FRUIT CROPS PRODUCTION AND MANAGEMENT
(MODULE 12)
STUDENT'S PRACTICAL GUIDEBOOK

First Edition May 2019

Fruit Crops Production and Management

Module 12

Student's Practical Guidebook

First Edition

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THIS PRACTICAL GUIDEBOOK IS DEVELOPED WITHIN THE FRAMEWORK OF NATIONALLY HARMONIZED CURRICULUM FOR HORTICULTURE BACHELOR OF SCIENCE (B.Sc.) DEGREE STUDENTS.

THIS PRACTICAL GUIDEBOOK CONTAINS:

1. Hort2121 – Tropical Fruit Crops Production and Management
2. Hort2122 – Sub-tropical and Temperate Fruit Crops Production and Management

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ACKNOWLEDGMENT

This Practical guidebook is prepared for B.Sc. Students attending a horticulture program of the nationally harmonized curriculum. The guidebook is developed by Instructors from Bahir Dar, Hawassa, Jimma and Mekelle Universities in collaboration with Horti-LIFE project of SNV. It aims to strengthen and upgrade the existing knowledge and skill in the horticulture subsector. We would like to thank all the four universities and their respective instructors and participants who worked as Leaders and contributors of the practical sessions. The names of the Lead and contributor instructors are mentioned in respective courses in the Guidebook.

Contents

Acronyms

BAP	6-Benzylaminopurine
IAA	Indole acetic acid
IBA	Indolebutyric acid
ICRAF	International Centre for Research in Agroforestry
IITA	International Institute of Tropical Agriculture
MS	Murashige and Skoog
NAA	Naphthaleneacetic acid
TSS	Total Soluble Solids

Introduction to the Module

Ethiopia is endowed with diverse climatic and edaphic conditions favorable for the production of quality horticultural produces. Fruit Production is an important part of horticulture that plays a pivotal role in the livelihoods and food and nutritional security of the community in the country. Due to the existence of large agro-climatic diversity, favorable soil conditions and ample water resources, different tropical, subtropical and temperate fruit crops are grown in different parts of the country. Hence, a variety of fruits can be produced in the country making fresh-produce available year-round. Ethiopia has also a comparative advantage for successful production of various fruit crops due to its proximity to major markets (Europe and Middle East) and availability of young and easily trainable work force.

Fruit crops allow efficient utilization of resources like land, water, labor and agricultural inputs, resulting in higher income per unit of available resource while maintaining and developing the natural resource base. The contribution of fruits towards diversification of the economy of the country is also enormous. The development of fruit crops could provide the basis for the establishment of agro-industries, contributing for the transformation of the Ethiopian agriculture.

In recent years, the demand for fruit consumption is increasing. The trend will definitely continue to grow as the awareness and purchasing power of the population is increasing. However, to meet the increasing consumer demand for fresh produce, the production and productivity of fruit crops produced in various parts of Ethiopia need to be improved. Modern fruit production is critically dependent on knowledge. It needs technically-competent, skilled people in all parts of the industry who can respond quickly to market opportunities and production demands. Hence, to achieve successful and sustained production of good quality fruits, application of appropriate knowledge and management practices are imperative. In connection with this, the higher learning institutions that are involved in training agricultural professionals in various disciplines are expected to produce competent graduates to satisfy trained human resource needs of the agriculture sector in general and horticulture subsector in particular of the country. Shortage of appropriate Practical Guidebooks, relevant to the local conditions is one of the major problems of the Ethiopian tertiary level agricultural education institutions. This Student's Practical Guidebook, focusing on "Fruit Crops Production and Management", is prepared with a prime aim of providing relevant procedures so the students can properly conduct the respective practical sessions indicated in the Tropical, and Subtropical and Temperate Fruit Crops Production and Management courses.

This Student's practical guidebook comprises two parts. The first part deals with practical sessions broadly addressing Tropical Fruit Crops Production and Management; while the second part addresses practical sessions on Sub-tropical and Temperate Fruit Crops Production and Management. The Student's Practical Guidebook has been developed within the framework of nationally harmonized curriculum for horticulture Bachelor of Science (B.Sc.) degree students.

Tropical Fruit Crops Production and Management

Hort 2121

Student's Practical Guidebook

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COURSE INTRODUCTION

Tropical fruit crops are those which do not withstand freezing temperatures, and many do not grow well if temperatures drop below 10°C. Many scholars indicated that tropical fruits are not only sensitive to temperatures below 20°C but indeed require a climate with average mean temperatures higher than 10°C for the coldest month. Based on their life span, tropical fruit crops can be categorized as long term perennials (e.g. mango, guava, date palm) and short-term perennials (e.g., papaya, banana, pineapple), while based on their plant nature, they are categorized as woody/tree fruits (e.g. mango, guava), and non-woody fruits (e.g., papaya, banana, pineapple).

Ethiopia endowed with diverse agro-ecologies and soil types has favorable environment (especially low and mid-altitude areas) for successful production of various tropical fruits. Banana, mango, papaya, guava and pineapple are the major tropical fruit crops widely grown in the country. According to CSA (2017/18), the area coverage and % distribution (from the total fruit production in Ethiopia) of these tropical fruit crops for private small-farmer holdings for Meher Season 2017/18 (2010 E.C) were 59,298.19ha (56.79%), 15,373.04ha (14.72), 3,484.46ha (3.34%), 2,469.91ha (2.37%) and 609.80ha (0.58%), respectively. These data indicate that tropical fruits such as banana and mango have a lion share in the fruit production subsector of the country.

Modern fruit production is critically dependent on knowledge. It needs technically-competent, skilled people in all parts of the industry who can respond quickly to market opportunities and production demands. Hence, to achieve successful and sustained production of good quality fruits, application of appropriate knowledge and management practices are imperative. In connection with this, the higher learning institutions that are involved in training agricultural professionals in various disciplines are expected to produce competent graduates to satisfy trained human resource needs of the agriculture sector in general and horticulture subsector in particular of the country.

This Student's Practical Guidebook is prepared with a prime aim of providing relevant procedures for the students so they can easily understand the procedures and accordingly conduct the respective practical sessions indicated in the Tropical Fruit Crops Production and Management course. It comprises six sessions: (1) Identification of Tropical Fruit Crops, (2) Demonstration of tropical fruit crops propagation, (3) Tropical fruits nursery establishment and management, (4) Orchard establishment and management, (5) Maturity determination and harvesting, and (6) Field visit to nearby fruit farm, agricultural research center and/or agro-industry. The Student's Practical Guidebook has been developed within the framework of nationally harmonized curriculum for horticulture Bachelor of Science (B.Sc.) degree students.

PRACTICAL SESSION 1

Practical Session 1

Identification of Horticultural Tools, Equipment's

PRACTICAL SESSIONS 1

Practical Session 1: Identification of Horticultural Tools, Equipments and Tropical Fruit Crops

Activity 1.1: Identification of Horticultural Tools and Equipments

Theory

Major field operations for fruit crops include nursery site preparation, propagation (by seed and vegetative means), pit digging for planting, intra-and inter-row cultivation, fertilizer application, irrigation, tree canopy management, plant protection, harvesting, handling, packaging and transport. Since commercial fruit cultivation in Ethiopia is only on a limited scale, the horticultural practices, followed in nurseries and orchards of different fruit crops, are predominantly dependent upon human labor.

Having the right tools, knowing how to use them and management decisions relating to the selection of horticultural tools and equipment, choice of practice, market availability, and availability of storage facilities among others are essential factors which can affect horticultural operations and production profits in several ways [1]. To improve productivity and efficiency, it is necessary to have comprehensive knowledge of horticultural tools and implement performance. Horticultural tools can be classified into two categories as either handheld tools or power driven tools.

The main aim of introducing the various horticultural tools and equipment is to enable the students have deep understanding on different types of tools and equipment used for a variety of horticultural practices, including nursery establishment and management, grafting/budding, pit digging and planting, inter-tillage and weed management, training and pruning, fertilizer and irrigation water application, plant protection, harvesting and handling of fruits.

Objectives

- To acquaint the students with common horticultural tools and equipment used for fruit production (at nursery as well as farm levels) and their function/uses.
- To help enable the students to develop the knowledge and skills necessary to use a range of horticultural tools and equipment correctly, being capable of identifying possible hazards and safety precautions required.

Materials

Equipment	Consumables
- Flip chart (color print pictorial display of tools and equipment), various tools and equipment	- Water

Procedure

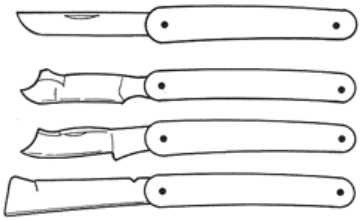
- Carefully follow the instruction given by your instructor.
- Observe the different horticultural tools and equipment presented pictorially on a flip chart (or displayed tools available in your area).
- Record your observations (based on the checklist).

Flip Chart 1-1 Horticultural tools and equipment and their use

No.	Horticultural tools	Description and their use
1	**Hoe** 	• Long handled with flat and perpendicular blade at the end. • Used to remove weeds by agitating and grooming the soil surface, • Used to dig, move and hill soil during preparation for planting
2	**Mattock** 	• For digging hard soils
3	**Axe** 	• Axe is multipurpose cutting tool used for felling and delimbing of trees, splitting of logs for firewood and dressing of logs for timber conversion.
4	**Spade** 	• A long handled tool traditionally used for • Digging, shoveling soil and compost, • Moving shrubs of plants

5	**Round Point Shovel** 	• All-purpose shovel, rounded, sharp point widely used garden tool. • Used to dig large holes and transport heavier materials such as wet soil and rocks • Its sharp edges can cut the roots and sods as well as break up compacted soil.
6	**Square Point Shovel** 	• Good for scooping and transferring heavy materials (soil, rock, cement, etc.)
7	**Cultivators** 	• Used to break up compacted soil, spread fertilizers and compost, remove shallow rooted weeds without disturbing the roots of surrounding plants
8	**Forks** 	• Used for digging of soils in situations where the use of spade may be difficult for turning of soils, • Used to till large areas of soil and break up compacted clods, • To rake out weeds and stones
9	**Trowels (planting/digging)** 	• A small hand held tool used to dig small hole (for planting & transplanting small plants/saplings),
10	**Garden Rake (or "soil rake")** 	• A long handled tool used to create a fine tilt and level the seedbeds (Short steel tines ideal for raking soil or moving heavy material), • Collect plant debris and stones from the seedbed surface, • Break soil clumps and spread fertilizers or compost

11	**Leaf Rake** 	• Long, flexible steel tines for raking leaves
12	**Watering can** 	• A portable water container used for watering smaller areas and containers
13	**Pegs** 	• Used for securing net, line or fleece to the ground
14	**String (Garden Twine)**  Nylon string	• Used for lay outing activities and tying plants to stakes • Available in natural jute and coated
15	**Wheelbarrow** 	• It is carrier, usually having only one wheel, a tray bolted to two handles and legs • Used to transport seedlings soil, com-post as well as small loads
16	**Anvil Clippers** 	• One blade & one flat surface, best for extremely hard wood

17	**Shears**  	• Shears for different purposes (Pruning, Harvesting)
18	**Budding Knife** 	• A small knife designed for delicate budding - grafting with a single eye or bud.
19	**Budding/grafting tape**  	• Used for wrapping graft-union point while grafting and/ or budding fruit species.
20	**Lopping Shear** 	• Long handles provide extra leverage for pruning thick branches

21	**Pruning Saw** 	• Short, sharp saw for cutting limbs too thick for hand or lopping shears
22	**Hedge shears** 	• Hedge shears are gardening tool used for trimming (cutting, pruning) hedges or solitary shrubs (bushes).
23	**Machete** 	• A large, strong blade usually around half a meter long. • Effective in cutting small branches and heavy underbrush.
24	**Measuring tape** 	• Made from steel or wooden and used for layout of seedbed, plots and plant spacing
25	**Gloves** 	• Used to protect hands and fingers from cuts, blisters, calluses, sun damages, abrasions and dirt.

26	**Footwear** 	• Used to protect feet from stones, falling items or tools.
27	**Fruit Harvester** 	• Clip and pick fruit picker
		• Fruit Tree Picking Pole with Basket
		

- Hydraulic platform (fruit picking lift) for harvesting, pruning and spraying operations in orchards

28 **Ladders**

- Different types ladders (that fold out into an A-shape) commonly used in fruit orchards (tree pruning, harvesting etc.)
- There are also ladders that sit straight against a stabilizing object (used for pruning and harvesting tree fruits).

29 **Crates**

- Crates (plastic, wooden) used for collecting harvested fruits

Observation and Expression of Results

- Discuss your observations (based on pictorial display/flip chart, and/or what you would observe from available tools and equipments at your area).
- Write a complete session report (individually or in group) and submit to your instructor.

Table 1.1 Fill the Table by observing the flip chart (and tools and equipments in your area).

No.	Tools/equipments	Functions/uses
1		
2		
3		

Discussions

- Guide the students discuss their observations (based on pictorial display/flip chart, and/or what they would observe from available tools and equipments at your area).

_____

_____

_____

Conclusion

- Write what you conclude based on your observations.

Recommendations

- Carefully follow instructions given by your instructor for safe and appropriate use of horticultural tools

Self-assessment

1. Do I distinguish among the various horticultural tools and equipment based on the observations (pictorial display/flip chart, and locally available tools and equipment)?
2. Do I clearly and concisely explain the functions of the observed horticultural tools and equipment to peer group and instructor?
3. Do I understand safety measures while using different horticultural tools and equipment?

References

Bello R. S. 2012. Horticultural Machinery Operations & Safety.
https://www.researchgate.net/publication/275642333_Horticultural_Machinery_Equipment_and_safety/download
https://www.easyelimu.com/high-school-notes/agriculture/form-1/item/469-farm-tools-and-equipment-garden-tools-and-equipment

Activity 1.2: Identification of Tropical Fruit Crops

Theory

The tropical zone lays 0-20º north and south from the equator. Tropical fruits do not withstand freezing temperatures, and many do not grow well if temperatures drop below 10°C [1]. These plants do not require cold temperature exposure for either vegetative growth or flower initiation (with some exceptions according to species and individual age). Tropical fruit species are not only sensitive to temperatures below 20°C but indeed require a climate with average mean temperatures higher than 10°C for the coldest month. The main feature associated with the tropics is not so much that of heat but rather steady warm temperatures throughout the year [2].

Tropical regions, especially those within 10° north or south of the equator, experience small fluctuations in day length at all elevations and diurnal temperatures in low and mid elevations [2]. Local climatic conditions vary considerably within the tropical regions based on elevation or proximity to water or mountain ranges which affect wind patterns and rainfall. Therefore, tropical regions may be further subdivided into lowland, midland or highland tropics and into wet (humid) or dry (arid or semiarid) regions [3]. Banana, pineapple, papaya, mango and guava are the major tropical fruit crops widely grown in Ethiopia.

Objective

- To acquaint students on how to distinguish tropical fruits based on their nature (trees, shrubs, vines or herbs), life span, fruit bearing habit, fruit type etc.

Materials

Equipment

- Sharp knife,
- Flip chart (color print pictorial display of tropical fruits)

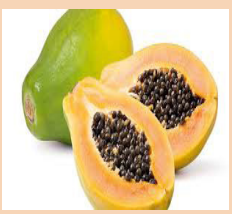
Consumables

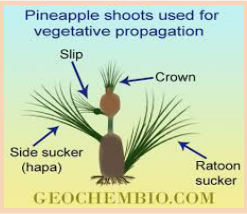
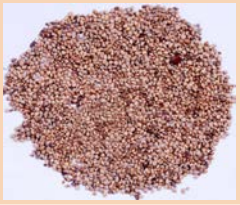
- Fruits (and seeds) of selected tropical fruit crops,
- Saplings of selected tropical fruits (if available),
- Check list

Procedure

- Carefully follow the instruction given by your instructor.
- Observe the different tropical fruits based on a pictorial display on a flip chart (or live fruit plants available in the area).
- Record your observations (based on the checklist) and distinguish among the various tropical fruits (the plant as well as the edible fruit).

Flip Chart 1. Pictorial description of major tropical fruits

Major Fruits	Plant Appearance	Flower	Fruit	Seed/Propagule
Banana *(Musa spp.)*				
Mango *(Mangifera indica)*				
Papaya *(Carica papaya L.)*				

Pineapple *(Ananas comosus)*				
Guava *(Psidium guajava L.)*				
Jackfruit *(Artocarpus heterophyllus)*				
Bullock's heart *(Annona reticulata)*				
Date palm *(Phoenix dactylifera)*				
Pomegran-ate *(Punica granatum)*				
Casimiroa/ White *sapote (Casimiroa edulis)*				
Olive *(Olea europaea L.)*				

Observation and Expression of Results

- Observe and record the distinguishing characteristics of the selected tropical fruits (the plant as well as the edible fruit), based on the pictorial display (on a flip chart) and/or the live fruit plants available in your area,
- Present your observation result to your peer-group and your instructor,
- Write a complete session report (individually or in group) and submit to your instructor.

