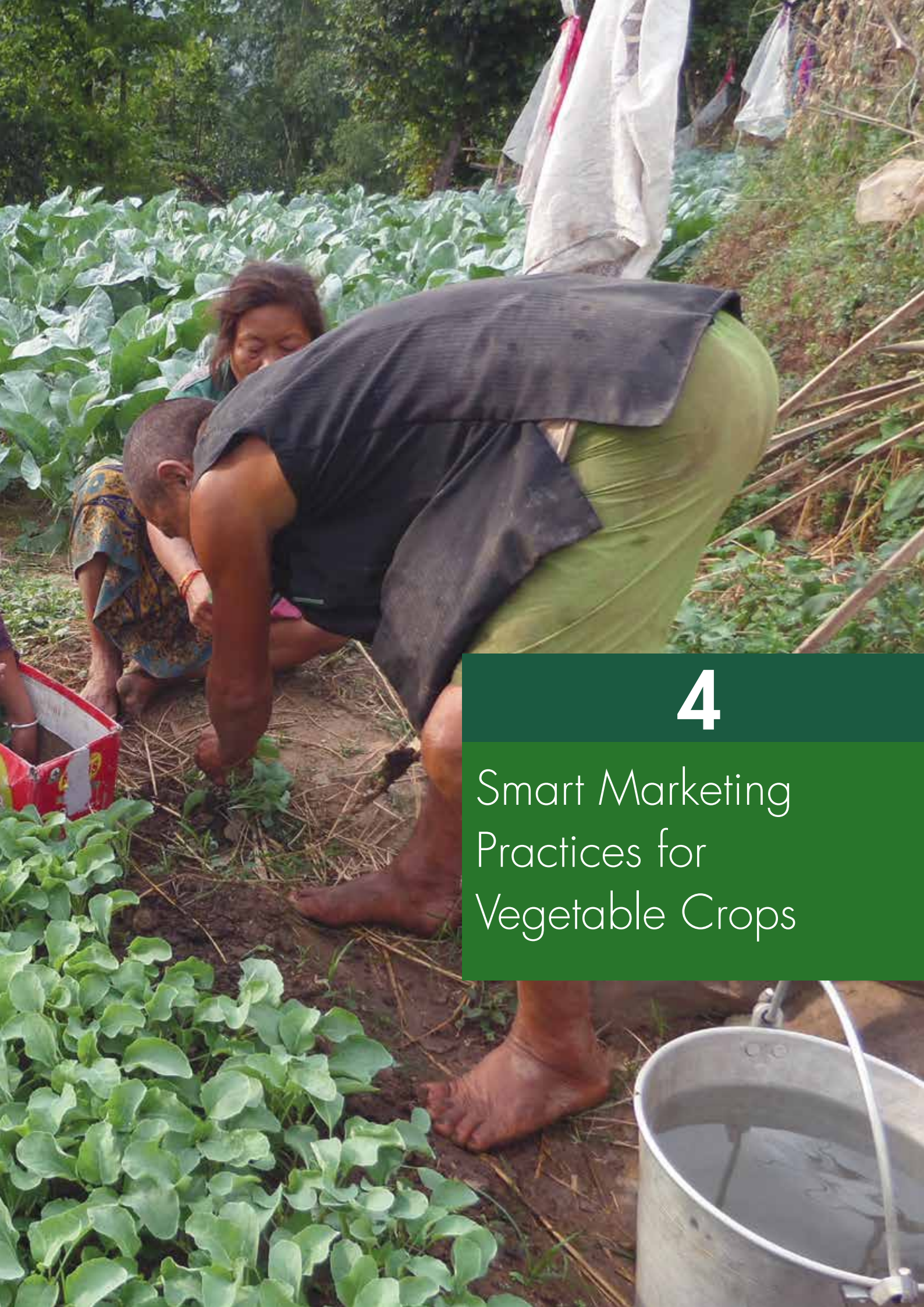


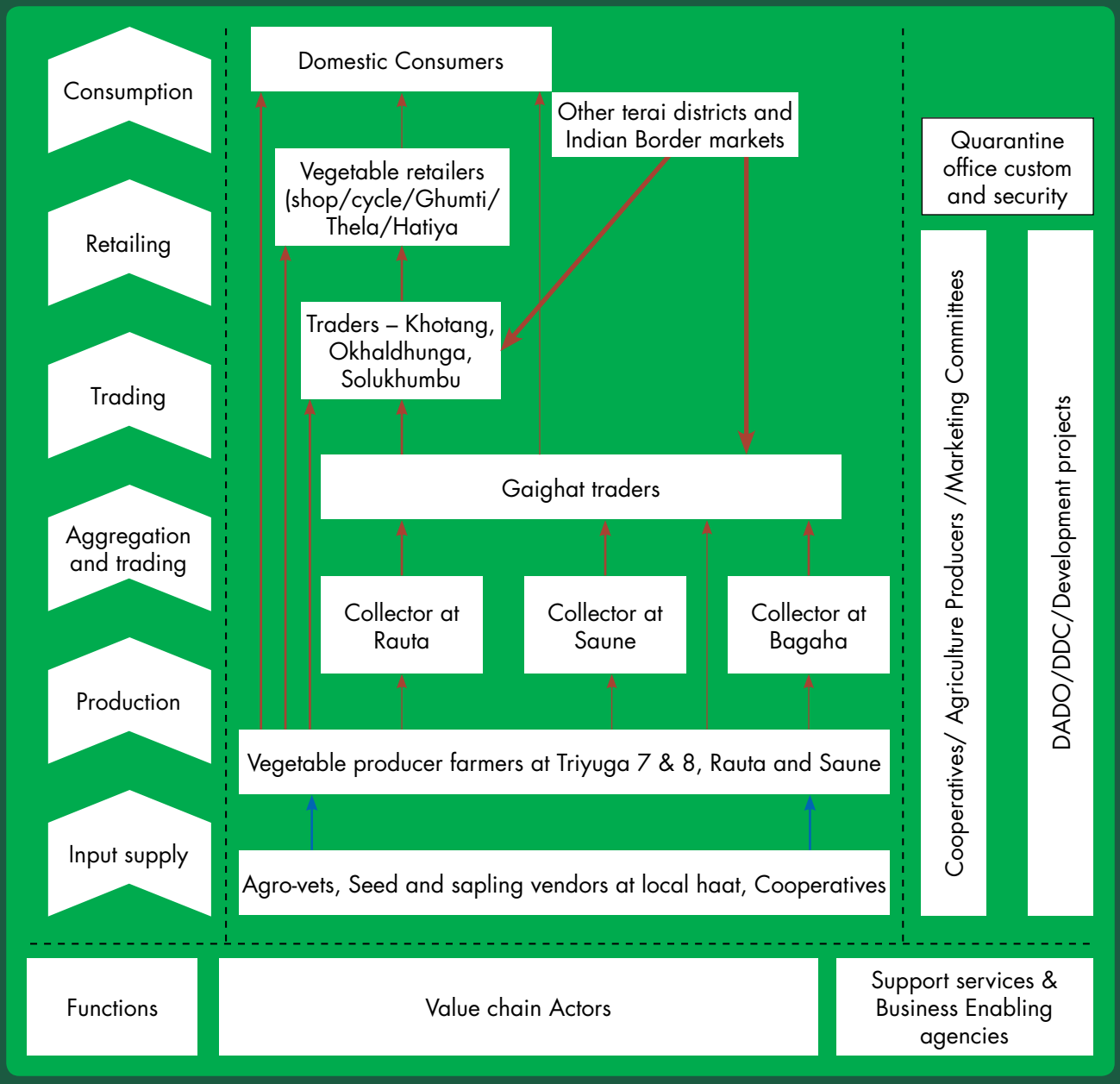
4

Smart Marketing Practices for Vegetable Crops

4: Smart Marketing Practices for Vegetable Crops

Farmers in Udaypur primarily engage in subsistence farming and have recently started moving towards commercial farming. Still there is a lack of proper cleaning, sorting, grading, packaging and labeling of the farm produce. The marketing system is ad-hoc group bringing vegetables to the wholesale market. Interactions with market actors revealed the presence of four marketing channels for fresh horticultural commodities including cauliflower. These channels are presented in Figure 4.

Figure 4: **Generic value chain map of fresh vegetables in Udayapur district, Nepal**



- Local agro-vets, seed & sapling vendors at the local haat and local cooperatives supply inputs to the farmers.
- Producer/farmers sell vegetables directly to the consumers (primary stage of marketing) or to the traders at different levels.
- Retailers buy at the farm gate and sell to the consumers.
- Wholesalers receive vegetables in bulk from the collector/commission agent and sell them to retailers at wholesale price and retailers sell them to the consumers.
- Collection centre send vegetables to wholesaler and wholesaler in turn sells them to retailer, who sell them to the ultimate consumers.

Retailers are important actors in vegetable marketing. There are different types of retailers: a) Absolute vegetable retailers (sometimes including fruits); b) Vegetable retailers in grocery shops; c) Vendor retailers who visit the locality to sell vegetables; and d) Departmental stores/marketing centre with a vegetable sale corner.

Vegetable sale at farm gate

Vegetable sale by the street vendor

Vegetable sale at Kalimati

Producers and consumers benefit from a short marketing channel. Increase in the marketing channel simultaneously adds up the marketing cost and profit margin and increases the price of the product at the end market. Paradoxically commercial farmers do not have time to do direct marketing. Farmers have therefore made marketing groups that would sell the produce to the market that offers a good margin. Right now as there is a lot of demand for local market produce, it would be better to send the produce directly to the retailers based in Udayapur/ Gaighat. National statistics show that the average price of cauliflower is NPR 50 (June) in the Kalimati market; however farmers are getting NPR 30 (June) in Gaighat market. Market price of the same commodity fluctuates depending on supply and demand and may also vary across cities. Thus farmers should have market information of major cities for direct marketing. Individual farmer or a group of farmers/cooperatives may contact delivery points of the big cities to sell their products. In addition to the higher market prices, farmers should also be careful about the payback date. Timely payment from the recipient parties is equally important.

4.1 Smart Marketing Practices

Smart marketing practices include strategy and actions required to maintain good balance between push and pull marketing. In push marketing, the idea is to produce vegetables, supply bulk quantity with collective dealing to the trades, who then push the products to different markets. In pull marketing, the idea is to create demand by building story and/or highlighting unique features of products and production processes.

Market oriented production and product marketing are two sides of the same coin and one cannot stand alone in the absence of the other. The traditional system of finding a market after the production is not a right approach. Commercial farmers have to analyse potential markets for better prices and be aware of the risks in the big markets. Smart marketing starts with the planting of a particular crop. Farmers who are planning to engage in commercial farming should keep the following points in mind:

- A farmer has to keep a good record of all production costs (Annex 1) including her/his own labour cost and other accidental costs. It helps farmers to judge what would be the most profitable crop and what would be the minimum price to cover the cost of cultivation. A rough calculation of the cost of production of cauliflower is present in the table at the end of the PoP for cauliflower.
- Selecting high quality products and cleaning, sorting, grading, packaging and labelling the products will fetch a higher market price.

- Farmers should analyse existing marketing channels and identify the most profitable channel taking their own geophysical and social circumstances into consideration.
- To shorten the marketing channel, farmers' group/cooperatives may perform the task of collecting, sorting, grading, packaging and labelling the produce and sending it to the destination market.
- It is important to note the maturity and harvesting stage of each crop in relation to the market distance, size, quantity and quality parameters set by the buyers before taking the produce to the market.

Vegetable sale at Kalimati

- Sustainable supply and continuity is very important for strengthening the relationship between farmers and buyers.
- Vegetable market is highly dependent on trust. Trust should be maintained by all market actors including producers.

4.2 Possible Reasons for Post Harvest Losses in Fresh Vegetables

There are several reasons behind post harvest losses of fresh vegetables. Adoption of appropriate crop management practices, harvesting at the right stage and with appropriate methods, field level cleaning, grading, packaging and transporting are important for reducing post harvest loss under smart marketing. The following steps and practices are effective in reducing post harvest losses:

- Selection of an appropriate variety: Among different varieties, variety that has high storability can bear transportation shock and distance to the destination market. Desire of the consumers must be considered during selection.
- Harvesting at an appropriate stage: Harvesting stage varies according to the crop and crop variety and the distance to the destination market. Tomato, for a distant market, should be picked when it starts yellowing at the base of the fruit; however, for the local market, it may be harvested when it's half ripe. Vegetables like eggplant, okra, beans and cow peas are harvested when they are tender, before they become fibrous.
- Appropriate methods of harvesting: While harvesting vegetables, care should be taken not to injure fruits, curd, head, and pods. Breaking and cracking should be avoided while harvesting and handling green leafy vegetables.
- Proper cleaning and sorting: After harvesting the produce, the rotten parts, damaged fruits, deformed heads and curds, diseased and damaged parts must be cleaned and sorted and separated from the batch that will be sent to the market. Sorting and selecting the produce at the farm, based on the size, colour and grading, increases the quality and enhances the appearance of vegetables.
- Proper storage: To retain the quality of produce after harvesting, they should be washed and stored in a shade and cool room. Depending on market demand, cabbage, radish, turnip, carrot, etc. can be harvested a few days after harvesting time but the harvest of tender fruits and tomato should not be delayed. In areas with low temperature and high humidity, tender fruits may be stored for a few days to fetch better prices.
- Proper packing and transportation: Once all the above precautions are taken, the produce should be packaged well and handled carefully during transportation, otherwise the loss may increase. Different vegetables need different packing materials such as high gauge plastic bags, crates, cartons, and gunny bags or bamboo baskets. While transporting vegetables, care should be taken to avoid bruising, pressing or breaking them.
- Sorting and grading: Some farmers mix good and bad vegetables and try to deceive the buyer. But this technique does not work in smart marketing. Grading vegetables based on their size, colour and appearance and then pricing them accordingly will fetch better prices. Buyers usually select better-looking fruit and vegetables, and the retailer has to ultimately bear cost of the rejected produce. If the produce is graded and packaged based on their quality and quantity (1kg, half kg pack) and sold with a price tag, it will encourage consumers to buy according to their need and economic capacity.

The following table provides a general guide on handling different vegetables under smart marketing techniques.

4.3 Role of Cost-Benefit Analysis in Smart Marketing

Planned production requires a cost benefit analysis to calculate the breakeven point and net profit. In vegetables, there are several alternatives for comparative advantage. Cost benefit analysis helps farmers select a particular crop/variety for a particular season and destination market. It helps in the following activities:

- Helps to determine the minimum price of the produce.

Table 2: **Harvesting and post harvest handling of different vegetables**

S.N	Vegetable kinds	Pre-harvest selection criterion				Post harvest grading criterion
		Maturity	Color	Size/shape	Taste	
1	Cauliflower	Tight full grown curd	White/creamy white	Depending on groups*	Plain	Depending on colour, shape, size
2	Cabbage	Tight full grown head, relatively long shelf life	Green to pale green	Round/oblong/ flat**	Plain	Based on size – small, medium, large
3	Tomato	Matured green to red	Matured green to red	Round/plum shaped/flat	Sour/ sweet	Shape, size, colour and maturity stage
4	Eggplant, chili, pepper, okra	Matured tender fruits	Green to purple	Round/conical/ slender	Plain	Shape, size, colour and maturity stage
5	Radish, turnip, carrot	Matured tender roots	White/purple/ orange	Slender long/ round/flat	Pungent/ sweet	Shape/size/length and root colour
6	Onion	Neck starts to break	Brown to dark red	Round/conical/ flat	Pungent	Shape/size and skin colour
7	Pumpkin,	Tender /Matured	Green/ striped/yellow	Round/Oblong	Plain	Shape/size and fruit colour
8	Squash, gourds	Tender unripe	White to green	Round/conical/ slender	Plain, bitter	Shape/size and fruit colour
9	Peas,	Matured grain filled	Green	Slender long	Plain/ sweet	Shape/size and pod colour
10	Beans	Tender pods	Green	Slender long	Plain	Shape/size and colour
11	Cow-pea/ Asparagus bean	Tender pods	Creamy white /green	Slender long	Plain	Shape/size and pod colour
12	Rayo, spinach, etc,	Tender green leaves	Green/red/ purple	Variety wise	Plain/ pungent	Shape/size and leaf colour

*early/ mid/late, early group: 0.5–1kg, mid season: 1–3kg, late: 1–3kg.**1–3 kg

- Helps to reduce per unit cost and prevent unnecessary expenditure.
- Helps to identify profitable future production enterprise.
- Helps to take right decisions in crop/enterprise selection, financial analysis, credit demand and repay planning.

There are generally four major headings of expenditure in crops production:

- Fixed cost such as land revenue, farm tools and equipments, interest on capital fund
- Variable cost are of three types i) Material cost such as seed, fertilizer etc. which varies from crop to crop ii) animals and machinery power cost and iii) human labour – both family and hired labour

The costs of production of different vegetables vary from crop to crop and variety to variety and place to place. For example, the estimated cost of production and net profit are given at the end of the production practices for each crop.

Farmers should keep a record of the production process for each crop and each season using the format provided in Annex 1 and calculate the minimum price.

5

Climate Smart Package of Practices for Major Vegetables

5: Climate Smart Package of Practices for Major Vegetables

5.1 Cauliflower

5.1.1 Introduction

Cauliflower (*Brassica oleracea* var botrytis) is a cool season crop in the Cole crop family. Other crops include broccoli, Brussels sprouts, cabbage, collards, kale, and kohlrabi (Knol-khol). The taxonomical description is presented in Annex 1. Cole crops are best suited for a cool climate. In the plains and mid-hills, they grow well in winter. At higher altitudes around 2,000 metres or above, these crops can also be grown in spring and summer/ rainy season. The edible parts of these crops may differ in appearance, but the climate, soils and cultural requirements are similar. Cole crops are of European origin but are cultivated all over the world in suitable seasons and at appropriate altitudes. Cole crops are cultivated across Nepal from the Terai to high hills. Cauliflower and cabbage are grown commercially, and broccoli and knoll-khol are slowly growing popular. Chinese cabbage, Brussels sprout and kale are new to the Nepali market. In Nepal these vegetables are generally cooked/boiled and eaten. Snacks like *pakaudi* and *tempuras* are also made from cauliflower and broccoli. Cabbage and knoll-khol are also consumed as salad.

5.1.2 Climatic requirements

Cauliflower is more temperamental than its relatives. The trick to growing cauliflower well is ensuring that the temperature is consistently cool. Timing is important to get the right temperature for curding. The growing site for this crop must have at least of 6 hours of full sun each day, and more is better. The site should not be shaded by trees, tall grasses and other crops. Cauliflower seed germinates in 10°–21°C temperature. For good vegetative growth, optimum temperature requirement is 15° to 25°C. For curd formation, early varieties require 25° to 20°C and mid-season variety 20° to 15°C descending temperature Late varieties grow well in 10° to 25°C and curd formation requires 15° to 25°C ascending temperature. Early varieties grow well in higher temperatures; curding takes place under comparatively short-day conditions. Late varieties grow well in lower temperatures and curding takes place under long-day conditions.

5.1.3 Soil requirements

Cauliflower needs fertile, well-drained soil with rich organic matter and a steady supply of water and nutrients. It requires slightly acidic soil with pH range varying from 6.5 to 6.8 (This pH range minimizes the danger of a cauliflower disease called club root and maximizes nutrient availability). Soil test before planting is always advised for pH and nutrient availability. Though cauliflower can be grown in all types of soil, light loam to sandy loam soil with rich organic matter is preferable. Well-drained soil with high water holding capacity is best for cauliflower cultivation. Soil should never be muddy and water logged.

5.1.4 Land preparation

Cauliflower grows well in well-drained fertile soil that can hold moisture. Soil should be prepared well. One or two rounds of deep corrosive plowing followed by 2–3 rounds of light plowing and clod breaking are needed to make soil friable, loose and level. For ridge transplanting for early varieties during summer/rainy season, 15 cm raised beds of 100 cm width with a 25 cm wide trench between two beds should be made. For mid and late varieties, the bed width should be made 120 cm. Two rows can be transplanted in each bed. Organic manures like FYM should be applied at the time of main field preparation. Before ridge making, all other fertilizers except a half dose of nitrogen should be thoroughly mixed in soil. This helps the transplanted crops to utilize nutrients efficiently.

5.1.5 Manure and fertilizer application

Cauliflower removes large quantities of nutrients from the soil. For best results, 15–20 tonnes /ha of FYM or any compost should be added to the soil 2–3 weeks before transplanting. To supplement the FYM, apply 75 kg of nitrogen, 85 kg of P_2O_5, 45 kg of K_2O per ha. If no FYM is applied, double the quantities of chemical fertilizer. However, for climate-smart nutrient supply, use of FYM is mandatory. To be sure of soil pH, test the soil. Apply fertilizer and lime based on test results.

The FYM is applied 2–3 weeks before transplanting so that the period of rapid release of nutrient from the manure coincides with rapid growth of the crop. The full dose of P_2O_5 and K_2O and half dose of nitrogen mix thoroughly in the soil at the time of making the beds. Apply the remaining half dose of nitrogen as top dressing in two batches – a month after transplanting and again when the plants start forming heads. Since the root system of cauliflower is dense and shallow, the top dressing of urea fertilizer in bands 5–10 cm away from the young plants at 2–3 cm deep in ring bands gives the best results. If fertilizer is applied close to the plants, it will kill the plant by burning.

Application of Jholmal at weekly intervals until a month before harvesting has been found to be effective in replacing the use of chemical fertilizers and can also effectively control most of the diseases and insect pests (see chapter 3.2.2.vi for details).

Use of micronutrients: Vegetable crops need micronutrients such as boron, zinc, molybdenum, manganese, iron, etc. Deficiency of boron and molybdenum is common in cauliflower. Supplement micronutrients are available in various multi-nutrient rich commercial formulations such as *Agrolic* and *Agromin* and also in single formulation. The plant needs a small amount of micronutrients but its effect is substantial. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. While using such formulations, it is important to read the instructions on the label and take the necessary precautions.

Boron deficiency symptoms first appear in the younger leaves. They remain small, are stiff and light green. Margins turn reddish or brown. Older leaves are curled down and may show reddish discoloration or chlorosis. Development of curds is retarded and only light curds are built. They are more or less brown. Several leaves and bracts penetrate curd surface. Taste is bitter. Boron deficiency on cauliflower results in yield losses. It becomes more prominent in sandy soils, alkaline soils and soils low in organic matter. High levels of nitrogen and calcium and cold wet weather also increases boron deficiency. In matured cauliflower, hollow stem with a black layer is very common. Molybdenum deficiency causes whip tail in cauliflower. As a corrective measure, borax 14 to 20 kg and sodium or ammonium molybdate 10 kg per ha can be applied while preparing the field. If the symptom appears after transplanting, two foliar sprays of micronutrient formulation at the rate of 1–2 ml per litre of water at weekly intervals will correct the deficiency.

Micronutrient deficiency is more prone in acidic soils. Soil pH must be maintained at 6.5 to 6.8. If it is lower than this, apply 200 to 300 kg lime per hectare while preparing the field.

5.1.6 Variety selection

Earlier varieties: Earlier varieties curd 60 to 75 days after transplanting. Currently available varieties in the market include Silver Cup-60, N.S 60, Snow King, Himlata, White Top, Deepali, Remy, Milk Way, White Flash, Sweta, etc. Early varieties require 25° to 20°C descending temperatures for curd formation.

Mid-season varieties: Mid-season varieties curd 75 to 100 days after transplanting. Currently available varieties in the market include Snow Crown, N.S. 90, N.S. 84, Snow Queen, Snow King, Kathmandu Local, Snow Mystic, Jyapu, etc. Mid-season varieties require 20° to 15° C descending temperate for curd formation.

Late varieties: Late varieties curd 120 to 150 days after transplanting. Currently available varieties in the market include Kibo Giant, Madhuri, Snow Ball 16, Dolpa Snow Ball, etc. Late varieties grow well in 10° to 25°C and curd formation requires 15° to 25°C ascending temperature.

Note: New varieties in the above groups are appearing in the market due to advancement in breeding. Farmers and technicians must be aware of their characteristics and duration.

5.1.7 Nursery establishment and management

Select a well-drained open space for the nursery. A 100 square metre nursery is required for one hectare transplanting. While preparing nursery beds, apply 5–7 kg of well-rotted FYM/compost per square metre on the land. 500–700 kg of FYM is needed for 100 square metres. During rainy season, make one metre-wide raised beds 15 cm height with a 25 cm wide trench between beds. Length of beds may vary but should not be more than 10 metres for easy care and management.

Where possible, soil solarization before seed sowing is recommended to kill the fungus and other germs and protect seedlings from fungal attack. Solarization is a process of covering nursery beds with a white plastic sheet for at least two weeks to a month under high temperature.



Before sowing, treating the seeds with 2–3 gram bavistin per kg seed prevents seedlings from soil-borne fungus.

After preparing raised beds, make 2–3 cm deep tiny U-shaped furrows 10 cm apart with the help of a small stick. Drop the seed using your thumb, forefinger and middle finger. Cover the seed with fine sand or fine soil compost mixture or with ash depending on availability. Then mulch the beds with straw or specially made thin perforated jute sack. After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that soil is moist but not over watered till the seedlings emerge. Cauliflower seed germinates after 4 days of sowing. When seed germinates remove mulch and water very carefully and lightly. Splashing water with force and heavy watering may damage young seedlings and damping off may attack the nursery.

After they sprout 3-4 leaves, cauliflower seedlings are transplanted into a second nursery for hardening. Among mid and late season varieties, this is generally done 10 to 15 days after germination. In early varieties, seeds are sown thinly and no hardening takes place as the plant has a very short life span.

5.1.8 Seed rate and seedling requirements

For one hectare land 200 to 500 gram seeds are required depending on germination percentage and seed vigor. Healthy and well-grown seedlings are required at a rate of 30,000 to 32,000 seedlings per hectare.

5.1.9 Transplanting

Early variety seedlings are ready for transplanting 25 days after sowing while it takes 30–35 days for mid and late varieties. Accordingly seed should be sown 25 to 30 days before transplanting time. Well-hardened seedlings that are 4–6 weeks old with 4–6 true leaves are ready for transplanting. Hardening enables the plant to withstand transplant shock. Moistening the nursery beds before lifting the seedlings make their removal easy and prevents injury to the root system. Select only healthy and strong seedlings for transplanting. Avoid blind and weak seedlings with constricted wire stems. Transplanting into narrow ridged beds during the rainy season and into flat beds during winter and dry period will be beneficial. Transplanting is preferably done in the evening. Soil should be packed tightly around the seedling to establish close contact with the roots following irrigation. Transplanting times may vary according to altitude, temperature and season. Transplanting distance depends on the variety. Early varieties are transplanted at 50 cm row to row and 25 cm plant to plant distance whereas mid and late season varieties are transplanted at 75 cm row to row and 50 cm plant to plant distance. While transplanting, only cover the stem part covered by soil in the nursery and gently press the soil around the stem.

Transplanting and harvesting time varies according to topography and altitude. As it takes 4–6 weeks from germination to transplanting, seeds should be sown in the nursery one month before transplanting.

Transplanting and harvesting months

Geographical areas	Early varieties	Mid season varieties	Late varieties
Terai, inner Terai and low hill basins (Terai to 600 metres)	August-September (October-November)	September-October (November-December)	October-November (December-February)
Mid hills (600 to 2,000 metres)	July-August (October-November)	August-September (November-December)	December-January (March-April)
High hills (more than 2,000 metres)	May- June (August-September)	June-July (September-October)	February-March (May-June)

Note: Months within parentheses are harvesting months.

5.1.10 Irrigation and water management

After transplanting, light irrigation with a watering can is necessary to maintain proper soil moisture level to get a good yield of cauliflower. Early and mid season varieties need only protective irrigation during the rainy and late rainy season. However, if there is no rainfall during October, irrigation is required. The critical stages of irrigation in cauliflower are just after transplanting, urea top dressing, weeding, intercultural operation, earthing up and at bulb formation. Water requirement varies according to soil type. Sandy and silt soil needs more irrigation whereas loam soil needs less irrigation. In normal conditions, soil moisture should be between 50 to 100% of field capacity.

Cauliflower transplanted in a ridge and furrow system of irrigation is always better. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds should be constructed near the cultivation area, and collected water should be applied by drip. After irrigation and heavy rain, draining of excess water is mandatory; otherwise root rot and fusarium wilt will increase.

5.1.11 Intercultural operations and care

A week after transplanting, a thorough inspection should be carried out and gaps should be filled in the spots where plants are dead and wilted. During the early stage of growth, weed competes with the crop for nutrients and moisture and crust formation also appears. Light hoeing and first urea top dressing 30–35 days after transplanting, followed by earthing up keeps growth uniform. Field should always be kept free of weed and soil should be kept loose around plants. Black polythene mulching and transplanting is emerging as weed control and moisture retention technology; it reduces the weeding cost and prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures. This technology is accepted as climate smart technology.

5.1.12 Plant protection

Protection of cauliflower from harmful insects and diseases is very important. The major insects are cabbage butterfly, cutworms, diamond back moth, and aphids. Common diseases include damping off of seedlings, downy mildew and club root.

Major insects and their management

Insects	Types of damage	Management
Aphids	Greenish white nymphs of aphids suck sap from the leaves, stems, flower and pods in seed crops. When the attack is severe, plants wilt and die. It causes severe damage from seedling stage to curd formation.	• Spray with soap water, human or cow urine, tobacco or neem extract or dust with ash. • Spray Diclorovus, Nuvan 76 EC @ 0.5 ml per litre of water at weekly intervals. • Spray 0.20% malathion at an interval of 10–15 days. • After spraying pesticide, wait for 7 to 21 days as indicated on the label of the poison container. • During the waiting period, do not harvest and do not eat any parts sprayed with pesticide.
Cabbage butterfly	Caterpillars eat tender leaves from the margin onwards, leaving the primary veins intact.	• Collect egg mass and larvae and destroy them. • If the attack is severe, spray 0.1% pyrethrums when curd formation is in process.
Diamond back moth	Caterpillars eat and damage young leaves including growing tips.	• Collect egg mass and larvae and destroy them. • If the attack is severe, spray 0.1% pyrethrums when curd formation is in process.
Cutworms	They cut the base of the seedlings and newly transplanted crops, causing the the plants to topple down. Caterpillars eat young leaves and growing tips.	• Collect larvae and kill them. • Spray multinim @ 2 ml/litre of water.
Red ants	They swarm and eat up the above-ground bark. Plants wilt and die.	• Spray cloropyriphus @ 1 ml/litre of water and make the base wet. • Use poisoned meat or bread as bait.

Major diseases and their management

Diseases	Symptoms	Management
Damping off	Fungus attacks the base of the seedlings above the soil level. The base then becomes water soaked, black and collapses rapidly, causing the seedling to die.	• Treat the seed with Bavistin @ 2.5 gm/kg seed. • Do not sow seed thickly in the nursery. • Drench the nursery beds a fortnight before sowing with 25–30 ml/litre formaldehyde and cover the nursery for about 3 days.

Downy mildew	Yellowish lesion appears on the upper surface and cottony fungal growth appears on the lower surface of the leaves.	• Spray Dithane -M-45 or Crylexil @ 2 gm/litre of water.
Club root	Knots of different sizes appear/ develop on the whole root. Plant becomes stunted and then wilts and dies.	• Select a healthy site for the nursery. • Burn debris and straws at the nursery site. • Apply 1 kg lime and 1 kg mustard cake per square metre of nursery bed. • Lime increases the soil pH and reduces the attack of club root.

5.1.13 Maturity and harvesting

In cauliflower, maturity standards are judged by visual observation. It is better to harvest a little early if the plant has reached prime condition. This means it should be tight, with a good appearance and shape. In case of doubt about maturity, it is better to harvest earlier than late. If harvesting is late, the curd starts to become loose due to the emergence of flower stalk. They may become leafy, ricey, fuzzy and of low quality. If possible, for distant markets, cauliflower should be harvested in the afternoon or when the sun is mild and there is no dew on the plants. While harvesting, the curd stalk is cut above the ground with a sharp knife and large leaves are trimmed away, leaving sufficient jacket leaves to protect the curd from bruising and other mechanical injury during transportation. More jacket leaves are left intact if the cauliflowers are being transported loose and less if they are to be packed in crates. In crates, the jacket leaves are trimmed, leaving a fringe of leaves projecting 2–3 cm above the curds. After harvesting, they should be kept in a shade for cleaning, grading and packaging.

Disorder	symptoms	Management
Browning	Boron deficiency causes browning and hollow stem, and later becomes brown. Curd appears purplish and the whole curd becomes brown and tasteless.	Apply 10 to 15 kg borax/ha during land preparation. Spray 50 gm borax mixed in 25 litres of water 30 days after transplanting and at the time of curd formation.
Whiptail	It is caused by molybdenum deficiency. Leaf becomes narrow like whip due to molybdenum deficiency.	Prepare a spray solution mixing 20 gm of sodium molybdate in 25 litres of water and spray 30 days after transplanting.
Buttoning	Early varieties and high temperature requiring varieties, if planted late and meet low temperature, form curds earlier and look like buttons.	Select suitable varieties and season.
Blindness	Growing tip is lost somehow and only leaves grow and no curd formation takes place.	Identify such plants and replace with other plants.

5.1.14 Yield

The yield of early varieties depends on the season and the variety. At higher temperature above 25°C, the curds are small and spacing is closer. In spite of this, the yield rarely exceeds 10 tonnes /ha. For mid season and late season varieties, at lower temperatures the yield may go up to 15–20 tonnes/ha for Kathmandu Local and Jyapu and even 20–30 tonnes/ha for Madhuri, Snow Ball and Kibo Giant varieties.

5.1.15 Cleaning and grading

After harvest, diseased, damaged, under-sized and injured curds should be separated. Based on their size, tightness and colour, cauliflowers can be graded into small, medium and large groups. Curds above 2 kg are classed as large, 1–2 kg as medium and less than 1 kg as small. Besides this, the curds should be firm, compact, and creamy or snow white, well trimmed, and free from discoloration, softening, bruises, fuzziness and ricyness. It should be free from wilting, disease and infestation. Grading provides a basis for orderly marketing of cauliflower and allows the consumers to assess the quality in relation to the price and provide a marketing incentive to the traders.

5.1.16 Packaging and transportation

In Nepal cauliflower is generally packed in bamboo baskets or in gunny bags after harvest with limited grading and sorting. Most of the time curds are bruised and damaged by the time they reach the market and look unattractive. To avoid such damage, the following steps should be followed while packaging cauliflowers:

- Graded and sorted cauliflowers should be packed in bamboo baskets or plastic crates with proper aeration.
- While packing, jacket leaves should be arranged so that curds do not rub each other during transportation.
- Curds should be placed uniformly upright or facing down and covered with young jacket leaves so that they are not exposed to sunlight and dust.
- Different varieties and grades should be packaged separately.
- While packing for distant markets, jacket leaves should be arranged to prevent curds from rubbing against each other.
- Cauliflowers are generally transported in trucks and buses. The packages should not shake and should stay tightly in place during transportation.

Nighttime is better for transporting the cauliflowers to distant markets. Careful handling is important and the produce should reach the main market early morning to facilitate timely marketing.

5.1.17 Storage and marketing

Most of the cauliflowers commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold to the local market or collected at a collection centre and sent to a wholesale market through marketing agents or cooperatives. The producer groups/cooperatives and even individual producers should contact the marketing agents or traders in advance. In Nepal there is no organized cold storage for cauliflower. However in higher altitudes, if marketing is obstructed or delayed due to transport problems, it can be stored at 0°–2°C temperature and relative humidity between 85–95% for up to seven days.

5.1.18 Cost of production and profit

Farmers should keep the production record of each crop for each season as per Annex 1 format and calculate the minimum selling price.



Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation. Actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling production in nursery		
1.1	Treated and packed hybrid seed	5 gm	300
1.2	Manure	LS	500
1.3	Nursery materials	LS	400
1.4	Nursery preparation, soil solarization and sowing to hardening	4 labour days	1,200
2	Crop production labour (planting to harvest)	15 labour days	4,500
3	Manure, fertilizer and micronutrient	LS	2,500
4	Plant protection inputs	LS	500
5	Irrigation pipes, sprinkles	LS	900
6	Packaging and transportation	LS	1,000
7	Others	LS	500
8	Total cost		12,300
9	Total production 2,000 kg and price @ NPR 30/kg	2,000 *30	60,000
10	Net profit in NPR	60,000 -12,300	47,700

5.2 Cabbage

5.2.1 Introduction

Cabbage (*Brassica oleracea* var. capitata) is a cool season crop in the Cole crop family and very popular across the world. The edible part of cabbage is the tight hard ball of tender leaves. In Nepal, cabbage is usually eaten fresh as salad or as boiled or curried vegetable, and is also used in vegetable momo. Each 100 gm of cabbage provides 120 microgram of Vitamin A and 124 milligram of Vitamin C. Among minerals, it provides phosphorus 44 milligram, potassium 4 milligram, calcium 39 milligram, and iron 0.8 milligram. It also provides sulphur, iodine, etc.

5.2.2 Climatic requirements

The growing site for cabbage must get at least 6 hours of full sun each day and more is better. The site should not be shaded by trees, tall grasses and other crops. Cabbage seed germinates at 7°–35°C temperature. For good vegetative growth and head formation, optimum temperature requirement is 15° to 20°C in general. It is harder than cauliflower and can thrive even in temperatures as low as 0°C. Above 25° C the growth of cabbage is retarded and in temperatures above 30°C rotting starts from the core of cabbage. Some heat tolerant varieties such as K.K Cross, Green Boy and Green Express have been developed and can be used as climate smart varieties even in temperatures up to 30°–35°C for head formation. In very low temperature, it may bolt directly instead of forming a head and therefore very low temperatures should be avoided.

5.2.3 Soil requirements

Cabbage can be cultivated in almost all types of soil; however, light loam to sandy loam soil with rich organic matter and a high level of fertility and high water holding capacity is best for cabbage cultivation. Soil should never be muddy and water logged. It requires slightly acidic soil with pH range varying from 5.5 to 6.5 (This pH range

minimizes the danger of a disease called club root and maximizes nutrient availability). Soil test before planting is always advised for pH and nutrient availability. For crops grown in the rainy season, sandy or sandy loam light soil is desirable. Cabbage is one of the main winter crops in the mid hills and plains. Heavy soils that hold moisture are more desirable for compact heads and higher yield. In the soil pH is low, club root attacks the plant and phosphorus availability is limited. Adding dolomite lime improves pH and increases phosphorus availability and magnesium.

5.2.4 Land preparation

The field should be drained well and able to hold moisture. Soil should be prepared well. 1–2 rounds of deep corrosive plowing followed by 2–3 rounds of light plowing and clod breaking are needed to make the soil friable, loose and level. Plowing should be done well in advance to ensure good tillage and decomposition of weeds and prepare the land for transplanting. Clod free soil provides a good growing medium for developing roots and soil micro-organism. Land should be well levelled for proper drainage and trench should be made for irrigation. For transplanting early varieties during summer/rainy season, 15 cm raised beds of 2–3 metre width with 25 cm wide trench between two beds should be made. For mid and late varieties, the width of bed should be 2 metres by 4 metres. Organic manures like FYM should be applied while preparing the main field. Before making the beds, all fertilizers except half dose of nitrogen should be thoroughly mixed in soil. This helps the transplanted crops use nutrients efficiently.

5.2.5 Manure and fertilizer application

Cabbage is a heavy feeder and requires adequate manure and nutrient for profitable yield. For best results, FYM 15–20 tonnes /ha or any compost should be added to the soil 2–3 weeks before transplanting. It is recommended that 75 kg nitrogen, 40 kg P_2O_5 and 30 kg K_2O per ha is applied to supplement the FYM. If FYM is not applied then, double the quantities of chemical fertilizer. However, applying FYM is crucial for the plant to cope with climate change-induced drought and heavy rain. Soil testing is important for determining the soil pH. Apply fertilizer and lime according to test recommendations. Add nitrogen-rich amendments such as blood meal and mustard cake to improve soil health.

Application of Jholmal at weekly intervals until one month before harvesting time has been found to effective in replacing the use of chemical fertilizers. Jholmal can also effectively control most of the diseases and insect pests (see chapter 3.2.2.vi for details). The FYM is applied 2–3 weeks before transplanting so that the period of rapid release of nutrient from the manure coincides with the rapid growth of the crop. Full doses of P_2O_5 and K_2O and a half dose of nitrogen should be mixed thoroughly in the soil at the time of making beds. Apply the remaining half dose of nitrogen as top dressing in two batches – after a month after transplanting and again when they start forming heads. Since the root system of cabbage is dense and shallow, placing the fertilizer in bands 5–10 cm away from the young plants at 2–3 cm depth in ring bands gives the best results. If fertilizer is applied close to the plants, it will kill the plant by burning.

Micronutrients: Cabbage needs micronutrients such as boron, zinc, molybdenum, manganese, iron, etc. The deficiency of boron and molybdenum is common in cabbage as in cauliflower. Supplement micronutrients are available in various multi-nutrient rich commercial formulations such as *Agrolic* and *Agromin* and also in single formulation. Micronutrients are needed but small amounts only. Micronutrient formulations available under different commercial names can be applied as basic dose and foliar spray. While using such formulations, it is important to read the instructions on the label and take necessary precautions.

Boron deficiency causes hollow stem in cabbage and young leaves are puckered. To correct the deficiency of boron in cabbage, apply 14 to 20 kg borax while preparing the soil. If symptom appears after transplanting, two foliar sprays of available boron formulation at the rate of 1–2 ml/litre of water at 7 days' interval corrects the deficiency. Micronutrient deficiency is more prone in acidic soils. Soil pH must be maintained at 5.5 to 6.5. If it is lower than this, apply lime 200 to 300 kg per hectare while preparing the land.

5.2.6 Variety selection

Short durational: Pride of India, Golden Acre, Green Coronet, Green Stone, T-621

Long durational: Copenhagen Market, Ruby Ball, Green Crown, K.K. Cross, K.Y. Cross, Late Large Drum Head, Marpha Drum Head, Kaveri, Meghana

(Note: Cabbage breeding is very fast in Japan, Korea, India and elsewhere. New varieties are coming into the market. Technicians and farmers should be aware of the new varieties)

5.2.7 Nursery establishment and management

Nursery establishment and management in cabbage is similar to that of cauliflower. Select a well-drained open space for the nursery. A 100 square metre nursery is required for one hectare transplanting. While preparing nursery beds, apply 5–7 kg of well-rotted FYM/compost per square metre on the land. 500–700 kg of FYM is needed for 100 square metres. During the rainy season, make one metre wide raised beds of 15 cm height with a 25 cm wide trench between two beds. Length of beds may vary but should not be more than 10 metres for easy care and management.

Soil solarization before seed sowing is recommended to kill the fungus and other germs and protect seedlings from fungal attack. Solarization is a process of covering nursery beds with white plastic sheet for at least two weeks to a month under high temperature.

In Nepal almost all cabbage varieties in commercial cultivation are imported hybrids. They are available in packages and already treated with fungicides. There is no need for seed treatment.

