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**Agriculture Research and Development Center**  
**Bajo Wangdue Phodrang**  
Department of Agriculture, Ministry of Agriculture and Forests



# Guidebook on Fruit Cultivation



*"Fruit Cultivation for the Better Health"*  
Integrated Horticulture Promotion Project  
2016-2021



# GUIDE BOOK ON FRUIT CULTIVATION

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Integrated Horticulture Promotion Project in the West Central Region of Bhutan (IHPP)  
Japan International Cooperation Agency (JICA)

Agriculture Research and Development Centre (ARDC), Bajo  
Department of Agriculture, Ministry of Agriculture and Forests  
Bajo, Wangdue Phodrang, Bhutan

## About the Guide Book

This guide book describes fruit crop species cultivated or are under trial at ARDC-Bajo and ARDC-Wengkhar. It also contains nursery management practices that may be of special interest to the private nursery growers. Moreover, this guide book compiles many fundamental issues in fruit production such as site selections, layout and planting, many cultural practices, growth and bearing habits of fruit crops, unfruitfulness, and so on. Understanding of all these topics will help the readers in knowing the basic fundamentals of fruit production. With the passage of time, cultivation practices of different fruit crops will also evolve. Hence, edition and updating of new knowledge will be done in future as and when necessary. We also hope to produce a similar guide book for tropical fruit crops in the near future.

In Bhutan, it is a common practice that **"Fruits are harvested when they are immature, while vegetables are harvested only they are fully mature"**. However, it is very important to harvest fruits and vegetables at the right stage. We hope this guidebook will help you to harvest your fruits at the right time.

We hope that this guide book would be helpful for fruit growers, nurserymen, farmers, teachers, researchers, extension officer and all those who wish to become familiar with fruit production technology. We have tried to keep the language as simple and straightforward as possible and consistent with an accurate representation of the content. Every effort has been made to present the ideas in very easy and understandable language in the interests of each reader.

We would like to thank the Program Director, horticultural researchers and staffs of ARDC-Wengkhar, ARDSC-Khangma, and ARDSC-Lingmithang. We also would like to thank the Program Director and horticultural staff of ARDC-Bajo and ARDSC-Menchuna who have contributed directly or indirectly in bringing out this book.

December 2018

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## FROM PROGRAM DIRECTOR'S DESK

Integrated Horticulture Promotional Project (IHPP), Agriculture Research and Development Centre (ARDC) Bajo take an enormous pleasure to publish this '**Guidebook on Fruit Cultivation**' which was prepared by Mr. Yuchi Tomiyasu, JICA Expert from 2000-2018, as his parting gift to the researchers, extension supervisors, farmers, practitioners, and stakeholders of agriculture in Bhutan.

Having worked wholeheartedly, tirelessly, and generously for almost nineteen years in the country to generate appropriate technologies in horticulture development, and to develop proper training and extension system to enhance efficiency and effectiveness in agriculture research and extension services delivery, the Expert devoted his last few months to put into black and white his ideas, knowledge, skills, experiences and wisdom into a tangible, valuable, and comprehensive guidebook.

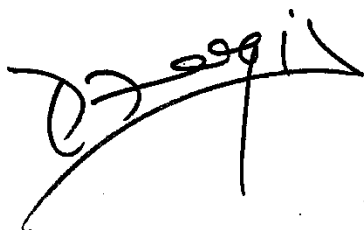
Given the vast knowledge, skills, and experiences of the Expert in horticulture development and more importantly as a gesture of respect for his contribution to horticulture development in Bhutan, the original contents in English which were translated from Japanese with his guidance is retained with changes only in language structure to convey messages clearly and correctly.

The guidebook not only contains comprehensive guidance on major horticulture crops grown in the West Central region of Bhutan but also contains sections on watermelon cultivation, nursery establishment and management, and top-working of the existing fruit crops. IHPP, ARDC-Bajo would like to encourage researchers, extension supervisors, practitioners, and other users to make use of the vast knowledge, skills, and experiences shared in the guidebook. Moreover, we would like to request all users to provide us with your valuable views, comments, and feedback to make this guidebook a living, practical, and impact-oriented document.

ARDC-Bajo would like to offer our sincere gratitude to Japan International Cooperation Agency (JICA) for providing Technical Cooperation Project (TCP) IHPP within the framework of which the guidebook is prepared and published. We not only remain indebted to the agency, experts, and officials for your generous assistance to expand horticulture production in the West Central region but also remain determined to continue to promote technologies generated and demonstrated in the farmers' fields.

We would like to wish all users the best in using and implementing the knowledge, skills, and experiences shared in this guidebook to producing quality fruits sustainably in Bhutan.

Trashhi Delek!

A handwritten signature in black ink, appearing to read 'Pema Chofil', with a large, sweeping flourish extending from the bottom left.

Pema Chofil  
Program Director  
ARDC Bajo



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## **Appendix 1 Fruits Calendar**

## **Appendix 2 Temperate Fruits Nursery and Cultivation Calendar**

## Guide book on Fruit Cultivation



### 1. Fruits cultivation in Bhutan

In Bhutan, horticulture fruits are dominated by apple production in Thimphu and Paro, and local mandarin production in Samtse, Dagana and Tsirang. Both apple and mandarin are cultivated on a large scale. Apple orchards are managed with some management practices such as pruning, training and modified central leader tree form. Local mandarins are mostly planted through seedlings which produce big and tall trees. Farmers do not follow fruit tree management practices at all. The trees are left to grow naturally with little or no cultivation management practices as compared to apple orchards. Except for mango and apples, other fruits are of local origin. The local fruits such as pear, guava, and peach are of low quality with low market value. Nevertheless, local mandarin has exceptional taste.

Apple cultivation is highly suitable in dry temperate areas such as Thimphu and Paro. The qualities of apples are optimum due to abundant sunshine and less rainfall during the summer season. However, apples grown in Bumthang and Haa are of low quality due to heavy rain, foggy weather conditions, and less sunshine in the summer. For the production of quality apple, an area should receive less rainfall in the summer, have good sunlight throughout the growing season, and less or no fog.

In general, Bhutanese apple quality is not good enough for commercial purpose because the tree bears small flowers and small fruits with uneven colouration. The main reasons for such results are poor orchard management practices with insufficient irrigation water application and less or no nutrient management. The flowers are smaller than their normal size. The fruit size remains small as there is not sufficient soil moisture during from blooming until fruit cell division stage. In addition, the lack of fruit thinning also hinders fruit size development.

The popular apple varieties grown are Red Delicious and Starking. Both varieties can be stored for one to two months in cold storage. However, the juice content of fruit decreases during storage. Most of the apples sold in the markets have marks of injury due to rough handling while harvesting and carrying out post-harvest activities. Golden Delicious fruits have a longer storage period with better quality than Red Delicious and Starking in Bhutan. However, the fruit injuries are easily noticeable on Golden Delicious variety. Therefore, the apple farmers should take extra care while harvesting and handling of the fruits to reduce post-harvest damages and losses.

Local mandarin is mostly cultivated in warm temperate and dry subtropical regions at elevations of 900 to 1300 meters above sea level (masl). It is the most suitable range for growing local mandarin and produces mandarin fruits with good taste and juice content. However, most mandarin orchards are left without any care and management. Basic requirement of fertilizers, manures and water are not provided. Basic orchard management practices such as pruning, training and canopy management are also not followed. As a result, the trees are very tall with dense canopy and fruits are mostly borne at the top of the

canopy. Moreover, the trees are planted densely in orchards creating a thick canopy and blocking sunlight penetration into the canopy. The dense plantings also lead to poor aeration in tree canopies. Due to the above reasons, it is very difficult to carry out the necessary management practices which in turn force trees to exhibit alternate bearing habit. The fruits produced from trees are also very small. Moreover, the trees are infested with many harmful pests and diseases such as stink bug, scale and *Diaporthe citri* (*citrus melanose*). At present, all citrus trees grown below 1400 masl are severely affected by *Huanglongbing* (HLB), also called citrus greening disease. Moreover, citrus fruit fly is the most common pest that damages the fruits. Consequently, citrus industry has been declining in Bhutan.

Fruits such as apple, mandarin and mango are mostly cultivated on large scale orchards. However, other fruit crops such as local pear, astringent persimmon, peach, plum, apricot, walnut, avocado, guava, banana, and litchi are grown on a small scale mainly as backyard farming. The fruits such as guava, mango, banana, jackfruit, papaya, and litchi are grown below 1300 masl. While backyard farming is important in meeting the needs for myriad traditional offerings and household consumption, there are very little economic benefits at the individual household level. Some local fruits are sold in the local markets in small quantities. However, due to low eating quality there are only a few buyers. For this reason, local pear and persimmon are sliced and dried for consumption or sold in the local market. However, drying methods are not satisfactory. Thus, the methods of drying have to be improved for better taste and higher price.

In the past, consumption of fresh vegetables and fruits were not common in Bhutan. Most of the vegetables and fruits were consumed after drying. The reason could be due to a smaller number of varieties in food basket and limited knowledge of nutritional value. There were not many promising fruit cultivars and not enough vegetable seeds for diversification. Today, the majority of Bhutanese people are educated and health-conscious. Moreover, there is a diversity of fruits and vegetable varieties that can be easily grown. Hence, backyard farming is slowly transitioning into semi-commercial or commercial farming. Now, people take advantages of wide ranges of suitable climatic conditions.

In eastern Bhutan, most of agricultural farming is done on the steep slope and less fertile land. In the west, though there is a high potential for fruits farming, most of the valley are terraced for paddy cultivation and orchards are established mostly on neglected sloppy lands in between cultivated fields and forests. The strong government policy does not allow cultivation of fruit trees in paddy fields. Despite the potential, areas for commercial fruit cultivation are limited and scattered. Hence, if the fruits production scale is small, the quality should be high (size, outlook, taste, etc.) as a cash crop. However, fruits production needs special techniques and careful daily management. It is quite different from the normal grain production. As a result of both the and management, fruits production could become a highly valued income source.

## **2. Suitable area for fruit cultivation**

Bhutan is situated in the Himalayas with steep slopes and rugged mountain terrains. Most of the areas fall under the hilly and difficult terrain with very steep slopes. Despite its rugged topography, the variations in altitude and climatic conditions in different regions of the country provide great scope for growing different fruits.

The potential of fruit crops in the different regions can be realized only if the right choices of crops are made based on climatic and soil conditions of the areas. If not, farmers usually

fail as the proper growth and development of plants are not obtained. It is important to select the most adaptable crop in a particular region for proper growth and development of fruit trees.

In Bhutan, there are some citrus and mango grown in farmlands above an elevation of 1700 masl which are not feasible. Some tropical fruit trees such as avocados are also grown above 1500 masl where small-sized fruits are produced. Although fruit quality is not optimum, farmers still prefer to cultivate.

Generally, all temperate fruits trees require certain chilling hours for its normal growth and functions. The chilling requirement can vary widely from one variety to another. If a fruit tree is grown in a place where winter cold is insufficient, blooming and foliation will be delayed and erratic, and fruit set and fruit quality will be poor. On the contrary, non-chilling (tropical fruits) cannot survive under a certain temperature and invite the high risk of cold injuries or happening the delay of growth. In areas about 1700 masl, it is ideal and virtually frost-free where any kind of deciduous fruit trees can be grown including varieties with the more chilling requirement.

### ***Agro-ecological Classification and Its Significance to Horticulture***

The topography of Bhutan is extremely variable which can be divided into five zones such as:

1. Mountainous Area
2. High Altitude and Dry In-land (Thimphu and Paro)
3. Mid-Altitude Region,
4. Southern Mid Altitude Region, and
5. Southern Low Altitude Region.

#### **(1) Mountainous Area**

It refers to the high Himalayan Mountains that face to the south. It has an alpine climate and receives rainfall from the south-west monsoon. The area receives less sunshine due to thick coverage of clouds which leads to growth of mosses on the trees. The alpine mountains are cold throughout the year with long winter season where cultivation of crops is very limited. However, at elevations between 2000 to 3000 masl, vegetable cultivation is feasible. Winter vegetables can be grown in the summer season, which has the market advantage over neighbouring countries in the south as off-season vegetable. In the cool temperate zone above 3,000 masl, rearing livestock is the most common way of living with some dryland farming. The main vegetable crops grown comprise of potato, radish, turnip, and mustard.

#### **(2) High Altitude and Dry In-land (Thimphu and Paro)**

High altitude and dry in-land region specifically include Thimphu and Paro districts only. These two Dzongkhags fall under a unique climatic zone. In the southern part of Thimphu and Paro, there are high mountains. During the summer, Southwest monsoon rains are blocked by these high mountains (4000 to 5000 masl) creating rain shadow in Thimphu and Paro valley. The middle valleys and inner hills are warm in summer with good sunshine and cold in winter with moderate annual rainfall (1000 mm). The low temperature in the winter and less rainfall in the summer reduce pests and diseases in apple production. Other temperate fruits such as pear, persimmon, peach, plum, kiwi, grapes and cherry are also suitable for the cultivation. However, areas in the river valleys

of Thimphu and Paro experience strong winds. Therefore, planting windbreak trees in orchards is necessary for proper growth of the fruit trees.

### **(3) Mid-Altitude Region**

Mid altitude area includes dzongkhags such as Trongsa, Punakha, and Wangdue Phodrang, the lower part of Haa, Chukha and northern part of Zhemgang. Most deciduous fruits trees except apples can be suitably cultivated in these areas. However, there are different altitude ranges within the Dzongkhag. The suitability of a crop depends on the elevation of a place. The mid-elevation region receives comparatively less rainfall of about 1500 mm in a year. It falls under the warm temperate zone and has moderately warm temperature except in the winter when frost occurs and agriculture is widely practised in terraced irrigated wetlands and dry-lands. The suitable fruit crops grown within this elevation ranges of 1700 to 2300 masl are pear, persimmon, kiwi, plum, peach, walnut, and so on.

At an elevation of 2000 masl and above, foggy weather condition prevails during most parts of the year and fruits are usually not cultivated. In elevation from 1400 to 1600 masl, some varieties of persimmon, kiwi, peach and plum are cultivated. In addition, some citrus varieties such as Satsuma mandarin (*Citrus unshiu*), Ponkan mandarin (*Citrus reticulata*) and Clementine (*Citrus × Clementina*) are recommended for cultivation in the eastern region of Bhutan. Other fruits such as guava and avocado can also be cultivated. Especially, guava fruits which are grown in low altitude areas are harvested in August and September and those grown at higher altitudes are harvested between October to November. Such crop has market value.

### **(4) Southern Hill mid-Altitude Region**

Southern hill mid-altitude region includes Samtse, southern Chukha, Dagana, Tsirang, southern Zhemgang, southern Pemagatshel, and northern Samdrup Jongkhar. These areas receive high rainfall and are located at low elevations. Therefore, the areas are not recommended for the planting of deciduous fruit trees. Local mandarin is cultivated as a major fruit in these areas with few local deciduous fruit trees. At elevation around 1,600 masl, there is potential to cultivate some improved deciduous fruits such as persimmon and kiwi. However, improved variety of pear is not recommended due to heavy rainfall and insufficient chilling hours. Therefore, local mandarin is suitable in the southern mid-hills. Those south mid-hill area (900 to 1300 masl) facing north produces good quality citrus. These areas receive moderate rainfall during the fruit development stage and remain dry from October to December. Therefore, the fruit has high sugar content and good taste. Citrus fruit cultivated at a higher altitude above 1300 masl produces fruits with good colour and has good shelf life. However, the fruits are small with thick rough skin and are acidic in nature. Therefore, citrus varieties which are cold tolerant are recommended for cultivation in the elevation between 1400 to 1600 masl.

### **(5) Southern Hill low Altitude Region**

Southern low altitude area is below the elevation of 1000 masl. It mostly includes southern foothills. The popular fruits cultivated are mango, banana, litchi, pineapple and other tropical fruits. In low altitude area of the sub-tropical region (southern mid-latitude area and southern low-altitude area), the citrus greening disease has almost wiped out mandarin trees. Therefore, to prevent further spread of the disease, scheduled spraying of insecticide is recommended to reduce the population of Asian citrus psyllid in the fields. In addition, some measures to prevent HLB infection are:



- 1) Increase the number of citrus plantations so that the area of infestation is spread out,
- 2) Produce HLB free seedlings, and
- 3) Maintain sanitation of orchards through proper management activities. In the citrus greening affected areas cultivate lemon and pomelo as they are tolerant.

Other tropical fruits such as avocado, papaya, custard apple, dragon fruits and guava can be recommended for cultivation.

### 3. Eight fundamental knowledge for fruit cultivation

Establishment of an orchard is a long-term investment and requires proper planning, selection of suitable location or site, a planting system and planting distance, varieties and nursery plants, and necessary inputs to ensure optimum production. Like any other agricultural production and processing firms, adequate fund, facilities, equipment, technologies and skills are required for the production of quality fruits. Depending upon the investment, desired quality and quantity of produces can be achieved from a fruit orchard. The following are the eight fundamentals of fruit production:

#### (1) Choice of Varieties and Seedlings

There are so many different kinds of fruits, vegetables, cereals and other crops. It is a prerequisite to select a variety depending on your preferences, soil and climate conditions, availability of local materials and seeds/seedlings.

##### a. Selection of varieties

Each fruit cultivar has its own unique characteristics such as early or late maturity; sweet or sour taste; big or small size; round or oval shape; bright colour or dull colour, and so on. Therefore, select fruit varieties which are most suited to your area and climatic conditions as they will give minimal disease problems and optimum yields.

##### b. The number of varieties

The number of varieties to be planted in an orchard is also one of the main considerations. Select varieties of the same kind which ripen at different times for a regular and steady supply of fruits to markets. For instance, if a single variety of plum is planted in an orchard, then there will be difficulties in harvesting and storage since the variety will mature at the same time. Cultivars of peach and plum ripe in the summer and have less shelf life. Therefore, plant several varieties so that some are early, some are mid, and some are late maturing. A citrus fruit harvested in the winter can be stored for a longer period without spoilage. However, it is convenient to manage if varieties with different maturity time are planted in the orchard. It is easier to harvest, store and market.



### c. Provision for cross-pollination

Many varieties of fruit require cross-pollination in order to produce fruits satisfactorily. It is important to understand the types of pollination required for each fruit variety to be fully sure and secure.

| No. of varieties required                     | Fruits   |
|---|--|
| Two varieties or more                         | Kiwi ( <i>female and male</i> ), Japanese pear, plum, pomelo, chestnut, apple, blueberry |
| Depend on varieties but better to plant mixed | Persimmon, peach   |

### d. Types of planting material

A fruit seedling is one or two years old young tree which is either grafted, seedling or raised from cuttings. Berries, fig and some other trees are propagated through cuttings. Generally, improved varieties developed through cross-breeding and selections are weak and less vigour and hence difficult to propagate them through cuttings. Therefore, it is multiplied through grafting. The local mandarins grown in Bhutan are mostly from seedlings but are vigorous and maintain the parental characteristics. It is highly fortunate that the local mandarin can produce true to type seedlings. For this reason, plant seedlings for large orchards where the soil fertility is low. Grafted citrus trees are less vigorous than the seedling trees. Therefore, grafted seedlings are planted in fertile land with good irrigation facility.

### e. Type of rootstock used

Rootstocks play an important role in the propagation of plants. Citrus grafted on Rangpur lime or Rough lemons are vigorous and strong but fruit quality is poor. Citrus grafted on Trifoliate is less vigorous but the fruit quality is optimum. Pomelo, a citrus species, has mono-embryonic seeds which do not inherit the characters of the parents. Therefore, propagate pomelo trees by grafting.

### f. Seedling quality

Nursery seedlings of evergreen trees such as avocado, citrus, loquat and mango are usually raised in poly pots. Moreover, these cultivars have large and thick leaves, thick trunks, and strong and spreading branches and good root systems. Consequently, it is easy to survive. On the other hand, deciduous fruits such as apple, peach, pear and persimmon seedlings are raised in open field nurseries which are then uprooted and distributed with bare roots. Therefore, select the seedlings which have a straight trunk, uniform internodes, the large size of buds, and good/still fibrous roots keeping in wet condition.

## (2) Site selection, Layout and Planting

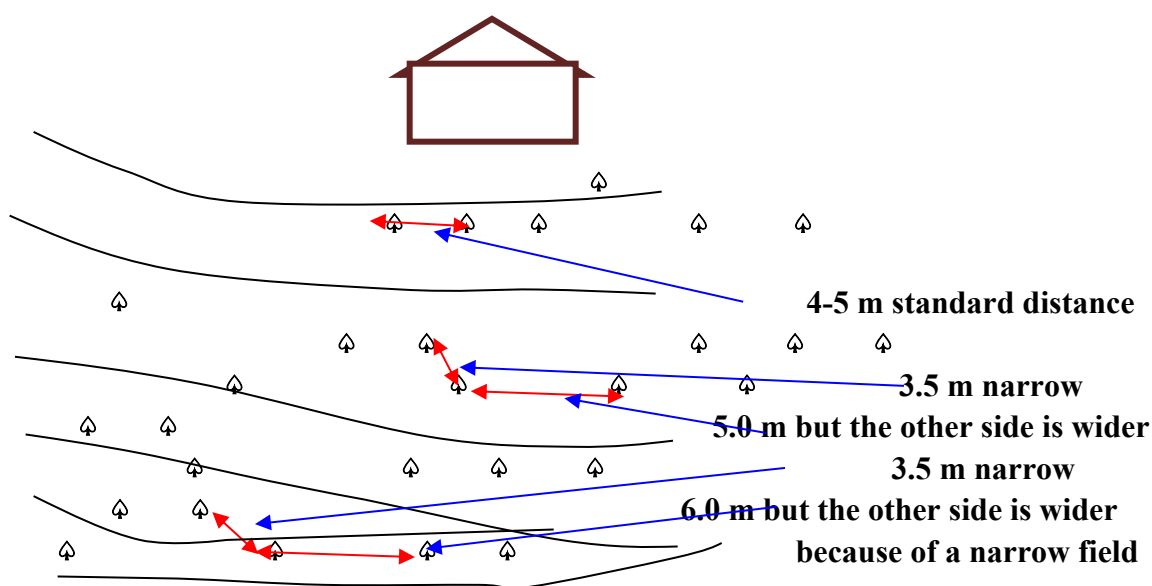
### a. Selection of the site

Fruit plants are the most productive if you carefully match them with proper climatic conditions and planting sites. All fruits require well-drained and fertile soil. Select a site nearby a house that is free from frost pockets, wet spots, frost, hailstorms, and strong

winds but with ample sunlight for optimum fruit production. Do not plant fruit trees nearby tall trees and shaded area in order to avoid pest and disease problems.

### **b. The layout of the orchard and planting distance**

Planting distances in different fruit crops are determined by soil type and fertility, type of fruit trees, tree growth, vigour of rootstocks, rainfall pattern, and a pruning and training system used. In general, plant almost all fruit trees with a spacing of 4.5-5m (average). However, maintain a spacing of 5m x 5m for pear and peaches; a spacing of 4.5m x 5m for grafted persimmon and citrus; and spacing of 6-8m for kiwi, avocado and grapes depending on the topography and soil fertility. In the hilly areas, some farmlands are terraced and most of the terraces are small and narrow. In such cases, plant the tree in the middle of the terrace and adjust the plant distances according to the shape of the terrace. Normally, a high-density planting is practised in Bhutan which leads to crowded canopy within a few years. Avoid high-density planting.



**Figure 1-1. The layout of an orchard**

### **c. Planting**

An ideal field should be well fenced and also have access to irrigation water. Prepare the field at least one month before planting by incorporating well-decomposed compost and farmyard manure (FYM). For ideal growth and development, dig a cylindrical pit of 1x1 metre dimension. Refill the pit with the soil mixed with FYM and compost one month after digging. Prepare a mound of about 30-40 cm above the ground.

Plant deciduous fruit trees during the dormant stage from mid-January to early March. Since evergreen seedlings are mostly raised in poly pots, plant them in May to early June after sprouting of spring shoots. However, it is strongly recommended to plant before spring shoots sprout for faster growth and survival. Moreover, the roots will develop faster and stronger, and the frequency of irrigation can be reduced after one year. For seedlings that are sourced from far off places, roots are mostly stressed and dry. Therefore, soak in a bucket of water for about 3-4 hours before planting such seedlings. While planting, apply Suphala (200-300g) mixed with soil around the roots. Spread out the roots properly to ensure that they are not twisted or crowded. Plant the seedlings at 30 cm above the ground. Do not bury the graft union into the soil.



**Pit preparation**



**Pit filling**



**Mound 30-40 cm  
above the ground**

### **(3) Management after the Plantation (Mulching, Irrigation and Intercrops)**

Irrigate the tree seedlings soon after planting. Provide stakes to the plants at the time of planting to protect from wind damages. Provide mulching with locally available materials such as paddy straw, straw dust, grass clippings, and paddy husks since young plants are subject to considerable dryness from strong sunshine. The rains mostly stop at the end of September when the plants are still in an active growing stage. Therefore, irrigate frequently depending on weather conditions. Timely irrigation is important until the trees are about 2-3 years old. Keep tree basins free from weeds at all times. Top dress the plants with urea (100g) in June. Add manure or compost mixed with Suphala (100g) to each tree basin in the winter up to five years.

For the bearing fruit trees, maintain optimum soil moisture during the critical stages (flowering and fruit development) to get optimum yield and better quality. The start-up topdressing with Suphala (300g) per tree when the rain starts in June. Most soils in Bhutan are deficient in nitrogen (N) and hence requires top-dressing with urea in June for proper growth of the trees. Phosphorous (P) is necessary for flower and fruit development and photosynthesis while potassium (K) is required for root and stem development, and also reduces pest and disease infestations.

### **(4) Pruning, Training and Tree Shaping**

#### **a. Purpose of pruning and training**

Pruning and training are important activities in fruit crops management to have a desirable framework and optimum fruiting points. Un-pruned trees grow very tall and become difficult to manage. Training refers to giving a desired shape to the trees by staking, tying or supporting over a structure and selective pruning for a strong framework. Pruning refers to the removal of certain parts of the trees to maintain high yields, quality fruits, and vigour of the trees or vines.

Pruning helps to get better fruiting and quality fruits. It is one of the most crucial operations which require some scientific knowledge regarding bearing habit of the trees. Commonly, trees are pruned twice in a year – in the winter and summer seasons. Winter pruning is done to remove unwanted branches, improve fruiting wood and regulate the production of floral buds. Generally, temperate fruits are pruned when they are dormant i.e. from September to early March. Evergreen fruit trees are pruned soon after harvest of fruit.

Pruning is an annual management practice for deciduous fruit trees (apple, pear, peach, plum, cherry, walnut, apricot, and grape) and subtropical crops such as pomegranate, lemon, and guava. In evergreen fruit trees such as mango, citrus, loquat, and litchi, pruning is rare and confined to removal of water sprouts and unproductive growth, and opening up of the

trees. The objective of the summer pruning is to remove/stop water shoots, open up tree canopy for aeration and sunlight, and remove dead woods and crisscross branches. Apple trees are pruned in the summer so that fruits will develop colour more satisfactorily. In pear, many water shoots develop some of which need to be removed to prevent shading inner branches. Few years after planting, a tree should be trained to the desired form.

#### **b. Types of tree forms and branches**

There are many training methods in fruit trees based on the growth habit as follows:

- Open Centre (vase shape),
- Central Leader,
- Modified Leader,
- Cordon System,
- Overhead Trellis, and
- Training on Pergola.

***However, the three most commonly used training methods are: open centre, central leader and modified leader***

‘Open Centre’ is commonly used in pear, peach, plum, apricot, persimmon, apple, and citrus. ‘Modified Centre Leader’ system is common in persimmon, apple, loquat, guava, local mandarin, and pomegranate. The framework of a tree contains centre leader (stem), scaffold branches (main branch), secondary branches, fruiting branches, and water shoots.

**Trunk:** It is the main stem or body of the tree. It is the portion of the tree from the soil surface to the first main branch. To keep the plant height short, it is headed back after planting.