Table 1.2 Fill the Table (checklist) by observing the flip chart and live fruits (field visit).

No	Common Name	Botanical Name	Brief description*
1			
2			
3			

Brief description* = This includes nature (growth habit, life span, bearing habit, fruit type etc.) of the selected tropical fruits.

Discussion

- Discuss your observations (based on pictorial display/flip chart, and/or what they would observe from fruit farm available in vicinity).

_____
_____

Conclusion

Write what you conclude based on your observations or visit

Recommendations

Self-assessment

1. Do I distinguish among the various tropical fruits based on the observations (pictorial display/flip chart and live fruit plants)?
2. Do I know the differences between climacteric and non-climacteric fruits? Give an example of each.
3. Do I clearly and concisely explain the observed results to peer group and my instructor?
4. Have I acquired report writing skill based on the observations I made?

References

1. Watson, B. J., and M. Moncur. 1985. Criteria for Determining Survival: Commercial and Best Minimum July Temperatures for Various Tropical Fruits in Australia (S. Hemisphere). Queensland, Australia: Wet Tropical Regional Publication.
2. Nakasone, Henry Y., and Robert E. Paull. Tropical Fruits. New York: Cab International, 1998.
3. Samson, J.A.1990.Tropical Fruits Longman group Ltd. London. 3.

PRACTICAL SESSION 2

Practical Session 2

Demonstration of Tropical Fruit Crops Propagation

Practical session 2

Practical session 2: Demonstration of Tropical Fruit Crops Propagation

Theory

Fruit plants may be propagated directly from seeds or by vegetative means. Although seed propagation of fruit plants is the easiest, generally it is not the best, because it scarcely allows for maintenance of the characters of the original plant. In addition, plants grown directly from seeds are slow to come into production. Seedlings are normally grown as a rootstock onto which desired fruit cultivars are budded or grafted.

A vegetative reproduction is the process of multiplication in which a portion of fragment of the plant body functions as propagules and develops into a new individual plant which involves the production of new plants without the act of fertilization or sexual union. It is accomplished entirely by mitosis, the cell division process by which the plant grows. Each daughter cell is an exact replica of its mother cell [1].

Several vegetative propagation methods are used to multiply tropical fruit crops. Some of these include grafting, budding, cutting, layering, micro propagation or tissue culture. Proper polarity is essential if the graft union is to be permanently successful. In all commercial grafting operations correct polarity is strictly observed. In top grafting, the proximal end of the scion is attached to the distal end of the stock [2, 3]. In root grafting, however, the proximal end of the scion is joined to the proximal end of the stock (Fig. 2.1).

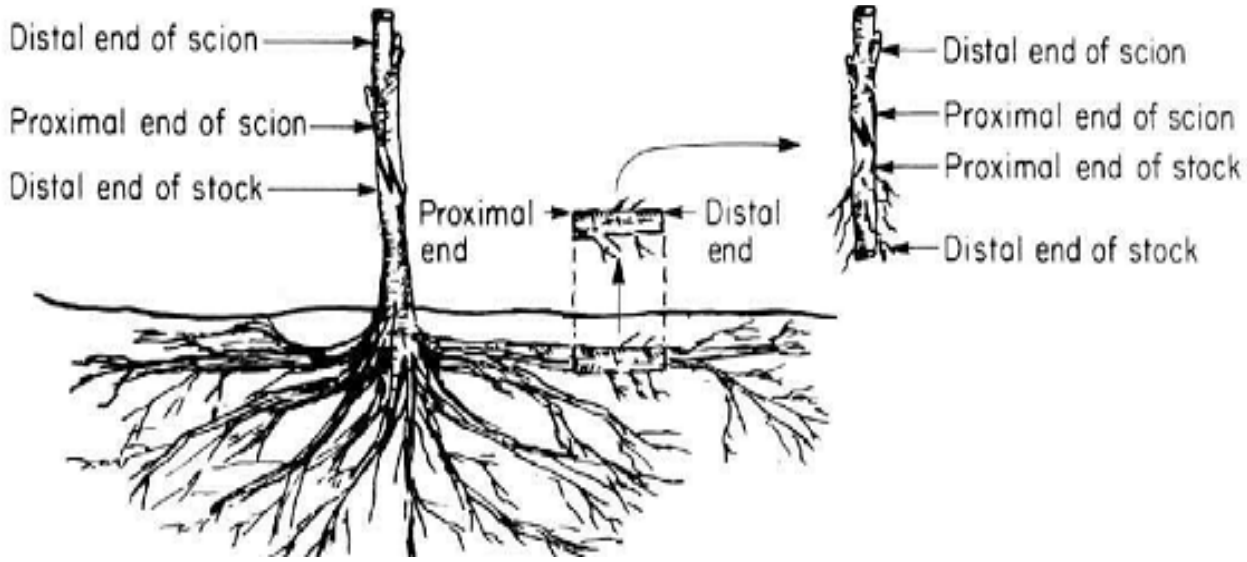


Figure 2.1 Polarity in grafting
Source: Hartmann and Kester (1983)

In contrast to grafting, in which the scion consists of a short detached piece of stem tissue with several buds, budding utilizes only one bud and a small section of bark, with or without wood. Budding makes more economical use of propagating wood than grafting, each bud potentially being capable of producing a new plant. The common budding techniques used to propagate tropical fruits include T-Budding, Inverted T-Budding, Patch Budding, I-budding and Chip budding.

In propagating by cuttings, a portion of a stem, root, or leaf is cut from the parent plant, after which this plant part is placed under certain favorable environmental conditions and induced to form roots and shoots, thus producing a new independent plant which, in most cases, is identical to the parent plant. Cuttings can be classified according to the parent of the plant from which they are obtained: Stem cuttings, leaf cuttings, leaf-bud cuttings, and root cuttings. Stem cuttings.

The stem cutting, which is one of the most important types in fruit propagation, can be divided into three groups, according to the nature of the wood used: hardwood, semi-hardwood, and softwood cuttings.

Layering is a propagation method in which a portion of plant is forced to produce adventitious roots while it is still attached to the parent plant [2, 4]. It is often used in species that are particularly difficult to root, as the intact stems allow a continuous supply of water, nutrients and plant hormones to the place of root development. The rooted, or layered, stem is detached to become a new plant growing on its own roots. Layering is similar to propagation by cuttings except that, instead of severing the part to be rooted from the mother plant, it is left attached and receives water and nutrients from the mother plant. Layering methods commonly used in tropical fruits include: Simple layering, Mound layering, and Air layering.

2.1 Procedure for propagation of selected tropical fruits by seed

2.1.1 Procedure for seed extraction of selected tropical fruits

Objectives

To acquaint the students with procedures of seed extraction of selected tropical fruit crops,
-To enable the students understand causes and treatments to overcome seed dormancy of selected tropical fruits.

Materials

Equipment

- Sharp knife,
- Small wooden box/tin can,
- Plastic pot,
- One to two liter jug,
- 100 ml conical flask,
- Juicer,
- Sieve,
- Fine plastic strainer.

Consumables

- Mature & well ripe healthy fruits
- Glove
- Water
- Charcoal

2.1.2 Procedure for raising seedlings for rootstocks of selected tropical fruits

Seedlings can be raised in the nursery beds or in polythene bags, however raising rootstocks in polyethylene bags is recommended due to better establishment of plants in the field on account of undisturbed tap root system.

Moreover, rootstock raising in polyethylene bags is cost effective as it saves labor in weeding, watering, shifting and lifting of plants.

A. Procedure for propagation of mango by seed

Most mango plants are grafted on to polyembryonic rootstocks in order to obtain plants that have a uniform root system, since they come from an asexual process and so are clones.

1. Collect mature mango fruits from healthy polyembrionic selected trees, and seeds must be free of pest and disease. Polyembryonic mango cultivars are theoretically recommended to be propagated by seeds in order to establish uniform mango rootstock,

2. Fruits and seeds should as much be larger as possible according with the selected cultivar since germination and vigor are positively related both to seed weight and to the size of the cotyledons,

3. Wash the pulp, adhering on endocarp of the seeds, immediately after the extraction and then dry in the shade under good aeration environment for 1-2 days,

4. Remove the endocarp after drying by use of a pruning scissor or a sharpened knife avoiding injury or wound the cotyledons. The removal of the endocarp promotes a quick seed germination and also favors the emergence of a larger number of right (erect) seedlings which improves the graft quality.

5. Execute sowing immediately after pulling out the cotyledons from the endocarp (i.e., because viability of mango seeds is short which decreases rapidly after 15 days of the fruit harvest),

6. Mango cotyledons are kidney-shaped and during sowing, the concave part of the seed should face down and be buried about 4–5 cm into sand or a sandy mix.

7. The seeds germinate within 20 days after sowing (Fig.-2.2a, Fig.-2.2b). The germinated seedlings are separated and transplanted singly into polyethylene bags (18 cm (w) × 13 cm (d) × 30 cm (h)), and bags up to 45 cm in height help to avoid early root deformation.

8. When the color of seedling leaves changes from coppery red (Fig.-2.2c) to green (Fig.-2.2d), the seedlings are shifted to permanent nursery beds.

9. The seedlings are grown under ~30% shade.

Note: The seeds of polyembryonic cultivars produce several seedlings, some of which become twisted together and have curved stems and roots, and should be discarded and not transplanted into nursery bags.

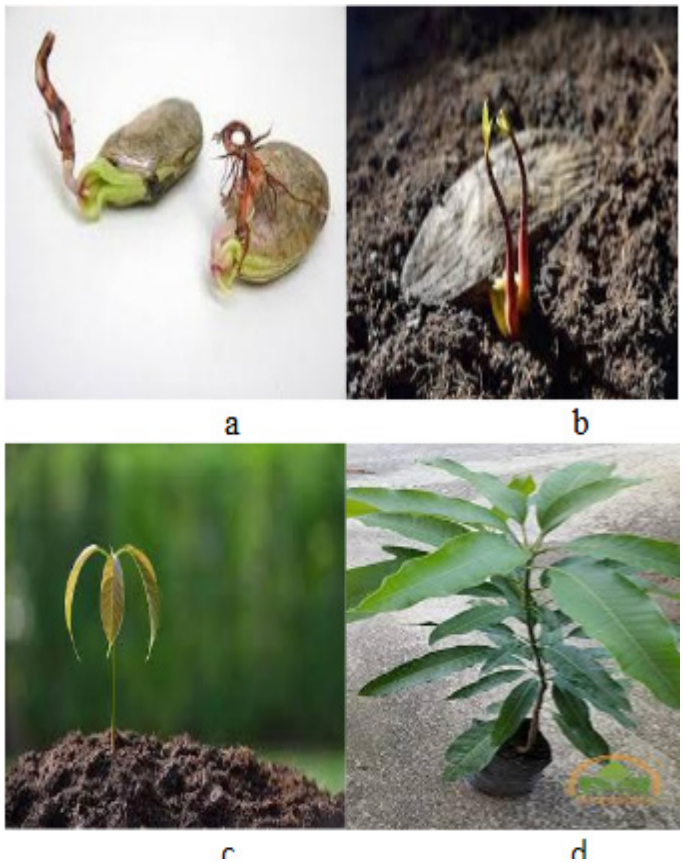


Figure 2.2 Mango seed germination and seedling growth (The seeds commonly germinate within 20 days after sowing (Fig.2.2a, Fig.2.2b). When the color of seedling leaves changes from coppery red (Fig.2.2c) to green (Fig.2.2d), the seedlings are shifted to permanent nursery beds).

Source:http://www.ijpab.com/form/2018%20Volume%206,%20issue%203/IJPAB-2018-6-3-575-586.pdf

B. Procedure for propagation of guava by seed

1. Harvest ripe fruits from selected plants,
2. Remove seeds from ripe fruits,
3. Considering the hard coat of the seeds, it is necessary to pour boiling water on the seeds and allowing them to soak in water for a few days prior to sowing or treating them with strong sulphuric acid for five minutes facilitates their germination,
4. Wash the treated seeds in running water and dry in the shade for 10 days. Spread the seeds thinly and evenly on a mat, canvas sheet, light-colored plastic sheet. Stir and turn the seeds 4–5 times a day for uniform drying. Protect the seeds from rodents and birds during drying.
5. Sow the seeds in nurseries or directly on plastic bags, containing substrate with good drainage. Germination usually occurs between 15 to 20 days. For propagation by grafting, seedlings need to have 12-20 mm of diameter to 20 cm.

C. Procedure for propagation of papaya by seed

Papayas are usually grown from seeds. Unlike the seed of many tropical species, papaya seed is neither recalcitrant nor dormant and are classified as intermediate for desiccation tolerance [5].

1. To obtain plants of the best quality, papaya seeds should be obtained from vigorous plants that possess the desired quality,

2. Place seeds in a cup or vessel with clean, room temperature water, and allow seeds to soak for 24 hours. During the soaking phase make sure to use very clean water. If the water has bacteria or is dirty it can drastically reduce the % of germination,

3. Drain all the water and fill again and let the remaining seeds soak for another 24 hours,

4. Discard damaged seeds, select healthy and mature seeds through floating technique prior to sowing. Plant the seeds that have sunk and discard the rest,

5. Papaya seeds are usually treated with fungicide and planted in beds 15 cm above ground level that have been organically enriched and fumigated,

6. Sow the seeds 5 cm apart and 2 - 3 cm deep in rows 15 cm apart, and water them daily,

7. In dioecious papaya (male and female flowers on different trees), plant about five seeds/bag and leave all the plants. Thinning will be done in the land when the plants start to flower.
8. For hermaphroditic cultivars, plant two seeds /container. The extra plants should be transplanted into empty containers within two weeks after germination. The plants should not be transplanted deeper than they were (only the white part of the stem should be covered by the medium),

9. Provide shade during germination to prevent the seeds from drying out. The shade must be removed soon after germination (usually at the four-leaf stage) because papaya plants develop poorly if shaded,

10. Transplant the seedlings (to permanent planting position) in 2 1/2 months when 15 - 20 cm high. Transplanting is more successful if polyethylene bags of enriched soil are used instead of raised beds. Two seeds are planted in each bag but only the stronger seedling is maintained. Transplanting is best done in the evening or on cloudy, damp days. On hot, dry days, each plant must be protected with a leafy branch or palm leaf stuck in the soil,

11. When growing dioecious papaya, one female or hermaphrodite plant is retained, after flowering, the rest are removed. But one male is kept for every 10 to 25 females, depending on plant density,

12. Watering is done every day until the plants are well established, but over watering is detrimental to young plants.

Observation and Expression of Results

Write your observations based on the following points:

- Take one or two fruits of any one or more of tropical fruits (available in your area) and observe number of seeds per fruit.
- Whether the seeds have germination barriers (hard seed coat/testa, gelatinous substance adhering on seed).
- Physical quality characteristics such as size, seed coat condition (example - absence of cracks), and absence of pests or diseases that may negatively affect germination of seeds of tropical fruits available in your area.
- Whether seeds of mango (if available in your area) are monoembryonic or polyembryonic (record their distinguishing characteristics).

Recommendations

- Fruit seeds need to be dried under shade.

Self Assessement

1. Do I know seed extraction procedures of tropical fruits available in my area?
2. Do I make a clear distinction between monoembryonic and polyembryonic mango seeds?
3. Why fruit seeds are washed and allowed to dry under shade before sowing?
4. Do I explain why seeds of dioecious papaya are planted up to five seeds per pot/planting position?
5. Do I know quality characteristics (example: physical and physiological) of seeds of tropical fruits such as mango, papaya and guava?
6. Am I clear whether the growers of tropical fruit crops in my area can obtain quality seeds from known source?

2.2 Procedure for propagation of selected tropical fruits by vegetative means

Objective

- To acquaint the students with the basic principles and common methods of vegetative propagation of tropical fruit crops.

Materials

Equipment

- Grafting/budding knife,
- Hammer (or Mallet),
- Cooler box (to collect scion -wood, optional),
- Fine tooth saw,
- Pruning shears

Consumables

- Stock plants (Root stock, Scion/scion-wood, Inter stock in some cases),
- Plastic bag to collect scion or wet newspaper,
- Tying Materials: tape, rubber strips,
- Grafting wax,
- Sterilizer such as spirit/ alcohol

A) Procedure for propagation of banana

1. The sucker multiplication plot is established with good quality, pest and disease free suckers planted at a high density on quality soils, rich in organic matter.

2. Remove suckers (Fig. 2.3) from the mother plant when they reach a min imum of 15cm diameter and 50 cm height above the soil [6].

3. Remove the sucker (cut away and out) from the mother plant using a sharp tool such as a narrow-bladed, straight-sided shovel, making sure to obtain an appre ciable amount of corm with the sucker,

4. At planting cut sword suckers back to about two thirds of their length, while maiden sucker is cut back just below the crown.