After preparing raised beds, make 2–3 cm deep tiny U-shaped furrows 10 cm apart with the help of a small stick. Drop the seed using your thumb, forefinger and middle finger. Cover the seed with fine sand or fine soil compost mixture or with ash depending on availability. Then mulch the beds with straw or specially made thin perforated jute sack. After sowing and mulching sprinkle water thoroughly with a fine rose can (hajari), ensuring that soil is moist but not over watered till the seedlings emerge. Cabbage seed germinates 4 days after sowing. When the seed germinates, remove mulch and water it very carefully and lightly. Splashing water with force and heavy watering may damage young seedlings and damping off may attack the nursery. Cabbage seedlings are ready for transplanting 25–35 days after germination.

After they sprout 3-4 leaves, cabbage seedlings are transplanted into a second nursery for hardening. Among mid and late season varieties, this is generally done 10 to 15 days after germination. In early varieties, seeds are sown thinly and no hardening is done as early varieties have a very short life span.

5.2.8 Seed rate and seedling requirements

For one hectare land, 200 to 300 gram seeds are required depending on germination percentage and seed vigor. Healthy and well-grown seedlings at a rate of 30,000 to 32,000 seedlings per hectare are required.

5.2.9 Transplanting

Well-hardened seedlings that are 4–6 weeks old with 4–6 true leaves are ready for transplanting. Hardening enables the plant to withstand transplant shock. Moistening the nursery beds before lifting the seedlings make their removal easy and prevents injury to the root system. Select only healthy and strong seedling for transplanting. Avoid blind and weak seedlings with constricted wire stems. Transplanting into narrow ridged beds during the rainy season and into flat beds during winter and dry period will be beneficial. Transplanting is preferably done in the evening. Soil should be packed tightly around the seedling to establish close contact with the roots following irrigation. Transplanting times may differ according to altitude, temperature and season. Transplanting distance depends on the variety. Early varieties are transplanted at 50 cm row to row and 25 cm plant to plant distance whereas mid and late season varieties are transplanted at 75 cm row to row and 50 cm plant to plant distance. While transplanting, only cover the stem part covered by soil in the nursery and gently press the soil around the stem.

Transplanting and harvesting time varies according to the topography and altitude. As there is a 4–6 week gap between germination and transplanting, seed should be sown in the nursery a month before transplanting.

Geographical areas	Short durational varieties	Long durational varieties
Terai, inner Terai and low hill basins (Terai to 600 metres)	September - October (December-January)	November-December (February-March)
Mid hills (600–2000 metres)	July-August (October-November)	November-December (February-March) January-February (April-June)
High hills above 2000 metres)	May-June (August–Sept)	June-July (September-October)
Note: Months inside the parentheses are harvesting months.		

5.2.10 Irrigation and water management

Lightly irrigate the plant with a watering can right after transplanting. Thereafter it is necessary to maintain proper soil moisture level for good harvest of cabbage. The rainy season varieties need only protective irrigation during rainy and late rainy season. The critical stages of irrigation in cabbage are just after transplanting, urea top dressing, weeding, intercultural operation, earthing up and at head formation. Water requirement varies according to soil type. Sandy and silt soil needs more irrigation whereas loam soil need less irrigation. In normal conditions, soil moisture should be between 60 to 100% of field capacity with an average of 80% field capacity. During dry weather, irrigation should be provided more frequently. Cabbage transplanted in ridges and furrows is always better. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds shoud be constructed near the cultivation area and collected water should be applied by drip. It is important to drain excess water after irrigation and heavy rain; otherwise club root, root rot and fusarium wilt will increase.

5.2.11 Intercultural operations and care

After 10–12 days of transplanting, a thorough inspection should be carried out and gaps should be filled in the spots where plants are dead and wilted. During the early stage of growth, weed competes with the crop for nutrients and moisture and crust formation also appears. Light hoeing and first urea top dressing 30–35 days after transplanting, followed by earthing up keeps growth uniform. Field should always be kept free of weed and soil should be kept loose around the plants. Black polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces the weeding cost and prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures. This technology is accepted as a climate smart technology.

5.2.12 Plant protection

Protecting cabbage from harmful insects and diseases is very important. The major insects are cabbage butterfly, cutworms, diamond back moth, and aphids. Among diseases, damping off of seedlings, downy mildew and club root are the important ones.

Major insects and their management

Insects	Types of damage	Management
Aphids	Greenish white nymphs of aphids suck sap from the leaves, stems, flower and pods in seed crops. When the attack is severe, plants wilt and die. It causes severe damage from seedling stage to curd formation.	• Spray with soap water, human or cow urine tobacco or neem extract or dust with ash. • Spray Diclorovus, Nuvan 76 EC @ 0.5 ml per litre of water at 7 days' interval. • Spray 0.20% malathion at an interval of 10–15 days. • After spraying pesticide. wait 7 to 21 days as indicated on the label of the poison container. • During waiting period do not harvest and do not eat or feed any parts sprayed with pesticide.
Cabbage butterfly	Caterpillars eat tender leaves from the margin onwards, leaving the primary veins intact.	• Collect egg mass and larvae and destroy them. • If the attack is severe, spray 0.1% pyrethrums when curd formation is in process.

Insects	Types of damage	Management
Diamond back moth	Caterpillars eat and damage young leaves and growing tips.	• Collect egg mass and larvae and destroy. • If the attack is severe, spray 0.1% pyrethrums when curd formation is in process.
Cut worms	They cut the base of the seedlings and newly transplanted crops, causing the the plants to topple down.	• Collect larvae and kill them. • Spray multinim @ 2 ml/litre of water.
Red ants	They swarm and eat up the above-ground bark. Plants wilt and die.	• Spray cloropyriphus @ 1 ml/litre of water and make the base wet.

Major diseases and their management

Diseases	Symptoms	Management
Damping off	The base of the seedlings above the soil level becomes water soaked, black and the seedlings topple down and die.	Treat the seed with Bavistin @ 2.5 gm/kg seed. Do not sow seed thickly in the nursery. Drenching nursery beds a fortnight before sowing with 25 ml to 30 ml/litre formaldehyde and cover the nursery for about 3 days.
Downy mildew	Yellowish lesion on the upper surface and cottony fungal growth appears on the lower surface of the leaves.	Spray Dithane-M-45 or Crylexil @ 2 gm/litre of water.
Club root	Knots of different sizes appear/ develop on the entire root. Plant is stunted, then wilts and dies.	Select a healthy site for the nursery. Burn debris and straws at the nursery site. Apply 1 kg lime and 1 kg mustard cake per square metre on the nursery bed. Lime increases the soil pH and reduces the attack of club root.

5.2.13 Maturity and harvesting

In general cabbage maturity standards are judged by visual observation. Cabbage is ready to harvest when the head is firm when pressed and compact and tender. It is better to harvest a little early once it reaches full growth. Full growth means it should be tight, good in appearance and shape. In case of doubt about maturity, it is better to harvest earlier than later. If harvesting is late, the head starts bursting and rotting from the inside and sometimes a flower stalk emerges. If possible, for distant markets, cabbage should be harvested in the afternoon or when the sun is mild and there is no dew on the plants. While harvesting, the head is tilted to one side and stalk is cut above the ground with a sharp knife, and large leaves are trimmed away leaving sufficient jacket leaves to protect the head from bruising and other mechanical injury during transportation. After harvesting, it should be kept in the shade for cleaning, grading and packaging.

5.2.14 Pre and post harvest loss and yield

In cabbage pre- and post harvest losses caused by different factors include mechanical injury (bruising, cracking) physio-biological (losses due to transportation and respiration), and microbial (losses due to bacteria and fungi in storage and transportation), which reduce the edible yield and shelf life. Proper handling of cabbage with cultural operations and treatment before harvest may prevent huge losses. Excessive application of nitrogen makes the head loose. Excessive irrigation after dry spell causes the head to crack and has no marketing value.

Post harvest handling of cabbage includes trimming of diseased, damaged, rotten and discoloured leaves, avoiding direct contact between the heads and soil or exposure to direct sunlight. Yield of cabbage varies depending on the season and the variety. The short durational varieties mature in 90 days while long durational varieties take up to 150 days and the yield varies accordingly. The yield of 25 to 35 tonnes/ha is normal in hybrid cabbage.

5.2.15 Cleaning and grading

After harvest, diseased, damaged and under-sized and injured and burst heads should be separated. Based on the size, tightness and colour, the cabbage can be categorized into small, medium and large groups. Heads above 2 kg are classed as large, 1–2 kg as medium and less than 1 kg as small. Heads should be firm and compact. Owing to higher prices and small family norms, there is greater demand for small to medium sized head of around 1 kg net weight. Before grading the heads are uniformly trimmed so that they all have the same number of wrapper leaves. Cleaning and grading provides a basis for orderly marketing of cabbage and allows the consumers to assess the quality in relation to the price and also provides a marketing incentive to the traders.

5.2.16 Packaging and transportation

In Nepal cabbage heads are sent loose to the market; they are transported in trucks or in gunny bags. Transporting off-season produce in trucks from high hills to lowland on poorly gravelled roads can damage the heads, as they are loose and succulent. The heads are often bruised, damaged and unattractive by the time they reach the market. To avoid such damage, the following steps should be followed while packaging cabbage:



- Graded and sorted cabbage should be packed in bamboo baskets or plastic crates with proper aeration.
- While packing, jacket leaves should be so arranged that the heads do not rub each other during transportation.
- Heads should be placed uniformly upright or facing down and covered with young jacket leaves so that they are not exposed to sunlight and dust.
- Different varieties and grades should be packaged separately.
- While packing for distant markets, jacket leaves should be arranged to prevent the heads from rubbing against each other.
- Cabbage is generally transported in trucks and buses. The packages should not shake and should stay tightly in place during transportation. Nighttime is better for transporting cabbage to distant markets. Careful handling is important and the produce should reach the main market early in the morning to facilitate timely marketing.
- Cabbage produced in the high hills are sold in the Terai and large towns in Nepal and also exported to Indian cities like Patna, Siligudi and Bareilly, and sometimes to Bangladesh.

5.2.17 Storage and marketing

Cabbage is an important vegetable in terms of production and consumption. The relatively long shelf life of cabbage is an important attribute for the hill farmers, as it allows them to transport it to distant markets. Since production season can be altered at different elevations, farmers can get a better price by escaping the local production season of big cities. Increased access to telecommunications in the rural areas has also played a vital role in vegetable distribution. As cabbage has a longer shelf life than other vegetables, assemblers or collectors get enough time to contact wholesalers based in cities and divert the product where they get a better price. In Udayapur, Gaighat is the major market but one can explore markets higher up, towards Khotang and Solukhumbu, as well as in the Terai with season advantage, as this crop is used widely in hotel and restaurant businesses. For better returns, farmers

could be organized in groups or cooperatives and the cooperative can market the product directly to these potential markets. As Udayapur is situated between the upland and the lowland and has the shortest transact, vegetables produced there can harness its seasonal advantage in both upland and lowland.

In Udayapur there is no organized cold storage for cabbage. However, in higher altitudes, if marketing is obstructed or delayed due to transportation problems, it can be stored at 0°–2°C temperature and relative humidity between 85–95% for up to 5 weeks.

Production and marketing of cabbage are two sides of the same coin in a market-oriented production system. As this system is a commercial venture, farmers have to analyse potential markets along with production and marketing risks beforehand to get better returns. Farmers have to consider the following points while engaging in commercial vegetable farming.

- Keeping records of all production costs is crucial for fixing the minimum price for the sale. A rough calculation of the cost of production of cauliflower is already presented in Table 3 in the previous section.
- A fair idea about the area under cultivation and crop variety in the vicinity gives an indication about potential competition in the local markets and estimated volume of production for distant markets.
- Focus should be on high quality products rather than on average produce.
- Analyse the existing marketing channels and select the most profitable one.
- Market vigilance is necessary for finding niche market demand for crops, variety and quality. Be prepared for the new crops if they promise better returns.
- Vegetable market is very much dependent on trust. Trust should be maintained by all market actors including producers.

5.2.18 Cost of production and profit

Farmers should keep the production record of each crop for each season in the Annex 1 format and calculate the minimum price that she/he can sell at profit compared the foregone crops. Estimated cost of production per ropani (508 square metre) is presented below (This is just estimation. Actual cost of production should be recorded in the format provided in Annex 1).

S.N	Particulars	Quantity	Amount in NPR
1	Seedling production in nursery		
1.1	Treated and packed hybrid seed	5 gm	300
1.2	Manure	LS	500
1.3	Nursery materials	LS	400
1.4	Nursery preparation, soil solarization and sowing to hardening	4 labour days	1,200
2	Crop production labour (planting to harvest)	15 labour days	4,500
3	Manure, fertilizer and micronutrient	LS	2,500
4	Plant protection inputs	LS	500
5	Irrigation pipes, sprinkles	LS	900
6	Packaging and transportation	LS	1,000
7	Others	LS	500
8	Total cost		12,300
9	Total production 2,500 kg and price NPR 20	2,500 *20	50,000
10	Net profit in NPR	50,000–12,300	37,700

5.3 Tomato

5.3.1 Introduction

Tomato (*Lycopersicon esculentum* Mill) of the family solanaceae is one of the most popular vegetables grown across the world. It is a protective food grown extensively as an annual plant, a very good source of income for small and marginal farmers, and contributes to the nutrition of the consumers. Tomato is a rich source of vitamins and minerals. Each 100 gm of fresh tomato contains 351 microgram of Vitamin A and 27 milligram of Vitamin C. Among minerals it contains 48 milligram of calcium, and 0.4 milligram of iron. Being rich in vitamins and minerals, tomato is called 'poor man's mandarin'. Tomatoes are used as raw vegetables in sandwiches, salad, and pickles. It is used in different curry preparations. Several processed products such as paste, puree, syrup, juice, ketchup, drinks, whole peeled tomato, etc. are prepared on a large scale. Tomato is a very good appetizer and its soup is said to be a good remedy for constipation. July to November is the lean season for fresh tomato in the Terai plains of Nepal and the plains of northern India. The mid-hills can produce and supply tomato to the Terai and northern India during the rainy season.

5.3.2 Climatic requirements

Tomato is a day neutral warm season crop. It is cultivated during winter in the Terai and during spring and summer/ rainy season in the hills. The optimum temperature for growth is 15° to 25°C; it cannot surive temperatures below 5°C. For fruiting 20° to 30°C temperature is the best. Lycopene, which is responsible for the red colour of tomato, is highest at 20° to 25°C. The production of this pigment drops rapidly at temperatures above 27°C, and above 35°C pollen dries and fruiting is highly reduced, and if there's fruiting, the shape of the fruit is deteriorated. Provided optimum temperature and nutrition is available, tomato can be cultivated in any season. Some heat tolerant varieties have been developed and can be used as climate smart varieties even at temperatures up to 35°C.

5.3.3 Soil requirements

Tomato can be cultivated in almost all types of soil; however, well-drained and fairly fertile soil rich in organic matter with high water holding capacity is best for tomato cultivation. For rainy season crop, light loam to sandy loam is most suitable, though heavy soil rich in organic matter is preferred for a higher yield. Tomato performs well in soil with a pH between 6 and 7. It is moderately tolerant to acidic soil (pH 5.5).

5.3.4 Land preparation

Land should be prepared well to make the soil suitable for transplanting tomato. The field should be well drained and hold moisture. Soil should be prepared thoroughly with 1–2 rounds of deep corrosive plowing followed by 2–3 rounds of light plowing and clod breaking to make soil friable, loose and well levelled. A clod free soil provides a good growing medium for developing roots and soil micro-organism. Land should be well levelled for proper drainage. Transplanting beds and trench should be made for irrigation and excess water drainage. The bed widths are different for bushy determinate varieties and indeterminate tall growing varieties. For non-staking bushy determinate, the width of the beds is 125 cm and two rows are transplanted keeping a row-to-row and plant-to-plant distance of 75 cm. For staking indeterminate varieties, 100 cm wide beds should be made and two rows are transplanted at 75 cm row-to0row and 50 cm plant-to-plant distance. The bushy varieties are transplanted further apart from each other as they have many branches and are self-determinate in nature.

5.3.5 Manure and fertilizer application

Tomato is also a heavy feeder and requires adequate manure and nutrient for profitable yield. The quantities of nutrients depend on several factors such as cultivar, soil and growing conditions, irrigation and season, etc. Balanced doses of NPK increases fruit shape, colour and size and help maintain quality. For best results, apply 20 tonnes/ha of FYM and supplement it with 90–100 kg of nitrogen, 60–75 kg P_2O_5 and 50–60 kg K_2O per ha. If FYM is not applied then, double the quantities of chemical fertilizer. However, application of FYM is very important as it increases the water holding capacity of the soil and helps the plant cope with climate change effects, drought and heavy rain. To be sure of soil pH, test the soil. Apply fertilizer and lime based on test recommendations. Add nitrogen-rich amendments such as blood meal and mustard cake to improve soil health. Lime application will prevent blossom end rot caused by calcium deficiency.

The FYM is applied 1–2 weeks before transplanting so that the periods of rapid release of nutrients from the manure coincides with rapid growth of the crop. The full dose of P_2O_5 and K_2O and one-third dose of nitrogen mix thoroughly in the soil at the time of bed making. The remaining dose of nitrogen is applied as top dressing in two batches: 25–30 after transplanting and again 50–60 days of transplanting. The application of micronutrients like Zn, Cu, Ca and Boron significantly helps to increase the number of fruits per plant yield and quality. Application of borax 20–30 kg/ha improves fruit yield and quality. Foliar sprays of N and micronutrients have also been found to be beneficial. Micronutrient formulations available under different commercial names can be applied as basic dose and foliar sprays. While using such formulations, information on the container label must be read carefully and precautions must be taken.

Application of Jholmal at weekly intervals until a month before harvesting has been found to be effective in replacing the use of chemical fertilizers and in controlling most of the diseases and insect pests (see Chapter 3.2.2.vi for details).

5.3.6 Variety selection

Two varieties of tomato are in use.

Determinate: Roma, Pusa Early Dwarf, Navin, CL 1131, BS 20, N.S 2535, etc.

Indeterminate: Lapsigede, S-20, Srijana, Manisha, Monprecos, Serex, Himsona, Themes-16, etc.

(Note: Tomato breeding is very fast in India and elsewhere. New varieties are coming into the market. Technicians and farmers should be aware of the new varieties.)

5.3.7 Nursery establishment and management

Select a well-drained open space with ample sunshine for nursery. For a hectare transplanting 60–80 square metre nursery is required. Generally nursery beds are 1 metre wide with a 25 cm wide trench between two beds. Length of beds may vary but should not be more than 10 metres for easy care and management. Well-decomposed farmyard manure is properly mixed in the topsoil of the beds at the rate of 5–7 kg/metre square. 400–600 kg of FYM is needed for 80 square metres. Where possible, soil solarization before seed sowing is recommended to kill fungus and other germs and protect the seedlings from fungal attack. Solarization is a process of covering nursery beds with a white plastic sheet for at least two weeks to a month under high temperature.

Open pollinated tomato varieties need seed treatment if they have not been treated before. Imported hybrids available in packages are already treated with fungicides.

After preparing raised beds, make 2–3 cm deep tiny U-shaped furrows 10 cm apart with the help of a small stick. Drop the seed using your thumb, forefinger and middle finger. Cover the seed with fine sand or fine soil compost mixture or with ash depending on availability. Then mulch the beds with straw or dry grasses or a specially made thin perforated jute sack. After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari) ensuring that soil is moist but not over-watered till the seedlings emerge. Tomato seed germinates within 6 days of sowing. When seed germinates, remove mulch and water it very carefully and lightly. Splashing water forcefully and heavy watering may damage young seedlings and damping off may attack the nursery. Tomato seedlings are ready for transplanting within 25–35 days of germination when it becomes 4–6 leaved and 10 cm high.

Nowadays nurseries are raised in low tunnels and low-cost polyhouses. A low tunnel made of a transparent plastic sheet provides ideal conditions for seedlings to rise successfully in winter. It allows transplanting within a short time for spring planting. The use of agro-nets in nursery protects the seedlings from insects and reduces vector borne virus infestation and damage by other insects. Young hybrid seedlings are hardened in plastic pots or trays before transplanting.



5.3.8 Seed rate and seedling requirements

For one hectare of land normally 200–300 gm of open pollinated seeds and 100–175 gm of hybrid seeds are required for transplanting depending on germination percentage and seed vigor. Healthy and well-grown seedlings at a rate of 30,000 to 35,000 per hectare are required, including for gap filling.

5.3.9 Transplanting

During winter as seedlings grow slow, well-hardened seedlings that are 4–6 weeks old with 4–6 true leaves are ready for transplanting. During summer seedlings become ready for transplanting in 3–4 weeks for rainy season plantation. To harden open pollinated seedlings, watering should be withheld for 3–4 days before transplanting. Hardening enables the plant to withstand transplanting shock. Moistening nursery beds before lifting the seedlings make their removal easy without causing much injury to the root system. Select only healthy and strong seedlings for transplanting. Avoid weak seedlings. Tomato seedlings are transplanted in flat beds in two rows per bed. Transplanting is preferably done in the evening. The soil should be pressed tightly around the seedling to establish a

close contact with roots following irrigation. Transplanting distance depends on the variety. Determinate and bushy varieties with no staking need more spacing and tall growing indeterminate staking varieties are planted a little closer and trained along staking, as a single or multi branched system (plastic house).

Determinate varieties are transplanted at a row-to-row and plant-to-plant distance of 75 cm whereas indeterminate, trained and staking varieties are transplanted at 75 cm row-to-row and 50 cm plant-to-plant distance. While transplanting, only cover the stem part covered by soil in the nursery and gently press the soil around the stem. Indeterminate varieties need staking and training for good fruit yield and quality. The planting distance for staking and non-staking varieties is given in the following box:

Staking and non-staking	Planting distance in cm		Width of beds and trench in cm	
	Plant to plant	Row to row	Width of beds	Width of trench
Non-staking	75	75	125	30
Staking	75	50	100	30

5.3.10 Irrigation and water management

Tomato plants require adequate moisture throughout their growth period. Irrigate the plant right after transplanting using a watering can and thereafter maintain proper soil moisture level for good fruiting and harvest of tomato. Irrigation is required at an interval of 3–4 days during summer and 10–15 days during winter to ensure that the soil is moderately wet. A long spell of drought followed by sudden heavy rain or irrigation may cause cracking of fruits. Drip irrigation is proving to be a smart water management technology for tomatoes planted in plastic houses and water scarce areas. In drip irrigation, water use is very efficient and moisture regime is maintained around the plant. In plastic house cultivation, drip irrigation is mandatory for a higher fruit yield and good quality fruit. Tomatoes are planted in beds; therefore furrow irrigation is more beneficial in the open field. Water stress and calcium deficiency leads to blossom end rot in tomato. Too much irrigation leads to tomato wilt and promotes fusarium fungal attack. Water requirement varies according to soil type. Sandy and silt soil needs more irrigation whereas loam soil needs less irrigation. Under normal conditions, soil moisture should be between 50 to 80% of field capacity with an average of 60% field capacity. After irrigation and heavy rain, draining excess water is mandatory otherwise bacterial and fusarium wilt will increase.

5.3.11 Intercultural operations and care

Seedlings should be carefully inspected 5–7 days after transplanting and gaps should be filled where plants are dead and wilted. During the early stage of growth, weed competes with the crop for nutrient and moisture. Two rounds of light hoeing in the first and third fortnight after transplanting and an earthing up operation during the second fortnight and one hand weeding 45 days after transplanting is recommended in general. However, the field should be kept free of weeds and soil should be kept loose around the plants.

Mulching

Mulches are used to reduce or increase soil temperature, suppress weed growth and conserve soil moisture. Organic mulches like straw can reduce soil temperature in hot weather/summer season;

however, plastic mulches increase soil temperature during winter season and help maintain the optimum temperature required for good growth, flowering, fruiting and fruit quality. Black polythene mulching and transplanting is emerging as a weed control and moisture retention technology; this climate smart and water smart technology reduces weeding cost and prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures.

Staking, pruning and training

In case of determinate varieties, first 2–4 four side branches below first flowering truss is removed and all other branches coming from the exile of leaves are allowed to grow and undergo fruiting. Indeterminate varieties, whether in an open or a plastic house, need pruning, staking and training for quality product. In such varieties only one main shoot is allowed to grow and all side branches coming from the base of leaf are pinched and removed as single shoot fruiting. In this case plant to plant distance is reduced. In multibranched training, the first few branches are pruned and the two side branches are allowed to grow towards right and left and main shoot straight upwards. In this case three shoots are allowed to grow and all unwanted side branches are pruned and removed. The main three branches are tied with a wire or plastic string or jute string and fruiting is allowed. Staking is necessary for indetrminate tomato for continuous quality fruiting. Pruning and staking are carried out as follows:

- In beds where tomato is planted in rows, stick a strong bamboo, wooden or iron stake after every four plants. The stake should be a metre high for determinate varieties and 1.5–2 metres high for indeterminate varieties.
- Tie 3–4 layers of cross stakes across the main stake and train the tomato branches along these stakes.
- If bamboo, wooden or iron stakes are not available, then plastic ropes can be tied up from above as shown in the picture.

Micronutrient management

Determinate varieties grown in plastic houses should be supplied with liquid fertilizer (see the box below) when fruit picking starts. In addition, after every two fruit pickings, Jeewatu mixed in five parts of water could be applied around the root zone twice a week for better results. It prevents and controls various diseases and root knot nematodes. Applying vegimax 1 ml per three litres of water at 7–10 day intervals and then 4–5 sprays at 15-day intervals maximizes fruit yield. Calcium deficiency causes blossom end rot as shown in the picture; multiplex or agromin 3 ml/litre of water if sprayed to control/prevent it.

Micronutrients should be sprayed mixed with pesticides. When tomato starts flowering, applying 1 ml of Miraculan or hitculan @ 1 ml/litre of water at 15-day intervals has been found to be beneficial.

In plastic house cultivation, tomato removes large quantities of nutrients from the soil. After three harvests, nutrient supplement is essential. For readily available nutrient supplement, prepare a nutrition solution of 5 gm of DAP, 5 gm of muriate of potash, and 5 gm of agricultural lime in one litre of water. This solution is applied around the base of tomato at the rate of 50–100 ml per plant 10 cm away from the stem. If micronutrients are to be applied, it should be applied as per the information on the container label.

5.3.12 Plant protection

Protection of tomato from harmful insects and diseases is very important. The major insects are fruit borer, whitefly and leaf miner. Among diseases damping off of seedlings, early and late blight, bacterial wilt, fusarium wilt, root knot nematodes and different leaf curl viruses are the important ones.

Major insects and their management

Insects	Types of damage	Management
Fruit borer (*Helicoverpa armigera*)	Caterpillars are green in colour. They roll over the leaves and find a way into the fruits where they make holes and feed on the flesh of young fruits. They eat leaves, stem, flower buds, flowers and young fruits. Such damaged fruits have no market value.	• Pick the damaged fruits along with caterpillars and destroy them. • Spray Bacillus thurenzensis 2 gm/litre of water twice at an interval of 15 days. • Spray Heli NPV 1 ml/litre of water. • Spray Neem based products (Margosom, Neemarin) 2 ml/litre of water. • Spray helicide 1ml/litre of water 2–3 times at weekly intervals.
Whitefly (*Bemicia tabaci*)	Adult whitefly lives under surface of the leaf. Young ones are small and cannot move. Both adult and young ones suck the sap and the leaves turn yellow. It transmits diseases.	• Gitimal or botanical extracts or servo can reduce the attack of whitefly. • Natural enemies and predator wasp eat it. • Spray cow or buffalo urine mixed in 10 parts water to drive away whiteflies. • Use yellow sticky traps to attract whiteflies; the whiteflies will get stuck to them.
(*Leaf Minor*),	The insect mines inside leaves, eats chlorophyll and the leaves dry up and become grey.	• To control these insects, spray urine or neem product. • Spray rogor 2ml/litre of water at weekly intervals.
Cutworms	They cut the base of seedlings and newly transplanted crops, and the plants topple down. Caterpillars eat young leaves and growing tips.	• Collect the larvae and kill them. • Spray multinim at @ 2 ml/litre of water.

Major diseases and their management

Diseases	Symptoms	Management
Damping off	This disease is caused by *Pythium altimum, Rhizoctonia solani*, and *phytopthora parasitica*. It leads to pre-emergence damping off, which kills te seedlings even before they emerge above soil. Post emergence, the cortical tissue of the hypocotyls shrinks and darkens rapidly and the seedlings topple down.	• Change the nursery site every year/season and make raised beds for nursery. • Spray 50 ml (40%) formalin mixed in 10 litres of water per square metre bed and cover the beds tightly with white polythene to kill the pathogens. • Seed treatment with Thrichoderma or captan or thiram or bavistin or ceresin @ 2–3g/kg of seed controls pre-emergence damping off. • Spraying copper oxychloride with captan or phytolan is effective in controlling post emergence damping off. • Mancozeb (0.25%) and Carbondazim (0.05%) spray also controls the incidence of this disease. • Excess water and high temperature favour the disease.
Early Blight	This disease is caused by soil borne fungi *Alternaria solani*. Circular angular dark brown spots appear on leaves, stems and fruits. Large, sunken, dark brown leathery spots appear on green fruits and stems. In later stages, fruits rot and decay.	• Long-term crop rotation should be followed; use any crops except solanacious crops. • Use resistance varieties if available. • Seed treatment with baviatin @ 3g/kg seed • Spray the crop with Dithane Z 78, Dithane M 45 (0.2%) or bavistin (0.1%) three times at an interval of 15 days.
Late Blight M	The disease is caused by *Phytopthera infestans*. Disease occurs on the foliage at any stage of the crop. Brown to purple black lesions appear on the leaflet, petiole, fruit and stem. Fruits decay and drop. At a later stage, plants die. The disease appears in low temperature and high humidity.	• Plant disease resistant varieties like Srijana. • Transplant seedings at a wider distance of 75 x 75 cm. • Provide aeration and sunshine to the entire plant by pruning, training and removing older leaves that touch the soil. • Apply a high dose of FYM or compost. • Spray dithane M 45 (0.2%), Ridomil (0.2%) bavistin (0.1%) or Crinoxyl gold 2g/litre of water twice at weekly intervals.

Diseases	Symptoms	Management
Fusarium Wilt	This disease is caused by fungi *Fusarium oxysporum lycopersci*. Fungus is soil borne. Plant is more prone to disease in warm humid conditions above 28°C. Symptoms include cleared veinlets, dropping of petiole and yellowing of lower leaves leading to death of the plants. Browning of vascular bundle is common at a later stage.	• Plant disease resistant varieties like Srijana. • Long-term crop rotation with crops other than solanacious crops should be followed. • Treat the seed, seedlings and field with Trichoderma viride or Sanjiwani, an organic formulation. • After transplanting, mix 5 g of Sanjiwani, 5g of sugar in a litre of water and apply twice around the base of plant @ 50 ml at a 15-day interval.
Bacterial Wilt	This disease is caused by *Pseudomonas solanacerum*, a soil borne bacterium. Lower leaves may drop down and later the whole plant wilts. Pith of root is dark brown to black in colour and if cut, thin pus like liquid oozes out. Whole plant or sometimes only a few branches wilt and die.	• Crop rotation with non-solanacious crops • Plant wilt resistant varieties like Srijana, Amar, Sens, Siris, HRD 17, etc. • Applying bleaching powder 15kg/ha 30 days before transplanting may reduce the incidence. • If wilt plant is seen, uproot it along with the soil and burn them. • Before transplanting, dip the seedling in 1g Streptocycline mixed in 40 litres of water. • In severe cases, spray Streptocycline 200 ppm or Agrimycin 100 ppm on the field.
Root knot Nematode	This disease is caused by *Meloidogyne* spp. Plants are stunted, leaves become yellow and plants wilt. When the plant is uprooted, knots of different sizes are visible.	• Crop rotation with non-solanacious crops • Deep summer plowing of the field to expose the nematodes • Plant marigold and when it starts flowering, mulch and turn the soil. • Plant nematode resistant varieties if available. • While transplanting, put 1–2 g of carbofuran in each hill. • Apply 500 kg of neem or mustard cake in the soil before transplanting. • Jhomla with Jiwatu diluted with three parts water should be applied twice at a week's interval.
Tobacco Leaf Curl Virus	It is caused by virus. The plants are stunted. Growing twigs and leaves are curled. Too many small branches appear and look bushy. This virus is transmitted by whitefly and sap sucking insects.	• To protect seedling from virus transmission by vectors like whitefly, cover the nursery beds with agro-nets. • When seedling reaches the two-leaved stage, spray 1 ml of rogor twice at 10 days' interval.

Physiological disorder of tomato

Sometimes, if the tomato plant gets heavy rainfall or irrigation after a long dry spell, the matured tomato cracks because the outer skin cannot hold the suddenly increased internal mass. Sometimes cracking is also due to calcium deficiency.

5.3.13 Maturity, harvesting and yield

In general tomato maturity standards are judged by visual observation. Tomatoes with appropriate crop managenment practice start fruiting 30–35 days after transplanting. From the date of flowering, it takes another 30–35 days to ripen. Thus in warm season, first harvest starts 60–65 days after transplanting.

Fruit harvesting should be done at the right stage depending on how the fruit is to be used. For marketing purposes, tomato is ready for harvest when it turns pink or half ripe. Full ripe or overripe tomato gets pressed and rots during transportation. While harvesting, tomatoes should not be pulled from vines but should be picked with a twisting motion of hand to separate the fruit along with pedicel and calyx from the stem. The harvesting is done at an interval of 2–4 days in summer and at weekly intervals during late autumn and winter. Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended.

Red ripe tomatoes are preferred in local markets. Fully matured, green or almost red or pink tomato is preferred for long-distant markets and storage. For processing fully ripe red tomatoes are harvested.

The yield of tomatoes varies according to the season, cultivation methods and varieties. Under open field conditions, the yield of open pollinated varieties ranges from 20–25 tonnes/ha in normal season. Hybrid varieties may yield up to 50 tonnes/ha. If tomatoes are cultivated in small areas with proper agronomic practices with pruning, training and staking the yield may go up to 40 tonnes/ha in determinate varieties and up to 60 tonnes/ha in indeterminate varieties. In polyhouse conditions, hybrid tomato yields up to 100 tonnes/ha.

5.3.14 Cleaning and grading

After harvest, diseased, damaged and under-sized, cracked and injured tomatoes should be separated. Materials stuck to tomato fruits such as soil particles, weed leaves etc. must be washed well and dried in an airy and shaded spot.

Based on their size, tomatoes should be graded as small, medium and large. They are also separated based on the degree of ripeness and colour as matured green, half ripe, fully ripe and overripe. Under-sized and rotten tomatoes are sorted and separated. Cleaning and grading provides a basis for orderly marketing of tomato and enables the consumers to assess the quality in relation to the price paid; it also provides marketing incentive to the traders. Tomato is graded in the following manner based on its colour:

5.3.15 Packaging and transportation

In Nepal harvested tomatoes are either sent to a collection centre or directly to the local market or haat bazaar. For distant markets, tomatoes are packed in bamboo baskets or plastic crates. Wooden boxes and paper bags are used on a limited scale for distant market across the border. Tomato is transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time tomatoes are damaged by the time they reach the market because poorly sorted fruit break and decay along the way. To avoid such damage, the following steps be followed while packaging tomatoes.

- Graded and sorted tomatoes should be packed in bamboo baskets or plastic crates with proper aeration. For local markets, high gauge poly bags can also be used.
- Overripe and cracked or diseased tomatoes should not be packed.
- Tomatoes should be placed evenly and covered with a newspaper so that they are not exposed to sunlight and dust.
- Different varieties and grades should not be mixed.
- While packing in crates and bamboo baskets, straw or dry grasses or newspapers should be placed on all four sides and on top. A few cm space should be left while stacking the crates so that the upper crate does not press the tomatoes in the lower crate.
- For distant markets, 15–20 kg tomato per crate or cardboard box should be packed for easy handling.



- For distant markets, it is better to transport tomatoes at night. They should be handled carefully and should reach the main market early in the morning to facilitate timely marketing.
- Tomatoes produced in the hills have market in the Terai and large towns of Nepal and are also exported to Indian cities as well as to Bangladesh.

5.3.16 Storage and marketing

In Nepal there is no organized cold storage for tomatoes. However, if marketing is obstructed or delayed due to transportation problems, tomatoes can be stored in low temperature and evaporative cool storage. For storing tomatoes pre-cooling is necessary. Tomato fruits harvested at matured green stage could be stored successfully at 12°–13° C in polythene bags of 100 gauge thickness for 4–5 weeks. Storage life of tomatoes could be increased by keeping them in evaporative cool storage (zero energy cool chambers) at or above 85% relative humidity.

Tomatoes grown in the hills during the rainy season fetch better prices in the Terai and large city markets. Similarly tomatoes grown in the Terai fetch better prices in the hills and high hills. Most of the tomatoes commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold to the local market or collected at a collection centre and sent to a wholesale market through marketing agents or cooperatives. The producer groups or cooperatives and even individual producers should have prior contact with the marketing agents or traders for organized marketing.

5.3.17 Cost of Production

Farmers should keep the production record of each crop for each season as per Annex 1 format and calculate the minimum price at which she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation; actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling production in nursery		
1.1	Treated and packed hybrid seed	5 gm	1,000
1.2	Manure	LS	500
1.3	Nursery materials	LS	400
1.4	Nursery preparation to hardening	3 labour days	900
2	Crop production labour (plant to harvest)	51 labour days	15,300
3	Manure, fertilizer and micro nutrient	LS	2,500
4	Plant protection inputs	LS	300
5	20 m long, 5 m wide, 4 plastic tunnel construction	LS	24,000
6	Drip irrigation	LS	6,400
7	Packaging and transportation	LS	1,000
8	Total cost		52,300
9	Total production 5,000 kg and price NPR 40	5,000 *40	200,000
10	Net profit in NPR	200,000–52,300	147,700

If cultivation is done in an open field, the total cost will be NPR 16,000 and yield 1800 kg and profit (72,000–16,000) = NPR 56,000 roughly.

5.4 Sweet Pepper

5.4.1 Introduction

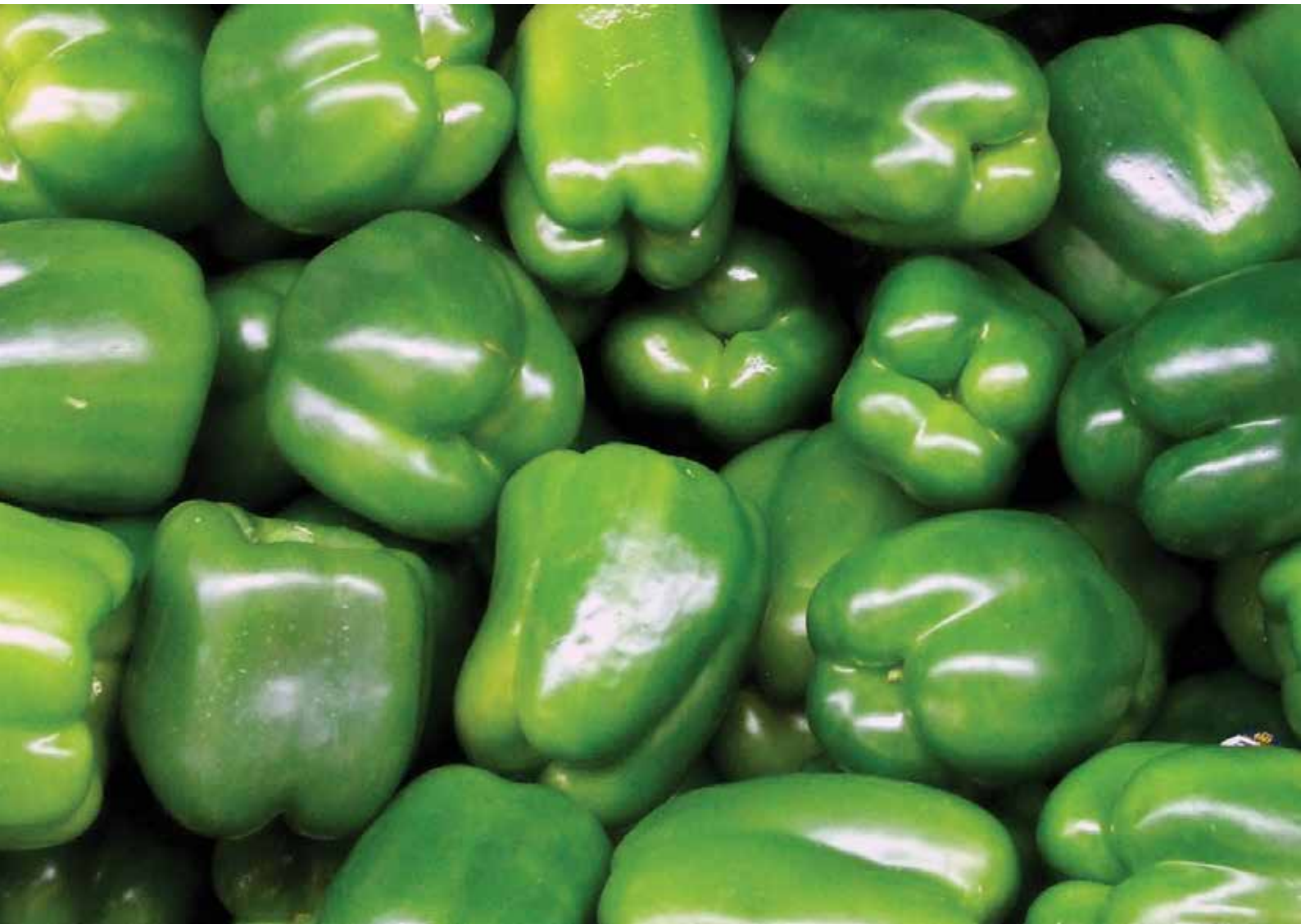
Sweet pepper (*Capsicum anuum*), also known as bell pepper, belongs to the family Solanaceae. It is a very good source of income for small and marginal farmers and contributes to the nutrition of the consumers. Sweet pepper is a rich source of vitamins and minerals. Each 100 gm of fresh bell pepper contains 421 microgram of Vitamin A and 137 milligram of Vitamin C. Among minerals it contains 10 milligram of calcium, and 1.2 milligram of iron. Being rich in vitamins and minerals, sweet pepper is very good for health. It is used as fresh vegetables. Sweet pepper is used to prepare various dishes like chicken chili, chicken, buff and pickles. It is mixed in different curry preparations. In the hills of Nepal it is available from October to February; during this season it is produced and supplied from the Terai, inner Terai and low hill river basins.

5.4.2 Climatic requirements

Sweet pepper is a day neutral warm season crop. It is cultivated during winter in the Terai and during spring and summer/rainy season in the hills. Seed germination is high at temperatures between 23° and 28°C. The optimum temperature for growth and fruiting is 20° to 25°C day temperature and 8° to 10°C night temperature. Soil temperature below 10°C retard crop growth and gradual rise of temperature from 15° to 35°C results in increased crop growth; further rise in temperature reduces growth, and beyond 40°C fruiting is poor and fruits drop. It cannot tolerate frost and dies at temperatures below 5°C. Sweet pepper is a day neutral crop and if optimum temperature and nutrition is provided, it can be cultivated in any season. However, under high temperature and in cloudy and humid weather (July-August), fruit rot disease attacks the crop.