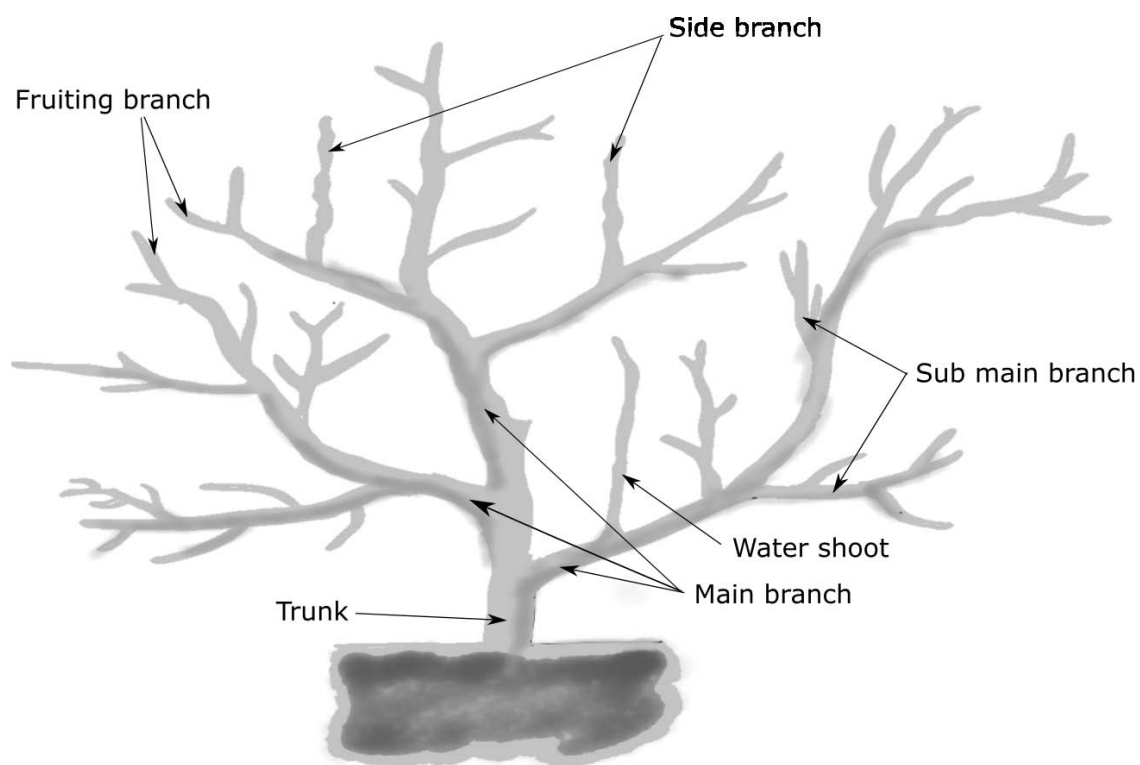
**Scaffold branches:** One of the branches making up the basic framework of the tree. They develop from the trunk and are selected as the main branches. Select 2-3 main branches in the tree. They form the permanent structure.

**Secondary branch:** It develops from a scaffold branch and bears 3-4 branches. It forms a permanent structure of the tree.

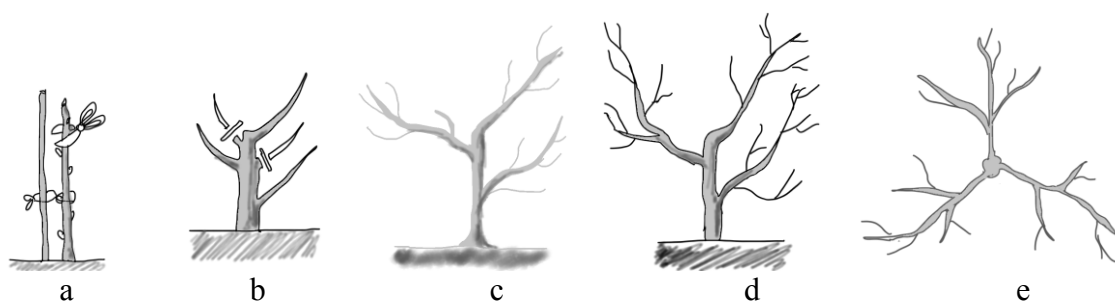
**Tertiary branch (shoot):** A new growth developed in the current season from the secondary branch. It holds fruiting branches.

**Fruiting branch:** It develops from a tertiary branch. It has short to medium length fruiting branches.

**Sucker (Water shoot):** Typically straight up growing shoots arising from a root or larger branches. A water sprout is a sucker growth that generally develops just below a major pruning cut. It is a leafy shoot that does not fruit. It depletes nutrient from the tree. Therefore, it should be removed.



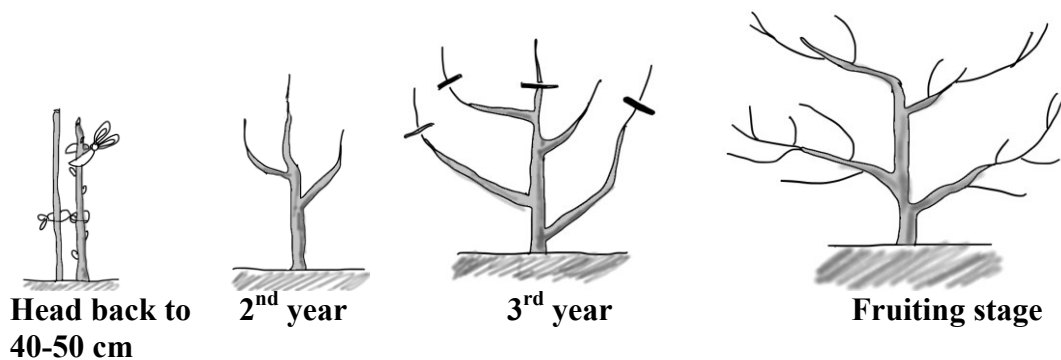
**Figure 1-2. Structure of a tree**



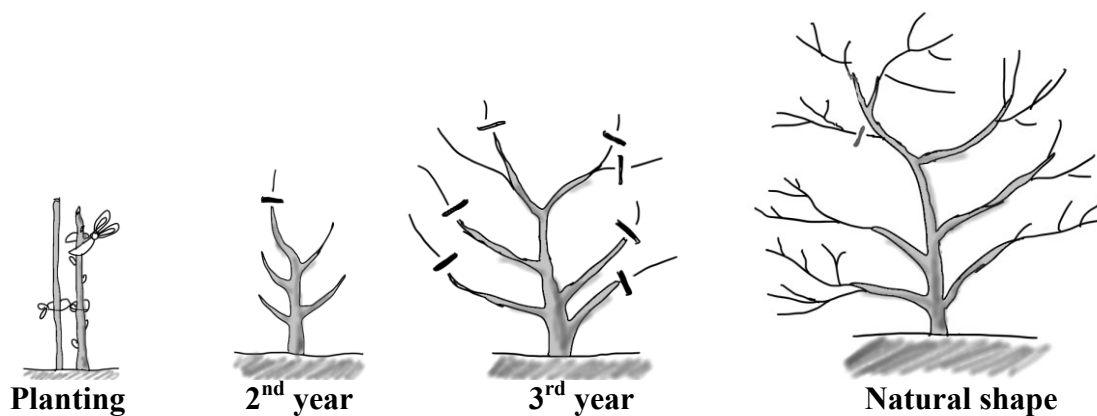
- a) 1<sup>st</sup> year tree headed back to obtain branching at the desired height.
- b) 2<sup>nd</sup> year branched tree pruned to 2 to 3 branches with wide angles.
- c) 3<sup>rd</sup> – 4<sup>th</sup> year tree starts fruiting
- d) A tree with 'Open Centre' system
- e) A tree with the desired distribution of scaffolds (Top view)

**Figure 1-3. Training and pruning for 'Open Centre' system**





**Figure 1-4. Training and pruning for 'Modified Centre Leader' system**



**Figure 1-5. Training and pruning for natural tree shape**

### **c. How to make a tree shape**

There are three most commonly used training methods in the fruit trees based on the growth habit. These are:

#### **Open Centre (Three Branch System)**

In this system of training, the main stem is allowed to grow only up to a certain height after which the leader or main stem is headed back to three lateral branches (scaffold branches). This system allows better distribution of sunshine to the branches of the tree and facilitates cultural operations such as spraying, thinning, and harvesting. The size of the main branch should be half the diameter of the main stem.

The priority of choosing main branches depends on:

1. The direction of spreading,
2. Angles between three main branches,

3. Vigorous of the branches, and
4. The diameter of the branches - should be less than half that of the main trunk.



**Open Centre System (pear)**



**Open Centre System (persimmon)**

#### **Open Centre (Vase System)**

It is same as that of the three-branch system. In this method, only two main branches are selected and trained in 180°. On each branch (scaffold branch), tertiary branches are maintained in alternate directions at uniform distance and angles.

#### **Modified Centre Leader System**

It is intermediate between the open centre and central leader training system. In this system, the main stem is allowed to grow unhampered for the first six or seven years after which it is headed back to four strong lateral branches as in the open centre system. The modified leader system produces fairly strong and moderately spreading trees. Tree heights are maintained at 2.5 - 3 m from the ground.

The open centre method is the easiest to manage among the training methods.



**Modified Centre Leader of  
Avocado**



**Natural Shape of Walnut**

#### **d. Fruiting branch management**

There are two types of flowering: terminal; and lateral. Within each type, flower shoots may be pure terminal or mix terminal, or pure lateral or mix laterally. Many deciduous fruit trees flower and fruit during the leafless period and exhibit wide separation between leafing and flowering such as peach, plum, apricot, loquat, and blueberry. In many evergreen fruit trees and in some deciduous fruit trees flower buds are not visible. Leaf flush and flowering occur at the same time on the same new shoot.

Mixed buds contain both immature leaf structure and flower parts on one bud such as citrus and persimmon. When pruning, take care not to remove the tip of the branch. Kiwi, grapes and fig bear the flowers along the middle of the branches. Apple and pear bear flowers on the tip of the branch (spur). Therefore, short flowering branches are maintained for fruiting.

#### **e. Pruning of vine fruit**

Grapes and kiwi are vigorous, woody, and twining vines or climbing shrubs. Both require strong horizontal trellises which are made with iron angle or wooden or concrete post 1.6 m to 1.8 m high and holding 4-5 wires which are 45 cm apart. Trellises are provided for easy access to manage crop for quality fruits.

#### **Overhead trellis system**

It is mostly used for kiwi and grape cultivars. In this system, vines are trained as a small bush. Allow the vines to grow supported on bamboo posts and then headed back to 1.5 meters to produce laterals. The vines are spread over a criss-cross network of wires which are usually at 1.8 to 2m above ground and supported by concrete or stone pillars or iron angle rod.

Train two lateral branches horizontally on the wires in the opposite direction and allow to grow but thin out the rest. In the next dormant season, cut back these laterals to 2 buds and allow two arms of 20-30 cm each as the secondary arm.



**Fence type trellis system**



**Overhead trellis system**

#### **Short branch pruning (spur pruning)**

The grapes variety Steuben bears most of the fruiting buds near the base of the each cane. On these vines, spur-prune or cut back the old woods to the short spurs for both renewal and fruit production. Train one stem vertically upon a post 1.8 m high and then allow to grow horizontally along the pole or wire up to 1.5 m and head back to encourage the formation of the lateral branches. This forms a nice “Y”. Select two strong shoots growing in opposite directions and train on the central horizontal wire on the post to form the two main arms. During the first dormant season, head back the main arms. As each arm grows in the spring through summer train along the wire. Retain the lateral branches at 1-1.2 m intervals that are produced from the main branch by tying the canes to the trellis wires. In the dormant season, head back the main branches and lateral branches to about 80 cm, cut canes back to 2-4 bud spurs. Remove any sucker and new growths on the plant. Thereafter, prune to renew fruiting canes and to maintain of the vine framework and crop load.

#### **Long shoot cutting method (cane pruning)**

The varieties such as Kyoho and Resamate are the best-suited vines where most fruitful buds are located midway on the canes. On these vines, leave the fairly long canes for fruiting wood and cut short only the wood that is retained for renewal.



#### **f. How to cut branches**

Pruning fruit trees encourages the production of flowers and fruits, triggers tree growth, prevents diseases by allowing better airflow, or simply gives shape to the trees for easy management.

However, improper pruning can invite the risks of diseases and pests. Therefore, you should understand and know how to trim tree branches correctly.

The cutting position of grape canes or spur should be the middle of the two buds. However, other fruit trees should be cut just above the buds, directed to the outside. The last bud direction should be carefully considered for inviting balanced new branches sprouting.

**Branch thinning:** Remove whole branches that overlap and rub against each other to provide aeration and sunlight. Cut an entire branch(es) from the bottom position, not need to leave the remaining parts (no cutback) and the damaged bark parts.

**Cut back pruning:** Cut back method is cutting the middle of branches based on its size and potential for inviting new branches and flower buds. To cut back long branches, bend and cut at the bending area just above the outward-facing bud. In general, the vigorous shoots are cut in keeping long size to force weak flowering branches, and weak branches are cut short to force strong shoots. The last bud retained should face outward.



**Improper pruning cut can initiate pockets of decay**



**Make a cut just outside a branch bark ridge and the tree collar**



**Clean cut with proper callus formation**



**Head back/cut young shoots at the bent point**

#### **(5) Fruit Management**

Fruit thinning is the most important management practice which determines the interannual profitability of any fruit orchard. The fruit thinning is the decreasing numbers of fruits after fruit-setting. It improves fruit yields, fruit quality and prevents alternate bearing habit. In Bhutan, almost all fruits produced are of small size and poor quality since fruit growers do not practise the fruit thinning. As many fruits compete against each other for carbohydrates, they remain small. Excessive fruit-bearing can also lead to alternate bearing - a cycle in

which the tree bears profusely in one year and very little the following year. Apple, pear and stone fruits (*a Prunus fruit whose seed is surrounded by three distinct layers: an exocarp(fruits skin); a fleshy mesocarp (flesh/pulp for eating); and extremely hard stone or endocarp*). The core part has a stable volume in each; therefore, if the size of the fruit is bigger, the flesh/pulp volume becomes bigger and gives more edible part. Hence, fruit thinning is necessary management for increasing the fruit size and quality, and the interannual harvest.

### **Time of fruit thinning**

Usually, fruits are thinned three times depending on the fruit type:

- The first fruit thinning: Do it 2-3 weeks after flowering, those flowers and fruits which are not properly pollinated turned yellow and dropped. Those fruits that are diseased or infested with insects or shapeless need to be thinned.
- The second thinning: Do it two months after the flowering, and natural fruits dropping. Those fruits that grow upward, deformed, damaged and small size are removed.
- The third thinning (final thinning): Remove the fruits carefully which are damaged by insects deformed, small and late grown fruits.

## **(6) How to harvest fruits**

All hard work in fruit production ends with the harvesting of fruits. Harvest the fruits very carefully to get a better market price. There are two types of maturing patterns of fruits, maturing (softening fruits) on the tree and not on the tree. Avocado, banana, kiwi fruits are the typical fruits of maturing after harvest, not on the tree type. However, all fruits need to be harvested at proper timing. If they are harvested before proper ripening, fruit quality becomes poor. Each fruit has its own maturity index.

In Bhutan, generally, almost all vegetables are harvested only when they are fully matured. However, fruits are harvested even before proper maturity. The fruits should be harvested at a comparatively more matured stage for selling in local markets as compared to those meant for selling in distant markets. The fruits should be free from any damage by picking and transportation that affects their quality.

Use proper tools such as harvesting clippers, harvesting baskets with cushions, and ladders to harvest fruits. Use hand picking (move up and harvesting) for stone fruits, pear, apple, guava, and mango (pear and apples need trim of fruits stems after harvest). Use harvesting clippers to harvest persimmon, citrus, grapes, loquat, and kiwi fruits. Use normal pruning scissors for dragon fruits harvesting. Use knives to harvest banana, jackfruit, and pineapple. In case of nuts and passion fruits, pick dropped fruits every day. No management on fruits trees consequences high position of fruiting that invites difficult to use any harvesting tool. As a result of handpicking, physical damage on harvested fruits decrease its market value and difficult in post-harvest handlings.

## **(7) Right ways to use agro-chemicals**

Diseases and pests are often the most important problem in the production of different fruits. They directly or indirectly reduce yields by damaging plants and deteriorating fruit quality. Therefore, control of insect pests and diseases is highly essential to ensure the survival of the fruit trees and healthy development of the fruits. The common control measure is the use of agrochemicals which are hazardous to the environment. But, integrated pest management (IPM) is a sustainable management practice that minimizes economic, health

and environmental risks. The following are some of the IPM measures that can reduce pests and disease incidences:

- In the winter, use tree spray oil (TSO) and Bordeaux mixture against pests and diseases. Spray TSO 2% (20 ml TSO/1 litre water) against scale and mites. Spray Bordeaux mixture 6x6 (6g copper sulphate + 6g quick lime + 1 litre water) against canker and scab. Spray when the initial symptoms or pests are detected for efficient and effective control. Spray the mixture in the morning from 8 am to 12 pm.
- In Bhutan, agrochemicals are sprayed at high dosages. The normal dose should be 0.1% (1ml or 1g/1lt water) to 0.05% (0.5 ml or 0.5g/1lt water). For scale 0.1% and for aphids 0.05% is effective.
- Maintain the orchard sanitation as far as possible to prevent pests and diseases and also to reduce the use of agrochemicals.
- Properly follow the recommended cultivation management practices as hereunder:
  1. Use healthy and strong seedlings,
  2. Plant pest and disease resistant/tolerant varieties,
  3. Prune and train every year for proper aeration and sunshine in a tree canopy,
  4. Carry out bagging of fruits before maturity or ripening, and
  5. Keep out weeds in the orchard.
- Remove dry branches from trees as citrus (melanose), chestnut, pecan nut, and grapes harbour pests and diseases.
- Bury all dropped leaves infested with pests and diseases in the soil.
- Do not keep pruned branches in the field.
- Keep the orchard soils fertile by incorporating manures and composts.
- Mulch every tree to keep the soil moist. Mulching also prevents splashing of soils on to the leaves and tree trunk during rain and irrigation.
- Remove scales/loose barks from the tree trunk and branches by brush and hard grass broom.
- Remove mites by using a water shower.
- Seal trunk borer holes after a thorough cleaning. Remove old barks from the trunk.
- Irrigate the orchard at the critical stages.

## **(8) Intercropping**

Fruit trees take many years to bear fruits. Therefore, farmers must use interspaces to grow short-duration crops such as vegetables. The most common intercrops are onion, tomato, radish, carrot, ginger, turmeric, cauliflower, cabbage, and so on. With the government's strong promotional program in horticulture, the farmers have developed mixed fruit orchards of pear, peach, plum and persimmon. Under these fruit trees, a variety of winter vegetables such as cabbage, cauliflower, broccoli, radish, sag, turnip, peas and carrot, and summer vegetables such as beans, ginger, garlic, taro, eggplant, and beans can be planted. However, do not grow seasonal crops such as maize and millet which grow tall. In addition, do not plant crops such as pumpkin, cucumber, bitter gourd, slipper gourd and so on. Add enough compost and manure in the intercrops. While watering the vegetable crops, the fruit trees are irrigated too.



## 4. Temperate fruits

### (1) Pear

There are many types of pears which are commonly known as European and Asian pears (*Pyrus serotina* L.). In Bhutan, pear production is suitable in cool places such as Paro and Thimphu. Pear fruits can be stored and consumed after softening (European) and in fresh (Asian). After the inception of Japanese assisted projects in the country, Japanese pears were introduced into Western Bhutan and thereafter the cultivation gradually picked up in Eastern and West Central regions. Two types of Japanese pear were introduced: red type; and green type. Hosui, Kosui, Chojuro and Shinko varieties are red type whereas Kekusui, Yakumo and Nejiseiki varieties are green type.

Japanese pears are categorized into four groups as follows:

- 1) Early variety (Kosui & Yakumo),
- 2) Mid-variety (Meigetsu, Hosui, Nijisseiki & Wengkhar Lee I),
- 3) Late variety (Niitaka & Shinko), and
- 4) Very Late variety (Okusankichi, Atago).

The qualities of Japanese pears are superior to the indigenous pears and can bring economic benefits to rural people. Most Japanese pears are cross-pollinated and require other varieties for pollination. Select compatible varieties which bloom at the same time for optimum fruit production. Although Japanese pear varieties can be grown in relatively hot and humid climates, the ideal zone for pear cultivation is above 1700 masl. The Japanese pear varieties which are grown in the highlands of southern Bhutan are found susceptible to diseases and pests. These areas usually receive high precipitation and less sunshine.

#### **Characteristics of variety (Altitude 1,700 m as reference)**

The Japanese pear varieties (Hosui and Kosui) were released in 2002 for commercial cultivation in Bhutan. Since then four more varieties were released (Bajo Lee 1, Zhey Lee, Wengkhar Lee 1 and Shinko) for commercial cultivation. In addition, there are other Japanese varieties such as Niitaka, Yakumo, Nijusseiki, Atago, Okusankichi and Meigetsu which are under evaluation.

**Kosui:** The trees grow upright and tall which make the management of the tree canopy difficult. It is a red type pear which produces small fruits with soft pulp. Each fruit weighs about 225 g. The fruit juice is sweet with TSS of 11.7%. It is an early maturing variety which is harvested from the end of July to early August.

**Hosui:** The trees grow upright and tall which make the management of the tree canopy difficult. It is also a red type pear which produces medium-size fruits with soft pulp. Each fruit weighs about 340 g. The fruit juice is sweet with TSS of 12.3%. The fruits are harvested a few days later than Kosui in early August.

**Chojuro:** The trees have a slightly spreading habit. It is a red type pear which produces medium-size fruits with hard pulp (pulp hardness is 1.93 unit). Each fruit weighs about 330 g. The fruit juice is sweet and has high TSS content. Fruits are harvested in the middle of August. It is also planted as pollinizer trees in orchards.

**Shinko:** The trees are spreading in nature and fruits every year. It is a red type pear which produces large-size fruits with soft pulp. Each fruit weighs about 425 g. The fruit juice has low TSS content. The fruits are harvested towards the end of August. The flower produces abundant pollens and is therefore preferred as pollinizers.

**Niitaka:** The trees are spreading in nature. It is a red type pear which produces large fruits with soft pulp. Each fruit weighs about 600 g. The fruit juice is sweet with TSS of 12.4%. The fruits are harvested in the middle of September. The flowers are weak in self-pollination and require pollinizers.

**Yakumo:** The trees are dwarf to some extent. It is a green type pear which produces small fruit with hard pulp. Each fruit weighs about 240 g. The fruit juice is sweet with high TSS content. The fruits are harvested in the first week of August. The flowers produce sufficient pollens and are used as early variety pollinizer.

**Meigetsu:** The trees are vigorous in growth habit. It gives good fruits with hard pulp and each fruit weighs about 450 g. It is suitable for places with the elevation of 1,800 masl and more. The fruits are harvested in mid-September.



**Kosui**



**Hosui**



**Chojuro**



**Shinko**



**Niitaka**



**Yakumo**

## **Planting**

*Field preparation:* Prepare the field at least one month, preferably in December, before planting. Incorporate well-decomposed farmyard manure during the field preparation.

*Planting space:* 5mx5m or 5mx6m.

*Pit size:* 1m<sup>3</sup> or 1 m deep with 1m diameter

*Soil mound preparation:* Fill the pit first with the topsoil followed by the sub-soil mixed with FYP and prepare a soil mound of at least 30 cm high from the ground.

*Planting time:* January, February and early March.

*Soaking of Seedlings:* Soak seedlings in water for 3-4 hours before planting if the roots are dry

*Planting:* Plant the seedling in the soil mound and not in the pit. Never ever bury the graft union of the plant, if any, in the soil.

*Mulching:* Mulch with locally available materials such as straws, grasses, stubbles, leaf litters, and sawdust.

*Staking:* Stake up plants to prevent from lodging.

*Heading back:* Cut the seedling at about 40-50cm from the ground.

*Nutrient application:* Apply 100g of urea to young trees and 200-300g Suphala to older trees (>7 years).

*Irrigation:* Irrigate with plenty of water right after planting

### **Pruning, Training and Tree shape**

#### ***Open Centre System***

Train Asian pears to ‘vase-shaped’ or ‘open centre system’. Initiate by heading back saplings to about 40-50cm high from the ground right after the planting. Select 2-3 main branches and remove others. Head back these selected branches by about 1/3 (each branch should be 30-60 cm long) depending on the length of the new growth.

In the third year, remove vertical, crossing and downward growing shoots. Thin out 10-20% of the previous year’s growth to open up the tree for sunlight and air. Once the trees start to produce fruits, the branches should be allowed to elongate about 45 cm per year and then they are headed back in the dormant season. Tiers of the branches should be well-spaced, spirally arranged with crotch angle of 45°.

If trees are growing excessively, then pull the branches to encourage fruit spur development. In general, maintain the height of the trees to about 3 meters so that you can harvest all the fruits by using a chair (stool). Avoid exposure of the branches to direct sunlight by retaining few shading branches within the tree canopy.



**One year old tree. Remove shoots from rootstock (Before head back)**



**Heading back to 40-50 cm from ground, Staking and tying (After head back)**



**Training of 3 main branches in 2<sup>nd</sup> year (Before training)**



**Main branches trained on bamboo post (After training)**





**Prune fruit branches in 3<sup>rd</sup> year at man's height (Before pruning)**



**Trained and pruned tree in 3<sup>rd</sup> year (After pruning)**



**Training for open centre system in 5<sup>th</sup> year**



**Ideal shape and blooming in 5<sup>th</sup> year**

### **Blooming and pollination**

Japanese pears flower in March and April in mid-altitude areas. Although pears are self-pollinated in nature, plant two or more cultivars together for effective pollination. Poor pollination results in a high rate of fruit drop. Cross incompatibility is also observed in some varieties. Therefore, plant those varieties together that bloom at the same time. Bees are mostly responsible for the pollination of the flowers. Irrigation during bloom period helps in increasing flower size.

### **Fruit Management and Thinning**

Pear has clustered flowers which develop into many fruits in the same position. Keep just one fruit from a cluster. Do the first fruit thinning after the first natural fruit drop at the end of April (marble size). Remove the fruits with short stalks but retain the fruits with long stalks. Also, remove small and injured fruits and retain big-sized fruits.

Do the second fruit thinning when the fruits reach the size of a ping-pong ball (1<sup>st</sup> week to 2<sup>nd</sup> week of June). Remove the small, injured and crowded fruits but retain only big-sized fruits. Maintain an ideal ratio of 30 leaves per fruit for development of good fruits.

Do the third and final fruit thinning in the first week of July. Remove diseased, shapeless and weak fruits. Maintain a fruit to fruit distance of 20 cm. After the third thinning, protect the fruits from birds, hornet bees and other pests by covering with paper bags (using old newspaper). Bagging of the fruits helps in producing clean fruits.



**4 - 6 fruits in a bunch**



**Retained one fruit per bunch**

### **Harvest**

Harvest the fruits when skin colour changes from green to yellowish-green or russet brown or light red depending on the varieties. Handpick the fruits by giving 'a twist rather than pulling'. While harvesting fruits with hand, hold the fruit in the palm, raise it slightly up and twist it. If the fruit is easily twisted off from the branch it is ready for harvest (over mature). While picking, take care not to bruise or injure the fruits since Asian pears are susceptible to bruising and discolouration. Keep note of different harvesting periods for different varieties of pears. Asian pears are non-climacteric in nature and mature on the trees. Take all possible care to minimize post-harvest losses.

### **Nutrient Management**

Application of fertilizers is essential in the fruit cultivation. Plants absorb water and nutrients from the soil through root hairs which are found about 15 cm away from the main trunk of the tree in the soil. Hence, always apply fertilizers and water little away from the main trunk and within the radius of tree canopy. The plants get injuries when they come in contact with chemical fertilizers.

- Apply 30-40 kg compost or FYM sometimes in January or February,
- Apply a mixture of chemical fertilizers at the emergence of new shoots and 2-3 weeks before flowering, and
- Apply the second dose of urea (100g) in June when the rainy season begins.

For young trees, apply 200-300g NPK mixed with farmyard manure to encourage growth.

### **Plant protection**

Under Bajo conditions, there is no serious incidence of pests and diseases except some depredation by aphids, thrips, birds, rodents, hornet bees and wasps. Leaf spot is common in the pear. Control the leaf spot by removing the infected branches and burning them. Protect the fruits from the hornets and wasps by bagging them with old newspapers and if possible by netting the orchard.

Spray winter oils on plant and apply Bordeaux paste on the trunk above the ground level.



**Damages by hornet**



**Potassium Deficiency**



**Adult fruit fly**



## (2) Persimmon

The persimmon (*Diospyros kaki* D) belongs to Ebenaceae family and genus *Diospyros*. The three fruit-bearing species of the genus are oriental or Japanese persimmon (*Diospyros kaki*); American persimmon (*Diospyros virginiana*); and, date plum (*Diospyros lotus*). Broadly, persimmon can be categorized into two groups:

- a) **Astringent type:** The fruits can be consumed only when it is fully ripened, and
- b) **Non-astringent type:** The fruits can be consumed like apples without the need for fruits to attain full maturity.

Non-astringent types are mostly of Japanese origin or bred in Japan. They tend to turn astringent when the mean average temperature drops due to reduction of solar radiation by fog during the rainy season. In Bhutan, sweet persimmon can be grown in higher places such as Paro and Thimphu where day temperature is high and less foggy.

Persimmon can be cultivated in areas with an altitude range of 1400-1600 masl. However, due to low-temperature, flesh tends to ripen before the pericarp changes its colour and thus the fruits are of inferior quality. Hence, it is recommended to cultivate sweet persimmon from elevations of 1600 masl to 2200 masl.

Grow non-astringent plants from grafted seedlings to retain true to type traits as plants raised from non-astringent fruit seeds will turn astringent. The plant has both male and female flowers but some varieties need pollinizer trees. Astringent cultivars in Bhutan are self-pollinated in nature. However, improved cultivars do not have male flower and therefore requires pollinizer trees.

### **Characteristics of variety (Altitude 1,700 m as reference)**

The commercial varieties of non-astringent types were released in 2004. The commercial varieties available in Bhutan are Fuyu, Jiro, and Wengkhari Anday I. Zenjamaru is often used as the pollinizer.

**Thimphu local:** Trees are strong and vigorous in nature. It is an astringent variety which produces a large fruit weighing about 350 g. It is good for preparing dried persimmon since it develops strong sweetness after drying. The tree is also used as pollinizer with other varieties.