Figure 2.3 Sword suckers, widely used planting material in Ethiopia
Source: https://www.researchgate.net/figure/Mother-plant-1-year-old-and-sword-suckers-of-banana-cv-Nanjangud-Rasabale_fig1_323208450

B) Procedure for propagation of pineapple

1. Pineapple is propagated by vegetative means using different propagules (suckers, slips, crowns) (Fig. 2.4).

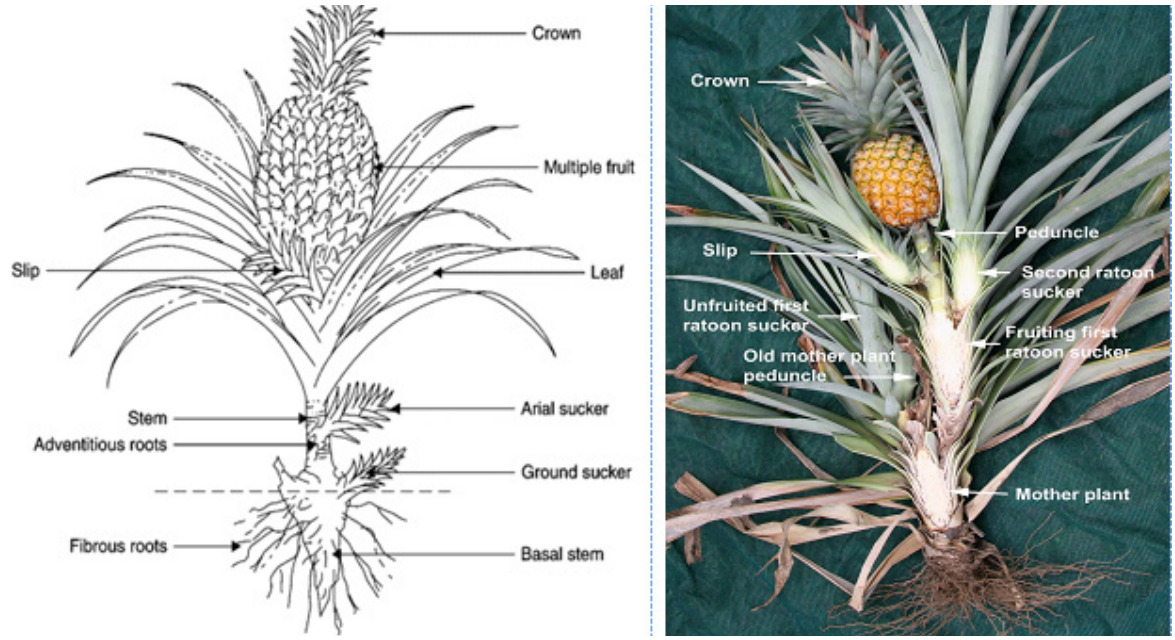


Figure 2.4 Parts of the pineapple plant showing the three major types of asexual planting material- crowns, slips and suckers.
Sources: http://www.uq.edu.au/_School_Science_Lessons/PineProj.html
https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/66247/Ch1-The-Pineapple.pdf

2. Separate (sort) the pineapple planting material based on the type and size (Fig. 2.5) so that a field is planted with uniform material [7].

Figure 2.5 The different types of pineapple propagules ready for curing and subsequent planting
Source: https://vdocuments.mx/pineapple-jai-prakash.html; https://slideplayer.com/slide/5205422/

3. Remove dried leaflets found at the base of the suckers and trim the ends with a sharp knife.

4. Cure or dry all types of planting materials (by turning each type of planting material upside down and let it dry) for one to several weeks (after they are separated from the mother plant). This allows a callus layer to develop over cut surface, reducing losses from decay organisms after they are planted.

5. When planting, ensure that the “heart” of the plant is above soil level otherwise rotting will occur, particularly if the soil is wet.

6. Commercially pineapples are commonly planted in a double row spacing of 90 x 60 x 30 cm (Fig. 2.6) i.e., 90 cm between beds (double rows), 60 cm between rows and 30 cm in the rows [8].

Figure 2.6 Double row spacing in pineapple
Source: http://www.itfnet.org/v1/2016/05/pineapple-agronomy/

C) Procedure for mango wedge grafting:

Use healthy, vigorous and uniform seedlings from polyembryonic seed for rootstocks. Monoembryonic seeds are not recommended for use because their sexual embryos produce non-uniform seedlings.

Select the rootstock according to these criteria:

1. Suitable variety; but if not available chose a seedling from a local mango tree that grows well in the area.

2. Healthy, strong and free of pests.

3. About 6 months old (which should be at least 25 cm tall) with a stem as thick as a pencil.

Scion wood: Collect scion wood when the trees are in active growth. Scions are obtained by removing the terminal 5 to 7.6 cm of a twig whose terminal bud is beginning to enlarge. Scions are removed from the tree and for veneer grafts all of the leaves are removed.

To get quality scions follow these steps:

1. Identify a highly productive, healthy mother tree of the desired variety and quality.
2. Select scions from the end of the branches which are as thick as a pencil and have an active, healthy terminal bud.
3. Cut the scion at 10 cm length with a pruning scissor or secateurs or a very sharp knife.
4. Remove the leaves from the scion with a clean sharp knife or secateurs.
5. Wrap the fresh cut scions in a wet newspaper and put the package in a plastic bag.
6. Transport your scions to the place of grafting soonest. Store the package at a cool place during transport and use a cooling box for longer transport if available.

Wedge grafting (Fig. 2.7) procedure:

1. Decapitate the rootstock seedlings leaving 30 cm of stem above ground level,
2. Then split the top with the help of grafting knife to a length of 4.5 cm scion shoot having nearly same diameter and of about 10 cm length needed to 4.0-4.5 cm as wedge by removing the bark along with wood from the opposite sides taking care to retain same bark on the two sides.

Preparing the scion for wedge grafting

1. Cut the scion to a final length of about 10 cm with a pruning scissor or a sharp knife.
2. Use the scalpel or razor blade to sharpen the cut lower end of the scion to a V-shape by removing the wood on both sides of the scion.
3. Try to make the V-shape as deep (about 2 – 3 cm long is suitable) as possible as this will increase the survival rate of your grafted scion.

Join rootstock and scion

1. Insert the wedge (sharpened end) of the scion shoot into the split of the stock (align the two parts) and tie with polythene strip firmly,

Important: Make sure the cambium parts (these are the white greenish layers just under the bark) of the scion and the rootstock are in close contact and quite firm. It is important that both the scion and rootstock have exactly the same thickness at the contact location. If this is not the case, it is advisable that you remove the scion and repeat the sharpening at a thinner end or cut the rootstock at a thicker part of its stem. Then repeat the joining and check if the two are matching better.

2. Fix both the scion and rootstock in place by covering the point of union until it is healed. To do this; (a) Hold the union carefully with one hand, (b) With your other hand, wrap the grafting tape or the polythene strip tightly around the union and knot or inter-loop the two ends of the tape/strip, (c) Make sure that the wrapping is tight enough and that the scion does not move out of the union while wrapping.

3. Bag the graft with transparent polyethylene to prevent dehydration and increase the success percentage.

Figure 2.7 Wedge grafting steps in mango
Source: https://www.worldagroforestry.org/sites/default/files/users/admin/mango-grafting-manual.pdf

4. Keep the grafted saplings in the shade and water them well.

5. After about 14-21 days the scion should have developed new leaves and the wound should have healed.

6. Remove the grafting tape or polythene strip when the wound is fully healed (when the sprouting is initiated). Be careful not to injure the stem when removing the tape/strip.

7. Harden your grafted saplings to avoid shock by placing them in a shade house or a shaded area for 6-8 weeks before transplanting.

D) Procedure for propagation of guava by wedge grafting

1. Raise seedling for rootstock in the nursery for approximately 6 to 8 months.

2. When the stem diameter of seedling is of pencil thickness (0.5 - 1.0 cm they are chosen for wedge grafting.

3. Select scion (15-20 cm long shoots; 3-4 months old) with 3-4 healthy buds and of pencil thickness.

4. Defoliate the selected scion shoots on the mother plant, about a week prior to detaching (as this will help in forcing the dormant buds to swell, in this way the buds on the scion are ready to start sprouting at the time of grafting).

5. After selection of the scion, rootstock (seedling) is headed back by retaining 15-20 cm long stem above the soil level in the polyethelene bag.

6. Split the beheaded rootstock to about 4.0-4.5 cm deep through the center of the stem with grafting knife.

7. Make a wedge shaped cut, slanting from both the sides (4.0-4.5 cm long) on the lower side of the scion shoot.

8. Insert the scion stick into the split of the stock and press properly so that cambium tissues of rootstock and scion stick should come in contact with each other.

9. Wrap (tie) the union with the help of 150 gauge polyethylene strip, 2 cm in width and 25-30 cm in length.

10. Immediately after grafting, cover the graft by 2.5x18.0 cm long cap which is tied with rubber band at lower end.

11. The scion starts sprouting after 10 to 12 days.

12. Remove the cap after 25 days in the evening hours.

13. Transfer the grafts to net house for hardening.

E) Procedure for propagation of guava by shoot (soft wood) cuttings

The guava tree can be propagated by shoot cuttings (example softwood cuttings) (Fig. 2.8).

1. Take the cuttings

- Choose a parent plant with soft healthy stems at the tips of the branches or the new growth of a herbaceous perennial
- Cut five soft shoots from the parent plant. Each cutting should be 5–8cm long.

2. Prepare your cuttings

- Cut the stem squarely across the stem, just below a node. This is where there is a concentration of natural hormone (auxin) and stored food.
- Remove the lower leaves. This helps expose the cambium tissue.

- Remove any flowers. You want all the plant's energy to go into forming roots.
- Trim large le aves in half. This slows water loss from the leaves.
- Remove the tip.

3. Plant your cuttings

- Dip the cuttings in rooting powder or gel and shake off any excess. Too much can cause tissue damage,
- Fill a container with the basic growing media, and firm it slightly,
- Make holes in the media, and put a cutting in each hole,
- Firm around the stems to stop air pockets,
- Label each pot with the plant's name and the date,
- Water the containers gently.

4. Create a warm humid environment

- Put the container in the plastic bag,
- Loosely close the top of the bag with a rubber band,
- Put the container in a warm, well-lit place but not in full sun.

Figure 2.8 Rooting of guava from softwood cuttings
Source: http://www.scielo.br/pdf/rbf/v39n4/0100-2945-rbf-39-4-e-358.pdf

Observation and Expression of Results

- Write your observation based on your activity conducted for different propagation techniques.

Discussion

- Discuss each methods of cutting briefly

Conclusion

- Conclude your findings based on your observation

Recommendation

Self assessment

Assess yourself answering the following questions:

- Define asexual propagation.
- How does vegetative propagation differ from sexual propagation.
- Distinguish between different propagules used for propagation of banana, pineapple, mango and guava.

References

1. Hartmann, H.T., D.E. Kester, and F.T. Davies. 1990. Plant Propagation: Principles and Practices. Prentice-Hall, Inc., New Jersey. p. 647.
2. Hartmann H.T. and D.E. Kester. 1983. Plant Propagation: Principles and Practices. Hall Inc., New Jercy.
3. Sharma, R.R. 2002. Propagation of Horticultural Crops (Principles and Practices). Kalyani Publishers Ludhiana.
4. Mitov P., T. Angelov, N. Dimov, G. Pepeliankov, and D. Diakov. 1990. Fruit Production: Zemizdat. Sofia, Bulgaria.
5. Ellis, R.H., T.D. Hong and E.H. Roberts. 1991. Effect of storage temperature and moisture on the germination of papaya seeds. Seed Sci. Res. 1:69-72.
6. Stover, R.H. and N.W. Simmonds. 1987. Bananas. John Wiley and Sons, Inc., New York.
7. Ray, P.K. 1996. Pineapple, In: A Textbook on Pomology (Tropical Fruits), Chattopadhyay, P.K., T.K, Bose (eds.). Kalyani Publishers, New Delhi. pp.141-165.
8. Samson, J.A. 1986. Tropical fruits. 2nd ed., Trop. Agr. Ser., Longman Scientific and Technical, New York.

2.3 Micropropagation of tropical fruit crops

Theory

Micro propagation is one of the plant cell and tissue culture techniques used to produce a large number of diseases free and genetically identical plants with their parental lines, as well as to each other using small pieces of tissues called “explants” collected from a stock plant, within a relatively very short period of time [1]. It offers several distinctive advantages for fruit crops propagation that are not possible with the conventional sexual or other asexual propagation techniques [2].

Among others, it enables multiplication of a single explant into several thousand even sometimes millions of true-to-type plants in less than a year, without affecting the growth and/or productivity of the mother plant [3]. Moreover, once established, actively dividing in vitro cultures also serve as a continuous source of micro-cuttings, thereby facilitating plant production under greenhouse conditions without any seasonal interruption [4]. This technology has now been commercialized globally and has contributed a lot towards successful production of high quality planting material [5]. Mostly, micro propagation is a 5 stage process viz: explants establishment, explants collection and surface sterilization, shoot multiplication, root induction and acclimatization of plantlets [7, 8].

Objectives

To acquaint students with:

- Micropropagation techniques of tropical fruit crops
- The knowledge of explant establishment, sterilization, shoot multiplication, root induction and acclimatization activities (Fig. 2.9) in tropical fruit crops micro propagation.

Materials

Equipment

- Bunssonburner
- Autoclave
- Jar
- Pippet
- Sensitive balance
- Refrigerator
- Stove
- Beaker
- Dispenser
- Stir bar
- Magnetic stirrer
- Dry oven
- Laminar flow hood cabinet
- Cylinder

Consumables

- MS Media
- Sucrose/sugar
- Alcohol
- Berekina
- Sodium hypochlorite
- Auxin (NAA, IAA, IBA)
- Cytokinin (BAP, Zeatin, kinetin)
- Soap
- Explant
- Glove
- Distilled water
- Almunium foil
- Maxing plaster
- Sharpie
- Weighing boat
- Labeling tape
- Agar/Phythagel
- Lab coat
- Lab shoe
- Notebook
- pen
- PPE
- Timer
- Tissue paper
- Cotton

Procedure

1. Establish explants source or take from the existing farm,
2. Prepare the culture media (Table 2.1),
3. Collect the explants from 3-5 week old seedling and surface sterilize using mercury chloride or sodium hypochlorite,
4. Culture the explants into the prepared media that contain cytokinin and put in the growth room for shoot multiplication and subsequent sub culturing,
5. Once the culture explants proliferate, transfer the plantlets into a new media that contain auxin,
6. Transfer the rooted plantlets into planting tray and acclimatize in green house.

Table 2.1. Nutrient composition and concentration of MS basal medium for fruit crops micropropagation

Basal media components	Concentration (mg l^{-1})	Stock solution
Macro nutrients		X 10 (g/100ml)
NH_4NO_3	1650	16.5
KNO_3	1900	19
$CaCl_2.2H_2O$	440	4.4
$MgSO_4.7H_2O$	370	3.7
KH_2PO_4	170	1.7
Micro nutrients		X20 (mg /200ml)
H_3BO_3	6.2	124
$MnSO_4.4H_2O$	22.3	446
$ZnSO_4.7H_2O$	10.6	212
KI	0.83	16.6
$FeSO_4.7H_2O$	27.8	0.556
Na_2Fe-EDTA	37.3	0.746
*$Na_2MoO_4.2H_2O$	0.25	Concentrate x 1000
*$CuSO_4.5H_2O$	0.025	(g/1000ml) and take 10
*$CoCl_2.6H_2O$	0.025	ml
Organic supplements		X 20 (mg/200ml)
Myo-inositol	100.0	2000
Glycine (Glycocoll)	2.0	40
Nicotinic acid	0.5	10
Pyridoxine -HCl (B6)	0.5	10
Thiamine -HCl (B1)	0.1	2
Sucrose	20000/30000	
Gelling agent		
Phytagel (Agar)	1500/3000	

Source: Murashige and Skoog (1962)

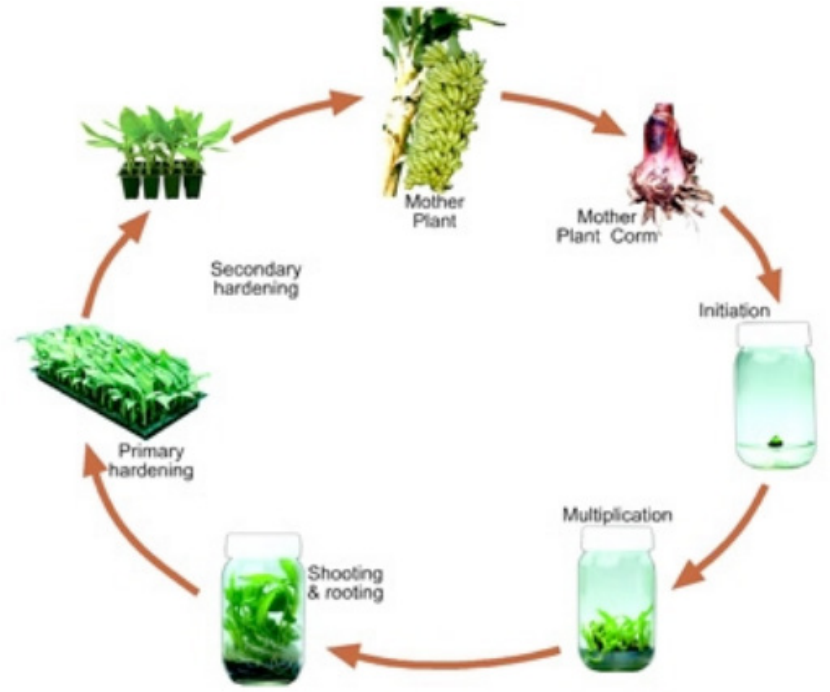


Figure. 2.9 Schematic diagram of micropropagation in tropical fruits (example banana)
Source: http://www.krishisewa.com/articles/miscellaneous/856-tissue-cultured-banana.html

Observation and Expression of Results

Explain results of your observation considering the following issues:

- State the type, concentrations of cytokinin and auxin used
- Show the cytokinin and auxin concentration that gives you the better shoots and roots respectively
- Percentage of infected explants

  Infected explant (%) = No. of infected plantlets/total No of explants * 100
- Percentage of field survival

  Field survival (%) = No. of survived plantlets/Total No of plantlets taken to field*100

Discussion

- Discuss how the different concentrations of cytokinin and auxin affect the shoot multiplication and root induction. Reason out why some of the plantlets get infected and some are dried once transferred to the field.