5.4.3 Soil requirements

Good fertile soils with humus are desirable for sweet pepper. It can be cultivated in almost all types of soil, though well-drained loam soil rich in organic matter with high water-holding capacity is most suitable. For rainy season



crop, light loam to sandy loam is best; for higher yield, heavy soil rich in organic matter is preferred. Sweet pepper performs well in soil with pH 5-6. It is moderately tolerant to acidic soil (pH 5.5).

5.4.4 Land preparation

Land should be prepared well for transplanting bell pepper. The field should be well drained and able to hold moisture. Soil should be thoroughly prepared with 1 deep corrosive plowing/digging followed by 2–3 rounds of light plowing/harrowing and clod breaking to make soil friable, loose and well-levelled. Clod free soil provides a good growing medium for developing roots and soil microorganisms. Land should be well levelled for proper drainage. Transplanting beds and trenches should be made for irrigation and excess water drainage. The bed width varies according to the cultivation season. For spring and autumn plantation, 1 m wide beds with 25 cm wide trenches between beds for irrigation and drainage are made and two-row planting completed. For rainy season plantation 50 cm wide ridges are prepared with 25 cm trenches and one-row transplanting is done. For protected production in a plastic house, the beds and trenches should be made to adjust two rows in central beds and single rows in two side beds.

5.4.5 Manure and fertilizer application

Sweet pepper requires a balanced dose of NPK fertilizer. A heavy dose of nitrogen may increase vegetative growth and delay fruiting. Balanced doses of NPK increase fruit shape and size and total yield. For best results, apply 20 tonnes /ha of FYM and supplement it with 60–75 kg of nitrogen, 60–75 kg of P_2O_5 and 50–60 kg of K_2O per ha. If FYM is not applied then, double the quantities of chemical fertilizer. However, application of FYM is very important to enable the plant to cope with climate change effects, drought and heavy rain. To be sure of soil pH and fertilizer requirement, soil test is recommended. Apply fertilizer and lime according to the test results. Add nitrogen-rich amendments such as blood meal and mustard cakes to improve soil heath. Application of lime will prevent blossom end rot caused by calcium deficiency.

The FYM is applied during the second plowing or digging so that it is mixed well in the soil and the period of rapid release of nutrients from the manure coincides with the rapid growth of the crop. The full dose of P_2O_5 and K_2O and one-third dose of nitrogen is mixed thoroughly in the soil at the time of making the beds. The remaining dose of nitrogen is applied as top dressing in two batches – first 25–30 days and second 50–60 days after transplanting.

Application of Jholmal at weekly intervals until a month before harvesting has been found to be effective in replacing the use of chemical fertilizers and in controlling most of the diseases and insect pests (see chapter 3.2.2.vi for details).

In acidic soil, lime should be applied while preparing the land. For prolonged fruit harvesting, sweet pepper needs supplementary top dressing of nitrogen. Application of micronutrients and liquid fertilizer solution significantly increases the number of fruits per plant yield and fruit quality. Liquid fertilizer solution is prepared by mixing 5g of DAP, 5g muriate of potash and 5g of agriculture lime in one litre of water and applied 50–100 ml per plant 5 cm away from the base of the plant. After 2–3 pickings of fruit, applying 1 part Jiwatu mixed in 4 parts water gives better results. This also controls different diseases and root knot nematodes in sweet pepper. Application of 20–30 kg/ha of borax is beneficial for fruit yield and quality. Foliar sprays of N and micronutrients have also been found to be beneficial. Micronutrient formulations available under different commercial names can be applied as basic doses as well as foliar sprays. While using such formulations, information on the container label must be read carefully and precautions must be taken. Sweet pepper planted in a plastic house should be applied with Jholmal and other nutrient solution and micronutrients. Similarly applying vegimax 1 ml per three litres of water for 7–10 days and then 4–5 sprays at 15-day intervals maximizes the fruit yield. Calcium deficiency causes blossom end rot. To control/prevent it, spray multiplex or agromin 3 ml /litre of water.

5.4.6 Variety selection

The popular varieties of sweet pepper are California Wonder, Yolo Wonder, Bharat, IAH, SP-2, Solan Hybrid, CH-1, etc.

(Note: Sweet pepper breeding in India and elsewhere is in progress. New varieties are coming into the market. Technicians and farmers should be aware of the new varieties)

5.4.7 Transplanting and fruit picking

Transplanting and fruit picking – for both open and plastic house cultivation – differs according to the geographical location, as described in the box below:

Geographical location	Transplanting and picking months
Terai and inner Terai up to 300 metres (winter crop)	September-October (November-April)
Low hill basins and mid hills 300–2,000 metres (spring crop)	February-March (April-July)
Mid hills 600–2,000 (Rainy season crop in a plastic house)	May-July (July-November)
Note: Months inside the parentheses are fruit picking months.	

5.4.8 Nursery establishment and management

As the saying goes, "As you sow, so you reap," planting good and healthy seedlings is one of the key factors for growing good crop of capsicum. Select a well-drained open space with ample sunshine for nursery. For a hectare transplanting 600–1,000 g of seed or 30,000 to 35,000 seedlings are required. To raise this number of seedlings, 80 to 100 square metre nursery is required. Generally nursery beds are 1 metre wide with a 25 cm wide trench between two beds. Length of beds may vary but should not be more than 10 meters for easy care and management. Well-decomposed farmyard manure is properly mixed into the topsoil of the beds at the rate of 5–7 kg/metre square. For 100 square metres, it needs 500– 700 kg of FYM, 150 gm of DAP and 100 gm of muriate of potash. Where possible, soil solarization before seed sowing is recommended to kill the fungus and other germs and protect the seedlings from fungal attack.

Imported, packaged, open and hybrid seeds available in the market are already treated with fungicides. If the seeds haven't been treated, treat them with 2–3 g of bavistin per kg of seed. After preparing raised beds, make 2–3 cm deep tiny U-shaped furrows 10 cm apart with the help of a small stick. Drop the seed with the help of your thumb, forefinger and middle finger. Cover the seed with fine sand or fine soil compost mixture or with ash depending on availability. Then mulch the beds with straw or dry grasses or a thin, perforated specially made jute sack. After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that soil is moist but not over watered till the seedlings emerge. Sweet pepper seed germinates within 10 days of sowing. When the seed germinates, remove the mulch and water it very carefully and lightly. Splashing water forcefully and heavy watering may damage young seedlings and damping off may attack the nursery. Sweet pepper seedlings are ready to transplant 25–30 days after germination when they become 4–6 leaved and 10 cm high.

Nurseries are raised in low tunnels during winter and in low-cost poly-houses for spring plantation. A low tunnel made out of a transparent plastic sheet provides warm conditions required for raising seedlings successfully in winter. To ensure healthy seedlings, cover the nursery with 40 mesh nylon nets; this will protect the seedlings from insects and reduce vector-borne virus infestation and damage by other insects. Seedlings are hardened in plastic pots or in trays before transplanting with young hybrid seedlings. Hardening of seedlings should be started 3–4 days before transplanting by withholding watering to nurseries.

5.4.9 Transplanting

As seedlings grow slow in winter, they take nearly 6 weeks to reach the 4–6 true leaved stage and become hardened for spring transplanting. During summer, seedlings become ready to transplant within 3–4 weeks, both for rainy season and autumn transplanting. Seedlings are hardened by withholding watering for 3–4 days before transplanting. Hardening enables the plant to withstand transplant shock. Moistening the nursery beds before lifting

the seedlings make their removal easy without causing much injury to the root system. Select only healthy and strong seedlings for transplanting. Sweet pepper seedlings are transplanted into flat beds in two rows per bed during autumn and spring and into ridges in single rows for rainy season harvesting. Transplanting is preferably done in the evening. Press the soil tightly around the seedling to establish a close contact with roots following irrigation.

During autumn, seedlings are transplanted at a row-to-row distance of 75 cm, during spring the row-to-row distance is 50 cm. Plant-to-plant distance is maintained at 50 cm. In case of late summer planting for rainy season harvest, both row-to-row and plant-to-plant distance is maintained at 75 cm for proper drainage and aeration. Width of beds, trench and planting distances are presented in the box below:

Planting season	Planting distance in cm		Width of beds and trench in cm	
	Plant to plant	Row to row	Width of beds	Width of trench
Rainy season	75	75	50	25
Autumn and spring season	50	75 (autumn) and 50 (spring)	100	25

5.4.10 Irrigation and water management

Sweet pepper plants require adequate moisture throughout their growth period. The critical periods of moisture requirement are immediately after transplanting, after top dressing, after weeding and earthing up, and during flowering and fruit initiation. First irrigation is done just after transplanting with a watering can and thereafter it is necessary to maintain proper soil moisture level for good fruiting and harvest. Water requirement varies according to soil type. Sandy and silt soil needs more irrigation whereas loam soil needs less irrigation. In normal conditions, soil moisture should be between 50 and 80% of field capacity with an average of 60% field capacity. After irrigation and heavy rain, draining of excess water is mandatory otherwise root rot and fusarium wilt will increase. Autumn and spring season cultivation requires more irrigation while rainy season cultivation needs irrigation only during transplanting time. Irrigation should be provided every 5–7 days during summer and every 10–15 days during winter to ensure that the soil is moderately wet. As sweet pepper is planted in beds, furrow irrigation is more beneficial. Water stress and calcium deficiency leads to blossom end rot. Too much irrigation leads to bacterial and fusarium wilt.

Drip irrigation is proving to be a smart water management technology for sweet pepper planted in a plastic house and in water scarce areas. In drip irrigation water use is very efficient and moisture regime is maintained around the plant. In plastic house cultivation, drip irrigation is mandatory for higher yield of quality fruits. The drip irrigation system described earlier for tomato can be used for sweet pepper as well.

5.4.11 Intercultural operations and care

A week after transplanting, seedlings should be inspected carefully and gaps should be filled in the hills with dead and wilted plants. During the early stage of growth, weed competes with the crop for nutrient and moisture. Therefore, soil around the plant should be turned with a hand hoe or khurpi and made loose and the crop kept free from weeds. An earthing-up operation is recommended 25–30 days after transplanting, and another round of hand weeding 45 days after transplanting. However, the field should always be kept free of weeds and soil should be kept loose around the plants.

Mulching

Mulches are used to reduce or increase the soil temperature, suppress weed growth and conserve soil moisture. Organic mulches like straw and dry grasses can reduce the soil temperature during hot weather/summer season. However, plastic mulches increase the soil temperature during winter season and help maintain the optimum temperature required for good growth, flowering, fruiting and fruit quality. Black polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it is a climate smart technology that

reduces the weeding cost, prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures.

Staking and training

In general sweet pepper does not need any pruning and staking. However, if it is planted in beds in rows, during heavy fruiting, the plant/fruit may fall down when it is irrigated or shaken by strong winds. To protect it, stick a strong bamboo, wooden or iron stake next to each plant. The stake should be a metre high to anchor the plant. If bamboo or wooden or iron stakes are not available, then plastic ropes can be tied from above as shown in the picture.

Micronutrient management

Sweet pepper grown in a plastic house should be supplied with liquid fertilizer when fruit picking starts. In addition to this, after every two fruit pickings, Jeewatu mixed in four parts of water should be applied around the root zone twice a week for better results. It prevents and controls various diseases and root knot nematodes. Similarly, applying vegimax 1 ml per three litres of water for 7–10 days and then 4–5 sprays at 15-day intervals maximizes the fruit yield. Calcium deficiency causes blossom end rot as shown in the picture; to control/prevent it, spray multiplex or agromin 3 ml/litre of water.

These micronutrients can be mixed with pesticides before they are sprayed. When capsicum starts flowering, applying 1 ml of Miraculan or hitculan @ 1 ml/litre of water at 15-day intervals could be beneficial.

5.4.12 Plant protection

The major insects that attack sweet pepper are cutworms, thrips, aphids, mites, fruit borer, whitefly and leaf miner.

In plastic house cultivation, sweet pepper removes large quantities of nutrients from the soil. After two harvests, nutrient supplement is essential. Readily available nutrient supplement can be prepared by mixing 5 gm of DAP, 5 gm of muriate of potash, and 5 gm of agricultural lime in 1 litre of water [CHECK IF THIS IS O.K. ORIGINAL WAS UNCLEAR. –ed.]. This solution is applied around the base of the capsicum at the rate of 50–100 ml per plant 10 cm away from the stem. If micronutrients are to be applied, they should be applied according to instructions on the container label.

Among diseases, damping off of seedlings, early and late blight, phomopsis blight bacterial wilt, fusarium wilt, root knot nematodes and different leaf curl viruses are the important ones.

Major insects and their management

Insects	Types of damage	Management
Thrips (*Scintothrips dorsalis*)	The larvae and adults infest tender leaves and suck the sap, causing curling of the leaves. Flower and buds are also damaged. Plants look grey and sickly.	• Before fruiting, spray Malathion or rogor 2ml/litre of water. • During fruiting, pick the fruits that are ready and then spray nuvan @ 2ml/litre of water. • After spraying, wait for at least 7 days (for nuvan) and 21 days (for rogor) before picking fruit.
European corn borer (*Ostrinia nubilalis*)	Caterpillars are white in colour. They roll over the leaves and find a way into the fruits where they make holes and feed on the flesh of young fruits. Such damaged fruits have no market value.	• Pick the damaged fruits along with caterpillars and destroy them. • Spray Bacillus thurenzensis 2 gm/litre of water twice at 15 days' interval. • Spray Heli NPV 1 ml/litre of water. • Spray Neem based products (Margosom, Neemarin) 2ml/litre of water. • Spray helicide 1ml/litre of water 2–3 times at weekly intervals.

Insects	Types of damage	Management
Whitefly	Adult whitefly (*Bemicia tabaci*) live under the surface of the leaf. Young ones are small and cannot move. Both adults and young ones suck the sap, and the leaves turn yellow. It transmits viral diseases.	• Gitimal or botanical extracts or servo can reduce the attack of whitefly. • Natural enemies and predator wasps eat it. • Spray cow or buffalo urine mixed in 10 parts water to drive away the insects. • Use yellow sticky traps to attract the insects, which wil then get stuck to the stripes.
(*Leaf Minor*),	The insect mines inside the leaves and eats the chlorophyll; leaves dry up and turn grey.	• To control it, spray urine or neem product. • Spray rogor 2ml/litre of water at weekly intervals.
Cut worms	They cut the base of the seedlings and newly transplanted crops, and plants topple down. Caterpillars eat young leaves and growing tips.	• Collect the larvae and kill them. • Spray multinim @ 2 ml/litre of water.

Major diseases and their management

Diseases	Symptoms	Management
Damping off	This disease is caused by *Pythium altimum, Rhizoctonia solani, and phytopthora parasitica*. It leads to pre-emergence damping-off, which kills seedling at the initial stage of germination. In post-emergence damping-off, the cortical tissue of the hypocotyls rapidly shrink and darken and the seedlings die.	• Change the nursery site/season. • Spray 50 ml (40%) formalin mixed in 10 litres of water per square metre bed and cover the beds for two weeks. • Seed treatment with Trichoderma or captan or thiram or bavistin or ceresan @ 2–3g/kg seed. • Spray copper oxychloride with captan or phytolan to control post-emergence damping-off. • Mancozeb (0.25%) and Cabondazim (0.05%) also controls the incidence.
Leaf spot	This disease is caused by *Alternaria solani*. Circular round brown spots with a white centre appear on the older leaves.	• Spray Dithane M 45 @ 2g/litre of water at weekly intervals.
Early Blight	This disease is caused by soil borne fungi *Cercospora capsici*. Circular, angular, dark brown spots appear on leaves, stems and fruits. Large, sunken, dark brown leathery spots appear on green fruits and stems. At a later stage, fruits rot and decay.	• Long-term crop rotation should be followed with non-solanacious crops. • Use resistant varieties if available. • Seed treatment with baviatin @ 3g/kg seed. • Spray crop with Dithane Z 78, Dithane M 45 (0.2%) or bavistin (0.1%) three times at 15-day intervals.
Late Blight M	The disease is caused by *Phytopthera capsici*. Disease occurs on the foliage at any stage of the crop. Brown to purple black lesions occur on the leaflet, petiole, fruit and stem. Fruits decay and drop. At a later stage, plants die. The disease appears at low temperatures and high humidity.	• Plant disease resistant varieties like Srijana. • Maintain a wider transplanting distance, i.e., 75 x 75 cm. • Provide aeration and sunshine to the entire plant by pruning, training and removing older leaves that touch the soil. • Apply a high dose of FYM or compost. • Spray dithane M 45 (0.2%) Ridomil (0.2%) bavistin (0.1%) or Crinoxyl gold 2g/litre of water twice at seven days' interval.

Diseases	Symptoms	Management
Anthracnose	Anthracnose is caused by *Colletotrichum capsici*. At first, anthracnose generally appears on leaves as small and irregular yellow, brown, dark-brown, or black spots. Infected fruit has small, water-soaked, sunken, circular spots that may increase in size, with up to 1.2 cm in diameter. As it ages, the centre of older spots becomes blackish and emits gelatinous pink spore masses.	• Sow only disease-free seeds with seed treatment. • Transplant only healthy seedlings. • Remove and destroy infected parts but avoid touching other plant parts, especially when these are wet. • Harvest unripe but mature fruits. • Plow under all the plant debris after harvest. • Practice crop rotation. Take note of plants that are susceptible to anthracnose disease and rotate these with those that are resistant. • Keep the area free of weeds.
Leaf curl virus	Curling of leaves accompanied by puckering, blistering of intervenial areas and thickening of veins. Auxiliary buds produce clusters of leaves that are reduced in size. The disease is transmitted by whitefly.	• Two to three sprays of rogor or metasystox @ 2ml/litre of water at 10–15 day intervals.
Verticillium wilt	The disease is caused by *Verticillium albo* atrum or *Verticillium dahalae*. In peppers, verticillium wilt typically begins with wilting. In severe cases, leaf yellowing first occurs on the older leaves. Eventually necrotic areas develop starting at the leaf tips and edges and the leaf drops.	• Plant disease resistant varieties. • Follow long-term crop rotation with non-solanacious crops. • Treat the seed, seedlings and field with Sanjiwani, an organic formulation. • After transplanting, mix 5g of Sanjiwani and 5g of sugar in a litre of water and apply twice around the base of the plant @ 50 ml at 15-day interval.
Bacterial Wilt	This disease is caused by *Pseudomonas solanacerum* a soil-borne bacterium. Lower leaves may drop and later the whole plant wilts. Pith of the root is dark brown to black in colour and when it's cut, thin pus-like liquid oozes out. The whole plant or sometimes only a few branches wilt and die.	• Crop rotation with non-solanacious crops. • Plant wilt-resistant varieties if available. • Applying bleaching powder 15 kg/ha 30 days before transplanting may reduce the incidence. • Uproot the diseased plant along with the soil and burn them. • Before transplanting, dip the seedlings in a solution of 1g of Streptocycline and 40 litres of water. • In severe cases, spray Streptocycline 20ppm or agrimycin 100 ppm on the field.
Root knot Nematode	This disease is caused by *Meloidogyne* spp. Plants are stunted, leaves become yellow and plants wilt. When the plant is uprooted, knots of different sizes are visible.	• Crop rotation with non-solanacious crops. • Deep summer plowing of the field to expose the nematodes. • Plant marigold and when it starts flowering, mulch and turn the soil. • Plant nematode-resistant varieties if available. • While transplanting, put carbofuran 1–2 g on each hill. • Apply 500 kg of neem or mustard cake in the soil before transplanting. • Jhomal with Jiwatu diluted with three parts water should be applied twice at seven days' interval.
Leaf curl virus	It is caused by virus. The plants are stunted. Growing twigs and leaves are curled. Too many small branches appear and look bushy. This virus is transmitted by whitefly and sap sucking insects.	• To protect seedlings from virus transmission by vectors like whitefly, cover the nursery beds with agro-nets. • When the seedling reaches the two-leaved stage, spray 1 ml of rogor twice at 10-day interval.

Physiological disorder in sweet pepper

Different types of physiological disorders occur in sweet pepper due to nutrient deficiencies, mismanagement of agronomy and diseases and pest attack. Sunscald and other physical injuries also cause physiological disorders.

5.4.13 Maturity, harvesting and yield

Fruit should be harvested at the right stage depending on the purpose of the harvest. Generally sweet peppers are harvested at the mature green stage. They should be shapely, waxy, firm and shiny. Sweet peppers are ready for harvest 60 to 95 days after transplanting. They mature from green to red as the seeds inside mature. For culinary purposes, sweet pepper is harvested when its peduncle becomes hard and the fruit is shiny green. For canning, it is harvested when it reaches full size and turns red. Sweet peppers are picked with an upward twist, which leaves a piece of stem attached to the fruit. Pulling a pepper away from the plant may cause the plant to come out of the soil.

Harvesting is done at an interval of 2–4 days in summer and weekly intervals during late autumn and winter. Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended.

The yield of sweet pepper varies according to season, cultivation methods and variety. Under open field conditions, the yield of open pollinated varieties normally ranges from 10–15 tonnes/ha. Hybrid varieties may yield up to 20 tonnes/ha. Under polyhouse conditions, hybrid sweet pepper yields up to 25 tonnes/ha but in Nepal the area under cultivation is never more than 0.25 ha due to land, labour and management constraints.

5.4.14 Cleaning and grading

After harvest, diseased, damaged, small, broken, sunscalded and injured sweet peppers should be separated. Foreign materials stuck to the fruits such as soil particles, weed leaves, etc. must be washed well and dried in an airy and shady place.

Based on their size, sweet peppers should be graded into small, medium and large groups. Cleaning and grading provides a basis for orderly marketing and allows the consumers to assess the quality in relation to the price.

5.4.15 Packaging and transportation

After harvest, sweet pepper is either sent to a collection centre or directly to the local market or haat bazaar. At the collection centre, sweet peppers are sorted, graded and packed in bamboo baskets or plastic crates and sent to distant markets. Wooden boxes and cardboard packaging are also used at times to transport sweet pepper to distant markets including markets across the border. Sweet pepper is transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time tomatoes are damaged by the time they reach the market, as poorly sorted fruit decay along the way. To avoid such damage, the following steps be followed while packaging sweet pepper.

- Graded and sorted sweet peppers should be packed in bamboo baskets or plastic crates with proper aeration. For local markets, high gauge poly-bags can also be used.
- Oversized, undersized, diseased or damaged peppers should not be packed.
- While packing in crates and bamboo baskets, straw or dry grasses or newspapers should be placed on all four sides and on top. A few cm space should be left while stacking the crates so that the upper crate does not press the sweet peppers in the lower crate.
- Sweet peppers should be placed evenly and covered with a newspaper so that they are not exposed to sunlight and dust.
- Sweet pepper is light in weight and large in volume, therefore, while transporting them to distant markets, only 8–10 kg of fruit should be packed in each crate or cardboard box for easy handling.

- For distant markets, it is better to transport sweet peppers at night. They should be handled carefully and should reach the main market early in the morning to facilitate timely marketing.
- Sweet peppers produced in the hills are sold in the Terai and large towns of Nepal. They are also exported to India and Bangladesh.

5.4.16 Storage and marketing

In Nepal there is no organized cold storage for fresh vegetables. However, if marketing is obstructed or delayed due to transport problems, sweet pepper can be stored at low temperature in evaporative cool storage. Pre-cooling are necessary for storing sweet pepper. Sweet peppers harvested at the mature green stage could be stored successfully at 8°–10°C in 85–95% humidity in crates or open polythene bags of 100 gauge thickness for 4–5 days. Storage life of sweet pepper can be increased by keeping them in evaporative cool storage (zero energy cool chambers) at or above 85% relative humidity.

Sweet peppers grown in the hills during the rainy season fetch better prices in the Terai and large city markets. Most of the sweet peppers commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold to the local market or collected at a collection centre and sent to a wholesale market through marketing agents or cooperatives. The producer groups or cooperatives and even individual producers should have prior contact with the marketing agents or traders for organized marketing.

5.4.17 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum selling price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1).

S.N	Particulars	Quantity	Amount in NPR
1	Seedling production in nursery		
1.1	Treated and packed hybrid seed	50 gm	500
1.2	Manure and fertilizer	LS	500
2	Crop production labour (nursery preparation, planting to harvest)	14 labour days	4,200
3	Manure, fertilizer and micro nutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Drip irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		8,900
8	Total production 1,000 kg and price NPR 75	1,000 *75	75,000
9	Net profit in NPR	75,000–8,900	66,100

5.5 Chilli

5.5.1 Introduction

Chilli pepper (*Capsicum fruitesence*) also known as hot pepper belongs to the family Solanaceae. It is a very good source of income for small and marginal farmers. Hot pepper is used in both green and dry forms as a spice. It is a rich source of vitamins and minerals. Each 100 gm of fresh hot pepper contains 390 microgram of Vitamin A and 111 milligram of Vitamin C. Among minerals it contains 1.2 milligram of iron. Chilli is produced for its hot and pungent taste. It is pungent due to its *capsaicin* content. Hot pepper is used in various dishes like curries, pickles and sauces.

5.5.2 Climatic requirements

Hot pepper is cultivated in winter in the Terai and during spring and summer/rainy season in the hills. Seed germination is high at temperatures between 23° and 28°C. The optimum temperature for growth and fruiting is 20° to 32°C day temperature and 8° to 10° C night temperature. Soil temperatures below 10°C retard crop growth, and gradual rise in temperature from 18°–32°C results in increased crop growth; further rise in temperature reduces growth, and under temperature beyond 40°C, fruiting is poor and fruits drop. The plant cannot tolerate frost and below 5°C it dies. Hot pepper is a day neutral crop and if optimum temperature and nutrition is provided, it can be cultivated in any season. However under high temperature and in cloudy and humid weather (July-August), fruit rot disease attacks the crop.

5.5.3 Soil requirements

Chilli can be can be cultivated in almost all types of soil; however well-drained loam soil rich in organic matter with high water holding capacity is best. For rainy season crop, light loam to sandy loam is the most suitable; for higher yield, heavy soil rich in organic matter is preferred. Hot pepper performs well in soil with pH 5.5 to 6.5.

5.5.4 Land preparation

Land should be prepared well for transplanting hot pepper. The field should be well drained and able to hold moisture. Soil should be thoroughly prepared with 1 deep corrosive plowing/digging followed by 2–3 rounds of light plowing/harrowing and clod breaking to make soil friable, loose and well-levelled. Clod free soil provides a good growing medium for developing roots and soil microorganisms. Land should be well levelled for proper drainage. Transplanting beds and trenches should be made for irrigation and excess water drainage. The bed width varies according to the cultivation season. For spring and autumn plantation, 1 m wide beds with 25 cm wide trenches between beds for irrigation and drainage are made and two-row planting is done. For rainy season plantation, 50 cm wide ridges are prepared with 25 cm trenches and one-row transplanting is done. For protected production in a plastic house, the beds and trenches should be made to adjust two rows in the central beds and single rows in the two side beds.

5.5.5 Manure and fertilizer application

Hot pepper requires a balanced dose of NPK fertilizer. A heavy dose of nitrogen may increase vegetative growth and delay fruiting. Balanced doses of NPK improve fruit shape and size and total yield. For best results, apply 20 tonnes /ha of FYM and supplement it with 60–75 kg of nitrogen, 60–75 kg of P_2O_5 and 50–60 kg of K_2O per ha. If FYM is not applied then, double the quantities of chemical fertilizer. However, application of FYM is very important to enable the plant to cope with climate change effects, drought and heavy rain. To be sure of soil pH and fertilizer requirement, soil test is recommended. Apply fertilizer and lime according to the test results. Add nitrogen-rich amendments such as blood meal and mustard cakes to improve soil heath. Application of lime will prevent blossom end rot caused by calcium deficiency.

The FYM is applied during the second plowing or digging so that it is mixed well in the soil. The full dose of P_2O_5 and K_2O and one-third dose of nitrogen is mixed thoroughly in the soil at the time of making the beds. The remaining dose of nitrogen is applied as top dressing in two batches – first 25–30 days and second 50–60 days after transplanting.

In acidic soil, lime should be applied while preparing the beds. Vegimax 1ml in 3 litres of water 10 days and 15 days after transplanting increases fruiting. Foliar sprays of N and micronutrients have also been found to be beneficial. Micronutrient formulations available under different commercial names can be applied as basic doses as well as foliar sprays. While using such formulations, information on the container label must be read carefully and precautions must be taken. Spraying multiplex or agromin at the rate of 3 ml/litre of water promotes uniform maturity. During flowering and fruiting, applying miraculan or hitculan at the rate of 1 ml/litre of water 2–3 times at 10–15 day intervals also promotes fruiting and uniform maturity.

Application of Jholmal at weekly intervals until one month before harvesting time has been found to be effective in replacing the use of chemical fertilizers and in controlling most of the diseases and insect pests (see chapter 3.2.2.vi for details).

5.5.6 Variety selection

The popular varieties of hot peppers:

Open pollinated varieties: Pusa Sadabahar, Pusa Jwala, Suryamukhi, NP-46, Pant C-1, Akabare, etc.

Hybrid varieties: NS 1,701, NS-1,101, Karma 747, Karma 777, etc.

5.5.7 Nursery establishment and management

Select a well-drained, open space with ample sunshine for nursery. For a hectare transplanting 1–1.5 kg seed or 50,000 to 60,000 seedlings are required. To raise this number of seedlings, 100–150 square metre nursery is required. Generally nursery beds are prepared 1 metre wide, with a 25 cm wide trench between two beds. Length of beds may vary; however they should not be more than 10 metres for easy care and management. Well-decomposed farmyard manure is properly mixed into the topsoil of the beds at the rate of 5–7 kg/metre square. For 100 square meters, it needs 500–700 kg of FYM. Where possible, soil solarization before seed sowing is recommended to kill the fungus and other germs and protect the seedlings from fungal attack. Solarization is a process of covering nursery beds with a white plastic sheet for at least two weeks to a month under high temperature.

Imported packed open and hybrid seeds available in the market might be already treated with fungicides. If not, then treat the seed with bavisting 2–3 g/kg seed.

After preparing raised beds make 2–3 cm deep tiny U-shaped furrows 10 cm apart with the help of a small stick. Drop the seed with the help of your thumb, forefinger and middle finger. Cover the seed with fine sand or fine soil compost mixture or with ash depending on availability. Then mulch the beds with straw or dry grasses or a specially made thin perforated jute sack. After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that soil is moist but not over watered till the seedlings emerge. Pepper seed germinates within 10 days of sowing. When seed germinates, remove the mulch and water it very carefully and lightly. Splash water forcefully and heavy watering may damage young seedlings and damping off may attack the nursery. Hot pepper seedlings are ready for transplanting 25–30 days after germination when they become 4–6 leaved and 10 cm high.

During winter the nurseries are raised in low tunnels and low-cost poly-houses for spring planting. Low tunnels made of transparent plastic sheets provide warm conditions required for raising seedlings successfully in winter. Cover the nursery with 40 nylon mesh nets to protect the seedlings from insects and reduce vector-borne virus infestation and damage by other insects. Hardening of seedlings should be started 3–4 days before transplanting by withholding watering to nurseries.

5.5.8 Transplanting and fruit picking time

Transplanting and fruit picking differs according to the geographic location and season.

Geographic location	Transplanting and picking months
Terai to low hill basins up to 300 meter (winter crop)	September-October (November-April)
Low hill basins and mid hills 300-1,500 meter (spring crop)	February-march (April-July)
Mid hills 600-2,000 (Rainy season crop)	May–July (July – September)
Note: Months inside the parentheses are fruit picking months.	

As seedlings grow slow in winter, they take nearly 6 weeks to reach the 4–6 true leaved stage and become hardened for spring transplanting. During summer, seedlings become ready to transplant within 4–5 weeks both for rainy season and autumn transplanting. Seedlings are hardened by withholding watering for 3–4 days before transplanting. Hardening enables the plant to withstand transplant shock. Moistening the nursery beds before lifting

the seedlings make their removal easy without causing much injury to the root system. Select only healthy and strong seedlings for transplanting. Hot pepper seedlings are transplanted into flat beds in two rows per bed during autumn and spring and into ridges in single rows for rainy season planting. Transplanting is preferably done in the evening. Press the soil tightly around the seedling to establish a close contact with roots following irrigation.

Transplanting distances are presented in box below:

Planting season	Planting distance in cm		Width of beds and trench in cm	
	Plant to plant	Row to row	Width of beds	Width of trench
Rainy season	75	75	50	25
Autumn and spring season	50	75 and 50 alternatively	100	25

5.5.9 Irrigation and water management

Hot pepper plants require adequate moisture throughout their growth period. The critical periods of moisture needs are immediately after transplanting, after top dressing, after weeding and earthing up, during flowering and fruit initiation. First irrigation is done just after transplanting with a watering can and thereafter it is necessary to maintain proper soil- moisture level for good fruiting and harvest. Water requirement varies according to soil type. Sandy and silt soil needs more irrigation whereas loam soil needs less irrigation. In normal conditions, soil moisture should be between 50 and 80% of field capacity with an average of 60% field capacity. After irrigation and heavy rain, draining of excess water is mandatory otherwise bacterial and fusarium wilt will increase. Autumn and spring season cultivation requires more irrigation while rainy season cultivation needs irrigation only during transplanting time. Irrigation should be provided at an interval of 5–7 days during summer and 10–15 days during winter to ensure that soil is moderately wet. As hot pepper is planted in beds, furrow irrigation is more beneficial. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds shoud be constructed near the cultivation area and collected water should be applied by drip. Water stress and calcium deficiency leads to blossom end rot. Too much irrigation leads to bacterial and fusarium wilt.

5.5.10 Intercultural operations and care

Cutworms are the main enemy of young transplanted chilli. A week after transplanting, the seedlings should be thoroughly inspected and gaps should be filled in the hills where plants are cut by cutworms and roots have decayed and wilted. During the early stage of growth, weed competes with the crop for nutrient and moisture. Therefore, soil should be turned with a hand hoe or khurpi; the crop should be kept free from weeds and the soil should be loose around the plant. An earthing-up operation is recommended 25–30 days after transplanting and another hand weeding 45 days after transplanting. However, the field should always be kept free from weeds and soil should be kept loose around the plants.

Mulching

Mulches are used to reduce or increase soil temperature, suppress weed growth and conserve soil moisture. Organic mulches like straw and dry grasses can reduce the soil temperature in hot weather/summer season. However, plastic mulches increase the soil temperature in winter season and help maintain the optimum temperature required for good growth, flowering, fruiting and fruit quality. Black polythene mulching and transplanting is emerging as a weed control and moisture retention technology; this climate-smart technology reduces weeding cost and prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures.

Staking and training

In general hot pepper does not need any staking. However, if it is planted in beds in rows, during heavy fruiting, the plant/fruit may fall down when it is irrigated or shaken by strong winds. To protect it, stick a strong bamboo, wooden or iron stake next to each plant. The stake should be a metre high to anchor the plant.

5.5.11 Plant protection

The major insects that attack hot pepper are cutworms, thrips, whitefly and leaf miner. Among diseases damping-off of seedlings, early and late blight, phomopsis blight, bacterial wilt, fusarium wilt, root knot nematodes and different leaf curl viruses are the important ones.

Major insects and their management

Insects	Types of damage	Management
Thrips (*Scintothrips dorsalis*)	The larvae and adults infest tender leaves and suck the sap, causing curling of the leaves. Flower and buds are also damaged. Plants look grey and sickly.	• Before fruiting, spray Malathion or Rogor 2ml/litre of water. • During fruiting, pick the ready fruits and then spray nuvan @ 2ml/litre of water. • After spraying, wait for at least 7 days (for nuvan) and 21 days (for rogor) before picking the fruit.
Whitefly	Adult whitefly (*Bemicia tabaci*) lives under the surface of the leaf. Young ones are small and cannot move. Both adults and young ones suck the sap and the leaves turn yellow. It transmits viruses that cause disease.	• Gitimal or botanical extracts or servo can reduce the attack of whitefly. • Natural enemies and predator wasps eat it. • Spray cow or buffalo urine mixed in 10 parts water to drive them away. • Use yellow sticky traps to attract whiteflies.
Leaf Minor	The insect mines inside the leaves, eats the chlorophyll and the leaves dry up and become grey.	• Spray urine or neem product to control the insects. • Spray rogor 2ml/litre of water at weekly intervals.
Cutworms	They cut the base of the seedlings and newly transplanted crops, and the plants topple down. Caterpillars eat the young leaves and growing tips.	• Collect the larvae and kill them. • Spray multinim at @ 2 ml /litre of water.

Major diseases and their management

Diseases	Symptoms	Management
Damping off	This disease is caused by *Pythium altimum, Rhizoctonia solani, and phytopthora parasitica*. It leads to pre-emergence damping-off, which kills the seedling at the initial stage of germination. In post-emergence damping-off, the cortical tissue of the hypocotyls rapidly shrink and darken, and the seedlings die.	• Change the nursery site every year/season. • Spray 50 ml (40%) of formalin mixed in 10 litres of water per square metre bed and cover the beds for two weeks. • Seed treatment with Trichoderma or captan or thiram or bavistin or ceresin @ 2–3g/kg seed. • Spray copper oxychloride with captan or phytolan to control post-emergence damping off. • Spraying Mancozeb (0.25%) and Carbondazim (0.05%) also controls the incidence.
Leaf spot	This disease is caused by *Alternaria solani*. Circular round brown spots with a white centre appear on the older leaves.	• Spray Dithane M 45 @ 2g/litre of water at weekly intervals.

Diseases	Symptoms	Management
Phomopsis blight	Caused by *Phomopsis vexans*. Occurs at the seedling stage as well as in the transplanted crop. Small circular spots develop in leaves. The spots turn grey later with a light coloured centre. Pale to light brown sunken spots develop on the old fruits. Individual spots expand and coalesce to cover the entire fruit or most part of the fruit.	• Use healthy seeds collected from healthy fruits and healthy field. • Grow resistant varieties like Pusa Bhairav and Florida market. • Give hot water treatment to seeds at 50°C for 30 minutes. • Seed treatment with carbendazim @ 0.25%. • At least three-year crop rotation is required with any non-host crop. • Burn infected crop residue. • Bavistin: Seed treatment (1g/kg) + seedling treatment for 30 minutes (0.05% solution) + (0.05% solution) spray at 10–15 days interval.
Early Blight	This disease is caused by soil borne fungi *Cercospora capsici*. Circular angular dark brown spots on leaves, stems and fruits. On green fruits and stems, large, sunken, dark brown leathery spots appear. At a later stage, fruits rot and decay.	• Long-term crop rotation with non-solanacious crops. • Use resistance varieties if available. • Seed treatment with bavistin @ 3g/kg seed. • Spray crop with Dithane Z 78, Dithane M 45 (0.2%) or bavistin (0.1%) three times at 15-day intervals.
Late Blight M	The disease is caused by *Phytopthera capsici*. Disease occurs on the foliage at any stage of the crop. Brown to purple black lesions occur on the leaflet, petiole, fruit and stem. Fruits decay and drop. At a later stage, plants die. The disease appears at low temperature and high humidity.	• Plant disease resistant varieties if available. • Maintain a wider transplanting distance, i.e., 75 x 75 cm. • Provide aeration and sunshine to the entire plant by pruning, training and removing the older leaves fallen on the soil. • Apply a high dose of FYM or compost. • Spray dithane M 45 (0.2%), Ridomil (0.2%), bavistin (0.1%) or Crinoxyl gold 2g/litre of water twice at seven days' interval.
Anthracnose	Anthracnose is caused by *Colletotrichum capsici*. At first, anthracnose generally appears on leaves as small and irregular yellow, brown, dark-brown, or black spots. Infected fruit has small, water soaked, sunken, circular spots that may increase in size up to 1.2 cm in diameter. As it ages, the centre of older spots becomes blackish and emits gelatinous pink spore masses.	• Proper seed and planting materials selection. Sow only disease free seeds. • Proper field sanitation and seed treatment • Transplant only healthy seedlings. • Remove and destroy infected parts but avoid touching other plant parts, especially when these are wet. • Harvest unripe but mature fruits. • Plow under all the plant debris after harvest. • Practice crop rotation. Identify plants that are susceptible to anthracnose disease and rotate these with those that are resistant. • Keep the area free of weeds.
Leaf curl virus	Curling of leaves accompanied by puckering, blistering of intervenial areas and thickening of the vein. Auxiliary buds produce clusters of leaves that are reduced in size. The disease is transmitted by whitefly.	• Two to three sprays of rogor or metasystox @ 2ml/litre of water at 10–15 day intervals to control vector seeds.
Verticillium wilt	The disease is caused by *Verticillium alboatrum* or *Verticillium dahalae*. In peppers verticillium wilt typically begins with wilting. In severe cases, leaf yellowing begins from the older leaves. Later, necrotic areas develop from the leaf tips and edges, and eventually the leaf drops.	• Plant disease resistant varieties. • Follow long-term crop rotation with non-solanacious crops. • Treat the seed, seedlings and field with Sanjiwani, an organic formulation. • After transplanting, mix 5 g of Sanjiwani and 5g of sugar in a litre of water and apply the solution twice around the base of the plant @ 50 ml at 15 days interval.

Diseases	Symptoms	Management
Bacterial wilt	This disease is caused by *Pseudomonas solanacerum*, a soil-borne bacterium. Lower leaves may drop and later the whole plant wilts. Pith of the root is dark brown to black in colour and if it's cut, thin pus-like liquid oozes out. The whole plant or sometimes only a few branches wilt and die.	• Crop rotation with non-solanacious crops. • Plant wilt resistant varieties if available. • Applying bleaching powder 15kg/ha 30 days before transplanting may reduce the incidence. • Uproot wilted plants along with the soil attached to the root zone and burn the plant and soil. • Before transplantin, dip the seedlings in 1g of Streptocycline mixed in 40 litres of water. • In severe cases, spray Streptocycline 20ppm or agrimycin 100 ppm on the field.
Root knot Nematode	This disease is caused by *Meloidogyne* spp. Plants are stunted, leaves become yellow and plants wilt. When uprooted, knots of different sizes are visible.	• Crop rotation with non-solanacious crops. • Deep summer plowing of the field to expose the nematodes. • Plant marigold and when it starts flowering, mulch and turn the soil. • Plant nematode resistant varieties if available. • While transplanting, put carbofuran 1–2 g in each hill. • Apply 500 kg of neem or mustard cake in the soil before transplanting. • Jhomal with Jiwati diluted with three parts water should be applied twice at seven days' interval.
Leaf curl virus	It is caused by virus. The plants are stunted. Growing twigs and leaves are curled. Too many small branches appear and look bushy. This virus is transmitted by whitefly and sap sucking insects.	• To protect the seedlings from virus-transmitting vectors like whitefly, cover the nursery beds with agro-nets. • When the seedlings reach the two-leaved stage, spray 1 ml of rogor twice at 10 days' interval.

5.5.12 Maturity, harvesting and yield

Fruit should be harvested at the right stage depending on the purpose of the harvest. Generally hot peppers are harvested at the mature green stage. They should be shapely, waxy, firm and shiny. Green chillis are ready for harvest 50–60 days after transplanting. They mature from green to red as the seeds inside mature. For culinary purposes hot peppers are harvested when their peduncles become hard and the fruits turn shiny green. For dry spice purposes, they are harvested when they turn red. Hot peppers are picked with an upward twist, which leaves a peduncle and calyx attached to the fruit. Pulling a pepper away from the plant may cause the plant to come out of the soil.