**Fuyu:** It is a non-astringent type and produces fruits smaller than Thimphu local. Each fruit weighs about 250 g. The fruit is oblate with hard pulp and deep orange skin when ripen. It is very sweet with TSS of 18.3%. It is harvested in mid-November.

**Jiro:** It is also a non-astringent type and produces larger fruit with each fruit weighing about 350 g. The fruit resembles Fuyu variety and has dense and sweet flesh with TSS of 18.9%. The fruits have dark orange pericarp and are harvested in the second fortnight of October.

**Yubeni:** It is also a non-astringent type. The fruit is more oblate than Fuyu and weighs about 265 g. The flesh is hard in texture with TSS of 18.6%. The fruit has red-orange pericarp which is harvested in early November.

**Zenjamaru:** It comes in round or round oblate shape. The fruits are small with each weighing about 180 g. It has dark orange-red or yellow-red pericarp. The flesh has black

streaks and is very sweet with high TSS of 23.9%. It is also grown as the pollinizer along with other varieties.

**Nakahara:** It is an astringent type but has the potential for turning to non-astringent type in places where the temperature is high. Use alcohol to remove astringency in the persimmon. It produces large fruit with each weighing about 350 g. It is also suitable for making dried persimmon products. It is also used as the pollinizer.



**Fuyu**



**Jiro**



**Yubeni**



**Zenjimaruru**

### **Planting**

*Field preparation:* Prepare the field at least one month before the planting preferably in December. Incorporate well-decomposed farmyard manure into the soil during the field preparation.

*Planting space:* 5mx5m.

*Pit size:* 1m<sup>3</sup> or 1m deep with 1m diameter

*Soil mound preparation:* Fill the pit first with the topsoil followed by the sub-soil mixed with FYM and prepare a soil mound of at least 30 cm high from the ground.

*Planting time:* January and February.

*Planting:* Plant the seedling in the soil mound and not in the pit. Never ever bury the graft union of the plant, if any, in the soil.

*Mulching:* Mulch with locally available materials such as straws, grasses, stubbles, leaf litters, and saw dust.

*Staking:* Stake up plants to bamboo or wooden poles to prevent lodging.

*Heading back:* Cut back the seedling at about 30 cm from the ground.

*Nutrient application:* Apply 100g of urea to young trees and 200-300g Suphala to older trees (>7 years).

*Irrigation:* Irrigate with plenty of water right after the planting

## **Pruning, Training and Tree shape**

Persimmon trees are pruned to encourage a strong modified central leader and open centre with the main branches at about 50-60 cm intervals on the trunk. Prune the trees from late December to February. Do the first pruning one year after the planting. If there is no branching within 50 cm from the ground, cut the single stem at that height. If the central leader is not the highest point, prune the branches to make that it is. Prune the central leader at about 70 cm to encourage branching at that height over the next two to three years. Head back the long lateral branches depending on the growth. Prune out excessive and unwanted growths. Always ensure that the basic shape of the tree is developed without branches crowding one over another.

Train persimmon trees in winter using bamboos poles, straight wooden poles or sticks staked criss-cross to maintain crotch angle of 45° (angle between the branch and the trunk) and to form a low head by heading back at 50 cm from the ground at the time of planting. This system of training is called a modified central leader.

Persimmon trees grow quite high. Select 2-3 main branches for open centre system from the main trunk. After 3-4 years, cut 1/3 of the branches. Remove crisscross branches. Prune and train the trees till the fifth year. After the fifth year, prune the trees to ensure continual fruit production. The parallel branches and branches growing from one point (keeping 1-2) are removed. Prune the past season fruiting branches short to encourage more fruiting shoots.



**Ideal shape at younger age**



**Open centre system at fruiting stage**

## **Blooming and Pollination**

Flowers are produced on new growths on one-year-old shoots in the spring. The flowering buds are found in the few bottom leaf axils of the new growths. Many persimmon varieties are self-fertile in nature. However, plant two or more varieties together for proper pollination, optimum yield, and good fruit shape. In Bhutan persimmon flowers in mid-April when the temperature starts to rise and bees' activities are high.

## **Fruit Management and Thinning**

*The numbers of fruit thinning:* Do two times fruit thinning to produce quality fruit and avoid the biennial bearing habit.

*First fruit thinning:* Do the first fruit thinning in mid-June after the first natural fruit drop.

*Purpose:* It reduces the number of fruit clusters borne on a branch.

*Fruits for removal:* Remove fruits that are weak, injured, growing upwards and with fewer leaves on a branch.

*Second fruit thinning:* Do the second fruit thinning in early July.

*Purpose:* To remove the fruits which are closer to the base of the shoots as they are most likely to fall down. Keep only one to two healthy fruits per laterals (long laterals carry two to three fruits).

*Fruits for removal:* Remove fruits that are misshaped, diseased, crowded and weak.

*Ideal leaf fruit ratio:* Maintain an ideal ratio of 25-30 leaves per fruit for development of good fruit size.

*Tools for fruit thinning:* Use secateurs for fruit thinning.

### **Harvest**

*Expected yield:* The fruit production capacity depends on the age of trees.

*Harvest time:* Harvest persimmon from mid-October to late November. Harvest the matured fruits as soon as possible to avoid attacks from birds and bees.

*Maturity indicators:* Pericarp turn orange to reddish in colour.

*How to harvest:* Clip the fruit from the tree with calyx attached to the fruits with short a stem.

*Care during harvesting:* Avoid bruising the fruit while harvesting.

*Care after harvesting:* Do not store the harvested fruits too long as the pulp softens and the fruit ripens very fast.

*Marketing:* Market the harvested fruits as soon as possible.

### **Nutrient management**

Fertilizer application is very important in the fruit cultivation. Trees absorb water and nutrients from the soil by the root hairs which are found about 15 cm away from the main trunk of the tree. Hence, always apply fertilizers and water little away from the main trunk and within the canopy. Fertilizers when in contact with the trunk may cause injury to the plants. Apply 30-40 kg compost or FYM in January or February followed by a split application of a mixture of chemical fertilizers 2-3 weeks before flowering and when new shoots emerge. Apply the second dose of urea (100g) in June when the rainy season begins.

### **Plant protection**

Under Bajo as well as Wengkhar conditions, there are no serious incidences of pests and diseases except fruit depredation by birds, rodents, fruit fly and wasps. Bag the fruits using old newspapers and if possible cover with nets the whole orchard to protect against the birds. Apply 0.1% Malathion or Cypermethrin (1ml/litre of water) to protect new shoots from the attack by larvae (oyster cigar). To control fruit fly, spray insecticide when fruits are small (marble size).



**Damage and larvae of oyster cigar [moth]**

### **How to making dry persimmon**

There are many types of persimmon in Bhutan. Astringent persimmon can be dried because of high sugar content. Immature fruits are hard but can be easily peeled off and also dry faster than the ripened ones. In Bhutanese tradition, persimmon fruits are sliced and dried in



an open area. In the traditional Japanese method, whole fruits are peeled and hung using strings until they shrivel and form natural sugar coating on the surface.

### ***Points to keep in mind when drying persimmon***

Persimmons are harvested from October to November and subsequently dried when the day temperature is high. If it rains during the drying process, there are chances of mould formation. Deep the whole peeled fruits in boiling water for few seconds to sterilize them. This helps to prevent mould formation during the drying process. If the mould develops during the drying process, sterilize again with hot water and dry again.

Most of the astringent persimmons in Bhutan are of the round type which has loose calyx attached to the stalk. It is not fit for drying by tying strings as the calyx region is weak. In Japan, the people prefer a variety called *Hachiyas* (astringent) to prepare dried persimmon. The fruits of this variety are long and pointed in shape. Unripe fruits are firm but as they ripen the flesh becomes gelatinous. Thimphu local and Nakahara variety can be used in Bhutan to prepare dried persimmon.

### ***Method of drying persimmon***

1. Harvest the fruits from the tree leaving the stalks attached to the fruits for hanging purpose. Discard damaged fruits and fruits with points of damages through which water might enter and later lead to mould formation. The pointed fruits are preferred for drying purpose.



**Stalk kept for hanging purpose**



**Damaged fruits not used for drying**

2. Peel the fruit leaving a short stem and ring of calyx intact. Tie the string (30-40 cm) at the end of the stem and dip the peeled fruits in boiling water for few seconds for sterilization.



**Peeled fruit with intact ring of calyx**



**Sterilize using hot water**

3. After sterilization, hang the fruits evenly spaced in a warm area with plenty of dry air circulation so that they do not get mould infection. Two fruits can be hanged on one string on a pole. Do not let the fruits touch each other to avoid sticking to each other.
4. Keeping the fruit under the direct sun may speed up the process but fruit needs to be massaged after every 3-4 days.
  - Start massaging when fruits become hard after drying.
  - Massaging helps to get rid of excess water and to make fruit soft with proper shape. After hanging for a few days, the persimmon fruit forms a skin and massaging helps to soften the inner hard pulp.
  - Massage each fruit with the tips of your fingers until the pulp softens up.
  - Be careful not to break the skin and make the fruit susceptible to mould infection. If mould develops after drying, brush it off with soft brush.
  - At least give two massages in a round.
  - The white powder that looks like mould is sugar in the fruit that has risen to the surface.



**Drying of persimmon**



**Massaging of fruits**

5) After the drying procedure is completed, remove the stems on the stalk of fruit to disconnect the strings. It is usually packed in rice straw and stored indoor in cool place or refrigerator. It can be preserved for several months.



**Stalk removed to disconnect string**



**Store in rice straw**

### (3) Peach

Most peaches are self-fruitful in nature but some varieties require pollinizer trees for proper fruit setting. Thus, plant enough pollinizers to make the main cultivar fruitful. Choose varieties suited to your area and its climatic conditions as they will have minimal disease problem and optimum yield. Peach has cold resistance and is suitable for elevations from 1,600 masl to 2,300 masl where there are less rainfall and mild velocity winds.

Peach grows quickly at first and then grows steadily from the third year after planting. However, after 20 years the tree exhibits dead branches and declines in fruit yield. Therefore, it is necessary to replant with young plants for better yield. Under Bajo condition, peach cultivation is not feasible due to high temperature. However, few varieties are maintained as the source of scion woods.

#### **Characteristics of Varieties (altitude 1,700 m as reference)**

**Beauty Cream:** The fruit has high juice content with strong sweetness and reddish-white pulp. Single fruit weight is about 200g. The fruits are harvested when the skin turns red around mid-June.

**Kuratake:** The fruit is slightly smaller than Beauty Cream and weighs about 120g. The fruit has red skin with reddish-white flesh and is harvested in early June.

**Ngawang:** It is a late variety which is harvested in early July. The flesh quality is coarse and hard. The fruit weighs about 130g.

**Florida Sun:** It is an early variety which is harvested around mid-May. The fruits are slightly smaller than other varieties. It has yellow-orange pulp with high acidity and somewhat red peel. The fruit weighs about 70g. This cultivar is recommended for elevations above 1,400 masl and is good for fruit processing.



**Florida Sun**



**Kuratake**



**Beauty Cream**

#### **Planting**

*Field preparation:* Prepare the field at least one month before the planting preferably in December. Incorporate well-decomposed farmyard manure into the soil during the field preparation.

*Planting space:* 4.5x4.5m, 5x5m, 5.5x5m.

*Pit size:* 1m<sup>3</sup> or 1m deep with 1m diameter

*Soil mound preparation:* Fill the pit first with the topsoil followed by the sub-soil mixed with FYP. Prepare a soil mound of at least 30 cm high.

*Planting time:* Complete planting within January.

*Planting:* Plant the seedling in the soil mound and not in the pit. Never ever bury the graft union of the plant, if any, in the soil.

*Mulching:* Mulch with locally available materials such as straws, grasses, stubbles, leaf litter, and sawdust.

*Staking:* Stake up plants using bamboo or wooden sticks to prevent lodging.

*Heading back:* Cut back the seedling at about 30-40cm from the ground

*Irrigation:* Irrigate with plenty of water right after planting

### **Training and Pruning**

*Time of pruning and training:* The peach trees are pruned and trained annually from December to mid- January.

*Tree training system:* Train the tree to open centre system. Continue to train on this system till the third year. Train and prune regularly after the third year.

*How to prune and train:* Head back the seedling to 30-40 cm right after the planting. Cut back to half those limbs arising below the heading back cut to promote the development of strong scaffolds. Thin out the wide-angled ( $>45^{\circ}$ ) scaffolds and keep only 2 or 3 main branches to open the plant as an open centre system.

*Reasons for pruning:* Good sunshine is necessary for tree canopy in peach.

*Things required for training:* Use bamboo poles to train the main branches.

*Flowering branches and fruit quality:* After three years, the tree starts to fruit. The quality of fruits differs as follows:

- The fruits from 10-15 cm long flowering branch are not good,
- The fruits from 20-40 cm long flowering branches are good and big in size, and
- The fruits from the flowering branches longer than 40cm are better in quality.

*Maintenance pruning:*

- Remove any limb growing below the lowest main branches from the ground.
- From the second to fourth year, remove any branch that grows straight up through or towards the centre of the tree.
- Prune lightly to remove overlapping and damaged limbs.
- Maintain bearing tree height at 3-4 meters by heading back scaffold branches to an outward growing lateral.
- Remove weak branches as well as those that grow upward, through or across the centre of the tree or downward.
- Thin out remaining vigorous branches to prevent crowding. The flower buds are borne on middle fruit branches (20-40cm) or along with the terminal shoots of the main branch (40cm or more) and on short branches (10-15cm).
- Remove dry and short fruiting branch by keeping 1-3 years old branches as fruiting branches. If branches are too long head back to  $1/3^{\text{rd}}$  its length.

### **Blooming and pollination**

Peach flowers are borne in the leaf axil on the shoots of the previous season's growth. All peach cultivars are self-fertile except few which require other cultivars for pollination. Plant cross-pollinating cultivars mixed with other cultivars. Time of flower bud initiation is from January to February and extends up to the first week of March. Under Bajo conditions, Florida Sun and Ngawang varieties are self-fruitful whereas Beauty Cream produces fewer fruits due to lack of pollen. Therefore, it needs other varieties as pollinizers that match its flowering time.

Honey bees in the orchard during the blooming period provide greater assurance for cross-pollination during adverse weather conditions.

### **Fruit management and thinning**

*Times of fruit thinning:* Two times fruits thinning is done to produce quality fruit.

*First fruit thinning:* Do the first fruit thinning 3-4 weeks after flowering.



*Fruits for removal:* Remove the fruits that are small, growing upwards, off shaped, and injured. Keep the fruits which grow from below and sides of the branch.

*Second fruit thinning:* Do the second fruit thinning when the fruits reach the size of local avocado seeds.

*Branches to retain:* Maintain about one (1) short branch, 1-2 medium branches and 2-3 long branches in a plant

*Fruit to fruit distance:* Keep about 20 cm distance between two adjacent fruits.

*Bagging:* Bag the fruits with old newspapers or magazine to produce quality fruits.

*Ideal leaf fruit ratio:* Maintain an ideal ratio of 20 leaves per fruit for development of good fruit size.

*Tools for fruit thinning:* Use secateurs to thin the fruits.

### **Harvest**

Harvest the fruits when the fruit colour starts to change from green to whitish-yellow and fragrance of peach is sensed. Peach becomes soft as it ripens. Therefore, harvest carefully by holding the fruit with the whole palm and pluck. Since natural colouration is not possible in bagged fruits, it is advised to remove the paper bags one week before the harvest to develop natural colour. Peach fruit starts colouration from the top and slowly progress toward the base of the fruit.

### **Nutrient management**

Apply compost or FYM mixed with chemical fertilizer in January and February. Apply 100 g of urea after harvest in July to replenish tree energy for next season flowering and fruiting.

### **Plant protection**

After flowering, the leaves and new shoots develop. Aphids usually attack new foliage which causes leaf curl and leaf thickening. The fruit deforms and does not develop well. Control the aphids by spraying 0.05% (0.5ml/litre of water) Dimethoate or Cypermethrin or Malathion.



### **Damage caused by aphids and leaf curling**

(The same symptoms of Peach leaf blight caused by bacteria)

#### (4) Plum and Apricot

Plum, apricot (*Prunus armeniaca*), peach, nectarines and cherry are called stone fruits. The Japanese plum and apricot varieties are less hardy and are best suited to cultivate in warm temperate regions. Both are fast-growing, have round to spreading canopy, winter hardy, drought-resistant, and are deciduous.

In Bhutan, Newcastle (apricot), Honey Rosa (plum) and Soldum (plum) can be cultivated in warm temperate regions at elevations of 1400 masl to 1600 masl. Plum varieties such as Oishiwase, Santa Rosa and Kiyo can be cultivated at elevations slightly above 1700 masl. Although Newcastle variety can bloom and fruit at a relatively low elevation below 1400 masl, it is more suitable at an elevation above 1500 masl for better quality fruits.

Peach, plum and apricot mature at the same time leading to harvesting, marketing and storage problems. Therefore, plant varieties that have different harvesting period. Although plum is self-fruitful in nature, some varieties require pollinizers. Plum flower can also be pollinated by flowers of peach and apricot.

##### **Characteristics of the plum variety (altitude 1,650 masl as reference)**

**Honey Rosa:** The fruit is small which weighs about 35 g and has a sweet taste with TSS of 17.0%. It has a red peel and reddish cream flesh with low acid content. It can be cultivated in warm regions for quality fruits every year. The fruits are harvested by early June.

**Soldum:** The fruit is medium in size and weighs about 85 g. It has a sweet taste with TSS of 13.3%. It has a greenish-red peel but the pulp turns dark red and sweetness increases when it ripens. It is good for making jam owing to its beautiful colour. It needs pollinizers as it is not self-fruitful. The fruits are harvested by mid-June.

**Ohishiwase:** The fruit is medium in size and weighs about 90 g. It has a sweet taste with TSS of 12.5%. It has an orange-red peel and yellowish creamy flesh when ripen. It can be cultivated above 1800 masl and requires pollinizer. The fruits are harvested by mid-June.

**Kiyo:** The trees are strong and vigorous in growth with a large fruit which weighs about 120 g. It has an orange-red peel, yellowish-red flesh and hard pulp when it ripens. It is a late maturing variety and is harvested from early July to mid-July.

**Santa Rosa:** The fruit is medium in size which weighs about 80 g. The fruit is juicy and sweet having TSS of 12.5% with soft and yellowish creamy flesh. The variety is self-fruitful and is suitable to cultivate above 1800 masl. The fruits are harvested by mid-July.

**Newcastle (Apricot):** It is suitable to cultivate at higher altitude. The fruit is small which weighs about 20 g. It has a sweet taste. It has yellowish-orange peel and pulp.



**Ohishi wase**



**Kiyo**



**Soldum**



**Honey Rosa**



**New Castle**

### **Planting**

*Field preparation:* Prepare the field at least one month before the planting preferably in December. Incorporate well-decomposed farmyard manure during the field preparation. The area should have good drainage and receive good sunshine.

*Planting space:* 5mx5m, 5mx6m depending on soil type, climate, and variety.

*Pit size:* 1m<sup>3</sup> or 1m deep with 1m diameter

*Soil mound preparation:* Fill the pit first with the topsoil followed by the sub-soil mixed with FYP. Prepare a soil mound of at least 30 cm high from the ground.

*Type of seedling:* If grafted seedlings are not available, plant local peach seedlings as rootstocks then top-work after two to three years.

*Planting time:* Complete planting within January.

*Planting:* Plant the seedling in the soil mound and not in the pit. Prepare the seedling single trunk cutback about 40cm above the ground. Never ever bury the graft union of the plant, if any, in the soil.

*Mulching:* Mulch with locally available materials such as straws, grasses, stubbles, leaf litters, and sawdust.

*Staking:* Stake up plants to prevent lodging.

*Heading back:* Cut back the seedling at about 40cm from the ground. Remove side branches to reduce the seedling to a single stem.

*Irrigation:* Irrigate with plenty of water right after planting and continue until the rainy season.

### **Training and pruning**



**Ideal plum tree shape**



**Open centre system in Honey Rosa**

*Time of pruning and training:* Prune and train plums in January. Train plum varieties such as Honey Rosa, Oishi wase and Santa Rosa as they have the upright growing habit.

*Tree training system:* Plum tree is trained to an open centre system. This should be continued until the third year of planting and then follow regular training and pruning.

*How to prune and train:* Head back vigorous new shoots to half its size to maintain tree shape.

*Reasons for pruning:* Good sunshine is necessary for tree canopy in plum.

*Things required for training:* Use bamboo poles to train the main branches.

*Flowering branches and fruit quality:* Make branches short to force more fruiting.

- In order to force small fruiting branches, cut 50% of one-year-old branches without buds.
- Two years old branches usually have many short fruiting branches.

*Maintenance pruning:*

- Remove any limb growing below the lowest main branches from the ground.
- From the second to the fourth year, remove any branch that grows straight up through or towards the centre of the tree.
- Prune lightly to remove overlapping and damaged limbs.
- Maintain bearing tree height at 3-4 meters by heading back scaffold branches to an outward growing lateral. In Soldum variety, cut back few branches with open type to encourage more flowering branches.
- Remove weak branches as well as those that grow upward, through or across the centre of the tree or downward.

### **Blooming and Pollination**

The flower buds in most varieties are borne on the short shoots or on the terminal shoots of the main branches. Flowering starts from late February to late March. Apricot is mostly self-fertile as they bear flowers with both male and female parts. However, plums are not self-fruitful in nature and require pollinizer. Plant different varieties including other stone fruits (peach, cherry, apricot) together for proper pollination. Honeybees can carry out pollination of the flowers.

### **Fruit Management and thinning**

Plum varieties such as Soldum and Honey Rosa tend to bear fruits heavily. Therefore, carry out fruit thinning in the plum trees to get optimum size fruits as follows:

- *Fruit spacing:* Maintain about 8-10 cm space between the fruits on the branches.
- *Fruits to thin:* In case of heavy fruiting, thin out upward growing fruits and off shape fruits.
- *First fruit thinning:* Carry out the first fruit thinning at 30-40 days (at marble size).
- *Second fruit thinning:* Carry out the second fruit thinning around two weeks after the first fruit thinning in Kiyo variety which produces large fruits.

### **Harvest**

Harvest fruits only when they are properly matured as young fruits have high acid content. At maturity, the fruits change colour and also become soft. Plum and apricot mature almost at the same time. Grafted apricot trees start bearing fruit after two years and reach the maximum bearing capacity at 8-10 years. Soldum and apricot can be processed and stored in the freezer for making jam (store in plastic). Frozen fruit skins are easy to break and easy to mesh during jam processing.

### **Nutrient management**

Soil nutrients required by apricot depends upon variety, age of trees, soil type, cultural practices and climatic conditions. For the trees older than 7 years, apply annually a mixture of 40 kg FYM, 500 g nitrogen (N), 250 g phosphorus (P) and 200 g potassium (K). Apply a full amount of FYM, K and P in December to January. Apply nitrogen in two split doses: half the amount in 2 to 3 weeks before flowering and the remaining after a month with irrigation water.

### **Pests and Diseases**

Various pests and diseases attack apricot but major ones include the following:

**Aphid (*Aphidoidea*):** Aphids damage the trees by curling, yellowing and distorting leaves which make tree growth stunted and also forms sooty mould. Destroy aphid colonies along with the infested plant parts and also remove weeds around trees. Spray regularly insecticidal soap, neem oil and other narrow ranged oil for aphid management.

**Peach twig borer (*Anarsia lineatella*):** It damages twigs and leaves by boring inside as well as causing superficial damages to the fruits. Control peach twig borer by spraying Spinosad @56g per acre, diflubenzuron @85g per acre or *Bacillus thuringiensis* (BT) during the dormant stage to destroy overwintering caterpillars. Prune out the pest infested shoots in late spring and early summer to prevent them from entering further into the twigs and completing their life cycle.

## **(5) Nut trees (walnut, pecan nut, chestnut and macadamia)**

Walnut and chestnut are grown in the warm temperate and temperate regions of Bhutan in elevations from 1300 masl to 3000 masl. Pecan nut and macadamia nuts are suitable for cultivation in the subtropical areas with elevations from 300 masl to 1000 masl. ARDC-Bajo planted a few macadamia nuts for evaluation in 2018. There is a potential to select suitable varieties for cultivation in the tropical zone.

Bhutan lies within the native range of *Juglans regia* and there are wild walnut trees especially at an elevation above 1700 masl. Several trees are found scattered in and around cultivated fields and wasteland. Therefore, the section mostly describes on walnut.

Two categories of walnuts are found in the country: hard-shell; and soft soft-shell. We cannot break hard-shell walnuts with hands whereas we can break some soft-shell walnuts with the hands. Bhutan has been selecting local soft-shell walnuts and largely propagating them through seeds which take seven to eight years to bear and also makes walnut production very expensive.

Harvesting is easy as nuts can be picked up from the ground as they shed from the hull. The nuts are dried and stored in gunny bags. Nuts have long shelf-life and it can be transported to longer distances without spoiling. Hence, walnut can be a potential cash crop where motorable roads are rough or unavailable. Moreover, it is suitable to grow in a wide range of elevations from 1300 masl to 2700 masl. Nevertheless, the most suitable elevation range is between 1800-2400 masl.

### **Characteristics of Varieties**

**Kanthel Selection:** The tree is vigorous and semi-erect; big size (26.11g) nut; shell is thin, and the fruits harvested in end-September under ARDC-Yusipang condition.

**Yusipang 2:** The tree is vigorous and semi-erect; big nut (20.75g); shell is thin, and the fruits are harvested in end-September under Yusipang condition.

### **Planting**

Walnut can be successfully cultivated in wastelands, sloppy area for proper land utilization. Not recommendable to plant nearby houses.

*Field preparation:* Prepare the field at least one month before planting preferably in December. Incorporate well-decomposed farmyard manure during field preparation.

*Planting space:* 7~10m x 7~10m.

*Pit size:* 1m<sup>3</sup> or 1m deep with 1m diameter

*Soil mound preparation:* Fill the pit first with the topsoil followed by the sub-soil mixed with FYP. Prepare a soil mound of at least 30 cm high from the ground.

*Type of seedling:* If grafted seedlings are not available, plant rootstocks and top-work after 2-3 years

*Planting time:* Complete planting within January.

*Heading back:* Cut back the seedlings that have 3 branches position.

*Irrigation:* Irrigate with plenty of water right after planting.

### **Training, Pruning and Tree shape**

Walnut tree can be maintained with its natural shape. However, it can also be trained to modify central leader system by retaining 3 scaffold branches. When branches develop one year after planting, head back to three strong branches. Thereafter, remove crisscross and crowded branches. Male and female flowers are separate but grow on the same tree. Since



most of the flowers are borne at the tip of the branch, take care not to remove them when pruning. Allow the main branches to grow strong by removing the fruiting branch and heading back. As the tree grows pruning is mainly done by using a pruning saw.

### **Blooming and Pollination**

Walnut is a dioecious tree with separate male and female flowers. Pollen dispersal and pistil flower receptivity occur at different times for each variety. Plant at least two varieties that have overlapping pollen dispersal and flower receptivity to ensure proper pollination by wind and fruit set. Avoid the foggy area for cultivation of walnut since high moisture and rainfall prevents the pollen dispersal.

A walnut tree bears fruits 5-6 years after planting.

### **Fruit management**

There is no special fruit management and no fruit thinning practices.

### **Harvest**

In Bhutan, walnut harvest starts from August to September depending on altitude. When 70% of green husk splits open and start shedding nuts, it is ready for harvest. Shake the branches or hit the husk with a stick. You can also pick up nuts that naturally fall down. Delay in harvest allows insects and moulds to enter the nuts. The longer the nuts remain on the ground, the greater the losses. Therefore, pick up nuts as soon as possible. If some dropped nuts have a dark shell, make it brighter by using rice water and drying in the shade.

### **Nutrient management**

Apply about 50kg of manure and 50kg compost to each tree every year to minimize the use of chemical fertilizer. Moreover, they are good sources of micronutrients. Apply these during the winter while cleaning and maintaining the basin of the tree. Provide two times mulch in a year to suppress weeds around the tree trunk and also to keep the soil moist. On the onset of the rainy season, apply about 100-200 g of Suphala per tree to boost the tree growth.

### **Pest and Disease**

Not many serious pest and disease problems in walnut. Some cases of trunk borer are reported. The larvae excavate large caverns just beneath the bark and bore deep into the wood for pupation. Excavated areas are usually filled with fine sawdust. Feeding by the trunk borer causes a portion of bark to die, and the young trees die if they are girdled. Infested branches on older trees often die. Dead, brown leaves remain on these branches during the summer and fall. The best way to avoid infestation is to keep the tree healthy and vigorous. Prune badly infested wood and burn or remove from the orchard before the growing season starts. In older trees, clean the excavated holes with a wire and then plug with a cotton ball soaked in 2% insecticide solution. The trunk borers appear after July, therefore monitor the orchard for its presence every one to two weeks.



**Adult trunk borer**



**Ideal tree shape of walnut**

Thin out undesired growth from a bearing or neglected fruit tree

## (6) Kiwi fruit

Kiwi (*Actinidia deliciosa*) is a berry and belongs to family Actinidiaceae. It is a new fruit crop in Bhutan which is cultivated on a small scale. People do not know much about its cultivation. It was first evaluated at Agriculture Research and Development Centre (ARDC) Wengkhar. The centre released two commercial varieties: *Zhimpeykotong Sep*; and *Zhimpeykotong Jangkhu*. The former produces the fruits with yellow flesh and less pubescence while the latter produces the fruits with green flesh and prominent pubescence.