Conclusion

- Based on your observation give a conclusion about the effect of cytokinin and auxin on the shoot multiplication and root induction of the attested tropical fruit

Recommendations

Recommend the type and concentration of cytokinin and auxin you find for micropropagation of the attested tropical fruit.

Self-assessment

- Do I know the major operational activities in micropropagation?
- Do I distinguish between auxin and cytokinin?
- Can I can prepare the MS, cytokinins and auxins stock solutions independently?
- Why I use gelling agent (agar and/or pythagel)?
- Why I pour the vitamins and the PGR in a brown glass bottle and store in deep freezer?
- Why I need to autoclave the growing media?
- Why I prepare the growing media 3-4 days ahead of the actual explants inoculation?
- Do I understand what acclimatization meant?
- Can I manage tropical fruit micropropagation activities independently?
- What additional knowledge/skill I need to take about micropropagation of tropical fruits? If so what sort of additional input is needed?

References

1. IITA, 2009. Fruit Crops Gene Banking Manual. www.iita.org. (Accessed on February 19, 2010).

2. Zimmermann, T.W., K. Williams, L. Joseph, J. Wiltshire, and J.A. Kowalski, 2009. Rooting and acclimatization of fruit plantlets ex vitro. A Proceeding organized by ISHS at International Symposium on Biotechnology of Temperate Fruit Crops and Tropical Species. http://www.actahort.org/members/showpdf?Booknrarnr =738_97 (Accessed on May 7, 2009)

3. Sigma Aldrich. com., 2010. Plant Tissue culture Protocols. http://www.sigma aldrich.com/life-science/molecular-biology/plant-biotechnology/tissue-cultureprotocols/ media preparation.html (Accessed on February 20, 2010).

4. George, E.F., 2008. Plant Tissue culture Procedure. 3: 1-28.In: Plant Propagation by Tissue culture. In: E.F. George, M.A. Hail, and G. Klerk, (eds.). Springer, Docrdrecht.

5. George, E.F., 1993. Plant Propagation by Tissue culture. Part-I. The Technology. Exegetics Ltd., Edington, Wilts, England, pp. 89-91

6. Staden, J.V., E. Zazimalova and E.F. George, 2008. Plant Growth Regulators II: Cytokinin, their Analogues and Antagonists. In: E.E. George, M.A. Hall, and G. De Klerk, (eds.). 3: 205-226.

7. Robert, N., and J. Dennis, 2000. Plant Tissue culture Concepts and Laboratory Exercises. 2nd ed., CRC press. 454p.

8. George, E.F., 2008. Plant Tissue culture Procedure. 3: 1-28.In: Plant Propagation by Tissue culture. In: E.F. George, M.A. Hail, and G. Klerk, (eds.). Springer, Dordrecht.

9. Murashige T, Skoog F., 1962. A Revised medium for rapid growth and bioassays with tobacco tissue culture. J. Plant Physiol. 9: 473-497.

PRACTICAL SESSION 3

Practical Session 3

Tropical Fruits Nursery Establishment and Management

Practical Session 3

Tropical Fruits Nursery Establishment and Management

Theory

Nursery is a location where plants are cared during their early stages of growth to provide optimum condition for germination and subsequent growth until seedlings are ready for budding and grafting and strong enough to be planted-out in their permanent field or get sold [1]. Young plants especially tropical fruit saplings whether produced from seed or through vegetative means, they need a special care during their early stages of growth [2]. Although their basic requirements remain the same, tropical fruit saplings differ in their needs for soil type (nursery substrate), light, temperature and moisture requirements [1, 2]. They also require protection from the sever heat of the Sun, heavy rain, drought and variety of pests and diseases especially in the tropical conditions. Thus, raising them in nursery is suggested as a plausible measure to optimize those factors. Generally, an area to be selected for tropical fruit saplings raising in nursery must have the following features. (a) Gently flat surface (an area up to 3% slope can also be selected provided that terraces are constructed perpendicular to the slope). (b) Continuous supply of clean water; (c) Free from any cyclonic and strong winds; (d) Well drained, fertile and light to medium textured soil; (e) For the last 3-4 years uncultivated with the same crop or crops belong to the same family to avoid the build-up of diseases and nematodes; (f) Should be outside the range of the roots and shade of trees, hedges and buildings; (g) Should be separated from the production field; (h) Should be near to main field, road and labor source; and (i) Should be free from flooding as tropical fruit seedlings cannot tolerate water logging conditions [3].

Depending on the weather condition and the soil type, tropical fruit seed beds in the nursery could be made into: (1) Raised bed- recommended for areas receiving high rain fall or poorly drained soils or during heavy rainy season. (2) Flat bed- recommended for areas receiving optimum rain fall or when plating tray are used). (3) Sunken bed- recommended for areas with shortage of optimum rainfall and/or during precipitation. The major nursery establishment and management considerations include site selection, clearing, land and seed bed preparation, determination of seed quality and rate, sowing/planting and post-planting care such as mulching, watering, shade construction, fertilization, weeding, thinning, pest management and hardening off [4].

Objectives

To familiarize students with the knowledge and skill on how to:

- Select an appropriate nursery site for tropical fruits seedling raising.
- Prepare seedling-raising media for beds and containers.
- Prepare seed beds and seed pans for seedling raising.
- Manage various activities of fruit nursery (watering, mulching, thinning, shade construction, fertilization, acclimatization, plant protection etc.).

Materials

Equipment

- Tape meter,
- Shovel,
- Digging fork,
- Rake,
- Watering can,
- Watering hose with nozzle,
- Hammer,
- Wheelbarrow,
- Pruning knife,
- Trowel,
- Secateurs/pruning shears,
- Knife
- Soil map (if available)

Consumables

- Propagules (Tropical fruit seeds, cuttings, bud-wood),
- Nursery substrates (top soil, sand, compost etc.)
- Polyethylene bag (containers)
- Wooden pole/pegs
- Nail
- Dried grass
- Fertilizer (organic & inorganic)
- Water,
- Rope/string,
- Checklist,
- Meteorological data (if available)

Procedure

1. The nursery area is selected near to the production site considering nurs ery selection criteria (Table 3.1),

2. The nursery site has to be clear from all vegetation (including trees, bush es, weeds, woody remains etc.),

3. The nursery site is ploughed at least three times (till the site during dry period two months ahead of sowing. The first till is done one month after the first tillage and the third tillage shall be carried by mixing FYM/compost at a rate of 6-12 kg/bed a week before sowing,

4. If polyethylene bag is to be used, prepare a potting mix comprising of top soil, sand and compost with their respective ratio of 2:1:1 by volume and fill the polyethylene bag a week before the actual sowing,

5. Layout of the nursery is prepared on paper (type of bed and size, spacing between beds…).

6. Depending on the weather condition and the soil type, different seedbed types (raised, flat and sunken bed) are prepared in such a way that pegs are pegged at a width of 1-1.20 m and length of convenient size (mostly 5 m or 10 m) with a path of 40 to 60 cm spacing and 5 cm deep between beds (Fig. 3.1).

7. If it's a must to locate a fruit nursery site on steep slopes (> 3%), terraces and contour lines need to be constructed perpendicular to the slope of the land.

8. The beds and/ or polyethylene bags are watered in 24 hours interval for a week carefully with a fine stream of water and weeds (if any) are removed.

9. Shallow rows are made at 20 cm interval with 8-10 cm deep and perpendic ular to the length of the seedbed.

10. The beds and / or media filled polyethylene bags are watered 24 hours before sowing the seed.

11. One to two fruit seeds (often with a germination percentage > 85%) are sown at 20 cm spacing on the row and covered lightly with moist friable soil.

12. The beds are covered with locally available mulching materials (dried grass, straw etc.) of about 5 cm thick and watered immediately (see Fig. 3.1).

13. Water is applied in an interval of one or two days (applied usually in the morning, between 9-10 am), until the seeds completely germinate (4-6 weeks).

14. Once the seeds germinate in 4-6 weeks, depending on fruit species, the mulch is removed (preferably late in the afternoon) and shade constructed with a height of 1-1.2m by fixing the poles at the edge of the beds and interwoven bamboo (or any other locally available material) over the poles and then the top covered commonly with dried grass (see Fig. 3.2 and 3.3).

15. When the seeds start germinating, the date and number of germinated seeds in each bed are recorded.

16. Once the seedlings form 3-4 true leaves (depending on the fruit species), weak and diseased ones are thinned out, usually late in the afternoon (after applying water to facilitate ease of thinning).

17. Light hoeing is made twice in the seedlings nursery life.

18. Weeds (if any) are pulled out through the seedlings life on nursery.

19. Once, the seedlings form 5-7 true leaves or reach 15-20 cm height, the shade is removed (6-8 days before the actual transplanting) by reducing the thickness of the shade every afternoon and gradually.

NB. Prior to seedbed preparation, nursery area is determined considering: (1) plant density required in the field, (2) spacing in the nursery, (3) size of the bed and (4) amount of reserve plants required.

$$\text{No of seedlings per bed} = \frac{10000\ cm^2 * \text{single bed dimension}}{\text{Intra-row spacing (cm)} * \text{Inter- raw spacing (cm)}}$$

$$\text{No of seed beds/ha} = \frac{\text{Total No of plants needed + Reserve plants required}}{\text{No of seedlings per bed}}$$

Net area of beds = No of beds * single bed dimension
Gross area of nursery = No of beds * 7.56 (for bed size of 5 m x 1 m)
= No of beds * 15.12 (for bed size of 10 m x 1 m)

It's also advisable to construct the longest side of the seed bed from East to West parallel to the sun rise and set (to protect the effect of the sun on the seedlings during rising and setting along the longest side of the bed) and the shortest from North to South.

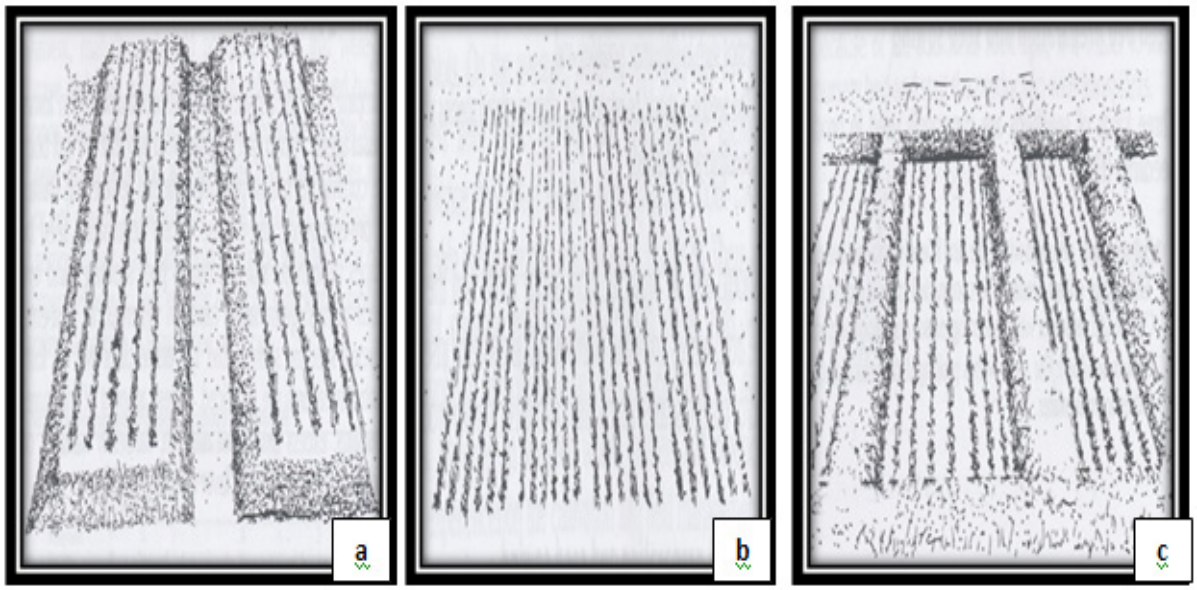


Figure 3.1. Recommended nursery bed types (a=raised bed, b= flat bed and c= sunken bed) for raising tropical fruit seedling.

Figure 3.2. Polyethylene bag filling for fruit crops seedling raising

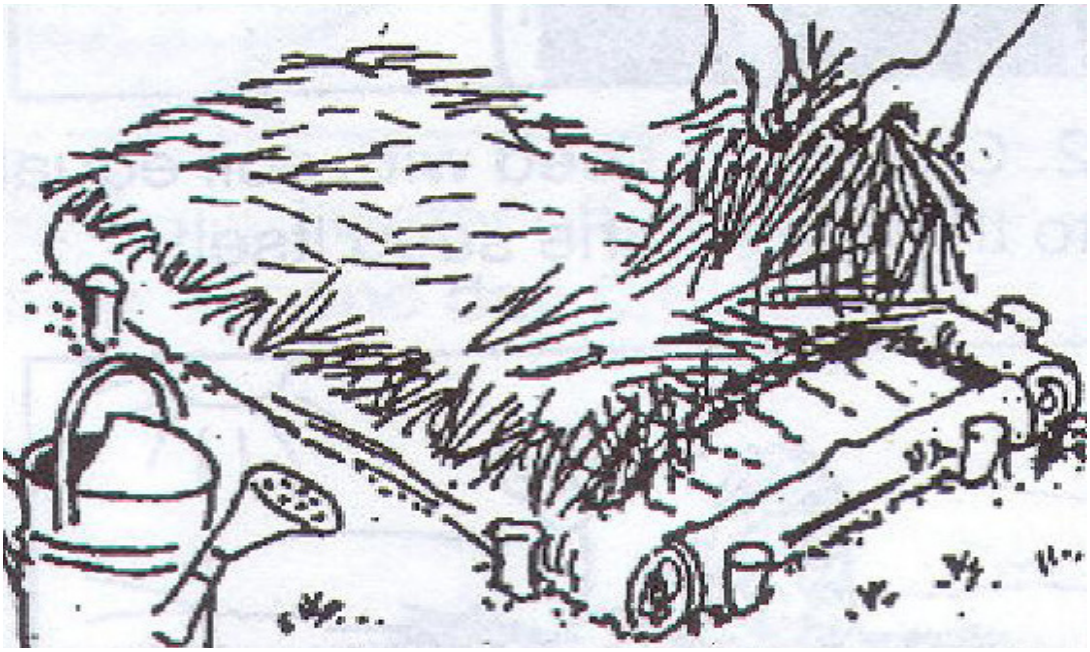


Figure 3.3. Mulching nursery bed for raising tropical fruit seedlings

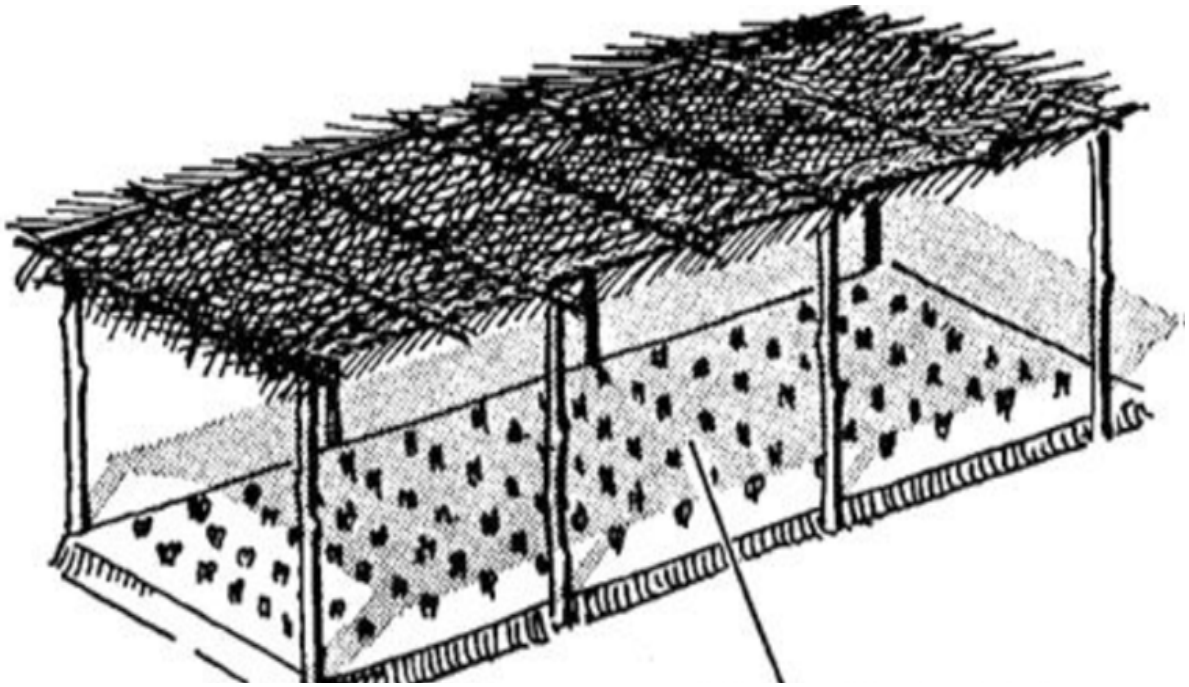


Figure 3.4 Shade construction on tropical fruit nursery bed

Table 3.1 Fruit crops nursery site selection and evaluation criteria check list

S.N	Selection or Evaluation criteria	Suitability
1.	**Climate:**	
	Temperature	
	Light (intensity and quality)	
	Wind (direction and speed)	
	Frost	
	Rain fall(amount and distribution)	
2	**Soil (edaphic factor)**	
	Structure texture depth	
	Fertility/nutrient level	
	PH	
	Drainage	
3.	**Topography**	
	Altitude	
	Aspects	
4.	Accessibility to the area, infrastructure etc.	
5.	Water availability	
6	Nearness to the permanent field, market	
7.	Labor availability	
8	Previous history of the area	
9	Other criteria (if any)	