Hot pepper is harvested at 3–4 day intervals in summer and at weekly intervals during late autumn and winter. Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended.

The yield of hot pepper varies according to the season, cultivation methods and variety. In open field conditions, the yield of green fruit ranges from 10–15 tonnes/ha. Once it's dried it amounts to 2–3 tonnes/ha.

5.5.13 Cleaning and grading

After harvest, diseased, decayed, damaged, undersize and broken peppers should be separated. Foreign materials stuck to the fruits such as soil particles, weed leaves, etc. must be washed well and dried in an airy and shady place.

5.5.14 Packaging and transportation

After harvest, green chilli is either sent to a collection centre or directly to the local market or haat bazaar. At the collection centre, peppers are sorted, graded and packed in bamboo baskets or plastic crates or gunny bags and sent to distant markets. Green chilli is transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time it is damaged by the time it reaches the market, as poorly sorted fruit decay along the way. To avoid such damage the following steps should be followed while packaging peppers:

- Graded and sorted chilli should be packed in bamboo baskets or plastic crates with proper aeration. For local market, high gauge poly bags can also be used.
- While packing in crates and bamboo baskets, straw or dry grasses or newspapers should be placed on all four sides and on the top. A few cm space should be left while stacking the crates so that the upper crate does not press the chilli in the lower crate.
- Chilli should be placed evenly and covered with a newspaper so that they are not exposed to sunlight and dust.
- Chilli is light in weight and large in volume, therefore, while transporting them to distant markets, only 8–10 kg of fruit should be packed in each crate or cardboard box for easy handling.
- For distant markets, it is better to transport chilli at night. They should be handled carefully and should reach the main market early in the morning to facilitate timely marketing.
- Chilli produced in the hills is sold in the Terai and large towns of Nepal. Chilli produced in the Terai is sold in the hills during winter.

5.5.15 Storage and marketing

In Nepal there is no organized cold storage for fresh vegetables. However, if marketing is obstructed or delayed due to transport problems, chilli can be stored at low temperature in evaporative cool storage. Pre-cooling are necessary for storing chilli. Chilli harvested at the mature green stage can be stored successfully at 8°–10°C in 85–95% humidity in crates or open polythene bags of 100 gauge thickness for 4–5 days. Storage life of chilli can be increased by keeping them in evaporative cool storage (zero energy cool chambers) at or above 85% relative humidity.

Most of the chilli commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold at the local market or collected at a collection centre and sent to a wholesale market through marketing agents or cooperatives. The producer groups or cooperatives and even individual producers should have prior contact with the marketing agents or traders for organized marketing.

5.5.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum selling price that she/he can sell at profit compared the foregone crops.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling production in nursery		
1.1	Treated and packed hybrid seed	50 gm	200
1.2	Manure and fertilizer	LS	500
2	Crop production labour (nursery preparation, planting to harvest)	14 labour days	4,200
3	Manure, fertilizer and micro nutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Drip irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		8,600
8	Total production 700 kg and price NPR 80	700 *80	56,000
9	Net profit in NPR	56,000–8,600	47,400

5.6 Eggplant

5.6.1 Introduction

Eggplant (*Solanum melongena*) belongs to the family Solanaceae. It is a hardy crop and a very good source of income for small and marginal farmers. Eggplant is eaten as fresh vegetable when it is fairly young. Eggplant fruits are a good source of calcium, phosphorus, iron and vitamins. Edible portion of the fresh fruit per 100 g provides moisture 92.0 gram, protein 1.4 g, fat 0.3g, minerals 0.3g, fibre 1.3g, and carbohydrate 4.0 g. Mineral contents per 100g of edible portion are Ca 18mg, Mg 16mg, Fe o.9mg, Na 3mg, Cu 0.17mg, S 44mg, Cl 53mg, Mn 2.4mg. A small quantity of iodine is also present. The vitamins present are Vitamin A 124 microgram, Thiamin (B1) 0.4 mg, riboflavin (B2) 0.11 mg, nicotine acid (niacin) 0.9 mg, vitamin C 12 mg, choline 52 mg. Eggplant is a rich source of vitamins and minerals and is also reported to stimulate intra-peptic metabolism of blood cholesterol. Eggplant is used in various curry recipes and also consumed as pakoda and bharta.

5.6.2 Climatic requirements

Eggplant is susceptible to severe frost. Seed germination is high at temperatures between 23° and 28°C. Optimum temperature for growth and fruiting is 21° to 37°C day temperature and 18° to 20°C night temperature. Soil temperatures below 15°C retard crop growth and gradual rise of temperature from 21° to 37°C results in increased crop growth; further rise in temperature reduces growth and beyond 40°C fruiting is poor and the fruit dies. Eggplant is a day neutral crop, and if optimum temperature and nutrition is provided, it can be cultivated in any season.

5.6.3 Soil requirements

Eggplant can be cultivated in almost all types of soil; however well-drained loam soil rich in organic matter with high water holding capacity is best. For rainy season crop, light loam to sandy loam is best. Eggplant grows well in slightly acidic soil with pH range 5.5 to 6.

5.6.4 Land preparation

Eggplants bear fruit for a long time, up to two years in warm areas. Land should be prepared well to make the soil suitable for the deep root system. The field should be well drained and be able to hold moisture. Soil should be thoroughly prepared with at least 30 cm deep corrosive plowing/digging followed by 2–3 rounds of light plowing and clod breaking to make soil friable, loose and well levelled. Transplanting beds and trenches should be made for irrigation and excess water drainage. The bed width may vary depending on the cultivation season. For spring and autumn plantation, make 125 cm wide beds with 25 cm wide trenches for two-row planting, and for rainy season 75 cm wide ridges and 25 cm wide trench for one-row planting. For protected production in plastic houses, the beds and trenches should be made to adjust two rows in the central beds and single rows in two side beds.

5.6.5 Manure and fertilizer application

Eggplant bears fruit for several months and is a good feeder of macro- and micronutrients. It requires a balanced dose of NPK fertilizer and a fair amount of micronutrients. A heavy dose of nitrogen may increase vegetative growth and delay fruiting. Balanced doses of NPK improve fruit shape and size and total yield. For best results, apply 30 tonnes/ha of FYM and supplement it with 60–75 kg of nitrogen, 75–90 kg of P_2O_5 and 50–60 kg of K_2O per ha. If FYM is not applied then, double the quantities of chemical fertilizer. However, application of FYM is very important to enable the plant to cope with climate change effects, drought and heavy rain. To be sure of soil pH and fertilizer requirement, soil test is recommended. Apply fertilizer and lime according to the test recommendations. Add micronutrients and mustard cake to improve soil heath.

The FYM is applied during second plowing or digging. A full dose of P_2O_5 and K_2O and one-third dose of nitrogen are mixed thoroughly in the soil at the time of making the beds. The remaining dose of nitrogen is applied as top dressing in three batches: 25–30 days after transplanting and again 50–60 days after transplanting. The third dose is applied after two pickings. In acidic soil, lime should be applied while preparing the beds. Application of 20–30 kg/ha of borax and lime depending on soil pH range is beneficial for yield and fruit quality. Foliar sprays of N and micronutrients have also been found to be beneficial. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. While using such formulations, information on the container label must be read carefully and precautions must be taken. In general, spraying multiplex or agromin 3 ml /litre of water promotes uniform fruiting and harvest. During flowering and fruiting, applying miraculan or hitculan 1 ml/litre of water 2–3 times at 10–15 day intervals also promotes fruiting.

Application of Jholmal at weekly intervals until a month before harvesting has been found to be effective in replacing the use of chemical fertilizers and in controlling most of the diseases and insect pests (see chapter 3.2.2.vi for details).

5.6.6 Variety selection

Open pollinated varieties: Pusa Purple Long, Pusa Kranti, Pusa Anupam, Pusa Upkar, Baishali, Betia Round, Sarlahi Green, Pusa Cluster, Pokhara Lurke, Nurki, Pant Rituraj, etc.

Hybrid varieties: NS 797, Pusa Hybrid 5, Pusa Hybrid 6, Pusa Hybrid 9, ABH 1, ABH 2, Arka Keshab, Arka Navneet, NDBH 1, NDBH 6, Anna 806, Runako, Chhaya, etc.

5.6.7 Nursery establishment and management

For eggplant nursery, select a well-drained open space with ample sunshine. For a hectare transplanting, 500–600 gm of Op seed and 200 gm of hybrid seed or 30,000 to 40,000 seedlings are required. To raise this number of seedlings, a 60–80 square metre nursery is required. Generally nursery beds made during the rainy season are raised, 1 metre wide with a 25 cm wide trench between two beds; in the dry

season, sunken beds are made with 25 cm wide ridges separating two beds. Length of beds may vary but should not be more than 10 metres for easy care and management. Well-decomposed farmyard manure is properly mixed into the topsoil of the beds at the rate of 5–7 kg and 150 gm DAP and 100 gm muriate of potash/metre square. Soil solarization before seed sowing is recommended to kill the fungus and other germs and protect the seedlings from fungal attack. Imported packed open and hybrids available in the market are already treated with fungicides. The seeds should be treated with bavisting 2–3 g/kg seed.

After preparing raised beds, make 2–3 cm deep tiny U-shaped furrows 10 cm apart with the help of a small stick. Drop the seed with the help of your thumb, forefinger and middle finger. Cover the seed with fine sand or fine soil compost mixture or with ash depending on availability. Then mulch the beds with straw or dry grasses or specially made thin perforated jute sacks. After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that soil is kept moist but not over-watered till the seedlings emerge. Eggplant seed germinates 7–10 days after sowing depending on soil temperature. When seed germinates, remove mulch and water it very carefully and lightly. Splashing water forcefully and heavy watering may damage young seedlings and damping-off may attack the nursery. Eggplant seedlings become ready to transplant 25–30 days after germination when it becomes 4–6 leaved and 10 cm high.

During winter season, nurseries are raised in low tunnels and low cost poly-house for spring plantation. A low tunnel made of a transparent plastic sheet provides warm conditions required for raising seedlings successfully in winter. Cover the nursery with 40 mesh nylon nets to protect the seedlings from insects and to reduce vector borne virus infestation and damage by other insects. Eggplant seedlings are transplanted in poly pots for hardening. If they are not transplanted into poly bags, direct hardening of seedlings in the main nursery should be started 3–4 days before transplanting by withholding watering to nurseries.

5.6.8 Transplanting and fruit picking time

Transplanting and fruit picking times vary according to the geographic location and season. In the mid hills, eggplant is transplanted after winter. In the Terai, eggplant is planted in autumn just after the rainy season. Eggplants from the mid hills and high hills are supplied to the market from April to November and eggplants from the Terai are supplied from December to April, covering year-round supply from different geographical areas.

The transplanting and fruit picking times in different geographical areas are presented in the box:

Geographical location	Transplanting and picking months
Terai to inner Terai up to 300 metres (winter to spring)	September-October (November-April)
Low hill basins and mid hills 600–1,500 metres (spring)	February-March (April-July)
Mid hills and high hills 1,000–2,000 metres (rainy season)	April-May (July-November)
Note: Months inside the parentheses are fruit picking months.	

For spring transplanting, seedlings grow slow in winter and take nearly 6 weeks to reach the 4–6 true leaved stage, including hardening. During summer, seedlings are ready to transplant in 3–4 weeks for rainy season and autumn planting. For hardening, seedlings are transplanted into poly pots; otherwise watering is withheld for 3–4 days before transplanting into the main nursery. Hardening enables the plant to withstand transplant shock. Moistening nursery beds before lifting the seedlings make their removal easy without causing much injury to the root system. Select only healthy and strong seedlings for transplanting. Eggplant seedlings are transplanted into flat beds in two rows per bed during autumn and spring; for rainy season planting, they are transplanted into ridges in single rows. Transplanting is preferably done in the evening; the soil around the seedling should be pressed tightly to establish a close contact with roots following irrigation.

Transplanting distances are presented in the box below:

Planting season	Planting distance in cm		Width of beds and trench in cm	
	Plant to plant	Row to row	Width of beds	Width of trench
Rainy season	75	75	50	25
Autumn and spring season	50	75	125	25

5.6.9 Irrigation and water management

Eggplants require adequate moisture throughout their growth period. The critical periods of moisture requirement are immediately after transplanting, after top dressing, after weeding and earthing up, during flowering and fruit initiation. First irrigation is done just after transplanting with a watering can and thereafter it is necessary to maintain proper soil- moisture level for good fruiting and harvest. Water requirement varies according to soil type. Sandy and silt soil needs more irrigation; loam soil needs less irrigation. Under normal conditions, soil moisture should be between 50 to 80% of field capacity with an average of 60% field capacity. After irrigation and heavy rain, draining of excess water is mandatory otherwise bacterial and fusarium wilt will attack the crop. Spring and winter crop needs irrigation at 5–7 day intervals during summer and 10–15 day intervals during winter to ensure that the soil is moderately wet. Eggplants are planted in beds; furrow irrigation is more beneficial. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds shoud be constructed near the cultivation area and collected water should be applied by drip. Too much irrigation leads to bacterial and fusarium wilt.

5.6.10 Intercultural operations and care

Cutworms are the main enemy of young transplanted eggplants. A week after transplanting, the plants should be thoroughly inspected and gaps should be filled in the hills where plants are wilted, cut off by cutworms, and roots are decayed. During the early stage of growth, weed competes with the crop for nutrient and moisture and soil crust formation occurs. Therefore, soil around the plant should be turned and loosened with a hand hoe or khurpi and the crop kept free from weeds. Top dressing of urea and an earthing-up operation is recommended 25–30 days after transplanting, followed by another hand weeding 45 days after transplanting. The field should always be kept free of weeds and soil should be kept loose around the plants.

Mulching

Mulches are used to reduce or increase the soil temperature, suppress weed growth and conserve soil moisture. Organic mulches like straw and dry grasses can reduce the soil temperature in hot weather/ summer season. However, plastic mulches increase the soil temperature during winter season and helps maintain the optimum temperature required for good growth, flowering, fruiting and fruit quality. Black polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces weeding cost and prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures.

Staking and training

Eggplants are quite sturdy and generally do not need staking. However, heavy fruiting occurs in plants growing in rows in beds and heavy fed plants. Irrigation and strong winds may cause such plants to

fall down. To protect them, stick a strong bamboo, wooden or iron stake next to each plant. The stake should be a metre high to anchor the plant.

5.6.11 Plant protection

The major insects that attack eggplants are stem and fruit borer, cutworms, whitefly and leaf miner. Among diseases, damping off of seedlings, early and late blight, phomopsis blight, bacterial wilt, fusarium wilt, root knot nematodes and different leaf curl viruses are the important ones.

Major insects and their management

Insects	Types of damage	Management
Fruit borer	The larva enters the tender twigs and feeds on them and causes wilting. It also bores the fruit and damages the fruit, making it inedible.	• Collect infested twigs and bored fruits and bury them. • Keep the trap of Lucien cultures to attract the males and reduce their population. • Before fruiting, spray Malathion or rogor 2ml/litre of water. • During fruiting, pick the fruits that are ready and then spray nuvan @ 2ml/litre of water.
Red mites	These insects colonize the underside of leaf and suck the sap. Leaves look burnt.	• Before fruiting, spray malathion or rogor. • During fruiting, pick all the fruits that are ready and then spray nuvan. • After spraying pesticide, wait for seven days (in case of nuvan) and 21 days (in case of rogor) before picking the fruit.
Whitefly	Adult whitefly (*Bemicia tabaci*) lives under the surface of the leaf. Young ones are small and cannot move. Both adults and young ones suck the sap and leaves turn yellow. They transmit viral diseases	• Gitimal or botanical extracts or servo can reduce the attack of whitefly. • Natural enemies and predator wasps eat it. • Spray cow or buffalo urine mixed in 10 parts of water to drive them away. • Use yellow sticky traps to attract the insects.
Leaf Minor	The insect mines inside leaves and eats chlorophyll, and the leaves dry up and become grey.	• To control the insect, spray urine or neem product. • Spray rogor 2ml/litre of water at weekly intervals.
Cutworms	The base of the seedlings and newly transplanted crops are cut off and the plants topple down. Caterpillars eat young leaves and growing tips.	• Collect larvae and kill them. • Spray multineem @ 2 ml/litre of water.
Spotted beetle	Beetles are brown with 12–28 black spots and semi circular in shape. Larvae have spines over the body. Both adults and larvae eat the leaves.	• Before fruiting, spay rogor or malathion and during fruiting, spray nuvan @ 2ml/litre of water. • After spraying pesticide, wait for seven days in case of nuvan and 21 days in case of rogor.
Aphids	Adult aphids are small, green, yellow, or mixed green and black. They suck the sap and plants look sick.	• Use ash dust in the morning. • Before fruiting, spay rogor or malathion and during fruiting spray nuvan @ 2ml/litre of water. • After spraying pesticide, wait for seven days in case of nuvan and 21 days in case of rogor.

Major diseases and their management

Diseases	Symptoms	Management
Damping off	This disease is caused by *Pythium altimum, Rhizoctonia solani, and Phytopthora parasitica*. It leads to pre-emergence damping off, which kills the seedling at the initial stage of germination. In post emergence damping-off, the cortical tissues of the hypocotyls shrink and darken rapidly and the seedlings die.	• Change the nursery site every year/season. • Spray 50 ml (40%) formalin mixed in 10 litres of water per square metre bed and cover the beds for two weeks. • Seed treatment with Trichoderma or captan or thiram or bavistin or ceresin @ 2–3g/kg seed. • Spraying copper oxychloride+captan or phytolan controls post-emergence damping off. • Spraying Mancozeb (0.25%) and Cabondazim (0.05%) also controls the incidence.
Leaf spot	This disease is caused by *Alternaria solani*. Circular round brown spots appear on the older leaves.	• Spray Dithane M 45 @ 2g/litre of water at weekly intervals.
Phomopsis blight	Caused by *Phomopsis vexans*. Occurs at the seedling stage as well as in transplanted crop. Small circular spots develop in leaves. Later, the leaves turn grey with a light coloured centre. Pale to light brown sunken spots develop on the old fruits. Individual spots expand and coalesce to cover the entire fruit or most part of the fruit.	• Use healthy seeds collected from healthy fruits and healthy field. • Grow resistant varieties like Pusa Bhairav and Florida market. • Give hot water treatment to seeds at 50° C for 30 minutes. • Seed treatment with carbendazim @ 0.25%. • At least three-year crop rotation with any non-host crop is required. • Burn infected crop residue. • Bavistin: Seed treatment (1g/kg) + seedling treatment for 30 minutes (0.05% solution) + 0.05% solution spray at 10–15 day intervals
Early Blight	This disease is caused by soil borne fungi *Cercospora capsici*. Circular, angular dark brown spots appear on leaves, stems and fruits. Sunken large dark brown leathery spots appear on green fruits and stems. At a later stage, fruits rot and decay.	• Long-term crop rotation should be followed with non-solanacious crops. • Use resistance varieties if available. • Seed treatment with baviatin @ 3g/kg seed. • Spray crop with Dithane Z 78, Dithane M 45 (0.2%) or bavistin (0.1%) three times at 15-day intervals.
Late Blight	The disease is caused by *Phytopthera capsici*. Disease occurs on the foliage at any stage of the crop. Brown to purple black lesions occur in the leaflet, petiole, fruit and stem. Fruits decay and drop. At a later stage, plants die. The disease appears at low temperature and high humidity.	• Plant disease resistant varieties like Srijana. • Maintain a wider transplanting distance, i.e., 75 x 75 cm. • Provide aeration and sunshine to the entire plant by pruning, training and removing the older leaves that touch the soil. • Apply a high dose of FYM or compost. • Spray dithane M 45 (0.2%), Ridomil (0.2%), bavistin (0.1%) or Crinoxyl gold 2g/litre of water twice at seven days' interval.
Anthracnose	Anthracnose is caused by *Colletotrichum capsici*. At first, anthracnose generally appears on the leaves as small and irregular yellow, brown, dark-brown or black spots. Infected fruit has small, water soaked, sunken, circular spots that may increase in size up to 1.2 cm in diameter. As it ages, the centre of the older spots turns blackish and emits gelatinous pink spore masses.	• Proper seed and planting materials selection. Sow only disease-free seeds. • Proper field sanitation and seed treatment • Transplant only healthy seedlings. • Remove and destroy infected parts but don't let them touch other plant parts, especially when these are wet. • Harvest unripe but mature fruits. • Plow under all the plant debris after harvest. • Practice crop rotation. Identify plants that are susceptible to anthracnose disease and rotate these with those that are resistant. • Keep the area free of weeds.

Diseases	Symptoms	Management
Leaf curl virus	Curling of leaves accompanied by puckering, blistering of intervenial areas and thickening of the veins. Auxiliary buds produce clusters of leaves are reduced in size. It is transmitted by whitefly.	• Two to three spray of rogor or metasystox @ 2ml /lit of water at an interval of 10-15 days to control vector inscets.
Verticillium wilt	The disease is caused by Verticillium albo atrum or Verticillium dahalae. In peppers verticillium wilt typically begins with wilting. In severe cases leaf yellowing occurs starting with the older leaves. Eventually necrotic areas develop starting at the leaf tips and edges progressing to leaf drop.	• Plant disease resistant varieties. • Follow long term crop rotation with other than solanacious crops. • Treat the seed, seedlings and field with Sanjiwani an organic formulation. • After transplanting mix 5 g sanjiwani, 5g sugar in a liter of water and apply around base of plant @ 50 ml two times at 15 days intervals.
Baal Wilt	This disease is caused by Pseudomonas solanacerum a soil borne bacterium. Lower leaves may drop down and later whole plant wilts. Pith of root is dark brown to black in color and if cut thin pus like liquid oozes out. Whole plant or sometimes only few branches wilt and die.	• Crop rotation with non-solanacious crops. • Plant wilt resistant varieties if available. • Bleaching powder 15kg/ha application before 30 days of transplanting may reduce the incidence. • If wilt plant is seen uproot along with soil and burn the plant along with root zone soil. • Dip the seeding before transplanting in 1g Streptocycline in 40 liter water solution. • Spray in severe cases Streptocycline 20ppm or agrimycin 100 ppm in the field.
Root knot Nematode	This disease is caused by Meloidogyne spp Plants stunted, leaves become yellow and pants wilt. When uprooted different sizes knots are visible.	• Crop rotation with non-solanacious crops. • Deep summer plowing of the field to expose the nematodes. • Plant marry gold and when starts flowering mulch and turn in the soil. • Plant nematode resistant varieties if available. • While transplanting put carbofuran 1-2 g in each hill. • Apply 500 kg neem or mustard cake in the soil before transplanting. • Jhomal with Jiwatu diluted with three parts water should be applied twice at seven days' interval.

5.6.12 Maturity, harvesting and yield

Fruit should be harvested at the right stage when the seed inside is tender. Generally eggplants are harvested when the fruit is tender. They should be shapely, waxy, firm and shiny. Fruit is ready for harvest within 7–10 days of flowering. Eggplants are picked with an upward twist, which leaves a part of the stem attached to the fruit. To harvest without damaging the plant, it is better to cut the peduncle with secateurs. Pulling the fruit away from the plant may cause the plant to come out of the soil.

Tender fruits are harvested at 3–4 day intervals in summer and weekly intervals during late autumn and winter. Harvesting should be done when there is no dew on the crop, preferably in the afternoon.

The yield of eggplant varies according to the variety. Early and short durational varieties yield 20–30 tonnes/ha whereas late and long durational varieties yield 35–40 tonnes/ha. Hybrids yield up to 40–80-tonnes/ha.

5.6.13 Cleaning and grading

After harvest, diseased, decayed, damaged, undersized and broken fruits should be separated. Foreign materials stuck to the fruits such as soil particles, weed leaves, etc. must be washed off and the fruits should be dried in an airy and shady place.

Based on their size, fruits should be graded into small, medium and large groups. Mixed varieties should be separated. Cleaning and grading provides a basis for orderly marketing.

5.6.14 Packaging and transportation

After harvest, eggplant is sent to a collection centre or directly to the local market or haat bazaar. At the collection centre, eggplants are sorted, graded and packed in bamboo baskets, plastic crates or gunny bags and sent to distant markets. Eggplants are transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time they are damaged by the time they reache the market as poorly sorted fruit break and decay along the way. To avoid such damage, the following steps should be followed while packaging eggplants:

- Graded and sorted eggplants should be packed in bamboo basket or in plastic crate with proper aeration. For Local market high gauge poly bags can also be used.
- While packing in crates and bamboo baskets, straw, dry grasses or newspapers should be placed on all four sides and at the top. A few cm space should be left at the top of the basket so that the upper crate does not press the eggplants in the lower crate.
- Fruits should be placed evenly and covered with a newspaper so that they are not exposed to sunlight and dust.
- Eggplants are light in weight and large in volume, therefore, while transporting them to distant markets, only 8–10 kg of fruit should be packed in each crate or cardboard box for easy handling.
- For distant markets, it is better to transport eggplants at night. They should be handled carefully and reach the main market early in the morning to facilitate timely marketing.
- Eggplants produced in the hills are sold in the Terai and large towns of Nepal. Eggplants produced in the Terai are sold in the hills during winter.

5.6.15 Storage and marketing

In Nepal there is no organized cold storage for fresh vegetables including eggplants. However, if marketing is obstructed or delayed due to transport problem, eggplants can be stored in low temperature and evaporative cool storage. Pre-cooling is necessary for storing fruits. Eggplants can be stored successfully at 8°–10°C in 85–95% humidity in crates or open polythene bags of 100 gauge thickness for 4–5 days.

Most of the eggplants commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold to the local market or collected at a collection centre and sent to a

wholesale market through marketing agents or cooperatives. The producer groups or cooperatives and even individual producers should have prior contact with the marketing agents or traders for organized marketing.

5.6.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling production in nursery		
1.1	Treated and packed hybrid seed	50 gm	500
1.2	Manure and fertilizer	LS	500
2	Crop production labour (nursery preparation, planting to harvest)	14 labour days	4,200
3	Manure, fertilizer and micro nutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Drip irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		8,900
8	Total production 2,000 kg and price NPR 40	2,000 *40	80,000
9	Net profit in NPR	80,000–89,000	71,100

5.7 Okra (Lady fingers)

5.7.1 Introduction

Okra (*Abelmoschus esculentus Moinch*), known in many English-speaking countries as ladies' fingers, belongs to the family Malvaceae. It is a hardy crop and a very good source of income for small and marginal farmers. Okra is eaten as fresh vegetable when it is fairly young. The energy and nutrition value of 100 g of consumable unripe fresh fruit includes 10.4 g dry matter, 3,100 calorie energy, 1.8 g protein, 90 mg calcium, 1.0 mg iron, 1.0 ml carotene, traces of thiamine, riboflavin and niacin, and 18mg of Vitamin C. Okra is used in various curry preparations and mostly eaten as a fried vegetable.

5.7.2 Climatic requirements

Okra is a hot weather crop and thrives well in hot humid season. It is susceptible to drought and low night temperatures. Although a tropical region crop, it can also be grown in selected seasons in warm temperate regions. Seed germination is high at temperatures between 25° and 35°C. The optimum temperature for growth and fruiting is 25° to 35°C day temperature and 18° to 20°C night temperature. Fruiting is poor and fruits may drop under temperatures above 40°C.

5.7.3 Soil requirements

Okra can be grown in a wide range of soils (sandy to clay) but due to its tap root system, well-drained deep loam soil rich in organic matter with high water holding capacity is best. Soil with pH 6.0 to 6.8 allows for maximum nutrient uptake through roots, leading to higher yield.

5.7.4 Land preparation

Land should be prepared well to make the soil suitable for the deep root system. The field should be well drained and be able to hold moisture. Soil should be thoroughly prepared with at least 30 cm deep corrosive plowing/

digging followed by 2–3 rounds of light plowing and clod breaking to make soil friable, loose and well leveled. Sowing beds and trenches should be made for irrigation and excess water drainage. The bed width may vary according to the cultivation season. For spring planting, 100 cm wide beds with 25 cm wide trenches are made for two-row planting and for rainy season planting, 75 cm wide ridges and 25 cm wide trenches are made for one-row planting.

5.7.5 Manure and fertilizer application

Okra bears fruit in each leaf base at least for two consecutive months. It is a good feeder of macro- and micronutrients. It requires a balanced dose of NPK fertilizer and a fair amount of micronutrients. A heavy dose of nitrogen may increase vegetative growth and delay fruiting. Balanced doses of NPK improve fruit shape and size and total yield. For best results, apply 20 tonnes/ha of FYM and supplement it with 60–75 kg of nitrogen, 75–90 kg of P_2O_5 and 50–60 kg of K_2O per ha. The FYM is applied during second plowing or digging. A full dose of P_2O_5 and K_2O and one-third dose of nitrogen are mixed thoroughly in the soil at the time of making the beds. The remaining dose of nitrogen is applied as top dressing in three batches: first two doses are applied 25–30 days and 50–60 days after sowing and the third dose after 3–4 pickings. In acidic soil, lime should be applied while preparing the beds. Application of micronutrients such as zinc, molybdenum and calcium positively affects the yield and quality of fruits. Foliar sprays of N and micronutrients have also been found to be beneficial. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. In general, application of multiplex or agromin at 3 ml/litre of water promotes uniform fruiting and harvest.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and control most of the diseases and insect pests (see chapter 3.2.2.vi for details).

5.7.6 Variety selection

Open pollinated varieties: Nepal has released only one variety (Parbati), a selection from Parwani Kranti, and one registered variety Arka Anamika. Several varieties developed in India are freely entering the market.

Hybrid varieties: Some hybrid varieties are also marketed by seed companies in Nepal. However SQCC is not registered and farmers should be cautious while using/ buying such varieties.

5.7.7 Sowing and fruit picking time

Sowing and fruit picking times differ according to the geographical location and season. Okra is sown in the Terai and low hill basin in the spring season and in upland areas where there is no water logging. In the mid hills and high hills, okra is grown as a rainy season crop.

Sowing and fruit picking times in different geographical areas are presented in the box below:

Geographical location	Transplanting and picking months
Terai to low hill basins up to 600 metres	Late January-June (March- October)
Mid hills 600–1,500 metres	March-June (May-October)
High hills 1,500–2,000 metres (rainy season crop)	April-May (July-September)
Note: Months inside the parentheses are fruit picking months.	

5.7.8 Sowing

Okra is sown directly as transplanting brings little success. Seeds are sown by seed drill, hand dibbling or dibbling with the help of a hoe or khurpi. It can also be sown behind the plough but not deeper than 5 cm.

5.7.9 Seed rate and sowing distance

Seed rate depends on germination percentage and sowing methods including soil moisture condition. The seed rate for spring crop is as high as 15 kg /ha as germination is poor due to low temperature. Higher seed rate and lower spacing is recommended for spring planting. For rainy season planting, wider spacing lowers the seed rate; if soil moisture is appropriate due to high temperature, 6–8 kg seed/ha is sufficient.

Sowing distance during the rainy season is maintained at 75 cm between rows and 50 cm between plants. In case of spring season planting, both row-to-row and plant-to-plant distances are maintained at 50 cm. Trench and planting distances are presented in the box below:

Planting season	Planting distance in cm		Width of beds and trench in cm	
	Row to row	Plant to plant	Width of beds	Width of trench
Rainy season	75	50	75	25
Spring season	50	50	100	25

5.7.10 Irrigation and water management

As a broad-leaved plant, okra requires adequate moisture throughout its growth period. During sowing, moisture stress reduces germination and poor crop stand. Spring crops need frequent irrigation in the trenches to keep the moisture level at 50 to 80% of field capacity with an average of 60% field capacity. After irrigation and heavy rain, draining of excess water is important. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds shoud be constructed near the cultivation area and collected water should be applied by drip. In the dry season, top dressing and earthing-up operation is critical after weeding. If the dry spell is long, light irrigation at weekly intervals will give better yield.

5.7.11 Intercultural operations and care

After germination, inspect the field and sow the seeds and fill the gaps in the hills where seeds are not germinated or seedlings appear very weak. If soil crust has formed, break the crust with light hoeing. During the early stage of growth, weed competes with the crop for nutrient and moisture. Therefore, soil around the plant should be turned and loosened with a hand hoe or khurpi and the crop kept free from weeds. Top dressing of urea and an earthing-up operation is recommended 25–30 days after transplanting, followed by another hand weeding 45 days after transplanting. The field should always be kept free of weeds and soil should be kept loose around the plants.

Mulching

Organic mulches like straw and dry grasses can help maintain the soil temperature in hot weather. Plastic mulches increase the soil temperature in winter and help maintain the optimum temperature required for good germination, growth, flowering, fruiting and fruit quality. Black polythene mulching and sowing is emerging as a weed control and moisture retention technology; as a climate-smart technology, it reduces weeding cost and prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures.

5.7.12 Plant protection

The major insects that attack okra fruit are shoot borer and leaf hopper. Among diseases, powdery mildew and yellow vein mosaic are the important ones.

Major insects and their management

Insects	Types of damage	Management
Fruit and shoot borer	The insect (*Earias* spp) attacks the crop. The larvae feed on tender buds, fruits and bores the fruit and damages making inedible.	• Collect infested and bored fruits and burry it. • Before fruiting spray Malathion or rogor 2ml/lit of water. • During fruiting pick the ready fruits and then spray nuvan @ 2ml/lit of water.
Leaf Hopper	Both young ones and adults suck the sap from the lower surface of the leaf. It transmits viral diseases.	• Before fruiting, spray Malathion or rogor 2ml/litre of water. • During fruiting, pick the fruits that are ready and then spray nuvan @ 2ml/litre of water.

Major diseases and their management

Diseases	Symptoms	Management
Powdery Mildew	It is caused by the fungus *Erysiphe cichoracecearum* under prolonged humid conditions. White powdery pustules appear on the lower surface of the leaf and at a later stage extend to the upper surface. White mass is seen and the leaf turns yellow and eventually dies.	• Spray wettable sulphur @ 2g/litre of water at weekly/ fortnightly intervals depending on the intensity of the disease. • Spraying bevistin or benlate 2 2g/lit of water once or twice also controls the spread of the disease.
Yellow vein mosaic virus	This virus has many alternative hosts and is transmitted by whitefly (*Bemicia tabaci*). The symptoms appear as vein clearing and later the whole leaf becomes yellow. Once the whitefly feeds on an infected plant, it becomes infective throughout its life and spreads the virus. The whole field looks yellow and yield loss is from 25% to 100%.	• Grow resistant varieties like Parbati, Arka Anamika etc. • Destroy alternative hosts of Malvaceae family from around the field. • Before fruiting, spray Malathion or rogor 2ml/litre of water. • During fruiting, pick the fruits that are ready and then spray nuvan @ 2ml/litre of water. • Monitor the field regularly. Inspect the leaves carefully and also monitor insect incidence.

5.7.13 Maturity, harvesting and yield

Fruit should be harvested at the right stage when the seed inside is tender. The right stage of harvesting in okra depends on the growing temperature. At lower temperatures of 15°–20°C, the fruit is ready to harvest within 8–10 days of flowering whereas in higher temperatures of 25°–30°C, it is ready for harvest within 4–6 days of flowering. After prolonged, the fruit becomes harder with fibre and cannot be used as vegetable. Too early harvest will give lower yield with tender fruits and shorter shelf life. Under normal temperatures of 20°–25°C, okra is ready for harvest within 6–8 days of flowering. During harvest, wear cotton gloves to protect your hands from the bristles on the plant. Okra is picked with a sideward twist by bending the pedicle with a jerk. However, to harvest it without damaging the plant, it is better to cut the peduncle with secateurs. Pulling the fruit away from the plant may damage the leaf and stem.

Tender fruits are harvested at 2–4 day intervals in the rainy season and weekly intervals during late spring. Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended. The yield of okra varies according to the variety. Early and short durational varieties yields 10–12 tonnes/ha whereas late and long durational varieties yield 15–20 tonnes/ha. Hybrids yield up to 20–25 tonnes/ha.

5.7.14 Cleaning and grading

After harvest, diseased, decayed, damaged, small, broken and curved fruits should be separated. Foreign materials stuck to the fruits such as soil particles, weed leaves, etc. must be washed off and the fruits should be dried in an airy and shady place. Based on their size, fruits should be graded into small, medium and large groups and mixed varieties should be separated. Cleaning and grading is done to provide a basis for orderly marketing.

5.7.15 Packaging and transportation

After harvest okra is sent to a collection centre or directly to the local market or haat bazaar. At the collection centre, okras are sorted, graded and packed in bamboo baskets, plastic crates or gunny bags and sent to distant markets. Okras are transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time they are damaged by the time they reach the market, as poorly sorted fruit decay along the way. To avoid such damage, the following steps should be followed while packaging okra:

- Graded and sorted okra should be packed in bamboo baskets or plastic crates with proper aeration. For local market, high gauge poly bags can also be used.
- While packing okra in crates and bamboo baskets, straw, dry grasses or newspapers should be placed on all four sides and at the top. A few cm space should be left while stacking the crates so that the upper crate does not press the okra in the lower crate.
- Fruits should be placed evenly and covered with a newspaper so that they are not exposed to sunlight and dust.
- Okra is light in weight and large in volume, therefore, while transporting them to distant markets, only 8–10 kg of fruit should be packed in each crate or cardboard box for easy handling.
- For distant markets, it is better to transport okra at night. They should be handled carefully and should reach the main market early in the morning to facilitate timely marketing.
- Okra produced in the Terai during early spring has off-season market in the hills.

5.7.16 Storage and marketing

In Nepal there is no organized cold storage for fresh vegetables including okra. However, if marketing is obstructed or delayed due to transport problems, it can be stored at low temperature in evaporative cool storage. For storing fruits pre-cooling are necessary. It can be stored successfully at 8°–10°C in 85–95% humidity in crates or open polythene bags of 100 gauge thickness for 2–3 days.

5.7.17 Cost of production and profit

Cost of Production

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit. Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1).

S.N	Particulars	Quantity	Amount in NPR
1	Direct sowing	500 gm	300
2	Crop production labour (planting to harvest)	16 labour days	4,800
3	Manure, fertilizer and micro nutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Packaging and transportation	LS	500
6	Total cost		8,400
7	Total production 1,000 kg and price NPR 40	1,000 *40	40,000
8	Net profit in NPR	40,000–8,400	31,600

5.8 Cucumber

5.8.1 Introduction

Cucumber (*Cucumis sativus*) belongs to the family Cucurbitaceae. It is a very good source of income for small and marginal farmers. Cucumber is eaten as fresh vegetable when it is fairly young and used to make good pickles (Khalpee) when matured. It is consumed raw with salt and pepper and also widely eaten as salad mixed with tomato, onion, carrot, radish, beetroot, chilli, etc. 100 gram of fresh cucumber contains Vitamin C 7 mg, phosphorus 25 mg, calcium 10 mg, and iron 0.6 mg. Consumption of fresh cucumber helps to reduce gastritis, acidity and constipation and is good for jaundice patients. It also helps control weight. In the hills of Nepal cucumbers are scarce during the period from November to March. During this season it is produced and supplied from the Terai, inner Terai and low hills, where they are grown under plastic houses and river basins.

5.8.2 Climatic requirements

Cucumber is a warm season crop and susceptible to severe frost. Seed germination is high at temperatures between 23° and 28°C. Optimum temperature for growth and fruiting is 18° to 35° C day temperature and 18° to 20°C night temperature. Soil temperature below 12°C retards crop growth and gradual rise in temperature from 18° to 35° C results in increased fruiting and crop growth. The best fruiting occurs at 25° to 30° C.

5.8.3 Soil requirements

Cucumber can be cultivated in almost all types of soils; however, sandy or sandy loam for early spring crop is desirable. For late spring crop, well-drained silt and clay loam soil rich in organic matter with high water holding capacity is best. For rainy season crop, light loam to sandy loam is best. Cucumber grows well in nearly neutral soil with pH range 6 to 7.

5.8.4 Land preparation

Cucumber bears fruit for a long and continuous period of time in warm areas. Land should be prepared well to make the soil suitable for the deep root system. The field for this crop should be well drained and be able to hold moisture. Soil should be thoroughly prepared and well leveled with at least 30 cm deep corrosive plowing/digging. Transplanting beds and furrows should be made for irrigation and excess water drainage. The bed width is generally 2.5 metres with 25 cm wide and 15 cm deep furrows for intercultural operations and irrigation and drainage. Length of beds may go up to 10 metres depending on the land. In the beds prepared for transplanting seedlings/ sowing seed, build pits 50 cm wide, 50 cm long and 50 cm deep and maintain 2 metres row-to-row and 1 metre plant-to-plant distance.

5.8.5 Manure and fertilizer application

Cucumber is a good feeder of macro and micronutrients. It requires a balanced dose of NPK fertilizer and a fair amount of micronutrients. Balanced doses of NPK improve fruit shape and size and total yield. The total blank dose of fertilizer recommended is FYM 35–40 tonnes, 50 kg of N, 60 kg of P_2O_5 and 30 kg of K_2O per ha. The basal doses of these manure and fertilizer should be applied using two methods. First basal dose of 20–25 tonnes of FYM, 40 kg of P_2O_5 and 20 kg of K_2O per ha should be applied during the second digging before making the beds. The second basal dose is applied in the 50 cm^3 pits after making the beds and furrows. 2–5 kg of FYM, 10 gm of urea, 15 gm of DAP and 10 gm of muriate of potash should be mixed thoroughly in each pit. Ten gm urea per pit, 25 kg of N is applied in the pit as a basal dose. The remaining 25 kg of N is applied as top dressing in two batches: first dose is applied 25–30 days after transplanting and second dose when fruiting starts. In acidic soil, lime should be applied while preparing the beds. Application of lime according to the pH range is beneficial for yield and fruit quality. Deficiency of micronutrients, especially calcium, is prominent in cucumber. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. While using such formulations, instructions on the container label must be read carefully and precaution must be taken. In general application of multiplex or agromin 3 ml/litre of water promotes uniform fruiting and harvest. During flowering and fruiting, applying miraculan or hitculan 1 ml /litre of water 2–3 times at 10–15 day intervals also promotes fruiting.

Application of Jholmal at weekly intervals until a month before harvesting time is effective in replacing the use of chemical fertilizers and in controlling most of the diseases and insect pests (see chapter 3.2.2.vi for details).

5.8.6 Variety selection

Open pollinated varieties: Kusule, Bhaktapur Local, Long Green, Poinsett are popular.
Hybrid varieties: Ninza 179, Priya, Belly, Malini, Dynasty, K-1, Mahico white, Mahico Green

5.8.7 Nursery establishment and management

For early crops, cucumber seedling is prepared in white or black polyethylene bags of size 15 cm X 10 cm and 100–200 gauge thickness. The bags are filled with a mixture of 2 parts sieved fertile soil, 2 parts well-rotted FYM/ compost and 1 part sand or ash. For each 10 kg mixture, 150 gm of DAP and 100 gm of muriate of potash, 5–10 gm of organic pesticide (neem or Bakaino seed dust) or safe insecticide (Malathion 5 gm) may be mixed to kill the insects and other germs and protect the seedlings from insect attack. The mixture is then moistened by sprinkling 2 gm of bavistin/litre of water and covered with a white plastic sheet for 48–72 hours to kill the fungus. Before filling the polyethylene bags, 4 to 6 holes are made on the basal sides of the bags with a punching machine to provide aeration and drain excess water. The bags are filled with the mixture leaving 2–3 cm space at the top. The filled bags are arranged in rows in a low plastic tunnel and a single seed is sown in each bag. If the seed does not germinate, it can be sown again. While sowing the seed, the pointed end of the seed should be dibbled downward at the depth of 4–5 cm. The nursery site where tunnels are made should be open and well drained and get ample sunshine. For a hectare transplanting, 500–600 gm of seed or 5,000–6,000 seedlings are required. Well packed open-pollinated and hybrid seeds are available in the market and are already treated with fungicides. If the seeds are not treated, treat them with bavisting 2–3 g/kg seed.