Kiwi can be cultivated in warm temperate regions from 1200 masl to 2400 masl. However, the most suitable region is from 1500 masl to 2300 masl. Areas with moderate to high rainfall, open area with low wind velocity, less foggy with enough sunshine, and free from frost in the winter are suitable for kiwi cultivation. Kiwi can be cultivated at about 1000 masl elevation but it is susceptible to sunburn and the plant's growth and development are slow.

Like the grape, kiwi requires support structure (trellis) and proper plant management (pruning and training). Therefore, the initial investment is high. Kiwi fruit is climacteric in nature and ripens only after it is removed from the vine. The fruits are harvested when they are still hard on the vines. The fruits can be stored for a long time or transported to a long distance. In order to hasten the ripening process, put kiwi fruits in a ventilated bag with apple or banana.

Kiwi is dioecious in nature and needs few male plants among female plants in an orchard.

### Varieties (1700 m as a reference)

**Wengkhar Yellow (Yellow Joy):** It is an early variety but vines are slightly weak in growth. It produces medium-sized fruit with hairs which weigh about 120 g. It has yellow and good quality pulp with high Brix content. The fruits are harvested in the second fortnight of October.

**Wengkhar Green (Elm Wood):** It is a late variety and vines are strong and vigorous in growth. It produces slightly bigger size fruit, with prominent hairs, which weighs about 135 g. The pulp is green. The fruits are harvested by mid-November.

**Hayward:** It is the most popular variety in the world. At ARDC-Bajo, the growth is strong and vigorous and produces fruit with green pulp. The fruits can be stored for a long duration and is suitable for transportation to far-away markets. The fruits are harvested in the first week of November.



**Wengkhar Yellow (Yellow Joy)**



**Wengkhar Green (ELM Wood)**

**Enri Red:** The trees are slightly weak in growth. It produces small size fruits, with fewer hairs, which weigh about 50-70 g. The pulp is slightly red. The fruits are harvested in the first week of October.

### **Planting**

Kiwi plants are functionally dioecious which require at least one (1) male plant for 8-9 female plants for proper fruit set and production.

*Site:* Avoid waterlogged and windy conditions

*Field preparation:* Prepare the field at least one month before planting, preferably in December. Incorporate well-decomposed farmyard manure during field preparation.

*Planting space:* 6x6m and 7x8m depending on soil type, climate and variety.

*Pit size:* 1m<sup>3</sup> or 1m deep with 1m diameter cylindrical pit

*Soil mound preparation:* Fill the pit first with the topsoil followed by the sub-soil mixed with FYF. Prepare a soil mound of at least 30 cm high from the ground.

*Planting time:* Complete planting within January and February.

*Planting:* Plant the seedling in the soil mound and not in the pit. Never ever bury the graft union of the plant, if any, in the soil.

*Mulching:* Mulch with locally available materials such as straws, grasses, stubbles, leaf litters, and sawdust.

*Staking:* Stake up plants to prevent lodging.

*Heading Back:* Head back to 30 cm right after the planting of the seedling.

*Irrigation:* Irrigate with plenty of water right after planting

### **Pruning, Training and Vine shape**

Almost all deciduous fruit trees need proper training and pruning every year in order to produce quality fruits. Kiwi vine-like grape requires structural support for the production of quality fruits. In fact, the vegetative and fruit load in kiwi is heavier than grape which necessitates even stronger support and heavier pruning. Carry out pruning in January.

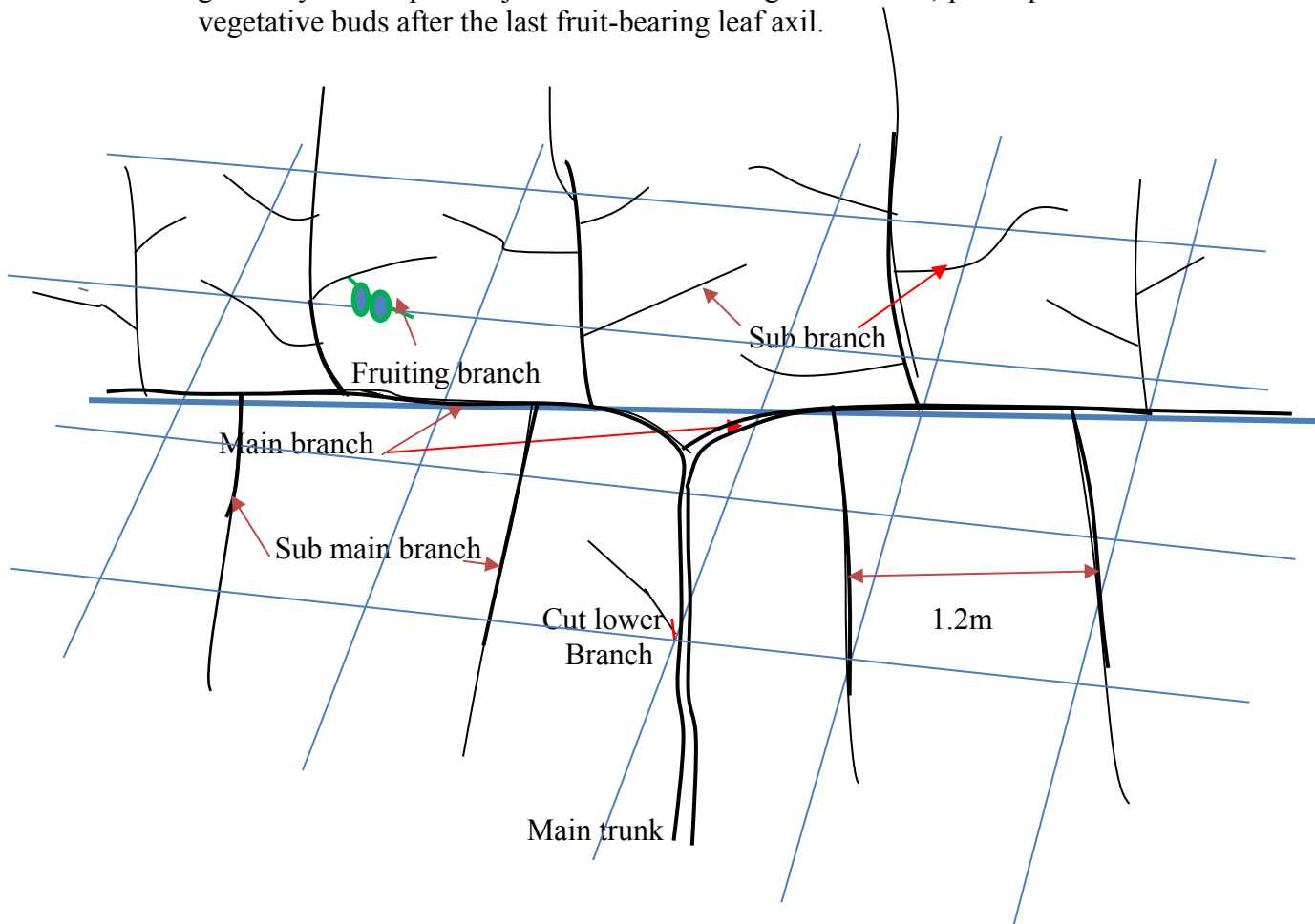
Training is to establish and maintain a well-formed framework of the main branches and fruiting arms in order to keep a balance between vegetative growth and fruit load throughout the lifespan of the vine. Training also facilitates cultural operations such as application of compost, fertilizers, spraying of insecticides and harvesting.

Erect the support frames as early as possible. Delays make training difficult and waste considerable time in untangling and pruning of vines. There are many types of support structures. However, an overhead trellis system is commonly adopted in Bhutan. The materials used as pillars or posts can be wood, concrete, iron angled rod (fencing pole) and so on. The pillars are erected at a convenient distance of 3-6 meters apart in rows. A flat-top metallic wire network or criss-cross metallic wires is prepared to train vines. This system is expensive to prepare and difficult to manage but gives higher yield.

Training of vines begins with the planting and continues throughout its life. Right after planting, head back the vine to 30cm above the ground surface to promote vigorous growth. Train and prune as follows:

- In the first year, allow only the single main stem to grow and remove all the side shoots to make the trunk strong. Use a 2m bamboo stake to support main stem to connect to the trellis network. Cutback at 1.5 m height to enable it to develop two horizontal central leaders in opposite direction along the wire above the stake.

- In the second year, head back the two leaders to 70 cm to 1 m. The laterals grow on these leaders at right angles. Maintain about 3-4 laterals with a spacing of 1.2 m between the laterals. Remove all the side shoots growing on the main trunk.
- In the third year, the fruiting branch develops from the laterals. The fruit is borne from the current season's growth arising from the bud developed in the previous year. The basal three to five buds of a current growth are only productive.
- Remove old fruiting laterals which have lost vigour or become overcrowded to encourage the development of new laterals.
- Prune off the vines that are crisscrossed too heavily and diseased. A shoot dies gradually if it is pruned just above the fruiting bud. Hence, prune past at least two vegetative buds after the last fruit-bearing leaf axil.



**Figure 4-1. Four to five (4-5) years old vine shape and pruning method**





**Un-pruned Kiwi vines**



**The first year tree before pruning**



**The first year tree after pruning**



**Thinning of the main branches  
(The second year before pruning)**



**The main branch and the sub main branch  
( The second year after pruning)**

### **Blooming and Pollination**

Kiwi plant starts flowering two or three years after planting but bears sizable fruits only after four to five years. Since Kiwi is dioecious in nature, the individual plant produces either male flowers or female flowers. The female plants bear fruits only when pollinated by a male plant. One pollinizer plant or male plant is required for eight to nine (8-9) female plants.

Kiwi flowering shoots produce about 5-7 flower buds. The blooming period of both male and female flowers should synchronize for proper fruit setting. Pollination is an important pre-requisite for fertilization and also influences fruit shape and size. Kiwi flowers do not produce nectars so honey bees mostly avoid visiting kiwi flowers. Therefore, supplement pollination artificially if necessary. A method of extracting pollen from flowers is; collecting kiwi pollens from picked male flowers from the male vine maintained in the orchard just before bloom, pack them in a cardboard box and store in refrigerator at 18°C. The flower opens and sheds pollens within 24 hours. Collect the pollen dust in a brown paper bag and store in the refrigerator until it is used.





**Kiwi female flower**



**Kiwi male flower**

### **Fruit Management and Thinning**

Too many fruits on the vine can reduce the overall quality of the fruit by reducing average fruit size and taste. Therefore, carry out fruit thinning to produce quality fruits. Remove the fruits which are relatively small, diseased, damaged and crowded. Complete the fruit thinning before July to prevent nutrient loss from unwanted fruits. Kiwi plant suffers very little fruit loss due to natural drop. Adjust fruit load as per shoot to obtain the minimum leaf shoot ratio (5 leaves per fruit). A flower cluster bears 4-5 fruits. Remove those fruits which are small and shapeless because of improper pollination.

- The first fruit thinning starts from mid-April to remove father finger size, round and brown fruits. Properly pollinated fruits look green and not round.
- The second fruit thinning is done in the 1<sup>st</sup> week of June to maintain 5 leaves per fruit depending on the shoot length and size.
  - For long terminated shoots (above 80cm), keep 3-4 fruits;
  - For medium terminated shoots (50-70cm length), keep 2-3 fruits; and
  - For spur (less than 30cm), keep only one fruit.

When there are twin fruits, remove the fruit which is growing on the side (lateral) as it will never be as big as the fruit in the centre. Similarly, in triplet fruits, remove the two side fruits.



**Six fruits present (Before thinning)**



**Three fruits kept (After thinning)**

### **Harvest**

Under Bajo condition, harvest the kiwi fruits from mid-October to mid-November when the fruits are still hard. Keep the harvested fruits in a cool room using paddy straw to prevent fruits from shrinking. If it is stored in a normal room, the fruit shrinks and reduces the quality. Unlike other fruits, kiwi fruits do not ripen after harvest unless exogenous ethylene is provided. Ripen the fruits by storing with high ethylene emitting fruits such as apples and bananas. Market the fruits before they become very soft.

### **Nutrient management**

Apply 50 kg of farmyard manure or compost mixed with 200 g of Suphala per tree in a year. It is recommended to grow vegetable such as beans and other legumes as intercrop when the trees are young. However, take care not to injure roots as kiwi develops many shallow roots. Mulch up by uprooting and cutting the weeds and other debris to conserve soil moisture.

### **Plant protection**

In Bhutan, no major pests and diseases incidences have been reported so far. In other countries, Phytophthora root rot is a major issue. Therefore, maintain phytosanitary conditions and avoid water logging by providing proper drainage.

Regular monitoring of the vines helps to reduce pest infestations. Closely examine vine trunk, blossoms and vegetative shoots in the vineyard during pre-blooming and blooming periods for presence of caterpillars, webbed leaves or feeding damage. If such signs are observed, control or take management measures. In the windy area, train the shoots to the trellis to prevent breakage.

## (7) Grapes

Grapes are native to Western Asia and Europe. The grapes are a good source of vitamins and minerals such as phosphorus, iron and calcium. They are cultivated for table purposes as well as exports. They are also used to prepare beverages and wines. The grapes have markets both inside and outside the country.

Grapes farming can be done in the tropical as well as sub-tropical climatic conditions. The plants require dry and sunny climatic conditions to give good yields. Temperature, humidity, moderate rainfall, and frost are the main factors which affect production. An optimum temperature ranging from 18 °C to 38 °C is considered ideal for growing grapes. However, a clear atmosphere without fog for about three months in a year is required during the growing period for proper growth and development.

There are three types of grapes: American (*Vitis labrusca*), European (*V. vinifera*), and North American native Muscadine (*V. rotundifolia*). American grapes are cold tolerant and hardy in nature, while European grapes do well in warm, dry and temperate zones. The conditions such as high temperature, high humidity and long rainy season are not feasible for European varieties. European grapes are usually cultivated for table purpose. Grapes hybrids are also available.

The European-American hybrids are cold tolerant and hardy in nature and are suitable for cultivation in Bhutan. However, suitable area for grapes cultivation in Bhutan is limited as most high-altitude areas have low temperature, long rainy season with foggy conditions throughout the year, and mid-altitude and southern belt receive high rainfall and have high humidity. Therefore, the only areas conducive for grapes cultivation are Paro, Wangdue and Punakha river valleys. These areas receive optimum rainfall and enough sunshine throughout the year.

Grapes like kiwi requires a trellis to support the vines which make the initial investment very high. The training and pruning operations in the grapes are difficult and require technical knowledge and experiences. It is planted through cuttings or by grafting but seedlings from cuttings are most susceptible to diseases. Therefore, planting of grafted seedling is recommended. The 5BB is generally used as rootstock.

At Bajo, European American hybrid varieties such as Kyoho, Stuben, Perlette, Campbell, Resamate Red and Bajo Green are planted for evaluation. Grapes are early fruit bearer and come to fruiting two years after planting. It can be planted near a residential area for home consumption purpose. Grapes are self-fruitful in nature and do not need pollinizers.

Although viticulture can be a lucrative opportunity for Bhutanese farmers but high initial investment and technical expertise hinder the cultivation. Therefore, it is recommended for those farmers who have all the resources needed.

### **Characteristics of a variety (1200 masl as reference)**

**Kyoho:** It is also a European-American hybrid. The berries are of medium size with large seeds and blackish purple or almost black skin. Each berry weighs about 15-18 g . The berries have juicy flesh with TSS of 16% and mild acidity. Fruiting takes place on long branches and a bunch of berries weigh about 300 g . Harvest the fruits in the middle of July.

**Stuben:** It is a European-American hybrid. The berries are small with bluish-black skin. Each berry weighs about 5 g . It has a sweet flavour with a little bit of spicy tang and TSS

of about 16.5%. The fruit bunch is long and tapering with compact clusters weighing about 800 g . The vines are hardy, vigorous and productive in nature and quite tolerant to most common diseases of the grapes. The fruiting take place on short branches. The thinning of berries in fruit cluster is required. Harvest the berries by the end of July.

**Perlette:** It is a European-American hybrid. The berries are small, spherical, yellowish-green, and each weighs about 6 g . It has soft flesh with mild acidity which can be easily removed. A bunch of berries usually weighs about 180 g . The translucent nature of matured fruits is the distinguishing feature of the variety. The small underdeveloped berries are usually scattered all over the fruiting branch and that is the major defect of the variety. The berries have good shelf life. It is an early maturing variety and which is harvested by the end of July under Bajo conditions.-

**Campbell:** It is also an American European hybrid. The berries are large, round, bluish-black, and each weighs about 9.6 g . It has sweet flavour like strawberry with some acidity. The fruiting takes place on short branches and a bunch of berries weigh about 200 g . The vine is quite hardy, vigorous in nature and tolerant to most pests and diseases of the grapes. Harvest the fruits are harvested in early July.

**Resamate:** The berries are small, light red, and each weighs about 7 g . They are sweet with little acidity which can be easily removed. The fruiting take place on short branches and a bunch of berries weigh about 500 g . The vine is susceptible to diseases and pests. Harvest the fruits in early August in Bajo.

**Bajo Green:** The berries are small, yellowish-green, and each weighs about 7 g . The flavour is sweet with less acidity. The leaves are light green in colour. The fruiting occurs on short branches and a bunch of berries weigh between 300 and 400 g . Harvest the fruits at the end of July.



**Kyoho**



**Stuben**



**Perlette**



**Bajo Green (Up, left)**  
**Bajo Black (below left)**

**Resamate Red (Upside right)**  
**Campbell Early (below right)**

### **Planting**

*Site:* Avoid waterlogged and windy conditions

*Field preparation:* Prepare the field at least one month before planting preferably in December. Incorporate well-decomposed farmyard manure during the field preparation.

*Planting space:* 6m x 7m for overhead trellis system; and 5 x 5m for fence type trellis system.

*Pit size:* 1m<sup>3</sup> or 1m deep with 1m diameter

*Soil mound preparation:* Fill the pit first with the topsoil followed by the sub-soil mixed with FYP and prepare a soil mound of at least 30 cm high.

*Type of seedling:* Plant grafted seedlings. The seedlings raised from cuttings are more susceptible to diseases and pests

*Planting time:* Complete planting within January and February

*Planting:* Plant the seedling in the soil mound and not in the pit. Never ever bury the graft union of the plant, if any, in the soil.

*Mulching:* Mulch with locally available materials such as straws, grasses, stubbles, leaf litters and sawdust.

*Staking:* Stake up plants to 2m bamboo posts or poles to prevent lodging.

*Heading back:* Head back the vine to 50-60 cm after planting.

*Irrigation:* Irrigate with plenty of water right after planting



### **Pruning, Training and Vine shape**

Construct trellis as soon as the vines are planted as they are vigorous in growth and cover a large area within a short duration.

#### **Overhead trellis system**

In this system, allow the vines to grow straight up to the height of 1.5 m and select two vigorous shoots are selected as primary arms and train on overhead trellis wires (60 cm apart) fixed to vertical post in the first year. The two shoots arising below the cut area are allowed to grow in the opposite direction on the wires. These two shoots develop into the main arms. Cutback the main or primary branches about 60 cm to force secondary branch formation. On the main arms, allow the side shoots to grow at regular intervals of 40 to 45 cm. These side shoots are called secondary and tertiary shoots from which fruiting spurs develop.

Train primary arm towards East and West direction to reduce damage due to sunburn in summer months, especially after dormant season pruning. The entire space allocated for each vine is covered in a gradual manner by intermittent pinching of the primary arms and secondary arms by not allowing them to grow more than 60cm at a time. As they grow, tie the shoots with jute twine and remove all tendrils.

#### **Fence type trellis system**

In this system, allow the vines to grow straight up to the height of 1.5 m and select two vigorous shoots are selected as primary arms and are trained on the horizontal wire. Head back the shoots or canes to 1-2 buds every year. During summer, remove unwanted non-flowering canes to open the vines to sunlight and aeration. Remove tendrils as it is not important for plant growth. While pruning, cut few centimetres away from apical end buds to avoid drying.

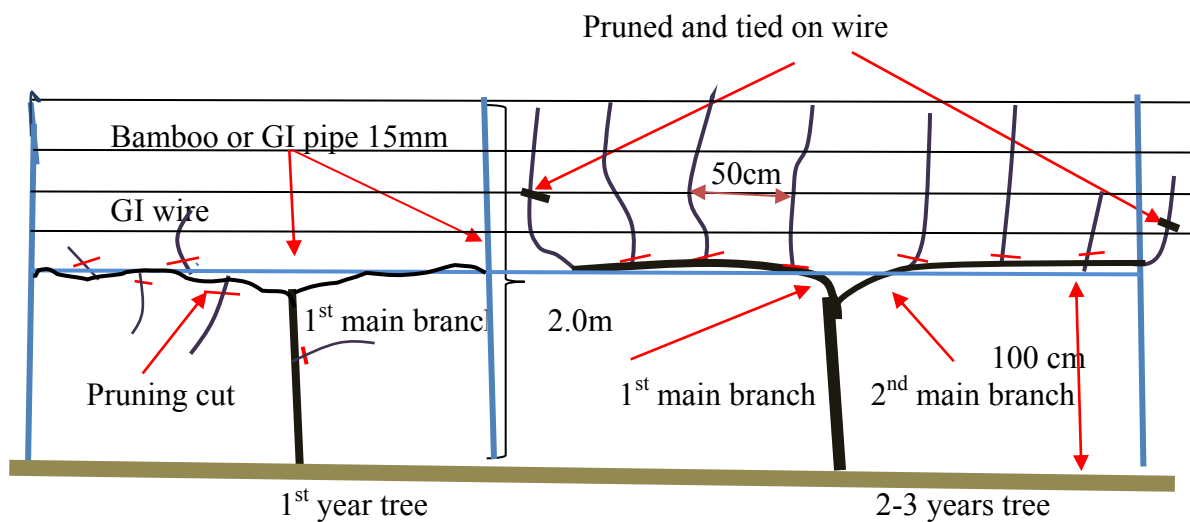
### **Pruning**

Pruning is an important operation to maintain vine canopy to produce good quality berries. It is required as the vines grow vigorously. Pruning is done when the plants are in dormant stage (December and January).

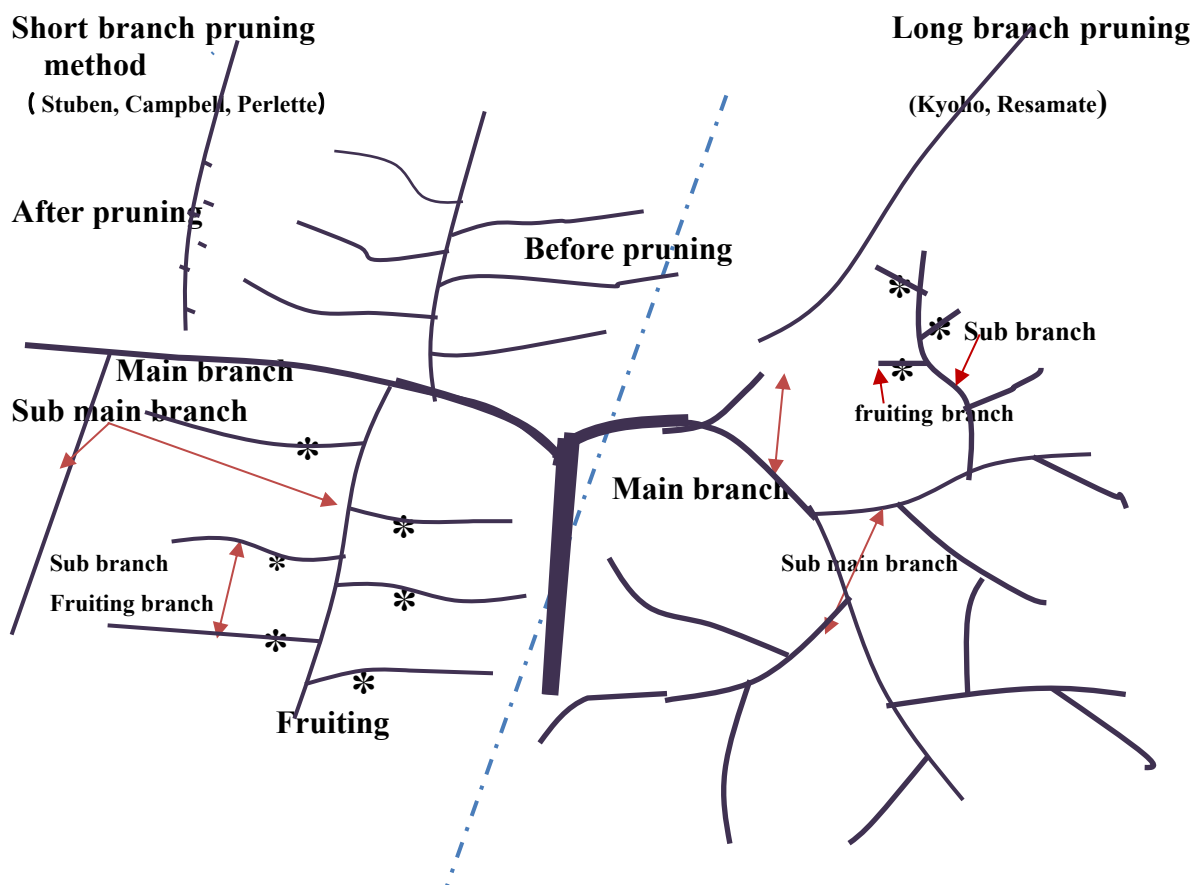
In grapes, fruits are borne mainly on current season growth that arises from the previous year's growth. Some fruiting also comes from the spurs. Start pruning just after the leaf fall and complete before new growth in the spring. Train the vines to develop the whole structure (Primary, secondary, and tertiary arm) slowly over a long period of time to produce productive fruiting branches. If not trained, the arms become unproductive and produce fruiting wood only at the apical end.

Under ARDC-Bajo conditions, pruning is done twice a year. The first pruning is done in January and the second in the summer. Summer pruning is done to open the vines to receive more sunlight and air. It is usually done by hand and not by using secateurs.

The cultivars such as Perlette, Campbell, Stuben and Bajo Green produce fruits on the shoots arising from the basal buds on the cane. Therefore, head back canes to 3-4 buds when pruning. On the other hand, head back Kyoho, called cane-pruned cultivar, to 8-12 buds. Only 3-6 basal buds are productive. A shoot generally dies off gradually if it is pruned just above the fruiting bud. Hence, prune past at least two vegetative buds after the last fruit-bearing leaf axil.



**Figure 4-2. Fence type trellis system**



**Figure 4-3. An example of pruning methods on Grape**



**The first year before pruning**



**The main branches as T-shape after pruning**



**The second year before pruning**



**(Main branches) (Sub main branches)**  
**The second-year after pruning**

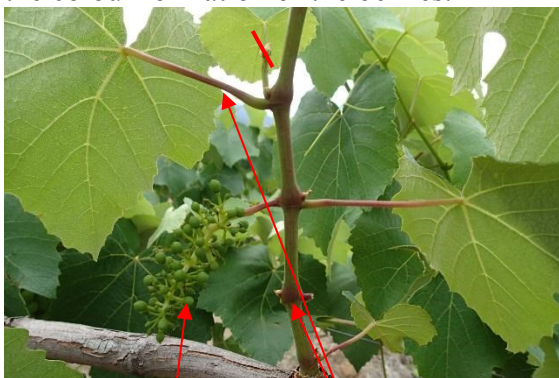
### **Fruit management and thinning**

The excessive bearing of fruits can be reduced by thinning out clusters or berries. Cluster thinning is done after the berry set. Thin out excessive clusters depending on varieties and fruit sizes. For instance, 1-2 clusters per branch are kept for variety such as Campbell and Perlette and one cluster per branch for Kyoho and Stuben varieties. Usually, one cluster



from the base and one cluster from the end of the fruiting branch are immediately removed during cluster thinning.

Berry thinning is done after proper berry formation. For cultivar which produces large-sized fruits such as Kyoho, maintain about 30-35 number of berries per bunch to improve berry quality. Bag fruiting bunch by using paper bags (old newspaper) to protect the berries from birds, hornets and other insect pests. It also keeps fruits clean. Bagging does not affect the colour formation of the berries.



**Keep**

**Remove (Before thinning)**



**After thinning**



**Fruit bunch after second thinning**



**Bagging fruit bunch with old newspaper**

### **Harvest**

Grape is non-climacteric in nature (fruits harvested after ripening on the tree). Therefore, harvest the grapes after ripening on the tree for better quality and taste. The grape starts ripening from the base (shoulder) of the fruit cluster and progresses towards the apex. The ripeness of an individual bunch is judged by observing the berries at the apex of the cluster which is the last to ripe. Harvest when berries on the tip of the cluster are ripened. Use secateurs to cut off the fruiting bunch from the branch as the fruit stalks are hard and strong.

The berries are soft and easily bruised. Therefore, take care not to over stack the fruits in a harvesting tray. In Bhutan, grapes are generally harvested from end-July to mid-August. The time is taken from fruit set to ripening largely depends upon a cultivar, crop load and atmospheric temperature.