Establishment of container-grown fruit saplings: Fruit saplings, started from seed or through vegetative means using cuttings (commonly stem cuttings), layers, budding, grafting, or tissue culture plantlets, are also grown in containers (Fig. 3.5). The containers are commonly filled with nursery substrates, consisting of several components such as site soil, forest soil, sand, well composted organic matter or certain materials like sawdust that may enhance the quality of the mixture. As a rule of thumb the following ratios can be proposed: (1) For heavy soils (1 soil: 2 sand: 2 well decomposed organic matter), (2) For medium textured (1 soil: 1 sand: 1 well decomposed organic matter), (3) For light soils (1 soil: 0 sand: 1well decomposed organic matter).

Figure 3.5 Container grown fruit saplings in the nursery

Establishment of stock plants of fruit species: Stock plants are the nursery plants from which material for propagation is obtained. Materials for propagation include cuttings, layers, bud-wood for budding and grafting, suckers etc. By establishing stock-plants near the propagation area, a nursery person will be able to supply enough and the right type of material needed in other processes. Stock plants are required[5]: (1) for producing many shoots quickly in order to get plenty of cuttings, (2) to have them near so that cuttings can be collected and set on the same day, (3) for easy planning and management of nursery operations.

Observation and Expression of Results

Consider the following issues when writing your report:

- Follow the report writing guideline,
- Session title and objective/s,
- Activities done in tropical fruit nursery establishment and management,
- Composition of nursery substrates for raising container-grown fruit saplings,
- The time taken to germinate, the total number and quality of seedlings raised, and other nursery activities based on the way the fruit saplings are raised (bare-root or container -grown).

Discussion

Discuss the need of nursery, repeated tillage, mulching, thinning, shade construction and hardening-off and give scientific explanation. In addition, explain irregularities (if any) related to nursery establishment and/or management that you have observed during the practical session.

Conclusion

Draw a conclusion based on your observation.

Recommendations

Self assessment

Assess yourself by answering the following questions:

- Do I understand what nursery meant?
- Why do I need to grow/establish fruit saplings in nursery?
- Do I know fruit nursery site selection criteria?
- Do I describe fruit nursery management practices?
- Do I distinguish composition of the different nursery substrates (media-mix)?
- Why do I mulch nursery beds?
- Why do I need constructing shade in nursery?
- Do I manage nursery establishment and management activities independently?
- What knowledge and skill did I gain from this particular session?

References

1. Chanana Y.R., 2008. General Horticulture Propagation and Nursery Management. Gill Department of Horticulture Punjab Agricultural University Ludhiana- 141004

2. Bose, T.K., Mitra, S.K., Sadhu, M.K. and Das, P. 2001. Propagation of Tropical and Subtropical Crops. NayaProkash Publishers, Calcutta.

3. Derbew Belew, 2001. Fruit Production and Management. Teaching Material, Jimma College of Agriculture, Jimma, Ethiopia.

4. Mahlstede, J.P. and E.S. Haber, 1959. Plant propagation. John Willey and sons Inc.

5. Dhliwayo P.D., Mwenye D. and Bhebhe E. 2003.Fruit Tree Nursery Establishment and Management: A Training Manual, ICRAF.

PRACTICAL SESSION 4

Practical Session 4

Orchard Establishment and Management

Practical Session 4

Orchard Establishment and Management

Theory

Establishment of an orchard is a long term investment, and deserves a very critical planning. The primary consideration before setting up an orchard is to analyze the available resources in the context of those, which are essential for a successful fruit production. Careful planning results in optimum production, high returns, and long tree life. Poor initial decisions can be costly and difficult to correct later. All available pertinent information should therefore be sought out before final commitments are made.

Site selection is one of the most important decisions a grower will make over the life of an orchard. Virtually every aspect of production and marketing is, to a degree, affected by site. It affects cropping consistency, fruit quality, pest pressures, and marketing success. Any method of layout of orchards should aim at providing maximum number of trees per hectare, adequate space for proper development of the trees and ensuring convenience in orchard cultural practices. The system of layout can be grouped under two broad categories viz. (a) vertical row planting pattern and (b) alternate row planting pattern. In the former planting pattern (e.g. square system, rectangular system), the trees set in a row are exactly perpendicular to those trees set in their adjacent rows. In the latter planting pattern (i.e. Hexagonal, Quincunx and Triangular), the trees in the adjacent rows are not exactly vertical instead the trees in the even rows are midway between those in the odd rows [1].

Land preparation, digging holes and planting are the most important practices in orchard establishment and management. The trees are planted exactly where the stakes stood. It can be easily done with the help of a planting board. The planting board is usually of 1.52 m long, 10 cm wide and 2.5cm thick with a central notch and one hole on either end, the central notch and the two holes (one on either end) are in a straight line. Seedlings need to be correctly planted per planting hole taking extra care not to break the roots or bend the tap root.

If fertility status of the orchard soil is low, fruits should be supplied with proper nutrition. Various fertilizer application methods are followed in fruits' nutrition, depending mainly on the type and form (solid or liquid) of fertilizer, local conditions, and availability of resources. Generally, in fruit plantations, fertilizers may be applied by using any one or more of the following methods: broadcasting, side dressing, ring application, foliar application and fertigation.

Irrigation water application is recommended for growing crops where or when rainfall is non-uniform or absent (spatially or temporally). Generally the methods of irrigation can be classified into two: surface and pressurized (power-driven) systems. The surface irrigation systems can further be classified into flooding (wild and controlled), basin, border and furrow irrigation systems. The pressurized system can be further classified into sprinkler and drip systems.

Pollination is transfer (landing) of active or live pollen onto a receptive stigma. Only flowers that are pollinated develop into fruit. Although some plants are able to pollinate their own flowers, most will produce better quality fruit and greater yield when they have another plant of the same type but of a different variety for pollination.

Objectives

The objectives of this practical session are to:

- familiarize the students with the different criteria to be considered during orchard site selection, land preparation, hole digging and planting,
- enable the students distinguish among different planting systems (Square planting, Rectangular planting, Hexagonal or Equilateral Triangular, Triangular planting, Quincunx or diagonal planting, Contour planting),
- equip the students with a practical skill on training and pruning of tropical fruit trees,
- familiarize the students with the criteria for fertilizer application planning and practices,
- enable the students understand the different irrigation methods,
- enable the students understand floral biology of open pollinated fruit trees such as mango, papaya, and also appreciate role of pollen donor cultivars on productivity of the respective fruits.
- help students identify major diseases and insect pests of tropical fruits, and also to motivate them suggest possible management mechanisms of the identified diseases and insect pests.

Materials

Equipment

- Measuring tape,
- Digging hoe,
- Shovel,
- Secateurs,
- Pruning saw (pruning shears),
- Hammer,
- Wheelbarrow,
- Ladder,
- Harvesting pole,
- Crates (plastic or wooden)

Consumables

- Fruit saplings,
- Tropical fruits (fruit bearing, if available),
- Polyethylene bag (containers),
- Jute bags,
- Fertilizer (organic & inorganic sources)
- Rope/string,
- Checklist

Procedure

4.1 Procedure for site selection

Proper selection of site is important. Selection may be made based on the following criteria.

1. The location should be in a well established fruit growing region because one could get the benefit of experience of other growers and also get the benefit of selling the produce through co-operative organizations with other fruit growers.
2. There should be a market close to the area.
3. The climate should be suitable to grow the chosen fruit crops.
4. Adequate water supply should be available round the year.

Before a grower selects a site for establishing a new orchard, he/she must have assessed the following factors:

1. Suitability of soil, its fertility, the nature of subsoil and soil depth,
2. Site must have proper drainage and no water stagnation during rainy season,
3. Irrigation water must be of good quality,
4. There must be proper transport facilities either by road or rail within the reach,
5. Whether the climatic conditions are suitable for the fruits to be grown and are whether site is free from the limiting factors such as frost, hailstorms and strong winds,
6. Whether there is assured demand in the market for the fruits to be grown,
7. Whether his/her orchard is a new venture or whether there are already other growers,
8. Availability of labour.

4.2 Procedure for selection of planting system/layout

- Identify the best planting system for the area (depending on topography, tree stature etc.),
- Establish a base line and mark the positions of the trees along this line putting wooden stakes in the ground.
- Another base line at right angle to the first base line, is then marked along with the other edge of the field with the help of a carpenter square or a cross staff.
- The right angle can also be drawn with the help of measuring tape.
- One end of this tape is fixed at 3 meter distance from the corner along the first line and the tape is then stretched along the second base line for a distance of 4 meter.
- The diagonal distance between these two points should be 5 meter (Fig. 4.1) [2].

- The wooden stakes are put in the ground at the desired distance along the second lines.
- All the four rows are thus established and staked. Three men, one putting the pegs in the field and other two correcting alignment, while moving along the base line, can easily layout the whole field.
- For laying out of an orchard according to the triangular system, a base line is set on one side of the field as in the square system.
- Large triangle with a ring in each corner (made of heavy wire or chain) is used. The sides of this triangle are equal to the distance to be kept of the plants in the orchard.
- Two of these rings are placed on the stakes of the base line. The position of the third ring indicates the position of the plant in the second row. This row then is used as a base line. The whole area is laid out in a similar manner.

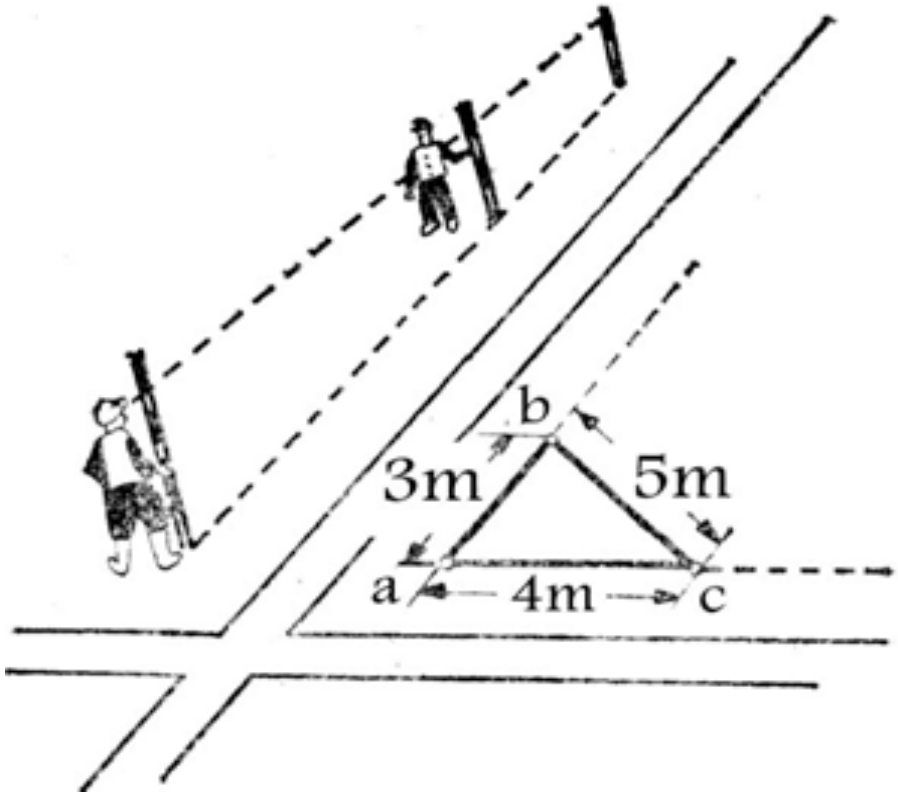


Figure 4.1 Marking planting position (base line)

Orchard layout is an important component and it should aim at providing maximum number of trees per hectare, adequate space for proper development of trees and ensuring convenience in orchard cultural practices. The main objectives of orchard designing are: (1) To have efficient utilization of orchard space and other resources, (2) To have maximum solar radiation interception and distribution within the orchard canopies in order to achieve maximum fruit quality and yield, (3) To minimize competition between trees for nutrients and moisture by having proper tree spacing, and (4) To have compatibility with various management practices such as pruning, thinning, harvesting, pest control etc. The following are different planting systems commonly followed in planning fruit orchard:

1. Square Planting System: This planting system is commonly followed as it is easy to layout, and inter-cropping and cultivation is visible in two directions (Fig. 4.2).

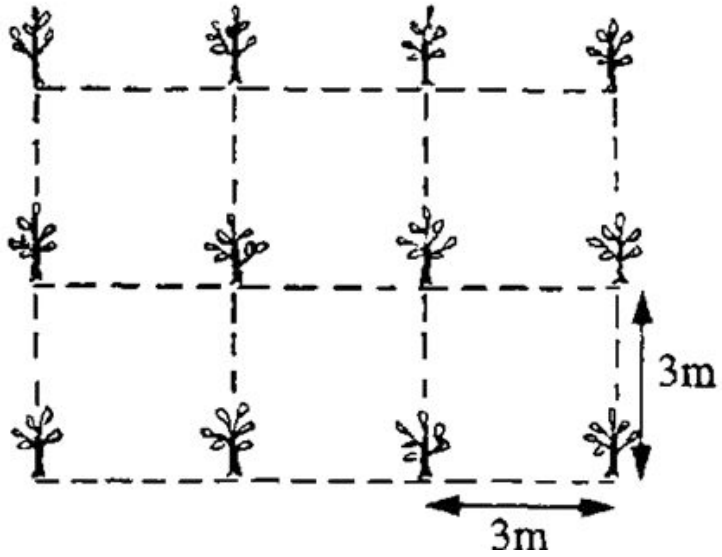


Figure 4.2 Square planting system
Source:https://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=3312&context=journal_agriculture4

2. Rectangular System: This system is similarly that of the square system in its layout except in this layout row to row and plant to plant spacing is not same (Fig.4.3).

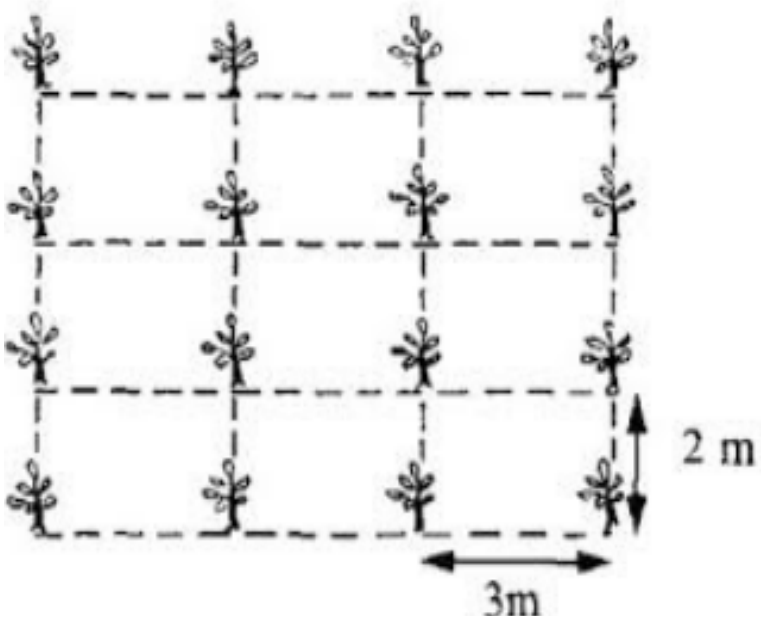


Figure 4.3 Rectangular planting system

3. Equilateral triangle or hexagonal System: In this planting system six trees form a hexagon (Fig.4.4), with another tree at its center. This allows cultivation in three directions and accommodates about 15 per cent more trees per hectare at any given distance, than by the square system.