After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that the soil is moist but not over-watered till the seedlings emerge. Cucumber seed germinates within 7–10 days of sowing depending on soil temperature. When seed germinates, remove mulch and water it very carefully and lightly. Forceful splash of water and heavy watering may damage young seedlings and damping-off may attack the nursery. Cucumber seedlings become ready for transplanting within 15–20 days of germination when it becomes 4–6 leaved and 10 cm high.

During winter season, nurseries are raised in low tunnels and low-cost poly-houses for spring plantation. A low tunnel made of a transparent plastic sheet provides an ideal environment for seedling growth in winter. It facilitates early transplanting for spring planting. Cover the nursery with 40 mesh nylon nets to protect the seedlings from insects and to reduce vector borne virus infestation and damage by other insects.

5.8.8 Transplanting and fruit picking time

Transplanting and fruit picking times vary according to the geographical location and season. In the Terai, river basins and low hill basins, cucumber is transplanted under low plastic tunnels for early crop; the tunnel is removed when temperature increases and frost is gone. Similarly in the mid-hills, seedlings are transplanted in late winter for spring and summer harvest. In some Terai areas with plenty of sunshine and no fog, seedlings are grown in large plastic houses for off-season winter harvest. In the hills and high hills, in situ planting is done with pre-monsoon showers for rainy season harvest. The transplanting/sowing and fruit picking times in different geographical areas are presented in the box below:

Geographical location	Transplanting and picking months
Terai to low hill basins up to 600 metres (early spring crop)	December-January (March-May)
Mid-hills 600–1,500 metres (spring to summer crop)	February-March (April-July)
Mid-hills and high hills 1,000–2,000 metres (rainy season crop)	April-May (July-November)
Note: Months inside the parentheses are fruit picking months.	

In winter, seedlings grow slowly and take nearly 6 weeks to reach the 4–6 true leaved stage for spring transplanting. In summer seedlings become ready in 3–4 weeks for rainy season transplanting. Select only healthy and strong seedlings for transplanting. While transplanting/sowing, maintain a 2 m row-to-row distance and 1 m plant-to-plant distance. In the rainy season, both row-to-row and plant-to-plant distance should be 2 metres.

5.8.9 Irrigation and water management

Cucumber requires adequate moisture throughout its growth period. The critical periods of moisture requirement are immediately after transplanting, after top dressing and weeding, during flowering and fruit initiation. First irrigation is done just after transplanting with a watering can and thereafter it is necessary to maintain proper soil-

moisture level for good fruiting and harvest. Water requirement varies according to soil type. Sandy and silt soil needs more irrigation whereas loam soil needs less irrigation. Under normal conditions, soil moisture should be between 50 to 80% of field capacity with an average of 60% field capacity. During dry summer, furrow irrigation at 5–7 day intervals is needed depending on soil type, location and temperature. During irrigation, the water should not wet the stem, leaves and growing tips. Cucumbers are planted in beds; furrow irrigation is more beneficial. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds near the cultivation area shoud be constructed and collected water should be applied by drip. Much irrigation leads to root rot and plants wilt.

5.8.10 Intercultural operations and care

After 2–3 days of transplanting, the plants should be thoroughly inspected and gaps should be filled in the hills where plants are wilted, cut off by cutworms, and roots are decayed. Field should be kept free of weed during the early stage of crop. Later the crop covers the field and not much weeding is required. However, weeds must be removed when they appear as they compete with the crop for nutrient and moisture. If immediately after transplanting soil crust formation occurs. Therefore, soil around the plant should be turned and loosened with a hand hoe or khurpi and the crop kept free from weeds. Top dressing of urea and a shallow earthing-up operation is recommnded after 25–30 days of transplanting and another hand weeding after 45 days of transplanting.

Mulching

Mulches are used to reduce or increase the soil temperature, suppress weed growth and conserve soil moisture. Organic mulches like straw and dry grasses can reduce the soil temperature in hot weather/summer season. However, plastic mulches increase the soil temperature during winter season and helps maintain the optimum temperature required for good growth, flowering, fruiting and fruit quality. Black polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces weeding cost and prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures. Mulching also helps prevent fruit rot that results from the fruit touching the soil when no stakes are used.

Staking and training

Cucumber is a vine crop that is highly suited for staking. Different staking methods can be used depending on the availability of staking materials, as shown in the picture below. The stake anchors the plant and helps improve fruiting.

Use of plant growth regulators

In cucumber, application of ethrel (150–200ppm) increases the number of female flowers and fruit-set, which in turn increases fruit yield. Growth regulators like GA (1,500–2,000 ppm) and chemicals like silver nitrate (200–300ppm) induce the male flowers on gynoecious cucumber. This helps maintain gynoecious lines in pure form, and this helps achieve heterosis. These chemical plant growth regulators may be applied at the 2-true-leaf stage and repeated at the 4-true-leaf stage.

5.8.11 Plant protection

The major insects that attack cucurbitaceous crops are quite common. However, the intensity varies from crops to crop. The major insects include fruit fly and spotted beetle, and major diseases include powdery mildew, downy mildew and viruses. The symptoms and control measures are presented at the end of the section.

5.8.12 Maturity, harvesting and yield

Fruit should be harvested at the right stage when the seed inside is tender, especially if it is to be eaten fresh and raw. It should be harvested 10–12 days after the flowering of female flower when it has become 15 cm long with a 5–8 cm diameter. For making pickles, it should be harvested at a mature stage when the skin has become hard and dark brown. Cucumbers are picked with an upward twist, which leaves the peduncle attached to the fruit. To harvest it without damaging the plant, it is better to cut the peduncle with secateurs. Pulling the fruit away from the plant may break the vine.

The harvesting is done at 3-4 day intervals in summer and at weekly intervals during late spring. Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended.

The yield of cucumber varies according to the variety. Early and short durational varieties yield 15–20 tonnes/ha whereas hybrids yield 30–40 tonnes/ha.

5.8.13 Cleaning and grading

After harvest, cracked, crooked, diseased, undersized, decayed and damaged fruits should be separated. Foreign materials stuck to the fruits such as soil particles, weed leaves, etc. must be washed off and the fruits should be dried in an airy and shady place.

Based on their size, fruits should be graded into small, medium and large groups. Mixed varieties should be separated. Cleaning and grading is done to provide a basis for orderly marketing.

5.8.14 Packaging and transportation

In cucumber crookneck-shaped fruits are produced at the later stage of growth. Such fruits are produced due to imperfect pollination and fertilization and also due to insect attack. Rainy season crop damaged by summer rain, fruit fly attack and crooked fruits should be culled before the fruits are sent to the market. Cucumber cannot fully withstand long-distance transportation. It is better to sell them in nearby markets. If they have to be taken to a distant market, they should be packaged carefully in bamboo baskets or plastic crates. In Nepal they are packed in gunny bags, which are not ideal for packaging the fruit. After harvest, cucumbers are sent either to a collection centre or directly to the local market or haat bazaar. At the collection centre, cucumbers are sorted, graded and packed in bamboo baskets, plastic crates or gunny bags and sent to distant markets. They are transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time they are damaged by the time they reach the market as the poorly sorted fruit break and decay along the way.

5.8.15 Storage and marketing

Cucumber does not have a long storage life. The optimum temperature for storing cucumber is 8–10°C with 85% relative humidity. Even at this temperature it can only be stored for 10–14 days. It's best to consume cucumbers immediately after taking them out of storage. Therefore, most of the cucumbers commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold to the local market or collected at a collection centre and sent to a wholesale market through marketing agents or cooperatives. The producer groups or cooperatives and even individual producers should have prior contact with the marketing agents or traders for organized marketing.

5.8.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1.1	Seedling production, treated and packed hybrid seed	50 gm	500
1.2	Manure and fertilizer	LS	500
1.3	Nursery plantation to hardening in poly-pots	3 labour days	900
2	Crop production labour (planting to harvest)	18 labour days	5,400
3	Manure, fertilizer and micro nutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		11,000
8	Total production 1,500 kg and price NPR 40	1,500 *40	60,000
9	Net profit in NPR	60,000–11,000	49,000

5.9 Bitter Gourd

5.9.1 Introduction

Bitter gourd (*Momordica charantia*) belongs to the family Cucurbitaceae. It is grown for its bitter tender fruits. Fruits are covered with blunt tubercles. It is a very good source of income for small and marginal farmers. Bitter gourd is eaten as a fried vegetable when it is fairly young. It is rich in iron and Vitamin A, B, C and is an inexpensive source of proteins and minerals. The edible 100 gram of fresh bitter gourd contains Vitamin A betacarotene 126 mg and Vitamin C 88 mg, and among minerals phosphorus 70 mg, calcium 20 mg, and iron 0.61 mg. It is believed to prevent cancer and reduce blood pressure and sugar. It also helps control weight. In the hills of Nepal bitter gourd is scarce during the period November to April. During this season it is produced and supplied from the Terai, inner Terai and low hill river basins, where it is grown in plastic houses in a protected environment.

5.9.2 Climatic requirements

Bitter gourd is a warm season crop and susceptible to severe frost. Seed germination is high at temperatures between 28° and 30°C. It can succesfully be cultivated in elevations ranging from the Terai up to 1,500 metres. The optimum temperature for growth and fruiting is 25° to 35°C day temperature and 18° to 20°C night temperature. Soil temperatures below 12°C retard crop growth. Beyond 38°C fruiting is reduced due to poor pollination if the fruit shape is crooked.

5.9.3 Soil requirements

Bitter gourd can be cultivated in almost all types of soils; however, well-drained silt and clay loam soil rich in organic matter with high water holding capacity is best for spring crop. For late summer and rainy season crop, sandy or sandy loam soil with good drainage is desirable. Bitter gourd grows well in nearly neutral soil with pH range 6.0 to 7.0.

5.9.4 Land preparation

Bitter gourd bears fruit for a long and contiuous period of time in warm areas. Land should be prepared well to make the soil suitable for the deep root system. The field should be well drained and be able to hold moisture. Soil should be thoroughly prepared and well levelled with at least 30 cm deep corrosive plowing/digging. Transplanting beds and furrows should be made for irrigation and excess water drainage. The bed width is generally 2.5 metres, with 50 cm wide and 15 cm deep furrows for irrigation and drainage. Length of beds may go up to 10 metres depending on land. In the beds prepared for transplanting seedlings /sowing seed, 50 cm wide, 50 cm long and 50 cm deep pits are made maintaining a 2 metre row-to-row and 1 metre plant-to-plant distance. For protected production in plastic houses, the beds and furrows should be made to adjust two rows in the central bed and a single row in the two side beds.

5.9.5 Manure and fertilizer application

Like cucumber, bitter gourd is a good feeder of macro and micronutrients. It requires a balanced dose of NPK fertilizer and a fair amount of micronutrients. Balanced doses of NPK improve fruit shape and size and total yield. The total blank dose of fertilizer recommended is 35–40 tonnes of FYM, 50 kg of N, 60 kg of P_2O_5 and 30 kg of K_2O per ha. The basal doses of these manure and fertilizer should be applied using two methods. First basal dose of 20–25 tonnes of FYM, 40 kg of P_2O_5 and 20 kg of K_2O per ha should be applied during second digging before making beds. Second basal dose is applied in the 50 cm3 pits after making beds and furrows. In each pit 2–5 kg of FYM, 10 gm of urea, 15 gm of DAP and 10 gm of muriate of potash should be mixed thoroughly. Ten gm of urea per pit, 25 kg of N is applied in pit as a basal dose. The remaining 25 kg of N is applied as top dressing in two batches: first dose after 25–30 days of transplanting and second dose when fruiting starts. In acidic soil, lime should be applied while preparing the beds. Application of lime according to pH range is beneficial for yield and fruit quality. Deficiency of micronutrients, especially calcium, is prominent in bitter gourd. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. While using such formulations, instructions on the container label must be read carefully and precaution must be taken. In general application of multiplex or agromin 3 ml/litre of water promotes uniform fruiting and harvest. During flowering and fruiting, applying miraculan or hitculan 1 ml/litre of water 2-3 times at 10–15 day intervals also promotes fruiting.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.9.6 Variety selection

Open pollinated varieties: Coimbatore Long, Pusa Domausami, Jonpuri, Nepali White, and Jhalari are popular.
Hybrid varieties: Pali, NS 433, Chandra, Laxmi 555, Peepal, Shiva, Ganga, Hira, Seti 444, Komal, Samriddhi, NS434, Chaman, etc.

5.9.7 Nursery establishment and management

For early crops, bitter gourd seedlings are prepared in white or black polyethylene bags of size 15 cm X 10 cm and 100–200 gauge thickness. The bags are filled with a mixture of 2 parts sieved fertile soil, 2 parts well-rotted FYM/compost and 1 part sand or ash. For each 10 kg mixture, 150 gm of DAP and 100 gm of muriate of potash, 5–10 gm of organic pesticide (neem or Bakaino seed dust) or safe insecticide (Malathion 5 gm) may be mixed to kill the insects and other germs and protect the seedlings from insect attack. The mixture is then moistened by sprinkling 2 gm of bavistin/litre of water and covered with a white plastic sheet for 48–72 hours to kill the fungus. Before filling the polyethylene bags, 4 to 6 holes are made on the basal sides of the bags with a punching machine to provide aeration and drain excess water. The bags are filled with the mixture leaving 2–3 cm space at the top.

The filled bags are arranged in rows in a low plastic tunnel and a single seed is sown in each bag. While sowing the seed, the pointed end of the seed should be dibbled downward at the depth of 4–5 cm. The nursery site where tunnels are made should be open and well drained and get ample sunshine. For a hectare transplanting, 1–1.5 kg of seed or 5,000–6,000 seedlings are required. Well packaged open-pollinated and hybrid seeds are available in the market and are already treated with fungicides. If the seeds are not treated, treat them with bavisting 2–3 g/kg seed.

After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that the soil is moist but not over-watered till the seedlings emerge. Bitter gourd seed germinates within 10–15 days of sowing depending on soil temperature. When the seed germinates, remove mulch and water it very carefully and lightly. Forceful splash of water and heavy watering may damage young seedlings and damping-off may attack the nursery. Bitter gourd seedlings become ready for transplanting within 25–30 days of germination when it becomes 4–6 leaved and 10 cm high.

During winter season, nurseries are raised in low tunnels and low-cost poly-houses for spring planting. A low tunnel made of a transparent plastic sheet provides an ideal environment for seedling growth in winter. It facilitates early transplanting for spring planting. Cover the nursery with 40 mesh nylon nets to protect the seedlings from insects and to reduce vector borne virus infestation and damage by other insects.

5.9.8 Transplanting and fruit picking time

In the Terai, river basins and low hill basins, bitter gourd is transplanted under low plastic tunnels for early crop; the tunnel is removed when temperature increases and frost is gone. Similarly in the mid-hills, seedlings are transplanted in late winter for spring and summer harvest. In some Terai areas with plenty of sunshine and no fog, seedlings are grown in large plastic houses for off-season winter harvest. In the hills and high hills, in situ planting is done with pre-monsoon showers for rainy season harvest. The transplanting/sowing and fruit picking times for different geographical areas are presented in the box below:

Geographical location	Transplanting and picking months
Terai to low hill basins up to 600 metres (early spring crop)	December-January (March-May)
Terai to low hill basins up to 600 metres (late summer crop)	February-March (April-August)
Mid hills 600–1,500 metres (spring to summer crop)	February-March (April-July)
Mid hills and high hills 1,000–2,000 metres (Rainy season crop)	April-May (July-November)
Note: Months inside the parentheses are fruit picking months.	

Select only healthy and strong seedlings for transplanting. While transplanting/sowing, maintain a 2 m row-to-row distance and 1 m plant-to-plant distance. In the rainy season, both row-to-row and plant-to-plant distance should be 2 m. Remove the seedlings from the poly-bags before transplanting.

5.9.9 Irrigation and water management

Bitter gourd is a shallow rooted crop. Its roots spread 30 cm into the topsoil layer and requires adequate moisture throughout its growth period. The critical periods of moisture requirement are immediately after transplanting, after top dressing, after weeding, during flowering and fruit initiation. Irrigation is done just after transplantation. Proper soil moisture level should be maintained for good fruiting and harvest. Water requirement varies according to soil type and season. Sandy and silt soil needs more irrigation whereas loam soil needs less irrigation. Under normal conditions, soil moisture should be between 50 and 80% of field capacity with an average of 60% field capacity. During dry summers, furrow irrigation at 5–7 day intervals is needed depending on soil type, location and temperature. Bitter gourds are planted in beds; furrow irrigation is more beneficial. In water scare areas, drip irrigation is provided to staked crops where possible. Wastewater and runoff collection ponds shoud be constructed near the cultivation area and collected water should be applied by drip.

5.9.10 Intercultural operations and care

After 2–3 days of transplanting, the plants should be thoroughly inspected and gaps should be filled in the hills where plants are wilted, cut off by cutworms, and roots are decayed. Field should be kept free of weed during the early stage of crop. Ground cover crops like watermelon or pumpkin can also be planted along with staked crops and these crops cover the field and not much weeding is required. However, weeds must be removed when they appear; otherwise weed competes with the crop for nutrient and moisture. If soil crust forms immediately after transplanting, soil around the plant should be turned and loosened with a hand hoe or khurpi and the crop kept free from weeds. Top dressing of urea and a shallow earthing-up operation is recommended after 25–30 days of transplanting and another hand weeding after 45 days of transplanting.

Mulching

Organic mulches like straw and dry grasses can reduce the soil temperature during hot summer season. Mulches are used to reduce or increase the soil temperature, suppress weed growth and conserve soil moisture. Plastic mulches increase the soil temperature during winter season and helps maintain the optimum temperature required for good growth, flowering, fruiting and fruit quality. Black or white polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces weeding cost and prevents soil structure deterioration and reduces the difference between minimum and maximum soil temperatures. Mulching also helps prevent fruit rot that results from the fruit touching the soil when no stakes are used.

Staking and training

Cucumber is a vine crop that is highly suited for staking. Different staking methods can be used depending on the availability of staking materials, as shown in the picture below. The stake anchors the plant and helps improve fruiting. Other creeping vine crops like pumpkin and watermelon can be inter-cropped with staked crops.

Use of plant growth regulators

Application of growth regulators such as ethrel 25 ppm increases the female flowers. GA at 60 ppm reduces the ratio of male to female flowers. These plant growth regulators may be applied at 2-true-leaf stage and repeated at 4-true-leaf stage for better fruit yield.

5.9.11 Plant protection

The major insects that attack cucurbitaceous crops are quite common. However, the intensity differs from crop to crop. The major insects are fruit fly and spotted beetle, and major diseases include powdery mildew, downy mildew and viruses. The symptoms and control measures are presented at the end of the section on cucurbitaceous crops.

5.9.12 Maturity, harvesting and yield

In bitter gourd, flowering starts after 35–45 days of transplanting and first picking could be done after 10 to 12 days of female flowering. Immature tender fruits are harvested before the seed inside is tender. The colour of tender fruits is light green, dark green or whitish green depending on the variety. At the fully ripe stage, fruits turn yellow and start bursting and should be harvested for seed purposes. While picking bitter gourds, the tendril peduncle is broken by hand, which leaves the peduncle attached to the fruit. To harvest without damaging the plant, it is better to cut the peduncle with secateurs. Pulling the fruit away from the plant may cause the vine to break.

Harvesting is done at 3–4 day intervals in summer and at weekly intervals during late spring. Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended. Regular harvesting will increase the fruit yield.

The yield of bitter gourd varies according to the variety and season. Early and short durational varieties yield 10–15 tonnes/ha whereas hybrids yield 20–30 tonnes/ha.

5.9.13 Cleaning and grading

After harvest remove all insect-affected, cracked, crooked, diseased and deformed fruits. Foreign materials stuck to fruits such as soil particles, leaves, etc. must be washed off and the fruits should be dried in an airy and shady place. Fruits should be graded based on their size. Sprinkling fresh water helps retain the freshness.

5.9.14 Packaging and transportation

In bitter gourd crookneck-shaped and smaller fruits are produced at the later stage of growth. Such fruits are produced due to imperfect pollination and fertilization and micronutrient deficiency. Rainy season crop damaged by fruit fly and crooked fruits should be culled before the fruits are sent to the market. It is better to sell the fruit in nearby markets. If they have to be taken to a distant market, they should be packaged carefully in bamboo baskets or plastic crates. In Nepal bitter gourds are packed in gunny bags, which are not ideal for packaging the fruit. They are transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time they are damaged by the time they reach the market as the poorly sorted fruit break and decay along the way.

5.9.15 Storage and marketing

Bitter gourd can be stored at the optimum temperature of 10°–12°C and relative humidity of 85% for 10–14 days. Bitter gourd can be canned and pickled. Sliced and dried bitter gourd is used as vegetable as and when needed. Dehydrated products of bitter gourd can be packaged properly in polythene bags and sold in the market. Most of the bitter gourds commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold to the local market or collected at a collection centre and sent to a wholesale market through marketing agents or cooperatives.

5.9.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling raising		
1.1	Seedling production, treated and packed hybrid seed	75 gm	300
1.2	Manure and fertilizer	LS	500
1.3	Nursery plantation to hardening in poly-pots	3 labour days	900
2	Crop production labor (planting to harvest)	19 labour days	5,700
3	Manure, fertilizer and micronutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		11,100
8	Total production 1,000 kg and price NPR 50	1,000 *50	50,000
9	Net profit in NPR	50,000–11,100	38,900

5.10 Bottle Gourd

5.10.1 Introduction

Bottle gourd (*Lagenaria siceraria*) belongs to the family Cucurbitaceae. It is grown for its tender fruit. Even people suffering from illnesses can easily digest it. A decoction made from its leaf is very good for curing jaundice. The fruit has a cooling effect; it is a cardiatonic and diuretic. The pulp and juice is a good remedy for cough, constipation, night blindness, and an antidote against certain poisons. The plant extract is used as a cathartic and seeds are used to treat dropsy. The tender fruit is cooked and eaten as a vegetable. It helps control weight. It is good for people who have high blood pressure and stomach problems. The edible 100 gram of fresh fruit contains phosphorus 10 mg, calcium 20 mg, and iron 0.7 mg. Different varieties bear different types of fruit, such as long, cylindrical, oblong and round in size and light green to white in colour. The hard shell can be used as a bowl or water pot.

5.10.2 Climatic requirements

Bottle gourd is a tropical plant that requires hot and humid climate for growth. It is highly susceptible to severe frost. Seed germination is high at temperatures between 28° and 30°C. It can be cultivated successfully in elevations ranging from the Terai to 1,500 metres; at higher altitudes, the fruiting time is very short. The optimum temperature for growth and fruiting is 25°–35°C day temperature and 18°–20°C night temperature. Temperatures below 10°C retard crop growth.

5.10.3 Soil requirements

Bottle gourd can be cultivated in almost all types of soil; however, well-drained, sandy loam rich in organic matter with high water holding capacity is best. Bottle gourd grows well in nearly neutral soil with pH range 5.5 to 7.0. It does not perform well in acidic soil and if pH is below 5.5, agricultural lime 200 to 300 kg/ha should be applied based on soil test report.

5.10.4 Land preparation

Bottle gourd bears fruit for a long and continuous period in warm areas. Land should be prepared well to make the soil suitable for the deep root system. Soil should be prepared well and levelled properly with at least 30 cm deep corrosive plowing/digging. Various systems of sowing have been adopted depending on the season, crop and cultivation system. Transplanting beds and furrows should be made during late winter to spring. The bed width is generally 2.5 to 3 metres with 30 cm wide and 15 cm deep furrows for irrigation and drainage. Length of beds may go up to 10 metres depending on the type of land. In the beds prepared for transplanting seedlings/sowing seed, 50 cm wide, 50 cm long and 50 cm deep pits are made maintaining 2 metre row-to-row and 1.5 metre plant-to-plant distance. The seedlings are transplanted on the edge of the bed and vines are allowed spread over the bed from both sides. For rainy season crop, trellis or staking is recommended for better fruiting.

5.10.5 Manure and fertilizer application

Bottle gourd is a heavy feeder of macro and micro nutrients. It requires a balanced dose of NPK fertilizer and a fair amount of micronutrients. Balanced doses of NPK improve fruit shape and size and total yield. The total blank dose of fertilizer recommended is 20–30 tonnes of FYM, 50 kg of N, 60 kg of P_2O_5 and 40 kg of K_2O per ha. The full dose of FYM, phosphorus, potash and half dose of N are applied as basal doses using two methods. First basal dose of 10–15 tonnes of FYM, 40 kg of P_2O_5 and 30 kg of K_2O per ha should be applied during second digging before making beds. Second basal dose is applied in the 50 cm3 pits after making beds and furrows. 2–5 kg of FYM, 10 gm of urea, 15 gm of DAP and 10 gm of muriate of potash should be mixed thoroughly in each pit. Ten gm of urea per pit, 25 kg of N is applied as a basal dose in the pit. The remaining 25 kg of N is applied as top dressing in two batches: first dose after 25–30 days of transplanting and second dose when fruiting starts. In acidic soil lime should be applied while preparing the beds. Applying lime according to the pH range is beneficial for yield and fruit quality. Deficiency of micronutrients, especially calcium, is prominent in bottle gourd. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. While using such formulations, instructions on the container label must be read carefully and precaution must be taken. In general, spraying multiplex or agromin 3 ml/litre of water promotes uniform fruiting and harvest. During flowering and fruiting, applying miraculan or hitculan 1 ml/litre of water 2–3 times at 10–15 day intervals also promotes fruiting.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.10.6 Variety selection

Open pollinated varieties: Pusa Summer Prolific Long, Pusa Summer Prolific Round, Pusa Meghdoot, Pusa Naveen, Pusa Manjari, Punjab Komal, Arka Bahar, Kalyanpur Long green, Samrat are popular.

Hybrid varieties: Kaveri, NS 421, NS 443, Anamol Pusa Hybrid-3, etc. are popular.

5.10.7 Nursery establishment and management

For early crops, bottle gourd seedlings, including ones that are to be planted in a river basin, are prepared in white or black polyethylene bags of 15 cm X 10 cm size and 100 to 200 gauge thickness. The bags are filled with a mixture of 2 parts sieved fertile soil, 2 parts well-rotted FYM/compost and 1 part sand or ash. With each 10 kg mixture, 150 gm DAP and 100 gm muriate of potash, 5–10 gm organic pesticide (Neem or Bakaino seed dust) or safe insecticide (Malathion 5 gm) may be mixed to kill insects and other germs and protect the seedlings from insect attack. The mixture is then moistened by sprinkling 2 gm bavistin/litre of water and covered with a white plastic sheet for 48–72 hours to kill fungus. Before filling the bags, 4–6 holes are made on the basal side of each bag with a punching machine to provide aeration and drain excess water. The bags are filled with the mixture leaving 2–3 cm gap at the top. The filled bags are arranged in rows in a low plastic tunnel and a single seed is sown in each bag. Soaking the seed in water for 12 hours will facilitate germination. While sowing, the pointed end of the seed should be dibbled downward at a depth of 4–5 cm. The nursery site where tunnels are made should be a well-drained, open space with ample sunshine. For a hectare transplanting, 1.5–2 kg seed or 4,000–4,500 seedlings

are required. Well-packaged open and hybrid seeds are available in the market and are already treated with fungicides. If the seeds are not treated, then treat them with bavisting 2–3 g/kg or thiram 2 gm/kg seed.

After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that soil is kept moist but not over-watered till the seedlings emerge. Bottle gourd seed germinates after 10–15 days of sowing depending on soil temperature. When seed germinates, remove the mulch and water it very carefully and lightly. Strong splash of water and heavy watering may damage young seedlings and damping off may attack the nursery. Seedlings become ready for transplanting after 25–30 days of germination when they becomes 4–6 leaved and 10 cm high.

During winter, nurseries are raised in low tunnels and low-cost poly-houses for spring plantation. Low tunnels made of transparent plastic sheets provide ideal conditions for raising seedlings successfully in winter. It facilitates early transplanting for spring planting. Cover the nurseries with 40 mesh nylon nets to protect the seedlings from insects and to reduce vector borne virus infestation.

5.10.8 Transplanting and fruit picking time

In the Terai and low hill basins, bottle gourd is first transplanted under low plastic tunnels for early crops, and the tunnel is removed when temperature increases and the frost is gone. In the mid hills, seedlings are transplanted in a similar manner during late winter for spring and summer harvest. Usually cucurbits like bottle gourd and pumpkin are sown or transplanted following the relay system just before potato harvest in late January or early February. In the hills and high hills, in situ planting is done with pre-monsoon showers for rainy season harvest. The transplanting/sowing and fruit picking times in different geographical areas are presented in the box below:

Geographical location	Transplanting and picking months
Terai to low hill basins up to 600 metres (river beds)	December-January (March-June)
Terai to low hill basins up to 600 metres (after paddy)	January-February (April-July)
Mid hills 600–1,500 metres (spring to summer crop)	February-March (April-July)
Mid hills and high hills 1,000–2,000 metres (rainy season crop)	April-May (July-November)
Note: Months inside the parentheses are fruit picking months.	

Select only healthy and strong seedlings for transplanting. While transplanting/sowing, row-to-row and plant-to-plant distance is maintained at 2 metres and 1.5 metres respectively for spring season. During rainy season, both row-to-row and plant-to-plant distance should be maintained at 2 metres, for both staked and non-staked plants.

5.10.9 Irrigation and water management

Bottle gourd is a deep-rooted crop. Root spreads approximately 60 cm deep into the soil and is relatively tolerant to waterlogging. It requires adequate moisture throughout its growth period. The critical periods of moisture requirement are immediately after transplanting, after top dressing, after weeding, during flowering and fruit initiation. First irrigation is provided just after transplanting with a watering can and thereafter it is necessary to maintain proper soil moisture level for good fruiting and harvest. Water requirement varies according to soil type and season. Sandy soil needs more irrigation whereas loam soil need less irrigation. During dry summers, furrow irrigation at 5–7 day intervals is necessary depending on the soil type, location and temperature. Bottle gourds are planted in beds; furrow irrigation is more beneficial. Drip irrigation with a water-harvesting pond will ensure water security in dry areas. Rainy season crop does not need irrigation but drainage is necessary.

5.10.10 Intercultural operations and care

After 2–3 days of transplanting, the plants should be thoroughly inspected and gaps should be filled in the hills where plants are wilted, cut off by cutworms, and roots are decayed. Field should be kept free of weed during the early stage of crop. Ground cover crops like watermelon or pumpkin can also be planted with staked crops, and as these crops cover the field, not much weeding is required. However, weeds must be removed when they appear, otherwise they compete with the crop for nutrient and moisture. If soil crust forms immediately after transplanting, soil should be turned and loosened with a hand hoe or khurpi and the crop around the canopy should be kept free of weed. After 25–30 days of transplanting, top dressing of urea and a shallow earthing-up operation is recommended, followed by hand weeding after 45 days of transplanting.

Mulching

Organic mulches like straw and dry grasses are placed under the vines and fruits to keep soil temperature cool in hot summer season. Mulches also help prevent fruits from rotting due to fungal diseases. Black or white polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces weeding cost and prevents soil structure deterioration. In non-staked plants, mulching also helps prevent fruit rot that results from the fruit touching the soil.

Staking and training

Bottle gourd is a vine crop that is highly suited for staking. Different staking methods can be used depending on the availability of staking materials, as shown in the picture below. The stake anchors the plant and helps improve fruiting. Other creeping vine crops like pumpkin and watermelon can be inter-cropped with staked bottle gourd. Staking helps produce straight and slender fruit and allows harvesting without damaging the vine.

Use of plant growth regulators

Application of growth regulators such as ethrel 100 to 150 ppm at the 2 and 4 true leaf stage increases the fruit set.

5.10.11 Plant protection

The major insects that attack bottle gourd are common to all cucurbitaceous crops. However, the intensity differs from crop to crop. The major insects are fruit fly and spotted beetle, and major diseases include powdery mildew, downy mildew and viruses. The symptoms and control measures are presented at the end of the section on cucurbitaceous crops.

5.10.12 Maturity, harvesting and yield

Bottle gourd is harvested when it is young and tender. The seed inside should be tender. The first picking could be done 12 to 15 days after fruit set. In tender fruit ready for harvest, the fruit surface is felt to be slightly pubescent when the outer skin is pressed. The colour of tender fruit is light green to whitish green depending on the variety. At the fully ripe stage, the rind is hard and dirty white; fruit should be harvested at this stage for seed purposes. While picking bottle gourds, the peduncle is broken by hand, which leaves the peduncle attached to the fruit. To harvest without damaging the plant, it is better to cut the peduncle with secateurs. Pulling the fruit away from the plant may cause the vine to break.

Harvesting is done at 3–4 intervals in summer and at weekly intervals during late spring. Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended. Regular harvesting will increase the fruit yield.

The yield of bottle gourd varies according to the variety and season. Early and short durational varieties yield 20–25 tonnes/ha whereas hybrids yield 30–35 tonnes/ha.

5.10.13 Cleaning and grading

Bottle gourd should be harvested and handled with care to avoid damaging the fruit. After harvest, remove all fruits that are insect-affected, cracked, crooked, diseased and deformed. Foreign materials stuck to the fruits such as soil particles, leaves, etc. must be washed off and dried in airy and shady place. Fruits should be graded based on size.

5.10.14 Packaging and transportation

In bottle gourd crookneck-shaped and smaller fruits are produced at the later stage of growth. Such fruits are produced due to imperfect pollination and fertilization and micronutrient deficiency. Rainy season crops damaged by fruit fly attack and crooked fruits should be culled before the fruits are sent to the market. If they have to be taken to a distant market, they should be packaged carefully in bamboo baskets or plastic crates. In Nepal they are packed in gunny bags, which are not ideal for packaging the fruit. They are transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time they are damaged by the time they reach the market as the poorly sorted fruit break and decay along the way.

5.10.15 Storage and marketing

Bottle gourd is a relatively hardy crop and can be stored at the optimum temperature of 10°–12°C and relative humidity of 75–85% for 10–14 days. Most of the bottle gourds commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold at the local market or collected at a collection centre and sent to a wholesale market through marketing agents or cooperatives.

5.10.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit compared the foregone crops.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1):

S.N.	Particulars	Quantity	Amount in NPR
1	Seedling raising		
1.1	Seedling production, treated and packed hybrid seed	100 gm	100
1.2	Manure and fertilizer	LS	500
1.3	Nursery plantation to hardening in poly-pots	3 labour days	900
2	Crop production labour (Planting to harvest)	18 labour days	5,400
3	Manure, fertilizer and micronutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		10,600
8	Total production 2,000 kg and price NPR 25	2,000 *25	50,000
9	Net profit in NPR	50,000–10,600	39,400

5.11 Sponge and Ridge Gourds

5.11.1 Introduction

Sponge and ridge gourds (*Luffa cylindrical and Luffa acutangula*) belong to the genus Luffa and the family Cucurbitaceae. It is grown for tender fruits. Fruits of sponge gourd are smooth and cylindrical and called *thulo ghiraula* or *chillo ghiraula* whereas the fruits of ridge gourds are ribbed and called *pate ghiraula*. The tender fruits of both groups are cooked and eaten as vegetable. The edible 100 grams of fresh fruit of ridge gourd contains 0.5% protein, 3.4% carbohydrate, 37 mg carotene and 18 mg Vitamin C. Sponge gourd fruits contain more protein and carotene than ridge gourd. The matured sponges are used to make bath scrub, doormat, pillow and mattress, dish sponge, etc.

5.11.2 Climatic requirements

Both crops are well adapted to a fairly wide range of climatic conditions. Luffa requires a long warm season for best production. It also grows well in the rainy season. It can be cultivated at elevations ranging from the Terai to high hills; however, at higher altitudes the fruiting time is very short. The optimum temperature for growth and fruiting is 25° to 30°C day temperature and 18° to 20°C night temperature. Seed germination is poor at temperatures below 20°C. Temperatures below 10°C retard crop growth; low temperatures and frost can kill the crop.

5.11.3 Soil requirements

Luffa can be grown in a variety of soils but well-drained loam soil rich in organic matter with high water holding capacity is most preferable. Luffa grows well in nearly neutral soil with pH range 5.5 to 7.0. It does not perform well in acidic soil. If pH is below 5.5, agricultural lime 200 to 300 kg/ha should be applied based on soil test report.

5.11.4 Land preparation

Luffa bears fruit for a long and continuous period in warm areas. Land should be prepared well to make the soil suitable for the deep root system. Soil should be thoroughly prepared and well leveled with at least 30 cm deep corrosive plowing/digging. Soil should be prepared well and levelled properly with at least 30 cm deep corrosive plowing/digging. Various systems of sowing have been adopted depending on the season, crop and cultivation system. Transplanting beds and furrows should be made during late winter to spring. The bed width is generally 2.5 to 3 metres with 30 cm wide and 15 cm deep furrows for irrigation and drainage. Length of beds may go up to 10 metres depending on the type of land. In the beds prepared for transplanting seedlings/sowing seed, 50 cm wide, 50 cm long and 50 cm deep pits are made maintaining 2 metre row-to-row and 1.5 metre plant-to-plant distance. The seedlings are transplanted on the edge of the bed and vines are allowed spread over the bed from both sides. For rainy season crop, trellis or staking is recommended for better fruiting.

5.11.5 Manure and fertilizer application

Luffa requires a balanced dose of NPK fertilizer and a fair amount of micronutrients. Balanced doses of NPK improve fruit shape and size and total yield. The total blank dose of fertilizer recommended is 15–20 tonnes FYM, 50 kg N, 40 kg P_2O_5 and 30 kg K_2O per ha. The full dose of FYM, phosphorus, potash and half dose of N are applied as basal doses using two methods. First basal dose of 10–15 tonnes of FYM, 20 kg P_2O_5 and 15 kg K_2O per ha should be applied during second digging before making beds. Second basal dose is applied in the 50 cm3 pits after making beds and furrows. In each pit 2 kg FYM, 10 gm urea, 20 gm DAP and 5 gm muriate of potash should be mixed thoroughly. Five gm urea per pit, 23 kg N is applied as a basal dose in the pit. The remaining 27 kg N is applied as top dressing in two batches: first dose after 25–30 days of transplanting and second dose when fruiting starts. In acidic soil, lime should be applied while preparing the beds. Application of lime according to pH range is beneficial for yield and fruit quality. Deficiency of micronutrients, especially calcium, is prominent in luffa. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. While using such formulations, instructions on the container label must be read carefully and precaution must be taken. In general application of multiplex or agromin 3 ml/litre of water promotes uniform fruiting and harvest.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.11.6 Variety selection

Open pollinated varieties: In sponge gourd Pusa Chillo, Kantipure, Pusa Supriya and local landraces are popular. In ridge gourd Pusa Nasdar, Co-1, Konkan Harita, Satputia, Punjab Sadabahar and IHR 8 and local land races are popular.

Hybrid varieties: Popular varieties of sponge gourds include New Narayani, NS-445, Geeta Kaveri, NS 421, NS 443, anamol Pusa Hybrid-3, etc.

5.11.7 Nursery establishment and management

Nursery establishment and management for luffa is similar to that of cucumber and bitter gourd. The nursery site where tunnels are made should be a well-drained, open space with ample sunshine. For a hectare transplanting/ sowing, 2–2.5 kg seed or 4,000–4,500 seedlings are required. Well-packaged open and hybrid seeds are available in the market and are already treated with fungicides. If the seeds are not treated, then treat them with bavisting 2–3 g/kg or thiram 2gm/kg seed.

5.11.8 Transplanting and fruit picking time

For early crops, in the Terai and low hill basins, luffa seedlings raised under low plastic tunnels are transplanted when the outside minimum temperature reaches above 9°C and the frost is gone. Similarly in the mid-hills, seedlings are transplanted in late winter for spring and summer harvest. For rainy season crop, seed is sown directly when pre-monsoon showers begin. The transplanting/sowing and fruit picking times are presented in the box below:

Geographical location	Transplanting and picking months
Terai to low hill basins up to 600 metres (river beds)	December-January (March-June)
Mid-hills 600–1,500 metres (spring to summer crop)	February-April (April-October)
All geographical zones (rainy season crop)	April-May (July-October)
Note: Months inside the parentheses are fruit picking months	

Select only healthy and strong seedlings for transplanting and high germinating seed for direct sowing. While transplanting/sowing, the row-to-row and plant-to-plant distances are maintained at 2 metres and 1.5 metres respectively for spring season. During the rainy season, both row-to-row and plant-to-plant distance should be maintained at 2 metres for staked plants.

5.11.9 Irrigation and water management

Luffa is a medium rooted crop. Root spreads approximately 50 cm deep into the soil layer. It requires adequate moisture throughout its growth period. The critical periods of moisture requirement are immediately after transplanting or sowing, after top dressing, after weeding, during flowering and fruit initiation during the dry season. First irrigation is provided just after transplanting with a watering can and thereafter it is necessary to maintain proper soil moisture level for good fruiting and harvest. Water requirement varies according to soil type and season. Sandy soil needs more irrigation whereas loam soil needs less irrigation. During dry summers, furrow irrigation is needed at 5–7 day intervals depending on soil type, location and temperature. Luffa is planted in beds; furrow irrigation is more beneficial. Drip irrigation with a water-harvesting pond will ensure water security in dry areas. Rainy season crop does not need irrigation but drainage is necessary.

5.11.10 Intercultural operations and care

Field should be kept free of weed during the early stage of crop. Weeding should be done after 10–15 days of transplanting/sowing. Soil around the base of the plant should be kept loose and friable. Weeds compete with the crop for nutrient and moisture. Second weeding and top dressing of urea should be done after 25–30 days of transplanting with a shallow earthing-up operation. Another hand weeding after 45 days of transplanting is recommended.

Mulching

When the crops are not staked, organic mulches like straw and dry grasses are placed under the vine and fruits to prevent soil fungus from attacking the fruits and to reduce the soil temperature in hot summers. Black or white polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces weeding cost and prevents soil structure deterioration. In staked crops, only the base of the crop is mulched and some other cover crops may be planted around the stakes.

Staking and training

In small homestead gardens, ridge gourd and sponge gourd are trailed over ropes across the wall, trellises, arbours or pendals at 1.5 to 2 metre height for easy picking. Commercial crops are trained on a thatch like kniffin system. The vines are trained when they are 15–30 cm tall along the main stake; when they reaches the top they spread all over the thatch-like strructure with the fruit hanging below. Luffas are a stake-loving vine crop. Different staking methods can be used depending on the availability of staking materials, as shown in the picture below. The stake anchors the plant and improves fruiting. Staking helps produce straight and slender fruits and also allows harvesting without damaging the vine.

Use of plant growth regulators

Male and female flowers are borne separately on the same plant. Male flowers generally outnumber female flowers. Application of growth regulators such as ethrel 250 ppm in sponge gourd and NAA 200 ppm in ridge gourd increases female flower production and in turn increases yield. These growth regulators can be applied at the 2 and 4 true leaf stage.