### **Nutrient Management**

Apply 50 kg of farmyard manure or compost mixed with 200 g of Suphala per tree in a year. Grow vegetable crops such as beans and other legumes as intercrops when the trees are young. However, take care not to injure roots as the grapes develop many shallow roots. Mulch up by uprooting and cutting weeds and other debris to conserve soil moisture.

### **Plant Protection**

The common cultivars cultivated in Bhutan are hybrids of American and European crosses. These cultivars are usually strong against pests and diseases but incidences of both are common.

Aphids are common pest during shoot formation and weevils are seen during flowering. Twig borer also attacks grapes (Larva of borer stay in the bark, so scrape the bark with a knife).

Some of the important diseases in the grapes are downy mildew (*Plasmopara viticola*), powdery mildew (*Uncinula necator*), Bird's Eye Spot/Anthracnose (*Gloeosporium ampelophagum*, *Elsinoe ampelina*), and Fruit Spot (*Cercospora spp*).

Spray Bordeaux mixture 6/7 (6 g copper sulphate and 7g quick lime per litre of water) in autumn after leaf fall and spray 4/5 (4 g copper sulphate and 5g quick lime per litre of water) in rainy season (May-June) and other fungicides (0.1%) such as Ridomil (Metalaxyl + Mancozeb) in May-June.

In general, maintain orchard sanitation to reduce the infestation of pests and diseases. In subtropical and temperate regions, it is always good to select cultivars which are proven for their tolerance to pests and diseases.



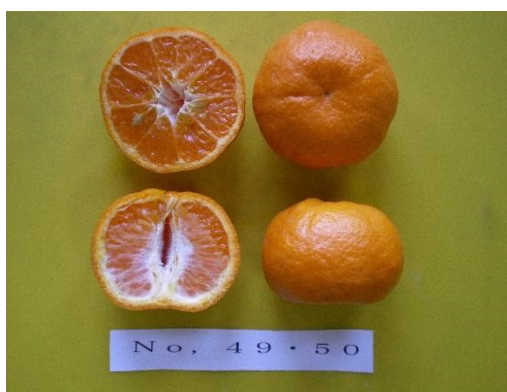
## 5. Evergreen fruits

### (1) Local Mandarin

Local mandarin is cultivated extensively in Bhutan. It is a late cultivar which starts to ripen in November and harvested in December and January. It is cultivated within an altitude range of 1000-1200 meter above mean sea level (masl). The fruit has well-balanced sugar and citric acid ratio, good taste, and smooth peel. Mandarin trees which are planted below 1000 masl with thin peel large fruits and good taste. However, full colouration of the fruits does not take place and hence the fruits may be pale green to pale yellow at maturity. The fruits have shorter shelf life. Mandarin trees cultivated above 1200 masl produce small fruits with thick peel and high citric acid content. The fruits have the brightest fruit colour and can be stored for a longer period. Therefore, the local mandarin can be cultivated within elevation range of 800-1600 masl if fruit qualities are not taken into consideration.

#### Varieties

In Bhutan, the best local mandarin fruits are produced in Kengkhar (Mongar), Dorokha (Samtse), Tsirang and Dagana. Among the mandarins, the variety Taraku introduced at ARDC-Wengkhar is recommended for general cultivation or planting. The fruits are small but have good balance of sugar content at 14.3% and citric acid at 1.12%. The fruits can be stored for a long duration. The variety is high yielding when planted below 1600 masl.



**Taraku variety**



**Kengkhar No. 49/50**

#### Planting

Many citrus cultivars have poly-embryonic nature and retain the characteristics of the mother plant, unlike other fruits. The trees grown from seedlings are strong and grow vigorously with a long life span of over 100 years. Choose fields with fertile and well-drained soil, and which receive good sunshine.

*Spacing:* Seed seedlings need wider spacing (6 m x 6 m or 6 m x 5 m). Grafted seedlings are much weaker than the seedling trees. Therefore, grafted seedlings are planted closer to each other (4.5 x 4.0 m or 4.5 x 4.5 m).

*Pit size:* Dig up pits of 1m x 1m size similar to deciduous fruit trees.

*Planting time:* Traditionally, citrus planting time is done in the rainy season (June-July). However, it is recommended to plant citrus in February before the spring bud sprouts. If someone wants to plant citrus taking advantages of the rainy season, plant them in May before summer buds sprout in the 1<sup>st</sup> week of June.

*Where to plant:* Plant citrus in a mound prepared above the pit which is about 30cm from the ground. Never bury the graft union under the soil.

*Mulching:* Mulching with paddy straws, grasses and other locally available materials are recommended to prevent the growth of weeds around the plant and to retain moisture in the soil.

*Head Back:* Once planted, cut back about half of the summer shoot that grew in the past year.

*Irrigation:* Young citrus trees need weekly irrigation during the dry season.

### **Pruning, Training and Tree shape**

Citrus is generally sprouting branches three times in a year. In warm areas spring buds start new growths in late February and short branches in March. In June-July, summer branches grow on the spring shoots. From September-October, some autumn branches grow on the summer shoots, which are later pruned off since they are not productive.

Spring shoots carry flower buds that will produce fruits. Weak summer shoots also carry fruit buds which should be left to fruit. Those branches which produced fruits in the previous year will not produce fruits. This is the main cause of biennial bearing habit of citrus. Therefore, to prevent biennial bearing habit, retain some fruiting branches for the next season production.

After planting, maintain tree growth for about three years. After 3-4 years, select 2 to 3 main branches while pruning in January and February. Since the local mandarin tree has an upright growing habit, select 2-3 well-spaced scaffolding branches and bend over into preferred position using bamboo poles. Arrange sub-branches and side branches of the main branch in a well-balanced manner, and eventually restrict upright growth. Reduce the tree height to facilitate easy management practices such as spraying, fruit thinning, pruning, and harvesting.

Citrus are evergreen trees and is not pruned like the deciduous fruit trees. Pruning is limited to removing of undesirable branches to allow enough aeration and sufficient sunshine interception inside the tree canopy. Use pruning saw to remove the unproductive branches and pruning scissors to thin out unwanted tender branches. The amount of foliage on a tree is directly related to the number of fruits the tree produces. As a thumb rule, prune about 15% of the tree each year depending on the growth.



**Training in 2<sup>nd</sup> year using bamboo**



**Local mandarin with reduced height**

To avoid alternate bearing habits in the citrus, one should have sound knowledge and experiences on the flowering habit of citrus. The citrus tree produces three flushes in a year. Each new flush carries flower buds that bloom to produce fruits. If all newly emerged shoots are retained to fruit, there will be less fruiting branches for the next season. Hence, most of the spring shoots (emerging in March) are allowed to bloom to produce fruit. Pinch off summer shoots to force spring shoots for the next season. Remove the autumn shoots as it is not productive.

### **Blooming and Pollination**

Citrus is evergreen trees that have two to three vegetative flushes every year. These new flushes occur in the spring, summer and autumn. Flowers bloom from the buds of the new shoots. There are two types of flowering: green; and white blossom. Green blossoms contain at least 4-5 leaves with only one or two flowers. A white blossom is when three and more flowers bloom without leaves or with few leaves. White blossom flower usually shed most of its flowers and produce small fruits. Green blossom is more reliable as all flowers set and produce larger fruits. All citrus are self-fruitful in nature but if it is pollinated with pollen from other flowers on the same plant, fruits are seedy with big size seeds.

### **Fruit management and thinning**

Fruit thinning is an operation to produce quality fruits and to avoid the biennial bearing habit of plants. Fruits are usually thinned after the June drop. Carry out the first fruit thinning in the first week of July to remove excessive fruits borne on a fruiting branch. Carry out the second fruit thinning in August to remove fruits that are abnormal, upward growing and injured. Carry out the third thinning in September to thin out those fruits which are growing attached to branches since they have the thick peel and sour taste. Keep those fruits which are growing with few leaves on the fruiting branch as they have good quality. The number of leaves per fruit determines the shape and taste of the fruit. Since the leaves of local mandarin are small, keep about 100 leaves for one fruit.

### **Harvest**

In Bhutan, farmers harvest mandarin in November before the fruits are fully ripening. On the other hand, some farmers harvest the fruits very late to fetch the better price. This practice is common on citrus grown in higher altitudes to develop sweetness. The delayed harvest stresses the tree and inhibits the development of flowering bud resulting in the biennial bearing. Moreover, if the harvesting is done too late, the fruit turns puffy (loose skin) with hardly any juice content. Therefore, harvest the fruits on time and store them in cool places to reduce citric acid content.

Some tips to follow when harvesting fruits are:

- 1) Do not pull the fruit to avoid damages to the peel;
- 2) Use harvesting clippers to cut off fruits from the stalks;
- 3) Keep fruit stalks short to avoid injury to other fruits and remove properly; and
- 4) Use harvesting ladders to avoid injury by pulling down branches.

Some of the necessary equipment for harvesting are harvesting bags, tripod ladders and harvesting clippers. Remember to store harvested fruits in a cool place under the roof.

### **Nutrient Management**

Apply 30-40 kg compost or FYM mixed with chemical fertilizers (200-300g Suphala) sometime in January and the first fortnight of February followed by a top dressing of urea (100-200g) in June for summer shoot development when the rainy season begins.

Citrus trees grow slower than the deciduous fruit trees and take a longer time to come to fruiting. Therefore, it is recommended to grow vegetable crops such as beans as an intercrop. Such practices will make the soil soft and fertile. However, take care to avoid injury to roots as the citrus develop many shallow ones. Uproot or cut weeds and use them as mulching materials to conserve soil moisture.

Stop irrigation water application when fruits near maturity stage for the development of sugar.

## **Pests and Diseases**

There are many diseases of citrus which cause considerable damages to their growth and production. The diseases such as citrus greening, powdery mildew, citrus melanose, canker, rust, root rot, citrus Tristeza virus (CTV) are of economic importance to the citrus industry.

**Citrus Greening:** Citrus greening disease is also known as *Huanglongbing* (HLB). HLB is a bacterial disease that is transmitted by an insect called psyllid. The disease attacks the vascular system of the plant. In Bhutan, psyllid thrives in warm areas up to an elevation of 1300 masl where most of the citrus are cultivated. Local mandarin and sweet orange are highly susceptible to HLB. If the plants are infected there is no cure. In some cases trees die within a year. However, planting of resistant citrus species such as pomelo and lemon is recommended as options. Another option is to plant other fruit tree species such as avocado, guava and mango.

One management strategy is to control the vector population. The life span of psyllid is about two months, and it feeds on new growing shoots. The spraying of insecticides 3-4 times when there are new flushes in the spring and summer can drastically reduce the vector population. However, this strategy can be effective only if there are cooperation and support in communities.

The branches which show greening symptoms should be immediately pruned and destroyed.



**Greening disease symptom**



**Powdery mildew**



**CTV Stem Pitting symptom**

In general, spray Bordeaux solution in 6/6 ratio (Copper sulphate 6g, quick lime 6g, and 1(one) litre water) every winter. Remove dead and diseased branches, twigs, and leaves to reduce the disease.

**Foot-rot:** It is a disease in which the roots rot. It develops in the rainy season. Proper cleaning and improving aeration around the trunk are helpful. Avoid intercropping with tall crops such as maize, sugarcane, tapioca, and so on. If the disease is detected, apply Bordeaux paste (1 litre of water, 20 g of copper sulfate, and 20 g of quicklime) with a brush. Trifoliolate rootstock should be used as it is tolerant to the disease. The planting at a higher ground is also effective as it avoids the waterlogged condition.

**Citrus tristeza virus (CTV):** It is generally referred to as seedling yellow, Tristeza, and stem pitting. It is transmitted by black aphids. It usually appears in the summer and attacks the summer shoots. Stem pitting symptoms appear on the old branches. Local mandarins are tolerant to canker and CTV whereas lime and sweet orange are susceptible.

There are many insect pests of citrus which cause considerable damage to growth and production. The major pests are fruit flies, leaf miners, aphids, mites, thrips, psylla, scales, and stem borer.

**Citrus fruit fly (*Bactrocera minax*):** Among citrus pests, the fruit fly is the most destructive. It is found widely distributed in the citrus-growing areas and also difficult to



control. The scheduled spraying of insecticides and collection and destruction of dropped fruits involving the whole community are the only solutions to reduce losses caused by the fruit fly. Destruction of the dropped fruits by burying in pits (about 2 m deep) can be more effective.

**Scale (*Pseudonida duplex*. COCKERELL).** Scrap off the scales with a knife or hard dry grasses. Spraying of 0.1% Dimethoate (1ml in 1-litre water) can be effective.

**Leaf miner:** Leaf miners mine the leaf surface causing white leaf which in turn affects tree growth. It infests mostly on new summer shoots. It can be controlled by spraying with Cypermethrin (0.075%) when the new shoots appear particularly from July to September.

**Mites:** In general insecticides do not have much effect on mites. It is better to wash mites away from plants using water. As a countermeasure, spray machine oil (TSO) emulsion 2% (20ml/1lt water) in the winter.

**Sooty mold:** It sucks sap from the tree and then produces honeydew. The honeydew is then fed upon by ants which further add to the tree injury. It disfigures the shape of fruits when infested on the fruits. Scraping off the pest with a knife or spatula in early season can be effective.

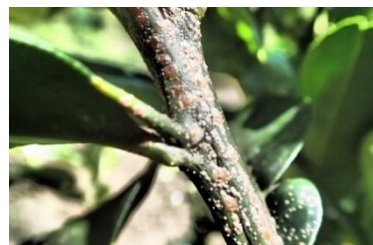
The adult population can be controlled by spraying of 0.1% Dimethoate. It is usually found infested on summer shoots in July. Spray insecticide when summer shoot starts to develop.



**Fruit fly larva**



**Leaf miner larva**



**Adult scale**



## (2) Mid-altitude Citrus

Local mandarins are grown commercially from 800 masl to 1600 masl in Bhutan. However, the incidence of *Huanglongbing* (HLB) disease has severely affected the citrus industry. In the light of the decline of citrus due to greening, ARDC-Wengkhar with support of Agriculture Research and Extension Support Project (AREP-JICA) introduced and evaluated several mandarin varieties, selected, and recommended few varieties for mid-altitude areas (1400 to 1700 masl). This expanded the citrus growing range by about 400m. Greening disease is usually not observed above 1400 masl.

### **Characteristics of variety (altitude 1650 m as reference)**

**AREP-1 (Hayaka):** The variety is produced from a crossbreeding between Satsuma mandarin and Ponkan. The fruit has a flat bottom, coarse and thick peel, and weighs about 160g. Its TSS is 11.0% and citric acid content 1.1 %. The acid content usually drains out fast. The trees are strong and spreading type in nature. The fruits are harvested from late October to mid-November.

**AREP-2 (Tsunokaori):** The variety is moderately strong and spreading in nature. The fruit has a round bottom and weighs about 270 g. Its TSS is 11.5% and citric acid content 1.3%. The peel is smooth and dense in nature. Acidity is high and difficult to remove. It is late maturing variety and harvested only in late January-February.

**Ohta Ponkan:** The variety is vigorous, medium-sized with an upright and slightly spreading habit. The fruit size is medium (150 g) with TSS of 11.5% and citric acid content 1.15%. The fruits can be identified through its oblate nature. The rind is moderately thick and loosely adhere to the main parts of the fruit. It is an early maturing variety and is harvested in late November. If it is harvested late, the fruit becomes puffy but tastes better. It gives good fruiting every year.

**Teisho Ponkan:** The variety is vigorous, medium-sized with upright growing habit. The fruit weighs about 155 g with TSS of 13% and citric acid content of 0.97%. It has a thick and orange coloured rind. The juice content is fairly low and slightly acidic in nature. However, the acidity reduces when it is kept in storage. It is harvested by the middle of December.

**Yoshida Ponkan:** The variety is slightly weaker than Teisho Ponkan and Ohta Ponkan with an upright and slightly spreading habit. The fruit weighs about 180 g with TSS of 13% and citric acid content of 0.9%. It produces large-size fruits which are sweet in taste. The fruits are round with rough rind. The fruits are harvested by the middle of December.

**Ohtsu 4:** It is a hybrid of Satsuma mandarin. The fruit weighs about 140 g with TSS of 11.2% and citric acid content of 1.2%. The fruits have flat bottoms, seedless and have smooth pericarp. The hybrid has good bearing capacity and is harvested by early December.

**Clementine:** The variety is strong with an upright and slightly spreading habit. The fruit weighs about 160 g. Its TSS 11.5% and citric acid content 0.95%. The skin is soft and reddish-orange in colour and is easily peeled off. The fruits are juicy and sometimes seedless. The seeds if present is mono-embryonic in nature and is used for breeding purpose. Clementine trees have a rounded crown formed by the drooping branches. The fruits are harvested by the middle of December.



**Clementine**



**Ohtsu 4**



**Ohta Ponkan**



**AREP 1[Hayaka]**

### **Planting**

Planting method is similar to the local mandarin. Grafted seedlings are easier to manage. Therefore, plant at a short distance of 4.0 m × 4.5 m or 4.5 m × 4.5 m.

### **Pruning, Training and Tree shape**

All mid-altitude varieties are trained on a modified central leader system to ensure uniform light penetration into the canopy. Pruning depends on the growth pattern, bearing habit and canopy structure.

Head back the plant to a height of about 30 cm when the plant grows to the height of 70-80 cm above the ground level. After 3-4 years, retain 2 to 3 main branches when pruning in January and February. Since Ponkan varieties have the upright growing habit, select 2-3 main branches and train them to bamboo posts to encourage lateral growth. Arrange the sub-branches and side branches of each main branches in a well-balanced manner and eventually restrict upright growth. Reducing tree height enhances easy management and fruit harvesting.

Maintain 2-3 strong scaffold branches as the main branches in Satsuma variety too as it has a wide-spreading canopy with wide-angled branches.

Unlike other fruit trees, citrus trees don't require regular pruning. Pruning is limited to removal of unwanted and overlapping branches to allow more sunlight into the tree for more yield. Use a pruning saw initially to remove unproductive branches and use secateurs later to thin out unnecessary tender branches. Prune or thin about 15% of the tree as a rule of thumb.



**Pruned and trained AREP-1 (7 years old)**



**Local mandarin without training and pruning**

### **Fruit management and thinning**

The objective of the fruit thinning is to produce quality fruits and avoid the biennial bearing habit. It is done in three different phases:

- The first thinning is done after the natural fruit drop in early July to remove excessive fruits bearing on a fruiting branch;
- The second thinning is done in August to remove those fruits which are small, abnormal, wounded and upward growing; and
- The third and final thinning is done in September to thin out fruits which are growing attached to branches because these fruits usually have a thick peel and sour taste.

The number of leaves per fruit determines the size and taste of the fruit. In citrus Unshiu, keep about 30 leaves per fruit since the leaves are large. In Ponkans, keep about 80-100 leaves per fruit since the leaves are small.

As a rule of thumb, 15% of the tree canopy should consist of summer shoots for next season fruit-bearing. The first and second fruit thinning should be done by hand and not by secateurs. Summer shoots develop from the spring shoots.

### **Harvest**

Harvest time depends on varieties. However, harvest the fruits when the colour changes to orange. Keep in mind the characteristics of a variety to harvest on time.

- Wengkhar Tshalu I fruits mature one month earlier than local mandarin. Harvest the fruits when they turn 70% orange in colour. Delayed harvest reduces juice content.
- Wengkhar Tshalu II fruits have more citric acid than local mandarin. Harvest them in February and store to remove citric acid.
- Teisho Ponkan and Yoshida Ponkan fruits have less juice content. Harvest them early and store for better taste.
- Ohta Ponkan fruits attain full colour in November but citric acid content is high. Harvest them in late December to January to improve the taste.
- Harvest clementine fruits when the skin becomes soft and turns reddish-orange. Delay in harvest reduces its juice content.

### **Nutrient Management**

Introduced improved varieties are weaker than local mandarin. Therefore, apply more manure and compost during the growth period. Apply 30-40 kg compost or FYM mixed with chemical fertilizers (200-300g of Urea or Suphala) sometime in January to the middle

of February followed by the second split of urea (100-200g) in June for summer shoot development when the rainy season begins.

For proper growth and development, grow leguminous vegetable crops such as beans as an intercrop. Such practices will improve soil texture and fertility. However, take care to avoid injuries to citrus roots as they develop many shallow roots. Uproot weeds and use them as mulching materials to conserve soil moisture.

Stop irrigation water when fruits show signs of maturity. This helps in sugar development.

### **Pests and Diseases**

The mid-altitude varieties are recommended for altitude range of 1400-1700 masl. Therefore, there are fewer chances of citrus greening disease.

Spray Bordeaux mixture in the ratio of 6/6 (Copper sulphate 6g, quick lime 6g, and 1liter water) in winter season annually. Remove dead and diseased branches and leaves annually. There are many insect pests of citrus which cause considerable damages to growth and production. The common pests are fruit fly, leaf miner, aphids, mites, thrips, psylla, scales, and stem borer.

**Citrus fruit fly (*Bactrocera minax*):** Among citrus pests, the citrus fruit fly is the most destructive. It is found widely distributed in the citrus-growing areas and is difficult to control. The scheduled spraying of insecticides, collection and destruction of dropped fruits involving the whole community are solutions to reduce losses caused by the fruit fly. Destruction of the dropped fruits by burial in pits (about 2 m deep) can be more effective.

The pests and diseases and their control measures are the same as that of the local mandarin.

### (3) Pomelo

Pomelo (*Citrus maxima*) called 'Tshangala' in West and 'Solonji' in Sharshop is the biggest fruit among the citrus species. Pomelo is not a priority citrus fruit in Bhutan but few trees can be found growing in home gardens with other fruit trees. Pomelo plant is a vigorous, tall, low branching and a spiny tree which is propagated through seeds. The grafted seedlings develop fewer thorns. The fruit is a special type of berry called hesperidium which is segmented with large, pale yellow or pink pulp vesicles filled with sweet juice. Seeds are usually large and mono-embryonic. The fresh juicy pulp vesicles are eaten and can also be used for the preparation of mixed salads.

Pomelo is slightly tolerant against greening disease. Therefore, it can be cultivated in areas affected by the greening disease. The fruit fly attack on pomelo is also very less as it has a very thick peel. Unlike other citrus varieties, it needs pollinizers for production of optimum yield. Hence, it is planted mixed with 2-3 different varieties in an orchard. Grafted trees are usually planted to produce true to type fruits and the plants come to fruiting within 3-4 years. However, it is important to maintain strong lateral branches to hold the weight of heavy fruits. Pomelo is also used for breeding of new cultivars of citrus. The pomelo varieties planted in ARDSC-Lingmithang have good taste and quality

#### **Characteristics of varieties (Altitude reference below 1200 masl)**

Three cultivars have been introduced at ARDC-Bajo from ARDC-Wengkhar. The varieties are:

**R3-P4:** The fruit is vertically long with smooth and yellow coloured pericarp. It weighs about 700 g. Its TSS is 12% and citric acid content 0.9%. The fruit has high juice content which is less bitter. The plant has small thorns. It is a late-maturing variety and is harvested by the middle of December.

**R4-P5:** The fruits are slightly flat in shape with coarse and yellowish-green pericarp. The fruit weighs about 800 g. Its TSS is 11% and citric acid content is 0.8%. The fruit is less bitter but the quantity of juice is low as it is harvested late. The plant has small thorns. It is harvested from the end of October to the middle of November.

**Banpeiyu:** The plant produces big fruits each of which weighs about 2.5 kg. The fruit has high juice content which is less bitter but sour in taste. The fruits are harvested in December. It is also used in the breeding of citrus cultivars and as pollinizers.



**Banpeiyu**



**R4-P5**



**R3-P4**

#### **Planting**

**Site:** Avoid water-logging condition and select site with proper drainage.

**Spacing:** 5m x 6m, 6m x 6m.

**Pits size:** Dig up pits of 1m x 1m similar to that of the deciduous fruit trees.

**Planting time:** It is recommended to plant pomelo in January and February. It is also planted after the onset of the rainy season.



*Planting on the mound:* Plant pomelo in a mound which is prepared above the pit and about 30cm above the ground. The graft union should not be buried under the soil.

*Basin preparation:* The size of the basin should be equal to the tree canopy. The basin helps to keep the soil surface clean and helps in irrigation and manuring.

*Mulching:* To prevent the growth of weeds around the plant and to retain moisture in the soil, mulch up with locally available materials such as straw, grasses, stubbles, sawdust, paddy husk and other debris.

*Staking:* Stake up plants to prevent lodging.

*Head Back:* Once planted, cut back to about 30 cm from the ground surface.

*Irrigation:* Young pomelo trees need weekly irrigation during the dry season.

*Shoots on rootstocks:* Remove shoots which grow below the graft union since they retard growth and development of the scion.

### **Training, Pruning and the tree shape**

The trees are pruned one year after planting to induce branching. This is done by heading back of the main stem to about 30-40 cm from the ground. Retain about 2-3 branches which are evenly distributed in separate horizontal directions and allow newly sprouting branches to develop. Pomelo tree grows very fast with upright wide-angled branches.

Thin out the crowded branches 2-3 years after planting, and select 2-3 main branches after 3-4 years. Tie them on bamboo posts to get the proper height and spreading canopy. Leave the lower branches up to 8 years and head back summer and autumn shoots annually.



**3 years old before pruning**



**Remove two middle branches**



**3 main branches trained**

### **Blooming and Pollination**

Flowers bloom by the middle of March. Plant two or more pomelo varieties together in an area to get quality fruit production. The flowers which not pollinated usually fall off or small fruits setting. Sometimes, those fruits remain on the tree but do not reach optimum size for commercial purpose.

### **Fruit Management and Thinning**

Flowers are borne on inflorescence and produce many fruitlets. Thin out the fruits when they attain walnut size. Keep those fruits which have good shape. The improper pollination leads to shapeless and small fruits which must be removed. Perform the second thinning when the fruit attains fist size in early July.

### **Harvest**

Harvest pomelo fruits when the skin of the fruits become shiny upon ripening – the oil glands become more prominent and shinier. Generally, they are harvested in December and January. However, the variety R4-P5 is harvested at the end of October. The fruits can be transported to long-distance as they have a hard and thick peel. It can be cultivated in remote sub-tropical areas as farmers can transport the fruits to market with minimum post-harvest damages and losses.

### **Pests and diseases**

All the pests of citrus attack the pomelo plant. These include the common leaf miners (*Phyllocnistis citrella*), leaf-eating caterpillar, and fruit boring caterpillar (*Citripestis* spp.), scales, red mites, fruit flies, nematodes and rats.

The major diseases are root rot, gummosis on the trunk and brown rot of the fruit which is all caused by *Phytophthora* fungi. Both fruits and leaves are also infected by a scab which is caused by *Elsinoe fawcetti*. Bagging of fruits can prevent serious damage due to insect pests and diseases.

The shoots of pomelo emerge earlier than other citrus fruits towards the end of February. The shoots appear depending on temperature till October. The shoots also appear after the rainy season. That is why leaf miner (*Mikan hamigriga*) is an important pest as it gets frequent chance to attack pomelo. The early and timely spraying of insecticides can reduce the damage the pest causes.

Ants often attack the young and tender rootstocks of pomelo during the dry season in March and April. Therefore, frequent monitoring of the pest and spraying of contact insecticides at 0.3% (3ml/litre water) on the trunk if needed is effective.

Scales are another pests. Spraying of 0.1 % Dimethoate for big trees is effective.

#### (4) Lemon and Lime

Lemon (*C. limon*) and lime (*C. aurantifolia*), in general, are heat tolerant as well as cold sensitive. Unlike mandarin, lemon and lime have high acidity, sour taste, and are not suitable to be eaten raw. Today both lemon and lime are gaining popularity in hotels around the country for their multipurpose uses. Although there are high demand and good price for lime and lemon in markets, most of them are imported from India as Bhutan produces very less.

In the country, very good quality lime and lemon are produced up to an altitude of 1000-1500m. Therefore, cultivation of lime and lemon can be promoted for better income to the farmers. Moreover, the cultivars are slightly tolerant against citrus greening disease and can be cultivated in greening affected areas. However, lime and lemon are susceptible to canker and *Citrus Tristeza* virus (CTV). Lime is cold tolerant and can be cultivated up to 1800 m. Lime is also used as an indicator plant for CTV detection.

Pollinizer tree is not required as they are self-fruitful. It gives early production at the age of 2-3 years. However, keep fewer fruits on the tree till 3-4 years to support tree growth.

##### Characteristics of Varieties

**Frost Eureka:** Trees are of medium size, early bearing, and cold-sensitive. The fruit is elliptic to oblong with a moderately protruding nipple at the apex and weighs about 120g. It has a low collar at the base and yellow coloured peel which is slightly rough and tightly clinging. The fruit is juicy with high acid content and good lemon flavour. Fruiting takes place twice in a year. It is harvested from November to March.



**Frost Eureka lemon**



**Fruits on 3 years old lemon**

**Mexican lime:** It is one of the most tender fruits among citrus fruits. The fruit is small with many seeds and each fruit weighs about 20g. The peel is smooth with a yellowish-green colour. It is juicy and has a strong lime flavour. It is sensitive to cold. However, it can be successfully grown in elevations between 1400m and 1600m in Bhutan.

**Local lime:** The fruit weighs about 20g and is juicy with the yellowish-green peel. It is slightly cold tolerant and can be cultivated up to 1800 m.