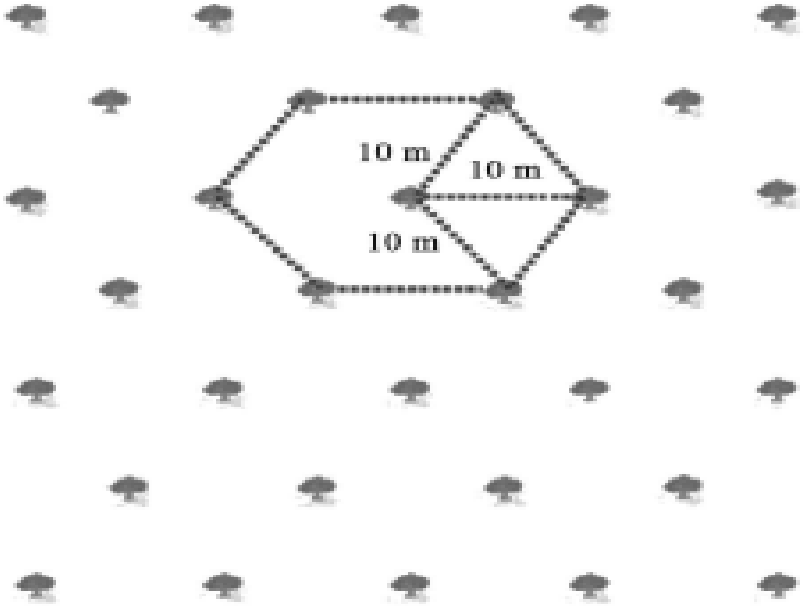


Figure 4.4 Hexagonal System

4. Triangular planting - It is a system in which plants in alternate rows are offset half the space between plants in a row. The distance between the rows is the same or more than that in row (Fig.4.5).

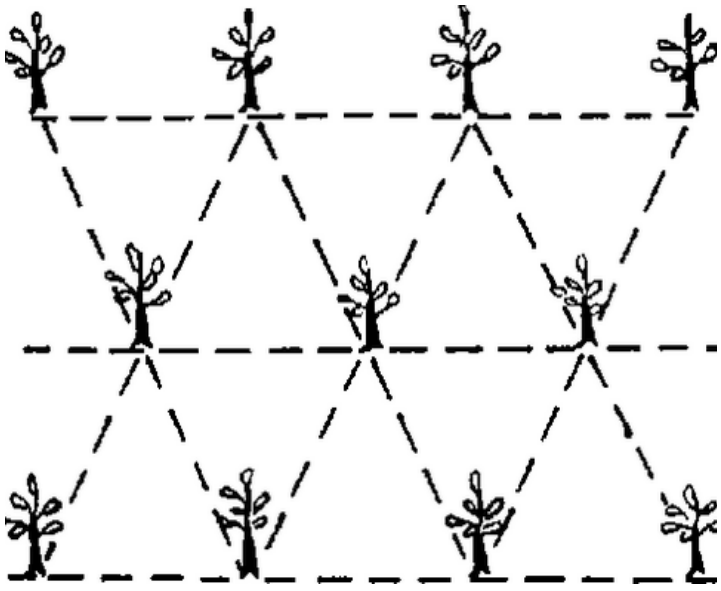


Figure 4.5 Triangular planting system

5. Quincunx or diagonal planting - This method of planting is a variation of the square system (Fig.4.6). An extra tree, often a temporary one (filler), is set in the center of each square. Filler plants are usually short-statured and early bearing.

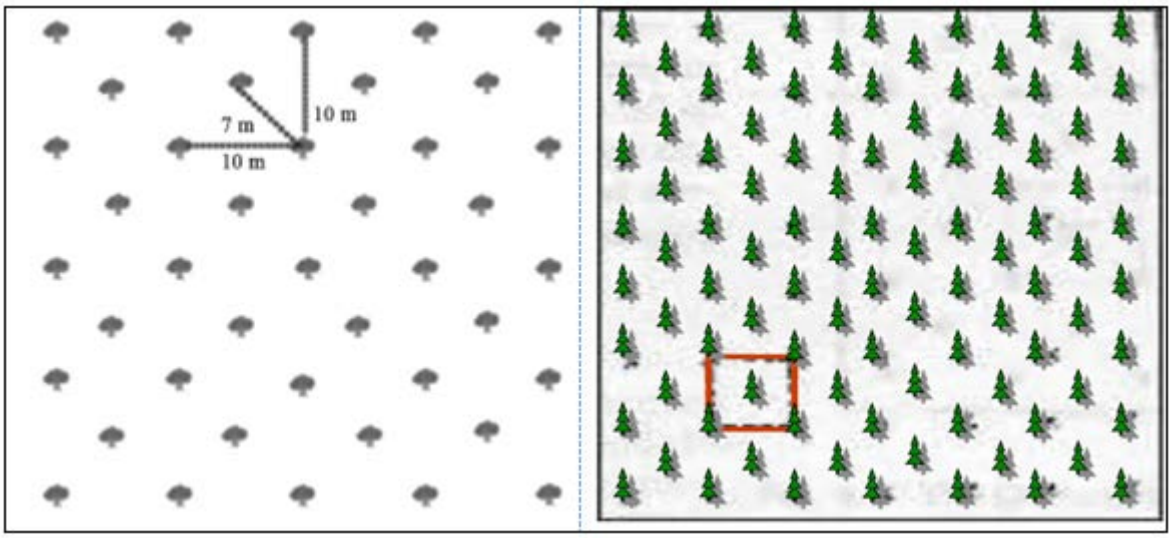


Figure 4.6 Quincunx or diagonal planting system
http://www.hillagric.ac.in/edu/coa/horticulture/lecture/Hort-351-Lectures/Hort-351-Lecture-5.pdf

6. Contour System: It is only followed on hills with high slopes (Fig.4.7). In this case the tree rows are planted along a uniform slope and usually at right angle to the slope with the idea of reducing loss of top soil due to soil erosion. The marking should be done from lowest level of top.

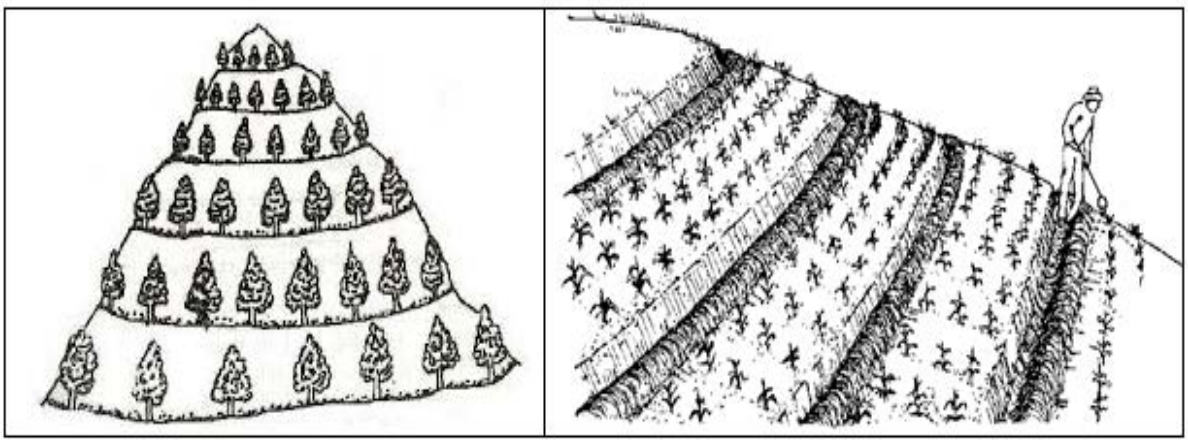


Figure 4.7 Contour planting system
https://www.google.com/search?q=Triangular+planting+system+diagram&client=firefox-b-ab&tbm=isch&tbs=rimg:CZFmw_1BoofeXIjhQBEH- :

4.3 Procedure for digging holes (pits) for planting of fruit saplings

Once the planting geometry is decided and the land prepared, the pits are dug for transplanting the saplings. This should be done one or two months prior to planting. The main purpose of digging and filling the pit is to provide congenial conditions for plant growth and development, especially during the establishment phase.

Before digging the pits, two outer pegs are fixed with the help of planting board (Fig.4.8). The planting board is placed over the planting hole at the position of the tree with its central notch at the stake. Two pegs are driven in the ground at the notches at the two ends of the planting board. The board is then removed, leaving the two pegs in the ground.

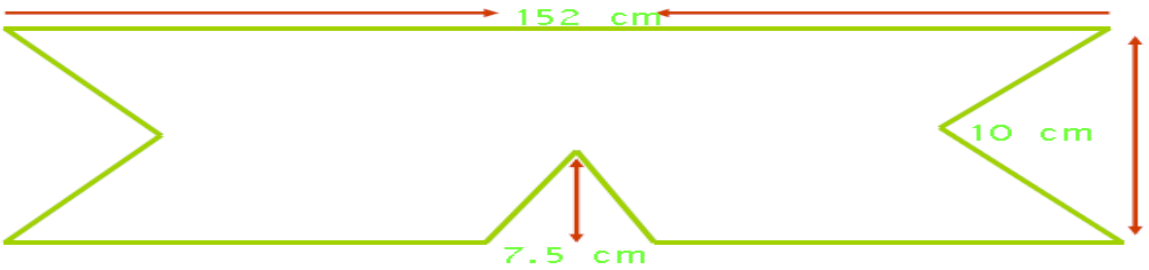


Figure 4.8 Planting board

- Already fixed peg is kept in the central notch to mark the right point to plant each tree.
- During digging of actual pit, the central peg is removed and two outer pegs remain undisturbed.
- These outer pegs help in locating the point where the plant is to be put in.
- Dig the pits 2-4 weeks in advance
- The ideal pit size would be 1x1x1m dimension (Fig. 4.9), this is commonly done for planting of tree fruits such as mango, avocado etc. Shallow rooted fruits such as papaya and banana are usually planted at relatively shallow pits (60 x 60 x 60cm) (Fig. 4.10).
- When the soil is fertile and does not have any type of hard pan, the size of pits may be of 50x50x50cm in dimension.

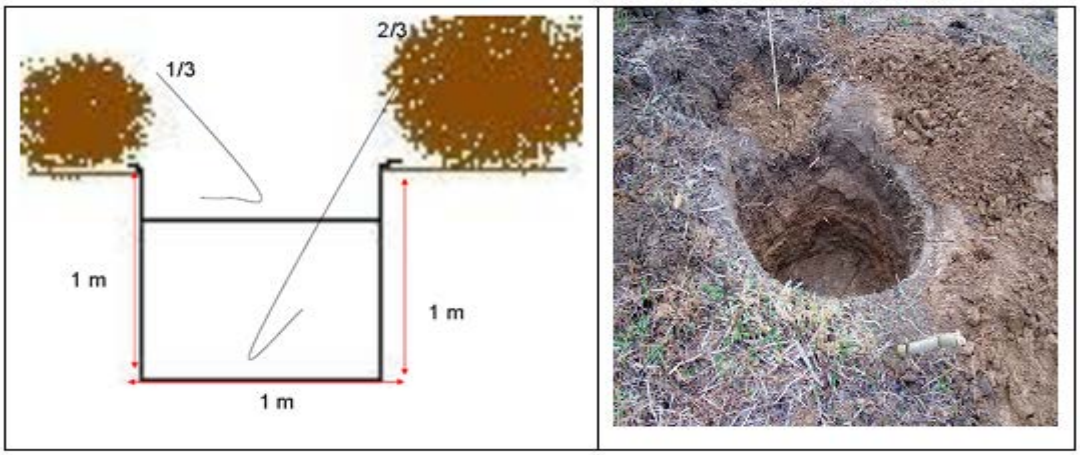


Figure 4.9 Pit (planting hole) digging. Note that top soil (1/3) and subsoil (2/3) are placed separately

Source: http://www.hillagric.ac.in/edu/coa/horticulture/lecture/Hort-351-Lectures/Hort-351-Lecture-5.pdf

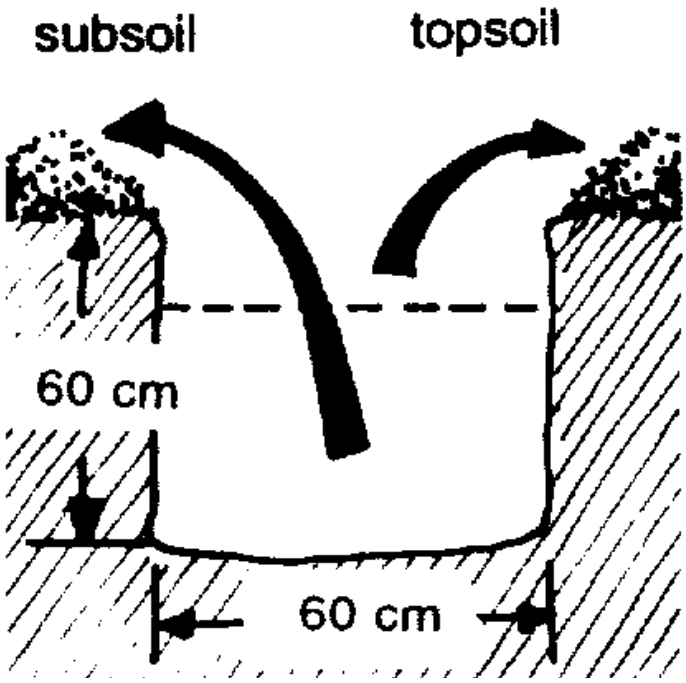


Figure 4.10 Planting hole for shallow-rooted, short-term perennial fruits such as papaya and banana. http://www.nzdl.org/gsdlmod?e=d-00000-00---off-0hdl--00-0----0-10-0---0---0di rect-10---4------- 0-1l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8- 00&cl=CL1.17&d=HASH01df274fb229ae826f6d2355.11&gt=2

4.4 Procedure for planting of fruit saplings

A) Procedure for planting bare rooted fruit tree saplings

1. Open a large hole to accommodate the root system.
2. Cut off any roots which are broken or kinked.
3. Using two pegs fix the planting board on top of the hole.
4. Replace the planting board with the tree stem fitted into the central notch with the graft at least 5-10 cm above the soil surface.
5. Commonly planting is done during rainy season. If planting is to be done during dry season (using irrigation), plant in evening when the high humidity prevails in the atmosphere.
6. Seedlings need to be correctly planted per planting hole taking extra care not to break the roots or bend the tap root (Fig. 4.11).
7. Fill the hole with soil until the root ball is fully covered.
8. Gently firm (press) the soil around the seedling with the fingers to make sure the seedling is stable.
9. Level off the soil (if the condition is dry, irrigate the pits just after planting to settle down the soil).
10. Regularly check the plants to detect the faults like sinking of soil, tilting of plant and cracking in basin etc.
11. Maintain sufficient moisture till the plants start new growth in the field.

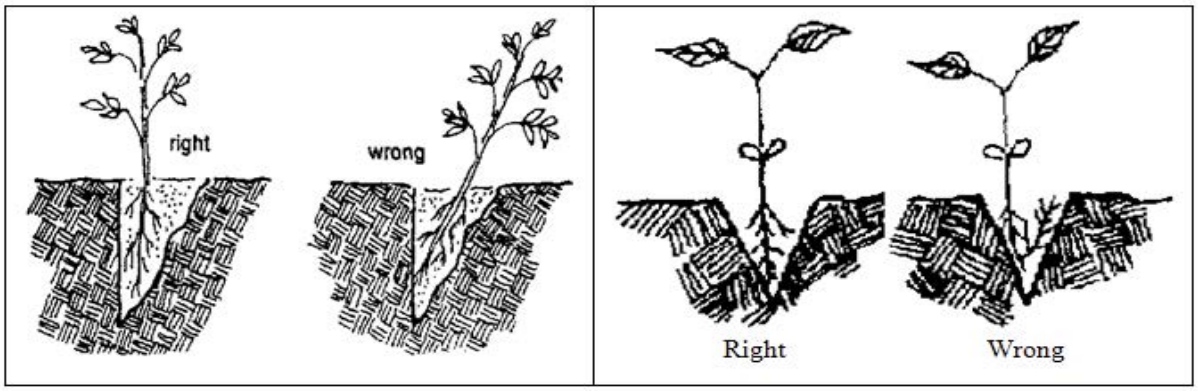


Figure 4.11 Planting fruit saplings

B) Procedure for planting of container grown fruit tree sapling

1. Dig the middle of the hole big enough to accommodate the sapling root ball.
2. Remove the cover (plastic bag or other container) of the sapling (Fig.4.12). However, plants grown in easily decomposing material can be planted as it is.
3. Make shallow cuts at the bottom of the root ball to induce quick root development.
4. Gently pull away from the root all circling or girdling roots.
5. Place the tree upright in the hole.
6. Set the tree at the same depth as it stood in the pot (up to the collar mark).
7. Fill the hole with soil until the root ball is fully covered.
8. Gently firm (press) the soil around the tree.
9. During pressing of soil, the earth ball should not be broken.
10. Level off the soil (if the condition is dry, irrigate the pits just after planting to settle down the soil).
11. Regularly check the plants to detect the faults like sinking of soil, tilting of plant and cracking in basin etc.
12. Maintain sufficient moisture till the plants start new growth in the field.

a b

Figure 4.12 Container grown mango (a) and papaya (b)

Control of early flowering: Young plants prepared through asexual methods of propagation start flowering immediately. This adversely affects the growth and vigour particularly when such types of plants are allowed to set fruits. This fruiting is on the expense of growth and hindrance of the formation of strong framework of the plant. These inflorescences therefore need to be removed immediately after emergence not to disturb vegetative growth. The deblossoming should continue till the plant attains three to four years of age (i.e., when the plant attains normal size and it is physiologically sound to bear the fruits).