5.11.11 Plant protection

The major insects that attack luffa are common to all cucurbitaceous crops. However, the intensity differs from crop to crop. The major insects are fruit fly and spotted beetle, and major diseases include powdery mildew, downy mildew and viruses. The details of symptoms and control measures are presented at the end of the section on cucurbitaceous crops.

5.11.12 Maturity, harvesting and yield

Both sponge and ridge gourds are harvested for consumption when they are young and tender. The seed inside should be tender and the flesh should not be fibrous. The first picking could be done 7–10 days after fruit set when the fruit is still immature. The tenderness is judged by pressing the skin. At the fully ripe stage, the rind becomes hard and dirty brown in colour; fruit should be harvested at this stage for seed purposes. To pick luffas, the peduncle is broken manually, leaving a part of it attached to the fruit. To harvest the fruit without damaging the plant, it is better to cut the peduncle with secateurs. Pulling the fruit away from the plant may cause the vine to break.

Harvesting is done at 3–4 day intervals in summer/rainy season and at weekly intervals during late spring. Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended. Regular harvesting will increase the fruit yield.

The yield of luffa varies according to the variety and season. Early spring crops yields 5–8 tonnes/ha whereas hybrids and rainy season crop yields 8–12 tonnes/ha.

5.11.13 Cleaning and grading

Both sponge and ridge gourds should be harvested and handled with care to avoid damaging the fruit. After harvest, remove all fruits that are insect-affected, cracked, crooked, diseased and deformed. Foreign materials stuck to the fruits such as soil particles, leaves, etc. must be washed off and the fruit should be dried in an airy and shady place. Fruits should be graded based on their size and shape.

5.11.14 Packaging and transportation

Before sending the fruit to the market, fruits that are crooked and damaged by fruit fly should be culled. If they have to be taken to a distant market, they should be packed carefully in bamboo baskets or plastic crates with proper padding to prevent injuries in transit. In Nepal gourds are usually packed in gunny bags; however, this is not an ideal option. They are transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Most of the time they are damaged by the time they reach the market as the poorly sorted fruit break and decay along the way.

5.11.15 Storage and marketing

Fruits at the marketable stage can be stored for 3–4 days in a cool place at the optimum temperature of 10°–12°C and relative humidity of 75–85%. Most of the luffa gourds commercially grown in Nepal are harvested and sent to the market within a day or two. The produce is sold at the local market or collected at a collection centre and sent to a wholesale market through marketing agents or cooperatives.

5.11.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling raising		
1.1	Seedling production, treated and packed hybrid seed	100 gm	100
1.2	Manure and fertilizer	LS	500
1.3	Nursery plantation to hardening in poly-pots	3 labour days	900
2	Crop production labour (planting to harvest)	15 labour days	4,500
3	Manure, fertilizer and micronutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		9,700
8	Total production 800 kg and price NPR 30	800 *30	24,000
9	Net profit in NPR	24,000–9,700	14,300

5.12 Pumpkin and Squash

5.12.1 Introduction

Pumpkin (*Cucurbita moschata*) and summer squash (*Cucurbita Peppo*) both belong to the family Cucurbitaeace. Pumpkin is grown for tender shoots and both tender and matured fruits. Summer squash is grown for tender fruits only. Pumpkin has several strains and species. It is tolerant to heavy rain and to some extent high soil moisture but not water logging. Pumpkin is a vining cultivar and produces large plants with one or more long vines that spread about six metres on the ground; both the root and side vine develop from the nodes. The delicate leaves and shoots are cooked and eaten as leafy greens. The fruit is consumed at both the tender and mature stages. The immature fruits are rich in Vitamin B and C and mature fruit contains Vitamin A in the form of carotene. Pumpkin is a popular vegetable during summer and rainy season. It is also served at feasts and ceremonies. Pumpkin can be stored for a long time on the roofs of houses and barns; it is exported to Tibet, China. Matured pumpkin fruit has diuretic properties and is used to treat gonorrhea and urinary diseases. The part of the peduncle that is attached to the ripe fruit is wetted with water and rubbed to make a paste, which is used as a remedy for the bite of venomous insects, especially centipedes.

Summer squash is an annual bush or vine. They generally produce stems with shortened internodes and set fruits in close succession. The fruits are harvested for consumption before the seed and skin harden. Bush squash cannot be eaten as a vegetable when it is matured. The edible 100 g of fresh fruit contains Vitamin A beta-carotene 13 mg and Vitamin C 18 mg. Among minerals it contains phosphorus 24 mg, calcium 25 mg, iron 0.9 mg and traces of magnesium and potassium.

5.12.2 Climatic requirements

Pumpkin requires a long and warm growing season. It can be grown in relatively cooler climate unlike other cucurbits. Short-days, long-night temperature and high relative humidity is best for pumpkin production. The plants

can be grown successfully at temperatures between 25° and 30°C. Above 40°C and below 15°C the growth of the plant will be very slow and the yield is low. It does not tolerate frost.

On the other hand, squash is a warm season crop. It is mainly cultivated during spring and summer. It cannot tolerate frost. The optimum temperature for growth and fruiting is 20° to 30°C. Seed germination is poor at temperatures below 20°C. Temperatures below 10°C retard crop growth.

5.12.3 Soil requirements

Both pumpkin and squash prefer deep well-drained loamy soil with ample organic matter content. They grow well in nearly neutral soil with pH range 5.5 to 7.0. They do not perform well in acidic soil it. If pH is below 5.5, agricultural lime 200 to 300 kg/ha should be applied based on soil test report.

5.12.4 Land preparation

Land should be prepared well to make the soil suitable for the deep root system. Soil should be prepared well and levelled with 2–3 rounds of at least 30 cm deep corrosive plowing/digging. Various systems of sowing are adopted depending on the season and crop. Pumpkin is directly sown and squash is transplanted during late winter to spring. For pumpkin 2.5 to 3 metres and for squash 150 cm wide beds are prepared with 30 cm wide and 15 cm deep furrows for irrigation and drainage. In the beds prepared for transplanting squash seedlings and sowing pumpkin seed, 50 cm wide 50 cm long and 50 cm deep pits are made, maintaining 2 metres row-to-row and plant-to-plant distance for pumpkin and 1 metre row-to-row and plant-to-plant distance for squash.

5.12.5 Manure and fertilizer application

Both pumpkin and squash requires a balanced dose of NPK fertilizer and some amount of micronutrients. At the time of soil preparation, a total of 25–35 tonnes of FYM, 40 kg of N, 80 kg of P_2O_5 and 40 kg of K_2O/ha have to be applied as basal dose. The remaining 40 kg of N is applied as top dressing after 40–45 days of sowing. The application method is similar to that of other cucurbits.

Deficiency of micronutrients, especially calcium, is prominent in pumpkin and squash. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. While using such formulations, instructions on the container label should be read carefully and precaution must be taken. In general application of multiplex or agromin 3 ml/litre of water promotes uniform fruiting and harvest. During fruit setting, applying miraculan or hitculan @ 1 ml/litre of water twice at 15 days' interval gives the best results. If soil pH is below 5.5, application of 100–200 kg of agricultural lime/ha improves fruiting and soil pH.

Besides, application of Jholmal at weekly intervals until a month before harvest helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.12.6 Variety selection

Pumpkin varieties: Very little research work and variety development has been done on pumpkin. Local land races protected and selected by farmers are used widely. Indian varieties available in the market include Arka Suryamukhi, Arka Chandan, Pusa Viswas, and Pusa Vikas. Some imported varieties from Thailand are also available.

Squash varieties: Asare Squash released in 1990, Black Zucchini, Black Beauty, and among hybrids, Anna 101, Anna 202, Anna 302, Tungeen, Sando-V, Long Green, Honey Desert.

5.12.7 Nursery establishment and management

Generally pumpkin is sown directly and squash is transplanted for early harvest. In late spring season when outside temperature is above 10°C, squash is also sown directly. Nursery establishment and management is similar to that of cucumber and bitter gourd. The nursery site where tunnels are made should be a well-drained, open space with ample sunshine. For a hectare transplanting/sowing, 2–2.5 kg of seed or 4,000–4,500 of seedlings are required. Well-packaged open and hybrid seeds are available in the market and are already treated with fungicides. If the seeds are not treated, then treat them with bavisting 2–3 gm/kg or thiram 2 gm/kg seed.

5.12.8 Transplanting and fruit picking time

For early crops, in the Terai and low hill basins, squash seedlings prepared under low plastic tunnels are transplanted when outside minimum temperature reaches above 9°C and frost is gone. Similarly in the mid hills seedlings are transplanted during late winter for spring and summer harvest. For rainy season crop, seed is sown directly with the pre-monsoon shower. The transplanting/sowing and fruit picking times for squash are presented in the box below:

Geographical location	Transplanting and picking months
Terai - production in plastic houses under protected conditions	November-December (December-March)
Terai to low hill basins up to 600 metres (river beds)	December-January (March-June)
Mid hills 600–1,500 metres (spring to summer crop)	February-March (April-July)
Note: Months inside the parentheses are fruit picking months.	

Pumpkin is sown directly from February to June in all geographical locations. They are sown in beds maintaining 2x2 metres at the two edges of the beds, and vines trail inside from both sides of the bed. While transplanting squash, row-to-row and plant-to-plant distance is maintained at 1 metre and the bed width is 150 cm.

5.12.9 Irrigation and water management

Pumpkin is a deep-rooted crop and squash is a medium-rooted crop. The critical periods of moisture requirement are immediately after transplanting or sowing. After transplanting, plant should be regularly watered for up to 4 days till the plant is established. The critical periods for irrigation are after top dressing, after weeding, during flowering and during fruit initiation if there is no rain and the field is dry. Water requirement varies according to soil type and season. Sandy soil needs more irrigation whereas loam soil needs less irrigation. During dry summers, furrow irrigation at 3–4 day intervals is necessary. As pumpkin and squash are planted in beds, furrow irrigation is more beneficial. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds shoud be constructed near the cultivation area and collected water should be applied by drip. Rainy season crop does not need irrigation but drainage is necessary.

5.12.10 Intercultural operations and care

Field should be kept weed free during the early stage of the crop. Weeding should be done after 10–15 days of transplanting/sowing. Soil around the base of the plant should be kept loose and friable. Weeds compete with the crop for nutrient and moisture. Second weeding and top dressing of urea should be done after 25–30 days of transplanting with a shallow earthing-up operation. Another hand weeding after 45 days of transplanting is recommended.

Mulching

Generally pumpkin and squash are not provided any staking. When stakes are not used, organic mulches like straw and dry grasses are placed below the vines

and fruits to prevent soil fungus from attacking the fruits and to reduce the soil temperature during hot summers. Black or white polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces weeding cost and prevents soil structure deterioration.

Use of plant growth regulators

As in other crops of this family, male and female flowers in pumpkin and squash are borne separately on the same plant and male flowers outnumber female flowers. Application of growth regulators such as ethrel 250 ppm increases female flower production and in turn increases fruit yield. These growth regulators can be applied at the 2 and 4 true leaf stage.

5.12.11 Plant protection

The major insects that attack these crops are common to all cucurbitaceous crops. However, the intensity differs from crop to crop. The major insects are fruit fly and spotted beetle, and major diseases include powdery mildew, downy mildew and viruses. The details of symptoms and control measures are presented at the end of the section on cucurbitaceous crops.

5.12.12 Maturity, harvesting and yield

The maturity standards for pumpkin depend on the purpose for which the fruit will be harvested and market demand. If it is to be consumed as a vegetable, it is better to harvest it at a tender stage, as this will increase the total yield. If Nepali pumpkins are being harvested for storage and for seed extraction or export, they should be harvested at the fully matured stage once their colour changes from green to brown. The fully matured fruits of pumpkin can be stored for a long time, from autumn through winter till summer.

Squash is one of the earliest crops to arrive in the market in spring and summer. Squash fruits become ready for harvest in about 7 days after fruit set. The picking should be done at 2–3 day intervals in order to maximize fruit yield. If earlier fruits are allowed to become larger in size, the new fruits will not set but will drop. Both pumpkin and squash are picked by manually breaking the peduncle, which leaves a part of the peduncle attached to the fruit. To harvest them without damaging the plant, it is better to cut the peduncle with secateurs; this also facilitates handling. Pulling the fruit away from the plant may cause the vine to break.

Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended. Regular harvesting will increase the fruit yield.

The yield of pumpkin varies according to the variety and season. Pumpkin yields 15–25 tonnes/ha and squash 20–30 tonnes/ha depending on harvesting stage and techniques.

5.12.13 Cleaning and grading

Both pumkin and squash should be harvested and handled with care to avoid damaging the fruit. After harvest, remove all fruits that are insect-affected, cracked, crooked, diseased and deformed. Foreign materials stuck to the fruits such as soil particles, leaves, etc. must be washed off and the fruit should be dried in an airy and shady place. Fruits should be graded based on their size and shape.

5.12.14 Packaging and transportation

Fruits are carefully packed in bamboo baskets, wooden boxes or plastic crates with proper padding to prevent injuries in transit. In Nepal they are usually packed in gunny bags; however it is not an ideal option. Sometimes they are packed in gunny bags and transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Often the bags open during the journey and the fruits spill out and get damaged by the time they reach the market.

5.12.15 Storage and marketing

Squash fruits at the marketable stage can be stored for 3–4 days in a cool place at the optimum temperature of 10°–12°C and relative humidity of 75–85%. Matured pumpkins are stored in an open, airy place at normal temperature for up to six months and sold when the market price is high.

5.12.16 Pest management in cucurbits

A large number of diseases and pests affect cucurbits at different stages of growth. The major diseases and pests that attack cucurbits, their symptoms and management practices are described below.

Major insects and their management

Insects	Symptoms	Management
Fruit fly	Maggots of this fly (Dacus cucrbititae and Dacus dorsalis) severely damage young developing fruits. The adult fly lays eggs on the skin of young fruits. The eggs hatch into maggots, which feed on the fruits and cause rotting. The attack is severe in all cucurbit crops when humidity is high.	• Maggots cannot be directly controlled because they are inside the fruits. However, the adult flies can be controlled by setting light traps at night and poison baits. • To control male flies, set pheromone cue-lure traps; use malathion with a piece of cotton inside @ 60 traps/ha. • Prepare baits of sugar or molasses and pieces of matured pumpkin with malathion on wide plates to attract and kill adult flies.
Red Pumpkin Beetle	The beetles (Aulacophora foveicollis) attack most of the cucurbit crops at the seedling stage. They make holes in cotyledonary leaves. Adults feed on tender vines and young leaves in the grown up stage also. Young larvae feed on the roots and stem and fruits touching the ground.	• Collect eggs and larvae and destroy them. • Spray neem products. • If numbers are small, collect the adults in the morning when they are active in feeding. • Nets can be used to collect the adults. • Spray carbaryl (sevin) @ 0.1–0.2% or rogor 0.1% 2–3 times at weekly intervals. • After spraying, wait for the period of time mentioned on the poison container before harvesting the fruit.
Aphids	Greenish white nymphs of aphids (Aphis sp) suck saps from the leaves, stems, flower and fruits. If the attack is severe, plants wilt and die. It causes severe damage from the seedling stage to fruit set stage.	• Spray soap water, human or cow urine, tobacco or neem extract or dust with ash. • Spray Diclorovus, Nuvan 76 EC @ 0.5 ml per litre of water at weekly intervals. • Spray 0.20% malathion at 10–15 day intervals. • After spraying pesticide, wait for 7 to 21 days as indicated on the posion container.

Insects	Symptoms	Management
Root knot Nematode	This disease is caused by Meloidogyne spp. Plants are stunted, leaves become yellow and the plants eventually wilt. When the plant is uprooted, knots of different sizes are visible.	• Crop rotation with non-cucurbit crops • Deep summer plowing • Put carbofuran 1–2 g in each hill before sowing/ transplanting. • Apply 500 kg of neem or mustard cake in the soil before transplanting.

Major diseases and their management

Diseases	Symptoms	Management
Powdery Mildew	It is caused by fungus Sphaerotheca fuliginea. In the initial stage, whitish or fluffy spots appear on the upper and lower surface of the leaves. At a later stage, the entire surface of the leaf and stem appears coated with a powdery substance and the plant eventually dies.	• Use only seed treated with bavistin @ 2gm/kg seed. • Remove diseased leaves when they appear. • Spray karathane @ 0.5% or sulfex @ 0.2% twice within the space of seven days. • Spray servo oil @ 10 ml/litre of water.
Downey Mildew	The disease is caused by fungus Pseudoperenospora cubensis and attacks all cucurbits. Yellow and purplish angular spots appear on the upper surface of the leaves. Black spots appear on the lower surface and the leaves dry.	• Follow crop rotation • Remove affected leaves and in severe cases, remove the diseased plants. • Use only seed treated with bavistin @ 2gm/kg seed. • Spray dithane M-45 @ 0.2% 2–3 times at weekly intervals. • In severe cases, spray copper oxychloride such as blitox 50 @ 2–3 gm/litre of water.
Leaf curl virus	The veins of new leaves are cleared by green and yellow stripes. Leaf curls upwards. Young fruits are deformed.	• Use healthy and treated seed. • Remove alternative host for vectors that transmit the virus, e.g., cress, banana, sugar, beet etc. • Keep the field clean and sanitized. • Control aphids. • Spray Virkone-H @ 3ml/litre of water or Bioleaf care 1ml/litre of water. • Spray Agrishakti @ 2 gm/litre of water.

5.12.17 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling raising		
1.1	Seedling production, treated and packed hybrid seed	100 gm	100
1.2	Manure and fertilizer	LS	500
1.3	Nursery plantation to hardening in poly-pots	3 labour days	900
2	Crop production labor (planting to harvest)	18 labour days	5,400
3	Manure, fertilizer and micronutrient	LS	2,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		10,600
8	Total production 2,000 kg and price NPR 25	2,000 *25	50,000
9	Net profit in NPR	50,000–10,600	39,400

5.13 French Beans

5.13.1 Introduction

French bean (*Phaseolus vulagaris*) belongs to the family Leguminaceae. French beans are of two types: a) bush bean and b) pole bean. They are grown for both tender pods and dried bean (*rajma*). The pods are slender, 10–25 cm long depending on the variety. The pods are straight or slightly curved with a prominent beak. Matured seeds are kidney shaped, elongated but somewhat compressed, and of various colours such as white, red, purple, blackish, or mottled. The bush type has short internodes; pole type has longer internodes and a climbing habit. The tender pods are rich in nutrients; 94% portion of the tender pod is edible, and contains protein 17 gm, vitamin A (betacarotene) 132 microgram, and Vitamin C 24 mg. Among minerals, each 100 gm of French bean contains phosphorus 28 mg, calcium 50 mg, and iron 0.61 mg. Dried beans are rich in protein and a good substitute for meat.

5.13.2 Climatic requirements

Beans are a warm season crop. The optimum temperature for germination is 10°C and for growth and fruiting 15°–30°C. Most beans are day neutral; only some semi pole type varieties are long day types. The crop is sensitive to frost, high temperature and high rainfall. Above 40°C and high rainfall, flowers and young pods drop. It is cultivated especially during spring and summer in the hills and during autumn and spring in the Terai.

5.13.3 Soil requirements

French beans grow in all types of soils ranging from light sandy loam to clay soil but it cannot withstand water logging. Both bush and pole beans prefer deep, well-drained loamy soil with ample organic matter content. Beans grow well in soil with pH range 5.3 to 6.0. It does not perform well in acidic soil. If pH is below 5.3, agricultural lime 200 to 300 kg/ha should be applied based on the soil test report.

5.13.4 Land preparation

For French bean, soil should be prepared well and levelled with 2–3 rounds of at least 25 cm deep corrosive plowing/digging. Beans are sown directly in well-drained raised beds. For pole beans 125 cm and for bush bean 100 cm wide beds should be made, with 25 cm wide and 15 cm deep furrows for irrigation and drainage.

5.13.5 Manure and fertilizer application

Although French bean is a legume, it responds well to the basal application of low level of nitrogen. While preparing the soil, 8–10 tonnes of well-rotted FYM along with 50 kg of nitrogen, 75 kg of P_2O_5 and 75 kg of K_2O/ha should be applied as a basal dose. Being a legume crop, it fixes nitrogen from the atmosphere at later stages, therefore no nitrogen top dressing is required. If micronutrients deficiency is observed, spraying micronutrients improves the quality and yield of crop.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.13.6 Variety selection

Bush bean: Contender, Provider, S-9, Carlos Favorite, L.B 25, and L.B 27 and some imported varieties are popular.

Pole beans: Trishuli (selection from Kentucky Wonder), Four Season (Chaumase) L.B 37, L.B 39, Pant Anupama, CEAPRED VSP White are popular.

Sowing and pod picking time

French beans are sown directly in a well-prepared field. However, for early harvest, seedlings are also raised in poly bags in the lower hills and river basins. Sowing and pod picking times for beans are presented in the box below:

Geographical location	Sowing months	Harvesting months
Terai and inner Terai up to 600 m	August-September	November-January
Mid hills 600–1,500 m	February-April Late July-August	April-July September-October
Mid hills and high hills 1,500–2,500 m	April-May	July-August

5.13.7 Seed rate and sowing methods

Pole beans are sown in 125 cm wide beds in two rows; the row-to-row distance should be 75 cm and hill-to-hill distance 30 cm. For bush bean, sow the seed in 100 cm wide beds with the help of a hand hoe or khurpi, maintaining a row-to-row distance of 50 cm and plant-to-plant distance of 30 cm. Pole bean seed requires 40 to 60 kg and bush bean requires 60 to 80 kg seed/ha. Before sowing, seed should be treated with bavistin @ 2–3 gm/kg seed.

5.13.8 Irrigation and water management

French bean is a shallow rooted crop. Water stress has marked influence on yield and quality of pods. The critical periods of moisture requirement are immediately before or after sowing. The critical periods of irrigation are after top dressing, after weeding, during flowering and during pod setting. Water requirement varies according to soil type and season. Sandy soil needs more irrigation whereas loam soil needs less irrigation. During dry summers, furrow irrigation at 6–7 day intervals is necessary. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds should be constructed near the cultivation area and collected water should be applied by drip. Rainy season crops do not need irrigation but drainage is necessary.

5.13.9 Intercultural operations and care

Field should be kept weed free during the early stage of the crop. Weeding should be done after 10–15 days of germination. Soil around the base of the plant should be kept loose and friable. Weeds compete with the crop for nutrient and moisture in the early stage. Second weeding should be done after 25–30 days of germination. Another hand weeding after 45 days of germination is recommended.

Mulching

Both bush and pole beans, if sown in plastic mulched beds, the beds will preserve temperature, moisture and soil deterioration. Mulching helps improve the quality of bush bean pods, as the plants are not provided staking. When the crops are not staked, organic mulches like straw and dry grasses are placed under the vine and fruits to prevent soil fungus from attacking the fruits and to reduce the soil temperature in hot summers. Black or white polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces weeding cost and prevents soil structure deterioration.

Staking

Staking is an important operation in pole bean. Bamboo sticks, wooden sticks or locally available branches can be used as stakes. If the plants are sown in the bed in two rows, a stick can be planted beside each row and the two sticks can be tied at the top like two arms of a triangle. The stake is thus reinforced and can withstand storms and speedy winds and provides good support.

Alternatively, for autumn sowing, pre-crops of maize can be sown in rows 75 cm apart. While harvesting maize, leave the maize stake up to cub height so that it can also be used to stake autumn sown pole bean.

5.13.10 Plant protection

The major insects that attack leguminacious crops are stem fly, aphids, leaf minor, pod borer and thrips. They are common to all legumes. However, the intensity differs from crop to crop. The major common diseases are powdery mildew, root rot, wilt, yellow vein mosaic, anthracnose, rhizoctonia root rot rust and viruses. The details of symptoms and control measures are presented at the end of the section on leguminacious crops.

5.13.11 Maturity, harvesting and yield

Green pods of both beans are ready for harvest when the pods and the seeds inside are still tender. The pods should easily break into small pieces and contain no fibre on the outer cover. If the pods are to be eaten as a vegetable, it is better to harvest them at a tender stage, as it increases the total yield. For grain and seed extraction purposes, the pods are harvested when they become dry and turn brown in colour and the outer shell shrivels.

In normal conditions, the flowering starts after 25 to 30 days of sowing in bush bean and after 35 to 40 days in pole bean. The pods become ready for harvest in about 7–12 days of flowering; about three pickings in bush bean and five pickings in pole beans are recommended. The green pods should be picked when they are immature but fully grown and still tender. If the harvest is delayed, the total yield increases but the quality deteriorates rapidly due to over maturity of the pods and fibre development and rough surface. The yield of tender pods ranges from 8–10 tonnes/ha in bush bean and 15–20 tonnes/ha in pole beans.

Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended. Regular harvesting will increase the pod yield.

5.13.12 Cleaning grading and packaging

Both bush and pole beans should be harvested and handled with care to avoid damaging the fruit. After harvest remove all pods affected by insects, rust and other diseases and broken pods. Foreign materials stuck to the pods such as soil particles, leaves, etc. must be removed gently using a smooth cloth. Pods are graded based on their size and shape.

5.13.13 Transportation and storage

For local market, pods can be packed in plastic bags and for distant markets they should be packed in bamboo baskets, wooden boxes or plastic crates with proper padding to prevent injuries in transit. Pods are transported in mini trucks, delivery vans, trucks and on the roofs of public buses. Fresh and whole pods can be stored for 2–3 weeks at 0°C and 90–95% humidity.

5.13.14 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seed	3 kg	600
2	Crop production labour (Planting to harvest)	17 labour days	5,100
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		8,400
8	Total production 1,000 kg and price NPR 50	1,000 *25	25,000
9	Net profit in NPR	8,400—25,000	16,600

5.14 Asparagus Bean

5.14.1 Introduction

Asparagus bean (*Tanebodi*), or *Vigna unguiculata var sesquipedialis*, belongs to the family Leguminaceae. It is grown throughout the year in different altitudes and geographical areas in specific months. The pods are slender and up to a metre long. It is also known as yard-long bean or metre-long bean. It is grown for tender pods. In Nepal red seeded and black seeded varieties cultivated. The tender 100 gm pod contains protein 17 gm, Vitamin A beta carotene 132 microgram, Vitamin C 24 mg. Among minerals, each 100 gm contains phosphorus 28 mg, calcium 50 mg, and iron 0.61 mg. Dried beans are rich in protein and a good substitue for meat. In Nepal it is mainly grown for tender pods, which are eaten as vegetables, because the seed yield is very low compared to that of local cowpea.

5.14.2 Climatic requirements

Asparagus bean is a warm season crop. For good germination 10°C and for good growth and fruiting 15°–30°C temperature is optimum. It is day neutral crop. It is cultivated especially during spring and autumn in mid hills, low hills and in Terai. In the mid hills and high hills it is cultivated during summer and rainy season.

5.14.3 Soil requirements

Asparagus bean grows in all types of soils ranging from light sandy loam to clay soils but it cannot withstand water logging. Deep, well-drained loamy soil with ample organic matter content is good for this crop. It grows well in soil with pH range 5.5 to 6.0.

5.14.4 Land preparation

For asparagus bean, soil should be prepared well and levelled with at least 25 cm deep corrosive plowing/digging. It is sown directly in well-drained raised beds. For climbing type 125 cm and for bushy type 100 cm wide beds are

made, with 25 cm wide and 15 cm deep furrows for irrigation and drainage.

5.14.5 Manure and fertilizer application

Although asparagus bean is a legume, it responds well to basal application of low level of nitrogen. About 8–10 tonnes of well-rotted FYM along with 25 kg of nitrogen, 75 kg of P_2O_5 and 60 kg of K_2O/ha should be applied as basal dose at the time of final preparation of the land. Being a legume crop, it fixes nitrogen from the atmosphere at a later stage and no nitrogen top dressing is required. If micronutrients deficiency is observed, spraying micronutrients improves the quality and yield of crop.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.14.6 Variety selection

Bush type: Pusa Phalguni, Arka Suman, Arka Samridhi, Akash, Prakash and new selections are available in the market.

Climbing type: Sarlahi Tane (Black seeded), Khumal Tane (Red seeded), Kashmiri, Meter Long, and Chinese are popular.

5.14.7 Sowing and pod picking time

Asparagus bean is directly sown in well-prepared beds. The sowing and pod picking times are presented in the box below:

Geographical location	Sowing months	Harvesting months
Terai and inner Terai up to 600 metres	August-September February-April	November-January April-July
Mid hills 600–1,500 metres	February-April Late July-August	April-July September-October
Mid hills and High hills 1,500–2,500 metres	April-June	July-September

5.14.8 Seed rate and sowing methods

The climbing type are sown in the 125 cm wide beds in two rows, maintaining a row-to-row distance of 75 cm and hill-to-hill distance of 30 cm. The bush type is sown in 100 cm wide beds in two rows with the help of a hand hoe or khurpi, maintaining a row-to-row distance of 50 cm and plant-to-plant distance of 30 cm. Seed rate for pole type is 40 kg/ha and for bush type is 60 kg/ha. Before sowing, seed should be treated with bavistin @ 2–3 gm/kg seed.

5.14.9 Irrigation and water management

Asparagus bean is a shallow rooted crop. Water stress has a marked influence on the yield and quality of pods. The critical periods of moisture needs are immediately before or after sowing. Flowering and pod development periods are the critical stages of irrigation. During dry season, the crop should be irrigated regularly at 5–7 day intervals for higher yield. In water scarce areas, drip irrigation with mulch is better than other irrigation systems. Wastewater and runoff collection ponds shoud be constructed near the cultivation area and collected water should be applied by drip. Rainy season crop does not need irrigation but drainage is necessary in heavy clay soil.

5.14.10 Intercultural operations and care

Field should be kept weed free during the early stage of the crop. Weeding should be done after 10–15 days of germination. Soil around the base of the plant should be kept loose and friable. Weeds compete with the crop for nutrient and moisture in the early stage. Second weeding should be done after 25–30 days of germination, followed by hand weeding after 45 days of germination.

Mulching

Both bush and climbing types, if sown in plastic mulched beds, the beds will preserve temperature, moisture and soil deterioration. Mulching gives better results on pod quality, as the plants are not provided any staking. When the crops are not staked, organic mulches like straw and dry grasses are placed under the vine and fruits to prevent soil fungus from attacking the fruits and to reduce the soil temperature in hot summers. Black or white polythene mulching and transplanting is emerging as a weed control and moisture retention technology; it reduces weeding cost and prevents soil structure deterioration.

Staking

Staking is an important operation in asparagus bean. Bamboo sticks, wooden sticks or locally available branches can be used as stakes. If the plants are sown in the bed in two rows, a stick can be planted beside each row and the two sticks can be tied at the top like two arms of a triangle. The stake is thus reinforced and can withstand storms and speedy winds and provides good support.

Alternatively, for autumn sowing, pre-crops of maize can be sown in rows 75 cm apart. While harvesting maize, leave the maize stake up to cub height so that it can also be used to stake autumn sown asparagus bean.

5.14.11 Plant protection

The major insects that attack leguminacious crops are stem fly, aphids, leaf minor, pod borer and thrips. However, the intensity differs from crop to crop. Common diseases include powdery mildew, root rot, wilt, yellow vein mosaic, anthracnose, rhizoctonia root rot, rust and viruses. The details of symptoms and control measures are presented at the end of the section on leguminacious crops.

5.14.12 Maturity, harvesting and yield

Green pods are ready for harvest when the pods and the seeds inside are still tender. The pods should easily break into small pieces and contain no fibre on the outer cover. If the pods are to be eaten as a vegetable, it is better to harvest them at a tender stage, as it increases the total yield. For grain and seed extraction purposes, the pods are harvested when they become dry and turn brown in colour and the outer shell shrivels. In normal conditions, flowering starts after 35–40 days of sowing in the bush type and after 45–50 days in the climbing type. The pods become ready for harvest within 7–12 days of flowering; about three pickings in the bush type and five pickings in the climbing type are recommended. The green pods should be picked when they are immature but fully grown and still tender. If the harvest is delayed, the total yield increases but the quality deteriorates rapidly due to over maturity of the pods and fibre development and rough surface. The yield of tender pods ranges from 8–10 tonnes/ha in the bush type and 15–20 tonnes/ha in the climbing type.

Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended. Regular harvesting will increase the pod yield.

5.14.13 Cleaning and grading

Pods should be harvested and handled with care to avoid damaging the fruit. After harvest remove all pods affected by insects, rust and other diseases and broken pods. Foreign materials stuck to the pods such as soil particles, leaves, etc. must be removed. Pods are graded based on their size and length.

5.14.14 Packaging and transportation

For local market pods can be packed in plastic bags and for distant markets they should be packed carefully in bamboo baskets, wooden boxes or plastic crates with proper padding to prevent injuries in transit. Pods are transported in mini trucks, delivery vans, trucks and on the roofs of public buses.

5.14.15 Storage

Fresh and whole pods can be stored for 2–3 weeks at 0°C and 90–95% humidity.

5.14.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation, and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seed	3 kg	600
2	Crop production labour (planting to harvest)	17 labour days	5,100
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		8,400
8	Total production 1,000 kg and price NPR 50	1,000 *25	25,000
9	Net profit in NPR	25,000–8,400	16,600

5.15 Peas

5.15.1 Introduction

Pea (*Pisum sativum*) belongs to the family leguminaceae. It is grown mainly as a winter crop in the Terai and mid hills. In high hills, it is grown during the late rainy season to autumn for off-season marketing around Dasain and Tihar festivals. It is grown for tender pods, which are eaten as a vegetable, and matured seed is also consumed as pulse. Dull creamy seeded and green seeded peas are cultivated in Nepal. Each 100 gm of tender pea contains protein 7.2 gm, Vitamin A beta-carotene 83 mg, and Vitamin C 9 mg. Among minerals, each 100 gm contains phosphorus 139 mg, calcium 20 mg, and iron 1.5 mg. Dried pea seed is rich in protein and is a good substitute of meat.

5.15.2 Climatic requirements

Pea is a cool weather crop. For good germination 10°C and for good growth and fruiting 10°–28°C temperature is optimum. It is a day-neutral crop. The plants are able to withstand low temperature during the early stage of growth; however, it cannot tolerate frost during flowering. Therefore, it shouldn't be exposed to heavy frost during flowering. In the mid hills, low hills and the Terai, it is planted in late autumn and it flowers in early spring after frost is gone. In the mid hills and high hills, it is cultivated during late season for off-season market during autumn.

5.15.3 Soil requirements

Pea can grow in all types of soils ranging from light sandy loam to clay soils but it cannot withstand water logging. Deep, well-drained loamy soil with ample organic matter is good for this crop. It grows well in soil with pH range 5.5 to 6.0.

5.15.4 Land preparation

Land should be prepared well to ensure good growth and allow the root system to spread, as the root fixes large quantities of atmospheric nitrogen. For this, at least 25 cm deep corrosive plowing/digging and levelling is required. Pea is sown directly in well-drained, levelled land. Sowing beds may be divided by a 25 cm wide furrow, with a 2 metre gap between the beds for walking and intercultural operations.

5.15.5 Manure and fertilizer application

A basal dose of about 8–10 tonnes of well-rotted FYM, 25 kg of nitrogen, 75 kg of P_2O_5 and 40 kg of K_2O/ha should be applied during final preparation of the land. The chemical fertilizer should not come into direct contact with seed; therefore it should be mixed well in the soil. Being a legume crop, pea fixes nitrogen from the atmosphere, so nitrogen top dressing is not required. If micronutrients deficiency is observed, spraying micronutrients improves the quality and yield of crop.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.15.6 Variety selection

Early varieties: Asauji, Arkel, Azad, etc.

Mid and late season: New line perfection, Sikkime, Bonneville,

5.15.7 Sowing and pod picking time

Peas are sown directly in well-prepared beds. The sowing and pod picking times are presented in the box below:

Geographical location	Sowing months	Harvesting months
Terai and inner Terai up to 600 metres	October-November	December-January
Mid hills 600–1,500 metres	November-December	March-April
Mid hills and High hills 1,500–2,500 metres	March-April July-August	May-June October-November

5.15.8 Seed rate and sowing methods

The seed rate for early varieties is 80 kg/ha and for mid and late varieties it is 60 kg/ha. For early variety, row-to-row distance is maintained at 50 cm and hill-to-hill distance is 20 cm. For mid and late varieties, row-to-row distance should be 75 cm and hill-to-hill 30 cm. Seed is planted by dibbling or with the help of a hand hoe or khurpi in raised beds of two rows or four rows. Accordingly the bed width can be either 2 m or 1 m. Before sowing, seed should be treated with bavistin @ 2–3 gm/kg seed. Seeds are soaked in water overnight before sowing for better germination.

5.15.9 Irrigation and water management

Water requirement of peas depends on the agro-climatic conditions of the locality. If the soil moisture is not sufficient at the time of sowing, a pre-sowing irrigation should be provided. Unlike with other crops, irrigation should not be provided immediately after sowing as it results in poor germination due to the formation of hard crust, which interferes with the emergence of seedlings. Furthermore excessive moisture causes seed decay and poor germination. During dry periods, light irrigation may be provided at 7–10 day intervals. Critical periods of moisture needs are at flowering and pod development and grain filling stage. Drip irrigation with a water-harvesting pond ensures water security in dry cultivated areas. Rainy season crop does not need irrigation but drainage is necessary.

5.15.10 Intercultural operations and care

Hoeing or hand weeding after 15 to 20 days of sowing prevents weed growth and provides aeration for root growth. Soil around the base of the plant should be kept loose and friable. Weeds compete with the crop for nutrient and moisture in the early stage. Second weeding should be done after 35–40 days of sowing, and hand weeding after 55–60 days of sowing will keep the field clean of weeds.

Mulching

Sowing beds, if covered with black plastic mulch and sowing peas, will preserve temperature, moisture and soil deterioration. Black or white polythene mulching and sowing is emerging as a weed control and moisture retention technology; it reduces the weeding cost and prevents soil structure deterioration.

Staking

In long vine growing varieties like Newline Perfection and Sikkime, staking is an important operation. Bamboo sticks, wooden sticks or locally available branches can be used as stakes. If the plants are sown in the bed in two rows, a stick can be planted beside each row and the two sticks can be tied at the top like two arms of a triangle. The stake is thus reinforced and can withstand storms and speedy winds and provides good support.

5.15.11 Plant protection

Insect pests that attack peas include stem fly, pea aphids, leaf minor, and pod borer. Common diseases in pea are powdery mildew, root rot and wilt. The details of symptoms and control measures are presented at the end of the section on leguminacious crops.

5.15.12 Maturity, harvesting and yield

If they are to be eaten as fresh vegetable, green pods are ready for harvest when they are full but not overmatured; the seeds inside are still tender. Tender pea seeds are cooked mixed with other vegetables like cauliflower, cabbage, potato, etc. For grain and seed purposes, the pods are harvested when they have dried and the outer shell becomes whitish brown and shrivelled.

In normal conditions, flowering starts after 35 to 40 days of sowing in early varieties and 45 to 50 days in late varieties. The pods become ready for harvest in about 10–12 days of flowering; about three pickings in early varieties and five pickings in late varieties are recommended. The yield of tender pods ranges from 8–10 tonnes/ha in early varieties and 15–20 tonnes/ha in late varieties.

Harvesting should be done when there is no dew on the crop. Generally afternoon harvest is recommended. Regular harvesting will increase the pod yield.

5.15.13 Cleaning and grading

Pods should be harvested and handled with care to avoid damaging the fruit. After harvest remove all pods affected by insects, rust and other diseases and broken pods. Pods are graded based on their size and length.

5.15.14 Packaging and transportation

For local market pods can be packed in plastic bags and for distant market they should be packed in bamboo baskets or gunny bags.

5.15.15 Storage

Fresh and whole pods can be stored for a week at 8°–10°C and 90–95% humidity.

5.15.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 format and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seed	3 kg	600
2	Crop production labor (planting to harvest)	14 labour days	4,200
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		7,500
8	Total production 1,000 kg and price NPR 50	1,000 *25	25,000
9	Net profit in NPR	7,500—25,000	17,500

5.15.17 Pest management in legumes (beans, cow peas and peas)

Various insect pests and diseases attack legume crops at different stages of growth. The major insects and diseases and their management are described below:

Major insects and their management

Insects	Symptoms	Management
Stem fly	Maggots of this fly (Ophiomiya sp) cause severe damage to stem, leaves and young developing pods. The adult fly lays eggs under the skin of young pods. The eggs hatch into maggots, which feed inside the pods and cause rotting. The attack is severe in all legume crops.	• Maggots can't be controlled directly because they are inside the pods. However, the adult flies can be controlled by setting light traps at night and poison baits. • Spraying of 0.1% monocrotophus at 15-day intervals controls the flies.
Pod borer	The pod borer (Heliothes sp) attacks most of the legume crops at seedling and pod development stage. They make holes in the pods. Adults feed on vines and young leaves in the later stage as well.	• Collect the eggs and larvae and destroy them. • If the attack is severe, spray metasystox or rogor @ 1ml/litre of water before flowering and Nuvan @ 0.5 ml/litre of water during fruiting.
Aphids	Greenish and black nymphs of aphids (Acyrthosiphon pisum) suck sap from the leaves, stems, flowers and fruits. If the attack is severe, plants wilt and die. Aphids cause severe damage from the seedling stage to pod set stage.	• Spray soap water, human or cow urine, tobacco or neem extract, or soil mixed with ash. • Spray Diclorovus, Nuvan 76 EC @ 0.5 ml per litre of water at 7-day intervals. • Spray 0.20% malathion at 10–15 day intervals. • After spraying pesticide, wait for 7 to 21 days as indicated on the poison container.
Leaf miner	The insect mines inside leaves and eats chlorophyll, and the leaves dry and turn grey.	• Spray urine or neem product. • Spray rogor @ 2ml/litre of water at weekly intervals. • Spraying 0.1% monocrotophus at 15-day intervals controls the insect.