##### Planting

Plant lime and lemon-like other citrus fruit trees. Avoid places where frost occurs in the winter season as they are susceptible to frost injury (leaf drop). Maintain plant to plant distance of 4m x 4m. Warm and sunny areas are suitable for its growth.

### **Pruning, Training and Tree shape**

Unlike other citrus plants, the growth of lime and lemon are slow and weak. If the trees are left without training and pruning they tend to grow tall and shapeless.

Lime and lemon fruits develop on new shoots which arise from old shoots of spring season flushes. Prune as early as possible after harvesting of the fruits to remove unwanted and dried branches. It is not recommended to prune a tree drastically at a time. Lemon and lime are evergreen trees and is not pruned like other deciduous fruit trees. Pruning must be limited to the removal of unnecessary and overlapping branches to allow enough aeration and sufficient sunshine inside the tree canopy. Use pruning saw initially to remove unproductive branches and pruning scissors to thin out unnecessary and tender branches. Thin and prune about 15% of the tree canopy as a guide.

### **Blooming and Pollination**

Lime and lemon are self-pollinated in nature. Both citrus species bloom twice a year. The first bloom occurs in March to April and the fruits are harvested in October and November. The second blooms occur in June and July and the fruits are harvested in January and March.

### **Fruit Management and Thinning**

Fruit thinning improves fruit quality and prevents the biennial bearing habit of the plants. Fruits are usually thinned after the natural dropping of fruits in June. Especially lemon needs fruit thinning as it has large leaves. The number of leaves per fruit determines the shape and taste of the fruit. Keep about 25-30 leaves for one lemon fruit. The fruit thinning is done from July to October in which the abnormal, wounded, upward growing and excessive fruits bearing on branches are removed. Fruit thinning is not required in lime as the fruits are small but remove the fruits that set after October.

### **Harvest**

At Agriculture Research and Development Centre (ARDC), Bajo and ARDC-Wengkhar, harvesting of lemon starts from December and ends in March whereas lime is harvested from October and ends in April when the fruit colour is yellow. Lime and lemon have a long harvesting period. Do not harvest too late since the fruits will turn puffy with less juice.

### **Nutrient management**

Lime and lemon trees grow slower than other citrus fruit trees. Apply 30-40kg of FYM or compost with chemical fertilizers (200-300g of urea or Suphala) in January or the first fortnight of February. Apply the second split of urea (100-200g) in June for summer shoot development after the onset of monsoon. Apply 100g of urea followed by light irrigation whenever the plant shows symptoms of light green to yellow foliage.

### **Pests and Diseases**

The citrus pests such as citrus fruit fly, citrus leaf miner, citrus psyllid, shield bug, trunk and twig borer attack lime and lemon. The diseases that attack both root and vegetative parts start appearing in the plant after the onset of monsoon.

**Citrus canker:** This is a bacterial disease caused by summer rain with high humid condition together with strong wind. It is a destructive disease that causes leaf spottings, rind blemishing, leaf shedding and premature fruit drop. If left untreated, the fruit quality gets inferior. Apply Bordeaux mixture 7/7 solution in the winter. In the summer, spray once a light Bordeaux solution (copper sulphate 4g, quicklime 5g, and water 1 litre).

**Leaf miner:** Leaf miners mine leaf surface causing white leaf which affects tree growth. Monitor to control insects by spraying the tree with Cypermethrin when new shoots appear particularly from June to September.

**Citrus fruit fly:** Among the pests, the citrus fruit fly is the most destructive. It is found widely distributed in the citrus-growing areas and is also difficult to control. Scheduled spraying with insecticides, collection and destruction of the dropped fruits involving the whole community are the solutions to reduce losses. Destruction of dropped fruits by burial in pits (about 2m deep) can be effective.



## **(5) Kumquat**

In Bhutan, kumquat (*Fortunella japonica* syn. *Citrus japonica*) is mostly grown as an ornamental plant. Kumquat is slow-growing, compact and shrubby that grows to a height of 2 metres. Fruits are small which can be eaten as a whole (eat with pulp). It is rich in antioxidants such as vitamin A, E and C. It has distinct characteristics of having a sweet rind and a bitter pulp inside. Kumquat nectar can be prepared from the fruits. It is good for curing throat pain. The variety Marumi is popular in the country which is not high in cold tolerant. It can be grown in altitudes between 1200m to 1700m. However, fruit produced at higher altitudes has high citric acid content. The trees which are more than 6-7 years bear larger fruits which are sweet in taste.

Kumquat can be propagated by seeds. Seedling trees have many thorns and take several years to fruit. Therefore, grafted seedlings are preferred for early production. The trees are self-fertile and do not need pollinizers to produce fruits. Growing kumquat trees is easy. They need full sunshine and well-drained soil.

### **Characteristics of Varieties**

**Marumi:** The fruit is spherical and weighs about 23g. The peel is smooth and yellowish-orange in colour. The only small quantity of fruit juice can be extracted from the fruit. The harvesting is done in December and January.



**Marumi Kumquat**



**Ornamental Kumquat (One year old)**

### **Planting**

Plant using the same methods as other citrus trees. Kumquats grow up to 2m in height. Plant spacing is maintained at 2.5 m × 3.0 m. They are also planted as the ornamental plant in a fertile soil nearby houses.

### **Pruning, Training and Tree shape**

Pruning is done to shape the tree in a square form and to maintain height. It is also done to remove dead branches and suckers. Pruning is done after harvesting of fruits. Like any other tree, kumquat needs good sunshine and aeration. Plant kumquat trees in the sunny area to produce quality fruits. Select 2-3 strong scaffold branches and remove the rest. Head back long shoots. However, take care of the spring shoots where flowers bloom at the tips and produce fruits. In the grafted kumquat, remove shoots that arise from the rootstock.

### **Blooming and Pollination**

A pollinizer tree is not necessary as it is self-fruitful. The flowers of kumquat bloom from both spring and summer shoots. The flowers from spring shoots are fewer than that from June. Those that bloom in July have many flowers (inflorescence). Flower buds are difficult to see as they emerge with the new shoots. Flower buds are found near the tip of the spring branch that grew in the previous year. Flowers also bloom from weak summer shoots.

### **Fruit Management and Thinning**

Fruit thinning is not necessary for kumquat. Early flowers produce large fruits and those that bloom late are small. Unlike other citrus trees, kumquat flower blooms late. For pot culture, maintain the trees at the dwarf size and maintain only 10-20 fruits per pot. Kumquat plants grown as the ornamental plant in cold places such as Thimphu have to be protected from the cold by covering with plastic sheet.

### **Nutrient Management**

Apply 30-40kg FYM or compost with chemical fertilizers (200-300g Suphala or urea) in January and the first fortnight of February. Apply the second split of urea (100-200g) in June for summer shoot development after the onset of monsoon. Stop irrigation when fruits near maturity stage for sugar development.

### **Pests and Diseases**

Root rot is common in kumquat due to excessive moisture at the root zone. Avoid excessive moisture and maintain proper drainage.

Aphids, spider mites, snails and slugs attack kumquat foliage. Leaf miners and scales are a general nuisance. The pests and diseases incidences are low in a potted plant.

### **Steps to prepare Kumquat Nectar**



**1. Soak in clean water for 24 hours to remove bitterness from the peel**



**2. Drain out water using sieve**



**3. Remove stalk end of fruit using sharp knife**



**4. Cut fruit from top to 1/3<sup>rd</sup> deep for effective mixing**



**5. Add 500-700 g sugar per kg of Kumquat**



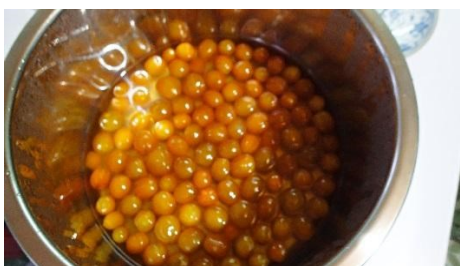
**6. Add 180 ml of edible or apple vinegar**



**7. Fruits cooked on medium flame with constant shaking to avoid burning (use stainless steel**



**8. Pot covered with lid after sugar gets melted. Improper covering deteriorates quality**



**9. Fruits cooked for 30 minutes and kept covered till it cools down**



**10. Sterilization of bottles in oven. Caps are sterilized by boiling in water**



**11. Fruits packed into sterilized bottle up to shoulder and soaked in syrup.**



**12. Heat the packed bottles gently in oven without lid till air bubbles appear on top**



**13<sup>1</sup>. Bottles covered with boiled and dried caps and kept for a minute and then loosened to release air making a noise**



**14. Final product of Kumquat Nectar**

<sup>1</sup>The caps are then tightened again. As the bottles cool down, the internal pressure gets reduced and caps get more tighten. Bottles are then kept upside down for five minutes which is usually practised.

The bottles are sterilized in boiling water if there is no oven. In a pot, keep a clean piece of cloth and place the bottles on it. Fill the bottles with water up to 60% and put the caps loosely. Boil for 20 minutes. The piece of cloth prevents rattling of the bottles in the pot. Caps should not be sterilized using an oven as they are made of rubber. The boiling method is used for sterilizing caps.



## **(6) Loquat**

Loquat (*Eriobotrya japonica*) is an evergreen fruit tree which is grown mainly in the warm temperate regions. It has rather an unusual habit of blooming in the fall and fruits maturing in the spring which makes it one of the earliest fruits to reach markets. It has a high potential for commercialization. Loquat trees are not grown in farmers' field in Bhutan. A few cultivars of loquat were brought from Japan in 2003 for evaluation trial at Agriculture Research and Development Centre (ARDC), Wengkhar, and ARDC-Bajo. The tree bears fruits in 3-4 years after planting but yield depends on the age of the tree. It can be grown in the elevation range of 1600-2000 masl in the hills of Bhutan. However, it is susceptible to frost injury in the winter. On the contrary, at the lower elevation with high temperature, flowering begins in September and fruits start colouring in November and December. Loquat planted at an elevation 1800 masl has advantage as it produces flowers in November and fruit ripens in April and May when no fruits are available in the market during the period. Loquats are self-fruitful. Although loquat fruits are easy to cultivate with less incidence of diseases and pests, the fruits are soft and hence difficult to handle during transportation.

### **Characteristics of Varieties**

Three cultivars of loquat namely Mogi, Tanaka and open-pollinated seedlings are under evaluation at ARDC-Bajo and ARDC-Wengkhar.

**Mogi:** The fruits are slightly small (50g) with deep orange skin colour. The fruit is sweet with a slightly sour taste and the sugar content is about 13%. The fruits are harvested from early April to the middle of April.

**Tanaka:** The fruit is slightly large (85g) with orange skin colour. The acid content remains high until it is ripe. It has cold-resistant and relatively strong. Fruits are harvested in early May.

**Seedlings:** Loquat is mono-embryonic and the open-pollinated seedlings produce different types of fruits. It takes around 6-7 years to come into fruiting. Fruit variations arise when trees are grown from seeds.



**Mogi**



**Tanaka**

### **Planting**

Planting method is similar to other fruit trees. The best time for planting in February and March where irrigation facilities are available. Unlike other fruit trees, heading back of loquat seedlings are not practised after planting. However, staking is necessary for 2-3 years after planting as the plants are shallow-rooted and subject to lodging due to strong wind. Unusually tall seedlings are headed back to 40-50cm from the ground.

### **Pruning, Training and Tree shape**



Loquat trees grow upright and tall when proper training method is not adopted. Central leader or open system is usually followed to train loquat for the first 1-2 years. Annual pruning is done towards the end of May to regulate the bearing habit of the plant. The flowers are borne on the current year's growth and start flowering in November and December and continue until January and February. The major fruiting is obtained mostly from the strong summer shoots (August-September). Always keep strong summer flushes for the following year production and remove weaker flushes. Avoid heavy pruning as it hampers the yield. Remove excessive shoots of young trees in the winter to increase branching. Train the tree into a modified central leader form to maintain desirable tree height. After flowering, thin out upright growing shoots.

### **Blooming and Pollination**

The loquat tree bears a complete flower and is self-fruitful in nature. However, loquat benefit from both self-pollination and cross-pollination. The scented and dull white loquat flowers are borne on panicles at the end of the branch and bloom from October to November. Fruits are harvested in early spring (April to May).



**Flowering from  
October to December**



**Fruit thinning in  
December and January**



**Keeping 3-4 fruits after  
fruit thinning**

### **Fruit Management and Thinning**

Occasionally prune out some branches from loquat tree canopy to encourage good fruit development. Fruits are borne on clusters. Remove flower clusters of September and late clusters of November and December. The clusters can be easily removed by hands. Thereafter, remove small, upright growing and crowded fruits in December and January. As the fruits near maturity, bag fruit clusters with a paper bag (old newspaper) to protect from bird attacks. Alternatively, cover the whole tree with a mosquito net to maintain fruit quality as well as protect from bird attacks.

### **Harvest**

Skin colour is the maturity index of loquat fruits. The skin colour changes from green to yellow or orange when ripe. Harvest the fruits when it is fully ripened (orange colour) on the tree. Handle the fruits with utmost care while harvesting and packaging since they are soft.

### **Nutrient management**

Apply an adequate amount of nutrients to produce luxuriant foliage and a large number of fruits. Loquats benefit from regular application of fertilizers - both organic and chemical fertilizers. Irrigation is crucial during fruit development stage.

### **Plant Protection**

Pests and diseases incidences are low in loquat. However, birds attack ripening fruits. Twig borer is also very common which can be removed along with the damaged branch and destroyed. Red mites are responsible for de-colourization of new shoots which can be

removed by water showerings. It is also important to maintain good drainage in and around loquat planting areas.



**Twig borer**

## **(7) Avocado**

There are more than 20 commercial varieties of avocados in the world. There are three main types of avocado: Mexican; Guatemalan; and West Indian. West Indian types are not cold-resistant and their fat content is low (7-8%). Mexican types are somewhat cold-resistant and their pulp contains about 30% fat.

Avocados are evergreen trees which shed some leaves mainly in the early spring. The grafted trees grow up to five meters high while seedling trees are more vigorous, grow fast and grow more than 5 meters. The avocado fruits have single seeds and come in various shapes such as round, pear-shaped, or oblong and the fruit skins too vary in texture and colour. Avocado is a highly nutritious fruit which is rich in protein, vitamins, fats, and low in sugar. It is relatively cold resistant and can be successfully cultivated up to an altitude of 1600 masl. The agro-climatic conditions in various parts of Bhutan are favourable for commercial production of avocado. However, plantation at higher altitudes gives small fruits due to low temperature.

Bhutanese farmers are accustomed to the taste of avocado as wild avocados are found in the forests of Bhutan up to an elevation of 2000 masl. However, avocado farming is a new farm activity and most farmers know very little about it. At present, avocado is gaining popularity due to its taste and high nutritive value. Among the evergreen fruit tree crops, avocado is now a priority crop among many Bhutanese farmers as:

- 1) Avocado has large favourable cultivation range and can be a potential commercial crop in the sub-tropical regions of Bhutan.
- 2) Demand for avocado in local markets is increasing every year.
- 3) Low incidences of pests and diseases reported in the crop so far.

Although the seedling avocado tree can be cultivated for commercial purpose, it is recommended to go for grafted plants to avoid variations in fruit quality. For effective pollination of flowers and successful fruiting, plant two to three varieties in an orchard.

### **Characteristics of Varieties**

**Hass:** The most popular Mexican variety grown in Bhutan. Hass has a thick, pebbled skin that changes from green to purplish-black as fruit ripens.

**Fuerte:** It is a cross between Mexican and Guatemala varieties. The fruit is pear-shaped with smooth green skin and weighs about 300g when ripen. Fat content is about 25%. It tends to exhibit biennial bearing.

**Bacon:** Fruits are medium in size with smooth skin and mild flavour. The flesh is yellowish-green in colour.

**Zutano:** It is pear-shaped and is easily recognizable by its shiny, yellowish-green skin. It also has mild flavour.

**Brogdon:** It is pear-shaped and dark purple skin with buttery yellow flesh. It is both self-pollinated and cross-pollinated in nature.

**Reed:** It bears large-sized fruits which weigh between 240g and 500g. Fruit skin is thick and green in colour.



**Fuerte**



**Hass**



**Bacon**



**Fruit from seedling tree**



**Small fruit for rootstocks**

### **Planting**

Planting method is the same as that of other fruit plants. Maintain plant spacing as follows:

- 5m x 5 m for grafted plants,
- 6m x 6 m for seedling plants,
- Total plant density of 130 to 180 plants per acre in a triangular layout system.

Avoid windy site for avocado orchard establishment as a strong wind can lodge and damage the tree. Stake individual plant to a strong wooden or bamboo stake right after planting to prevent lodging. Avoid waterlogged conditions as the avocado is highly susceptible to root rot disease. Plant one-year-old seedlings in an orchard and top-work them with desired varieties. Alternatively, allow the seedlings to grow and produce fruits and top work with desirable varieties if the fruits from trees are of poor quality.

### **Pruning, Training and Tree shape**

Most avocado trees are wide spreading with only moderate apical dominance. Nevertheless, they grow very fast and become tall within a few years. Head back the trees to 3-4 main branches. Maintain spacing of 90-120 cm between the main branches for proper aeration and sunlight. Do not pull the branches of avocado trees like in non-spreading fruit trees. However, provide staking to the main trunk to prevent lodging by strong winds.

The tree is productive up to 15 years after which the branches tend to dry out and produce less. Therefore, head back long branches to force young productive fruiting branches. Limit pruning of avocado to the removal of crowded, criss-cross, upright growing branches and shoots, and dead branches to get a good modified central leader canopy.

### **Blooming and Pollination**

Although some cultivars such as Hass can fruit on their own through self-pollination yet plant different types of avocados to ensure cross-pollination and high yield. Flowering usually starts from February through to early March as the temperature rises.

### **Fruit Management and Thinning**

It is not practical to carry out fruit thinning in tall tropical fruit trees. This makes the trees to exhibit biennial bearing habit. Usually, fruit thinning is not done in avocado but heavy fruiting reduces fruit size and quality. Therefore, it is recommended to thin out small and off-shape fruits in July for better quality fruits for markets.

## **Harvest**

It is difficult to judge the maturity of avocado fruit. The time of harvest varies greatly with the cultivar, weather and climatic conditions, and elevations of places where the fruit trees are grown. Under ARDC-Bajo condition, some variety takes about 9 months to mature from the date of fruit set. Early varieties such as Brogdon are harvested in August-September and other varieties such as Bacon, Hass, and Zutano are harvested in October-November. Avoid fruit injury during harvest to prevent fruit rot. Avocado fruit does not ripen on the tree and remains hard in texture. It becomes soft and edible only after harvest.

Mature fruit ripens evenly. Immature fruit does not ripen properly and the skin shrivels eventually. Harvest large fruits first as they are considered as matured. If fruits are kept too long on the tree, the fruits may be blown down by the wind and damaged. After harvesting, fruits are stored in a room at 20°C temperature until they become soft and ripe within one week.

## **Nutrient management**

An avocado tree needs fertile soil to grow and produce quality fruits. In the winter season, apply compost or FYM and NPK chemical fertilizers for both old (NPK 300g) and young (NPK 200g) trees. On the onset of the rainy season, apply NPK chemical fertilizers (300g for older trees and 200g for young trees). Apply various micro<sup>^</sup>nutrients (Fe, Zn, and B) depending on the nutrient deficiency. Apply sufficient or abundant FYM and compost if micro-nutrients sources are not available.

## **Plant protection**

**Trunk borer:** Borers tunnel into avocado trees and feed or lay eggs. The most obvious sign of tree damages by borer insects are the tiny holes they cut into the trunk, branches, and stems. Entry holes are usually visible and sometimes sawdust-like materials called frass are seen on the branches just below the holes and forms a cylinder-like tunnel as the borer excavates through the trunk and branches. Monitor orchards from April to July to manage this pest. Plug the holes with a cotton ball soaked in petrol or insecticide to kill the larvae.

**Fruit fly:** The pest appears during the rainy season and it is recommended to spray insecticide during that time. The larva pupates in the soil after infested fruit drops on the ground. Collect the dropped fruits and destroy them to reduce the pest population over the years.

**Scales (*Pseudaonida spp*):** Scrap off the scales with a knife or hard dry grasses. Spray 0.1% Dimethoate (1ml/liter water).

**Phytophthora root rot (*Phytophthora cinnamomi*):** It is the most destructive disease in avocado. The disease attacks the plant roots which are in waterlogged soil. A fungus causes the root rot. Species of *Pythium*, *Phytophthora*, *Rhizoctonia*, or *Fusarium* fungi are usually the causal organisms. The fungi feed on the feeder roots and cause the death of the trees. Typical symptoms are pale green wilted leaves with brown tips which drop easily. Some important cultivation practices are as follows:

- 1) Manage carefully irrigation water to avoid excessive soil moisture.
- 2) Check drainage system regularly to ensure that there is no water-logging.
- 3) Avoid high-density planting in one place.
- 4) Pay attention to orchard hygiene by pruning out dead wood before flowering and regularly removing infected fruit and dead leaves entangled in the canopy.
- 5) Keep the canopy open by judicious pruning and shaping tree to reduce the severity of the infection.



## **(8) Dragon fruit**

Dragon fruit (*Hylocereus undatus*) is a new crop to Bhutan. There are several commercial varieties: white, red, pink, golden, and mini. Two types of dragon fruit of white and red flesh have cultivated in Bhutan. It contains rich in fibre, D-glucose and other minerals which are known as good for patients suffering from diabetes and high blood pressure. Not only the flesh but also the flowers and fruits skins are edible.

ARDC Wengkhar released pinkish-purple skin (white flesh) type (Wengkhar Gyalwaringatsang I) in May 2017. Red type is still under evaluation at ARDSC-Lingmithang. ARDC-Bajo introduced the white-flesh type (pink skin) in 2016 and found it suitable to grow in sub-tropical areas which are free from frost in the winter. It is now promoted as one of the sub-tropical fruits in the West Central region. The dragon fruit stem is triangular fleshy green and its white flowers bloom from early July. It is night-blooming cactus and is usually self-pollinating in nature but also cross-pollinates. Bats and moths help in cross-pollination. The juicy pulp of the fruit is delicious in taste. Comparatively, it has greater adaptability to poor soil and slightly cold-tolerant up to 3<sup>0</sup>C. Hence, it can be grown up to 1400 m above mean sea level. However, areas with a tropical type of climate with an ideal temperature of 25<sup>0</sup>C to 30<sup>0</sup>C are the best for its cultivation.

Plants from cuttings bear fruits in the second year. Fruits are borne on drooping branches. Both flower bud and fruit can be consumed. Under ARDC-Bajo condition, fruits are produced twice in a year. The first bloom in early June with 20 cm long flowers produce fruits which can be harvested in mid-August. The second bloom in early to mid-August produce fruits which can be harvested in August to September. Fruits are round and long and weigh about 300g. Its TSS is 15%. The pulp is creamy whitish and contains evenly scattered tiny seeds.



**Planting**



**Training in 2<sup>nd</sup> year**



**Matured fruits**

### **Planting**

Plant rooted cuttings in well-prepared pits. Ideally, prepare the pits at least one month before planting. The pit should be about 0.6 m deep and 0.6 m wide. The planting system depends on the topography of the land. However, the square system of planting is widely used in flat land. Plant spacing depends on the training system and the desired plant structure. However, for convenience of intercultural operations, the recommended spacing is 3m between plant to plant and 3m between rows.

Plant the cuttings only after proper development of roots which takes about a year. Plants from cuttings usually start bearing fruit from the second year. Plant the cuttings at a spacing of 3 x 3 m or 3 x 2 m. Plant the cuttings from April to June. However, plant potted plants in any season as long as enough irrigation is provided.

### **Training**

No fixed method of training dragon fruit plants. They can be trained to any system as per growers' convenience. However, a single post trellis system of training is quite common. Train one or two stems on a single upright pole (diameter 15-20cm) of about 1.5m height. Many side branches develop from the main stem which should be tied together with wire and pulled to spread over a square frame (use old tyres) fixed on the top of the post as shown in the picture. Pruning is done to cut off lateral branches to encourage upright growth in the first year. Remove the dead and diseased branches to maintain proper sanitation and thin out crowded branches.

### **Blooming and Pollination**

Flowering starts in early summer when the night temperature reaches about 25°C in July. The flower blooms at night (8-9 PM) and pollination generally occur in the early morning after which the flower wilts by mid-morning. Under ARDC-Bajo condition, the flowering starts from 5<sup>th</sup> July to 10<sup>th</sup> July. The fruit matures 40 days after the flowering. The second blooming starts from around 10<sup>th</sup> August and produces fruits which are harvested in late September. It is a self-pollinated plant.



**Blooming at night**



**Fruit setting stage**



**White fruit pulp**

### **Fruit Management and Harvest**

Fruit thinning is not practised. Dragon fruit plant bears fruits during the summer season. The first fruits are produced from the past season stem and the other ones from the flowers on the spring (March-April) sprouted shoots. Flowers bloom on the upper side of fleshy stem and on tips of branches. The fruits remain small and green for 25 days. As green fruit starts to change its colour to pink, the whole fruit turns pink within a few days and fruit size increases. Subsequently, after 15-20 days the fruits are ready for harvest. Fruits can be harvested from August till October. When the fruit is matured, it is soft and tip of the fruit shrinks. To avoid fruit cracking, harvest as soon as it is ripened. The fruits can be stored for about a week.

### **Nutrient & Water management**

Dragon fruit requires the judicious application of fertilizers and manures for proper growth and high yields. However, incorporation of about 20 kg of well-decomposed farmyard manure or compost at the time of planting and annual top-dressing with well-decomposed manure is necessary. Inorganic fertilizer is not required unless deficiency symptoms occur. Dragon fruit is a member of the Cactus family and, compared to other fruit crops, it can absorb atmospheric moisture. However, their root system is distributed at the top 15-30 cm of the soil and thus irrigation is crucial to ensure adequate soil moisture especially during the dry periods.

### **Plant protection**

Insect pests are not a major concern under Bajo conditions. However, some diseases such as anthracnose, brown spots on stem and fruit rot can sometimes be a problem in the wet

season. Hornet bees were observed feeding on damaged fruits, and fruits crack if harvesting is delayed. Therefore, harvest fruits on time to prevent cracking and damages by hornet bees. There are high chances of sunburn effects on the stem in places such as Bajo where rainfall is scarce and sunshine strong.

## **(9) Passion fruit**

There are two types of passion fruit (*Passiflora. spp*): purple and green. Purple type is mostly grown at high altitude region where there is no frost in the winter. In Bhutan, passion fruits are grown in elevation from 300-1800 masl. It can be grown under a wide range of climatic conditions. Passion fruit is a vine that grows vigorously like kiwi and grapes. It produces fruits within a year after planting.

It can be propagated through both seeds and cuttings. Prepare and plant semi-hardwood cuttings with 3-4 nodes in March. The vines are grown not only for fruits but also to provide shade in resting place nearby residential areas by properly training the vines on a trellis. The fruit contains folic acids, minerals and pectin fibres that helps to cure constipation, especially in pregnant women.

### **Planting**

For ideal growth and development, 1 m<sup>3</sup> pit size is recommended. Fill up the pits with soil mixed with well-decomposed farmyard manure. Passion fruit vines prefer slightly acidic soil with 5-6 pH. Plant rooted cuttings in March and April. Plant about 20-30 cm above the ground by making a mound of soil. Mulch up with grasses and other materials to prevent the growth of weeds around the plant and to retain moisture in the soil. Stake up the plants to guide the plant to grow upright to about 1.8m height.

### **Training and pruning**

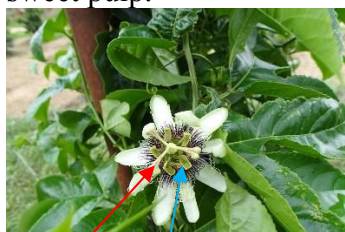
Passion fruit plant can be grown in the backyard of a farm. Passion fruit plant consists of woody vines that require supporting frames such as wooden or bamboo or iron posts and wires which are 1.5 to 2m above the soil surface. Many side branches develop from the main stem. However, select 2-3 strong vines and allow them to grow over the trellis. In January and February, thin out crowded side branches to encourage lateral fruiting.

### **Blooming and Pollination**

Under ARDC-Bajo condition, flowering starts from May followed by fruit settings. New shoots bearing flowers keep on appearing until October. Passion fruit flower has both male and female parts but the stamens are borne below the pistil which makes it difficult for pollination to take place naturally. However, it is not a problem in Bhutan as pollinating agents such as bees, butterfly, and so on do the job.

### **Fruit Management and Harvest**

Passion fruit takes about 2-2.5 months after flowering to mature. The fruits are round (20-25cm diameter). It is slightly purple in colour. The fruit quickly turns from green to deep purple (or yellow) when ripe and fall down onto the ground within few days. Harvest fruits along with a small portion of stem/pedicel and store them for several days until the rind becomes wrinkled but the pulp remains in good condition. Fallen fruits on the ground can be collected and consumed. The fruits are generally eaten by cutting with a knife into two equal halves and scooping out the pulp using a spoon. The ripened fruits have soft and sweet pulp.