4.5 Procedure for training and pruning of fruit crops

4.5.1 Training involves physical techniques that control the shape, size and direction of plant growth. Training is in effect the orientation of the plant in space. It may include bending, twisting, or fastening of the plant to the supporting structure.
A well trained fruit trees will have strong branches with wide crotches (Fig. 4.13B).

Figure 4.13A A young tree wherein limb spreaders are inserted to spread the crotch angle. Spreading improves the crotch angle, reduces scaffold vigor, favors flower bud formation, reduces competition with the leader, and eliminates interference of lower scaffolds with the growth of scaffolds originating higher on the trunk.

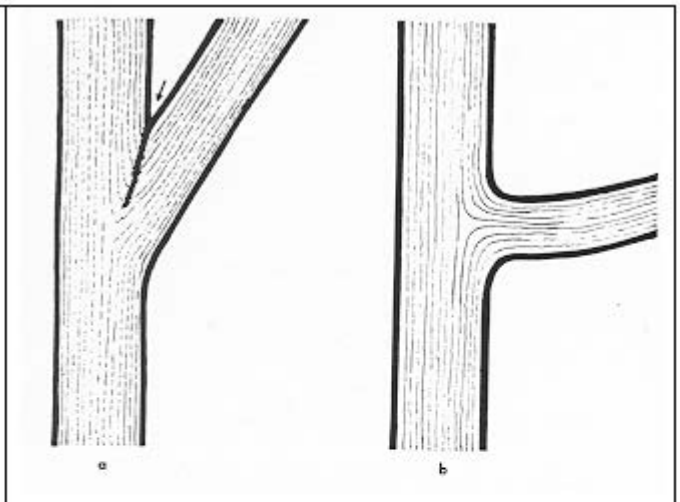


Figure 4.13B Structure of narrow and wide crotches. (a) Narrow crotch. Note the development of a bark inclusion (narrow) where bark of the trunk and branch have been pressed together. This structure weakens the crotch and serves as an entry point for decay organisms and organisms and pathogens. (b) Wide crotch. Annual rings of wood are deposited all around the junction of the scaffold and trunk, increasing crotch strength as the scaffold increases in size and fruit-bearing capacity.

Source: https://eap.mcgill.ca/CPTFP_7.htm

4.5.2 Pruning involves the removal of parts of the top or root system of plants. Pruning of fruit plants is an integral part of the procedures used for high production of quality fruits. Three types of pruning are known [3]: frame, maintenance (Fig. 4.14) and rejuvenation (Fig.4.15) pruning. Frame pruning is practiced to enable young fruit trees develop a strong, balanced structure. Trees of most species are strongest if they have a strong central leader (i.e., one stem that leads straight up through the center), with other branches spaced more or less evenly around it.

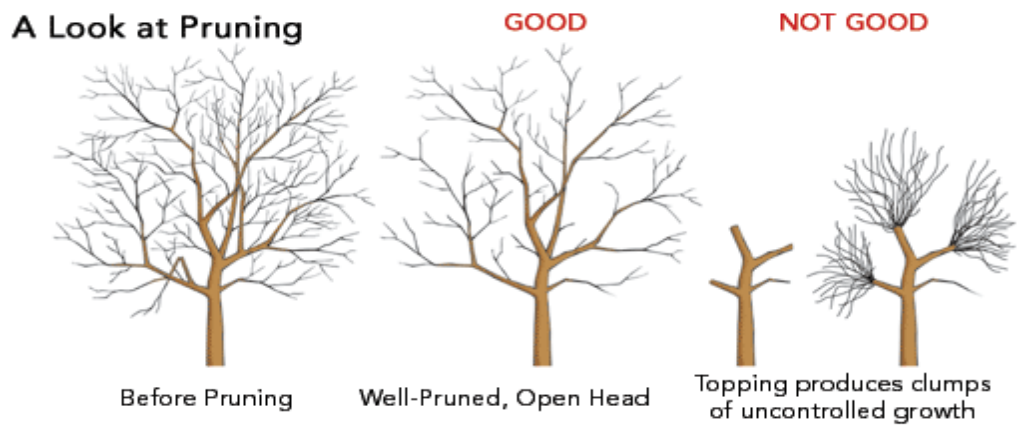


Figure 4.14 Maintenance pruning of tree fruits such as mango
Source: https://www.stpaulsgarwood.com/pruning-apple-tree.html

Figure 4.15 Rejuvenation pruning of tree fruits such as guava
Source: http://www.yspuniversity.ac.in/jachh/jachh-achi.html

Training and pruning of mango:

- Training of young plant is done in early years of planting by removing side branches upto the height of one meter from the ground level and side branches are allowed to grow beyond one meter height.
- Such type of initial training provides good architecture of the plant and it is helpful in good fruit production.
- When starting seedling trees, allow the trees to grow upright for some time. When about 50 cm high, pinch the terminal bud to force lateral shoots to sprout.
- Allow the shoots to mature and again pinch the terminal bud on each shoot. Repeat this process until the end of the third year. Allow all shoots to mature and start forcing them to flower.
- Control the tree height to about 3.5 m and all branches at knee level (about 0.5m) be pruned.
- Most cultivars of mango grow erect; from a natural dome shape canopy and having symmetrical branching need only occasional pruning. Carry out pruning later for proper tree maintenance and should be carried out after fruit harvest.
- Once the trees are bearing, limit pruning to removing weak branches at the tree interior and those damaged by pests. Generally dead, diseased or crisscross branches are pruned.

- Mango being an evergreen plant requires very little training and pruning.
- Severe pruning is needed only in high density of some varieties of mango.

Training and pruning of guava:

- Training in guava is done primarily to give form to the tree.
- For development of a strong framework, the first 60 to 90 cm from base of the trunk should be cleaned followed by 4 to 5 scaffold branches at an interval of 20-25 cm.
- When the plants attained a height of about 1.5m to 1.8 m, it is headed back to make the center open.
- Some guava variety trees are rarely pruned, but light annual pruning after harvesting to promote vegetative growth and flowering is desirable.
- All dead, diseased, crowded growth and suckers sprouting from the base and sides of the framework are pruned back annually.
- Pruned trees give larger fruits and early ripening.

There are two kinds of top pruning [3, 4]: (1) heading back and (2) thinning out.
Heading back consists of cutting back the terminal portion of a branch to a bud (Fig. 4.16), that is, the terminal portion of twigs, canes, or shoots are removed, but the basal portion is not.

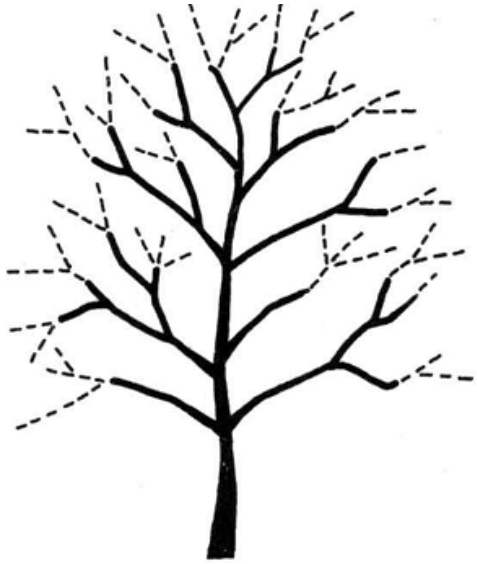


Figure 4.16 Pruning by the heading back method.
Source: Mathew and Karikari (1990)

Thinning out is the complete removal of a branch to a lateral or main trunk (Fig. 4.17), that is, the entire twig, cane, or shoot is removed. Thinning out corrects an overly dense area or removes unneeded branches, or undesirable growth such as upright branches that compete or interfere with the leader and branches that will be structurally weak because of narrow crotch angles.

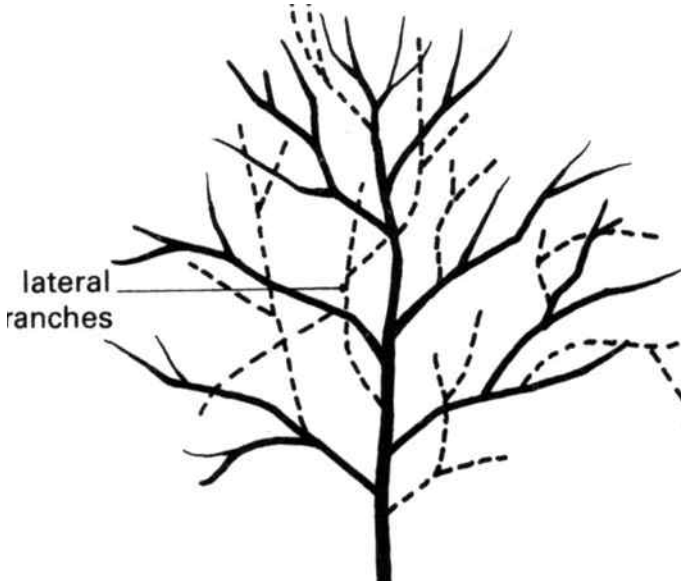


Figure 4.17 Pruning by the thinning out method.
Source: Mathew and Karikari (1990)

When branches are headed back, it should be done with a slanting cut at an angle of approximately 45°, just above a healthy bud as shown in Fig. 4-18a and b, with the bud opposite the slant [4]. The lower part of the slant should be above the base of the bud. The cut should be clean and sharp to encourage rapid healing. No stub should be left above the bud and the cut surface should be as small as possible. Also when thinning out, branches should be cut close to the bulge on the main stem leaving no stub (Fig. 4.19). Any stub left will give rise to fungal infection due to delay in healing and this may eventually affect the main stem.

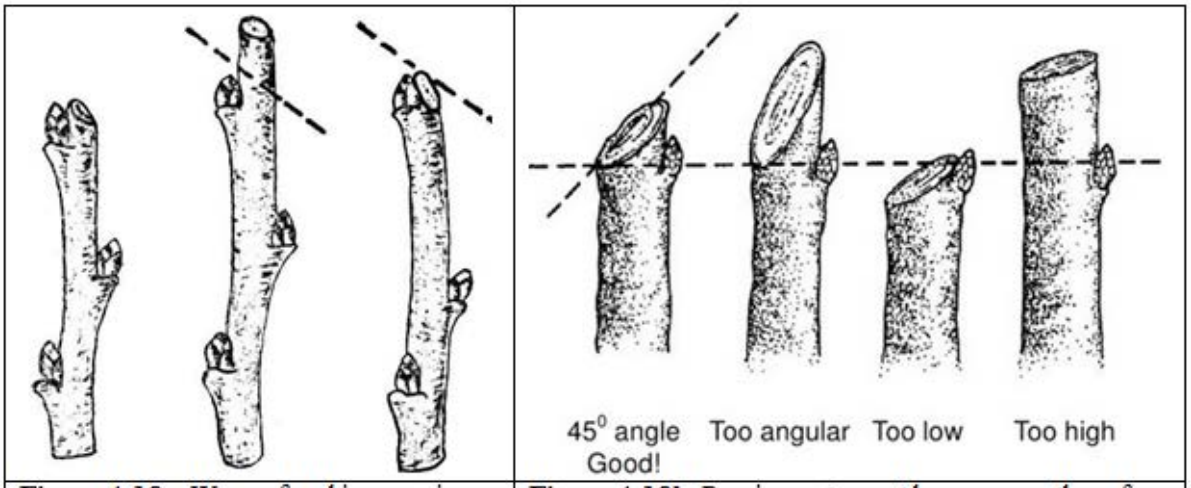


Figure 4-18a. Ways of making pruning cuts (heading back method): (a) correct (b) incorrect, far from bud (c) incorrect, too close to bud

Figure 4-18b. Pruning cuts must have a smooth surface to heal properly. Cuts should be clean with as little stub as possible

Source: Mitov et al. (1990): http://www.thewheelbarrow.net/?page_id=35

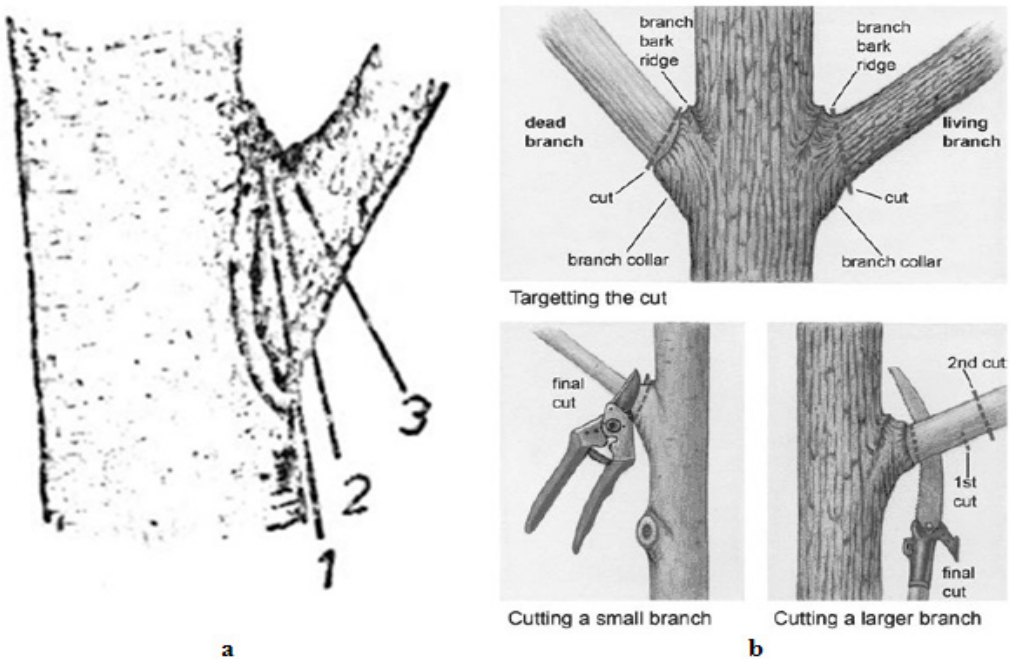


Figure 4.19 Ways of making pruning cuts (thinning out method) (a): (1) incorrect, too close to the main stem (2) correct (3) incorrect, too far from the main stem, (b) When cutting larger branches, remove the weight by cutting further up the branch so that your cut doesn't tear. Make a clean cut and slope slightly downwards so that any water drains off of the cut. If necessary clean up any tearing with a sharp knife. Source: Mitov et al. (1990), https://www2.bgky.org/tree/pruning.php

Observation and Expression of Results

If established tree fruit farm is available in the area (and the trees are at fruit bearing stage), observe whether.

- scaffold branches are strong and spaced more or less evenly around the central leader.
- trees require selective pruning to remove dead, diseased, and/or broken branches (if any).
- trees require selective pruning to reduce density of live branches. Thinning trees reduces the density at the edge of the crown (not the interior), which increases sunlight penetration and air movement.
- trees require selective pruning to decrease height and/or spread (canopy). This type of pruning is done to reduce height or spread, or to improve the appearance of the plant. Not all tree and shrub species can tolerate reduction pruning, so the species and plant health should be considered.

4.6 Procedure for fertilizer and water application

4.6.1 Procedure for fertilizer application

A sustainable optimum yield of fruits depends, besides other factors, such as water and solar radiation, on the availability of essential elements and the content of organic matter in the soil. Soil fertility has a direct effect on all aspects of crop growth and development.

When the crop requirements are higher than the soil supplying capacity, nutrients are applied as manures or fertilizers or both.

If fertility status of the orchard soil is low, fruits should be supplied with proper nutrition. In this case, four important points deserve due considerations, i.e., determination of: (1) the type of fertilizer to be used, (2) time of fertilizer application, (3) rate of fertilizer to be used, and (4) method of fertilizer application.