Major diseases and their management

Diseases	Symptoms	Management
Powdery Mildew	This disease is caused by fungus Erysiphe polygoni. In the initial stage, whitish or fluffy spots appear on the upper and lower surface of the leaves. At a later stage the entire surface of leaves and stem appears dusted with powder. The plant eventually dies.	• Use only seed treated with bavistin @ 2gm/kg seed. • Remove diseased leaves when they appear. • Spray karathane @ 0.5% or sulfex @0.2% twice within the space of seven days. • Spray servo oil @ 10 ml/litre of water
Leaf curl virus	Bean common mosaic virus (BCMV) stunts the plant and causes mottling and leaf malformation. Leaves affected with BCMV have irregular shape, light yellow and green patches and may also show puckering. The virus spreads by direct contact, by aphids and by seed.	• Use resistant varieties and good quality seed. • Removing infected plants from the field prevents secondary spread. • Use healthy and treated seed. • Remove alternative host for insect vectors that transmit virus like aphids. • Keep the field clean and sanitized.
Root rot	*Fusarium solani f.* sp. *phaseoli, Rhizoctonia solani* and various *Pythium* sp. commonly cause root rot in peas and beans. Reddish brown sunken lesions surrounded by a reddish brown margin appear on roots and hypocotyls. The lesions enlarge with age, become darker and rough-textured. The fungus can cause brick-red discoloration of the central part of the lower stem.	• Three to four year rotation between beans and corn and small grains is recommended. • Manage drainage. • Use fungicide treated seed. • Use resistant varieties.
Anthracnose	*Colletotrichum lindemuthianum* affect the bean plant. Lesions first appear as water soaked lesions that darken. Lesions found on the petioles and on the lower surface of leaves and leaf veins are elongated, angular and brick-red to purple, becoming dark brown to black. Pod lesions are tan to rust-coloured and develop into sunken black rings surrounded by a reddish brown border.	• Treat the seed with bavistin @ 2–3 gm/kg seed before sowing. • Follow crop rotation. • Seed treatment and certain copper fungicides are available for use. • Look for resistant varieties and rotate every three years to reduce the buildup of disease inoculums.
Bean rust	Bean rust is caused by the fungus Uromyces appendiculatus and first appears as small pale spots (lesions), which become yellow with a small dark centre. These spots enlarge and produce brick-red rust (summer) spores to spread the disease. Lesions develop black (overwintering) spores later in the season. Infection is favoured by ten hours or more of dew. Later, leaf is covered with brown dust like spores, which also appear on pods.	• Follow three to four year rotation with cereal crops. • After harvest, collect all crop residue and burn or bury by deep plowing. • Do not use stakes used for previous crops. • Spray Bordeaux mixture at 10-day intervals. • Spray Dithane M @ 2gm/litre of water at 7–10 day intervals.
Pod rots	White mold is caused by the fungus Sclerotinia sclerotiorum and develops as a white cottony growth on the stem, branches and pods of bean plants. The fungus also produces black, hard mats of mycelium (called sclerotia) near these cottony growths. Sclerotia allow the organism to survive adverse (winter) conditions.	• Treat the seed before sowing with captan or benlate or thiram or Dithane M 45 @ 2–3 gm/kg seed.

5.16 Broad Leaf Mustard

5.16.1 Introduction

Broad leaf mustard (*Brassica juncea var. Rugosa*) belongs to the family Brassicaceae and is a cool season crop. The tender leaf is eaten cooked. It is usually steamed with a little turmeric, chilli and salt. Sometimes cornflour and tomato are added to it. Broad leaf mustard is rich in Vitamin A, B, C and E. Among minerals it is rich in calcium and iron; it is also rich in protein.

5.16.2 Climatic requirements

Broad leaf mustard grows well in full sunshine and can also grow in the shade. Mustard seed germinates at 7°–35°C temperature. For good vegetative growth, optimum temperature is 10° to 25°C in general. It is cold tolerant and thrives even at temperatures up to 0°C. Above 25°C leaves become a little hard and some varieties develop a bitter taste. Khumal Rato Pat can tolerate a higher temperature and can be grown at temperature up to 30°C but Marpha Chauda Pat cannot tolerate temperature above 25°C.

5.16.3 Soil requirements

Broad leaf mustard can be cultivated in almost all types of soil; however, light loam to sandy loam soil that is rich in organic matter and has a high level of fertility and high water-holding capacity is best for good quality leaf production. Soil should never be muddy and water logged. Broad leaf requires slightly acidic soil with pH range 5.5 to 7.0. Soil test before planting is always advisable for pH and nutrient availability. For crops grown in the rainy season, sandy or sandy loam light soil is desirable. For main crops during winter in the mid hills and plains, heavy soil that hold moisture is more desirable. In soil with lower pH, club root attacks the crop and phosphorus and calcium availability is restricted. Adding agricultural lime improves the pH and increases phosphorus and calcium availability.

5.16.4 Land preparation

The field for broad leaf mustard should be well drained and be able to hold moisture. Soil should be prepared well with 1–2 rounds of deep corrosive plowing followed by 2–3 rounds of light plowing and clod breaking to make soil friable, loose and well levelled. Plowing or digging should be done properly to ensure good tillage and decomposition of weeds and prepare the land for transplanting. Clod free soil provides a good growing medium for developing roots and soil microorganisms. Traditionally, broad leaf mustard was grown in a heap of FYM without any chemical fertilizer. The taste of mustard grown in this manner is excellent. For normal commercial production, land should be well levelled for proper drainage and a trench should be made for irrigation. For transplanting early varieties during summer/rainy season, 15 cm raised beds that are 2 metres wide should be made, with a 25 cm wide trench between two beds. For mid and late season, the bed width should be 4 metres. Four rows during the rainy season and eight rows during the main season can be transplanted in each bed. Organic manures like farmyard manure (FYM) should be applied at the time of preparing the main field. Before making beds, all fertilizers except a half dose of nitrogen should be thoroughly mixed in soil.

5.16.5 Manure and fertilizer application

Broad leaf mustard is a heavy feeder and requires adequate manure and nutrient for profitable yield. For best results, 35–40 tonnes/ha of FYM or any compost should be added to the soil a week before transplanting during the final preparation of soil. To supplement the FYM, apply 80 kg of nitrogen, 20 kg of P_2O_5 and 40 kg of K_2O per ha. To be sure of soil pH, test the soil. Apply fertilizer and lime according to test recommendations. Add nitrogen-rich amendments such as blood meal and mustard cake to improve soil heath.

The full dose of FYM, P_2O_5 and K_2O and half dose of nitrogen mix thoroughly in the soil at the time of making beds. Apply the remaining half dose of nitrogen as top dressing in two batchesL after one month of transplanting and again after 2–3 pickings of leaves. Since the root system of mustard is dense and shallow, applying top dressing of urea in 5–10 cm bands away from the young plants at 2–3 cm depth gives the best results. If fertilizer is applied close to the plants, it will kill the plant by burning.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

Micronutrients: Broad leaf mustard needs micronutrients such as boron, zinc, molybdenum, manganese, iron, etc. The deficiency of boron and molybdenum is crucial. Supplement micronutrients are available in various multi-nutrient rich commercial formulations such as *Agrolic* and *Agromin* and in single formulation such as boron and calcium. The plant needs only a small amount of micronutrients but its effect is substantial. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. While using such formulations, it is important to read the instructions on the label and take necessary precautions.

5.16.6 Variety selection

Five major varieties are cultivated in general: Khumal Chauda Pat, Marpha Chauda Pat, Khumal Rato Pat, Tangkhuwa Selection, and Manakamana. Many local/indigenous land races are also used.

5.16.7 Nursery establishment and management

Nursery establishment and management in broad leaf mustard is similar to that of cabbage and cauliflower. Select a well-drained, open space for the nursery. For a hectare transplanting, a 100 square metre nursery is required. While preparing nursery beds, apply 5–7 kg of well-rotted FYM/compost per square metre land. For 100 square meters, it needs 500–700 kg of FYM. During the rainy season, make 1 metre wide 15 cm

raised beds with a 25 cm wide trench between two beds. The length of beds may vary; however it should not be more than 10 metres for easy care and management. During the dry season, sunken beds are prepared instead of raised beds for moisture conservation.

After preparing the beds, make 2–3 cm deep tiny U-shaped furrows that are 10 cm apart with the help of a small stick. Drop the seed with the help of your thumb, forefinger and middle finger. Cover the seed with fine sand or fine soil compost mixture or with ash depending on availability. Then mulch the beds with straw or specially made thin perforated jute sack. After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that the soil is moist but not over-watered till the seedlings emerge. Mustard seed germinates after 4 days of sowing. When the seed germinates, remove mulch and water it very carefully and lightly. A forceful splash of water and heavy watering may damage young seedlings and damping-off may attack the nursery. Broad leaf mustard seedlings become ready for transplanting after 20–25 days of germination.

5.16.8 Seed rate and seedling requirements

For one hectare land, 500 to 600 g of seeds are required depending on germination percentage and seed vigor. Healthy 70,000 to 80,000 seedlings per hectare are required including for gap filling.

5.16.9 Transplanting

Seedlings that are 3–4 weeks old with 4–6 true leaves are ready for transplanting. Nursery beds should be moistened before the seedlings are pulled out of the soil to make their removal easy and prevent injury to the root system. Select only healthy and strong seedlings for transplanting. Avoid blind and weak seedlings. Soil should be packed tightly around the seedling to establish close contact with the roots following irrigation. Transplanting distance is 50 cm row to row and 30 cm plant to plant.

Transplanting and harvesting time varies according to the topography and altitude. As there is a 3–4 week gap between germination and transplanting, seeds should be sown in the nursery a month before transplanting.

Seed sowing, transplanting and harvesting months in different geographical areas

Geographical areas	Seed sowing	Transplanting	Leaf harvesting
High hills	February-March	March-May	May-November
Mid-hills	August-November	September-November	October-March
Low hills and Terai	September-November	October-December	November-February

5.16.10 Irrigation and water management

Just after transplanting, provide light irrigation with a watering can and thereafter it is necessary to maintain proper soil moisture level for good harvest. During the rainy season, only protective irrigation is provided during transplanting. The critical stages of irrigation in broad leaf mustard are just after transplanting, urea top dressing, after weeding, intercultural operation and earthing up. In normal conditions, soil moisture should be 60–100% of field capacity with an average of 80% field capacity. During dry weather, irrigation should be provided more frequently. Furrow system of irrigation is always better. After irrigation and heavy rain, it is important to drain excess water; otherwise club root, root rot and fusarium wilt will increase. Construction of water harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.16.11 Intercultural operations and care

After 5–6 days of transplanting, a thorough inspection should be carried out and gaps should be filled in the spots where plants are dead and wilted. During the early stage of growth, weed competes with the crop for nutrient and moisture. Light hoeing and first urea top dressing after 20–25 days of transplanting, followed by earthing up, ensures uniform growth. Field should always be kept free of weed and soil should be kept loose around the plants.

5.16.12 Plant protection

Aphids and caterpillars are the two main insects and damping-off of seedlings, leaf spots and club root are the main diseases in broad leaf mustard.

As the leaves of broad leaf mustard are continuously harvested, no chemical spray is recommended. To manage aphids and caterpillars, spray soap water, human or cow urine or neem products. Jholmal mixed in 10 parts water or neem extract at the rate of 3 ml/ litre of water kills the insects.

Alternaria leaf spots appear on older leaves. Remove such leaves and bury or burn them. Club root is prevalent in water logging conditions and soil with low pH. It is generally transmitted from seedlings. Therefore,

- Select a healthy site for nursery.
- Burn debris and straws in the nursery site.
- Apply 1 kg of lime and 1 kg of mustard cake per square metre of nursery bed.
- Lime increases the soil pH and reduces the attack of club root.

5.16.13 Maturity, harvesting and yield

Broad leaf mustard is a leafy vegetable and its tender leaves are cooked and eaten. The readiness for leaf harvest is judged by visual observation of the tender leaves. The older and yellow leaves are removed and used for compost making. 2–3 young leaves are harvested from each plant. They are broken near the base of the sheath or cut with a sharp knife with no injury to leaf base. Harvesting should not be done when there is dew on the plant. Harvesting in the afternoon when the sun is mild is advisable. After harvesting, the leaves should be kept in the shade for cleaning, grading and packaging. The total leaf yield varies from 20–30 tonnes/ha.

5.16.14 Cleaning and grading

After harvest, leaves are sorted, and diseased, damaged and very small and yellow leaves are separated. Leaves are graded as small, medium and large. Leaves are made into small bundles weighing up to half kg and tied with a straw or plastic rope. Cleaning and grading provides a basis for orderly marketing and allows the consumers to assess the quality in relation to the price.

5.16.15 Packaging and transportation

The bundles should be padded well and tied with ropes and placed in gunny bags for distant markets. For local market they are often transported on bicycles. If the leaves are packed in bamboo baskets or plastic crates with proper aeration, they stay fresh when they reach the market.

The leaves are usually transported in trucks and minibuses to distant markets. The packages should be piled up carefully so that they don't shake on the journey. Mustard leaves produced in the high hills are sold in the Terai and large towns of Nepal during the rainy and summer season.

5.16.16 Storage and marketing

Broad leaf mustard commercially grown in Nepal is generally harvested and sent to the market within a day to the local and distant market. Smallholder producers who live in the periphery of cities make bundles and carry them to the market in padded bamboo baskets. They sell them either to local wholesaler or retailers, or directly to consumers in common market areas. If marketing is obstructed or delayed, it can be stored at 10°–12°C and 85–95% humidity for 2–4 days.

5.16.17 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below (this is just estimation and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling raising		
1.1	Seed	50 gm	50
1.2	Manure and fertilizer	LS	500
1.3	Labour nursery management	2 labour days	600
2	Crop production labour (planting to harvest)	15 labour days	4,500
3	Manure, fertilizer	LS	2,500
4	Plant protection inputs	LS	300
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		9,350
8	Total production 1,000 kg and price NPR 50	1,000 *50	50,000
9	Net profit in NPR	9,35-0—50,000	40,650

5.17 Swiss Chard

5.17.1 Introduction

Swiss chard (*Beta vulgaris var clicla*) belongs to the family Chenopodiaceae. It is an all-season leafy vegetable. It can tolerate both frost and high temperature. The tender leaf is eaten as a cooked vegetable. It is commonly steamed with a little turmeric, chilli and salt, or mixed with potato and sometimes cornflour and tomato. Swiss chard is rich in Vitamin A and C. Among minerals, it is rich in calcium and iron.

5.17.2 Climatic requirements

Swiss chard can grow well in winter and summer. It grows well in full sunshine and its seed germinates at 7°–35°C. For good vegetative growth, optimum temperature is 15° to 35°C. It fetches better prices during late spring to summer when broad leaf mustard and spinach are not available in the market. It flowers in long day conditions.

5.17.3 Soil requirements

Swiss chard can be cultivated in almost all types of soil; however light loam to sandy loam soil with rich organic matter and a high level of fertility and high water holding capacity is best for leaf production. Soil pH range of 5.5 to 6.5 is most desirable. For crops grown in the rainy season, sandy or sandy loam light soil is desirable.

5.17.4 Land preparation

The field for Swiss chard should be well drained in order to hold moisture. Soil should be prepared well with 1–2 rounds of deep corrosive plowing followed by 2–3 rounds of light plowing and clod breaking to make soil friable, loose and well levelled. Plowing or digging should be done well to ensure good tillage and decomposition of weeds and prepare the land for transplanting. For transplanting, prepare 15 cm raised beds 1 metre and 2 metre wide, with a 25 cm wide trench between two beds. Two rows can be transplanted in the 1 metre wide bed and four rows

in 2 metre wide bed. Organic manures like FYM should be applied at the time of preparing the main field. Before making beds, all fertilizers except half dose of nitrogen should be thoroughly mixed in soil.

5.17.5 Manure and fertilizer application

Swiss chard is a long durational heavy feeder and requires adequate manure and nutrient for profitable yield. For best results, FYM 25–30 tonnes/ha or compost should be added to the soil before a week of transplanting during the final preparation of soil. To supplement the FYM, apply 80 kg of nitrogen, 40 kg of P_2O_5 and 40 kg of K_2O per ha. Apply all manure and fertilizer except half dose of nitrogen before bed preparation. Apply the remaining half dose of nitrogen as top dressing in two batches – first dose after 30–40 days of transplanting and second dose after 60 days of transplanting. Add nitrogen-rich amendments such as blood meal and mustard cake to improve soil heath.

Application of Jholmal at weekly intervals until a month before harvesting helps replace the use of chemical fertilizers and controls most of the diseases and insect pests (see chapter 3.2.2.vi for details).

5.17.6 Variety selection

Only one variety Ford Hook Giant is officially recommended in Nepal. However, red-leaved variety is also popular as a Vitamin A rich variety.

5.17.7 Nursery establishment and management

Nursery establishment and management is similar to that of cauliflower, cabbage and broad leaf mustard.

5.17.8 Seed rate and seedling requirements

For one hectare of land, 2–2.5 kg of seeds are required depending on germination percentage and seed vigor. Healthy 60,000 to 70,000 seedlings per hectare are required including for gap filling.

5.17.9 Transplanting

Seedlings that are 4–6 weeks old with 4–6 true leaves are ready for transplanting. Moistening the nursery beds before pulling the seedlings out of the soil makes their removal easy and prevents injury to the root system. Transplanting is preferably done in the evening. Soil around the seedling should be pressed and made compact to establish a close contact with roots following irrigation. Transplanting distance is 50 cm row-to-row and 30 cm plant-to-plant.

Transplanting and harvesting time varies according to the topography and altitude. Seed sowing, transplanting and harvesting months at different geographical areas are presented below:

Geographical areas	Seed sowing	Transplanting	Leaf harvesting
High hills	February-March	March-May	May-November
Mid-hills	October-November	November-March	December-June
Low hills and Terai	October-December	November-January	December-July

5.17.10 Irrigation and water management

Just after transplanting, light irrigation is provided with a watering can and thereafter it is necessary to maintain proper soil moisture level for good harvest of leaf. In normal conditions, soil moisture should be 60–80 % of field capacity with an average of 60% field capacity. During dry weather, irrigation should be provided more frequently. Furrow system of irrigation is always better. Building a water harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.17.11 Intercultural operations and care

After 5–6 days of transplanting, the field should be carefully inspected and gaps should be filled in the hills where plants are dead and wilted. During the early stage of growth, weed competes with the crop for nutrient and

moisture. Light hoeing and first urea top dressing after 30–40 days of transplanting followed by earthing up ensures uniform growth. Field should always be kept free of weed and soil around the plants should be kept loose.

5.17.12 Plant protection

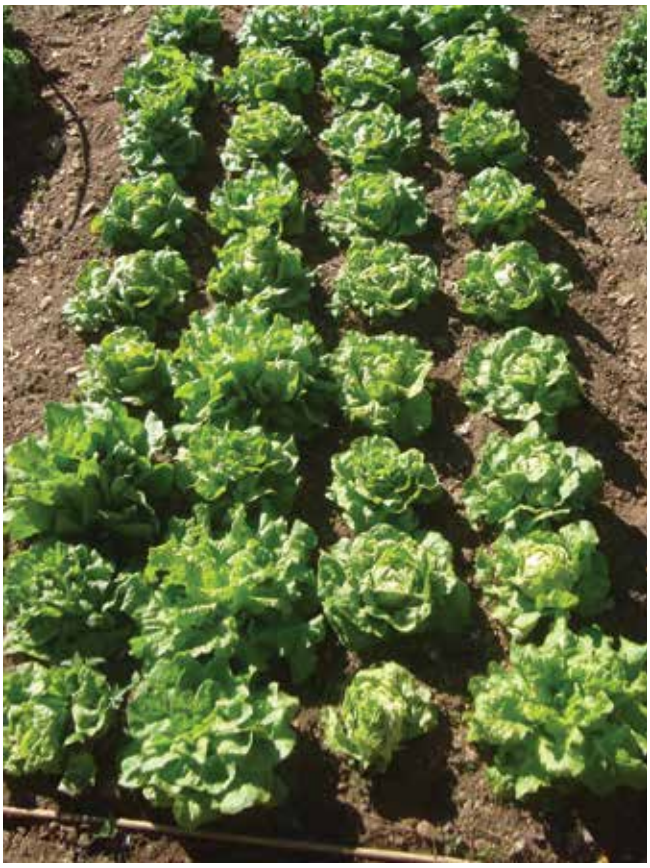
Black aphids and blister beetle are the two main insects that attack Swiss chard.

As the leaves of Swiss chard are harvested continuously, no chemical spray is recommended. To manage aphids and caterpillars, spray soap water, human or cow urine or neem products.

So far no serious diseases that can cause economic losses have been found in Swiss chard in Nepal. Alternaria leaf spots appear on older leaves. Remove such leaves and bury or burn them.

5.17.13 Maturity harvesting and yield

The tender leaves of Swiss chard are cooked and eaten as a vegetable. The readiness for leaf harvest is judged by visual observation of the tender leaves. While harvesting, young leaves are broken above the base of the sheath or cut with a sharp knife without injuring the leaf base. Harvesting should not be done when there is dew on the plant. It is better to harvest in the afternoon when the sun is mild. Total leaf yield ranges from 15–20 tonnes/ha.



5.17.14 Cleaning and grading

To market the produce after harvest, leaves are sorted, and diseased, damaged, yellow and undersized leaves are separated. Leaves are graded as small, medium and large, and then made into and small bundles weighing up to half kg and tied with a straw or plastic rope. Cleaning and grading provides a basis for orderly marketing and enables the consumers to assess the quality of the produce in relation to the price while also providing marketing incentive to the traders.

5.17.15 Packaging and transportation

The bundles should be padded well and tied with ropes and placed in gunny bags for distant markets. For local market they are often transported on bicycles. If the leaves are packed in bamboo baskets or plastic crates with proper aeration, they stay fresh when they reach the market.

The packages should be piled up carefully so that they don't shake on the journey. Swiss chard leaves produced in high hills are sold in the Terai and large towns of Nepal.

5.17.16 Storage and marketing

Most of the Swiss chard commercially grown in Nepal are harvested and sent to the market within a day or two. Smallholder producers who live in the periphery of cities make bundles and carry them to the market in padded bamboo baskets. They sell them either to the local wholesaler or retailers, or directly to consumers in common market areas.

If marketing is obstructed or delayed due to transport problems, it can be stored at 10°–12°C and relative humidity of 85–95 % for 2–4 days only.

5.17.17 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling raising		
1.1	Seed	100 gm	100
1.2	Manure and fertilizer	LS	500
1.3	Labour nursery management	2 labour days	600
2	Crop production labour (planting to harvest)	13 labour days	3,900
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	100
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		7,600
8	Total production 700 kg and price NPR 30	700 *30	21,000
9	Net profit in NPR	7,600-21,000	13,400

5.18 Spinach

5.18.1 Introduction

Spinach (*Spinacea oleracea*) belongs to the family Chenopodiaceae. It is a cool season leafy vegetable. It can tolerate frost better than other winter vegetables but cannot tolerate high temperature. The young plants are cooked and eaten. It is usually steamed with a little turmeric, chilli and salt. Spinach contains Vitamin A, B and C. Among minerals it is rich in calcium and iron. This crop has a high cultural value and is required during marriage ceremonies. It is also one of the main items eaten during Maghe Sankranti festival.

5.18.2 Climatic requirements

Spinach can grow well in full sunshine as well as in the shade. Spinach seed can even germinates at 4°C. For good vegetative growth, optimum temperature is 10°–25°C. It flowers under long day conditions.

5.18.3 Soil requirements

Spinach can be cultivated in almost all types of soil ranging from light sand to clay loam and silt soil; however, light loam to sandy loam soil rich in organic matter and high level of fertility with high water holding capacity is best for quality leaf production. It is sensitive to acidity, and in soils with pH below 5.5, liming is required. The most suitable pH range is 5.5 to 6.5.

5.18.4 Land preparation

The field for spinach should be well drained and can hold moisture. Soil should be prepared with 1–2 rounds of deep plowing followed by clod breaking to make the soil friable, loose and well levelled. Irrigation and drainage in the spinach field must be easy. Spinach is sown in flat raised beds during the rainy season and in sunken beds during the dry season. For sowing, 15 cm raised beds of 1 metre and 2 metre widths should be made, with a

25 cm wide trench between two beds. Five rows can be sown in 1 metre wide beds and 10 rows in 2 metre wide beds. Organic manures like farmyard manure (FYM) should be applied at the time of preparing the main field. Before making beds, all fertilizers except half dose of nitrogen should be thoroughly mixed in soil.

5.18.5 Manure and fertilizer application

Spinach is organic manure loving crop and a heavy feeder and requires adequate manure and nutrient for profitable yield. For best results, FYM 15–20 tonnes/ha or compost should be added to the soil before a week of sowing during the final preparation of soil. To supplement the FYM, apply 60 kg nitrogen, 20 kg P_2O_5 and 40 kg K_2O per ha. Apply all manure and fertilizer except half dose of nitrogen before bed preparation. Apply the remaining half dose of nitrogen as top dressing in two batches: first after 20–30 days of sowing and second after thinning or first harvest.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.18.6 Variety selection and sowing time

Prickly seeded released variety selected from local Patane Spinach and Japanese variety is cultivated in the mid-hills. In the Terai, Indian smooth-seeded varieties All Green and Pusa Jyoti are also popular. All Green can tolerate high temperature and is cultivated in the mid-hills and Kathmandu Valley during summer.

As a winter crop, spinach is sown in the Terai from October to January and in the mid-hills from October to March. In the high-hills it is cultivated from March to July.

5.18.7 Nursery establishment and management

Spinach is sown directly.

5.18.8 Seed rate and seedling requirements

For one hectare of land, 20–30 kg of seed is required.

5.18.9 Sowing

Before sowing, seed is soaked in water for 24 hours for quick and good germination. In the raised beds or sunken beds, 3–4 cm deep small furrows are made at 20 cm distance and seed is dropped. To drop the seed properly, mix two parts sand or ash with the seed and drop the mixture in the furrows. Then plank the furrows with a wooden hand plank (Dalletho). Plants rows should be thinned to maintain a plant-to-plant distance of 3–4 cm.

5.18.10 Irrigation and water management

Spinach seed requires good moisture for germination. For good germination pre-sowing irrigation or light irrigation after sowing is recommended. In case of post-sowing irrigation, care should be taken to prevent the soil from forming any crust. Depending on moisture, second irrigation may be provided right after the first to ensure uniform and maximum germination. Since spinach is a shallow-rooted crop, subsequent irrigations are required at 10–15 day intervals. It is necessary to maintain proper soil moisture level for good harvest. In normal conditions, soil moisture should be 60–80% of field capacity with an average of 60% field capacity. Building a water harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.18.11 Intercultural operations and care

Weed control is very important in spinach because it cannot compete with the weeds. Thinning and weeding is done after 10–15 days of germination. During the early stage of growth, weed competes with the crop for nutrient and moisture. Light hoeing and first urea top dressing after 20–25 days of germination ensures uniform growth. The field should always be kept free of weed. Moisture level should be adequate but water logging should be prevented.

5.18.12 Plant protection

Beet army worm, blister beetle and green aphids sometimes attack spinach.

As spinach leaves are harvested continuously, chemical spray is not recommended. To manage aphids and caterpillars, spray soap water, human or cow urine or neem products.

So far no diseases that cause serious economic losses have been found in spinach. Alternaria leaf spots appear on older leaves. Remove such leaves and bury or burn them.

5.18.13 Maturity harvesting and yield

Spinach becomes ready to harvest in 30–40 days after germination. Harvesting can be manipulated as per the requirements and varies from 5–6 leaf stage to just before seed stalk formation. In prickly seeded varieties, the whole plant is harvested. In case of All Green and Pusa Jyoti, 2–3 leaf pickings at 10–15 day intervals are recommended and the whole plant is harvested at the end. While harvesting, young leaves from each plant are broken above the base of the sheath or cut with a sharp knife without injuring the leaf base. The total yield varies from 10–15 tonnes/ha.

5.18.14 Cleaning and grading

After harvest, roots are trimmed for marketing. Old leaves are sorted, and diseased, damaged, yellow and undersized leaves are separated. Bundles are made and tied with a straw. Cleaning and grading provides a basis for orderly marketing.

5.18.15 Packaging and transportation

The bundles are tied with a rope and piled up. They should be properly padded to prevent breakage. For local market they are often transported on bicycles. If they are packed in bamboo baskets or plastic crates with proper aeration, they stay fresh when they reach the market.

The packages should be piled up carefully so that they don't shake on the journey. Spinach produced in high hills is sold in the Terai and large towns in the summer and rainy season.

5.18.16 Storage and marketing

Most of the spinach commercially grown in Nepal is harvested and sent to the market within a day to the local and distant markets. Smallholder producers who live in the periphery of cities make bundles and carry them to the market in padded bamboo baskets. They sell them either to the local wholesaler or retailers, or directly to consumers in the market areas.

If marketing is obstructed or delayed, it can be stored at 10°–12°C and 85–95% humidity for 2–3 days.

5.18.17 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seed directly sown	500 gm	500
2	Crop production labour (planting to harvest)	13 labour days	3,900
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	100
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		6,900
8	Total production 500 kg and price NPR 60	500 *60	30,000
9	Net profit in NPR	6,900—30,000	23,100

5.19 Cress

5.19.1 Introduction

Cress (*Lepidium sativum*) belongs to the family Crucifarae and also is a cool season leafy vegetable. It can tolerate frost but cannot tolerate high temperature. The young plants are generally cooked with spinach. Cress contains Vitamin A and C. Among minerals it is rich in calcium and iron.

5.19.2 Climatic requirements

Cress can grow well in full sunshine as well as in the shade. Its seed germinates at 4°C. For good vegetative growth, optimum temperature is 10°–25°C.

5.19.3 Soil requirements

Cress can be cultivated in almost all types of soil ranging from light sand to clay loam and silt soil; however, light loam to sandy loam soil with rich organic matter and a high level of fertility with high water-holding capacity is best for quality production. It is sensitive to acidity; liming is required in soil with pH below 5.5. Soil with pH range 5.5–6.5 is most desirable.

5.19.4 Land preparation

As with spinach, land for cress should be well drained and able to hold moisture. Soil should be prepared well with 1–2 rounds of deep plowing followed by clod breaking to make it friable, loose and well levelled. Irrigation and drainage in the spinach field must be easy. Spinach is sown in flat raised beds during the rainy season and in sunken beds during the dry season. For sowing 15 cm raised beds of 1 metre and 2 metre widths should be made, with a 25 cm wide trench between two beds. Five rows can be sown in 1 metre wide beds and 10 rows in 2 metre

wide beds. Organic manures like FYM should be applied at the time of preparing the main field. Before making beds, all fertilizers except half dose of nitrogen should be thoroughly mixed in soil.

5.19.5 Manure and fertilizer application

Cress is also an organic manure-loving crop and a heavy feeder that requires adequate manure and nutrients for profitable yield. For best results, FYM 15–20 tonnes/ha or compost should be added to the soil before a week of sowing during the final preparation of soil. To supplement the FYM, apply 40 kg nitrogen, 20 kg P_2O_5 and 20 kg K_2O per ha. Apply all manure and fertilizer except half dose of nitrogen before bed preparation. Apply the remaining half dose of nitrogen as top dressing in two batches: first after 10–15 days of sowing and second top dressing after first harvest.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.19.6 Variety selection and sowing time

Only one variety, Chamsur Nepali, is under cultivation. It is sown from October to January in the Terai and from October to March in the mid-hills. In high hills, it is cultivated from March to June.

5.19.7 Nursery establishment and management

Cress is sown directly.

5.19.8 Seed rate and seedling requirements

For one hectare of land, 10–15 kg of seed is required.

5.19.9 Sowing

In the raised beds or sunken beds, 3–4 cm deep small furrows are made at a spacing of 20 cm and seed is dropped in the furrow. To ensure that seed is dropped properly, it is first mixed with four parts sand or ash. Then cover the furrows with wooden hand planks (dalletho). Plants rows should be thinned to maintain a plant-to-plant distance of 3–4 cm. Broadcasting and planking are also practised.

5.19.10 Irrigation and water management

Cress seed requires good moisture for germination. For good germination, pre-sowing irrigation or light irrigation is recommended after sowing. In case of post-sowing irrigation, care should be taken to prevent the soil from forming any crust. Since cress is a shallow-rooted crop, subsequent irrigations are required at 10–15 day intervals. It is necessary to maintain a proper soil moisture level for good harvest. Constructing a water-harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.19.11 Intercultural operations and care

Weed control is very important in cress because it cannot compete with weeds. Thinning and weeding is done after 10–15 days of germination. During the early stage of growth, weed competes with the crop for nutrient and moisture. Light hoeing and urea top dressing after 10–15 days of germination ensures uniform growth. The field should always be kept free of weed Moisture level should be adequate but water logging should be prevented.

5.19.12 Plant protection

No serious pest attack is found in cress. However, clubroot is seen in soil with low pH. Application of lime 100–200 kg/ha is recommended in acidic soil.

5.19.13 Maturity harvesting and yield

Cress becomes ready for harvest in 20–25 days after germination. Harvesting should be done when the stems are tender. Yield ranges from 10–12 tonnes/ha.

5.19.14 Cleaning and grading

After harvest, roots are trimmed for marketing. The leaves are sorted, and diseased, damaged, yellow and undersized leaves are separated. Bundles are made and tied with a straw or plastic rope. Cleaning and grading is done to provide a basis for orderly marketing.

5.19.15 Packaging and transportation

The bundles are tied with a rope and piled up. They should be properly padded to prevent breakage. For local market they are often transported on bicycles.

The packages should be piled up carefully so that they don't shake on the journey.

5.19.16 Storage and marketing

Cress is harvested and sent to the market within a day to the market. Smallholder producers who live in the periphery of cities make bundles and carry them to the market in padded bamboo baskets. They sell them either to the local wholesaler or retailers, or directly to consumers in the market areas.

If marketing is obstructed or delayed due to transportation problems, they can be stored at 10°–12°C and relative humidity of 85–95% for 2–3 days only.

5.19.17 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation, and the actual cost of production should be recorded in the format provided in Annex 1.)

S.N	Particulars	Quantity	Amount in NPR
1	Seed directly sown	500 gm	500
2	Crop production labour (planting to harvest)	13 labour days	3,900
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	100
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		6,900
8	Total production 500 kg and price NPR 60	500 *60	30,000
9	Net profit in NPR	6,900—30,000	23,100

5.20 Radishes

5.20.1 Introduction

Radishes (*Raphanus sativus*) belong to the family Brassicaceae. It is both a cool and warm season crop. It is a leaf-cum-root vegetable. The tender leaf and root are eaten cooked, or used in salads and pickles. Radish roots make a good appetizer. Radish also helps cure liver and gall bladder problems. Roots are used in treating urinary problems and piles. The juice of fresh leaves is used as diuretic and laxative. Roots and leaves are dried or fermented and made into gundruk, chaana, or kimchi. Radish is rich in vitamins and minerals like calcium, iron, etc.

5.20.2 Climatic requirements

Radishes are grown in sub-tropical and temperate climate. It is predominantly a cool season crop but some Asiatic types can tolerate higher temperatures than temperate types. Radish grows well in full sunshine as well as in the shade. For good root growth, optimum temperature is 10°–25°C. Long day conditions and high temperature result in bolting before proper root development. Seed sown at temperatures below 10°C also leads to bolting and above 25°C the root becomes a little hard, pithy and pungent. Asiatic varieties like Pusa Chetaki, Chalis Dine, and Tokinashi can also be grown at higher temperatures up to 30°C.

5.20.3 Soil requirements

Radish can be grown in almost all types of soil; however light loam to sandy loam soil rich in organic matter, with a high level of fertility and high water-holding capacity is best for quality root production. Heavy, muddy and water-logged soils should be avoided. It requires slightly acidic soil with the pH range 5.5 to 7.0. In soil with lower pH, club root attacks the plant and phosphorus and calcium availability is restricted. Adding agricultural lime improves pH, thus increasing phosphorus availability.

5.20.4 Land preparation

Radish is a deep-rooted root crop. The field for radish should be prepared well with 1–2 rounds of deep corrosive plowing/digging followed by clod breaking to make the soil friable, loose and well levelled. For normal commercial production, land should be well levelled for proper drainage and a trench should be made for irrigation. Radish is sown in 20–30 cm raised beds in 4 rows per bed or two rows per bed. For four rows per bed, 1.25 metre wide beds with a 25 cm wide trench between two beds and for two rows, 75 cm wide beds are prepared. Four rows can be sown during the rainy and autumn season and 2 rows during spring season for better irrigation in each bed. Organic manures like farmyard manure (FYM) should be applied at the time of preparing the main field. All chemical fertilizers except half dose of nitrogen should be thoroughly mixed in soil during bed preparation.

5.20.5 Manure and fertilizer application

Radish is a heavy feeder and requires adequate manure and nutrients for slender and thick root development. Balanced and judicious application of NPK favours early vegetative growth and rapid root thickening, leading to quality root yield. For best results FYM 20 tonnes/ha or compost should be added to the soil during final digging before bed preparation. To supplement the FYM, apply 60 kg nitrogen, 40 kg P_2O_5 and 30 kg K_2O per ha. Apply the full dose of FYM during the final digging. The full doses of P_2O_5 and K_2O and half dose of nitrogen mix thoroughly in the soil at the time of making beds. Apply the remaining half dose of nitrogen as top dressing in two batches: first after 15–20 days of germination and second (in long durational varieties like Mino Early and Pyuthane) after 35– 40 days of germination, at 2–3 cm deep band placement and do slight hoeing.

5.20.6 Boron deficiency in Radish

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

Micronutrients: Radish needs micronutrients such as boron, zinc, molybdenum, manganese, iron, etc. Supplement micronutrients are available in various multi-nutrient rich commercial formulations such as *Agrolic* and *Agromin* and in single formulations such as boron and calcium. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. Borax @ 10 kg/ha during bed making will help address boron deficiency.

5.20.7 Variety selection

Early varieties: Pusa Resmi, Pusa Chetki, Chalish Dine (forty days)

Mid-season/main season varieties: Mino Early, White Neck, Green Neck, Pyuthane Rato

Late varieties: Tokinashi, White Icicle, Pusa Humane, French break Fast, Scarlet Globe, etc.

5.20.8 Nursery establishment and management

Radish is a directly sown crop.

5.20.9 Seed rate and seedling requirements

For one hectare of land, 5–6 kg seed is required.

5.20.10 Sowing and sowing time

In the raised beds, 3–4 cm deep small furrows are made at a spacing of 20–25 cm, and seed is dibbled 3–4 cm deep, maintaining a 10–15 cm distance depending on the variety. Seed sowing and harvesting months in different geographical areas are presented below:

Geographical areas	Early varieties	Mid-season varieties	Late varieties
Low hills and Terai up to 600 metres	August–September (October-November)	September-October (November- January)	November-December (January-February)
Mid-hills 600–1,500 metres	July-August (August-September)	September-October (November-January)	January-February (April-May)
High hills above 1,500 metres	April-May (May-July)	April-July (July-Oct.)	February-March (April-June)
Months inside the parentheses are root harvesting months.			

5.20.11 Irrigation and water management

Water management is necessary for quick germination and vigorous growth and production of tender and slender roots. Irrigation should be provided just after sowing, and thereafter light irrigation should be provided at 5–7 day intervals to maintain a proper soil moisture level. During the rainy season, only protective irrigation should be given. The critical stages of irrigation in radish are just after sowing, urea top dressing, after weeding, and intercultural operation. In normal conditions, soil moisture should be 60 to 100% of field capacity, with an average of 80% field capacity. During dry weather, irrigation should be provided more frequently. Furrow system of irrigation is always better. After irrigation and heavy rain, it is important to drain excess water, otherwise club root, root rot, etc. may attack the crop. Constructing a water harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.20.12 Intercultural operations and care

After 5–6 days of sowing, a thorough inspection should be carried out and seeds should be sown in blind hills to fill the gaps. During the early stage of growth, weed competes with the crop for nutrient and moisture. Light hoeing, thinning and singling is done. First urea top dressing is done after 15–20 days of sowing and second top dressing after 35–40 of sowing in mid season and late season varieties. Field should always be kept free of weed and soil should be kept loose around the plants.

5.20.13 Plant protection

Aphids and caterpillars are the two main insects and damping-off of seedlings, leaf spots and club root are the main diseases in radish.

Being a short durational crop, no chemical spray is recommended. To manage aphids and caterpillars, spray soap water, human or cow urine or neem based pesticides. Jholmal or urine mixed in 10 parts water or neem extract 3ml/litre of water cures the aphids.

Alternaria leaf spots appear on older leaves. Remove such leaves and bury or burn them. Club root is prevalent in water-logged conditions and in soils with low pH. Therefore, apply 100 kg lime and 100 kg mustard cake/ha. Lime increases the soil pH and reduces the attack of club root.

5.20.14 Maturity, harvesting and yield

Radish roots become ready for harvest 25–55 days after germination depending on the variety. European table varieties become ready in 25 to 30 days, and will become pithy if they are are harvested. Light

irrigation before harvest facilitates easy uprooting without root breakage and other mechanical injury. Harvesting is prohibited when there is dew on the plant. It is better to harvest in the afternoon when the sun is mild and there is no dew on the plants. After harvesting, radish should be kept in the shade for cleaning, grading and packaging. The root yield ranges from 10–40 tonnes/ha depending on the variety.

5.20.15 Cleaning and grading

After harvest, the roots should be washed, graded and packed for marketing. Roots are graded as small, medium and large. They are made into bundles, each weighing up to one kg, and tied with a straw or a plastic rope.

5.20.16 Packaging and transportation

The leaves are removed before the bundles are piled up and packed in gunny bags for distant markets. For local market they are usually transported on bicycles. If they are packed in bamboo baskets or plastic crates along with the leaves, with proper aeration, they will reach the market in fresh condition.

They are usually transported in trucks and minibuses. The packages should be piled up carefully so that they don't shake during the journey. Radishes produced in the high hills are sold in the Terai and large towns of Nepal

5.20.17 Storage and marketing

Most of the radishes commercially grown in Nepal are harvested and sent to the market within a day or two. Smallholder producers who live in the periphery of cities make bundles and carry them to the market in padded bamboo baskets. They sell them either to local wholesaler or retailers, or directly to consumers in market areas. If marketing is obstructed or delayed due to transportation problems, they can be stored at 10°–12°C and 85–95% humidity for up to 10 days.

5.20.18 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation, and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seed directly sown	300	150
2	Crop production labour (planting to harvest)	13 labour days	3,900
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	100
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		6,550
8	Total production 2,000 kg and price NPR 20	2,000 *20	40,000
9	Net profit in NPR	6,500—40,000	33,450

5.21 Carrot

5.21.1 Introduction

Carrot (*Daucus carota*) belongs to the family Apiaceae and it is a cool and warm season crop. Carrot is a popular vegetable grown in temperate regions during spring and summer and during winter in sub-tropical and tropical regions. Carrot roots are eaten cooked or used in salads. They are also used to prepare soup, stew, pickles and *gajar ko haluwa*. Carrot leaves can be eaten cooked or used to make pakoda. Carrot juice is a rich source of carotene, a precursor of Vitamin A. It is also rich in Vitamin B, C and K. Carrot is rich in minerals like calcium, phosphorus and iron.

5.21.2 Climatic requirements

Carrot seed germinates in a wide range of temperatures from 7°–24°C. For good root growth, optimum temperature is 15° to 25°C. Tropical types can form root at temperatures up to 30°C. At higher temperatures, roots tend to be green.

5.21.3 Soil requirements

Deep, well-drained, loose loamy soil is ideal for the growth and development of carrot roots. In hard soil, root formation is disturbed and roots become rough and branched. High acidic soil is not favourable for this crop and the most suitable pH range is 5.5 to 6.5. Carrot is a sunshine loving crop and cannot grow well in shady places.

5.21.4 Land preparation

Carrot is a deep-rooted root crop. The field for carrot should be prepared well with 1–2 rounds of deep corrosive plowing/digging followed by clod breaking to make soil friable, loose and well levelled. If the soil is hard with clods, the roots will be deformed. Carrot should be sown in well-prepared flat raised beds in four rows per bed or two rows per bed. For four rows per bed, 120 cm wide beds should be made with a 25 cm wide trench between

two beds. Four rows should be sown for better yield and easy irrigation in 2 metre wide beds. Organic manures like FYM should be applied at the time of preparing the main field. All chemical fertilizers except half dose of nitrogen should be mixed thoroughly in soil during bed preparation.