**Pistil      Stamen**



**Fruiting**



**Attaining maturity**

## 6. Others

### (1) Watermelon

Unlike other fruits, watermelon is not produced on a tree. It is a plant which is cultivated like vegetables but eaten like fruits. It is believed to be originated from Africa where there are large dry areas. It prefers high temperature with good sunshine and does better in dry areas. Therefore, it is recommended to cultivate watermelon in areas which receive good sunshine. In Bhutan, watermelons are mostly cultivated in open fields which makes it difficult to produce good quality watermelon above 1500 masl.

There are numbers of watermelon varieties in the country. Select varieties which are easy to transport on rough roads of Bhutan. In areas below 1000masl, sow seeds from the end of January to the first week of February and for areas above 1000masl, sow seeds in mid-February.

Cultivate watermelon in the dry season. The flowering and fruiting period should be completed before the onset of the monsoon. Pumpkin beetle and fruit fly infest watermelon severely after the onset of monsoon.

Watermelon (*Citrullus lantatus*), a popular dessert vegetable, belongs to Cucurbitaceae family (gourd family) which includes pumpkin, squash and cucumber. It is a warm-weather crop. Watermelons vary in shape from globular to oblong. External rind colour varies from light to dark green and maybe solid, striped or marbled. The pulp colour of most commercial varieties is red. The fruit is generally eaten raw. Fruit size varies from 2-15kgs depending on a variety. Watermelon contains:

- Water (93ml/100g edible portion);
- Carbohydrates (5 mg);
- Calcium (8 mg);
- Phosphorous (9 mg);
- Ascorbic acid (8 mg); and
- Vitamins (0.64 g) per 100 g of edible portion.

Watermelons need five things to grow and produce fruit:

- Sun,
- Water,
- Bees,
- Nutrients, and
- A lot of space.

They thrive in sandy or sandy loam soil. Give each plant at least 1.5-2 meters of space as the vines spread rapidly. Although watermelon produces both male and female flowers, hand pollination or pollination by honey bees is needed for the watermelon blossoms to produce fruits. Watermelon can be successfully grown in fields, greenhouse and poly houses. Farmers can make good profits from the cultivation of watermelon if they follow proper cultivation methods and management practices.

There are many watermelon varieties in the world but major ones introduced in Bhutan are Kabuki, Sugar Baby, and Black Ball. All varieties of watermelon share distinctive features of mouth-watering, thirst-quenching, sugary flesh encased in a solid rind. Some watermelon types have higher sugar content and are sweeter and some varieties have different coloured rind and flesh.



### **Important Cultivation Points**

- Do not cultivate watermelon consecutively for 5 years in the same field;
- Make the soil fertile by adding well decomposed FYM/compost every year before planting;
- Pinch off the main shoot when it has 6-7 main leaves to produce 4-5 side branches;
- Harvest the fruit in time; and
- Production and harvesting of fruits should be completed by April or May to reduce damages from pumpkin beetle and fruit fly.

### **Climate**

Watermelon is a warm-season crop grown in the subtropical region. It is sensitive to cold and even a mild frost can severely damage the crop and considerably reduce the yield. The watermelon prefers dry weather with full sunshine for quality fruit production. The favourable temperature for watermelon production ranges from 18°C to 35°C. Cool night and warm days are ideal for the accumulation of sugar. Seeds germinate when the temperature is higher than 18°C. The heavy shower or high humidity during vegetative growth makes the crop susceptible to many fungal diseases. Watermelon is successfully grown at an elevation below 1500 masl.

### **Soil**

Watermelon crop can be grown successfully in well-aerated sandy or sandy loam soils and clay soil with good organic matter. The ideal pH range is 6.0 to 7.5 for watermelon production.

### **Field Preparation**

Prepare the land by clearing all vegetative cover and plant debris. Avoid using the same field where other cucurbits were planted. Incorporate about 9 tons of well-decomposed organic matter or manure in an acre of land. In one acre of land it is estimated to have about 900 mounds. Apply about 10kg of fully decomposed compost or FYM to each mound. After soil pulverization, prepare mounds with 15cm height and 70cm diameter. The spacing of the mounds should be about 1.5 to 2 meters apart.

### **Nursery Management**

Select seeds of high yielding varieties. Watermelon seeds need special care during germination as the embryo is enclosed in the hard seed coat. Temperature and moisture control is important as too much moisture during germination can kill the seeds. Under ARDC-Bajo condition, the best time to sow watermelon seeds is mid-February to early March in greenhouses so that the fruits can be harvested at the beginning of the summer season.

Direct seeding or sowing in the field give very low success because it is difficult to control or predict outside climatic conditions. Therefore, raise seedlings under a protected condition. For one acre of land about 1500 watermelon seeds are required. In one acre of land about 1300 seedlings are required. Sow seeds in the first week of February. Sow seeds in a group of 2-3 at 2-4 cm depth in a container (poly pot). Seedlings are later thinned to 1 per poly pot and transplanted when 10-14 cm high. Watermelon seeds germinate in about 7-8 days. Transplant watermelon in mid-March through early April. Transplant and water the seedlings as soon as possible after they have been taken out of the nursery. Keep the seedlings in cool and moist shed before transplanting. The crop can be harvested from the first week of June to early July.

### **Transplanting**

Watermelon can be either direct sowing or transplanted after the nursery period. When direct sowing, sow 2-3 seeds in each mound after adequate irrigation. Cover the mounds with plastic sheets (plastic caps) after the seeds are sown to increase temperature and maintain moisture for germination. This also protects the plants from leaf-feeding beetles during the seedling stage until they are removed. The plastic sheets are covered on the bamboo splits formed into conical shapes. Cover the open ends with soils to prevent from wind blowing away the plastic sheets. The plastic should have some breathing holes to regulate temperature.

To transplant seedlings, dig holes of 30cm wide, 30cm length and 10cm deep (do not plant too deep). Use of seedlings not only reduces seed cost but also ensures 100% seedling density. Keep the soil moist after transplanting. It is recommended to have an irrigation schedule because the fruits become stressed when irrigation water pattern changes which in turn affects the fruit development and the spray program.

When transplanting, remove the seedlings from the poly pots with the soil and without damaging the roots. Irrigate the nursery seedlings a day before actual transplanting. After transplanting provide plastic cape-like in direct sowing method.

### **Cultural practices**

#### **Weeding**

During the seedling stage, young plants are very sensitive to weeds which compete for water, nutrients and sunlight. Therefore, three to four hand weeding and earthing up may be necessary depending upon the weed pressure. While hand weeding, take care not to damage the roots. A weed-free condition is necessary until the plants have reached the root or bulb formation stage.

Mulch watermelon vines to keep down the weeds and conserve moisture but do not apply mulches until the soil is thoroughly warm in the initial stage. Straw, sawdust, crop residues are the best mulching materials to use.

#### **Intercultural Operation**

After germination, check the breathing holes and prick more holes if required. Open the plastic in a very hot day and cover again in the evening when the temperature falls. Remove the plastic cover when the seedlings reach 5-6 leaf stage. Retain one or two healthy seedlings per mound if direct sowing. Pinch off the apical shoot when the vine reaches about 1m to encourage side shoots to grow. Apply urea top-dressing to promote healthy branching.

Once flowering starts, lay straw or dry grasses between the mounds so that the flowers and fruits do not come in direct contact with soil and lead to fruit rot. These materials also retain soil moisture. For better and uniform size and yield, allow only three to four fruits per plant or vines to develop. Remove fruits below the 12<sup>th</sup> node and retain one fruit between 12<sup>th</sup>-17<sup>th</sup> nodes. This practice gives a significantly higher yield. Remove diseased, off-shaped and damaged fruits during the initial fruit setting.

#### **Nutrient Management**

Apply both manure and fertilizers to watermelon for a good yield. Incorporate about 8-9 tons of FYM and compost per acre in the soil during land preparation. Apply N-P-K at 80-40-15 kg per acre. Apply half the nitrogen and full phosphorus and potassium during mound preparation or before planting. Apply the balance half of nitrogen about one month after planting. Thoroughly mix the fertilizer with the soil before planting or sowing.

### **Water Management**

Watermelon requires a lot of water. Keep the soil evenly moist but not wet. Water must drain freely from the bottom. When growing watermelon in dry areas needs watering the plant every day. Critical stages of the plant when moisture stress is most harmful are:

- Before seedling emergence;
- At early bloom and during fruit set; and
- Once fruits reach the size of a tennis ball, water use can triple in a matter of a few days.

Melons can have extensive root systems depending on the irrigation system and extract the water to a depth of 60 cm. However, melons can be very sensitive to water stress during fruit fill. Avoid both overwatering and under watering to get the sweetest melons.

### **Plant Protection**

The common insect pests which affect watermelons include cutworms, cucumber beetles, aphids, thrips, and fruit flies. Cucumber beetles are the most destructive of all. Some cultural practices reduce potential injury by certain insects. Planting of watermelon under optimum growing conditions ensuring rapid seedling growth, for example, minimizes the period when plants are vulnerable to injury from seedling insect pests such as cutworms and beetles. Under Bajo condition, seeding in mid-February, transplanting in late March, and harvesting by mid-June and early July escape the periods when many insect pests damage the most. In general, insect pests can be controlled by the following:

- Control beetles by spraying Malathion 50 EC 1ml/litre of water two to three times in a month during vegetative growth;
- Collect and destroy all affected fruits;
- Cultivate watermelon in the dry season. Fruit flies are fewer in the hot or dry season and many in the rainy season;
- Plough the field after harvest to expose the pupae;
- Spray Dimethoate @0.5ml/litre of water as foliar spray whenever necessary;
- Manage aphids, thrips and whiteflies by keeping out weeds, crop rotation, and use of recommended insecticides in severe cases.
- Treat seed with fungicide (Thiram) to repel mice and rats from destroying watermelon seeds in the field.



**Pumpkin beetles**



**Aphids on dorsal side of leaves**

Diseases that affect watermelon are similar to those of pumpkins. The following are some of the common diseases:

### **Bacterial Wilt**

Bacterial wilt causes runners to wilt and eventually causes the entire plant to die. It is transmitted by cucumber beetles feeding on the young watermelon plant. Prevent the disease by controlling cucumber beetles with foliar insecticides.

### **Powdery Mildew**

Powdery mildew affects only the leaves causing white and powdery mould on the leaf surfaces. Control it with fungicide sprays.

### **Sunscald or Sunburn**

Sunscald (sunburn) damage is caused when the rinds are exposed to intense sunlight. Sunscald lowers quality by making the melons less attractive and may also cause them to rot. Buyers usually do not purchase watermelons with sunscald damages. Sunscald can be prevented if the plants develop and maintain a leaf canopy that shades the melons from direct sunlight. Sunscald is more serious among darker coloured varieties such as Sugar Baby, Kabuki and Black Ball.

***Do not cultivate the same crop in one plot every year. Rotate crops to avoid insect pests and diseases. Keep a minimum gap of at least 4-5 years.***

### **Harvest**

Depending on the variety and climatic condition, watermelon can be harvested 80 to 120 days after transplanting. Watermelon fruit cannot be pulled off the vine easily. Cut off the stems with secateurs or sharp knife. Do not pull or twist the fruit from the vine. This can result in breakage or removal of rind tissue which is likely to decay. Therefore, keep about 2-2.5 cm long stem to prevent from stem-end rot. Pick the fruits carefully and place them in rows in the field before they are transported to prevent from breaking. Put the fruits of small-sized cultivars (less than 5 kg per fruit) in strong harvesting trays and carry out of the field. Handle watermelons gently to avoid cracking and bruising. Handle properly large watermelons as they easily break. Also, do not pick wet fruits. Stack harvested watermelons on the stem end or blossom end during transport. The internal flesh is more at risk of damaging from shaking if the fruit is stacked in this manner.

### **Harvest Maturity Indices**

There are several methods to assess the maturity of watermelon. However, there is no single concrete recommendation to follow. Apply all the following methods to ensure that fruits are harvested at the correct stage:

#### **i. Tendril colour change**

It is small curly stem attached to the fruit stem slightly above the fruit. As the fruit matures and ripens, the tendril wilts change from a healthy green colour to brown and dry up.

#### **ii. The ground spot (the portion of the melon resting on the ground) colour change**

The portion of the melon resting on the ground changes colour from pale white to a deep yellow as fruit matures. The side and top of the watermelon surfaces change from glossy to dull.

iii. **The dull or hollow sound**

It is also determined by thumping or tapping with a knuckle or fingers on the fruit. Matured fruit will sound dull or hollow whereas immature fruit will give a metallic ringing sound.

iv. **Destructive method**

The fruits are cut in half lengthwise and the entire flesh should be uniform red to dark red (unless it is a yellow flesh type). In addition, the flesh of matured fruit should be firm, crisp, and free of hollow heart. Immature melons have pink coloured flesh and over-matured ones have reddish flesh. A fruit with a lot of white seeds is not mature and not ready for harvest.

v. **The soluble solids (SS)**

The soluble solids (SS) content (sugars) of the juice is another commonly used measurement of harvest maturity. SS content in the centre of the fruit of at least 10% is an indication of good maturity. The SS is determined by squeezing a few drops of juice on a hand-held refractometer.

vi. **Recording date from Ping-Pong size**

The technique is rather difficult for commercial production but it is very effective in small scale production. When a watermelon fruit reaches ping pong ball size, the date is recorded and tagged (write the date on a label stick and place nearby the fruit). The fruit will be ready for harvest 35 days after reaching ping pong ball size depending on temperature.

**Post-harvest Management**

Clean any soil on the ground spot area or the other surface with a soft cloth or cotton gloves at the time of harvesting. Watermelons are graded according to external appearance. Fruit shape should be symmetrical and uniform in size. Though there is no standard grading system, grade them **small (<4kg)**, **medium (4-7 kg)** and **large (>7 kg)** based on fruit size and shape for local markets.



**Capping seedling using plastic**

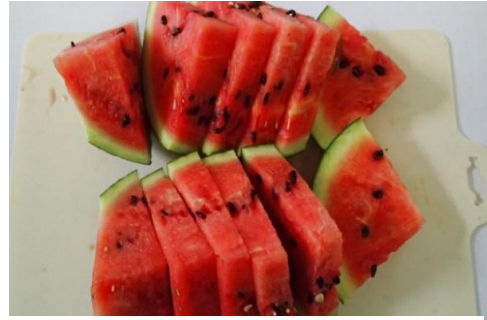


**Grading of watermelon into different size**





**Top and bottom parts removed  
and divide into four equal parts**



**Cut into slices for easy  
consumption**

## **(2) Strawberry**

Strawberry is produced on a small scale in Bhutan and the quality of fruit is not that good. With the change in the dietary habit of Bhutanese, consumption of the strawberry is becoming popular.

Flowering and fruiting of strawberry start only after the plant undergoes vernalization. The short-day condition and low temperature after the end of the rainy season generally lead to vernalization. Under Bajo condition, the temperature decreases drastically in December whereby the plant stops the growth and enters dormancy. This aspect plays an important role at Bajo where day temperature is optimum for flowering and fruiting.



**Flowering continues for 4 days**



**Fruits (red) ready for harvest**

Growth starts when the season changes based on elevation. It is very important to understand the climatic condition of an area for cultivation of strawberries. For instance, despite the growing same variety in Wangdue and Paro, flowering and fruiting season differ in the two places. The peak fruiting season at Bajo is from February to March. At Paro, the plants start flowering only from March and the peak fruiting season is from May and June.

### **Nursery Raising**

After the harvesting season is completed in June and July, the runners develop and form roots. Under Bajo condition, the runners are cut in August and seedlings raised in poly pots. The seedlings from the runners differ in size. The seedlings of the runners which are close to the mother plant are bigger than the runners farther away. The seedling from the runner close to the mother plant is too big for potting and the one towards the tip is small due to poor root formation. Hence, the second, third and fourth seedlings from the runners are preferred for potting.

Select the seedlings which have 4 to 5 leaves. Cut the runner 2 cm away from the plant. The 2 cm cut runner forms the mark for sowing seedlings. The flowering takes place in the opposite direction of the cut runner. Keep the cut portion of the runner inside the bed and not towards the ridge. Do not plant deep. Irrigate after transplanting and cover by a net. Covering by a net provides shade, prevents moisture loss and reduces transplanting shock. If a net is not available, keep the potted plants below trees to provide shade. Once the plants have established properly, take them to a sunny area. Strawberry becomes weak in a dry condition as well as in a waterlogged area. Irrigate frequently with less quantity of water.

In subtropical areas, seedlings do not get the required temperature for vernalization. Therefore, the potted seedlings are taken to high elevation areas and kept for 4 to 5 weeks. When the vernalization process is completed, the seedlings are planted in low elevation areas for early flowering and fruit production.

### **Land Preparation**

Select fertile land which receives good sunshine. Prepare the land 3-4 weeks before planting. Incorporate or plough an insufficient quantity of well-decomposed FYM or compost. Prepare beds of 80cm breadth and 15-20 cm height. Keep 50-60 cm between the beds for easy weeding and carrying out other cultural practices.

### **Transplanting**

Maintain 30cm spacing between each plant. Plant seedlings in two lines. Do not plant the seedlings deep into the soil. Make sure that the crown of a seedling is kept above the soil surface. The deep planting leads to crown injury, rotting and slow growth of new shoots which hinder uniform growth of the plants.



**Potted seedlings with a runner**



**Transplanted seedling**

When the potted seedlings are planted above the required level of the soil surface, root growth and development slow down which in turn delays the plant growth. The flowers are borne opposite to the cut runners and hence the seedlings are planted in such a way that the cut runners are aligned towards the inner side of the bed and not towards the ridge. The fruiting takes place on the side of the ridge. Therefore, keep more walking space between the rows.

The fruiting bud is visible at the time of planting. Plant the seedlings such that the buds face the ridge. Remove the old and diseased leaves from the seedlings before planting them. Irrigate frequently to prevent the soil from drying up.



**Straw mulching**



**Black plastic mulching**

In a warmer area, the growth takes place from December to February followed by flowering. When strawberry is planted in October, irrigate frequently to prevent the soil from drying up. The temperature is quite high in October and November which favours the development of the root system. Therefore, take proper care of the plants.

Top dress with Suphala 20g one month after the transplantation between plants. Try to avoid direct contact of the fertilizer with the roots and plant parts. Irrigate the crop and mulching with paddy straw or dry grasses.

### **Plant Protection**

Mulching with dry grasses and paddy straw is mainly to produce clean fruits, control weeds, conserve soil moisture and maintain temperature. Remove the dried and damaged leaves and clean the base of the plants at the time of mulching. Remove winter weeds and keep the field clean.

Aphid and anthracnose are the major pest and disease of strawberry at Bajo which is warm in the winter. Spray Dithane (0.1%) to control anthracnose and spray Malathion and Cypermethrin (0.1%) to control aphids. Birds are also the major pest of strawberries in Bajo. Use mosquito net or swapping net to cover the plant/fruits.

### **High altitude strawberry cultivation**

The cultivation practices of strawberries are the same in all locations. The only difference is planting time. In higher elevations such as Paro and Thimphu, planting should be done in September to avoid dormancy. Strawberry is cold-tolerant and survives even in the winter. In the cold season, the growth of the plant stops but need frequent irrigation to prevent dryness. In areas where snow or frost are the major problems, cover the plant with straw and dry grasses to prevent from frost injury.

Winter weeds are an issue even in the cold season, so timely weeding is important. When the temperature increases from the beginning of February, the growth and development of the plants start. Top dress with Suphala at 20g per decimal and mulch to enhance growth and development for better production.

### **Blooming and Pollination**

Strawberry needs proper pollination by insects without which fruits are small. Insects help to pollinate strawberries and produce quality fruits. Bee is the most important insect for pollination. In one flower, there are about 200-400 pistils all of which need to be pollinated to have bigger fruit with proper shape. Flowering takes place continuously for 3 to 4 days.

The fruits produced in December and January are deformed and of low quality as the population of bees decrease due to cold temperature. The temperature increases from February whereby the movement of the bees increase and help pollination. This helps to produce quality fruits.

### **Harvest**

Harvest the crop when the whole fruit becomes red. Harvest the fruits gently to avoid injury since the pulp is soft. Strawberry do not ripen after harvest, unlike grapes, watermelon and loquat. Therefore, eat or sell the fruits immediately after harvest.

## 7. Fruit nursery

### (1) Temperate Fruit Tree Nursery

National Seed Centre (NSC) is mandated to produce quality and certified seeds and seedlings of recommended and released or notified varieties. However, with increasing demand for quality seedlings, many private nurseries are establishing fruit nurseries. Nonetheless, there are no standard nursery production practices to produce high-quality seedlings. Hence, ARDC-Bajo with support of JICA Technical Cooperation Project (TCP) Integrated Horticulture Promotional Project (IHPP) works on development and promotion of fruit crops in the West Central region of Bhutan. Building capacity of researchers, extension, and farmers to produce quality seedlings is one of the major outputs of the project. The project adopts Research Outreach Program (ROP) wherein systematic training, demo-orchard establishment, Focus Village orchard establishment, nursery establishment, and direct support are major components of the project.

At present lack of quantity and quality planting materials for fruit crop development in the region is one of the major constraints. Moreover, the costs of planting materials produced in private farms are unreasonably high and not affordable. Therefore, planting materials required for the project are developed in the research stations to build the capacity of researchers and extension supervisors through on the job training. Nursery establishment, operations and maintenance technologies and mother planting materials are transferred to private nursery operators to enable them to produce quality seeds and seedlings for the market. Moreover, experiences of JICA Experts working in nursery development and production of quality planting materials can be transferred to nursery operators, extension staff and researchers through this manual.

#### a. Basic requirements of fruit nursery

##### **Mother trees block (bud wood/scions production)**

A nursery should have a permanent block of different types of mother plants for further multiplication. These plants should be true to type, heavy bearer with standard quality, fruit tolerant to abiotic stress, healthy and free from diseases. Label the plants correctly indicating botanical name, family name, and local name for identification. Maintain high-level field sanitation in the mother blocks. Maintain about 2-3 plants per variety. Some of the recommended fruits are: pear (*Yakumo*, *Chojuro*, *Kosui*, and *Hosui*); persimmon (*Jiro*, *Fuyu* and *Zenjamaru*); peach (*Beauty Cream*, *Kuratake*); plum (*Soldum*, *Ohishiwase*, *Honey Rosa*), and kiwi (*Wengkhar Yellow*, *Wengkhar Green* and *Hayward*) with a male.

##### **Rootstock and seed production block**

After the establishment of the scion wood bank, the next priority is the establishment of rootstocks. Propagation through seeds is the most common practice for mass production of the rootstocks. A rootstock seed parent tree should produce seedlings that are uniform in size, vigour, and with qualities which make a seedling a good rootstock. Preferably, fruits for seeds should all mature at the same time for easy harvesting.

The seed block has to be a permanent block nearby the nursery area. The trees that are sources of seeds should be productive. The seed should have a high percentage of germination. Maintain basic information about the progeny.

Most rootstock seeds are sourced from local cultivars. However, there are improved rootstock cultivars for pear, persimmon, peach, plum, apricot, and citrus. Walnut rootstocks are mainly hard-shell walnuts. In citrus, most common rootstocks used are USDA trifoliate,



Rangpur lime and local citrus. For others such as Kiwi, guava, and avocado, extract seeds from available fruits in markets. For grape plants, cuttings from the rootstock variety (5BB) are used as the rootstock.

### **Irrigation**

The mother trees (scion and seed block) orchard should have a good supply of irrigation water to enable healthy growth and development of the trees.

### **Importance of root-stock**

Rootstock plays an important role in the propagation of plants. It is important for plant adaption in various soil condition, fit to various climate, resist disease, increase production, hasten or prolong maturity, change colour of fruit, change flavour of fruit, increase or decrease life of fruit tree, affect fruit flavour, increase size of fruit, develop vigour, affect salt tolerance and influence storage capacity.

### **Rootstock seed extraction process**



**Pear seed extraction**



**Dry seeds under the shade**

### **b. Peach**

Peach seeds are collected in August. Harvest matured fruits and remove seeds. After removing the seeds, wash properly and dry under shade. When the outer cover has dried, pack in a plastic bag and store in a refrigerator. Peach seeds need stratification for uniform germination. The best place for stratification is at an altitude of 2,000 m. Do stratification at low temperature in November. Stratify peach seeds in a pit with layers of sand for one month before sowing, and plant in early February when 70% of the seeds germinate. Sow or transplant the germinated seeds in February and March.

Plant the germinated seeds in the nursery bed. Peach seedlings are vigorous and reach graftable size within one year. Make sure that the seeds are not affected by the fungus during storage. If the fungus infection is observed, wash the seeds with mineral water, dry under the shade, pack and store again in the refrigerator.

### **c. Persimmon**

Local persimmons grown in Bhutan are mostly round and flat type. Seeds extracted from local persimmon are of inferior quality and have poor germination. The other type of local persimmon, though small, oval and pointed at the tip has better quality seed with good germination rate. Therefore, select such types of fruits to extract seeds. However, the number of seeds on average is about 3 per fruit.



**Japanese rootstock variety**



**Washed seed after extraction**



**Packaged and stored in refrigerator in semi-dry state**

Due to difficulties in getting quality persimmon seeds, ARDC-Bajo and ARDC-Wengkhar have planted few trees of Japanese rootstock variety as the sources of rootstock seeds. The variety produces about 7 seeds per fruit on average.

Extract seeds from persimmon fruits when they are ripe and firm. Do not let the fruits rot to extract seeds since it creates room for fungal infection. Extract the seeds, wash them thoroughly to get rid of any sugar taste, dry them properly before the seed coat begin to shrivel. After drying for about two days in a shade, soak them for about 2-3 minutes in fungicide solution 0.5%, rinse 2-3 times with mineral water or distilled water, and dry in the shade with good air circulation. Pack the seeds in airtight plastic and store in the refrigerator. Check every week for fungal infection. Persimmon seeds are sown in early April under ARDC-Bajo condition.

Germination takes time after sowing due to the hard seed coat. The nursery soil should be fine to facilitate germination. Unlike other deciduous fruit plants, persimmon seedlings grow slowly and take about two years to attend graftable size.

#### **d. Kiwi**

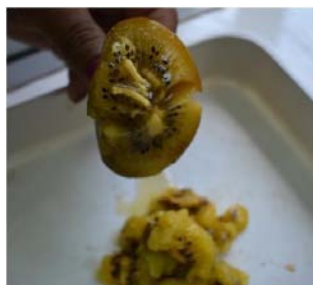
To raise kiwi rootstocks, collect seeds from matured fruits. Cut a matured fruit into the half with a sharp knife. Scoop pulp with a spoon and put in a clean container. To separate seeds from the flesh, take out the pulp in a cloth bag or net (a piece of mosquito net) and squeeze under running water until only the clean seeds are left. Dry the seeds in a shade with good air circulation. Pack in zip-lock plastic or airtight container and store in a refrigerator. Check for fungal infection every week. Sow kiwi seeds in the nursery in early April. Since the kiwi seeds are very small, sow them in lines on a finely prepared nursery bed preferably in a wooden nursery box. Irrigate the nursery to avoid the dry condition.

Allow the seedlings to grow in the nursery for about a year and transplant them in the nursery block with a spacing of 20cm between seedlings. When the seedlings reach pencil size, graft them from December to March by using side veneer grafting method.

Kiwi plant consists of vines that need support. Provide support with bamboo poles in the nursery to prevent the vines from falling on the ground. Tie a single shoot to the post or stake to the height of about 1m. Do not allow the main stem to wind around the post. Plant the grafted seedlings in March in the field.



**1. Cut a fruit into equal half**



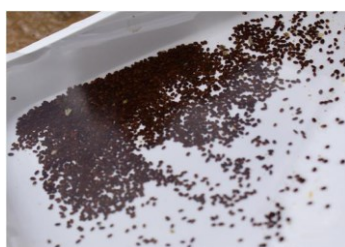
**2. Squeeze fruit to extract seeds**



**3. Use net bag to separate seed and**



**4. Wash in clean water to remove pulp**



**5. Remove floating seeds and keep those that sink**



**6. Dry the seeds in shade**

Seeds from wild kiwi are not recommended for rootstocks as its growth is not vigorous.

#### **e. Walnut**

Both local and soft-shelled walnut seeds can be used to raise seedlings for rootstocks. However, local hard-shell walnut seeds are mostly used as rootstock. Local walnut trees grow in the forest of Bhutan at an elevation about 1700masl and above. Collect the seeds in September and October from healthy mother plants and stratify them for better germination. Sow the stratified seeds in February and March in nursery beds which are prepared by mixing soil and FYM. Once the rootstocks reach pencil size thickness, graft them in March and April depending on the temperature. Apply the same procedure for pecan nut rootstock nursery.

#### **f. Grafting**

##### **Scion Wood Collection and Preparation**

The success of plant propagation depends on the quality of scion wood for grafting. Collect scion woods from early January to end of February when the plants are dormant and still tight. The best scion is from the current season growth or one-year dormant wood. To protect bud woods from drying out, place the bud woods in a plastic bag or wrap them in a moist piece of cloth and keep in a shade. Place bud woods of only one variety in a labelled bag.

Since plum and peaches flower earlier than other temperate fruit trees, graft them before the end of January. Collect scion woods within December. For pear, walnut, persimmon and pecan which are grafted from February to the first week of March, collect scion woods from January until mid-February.

Collect kiwi and grape scion woods before the plants become active with approaching warm season to prevent excessive sap bleeding.



Cut scion woods with 2-3 buds for nursery grafting and with 4-5 buds for top-working. Wax with candle heated at 70-80°C. Do not dip the scion woods too long in the heated candle wax as it would burn the plant cells and chances of graft failure increase. Cool down the scion woods after waxing, pack them into a plastic bag and store them in the refrigerator or in a cool place until grafting operation starts. Use a dedicated refrigerator to store the scion woods to avoid exposing them to ethylene from other stored items. Check the scion woods regularly for moistness and mould infection which damage them. Seal the plastic bags completely since wood will quickly dry out. Label properly varietal names and other details. Generally, bud woods stored for long time are likely to fail.



**Cut scion into pieces**



**Keep 2-4 buds**



**Waxed at 70 °c**



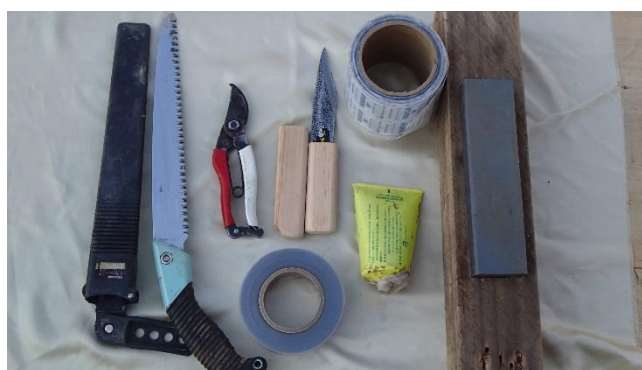
**Packed and stored**

### **Important Tools for grafting**

Equipment is as follows:

- Grafting knife;
- Sharpening stone;
- Grafting tape;
- Pruning saw; and
- Paraffin wax ILM

The grafting knife should be razor-sharp to prepare and get clean cuts. Adhesive graft tape made of vinyl (thickness 0.05mm x width 30-40mm) is appropriate. Ordinary plastic sheet cut into strips can also be used.



**Tools for grafting**

### **Grafting method**

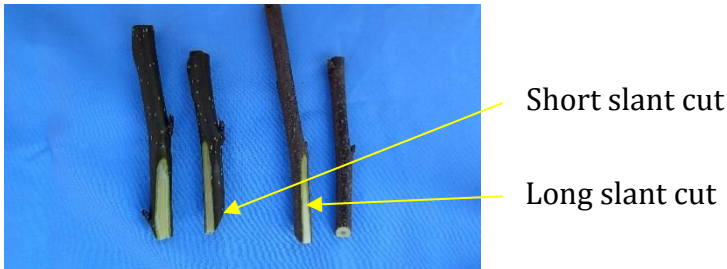
There are many methods of grafting such as whip grafting, whip and tongue grafting, cleft grafting, veneer grafting and so on. However, a nursery operator should choose a method that is more convenient to him/her. The most important to keep in mind is that vascular cambium of the scion wood should come in close contact with the vascular cambium of the rootstock. Practically, use the scion wood of same or almost the same size as that of the rootstock. Generally, the veneer side grafting method is practised for grafting of pear, persimmon, peach, plum, and apricot, walnut and citrus.

### **Side veneer grafting method**

The method is very popular in Bhutan. It is a simple method of propagation and can be used with one-year-old rootstock seedlings.

### **Preparation of scion wood for grafting**

Make the first long slanting cut of about 3cm just below the last active bud on one side of the scion wood and the second short slanting cut on the side exactly opposite to the first slant cut to expose the cambium layer. The longer cut on the scion should fit snugly to the cut made on the rootstock.



**Readymade bud wood of pear and persimmon**

### **Preparation of rootstock**

The height at which the rootstock is cut depends on the rootstock seedling size. Usually, the rootstock is cut at about 7-8cm from the ground. Prepared the rootstock by making about 3cm downward slanting cut through the bark and wood and slipping them.



**Cut rootstock at about 7-8cm from ground. With grafting knife, make a slant downward cut (3cm long)**

### **Insertion of the scion into rootstock and tying with grafting tape**

Insert the scion into the rootstock in such a manner that the cut surfaces including the cambium layers of the scion and rootstock match against each other. The union is tied firmly together with grafting tape to make it airtight. Graft tape can be about 20-30cm long depending on the size of the graft seedlings.

***Important: Remember to wrap budding tape just once around the bud as shown in figure (left)***



**Insert the scion into the rootstock slice cut and wrap airtight with grafting tape.**



When preparing persimmon and walnut scion woods, tannin comes out and covers the cambium layers. Therefore, cut scion wood deeper into the wood and insert into the rootstocks.

Pear, apple, peach, plum, and kiwifruit are often grafted on the rootstocks that are transplanted in the nursery bed. However, persimmon and walnut should be grafted on the rootstocks that are established in the nursery, since grafting on the uprooted rootstocks of persimmon and walnut have low graft success.

### **After the grafting**

Since grafting is done in the dry season (January, February and March), prevent seedlings from drying up by irrigating once or twice a week until the rainy season begins. Mulch with straw and dry grasses to reduce water loss from the nursery. Before the scion buds sprout, the rootstocks develop many sprouts. Remove these sprouts to ensure proper and healthy growth of seedlings from the scion woods. Graft take in pear, peach, and plum is faster whereas persimmon and walnut take about a month to sprout from the scion woods. In the windy area, stake individual seedlings to prevent breaking of young shoots by strong winds. Provide a supporting stake to grafted kiwi in the nursery.

Remove the grafting tape or plastic strips once graft union is formed after 4-5 months for peach and plum. Remove grafting tape of kiwi and pear in August and for walnut and persimmon in September.

In general, the grafted seedlings produce shoots in March and April. Therefore, top-dress with urea in June to supplement nutrient to the growing shoots. However, the application of urea should be based on the health of the growth of the seedling.

Provide proper drainage in the nursery field to prevent root rot in the rainy season. Peach and kiwi seedlings cannot withstand wet conditions. Weed 4-5 times in the summer to keep the field clean and also lessen competition by the weeds to the seedlings.

### **Pests and Diseases**

During the dry season from March to May, there are no major pests and disease problem but during the rainy season, many harmful insects and diseases infest the nursery. Aphids and caterpillars defoliate leaves affecting the growth of the seedlings. Spray Cypermethrin and Dimethoate 0.1%).

## **g. Transplanting grafted seedlings**

### **Digging out seedlings and care**

Before digging out the seedlings, prepare trenches in a shaded place to store the seedlings for distribution. Uproot temperate fruit seedlings during cloudy days. It is not necessary to dig up the trenches if seedlings are few. However, for commercial purposes, it is easier to handle if the trenches are dug up and the seedlings kept in the trenches ready for dispatch.

After uprooting, trim the damaged root tips, cut back long roots to half, and remove branches.

### **Packing method and transfer of seedlings**

Pack seedlings in a piece of gunny cloth (3 to 3 square feet). For convenience, make small bundles of plants containing about 10-20 seedlings. The tops are tied to prevent the stems from shaking, jaggging or rubbing against each other. Follow the followings steps to prepare bundles:

- Spread cushion or moist mosses on the gunny cloth;
- Soak the roots of the plant bundle in water and plant roots are laid in the middle of the spread mosses on the cloth;

- Bring the four ends of the cloth over the roots wrapped with mosses and tie fairly tightly all around the root ball; and
- Label all the bundles, and store in a cool place.

The moist mosses are secured around the roots which reduce chances of the roots breaking and drying up during the transportation. If a plantation area is nearby, supply bare-rooted seedlings but they should be planted immediately.

## (2) Raising seedlings of evergreen fruit trees

### a. Citrus

In Bhutan, private nursery growers are not allowed to produce citrus planting materials due to the danger of spreading greening disease. Also, there is a risk of spreading viral diseases that are devastating to the citrus industry.

#### Tips for raising healthy citrus nursery

Avoid citrus nursery in areas below 1500m since the citrus growing areas are affected by the greening disease. Also, avoid areas having citrus whiteflies (*Dialeurodes citri*). Do not use scion woods from greening affected areas. Use released varieties for scion woods for multiplication and adopt scheduled spray of insecticides and fungicides.

#### Rootstock plant

Choosing the right rootstock is important for graft success and fruit production. Many rootstock varieties have desirable horticultural traits. However, commonly used rootstocks in Bhutan are rough lemon, Rangpur lime, Troyer citrange and Trifoliate USDA. At Wengkhar and Bajo, Trifoliate USDA varieties are used as rootstocks. Nevertheless, all rootstocks have both advantages and disadvantages.

#### **The characters of common citrus rootstocks in Bhutan are as follow:**

- i. **Rangpur lime (*Citrus x limonia*)** seems to be native to India. It matures early with higher yields; fruits quality is moderate, and it is sensitive to Phytophthora. Trees on this rootstock are vigorous, precocious and prolific with quality produce. It is highly resistant to *Tristeza* and does well in heavy soils. However, the fruit peel changes to rough with large fruit and high acidity.
- ii. **Rough lemon (*Citrus jambhiri*):** It grows wild in India, Nepal and Bhutan. It is highly vigorous in nature and produces large trees. The growth of grafted seedlings is very fast. It produces large fruits with rough peel, large seeds, less juice, low sugar pulp and high acid content. It is sensitive to cold. It is widely used in India, Brazil and Australia.
- iii. **Citrango (*C. sinensis x P. trifoliata*). Carizo and Troyer** are the most commonly used rootstocks. It is generally cold hardy and vigorous in nature. The fruit quality and yield are good on this rootstock. It is semi-deciduous, leaves are longer than trifoliate. The fruit is spherical in shape and larger than that of trifoliate orange. The growth of seedlings is more vigorous and cold-resistant than trifoliate orange and is also resistant to CTV. In the soil with high humidity, root rot occurs.
- iv. **Trifoliate (*Poncirus trifoliata*) USDA** originated in China. It is deciduous and extremely cold-hardy. It is resistant to Phytophthora root rot and citrus nematodes. The fruit is spherical and very seedy (more than 20 per fruit). It is a shallow-rooted plant with many fibrous roots, so it is weak against the dry condition. On the other hand, the quality of the fruit is good. Trifoliate seeds are harvested from the middle of September to November. It has curved thorns, small leaves, and is dwarf.

#### Collection of seeds and storage

The process of seed collection is the same for all citrus rootstocks. However, the following steps describe the procedure for collection of trifoliate orange seed:

- Harvest fruits and extract seeds within 1-2 days as the fruits may rot and increase chances of infection.
- Cut trifoliate fruit with a knife around the centre of the fruit (avoid cutting through seeds), twist the fruit into half, and squeeze the juice and seeds into a container.
- Remove the seeds from the pulp and wash them thoroughly with water.
- Remove shrivelled, underdeveloped, and floating seeds and collect the best ones.
- Rinse the seeds well with water and soak in a fungicide (5%) solution (*use distilled or mineral water*). If the fungicide is not available, use chlorine bleach (1/10 diluted) to treat the seeds.
- Briefly dry the seeds in a container (bamboo mat or basket) in the indoor shade. Do not dry up, keeping approximately 70% moisture content (still wet in the surface).
- Pack the seeds in an airtight container or plastic bag and store in the refrigerator for 6 months.
- Check every week to monitor any fungus attack. Wash and sterilize with fungicide if fungus infection is detected.



**Trifoliate flower**



**Cut around fruit and twist it without damaging seeds**



**Washing of seeds**

### **Sowing of seeds**

Sow the seeds in a greenhouse just like kiwi seeds. Provide mulch with rice straw to preserve moisture in the soil. Mulch should be removed as the seeds start to germinate. Take utmost care to achieve a high germination percentage through weeding and timely watering. When the seedlings are about 7-8 cm high, transplant into poly pots. Transplanting is done in July when the seedlings are in an active growing stage. Take care to avoid damages of the seedlings during handling. To reduce excessive transpiration, cut off about half the length of the seedlings while transplanting into the poly pots. However, if transplanting is not possible in July, transplant in February. Use 25cm x 15cm size poly pots to encourage root growth for another year.

### **Potting media**

Fertile potting media is necessary to support plant growth for two years. Prepare the media by mixing and composting of farmyard manure (FYM), chicken manure, forest soil and topsoil in the ratio of 1:1:1:1 for about 6 months to one (1) year. Carry out weeding, irrigation and pest control measures as recommended since the potted plants need intensive care.

### **Grafting of citrus**

The success rate of budding or grafting depends on graft aftercare. Most of the grafting failures are caused by negligence in carrying out after graft operations. Depending on the number of buds in the scion woods, there are two types of grafting: budding and grafting.

#### ***One bud grafting method***

Budding is a grafting where only one bud in a scion wood is used. It is quite difficult compared to grafting. Moreover, the growth of a new shoot is also weak. Budding is also

practised in grafting temperate fruit seedlings. However, deciduous scion woods can be waxed to prevent from drying up. On the other hand, scion wood of citrus cannot be waxed since waxing causes burns on the buds. Nevertheless, grafting is practised in citrus since it is easier than budding. To prevent scion or bud desiccation, parafilm is used. One bud grafting method is usually practised in grafting citrus.

Head back a rootstock to about 15cm from the ground. A bud is grafted at about 6-7cm from the ground. Make a downward slanting cut and slip the bark of about 2-5cm in the rootstock. Cut off about half of the peeled bark from the base with a sharp knife so that the lifted bark does not cover the scion bud. Prepare one bud scion wood and insert it into the rootstock with the long cut matching with the cut on rootstock. Tie the union with grafting tape firmly with just one round covering the bud and several rounds below and above the bud. The bud is wrapped with just one round of grafting type to ease bud break and sprouting. If the sprout cannot break the plastic tape, use a blade or sharp pin to cut open.



**Left: One bud grafting scion wood  
Right: Veener grafting scion wood**



**Make a slice cut of about 2-5cm so that cut size match with prepared bud**

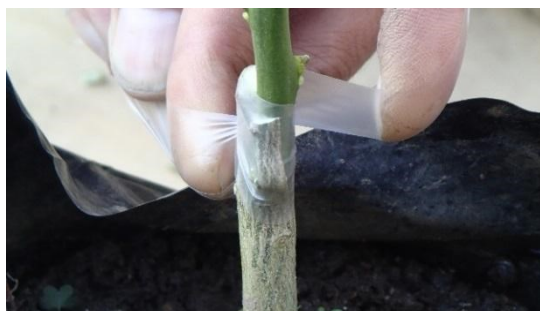


**Carefully wrap grafting tape just once around the bud as shown in figure and then wrap (airtight) several rounds just above and below the bud.**

#### **Veneer grafting**



**Rootstock downward cut surface should be of 3-4 cm long**



**Insert the scion wood and wrap with graft tape at the union.**





**To avoid desiccation parafilm is wrapped around the scion as shown in the figure**

### **Nursery Management**

Shoots growing below a graft union are the main cause of graft failure. These water shoots draw nutrients and make them unavailable to the graft union. Delay in the removal of the suckers results in stunted growth of grafted plants or may even dry up and die at a later stage. Therefore, monitor and remove the suckers regularly. During the de-suckering, it is recommended to remove the secondary buds with a sharp knife to prevent from sprouting again.

Schedule weeding, irrigation and fertilizer application after observing nursery conditions. Top dress with urea in June to stimulate the growth of healthy summer shoots.

Ideally, the grafting tape should be removed six weeks after grafting. Practically, remove graft tape once the graft union is formed. Before removal, check if the cut wounds around the graft union are healed. If the wound is not healed properly, wait for another few weeks. On the other hand, delay in removal can cause girdling or ringing which interrupts translocation of nutrients and water.

***Cutting rootstock above graft union:*** Once the graft union is formed, cut off the part of the rootstock above the graft union before removing grafting tape. The cut must be sloping about one (1) cm above the bud union.

### **Pest and Disease Management**

Many pests and diseases affect the production of citrus seedlings. Among insect pests, leaf miner is most harmful which cannot be controlled by agrochemicals. In summer, aphids, thrips, spider mites and shallow tail larva feed on the leaves. Therefore, spray 0.075-0.1% Rogor (Dimethoate) and Cypermethrin to avoid seedling damages.

### **b. Avocado**

Avocado seeds are extracted from fruits available in markets. Seeds can be easily removed from the pulp without spoiling.

Extract the seeds from the fruits. Wash them and sow immediately in nursery pots or poly pots (10cm x 20cm). Sow with the pointed tip upright and cover with 3-4cm thick soil. The viability of avocado seeds is quite short if they are stored in normal temperature. Therefore, wash the seeds, dry them in shade, pack properly in a non-perforated polyethene bag, and

store at 4-5<sup>0</sup>C. Removal of a small portion of a seed at the base by a sharp knife before sowing hastens germination. The seedlings reach a pencil size within 3-4 months under Bajo condition.

The seedlings can be grafted (in a greenhouse) in the winter. Side veneer grafting is the popular method for avocado propagation in Bhutan for mass propagation. It has a high rate of success (70-80%). The time of grafting is from mid-February to mid-March at Bajo.

### **c. Loquat**

The method of seed collection and sowing is the same as that of avocado. Remove seeds from fruits and wash properly. The seeds germinate readily (100%) with rapid seedling growth. The seedlings reach graftable size within one year.

### **d. Guava**

Harvest ripe fruits from a tree in September and October. Extract seeds, wash them thoroughly and dry in a shade. Sow guava seeds immediately after extraction. However, sow them in a greenhouse for optimum germination rate. Sow the seeds in the nursery and transplant into poly pots in February and March. The seedlings are grafted after two years of growth in the nursery.

### (3) Propagation by cuttings

Many plants can be propagated by cuttings. A cutting is a vegetative plant part which is severed from the parent plant in order to regenerate and form a whole new plant. Some of the advantages of cutting are:

- 1) It is more rapid, simple, and cheaper than asexual methods.
- 2) It produces true to type clones.
- 3) The plant reaches maturity at an earlier age.
- 4) The plants which are difficult to propagate through seed can be propagated through cuttings.

On the other hand, plants from the cuttings are weak against pests and diseases. Cuttings prepared from local varieties are easy to root and strong against diseases whereas cuttings collected from exotic cultivars are difficult to root and weak against diseases. Therefore, propagation through cutting in horticulture crops is not very popular. Some of the common fruit plants prepared through cuttings are grape, kiwi, and loquats.

#### a. Grapes

Grape rootstock or seedlings are mostly prepared from cuttings. Preparation of seedlings through cuttings is easy and convenient but it is far better if grafted seedlings are planted. Although there are many rootstock varieties for grapes, the variety 5BB (*V. berlandieri* x *V. riparia*) is only adopted.

Collect the grape cuttings in January after the leaf fall. Nursery bed soil for the propagation of cuttings should be well-drained (sandy). Collect cuttings from the previous year's growth or one-year-old wood. Once cuttings are stored, it is sometimes difficult to differentiate the top and bottom of a cutting. To differentiate easily, make a diagonal or slant cut at the top and straight cut at the bottom. Prepare cuttings with 2-3 buds so that one or two buds can be inserted into the soil for rooting and leave one bud above the soil to grow into a vegetative shoot. When the shoot grows up to about 30-40cm, it is headed back in the winter and transplanted into poly pot.

#### b. Shoot tip grafting

Grapes are grafted on the spring shoot. Cut the scion of 3-4 cm length from the terminal shoot which is more than three months old. Cleft grafting method is used to graft. Prepare the scions with slant cuts on both sides with a sharp knife. Split the stock to about 5 cm through the centre of the stem. Insert the scion into the split of the stock. Tie the union firmly with grafting tape. Cover with parafilm wax tape to prevent scion from desiccation.



Stock split to 2-3 cm



Insertion, tying (grafting tape) and covering (para film) scion



Sprouting from grafted scion

**c. Dragon fruit**

Commercially, dragon fruit is propagated by cuttings. Prepare 20 cm long cuttings from one-year-old stems. Dry the cut ends for 2-3 days for callus development and hardening of wounds. Prepare cuttings from March to September. Plant the cuttings in poly pots containing clean media mix (soil, compost and sand). The cuttings require full sunshine for optimum growth. Irrigate the cuttings regularly. Plant rooted cuttings directly in the field.

**d. Passion fruit**

Prepare cuttings from May to August. Select hardwood with two to three buds. Keep one bud above the soil surface. Cutting comes better in poly pots. The soil requirement is the same as the grapes which are a well-drained soil. Plant the cuttings in the coming spring season.

## 8. Top-grafting

In Bhutan, many households grow local pears, astringent persimmons and walnuts in backyard farms. In addition, some existing orchards have varieties that need to be changed since replanting with high-density plants would be expensive. This makes top-working a more realistic, cost-effective, and appealing option since replanting takes a minimum of 2-3 years to prepare the field and plant and another 2-3 years to come to partial production. Since there is no need for site preparation, a top-worked tree orchard can produce marketable fruits within 3-4 years. Top-worked trees also have vigorous re-growth and early fruit production. 3-4 years old trees are easier to top-work than old trees. Local trees that can be successfully top-worked are: pear, apple, peach, plum, apricot, persimmon, and walnut.

The citrus tree can also be top-worked but it is not recommended due to fear of spreading the virus and greening disease.

### a. Equipment

Tools and materials required for top-grafting are as follows:

- Secateurs,
- Pruning saw,
- Power chain saw,
- Grafting knife,
- Vinyl tape (width 6cm),
- Elastic-plastic tape (grafting tape),
- Black plastic sheet,
- Fungicide paste,
- Sharpening stone, and
- Rubber band or jute rope.

### b. Top-working Time

Grafting is most successful when the temperature is consistently warm. In Bhutan, top-working is done when the tree starts new shoots and blooms. When there is a very little chance of the extended cool period, frost, or freezing, the bark easily separates from the wood. When the plant starts leafing, sap flow is good and the bark easily peels. Top-work peach and pear in the middle of March. Top-work persimmon and walnut at the end of March. Top-work trees at about one (1) metre from the ground. The cut wound made by a saw is rough. Make the cut wound smooth or clean by a sharp grafting knife for uniform callus formation after grafting. The number of scion woods required depends on the age of a tree or size of the trunk as follows.

- For two (2) years old plant, use one scion wood;
- For three (3) years old trees, use two scion woods; and
- For trees above four (4) years (size of pet bottle), use more than three scion woods.

### c. Top-grafting Methods

#### Preparation of Stock

Make a fresh clean cut on the trunk with a pruning saw. Be careful not to split the bark and expose the cambium. Make two parallel cuts with a sharp knife through the bark to the solid wood beneath perpendicular to the ground. These cuts should be approximately 3cm in length. Loosen the bark on both sides of the cuts by carefully rotating the knife blade in the direction where the stick will be inserted. As soon as the bark starts to separate from the wood, stop rotating and peel off the bark with your finger or a sharpened stick.



### **Preparation of scion**

Prepare scion woods in the same way like that in a nursery grafting.

### **Insertion of the scion(s) into stock**

Insert the scion stick into the loosened bark. Carefully push the scion stick into the gap until the entire short slant cut made on the scion stick is completely covered by the bark on the stock. Tie the union with plastic tape firmly and cover the stock end with a black plastic sheet to prevent from drying up. If the trunk is big, use a rubber band or jute rope to hold the union tight.



**Apple top grafting**



**New flushes after grafting**



**Grafted pear after 2 years**

### **d. Management after grafting**

Check the buds to swell and begin to sprout. If it is evident that grafts have not taken, re-graft the tree provided scion woods are still available. The most common graft failures are bad scion wood and loose contact between the scion and the stock. Depending on the weather conditions, new shoots should grow slowly at first and then rapidly thereafter. At the same time, new shoots will also form on the stock. Remove these shoots regularly as they appear in the growing season. These water shoots draw the nutrients and make it unavailable to the graft union. Delay in the removal of the suckers may result in stunted growth of grafted plants or death at a later stage.

As grafts become firmly established later in the first season, make a single cut across the grafting tape to allow for scion stick growth and callus expansion. This prevents potential girdling by the rubber, rope and plastic tape. As grafts grow, they become susceptible to breaking by birds or strong winds. Provide stakes tied to the existing tree trunk to prevent the damages. Do not thin out any shoot during the first growing season.

1,220m altitude at Bajo center

Figure 1: Comparison of the fruiting cycle of different fruit species. The diagram shows four horizontal timelines for Grapes (Kyoho, Steuben etc), Avocado (Hass and others), Pummelo (R3-P4, R4-P5), and Dragon fruit (White pulp). The timelines are marked with various events: Pruning/Training (brown line), Flowering (red dashed arrow), New shoot (green double arrow), Natural fruit drop (black dashed arrow), 1st fruit thinning (black arrow with a downward hook), 2nd fruit thinning (blue arrow with a downward hook), and Harvest (orange line). The fruiting cycle for each species is represented by a green line with orange bars indicating the fruiting period. The fruiting cycle for Grapes and Pummelo is relatively short, while the fruiting cycle for Avocado and Dragon fruit is much longer, spanning several years.

## Temperate Fruit Nursery and Cultivation Calendar (Pear, Persimmon, Peach, Plum, Kiwi and Walnut)

| Month/Day  | Technical Management   | FieldWorks   |
|------------|--|--|
| Jan 1-15   | Scion wood collection, Scion size cutting keeping 2-3 buds, waxing, packing in vinyl bag and store in a cool dark place or in refrigerators.   | Irrigation of nursery fields to keep the soil moist (both rootstock seedlings and grafted seedlings)   |
| 16-31      | Continue pruning and training of fruit trees, and preparation of scion woods   | Prepare nursery field incorporating with well-decomposed FYM or compost for seed sowing and rootstock transplanting                                  |
|            |  | Dig out grafted seedlings and store in a cool shady place. Keep the plant root moist   |
|            |  | Dig out rootstock seedlings, and sort out the graftable size and non-graftable size. Keep in a cool shady place. Keep the root moist.                |
|            |  | Add compost in all the fruit trees.  |
| Feb 1-15   | Grafting of selected fruit trees till February end   | Prepare trench in the nursery field, and plant (0.5 to 1' apart) all the graftable size rootstocks. Head back the stock to 30-40cm above the ground. |
|            | Sorting, variety tagging and packing of grafted seedlings for distribution. Keep the plant in a cool shady place. Keep the roots moist. Use sphagnum moss and gunny bags to cover the plant roots. | Properly irrigate the planted stocks daily depending on the weather condition.   |
|            | Planting of grafted seedlings till 1st week of March.  |  |
| 16-28      | Check and lift peach, apricot, plum and walnut seeds from the stratification pit.  | Sow all the germinated seeds in the nursery  |
| March 1-15 | Complete grafting operations   | Sow the rootstock seeds in the nursery   |
|            | Check and cut shoot growth from the rootstock.   |  |
| 16-31      | Check for aphids and other harmful insects. Spray chemicals if necessary.  | Weeding and irrigation in all the nursery  |
| April 1-15 | Provide support for kiwi vines in the nursery (both grafted and stock seedlings)   | Collect bamboo poles for kiwi stacking and training  |
| 16-30      | Remove growths from the rootstocks   | Continue weeding and irrigation in the nursery   |
| May 1-15   | Check for aphids and other harmful insects. Spray chemicals if necessary.  | Application of nitrogen (top dressing)   |
| 16-31      |  | Spraying of insecticides if necessary  |

(Continued from the left page)

| Month/Day   | Technical Management  | FieldWorks  |
|-------------|---|---|
| June 1-15   | Remove growths from the rootstocks  | Weeding and irrigation in all the nursery   |
|             | Check for aphids and other harmful insects. Spray chemicals if necessary.                               |   |
| 16-30       |   | Collect bamboo poles for staking and training of grafted plants   |
| Month/Day   | Technical Management  | FieldWorks  |
| July 1-15   | Check peach, apricot and plum graft unions and remove the grafting tape                                 | Top dress nursery with chicken manure   |
| 16-31       |   | Peach seed collection   |
| August 1-15 | Check graft unions and remove the grafting tape on pear grafted seedlings                               | Continue weeding and provide irrigation in the nursery when necessary. Avoid waterlogged condition in nursery field |
|             | Check for aphids and other harmful insects. Spray chemicals if necessary.                               | Check for stagnant water in the nursery and provide drainage for excess water.                                      |
| Sep 1-15    | Collect persimmon seed  | Weeding and irrigation in all the nursery when necessary. Avoid waterlogged condition in the nursery field          |
| 16-30       | Treat persimmon seeds with Fungicide 5% or antiholmin5% and 80% dry. Pack and keep in the refrigerator. |   |
|             |   | Remove all shoot growths from the rootstocks  |
| Oct 1-15    | Check for pear harvest and collect seed   | Continue removing shoot growth from the rootstocks. Avoid waterlogged condition in the nursery field                |
| 16-31       | Collect kiwi seeds  |   |
|             | Treat seeds with Fungicide 5% or antiholmin5% and 80% dry. Pack and keep in the refrigerator            | Continue weeding and irrigation in the nursery. Avoid waterlogged condition in the nursery field                    |
| Nov 1-15    | Check and collect pear and kiwi seeds for rootstock seedling production                                 | Continue weeding and irrigation in the nursery  |
| 16-30       | Treat seeds with Fungicide 5% or antiholmin5% and 80% dry. Pack and keep in the refrigerator            | Last weeding and cleaning in the nursery  |
| Dec 1-15    | Stratification of peach, apricot, plum and walnut in cool places above 1800masl                         | Irrigation of nursery fields to keep the soil moist (both rootstock seedlings and grafted seedlings)                |
| 16-31       |   | Irrigation in all the fruit tree plantations  |



ISBN 978-99936-988-2-1



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MoAF, IHPP/JICA, ARDC Bajo