5.21.5 Manure and fertilizer application

Carrot is a heavy feeder and requires adequate manure and nutrients for slender and thick root development. Balanced and judicious application of NPK favours early vegetative growth and rapid root thickening, leading to quality root production. For best results, farmyard manure (FYM) 20 tonnes/ha or compost should be added to the soil during final digging before bed preparation. To supplement the FYM, apply 40 kg nitrogen, 40 kg P_2O_5 and 60 kg K_2O per ha. Apply the full dose of FYM during the final digging of soil. Full doses of P_2O_5 and K_2O and half dose of nitrogen mix thoroughly in the soil at the time of making beds. Apply the remaining half dose of nitrogen as top dressing in two batches: first dose after 15–20 days of germination after thinning and second dose after 35–40 days of germination.

5.21.6 Boron deficiency in Radish

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

Micronutrients: Carrot needs micronutrients such as boron, zinc, molybdenum, manganese, iron, etc. Supplement micronutrients are available in various multi-nutrient rich commercial formulations such as Agrolic and Agromin and in single formulations such as boron and calcium. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays. Borax @ 10 kg/ha during bed making will help address boron deficiency.

5.21.7 Variety selection

Open pollinated varieties: Nantes Forto, New Kuroda, Chantenay, Early Nantes, etc.

Hybrid varieties: Kuroda Mark. Nepa Dream, Sigma, etc.

5.21.8 Nursery establishment and management

Carrots are directly sown.

5.21.9 Seed rate and seedling requirements

For one hectare of land, 2–3 kg of seed is required.

5.21.10 Sowing and sowing time

In the raised flat beds, 3–4 cm deep small furrows are made at a spacing of 20 cm. 8–10 parts sand or ash is mixed thoroughly with carrot seeds and the seed mixture is dropped continuously in the furrows. The seed is then covered with a wooden hand plank. After 10–15 days of germination when plants develop 3–4 true leaves, the plants are thinned to maintain a plant-to-plant distance of 10 cm.

Seed sowing and harvesting months in different geographical areas are presented below:

Geographical areas	sowing and harvesting months
Low hills and the Terai up to 600 metres (winter)	September-October (November–January)
Mid-hills 600–1,500 metres (Winter) (Spring/summer)	September-October (November-January) January-March (April-June)
High hills above 1,500 metres (summer/rainy)	April-June (July-October.)
Months inside the parentheses are harvesting months.	

5.21.11 Irrigation and water management

Water management is necessary for quick germination and vigorous growth and production of tender and slender roots. Irrigation should be provided just after sowing, and thereafter light irrigation should be provided at 5–7 day intervals to maintain a proper soil moisture level. During the rainy season, only protective irrigation should be given. The critical stages of irrigation in radish are just after sowing, urea top dressing, after weeding, and intercultural operation. In normal conditions, soil moisture should be 60 to 100% of field capacity, with an average of 80% field capacity. During dry weather, irrigation should be provided more frequently. Furrow system of irrigation is always better. After irrigation and heavy rain, it is important to drain excess water, otherwise club root, root rot, etc. may attack the crop. Constructing a water harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.21.12 Intercultural operations and care

After 5–6 days of sowing, a thorough inspection should be carried out and seeds should be sown in the blind hills to fill the gaps. During the early stage of growth, weed competes with the crop for nutrient and moisture. Light hoeing, thinning and singling is done to maintain a plant-to-plant distance of 10 cm. First urea top dressing is done after 15–20 days of sowing and second top dressing after 35–40 of sowing in mid season and late season varieties. Field should always be kept free of weed and soil should be kept loose around the plants.

5.21.13 Plant protection

Compared to other crops, diseases and insect attack are less common in carrot. To some extent, beetle, caterpillar and carrot rust fly maggot attack the root. Intercropping with shallot and chive can reduce the incidence. In the early stage, if the attack is severe, spraying Metacid and Nuvan @ 2ml/litre of water can control these pests. Some diseases like yellow leaf virus alternaria and root rot may appear. Proper drainage can prevent these problems.

To manage virus-transmitting aphids, spray soap water, human or cow urine, or neem products. Jholmal or urine mixed in 10 parts water or neem extract 3 ml/litre of water cures the aphids.

Other physiological disorders in carrot are forking, splitting and cavity spots, which occur when soil does not allow straight growth. Spliting of root occurs when the soil accumulates excess nitrogen or heavy moisture. Cavity spot is due to calcium deficiency.

5.21.14 Maturity, harvesting and yield

Carrot roots become ready for harvest in 90–100 days after germination depending on the variety. The roots can be marketed when their upper diameter is 2–4 cm. If harvesting is delayed, the core will become hard and the roots will split. Light irrigation before harvest facilitates easy uprooting without root breakage and other mechanical injury. It is better to harvest in the afternoon when the sun is mild and there is no dew on the plants. After harvest, carrots should be kept in the shade for cleaning, grading and packaging. The root yield ranges from 20–25 tonnes/ha depending on the variety.

5.21.15 Cleaning and grading

After harvest, the roots should be washed, graded and packed for marketing. Roots are graded as small, medium and large. They are made into bundles, each weighing up to one kg, and tied with a straw or a plastic rope.

5.21.16 Packaging and transportation

The leaves are removed before the bundles are piled up and packed in crates for distant markets. For local market they are usually transported on bicycles. If they are packed in bamboo baskets or plastic crates along with the

leaves, with proper aeration, they will reach the market in fresh condition.

They are usually transported in trucks and minibuses. The packages should be piled up carefully so that they don't shake during the journey. Carrots produced in the high hills are sold in the Terai and large towns of Nepal.

5.21.17 Storage and marketing

Most of the carrots commercially grown in Nepal are harvested and sent to the market within a day or two. Smallholder producers who live in the periphery of cities make bundles and carry them to the market in padded bamboo baskets. They sell them either to the local wholesaler or retailer, or directly to consumers in market areas.

If marketing is obstructed or delayed due to transportation problems, they can be stored at 10°–12°C and 85–95% humidity for up to 10 days.

5.21.18 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seed directly sown	200	400
2	Crop production labour (planting to harvest)	13 labour days	3,900
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	100
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		6,800
8	Total production 1,000 kg and price NPR 40	1,000 *40	40,000
9	Net profit in NPR	6,800—14,000	33,200

5.22 Turnips

5.22.1 Introduction

Turnip (*Brassica rapa*) belongs to the family Brassicaceae. It is a cool and warm season crop. It is a leaf-cum-root vegetable. The root, along with the tender leaf, eaten cooked, or used in salads and pickles. The root contains 7–9% sugar and Vitamin B. The leaf contains Vitamin A and C. The leaf contains different minerals and vitamins and has a higher nutritional value than the root.

5.22.2 Climatic requirements

Turnip requires a cool or moderate climate and grows well in sub-tropical and temperate climate. It is predominantly a cool season crop. It can tolerate frost and mildly freezing temperature. Turnip grows well in full sunshine and cannot be grown in the shade. For good root growth, optimum temperature is 15° to 25°C. Turnip seed germinates at 10°–15°C. If seed is sown at temperatures below 10°C, it may lead to bolting; above 25°C the root becomes a little hard, pithy and pungent.

5.22.3 Soil requirements

Turnip can be grown in almost all types of soil; however, light loam to sandy loam soil rich in organic matter, a high level of fertility and high water-holding capacity is best for quality root production. Soils with high clay and high sand, and muddy and water-logged soils should be avoided. Turnip requires slightly acidic soil with pH range 5.5 to 6.8. In soils with lower pH, club root attacks the plant and phosphorus and calcium availability is restricted. Adding agricultural lime improves pH and increases phosphorus and calcium availability.

5.22.4 Land preparation

Turnip is a shallow-rooted root crop. The field should be ploughed or dug 15–20 cm deep and soil should be friable, loose and well levelled. To plant four rows per bed, 120 cm wide beds are prepared with a 25 cm wide trench between two beds. Turnip is sown in well-prepared 15 cm raised beds, maintaining a 20 cm row-to-row distance. Organic manures like FYM should be applied at the time of preparing the main field. All chemical fertilizers except half dose of nitrogen should be mixed thoroughly in soil during bed preparation.

5.22.5 Manure and fertilizer application

Turnip requires a smaller amount of NPK compared to other root crops. FYM 20 tonnes/ha or compost should be added to the soil during final digging before bed preparation. To supplement the FYM, apply 40 kg nitrogen, 20 kg P_2O_5 and 20 kg K_2O per ha. Apply the full dose of FYM during the final digging. The full dose of P_2O_5 and K_2O and half dose of nitrogen mix thoroughly in the soil at the time of making beds. Apply the remaining half dose of nitrogen as top dressing in two batches: first after 15–20 days of germination after thinning and second dose after 35–40 days of germination at 2–3 cm deep as band placement with slight hoeing.

Application of Jholmal at weekly intervals until a month before harvesting time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

Micronutrients such as boron are important for turnip. Borax @ 10 kg/ha can be applied during bed making to treat boron deficiency. Supplement micronutrients are available in various multi-nutrient rich commercial formulations such as *Agrolic* and *Agromin* and in single formulations such as boron and calcium. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays.

5.22.6 Variety selection

Indian varieties like Pusa Chandrima, Pusa Swarnima, Pusa Kanchan are also available. In Nepal two varieties, Purple Top White Glove and Kathmandu Rato, are popular.

5.22.7 Nursery establishment and management

Turnip is a directly sown crop.

5.22.8 Seed rate and seedling requirements

For one hectare of land, 2 kg of seed is required.

5.22.9 Sowing and sowing time

In the 120 cm wide raised flat beds, 3–4 cm deep small furrows are made at a spacing of 20 cm. To make sowing easy, 8–10 parts sand or ash is thoroughly mixed with seed and the seed mixture is dropped continuously in the furrows. The seed is then covered with a wooden hand plank. After 10–15 days of germination when plants develop 3–4 true leaves, the plants are thinned to maintain a plant-to-plant distance of 10 cm.

Seed sowing and harvesting months in different geographical areas are presented below:

Geographical areas	Sowing and harvesting months
Low hills and Terai up to 600 metres (winter)	September-October (November-January)
Mid-hills 600–1,500 metres (winter)	September-October (November-January)
Mid-hills 600–1,500 metres (spring/summer)	January-March (April-June)
High-hills above 1,500 meter (summer/rainy)	April-June (July-October.)
Months inside the parentheses are harvesting months.	

5.22.10 Irrigation and water management

If the soil is dry, pre-sowing irrigation is essential for quick germination and vigorous growth and production of roots. If pre-irrigation is not possible, irrigation just after sowing and light irrigation at 5–7 day intervals is necessary

to maintain a proper soil moisture level. During the rainy season, only protective irrigation should be provided. The critical stages of irrigation in turnip are just after sowing, urea top dressing, after weeding and intercultural operation. During dry weather, irrigation should be provided more frequently. Furrow system of irrigation is always better. After irrigation and heavy rain, it is important to drain excess water; otherwise club root, root rot, etc. may attack the crop. Constructing a water-harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.22.11 Intercultural operations and care

After 5–6 days of sowing, a thorough inspection should be carried out and the seeds should be sown in the blind hills for gap filling. During the early stage of growth, weed competes with the crop for nutrients and moisture. Light hoeing, thinning and singling is done. First urea top dressing is done after 15–20 days of sowing and second top dressing after 35–40 days of sowing. Field should always be kept free of weed and soil should be kept loose around the plants.

5.22.12 Plant protection

Aphids, Mustard Saw Fly and Flea Beetle are the main insects that attack turnip. When the attack is severe at the early stage of crop growth, these insects can be controlled by spraying metasystox @ 1ml/litre of water twice within 15 days. Main diseases include damping-off of seedlings, leaf spots and club root.

Alternaria leaf spots appear on older leaves. Remove such leaves and bury or burn them. Club root appears in water-logged conditions and soils with low pH. Therefore, apply 100 kg lime and 100 kg mustard cake/ha. Lime increases the soil pH and reduces the attack of club root.

5.22.13 Maturity, harvesting and yield

Turnip roots become ready for harvest in 45–55 days after germination depending on the variety. Light irrigation before harvest facilitates easy uprooting. It is better to harvest in the afternoon when the sun is mild and there is no dew on the plants. After harvest, turnips should be kept in the shade for cleaning, grading and packaging. The root yield ranges from 20–25 tonnes/ha depending on the variety.

5.22.14 Cleaning and grading

After harvest, the roots should be washed, graded and packed for marketing. Roots are graded as small, medium and large. They are made into bundles, each weighing up to one kg, and tied with a straw or a plastic rope.

5.22.15 Packaging and transportation

The leaves are removed before the bundles are piled up and packed in gunny bags for distant markets. For local market they are usually transported on bicycles. If they are packed in bamboo baskets or plastic crates along with the leaves with proper aeration, they will reach the market in fresh condition.

They are usually transported in trucks and minibuses. The packages should be piled up carefully so that they don't shake during the journey. Turnips produced in the high hills are sold in the Terai and large towns of Nepal

5.22.16 Storage and marketing

Most of the turnips commercially grown in Nepal are harvested and sent to the market within a day or two. Smallholder producers who live in the periphery of cities make bundles and carry them to the market in padded bamboo baskets. They sell them either to local wholesaler or retailers, or directly to consumers in market areas.

If marketing is obstructed or delayed due to transportation problems, they can be stored at 10°–12°C and 85–95% humidity for up to 10 days.

5.22.17 Cost of Production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seed directly sown	200	400
2	Crop production labour (planting to harvest)	13 labour days	3,900
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	100
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		6,800
8	Total production 1,000 kg and price NPR 30	1,000 *30	30,000
9	Net profit in NPR	6,800—30,000	23,200

5.23 Onion

5.23.1 Introduction

Onion (*Allium cepa*) is cultivated and consumed across the world. The Sanskrit term for onion, 'Palandu', appears in *Apastamba Dharma Sutra-I* (dated 800 BC to 300 BC), which signifies its very early introduction in the Indian sub-continent. References to edible onion can be found in the Bible, Koran, and in the ancient inscriptions of Egypt, Rome, Greece and China.

Onion (*Allium cepa*) is a warm season crop and belongs to the family Amaryllidaceae. Onions are generally consumed in small quantities as a spice. They are used as a seasoning ingredient in a wide variety of dishes. They are also eaten raw mixed in salads. The matured onion bulb mixed with potato is a popular curry dish in many Nepalese homes. Green onions are cooked as vegetables. Onions help in the prevention and treatment of atherosclerosis and coronary heart diseases. The pungency of onion is due to the presence of a sulphur containing volatile oil known as *allyl-propyl-disulphide*. The succulent bulb of onion is 15% solid and 85% water. It contains carbohydrate, protein, carotene, and Vitamin B and C. Onion can be cultivated in different regions ranging from the Terai to the hills in different seasons.

5.23.2 Climatic requirements

Onion is a cool season crop. It can be grown under a wide range of climatic conditions. It grows well in a mild climate without extreme heat or cold. The plants are hardy at the early stage and can tolerate frost. For good bulb formation and vegetative growth 13°–24°C temperature is required. Seedlings die at temperatures below 4°C. High temperature at the beginning and then low temperature below 10°C, followed again by high temperature, can lead to bolting.

Day length requirements may differ according to the variety. Almost all varieties grown in Nepal are short-day varieties. Brown Spanish and Early Grano are long-day varieties and need more than 14 hours day length for bulb

formation. Onion needs full sunshine for good bulb formation. Onion does not form a good bulb in a shady place with inadequate sunshine.

5.23.3 Soil requirements

Onion needs fertile and well-drained soil rich in humus and organic matter. It requires nearly neutral soil with pH range 6.0–6.8. It can be grown in all types of soil; however, light loam to loam soil is best. If pH is below 5.5, calcium and phosphorus availability is reduced and iron and manganese availability increases to toxic level. In clay soil, bulb formation is restricted. In more sandy soils, the crop needs frequent irrigation and most nutrients leach out and soil structure is distorted. Well-drained soil with a high water-holding capacity is best for onion cultivation. Soil should never be muddy or water-logged.

5.23.4 Land preparation

Soil should be prepared well with 2–3 rounds of deep corrosive plowing followed by light harrowing and clod breaking to make soil friable, loose and well levelled. For off-season summer/rainy season planting, 15 cm raised beds of 100 cm width should be made with a 25 cm wide trench between two beds. For winter season planting 1–1.5 metre wide sunken beds should be made with 15 cm raised bunds all around. Length may go up to 10 metres. Five to seven rows can be transplanted in each bed. Organic manures like farmyard manure (FYM) should be applied at the time of preparing the main field. Before making beds, all fertilizers except half dose of nitrogen should be mixed thoroughly in soil. This helps the transplanted crop utilize nutrients efficiently.

5.23.5 Manure and fertilizer application

For best results, a basal dose of 20–30 tonnes of FYM, 75 kg of nitrogen, 75 kg of P_2O_5, and 60 kg of K_2O per hectare is recommended. The FYM is applied 4–6 weeks before transplanting so that the period of rapid release of nutrient from the manure coincides with rapid growth of the crop. The full dose of P_2O_5 and K_2O and half dose of nitrogen mix thoroughly in the soil at the time of making beds. Apply the remaining half dose of nitrogen as top dressing in two batches: first dose after one month of transplanting and second dose when they start forming bulbs. As the root system of onion is dense and shallow, applying the fertilizer in bands 5 cm away from the young plants at 2 cm depth gives the best results. If the fertilizer is applied close to the plans, it will kill the plant by burning.

Application of Jholmal at weekly intervals until a month before harvest time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

If micronutrient deficiency appears, apply multiplex, zincoplex or agromin at 2ml/litre of water four times at 15-day intervals for better bulb formation. Supplements are available in multi-nutrient rich commercial formulations such as *Agrolic* and *Agromin* and in single formulations such as boron and calcium. Micronutrient formulations available under different commercial names can be applied as basic doses and foliar sprays.

5.23.6 Variety selection

Open pollinated varieties: Red Creole, Pusa Red, Nasik Red, N-53, Pusa Ratnar, Agrifound Dark Red, and Agrifound Light Red etc.

Hybrid varieties: Superex, TI-172, Cass, Venus, Winter Silver, etc.

5.23.7 Nursery establishment and management

Select a well-drained open space for nursery. For a hectare transplanting, a 200 square metre nursery is required. While preparing nursery beds, apply 5–7 kg of well-rotted FYM/compost per square metre of land. For 200 square metres, it needs 1,000–1,500 kg of FYM. During the rainy season, make one metre wide 15 cm raised beds with a 25 cm wide trench between two beds. Length of beds may vary; however it should not be more than 10 metres for easy care and management.

Before sowing, seed treatment with thiram, bavistin or Trichoderma at 2–3 gram per kg of seed prevents the seedlings from damping-off and soil-borne fungus.

After preparing sunken beds, make 2–3 cm deep tiny U-shaped furrows at a spacing of 10 cm with the help of a small stick. Drop the seed using your thumb, forefinger and middle finger. Cover the seed with fine sand or fine soil compost mixture or with ash depending on availability. Then mulch the beds with straw or specially made thin perforated jute sack. After sowing and mulching, sprinkle water thoroughly with a fine rose can (hajari), ensuring that soil is moist but not over-watered. Water the plant daily or on alternate days depending on soil moisture till the seedlings emerge. Onion seedling germinates after 7–10 days of sowing. Remove the mulch as soon as the seed germinates. Any delay in removing the mulch will result in lanky seedlings. Apply water very carefully and lightly. A forceful splash of water and heavy watering may damage young seedlings and damping-off may attack the nursery.

The seedlings become ready for transplanting when plants are 6–7 weeks old and of pencil thickness. Transplanting seedlings that are too young and weak will hamper plant establishment. On the other hand, if aged seedlings are transplanted, premature bolting will occur instead of bulb formation.

5.23.8 Seed rate and seedling requirements

For one hectare land 10–12 kg of seeds is required depending on germination percentage and seed vigor. Healthy and well-grown 600,000 to 800,000 seedlings per hectare are required including for gap filling.

5.23.9 Transplanting

Onion seedlings are ready for transplanting in 5–7 weeks after germination. Accordingly seed should be sown 40 to 50 days before transplanting. Well-grown seedlings that are 5–7 weeks old and pencil-thick are ready for transplanting. Moistening nursery beds before lifting the seedlings makes their removal easy and prevents injury to the root system. Select healthy and strong seedlings for transplanting. Avoid weak seedlings. During the rainy season, for off-season production, seeds should be transplanted in raised beds, and during winter and dry periods, they should be transplanted in sunken beds with raised ridges all around to hold moisture. Transplanting times may vary according to the altitude and the temperature and season. Seedlings are transplanted maintaining a row-to-row distance of 20 cm and plant-to-plant distance of 10–15 cm.

Transplanting and harvesting months in different altitudes and seasons

Geographical areas	Transplanting months	Harvesting months
Terai to low hill basins up to 600 metres	December-January	March-April
Mid hills (600 to 1,500 metres)	December-January	April-May
Off-season (Terai and mid-hills)	July-August	November-December

5.23.10 Irrigation and water management

Pre-planting irrigation just two days before transplanting and light irrigation just after transplanting is necessary to establish the crop and maintain a proper soil moisture level. Required frequency of irrigation depends on several factors such as soil and climatic conditions. The moisture level of the soil should be kept optimum. Off-season onion transplanted during July-August in Nepal only needs protective irrigation during the rainy and late rainy season. If there is no rain in October, irrigation is required. The critical stages of irrigation in onion are just after transplanting, urea top dressing, after weeding and at bulb formation. Irrigation should be stopped when the tops mature and neck break becomes visible. Constructing a water-harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.23.11 Intercultural operations and care

During the early stage of growth, crust breaking and weed control is important. Onion cannot compete with weeds. Light hoeing and first urea top dressing after 30–35 days of transplanting ensures uniform growth. Field should always be kept free of weed and soil should be kept loose around the plants. There should be minimum damage to shallow and fibrous roots. Being a shallow-rooted and densely planted crop, any root pruning reduces the bulb yield. Applying chemical weedicides such as Lasso or Baseline @ 1litre/ha immediately after transplanting and before irrigation with one hand weeding gives the best results.

5.23.12 Plant protection

Protection of onion from harmful insects and diseases is very important. Major insect is thrips. Major diseases include purple blotch, stem phylum blight, black mold and bottom rot. The causal organism, symptoms and management practices are presented below:

Bolting in Onion

Untimely bolting in onion is a serious problem. It occurs due to temperature, the age of seedling and the time of transplanting. Transplanting warm season varieties in cool season, transplanting aged seedlings, and transplanting before winter also lead to early bolting. Onion bulb formation takes place at temperatures between 130 and 240C. If the temperature is below 10°C and onion bulb weighs more than 10 gm, vernalization requirements for onion bolting are met. This thermal induction affects the bulbs weighing more than 10 gm. Bulbs less than 10 gm will have no vernalization. If the onion seedlings are grown earlier and transplanting is done before 15 December, the plant will receive temperatures above 130C and bulb formation will be initiated and will weigh more than 10 gm. It will then pass through winter and will get temperature less than 100C and vernalization or thermal induction will be fulfilled. After winter, in February when it again receives higher temperatures, then bolting will occur instead of bulb growth. Thus, when it receives high temperature during the earlier stage, lower temperature for vernalization during winter and again high temperature in early spring, the onion bolts as its juvenile phase is over. To overcome this problem, seeds should be sown in nursery a little late and transplanting should be done after 15 December using 40–45 days old, pencil size seedlings with no bulb initiation. Thus by adjusting seed sowing and transplanting time, we may get rid of early bolting in onion. Late-planted crop does not have bulb developed enough to receive thermal induction effect, and with the rise in temperature, it starts bluing from March and continues through April.

Major Insects and their Management

Insects	Types of damage	Management
Thrips	Both the larvae and adult *Thrips tabaci* cause injury by rasping the surface of leaves and sucking the liberated juice. Badly damaged foliage may give the entire field a silvery appearance and yield will be greatly reduced and the quality impaired.	• Spray 0.1% Malathion + 0.1 % Sandovit four times at 15 day intervals. • Spray Nuvan 76 EC @ 0.5 ml per litre of water at weekly intervals. • Spray metasystox @ 1ml per litre of water + Sandovit 0.1% to control the insect. • After spraying pesticide, wait for 7 to 21 days as indicated on label of the poison container. • During the waiting period, do not harvest and do not eat or feed any parts sprayed with pesticide.

Major diseases and their management

Diseases	Symptoms	Management
Damping off	Pre-emergence and post-emergence damping-off caused by different fungi (*Fusarium, Pythium*, and *Rhizoctonia*) and seed rotting occur. Fungus attacks the base of the seedlings above the soil level, and they become water soaked, black and collapse rapidly. The seedling eventually dies.	• Treat the seed with Trichoderma or thiram or Bavistin @ 2.5 gm/kg seed. • Do not sow seed thickly in the nursery. • Drench nursery beds a fortnight before sowing the seed with 25 ml to 30 ml/litre formaldehyde and cover the nursery for about 3 days.

Purple Blotch	It is caused by *Alternaria porri*. Large bleached lesions appear on the leaves with a purple centre that gets rapidly enlarged, leading the infected bulbs to rot.	• Spray Dithane-M-45 (0.25%) with sticker triton (0.1%) 2–3 spray at 15-day intervals.
Black rot of onion	The outer or inner scales are coated with black, powdery mass spores that can be rubbed off easily.	• To control the disease, protect the bulb from moisture after harvest. Store the bulbs at about 0°C.

5.23.13 Maturity, harvesting, curing and yield

In onion, maturity standards are judged by visual observation. The best time for harvest is a week later when 50–70% onions show neck fall. During harvest, the bulbs are pulled out of the soil after the leaves have completely dried and 100% neck break. After harvesting, onions should be left in the field for a day or two to remove excess moisture and to allow skin colour to develop. Then top part is cut off and the onions are kept in the shade for cleaning, grading and packaging. The yield of onion ranges from 20–25 tonnes/ha.

5.23.14 Sorting and grading

After harvest, thick-necked, bolted, doubled, injured and decayed bulbs are separated. There is market demand for onion of various sizes. Some markets want large bulbs while others demand small and medium sized bulbs. Grading is done as per the market demand. Based on their size, onions can be graded into small, medium and large groups. Grading provides a basis for orderly marketing and enables the consumers to assess the quality of onions in relation to the price while also providing a marketing incentive to the traders.

5.23.15 Packaging and transportation

Onions are packed in jute/gunny bags for transportation. For safe handling, 40 kg open mesh jute bags are preferred.

5.23.16 Storage and Marketing

At all temperatures, there is a gradual loss of weight. The bulbs can be stored at a higher temperature (20–30°C) for 4–5 months without sprouting but weight loss cannot be avoided. Onion stored at lower temperatures undergoes minimum weight loss but sprouts when taken out of cold storage. However, 0°C storage temperature and around 65% relative humidity is best for long-term storage of onion bulbs.

In Nepal there is no organized cold storage for onion. However, if market price is too low during harvest, it can be stored at 0°–2°C and 65–70% relative humidity for up to 4 months from June to September. During this period the price of onion hikes and compensates for the weight loss.

It is important to analyse market trends and assess the demand for onion in advance. As this product has a long shelf life and can be transported across long distances, it also generates more competition than produce with a lower shelf life. Demand for onion is largely determined by the amount of onions coming from India. As price fluctuation in this product is higher, it is important for farmers to analyse demand trends and identify a market for their product.

5.23.17 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seedling production in nursery		
1.1	Treated and packed hybrid seed	500 gm	1,500
1.2	Manure	LS	500
1.3	Nursery materials	LS	400
1.4	Nursery preparation, soil solarization and sowing to hardening	4 labour days	1,200
2	Crop production labour (planting to harvest)	20 labour days	6,000
3	Manure, fertilizer and micronutrient	LS	2,500
4	Plant protection inputs	LS	500
5	Irrigation pipes, sprinkles	LS	900
6	Packaging and transportation	LS	1,000
7	Others	LS	500
8	Total cost		15,000
9	Total production 2,500 kg and price NPR 20	2,500 *20	50,000
10	Net profit in NPR	15,000—50,000	35,000

5.24 Turmeric

5.24.1 Introduction

Turmeric (*Curcuma longa*) is a hot humid season crop and belongs to the family Zingiberaceae. Turmeric is a pungent yellow spice commonly used in Nepalese, Indian and Thai cuisine. The health benefits of turmeric include anti-cancer properties, protection against Alzheimer's, pain relief and much more. Turmeric contains 1.8–5.4% curcumin, a kind of colour with medicinal value. It also contains 2.5–6.2% good-smelling ether oil. Turmeric can be cultivated in a range of terrain in Nepal, from the Terai to elevations up to 1,600 metres.

5.24.2 Climatic requirements

Turmeric is a tropical crop requiring a warm and humid climate. In warm and cooler areas, it requires full sun for proper growth; however, in hot areas it can grow in the shade too. The temperature range of 20°–30°C is best for its growth and rhizome formation. Growth ceases when the temperature falls below 20°C, and hence early-planted turmeric gives good yield.

5.24.3 Soil requirements

Different kinds of soils such as sandy loam to clay loam or alluvial soils are suitable for turmeric. Well-drained loamy soil is best. Soil should be rich in organic matter and uniform in texture. Rich loamy soils with natural drainage and irrigation facilities are most desirable. Turmeric cannot withstand water stagnation or alkalinity and requires nearly neutral soil with the pH range 5.5 to 6.5.

5.24.4 Land preparation

Soil should be prepared well with 2–3 rounds of deep corrosive plowing followed by light harrowing and clod breaking to make soil friable, loose and well levelled. Turmeric is planted in 15 cm raised flat beds that are 1.5 metre wide. For intercultural operations a 25 cm wide trench should be made between two beds. Four rows can be planted in each bed. Organic manures like farmyard manure (FYM) should be applied at the time of preparing the main field. Before making beds, all fertilizers except half dose of nitrogen should be thoroughly mixed in soil.

5.24.5 Manure and fertilizer application

Turmeric is a heavy feeder crop. Recommended fertilizer dose is 25–30 tonnes of FYM, 120 kg of N, 50 kg of P_2O_5 and 50 kg of K_20/ha. FYM should be applied during preparatory tillage, i.e. before the final harrowing, 4–5 weeks before planting. The full dose of P_2O_5 and K_2O and half dose of nitrogen mix thoroughly in the soil at the time of making beds. Apply the remaining half dose of nitrogen as top dressing in two batches: after one month of planting and again after 60 days of planting. Since the root system of turmeric is medium and dense, placing the fertilizer in bands 5 cm away from the young plants at 2 cm depth gives best results. If fertilizer is applied close to the plants, it will kill the plant by burning.

Application of Jholmal at weekly intervals until a month before harvest time helps replace the use of chemical fertilizers and controls diseases and insect pests (see chapter 3.2.2.vi for details).

5.24.6 Variety selection

Variety development for turmeric is underway at NARC's ginger research farm in Kapurkot, Salyan. Some promising lines are in the process of being released. In general farmers use local specific cultivars. Kapurkot 1 is the variety selected by the NARC.

5.24.7 Planting material management

Turmeric is a vegetatively propagated crop. The seed of turmeric consists of rhizomes. Both mother and finger rhizomes are used. The fingers are cut into pieces, each 4–5 cm long with 1–2 buds. Mother rhizomes are planted or split into two, each having one sound bud. Mother rhizome is preferred since they give 50% more yield than the finger rhizome and also gives good growth. Large, plumy and healthy mother rhizomes at least 100 g in weight should be used. In case of finger rhizomes, healthy rhizomes with 2–3 growing buds are selected from the harvested lot and preserved as seed rhizomes. The seed rhizomes are stored in a well-ventilated airy room or buried in soil and covered with rice husks or light soil. Sometimes seed rhizomes are heaped and plastered over with soil mixed with cow dung.

5.24.8 Seed rate

Seed rate varies according to the type of planting material, spacing and weight of rhizomes. Mother rhizomes require 2,000–2,500 kg/ha, whereas finger rhizomes required 1,500–2,000 kg/ha. For intercropping in a fruit garden, 400–500 kg/ha seeds are required. Rhizomes are treated with Trichoderma or Bavistin solution at 2 g/litre of water. They are dipped in the solution for 15–20 minutes to prevent diseases and rhizome fly during the early period.

5.24.9 Planting

In slopy land used under rain-fed conditions and where soils are light, flat beds of 1.5 m width and suitable length varying according to the slope are prepared. Under irrigated conditions where the land is levelled or plain and soils are heavy, planting is done on ridges and furrows, opened at 75 cm distance. Broad flat beds of 100–150 cm width and 3–6 m length depending on the slope are preferred.

Planting time is from April to May depending on soil moisture. In the hills of Nepal, second fortnight of April to first fortnight of May is the best time for planting rhizomes. While planting in flat beds, row-to-row distance is maintained at 30 cm and hill-to-hill distance at 25 cm; in the single ridge system, row-to-row distance is 60 cm and hill-to-hill 25 cm. Rhizomes are planted at 5 cm depth in the small furrows on the beds/ridges.

5.24.10 Mulching and water management

Turmeric is a rain-fed crop. To preserve moisture and control weeds, mulching is necessary. Mulching also protects soils from erosion in slopy land in the hills. Organic mulching like dried leaves, twigs, straw, dry grasses, banana leaves and rice husks can be used as mulch. In Nepal, turmeric is planted in marginal land without irrigation. For commercial production in flat lands, pre-planting irrigation just two days before planting and light irrigation just after planting is necessary to establish the crop and maintain a proper soil moisture level. Required frequency of irrigation depends on several factors such as soil and climatic conditions. During the rainy season no irrigation is required. If there is no rain in October, irrigation is required. Constructing a water harvesting and wastewater collection pond near the cultivated field ensures water security for irrigation.

5.24.11 Intercultural operations and care

During the early stage of growth, hand weeding is important. To protect developing underground rhizomes from sun exposure due to soil erosion, light hoeing and covering exposed rhizomes is necessary. Field should be kept free of weed for up to 6 weeks after planting. Later turmeric leaves cover the soil and weed cannot compete with turmeric.

5.24.12 Plant protection

No serious insects and diseases attack turmeric. However, shoot borer, thrips and brown leaf spot appear sometimes. The causal organism, symptoms and management practices are described below:

Major insects and their management

Insects	Types of damage	Management
Thrips	Both the larvae and adult *Thrips tabaci* cause injury by rasping the surface of leaves and sucking the liberated juice. Badly damaged foliage may give the entire field a silvery appearance and yield will be greatly reduced and the quality impaired.	• Spray soap water twice within seven days at the initial stage of attack. • Spray 0.1% Malathion + 0.1% Sandovit four times at 15-day intervals. • Spray Nuvan 76 EC @ 0.5 ml per litre of water at weekly intervals. • Spray metasystox @ 1ml/litre of water + Sandovit 0.1% to control the insect.
Leaf and rhizome borer	The larvae bore into the pseudostem and feeds on internal tissues, resulting in yellowing and drying of the leaves of pseudo stem. Presence of bore holes in the pseudo stems, extruded frass, and withered, yellow central shoot are characteristic symptoms.	• Collect and destroy gregarious larvae. • Spray dichlorvus 1ml/litre of water or 2ml /litre of water chlorpyriohos at 15-day intervals. • Moths can be trapped in light traps and killed. • From July to September, spray 0.1% malathion at 15–30 day intervals.

Major diseases and their management

Diseases	Symptoms	Management
Brown spot	This disease is caused by a fungus *Taphrina maculans*. Brown spots with with an ashy centre appear on the upper surface of the leaves. Later on it spreads and the whole leaves become dry.	• Spray Bordeaux mixture 1% at 15-day intervals. • Spray Blitox-50 0.2% solutions at 15-day intervals.

Rhizome rot	The rhizome rot caused by *Pythium aphanidermatum* is one of the most serious diseases in the turmeric crop. Infected rhizomes decay and becomes useless.	• Deep seed rhizomes in 55 solution of Trichoderma. • Spray Bordeaux mixture 1% at 15-day intervals. • Spray 0.2% captan or zineb or dithane z-78 at 15-day intervals. • Use healthy seed and treat the seed with bavivtine 2g/ litre of water, dipping the seed for 15–20 minutes.

5.24.13 Maturity, harvesting, curing and yield

Turmeric is harvested when the leaves start yellowing and ultimately the stem dries up. Rhizomes are ready for harvest 7–9 months after planting. In Nepal they are ready for harvest by December; however, harvesting starts from January and continues till March depending on the availability of labour and drying and marketing facilities. Before harvest the plants are cut close to the ground. The crop is irrigated lightly for easy digging. Harvesting entails digging the underground clumps of rhizomes with a hand hoe, pick axe or digging fork. Sometimes plowing between rows and collecting is also done. The yield of turmeric ranges from 20–30 tonnes/ha.

5.24.14 Sorting, boiling and drying

After harvesting turmeric should be collected and soils and roots should be removed from mother rhizomes. Fingers are separated from mother rhizomes. Diseased and damaged rhizomes should also be sorted and discarded. Both mother rhizomes and clumps are cleaned and washed. Washed rhizomes are cut into small pieces. The drying process starts with the slicing of rhizomes into small pieces with a knife. This increases the rhizome's surface area for drying. Ideal moisture content in final dried product should be around 5–10%.

Turmeric rhizomes cannot be dried straight away. They are boiled first. Boiling softens the rhizomes and accelerates the drying process. The starch inside is gelatinized and thus dries faster. Boiling also removes the raw odor from turmeric; this is why raw turmeric tastes different from powdered turmeric. Another important aspect (mainly from a commercial point of view) is that boiling ensures that powdered turmeric has a uniform colour. From a health standpoint, boiling kills any harmful germs /bacteria present in the product.

The ideal boiling time is around 45 minutes. By then froth will appear at the surface and turmeric will release its particular aroma. If it is over boiled, powder will look decolorized and if it is under-boiled, the rhizomes will become brittle. If the rhizomes feel soft to the touch, then they are ready.

After boiling, rhizome is dried in the sun, which takes 10–15 days depending on the weather. In large-scale production, commercial dryers are used; they run at around 60°C. Mother rhizomes and finger rhizomes should be boiled and dried separately. Mother rhizome takes more time to dry. The dried turmeric is put in bags and rubbed to remove the outer skin and scales. Then winnowing is done to remove the dust.

5.24.15 Grinding storage and marketing

This is the final step and an easy one. Just make sure the rhizomes are dry enough so as to enable grinding. A simple grinder can also be used for small-scale production. Grinding mill can be used to do the job. Grinding machines are used in larger mills/factories. After grinding, pass the ground product through a strainer and grind the residue again.

Storage of ground turmeric is important. Turmeric powder is stored in earthen pots, cloth bags or high-quality plastic bags and transported to the market.

5.24.16 Cost of production and profit

Farmers should keep the production record of each crop for each season in the format provided in Annex 1 and calculate the minimum price that she/he can sell at profit.

Estimated cost of production per ropani (508 square metres) is presented below. (This is just estimation and the actual cost of production should be recorded in the format provided in Annex 1):

S.N	Particulars	Quantity	Amount in NPR
1	Seed directly sown	100 kg	5,000
2	Crop production labour (planting to harvest)	13 labour days	3,900
3	Manure, fertilizer	LS	1,500
4	Plant protection inputs	LS	200
5	Irrigation	LS	400
6	Packaging and transportation	LS	500
7	Total cost		11,500
8	Total production 1,500 kg and price NPR 30	1,500 *30	45,000
9	Net profit in NPR	11,500—45,000	33,500

References

References

Annual Report, (2014). *Himalayan College of Agricultural Sciences and Technology*.

Asia, B. (2009). *Vegetable seed to improve livelihood in rural Nepal.*

Bhomi, B. (1993). Some information about horticulture development in Nepal, A collection of book on "*Horticulture Development in Nepal*", PP 36-46

Bose, T. K. & Som, M. G. (1986). *Vegetable Crops in India*

Chauhan, D.V.S. (1968). *Vegetable production in India*

Elmore, C. L., Stapleton, J. J., Bell, C. E. & Davey, J. E. (1997). *Soil Solarization: A Non-pesticide Method for Controlling, Diseases, Nematodes, and Weeds*

Hara, H. Steam, W. T. & William, J. H. J. (1978). *An enumeration of the flowering plants of Nepal*, Volumes 1-2

HMG, FAO. (1995). *Fresh vegetable and vegetable seed production project completion report*

Mekdaschi, S. R. & Liniger, H. (2013). *Water Harvesting: Guidelines to Good Practice*

Pandey, I. R. (1994). *Indigenous methods of sustainable vegetable production in Kathmandu valley*

Pandey, I. R. (1995). Status of vegetable genetic resources in Nepal, proceedings of workshop *Wild relatives of cultivated plants in Nepal*

Pandey, I. R. (1998). *Improved Techniques of Vegetable Production*

Pandey I. R. (2013). Chronological History of Vegetable Seed Production in Nepal, P 64- 86. a collection of book on "*Horticulture Development in Nepal*" published by Nepal Horticulture Society, 2013.

Regmi, P. P. (1982). *An introduction to Nepalese food plants*

Stapleton, J. J. &, Statewide UC (2008). Soil Solarization Informational Web site

Verma S. K. (1994). HMG/FAO Fresh vegetable and vegetable seed production project impact study report conducted by Swastik Development and Consultant

Wilen, C. A. & Elmore, C. L. (2007). *Pest Notes: Weed Management in Landscapes*.

Annexes

Annexes

Annex 1: Production Record of Vegetable Crops

Name of vegetable…….. variety……

Planted area…….. Ropani/Kaththa

Production year …….. Month from …….. to ……..

S.N	Date	Particulars	Unit	Rate /unit NPR	Quantity	Total cost NPR	Remarks
Fixed cost A							
1		Land revenue					
2		Water tax/charge					
3		Farm tools and equipments					
4		Sprayer					
5		Depreciation on equipments					
6		Interest on variable cost					
7		Others (if any)					
		Sub Total A					
Input cost B							
1		Seed					
2		Seedling					
3		FYM/Compost					
4		Urea					
5		DAP					
6		Potash					
7		Fungicide					
8		Insecticide					
9		Bio-pesticide					
10		Jholmal					
11		Irrigation					
12		Others (specify)					
		Sub-total B					
Power cost C							
1		Tractor hours					
2		Bullock pairs					
		Sub-total C					
Labor cost D							
1		Land preparation					
2		Manure and fertilizer application					
3		Nursery management					
4		Sowing/Transplantation					
5		Irrigation and water management					
6		Intercultural operation and top dressing					
7		Staking/earthing					

8		Fungicide application					
9		Insecticide application					
10		Harvesting, grading and packaging					
11		Transportation					
12		Marketing					
13		Others					
14		Others					
		Sub-total D					
Total cost (A+B+C+D) = E							

Income from fresh vegetable and by-products sale

S.N	Date	Particulars	Unit	Rate /unit NPR	Quantity	Cost / time NPR	Remarks
1		Fresh vegetable					
2		Fresh vegetable					
3		Fresh vegetable					
4		Fresh vegetable					
5		Fresh vegetable					
6		By-product					
7		By-product (household consumption)					
Total gross income NPR = F							
Total cost (A+B+C+D) NPR = E							
Net profit (Total gross income NPR F – Total cost E) = F-E =G							
Per kg production cost = Total production kg / Total production cost NPR							

By-product means quantity not sold as vegetable but used for other purposes like animal feed, compost and consumption by family members.
Per kg production cost = Cost incurred while producing 1 kg of vegetable, which is calculated by dividing the total production (kg) by total production cost (NPR).

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