Various fertilizer application methods are followed in fruits' nutrition, depending mainly on the type and form (solid or liquid) of fertilizer, local conditions, and availability of resources. Generally, in fruit plantations, fertilizers may be applied by using any one or more of the following methods: broadcasting, side dressing, ring application, foliar application and fertigation.

4.6.2 Procedure for irrigation water application

Successful fruit growing requires, among other factors, adequate supply of water using rainfall and or irrigation. If the amount of rainfall is not adequate either in amount or distribution, a proper irrigation method should be adopted to obtain the maximum possible output at a reasonable cost. Irrigation should be programmed in accordance with the phenological growth cycle of the target fruit plant to achieve maximum yield.

The methods of irrigation can be classified into two: surface (gravity-driven) and pressurized (power-driven) systems. The surface irrigation systems can further be classified into flooding (uncontrolled and controlled), basin (Fig. 4.20), border and furrow irrigation systems. The pressurized system can be further classified into sprinkler and drip systems.

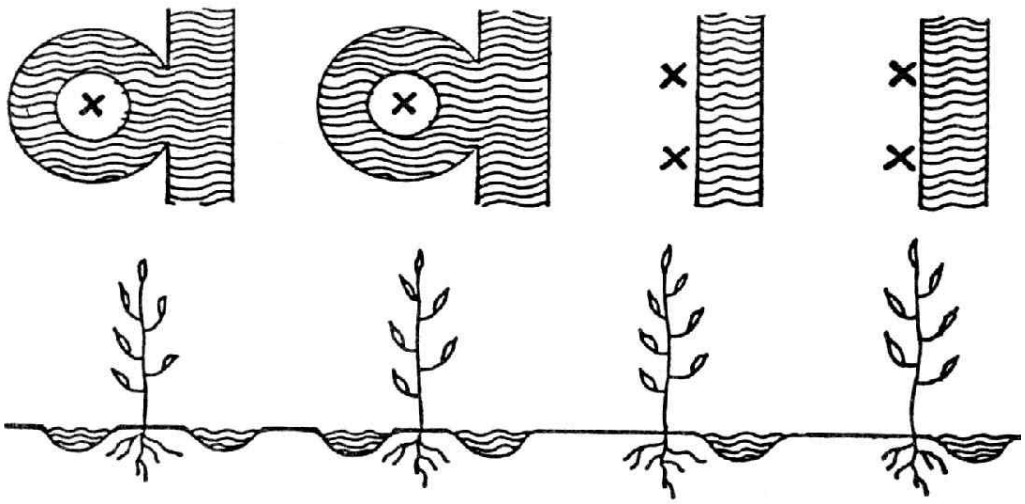


Figure 4.20 Basin irrigation (later changed into furrow irrigation when trees are well established). X represents the plant (A). Basin irrigation (ring basin) in an orchard (B).Source: Jackson et al. (1985)

Observation and Expression of Results

If established fruit farm is available in the area, observe:

- deficiency symptoms (if any) on fruit plants,
- whether inorganic or organic fertilizers are applied,
- how and when the inorganic or/and organic fertilizers are applied,
- whether fruit plants have received sufficient water (i.e., whether the soil around the fruit tree is moist or not),
- irrigation method being practiced,
- irrigation interval (watering frequency),
- time of application during the days,
- whether the orchard floor is free from weed, as weeds will compete for water as well.

4.7 Procedure for pollination and pollination management

The process of pollination requires pollinators: agents that carry or move the pollen grains from the anther to the receptive part of the carpel. Most flowering plant species rely on pollinators (e.g., insects, birds, bats, other animals, wind etc.) to carry pollen from the male to the female parts of flowers for reproduction.

Pollination also requires consideration of pollenizers: plants that provide pollen (pollen donor). Some plants are self-fertile or self-compatible and can pollinate themselves. Other plants have chemical or physical barriers to self-pollination and need to be cross-pollinated: with these self-infertile plants, not only pollinators must be considered but pollenizers as well. The placement of pollenizers is important and it varies based on crop species. Ideally, every tree in an orchard should be located as close to a pollenizer tree as possible. If another commercial variety is used as the pollenizer, the preferred arrangement is in solid rows.

In some fruit tree species (example avocado, apple), one or two rows of major cultivar is accompanied with one row of pollen donor cultivar (pollenizer). In planting apple cultivars such as Delicious that have a tendency to be less self-fruitful, and when it is desirable to maximize pollination, a pollenizer row should be set every third row. In dioecious type of papaya, one male (pollen donor) is commonly planted for 10-25 female plants (depending mainly on planting density).

Observation and Expression of Results

- Observe floral biology of open pollinated fruit trees (in established orchard) such as mango, papaya, avocado, apple etc.
- Identify pollen donor cultivars (if available) of the respective fruit trees.
- Understand the different pollinators (pollen transferring agents) for each fruit type.
- Observe competing flowering plant species (if any) in the established orchard of the selected fruit species in your area.
- Appreciate the relevance of pollination and pollination management in fruit production.

4.8 Procedure for fruit thinning

Under optimum conditions most trees will set more fruits than needed for a full crop. Fruit thinning is carried out to reduce limb breakage, increase fruit size, improve color and quality, and stimulate floral initiation for next year's crop [5]. Thinning is often practiced for large-fruited species that normally set too many fruit. By thinning, one directs the available photosynthate produced by the leaves into fewer, but ultimately larger fruit, rather than many small, unmarketable fruit. Thinning is accomplished by hand usually, and is obviously very labor intensive. In terms of timing, the earlier the tree is thinned, the better the result. Fruits are removed such that a certain number of fruit per tree, or a certain spacing between fruit on a limb is achieved. Thinning should be uniform throughout the canopy, as fruit in clusters will remain small even if the correct total number of fruits are left. Thinning based on fruit size is preferred, as it facilitates selective removal of small and weak fruits irrespective of spacing with the consideration of the desired degree of thinning.

Observation and Expression of Results

If established fruit farm is available in the area (and the trees are at fruit bearing stage), motivate the students observe whether:

- fruit thinning is practiced,
- the individual fruits are well spaced or crowded,
- size and shape of individual fruits are affected due to lack of fruit thinning,
- there are any disease affected (and or deformed) fruits.

4.9 Procedure for pest management in orchards

Various pests such as diseases, insects, nematodes and vertebrates (e.g., birds, rodents and wild animals) attack and cause serious damage to both the plant and the useable parts (fruits). Weeds also compete for nutrients, water, light, carbon dioxide and space leading to lower yields and quality of fruit crops. Weeds may also harbor pests and diseases, which attack the crop, detract from their appearance and increase postharvest spoilage incidence. Various integrated pest management approaches are followed in fruit orchards in managing the different pests indicated above.

Observation and Expression of Results

If established fruit farm is available in the area, observe whether:

- the orchard floor is free from weeds (if so, what weed control measure is followed?),
- there are any disease symptoms (if so, try to identify the observed disease/s),
- there are any insect pests (if so, try to identify the observed insect pest/s),
- the fruit quality is affected by the observed diseases and or insect pests. And determine the susceptibility (if such case occurs) of the fruit species available in your area, to pest and disease problems.

Discussion

- Compare your results that you obtained from your practical session with that of other groups' and discuss.

Conclusion

Write what you conclude based on your practical session and results

Recommendations, if any

Self-assessment

Assess your knowledge and skill levels by answering the following questions:

- What are the major criteria considered while selecting an orchard site?
- What factors are considered while selecting planting system to be followed in orchards?
- Explain how pits (planting holes) are prepared for planting of fruit saplings.
- What are the main purposes of training and pruning?
- Distinguish between frame, maintenance and rejuvenation pruning in tree fruits.
- Why are narrow crotches undesirable in a fruit tree?
- What are the four important points you need to consider in planning of fertilizer application in fruit orchard?
- Distinguish between the various irrigation water application methods.
- How are weeds, diseases, insects and other pests managed in fruit orchards?
- Roles of pollinators and pollenizers in improving yield and quality of fruits crops.
- Explain how fruit thinning improves size and shape of individual fruits.

References

1. Kumar, N. 1997. Introduction to Horticulture. Rajalakshmi Publications, 28/5 – 693, Vepamoodu Junction, Nagercoil. pp: 15.47- 15.50.

2. Mitov P., T. Angelov, N. Dimov, G. Pepeliankov, and D. Diakov. 1990. Fruit Production: Zemizdat. Sofia, Bulgaria.

3. Samson, J.A. 1986. Tropical fruits. 2nd ed., Trop. Agr. Ser., Longman Scientific and Technical, New York.

4. Mathew, I.P. and S.K. Karikari. 1990. Horticulture: Principles and Practices. Macmillan Education Ltd., London and Basingstoke.

5. Westwood, M.N. 1993. Temperate Zone Pomology Timber Press

PRACTICAL SESSIONS 5

Practical Session 5

Maturity Determination and Harvesting

Practical Session 5

Maturity Determination and Harvesting

Theory

Maturity can be described as the attainment of a particular size and stage after which ripening takes place [1, 2]. Two types of maturity are distinguished: physiological maturity and commercial (horticultural) maturity. Physiological maturity refers to the stage in the development of the fruit, when maximum growth and maturation has occurred, i.e., the fruit is fully ripened and is followed by senescence. Commercial maturity refers to the stage of development when a fruit possesses the necessary characteristics for use by consumers (i.e., the stage of a fruit required by a market).

Harvesting of fruits at optimum maturity will produce the best quality fruits in terms of size, color, flavor and shelf life than those not harvested at appropriate maturity. Harvesting when fruit is cool (early morning) and cooling the fruit as soon as possible promotes quality and shelf life.

Maturity indices, also called “harvest indices”, are important for deciding when a given fruit should be harvested to provide some marketing flexibility and to ensure the attainment of acceptable eating quality to the consumer [2, 3].

There are many methods to determine fruit maturity. The most common is the size of the individual commodity. Some other commonly used crude methods are color change, softening of the tissues, shriveling of fruit stalk; time elapsed from the date of flowering to picking maturity [2, 3]. Another physical characteristic is the firmness and it is determined with a pressure tester (Fig. 5.1). Firmness is often correlated with chemical changes that occur during ripening. Chemical characteristics include TSS (Fig.5.2), acidity, sugar, vitamins and pigments. Some commonly used maturity indices are given below in some of the important fruits.

Figure 5.1 Penetrometer

Figure 5.2 Refractometer

Objectives

- To acquaint the students with various methods of determining stage of maturity at harvest (maturity indices) of the major tropical fruits,
- To enable the students understand different harvesting methods.

Materials

Equipment

- Color chart,
- Refractrometer,
- Tendrometer (penetrometer),
- Curved blade,
- Cut and hold hand shears,
- Pole mounted cut and hold picking shears,
- Tripod ladders

Consumables

- Tropical fruit trees (at fruiting stage), or/and sample fruits of different type (Climacteric & Non-climacteric),
- Picking bags,
- Crates (plastic or wooden)

Procedure

5.1 Banana maturity determination

Common maturity stages at harvest (maturity indices) of banana include: drying of top leaves, degree of roundness (i.e., fruits become plumpy and angles are filled and disappear at full maturity) (Fig.5.3), days after flowering (fruits matures in about 4-5 months depending upon varieties, climate etc), change of color of fingers (changing of fruit color from green to light green; in some varieties one or two fruits ripe at the basal end) or, drying and easily dropping off of parts of flowers (floral remnants) at the top the fruit, pulp to peel ratio, and pH of fruit. Some other important harvest indices for banana are: Fall of floral remnants, Pulp to peel ratio (10:1), pH of fruit (5.2-5.6).

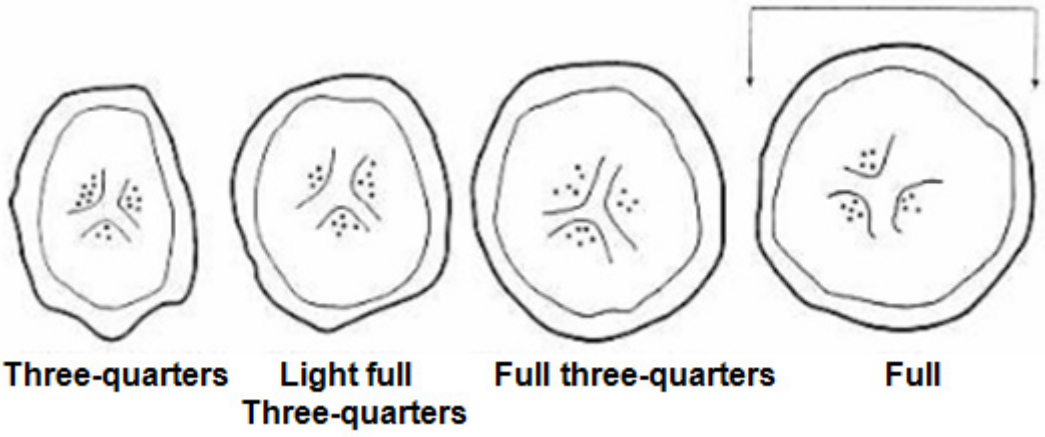


Figure 5.3 Cross section of the middle banana fingers showing the changes in angularity as they mature on the plant.
Source: Von Loesecke, 1949; Kader and Yahia, 2011
https://www.slideshare.net/KarlLouisseObispo/lecture-3-fruits-and-vegetables-harvesting

Observation and Expression of Results

Take a random sample of three fruits/fingers (that is, from basal, middle and apical parts of the bunch), and judge: (1) the degree of roundness (angularity), (2) change of color of fruits or fingers, (3) dryness and easily dropping off parts of flowers (floral remnants) at the top of the fruit. At the end of the observation, encourage the students compare their results with the standard maturity indices of banana and accordingly draw conclusion.

Banana harvesting

- Bananas are harvested at 3/4th maturity stage for distant markets while, for local markets are harvested at full maturity.

- Whole bunch should be cut with the help of sharp knife or with the help of harvesting device developed specially for harvesting banana.

- Harvesting should be done in the morning or evening hours.

- Harvested bunches should be kept in a dry cool place.

- These are sorted or graded according to color, or size.

5.2 Mango maturity determination

Mango fruits harvested at the correct stage of maturity develop good peel and pulp color and have full flavor and aroma at the ripe stage. Mangoes harvested at an immature stage of development can be induced to ripen but the quality of the ripe fruit and particularly the flavor is inferior.

Common maturity indices for mango include: number of days after full bloom (the fruit-set date for each tree is determined when the panicle shows a high percentage of initial fruit set), fruit size, flesh/pulp color (Fig. 5.4), skin color (change in peel color from dark to light green -for some varieties), fruit shape (“fullness” of the cheeks or shoulders) (Fig. 5.5), peel appearance (presence of bloom/white powdery substance on the peel), soluble solids content, specific gravity (the ratio of the mango density to the density of water), starch content, titratable acidity, and total solids (dry matter) content.

Observation and Expression of Results

Take a random sample of five to ten fruits from, at least, three different canopy locations, and record (1) the degree of the "fullness" of the cheeks or shoulders of sampled fruits, (2) extent of change of color of fruits from dark green to pale green, (3) specific gravity (the ratio of the mango density to the density of water). At the end of the observation, encourage the students compare their results with standard maturity indices of mango.

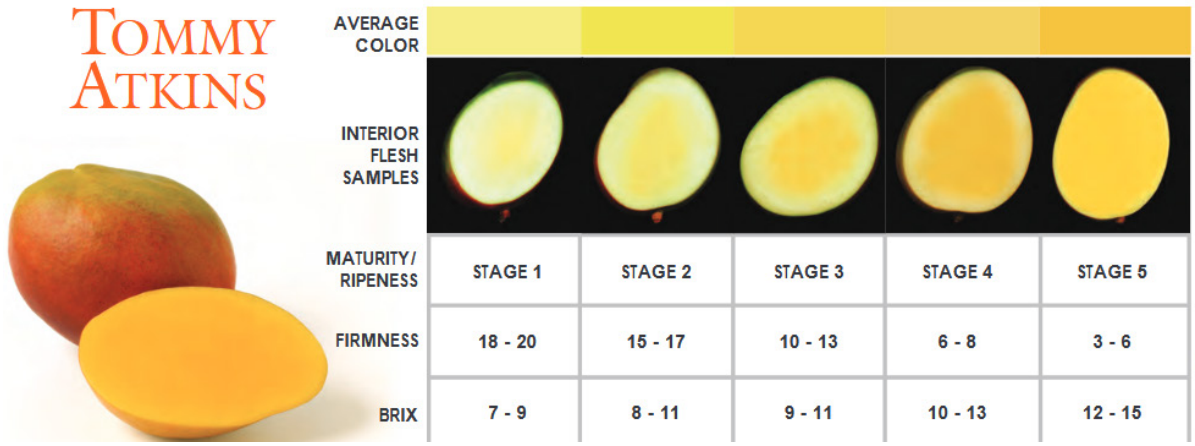


Figure 5.4 Different stages of maturity at harvest of mango fruit
Source: https://www.mango.org/wp-content/uploads/2017/10/Mango_Maturity_And_Ripeness_Guide.pdf

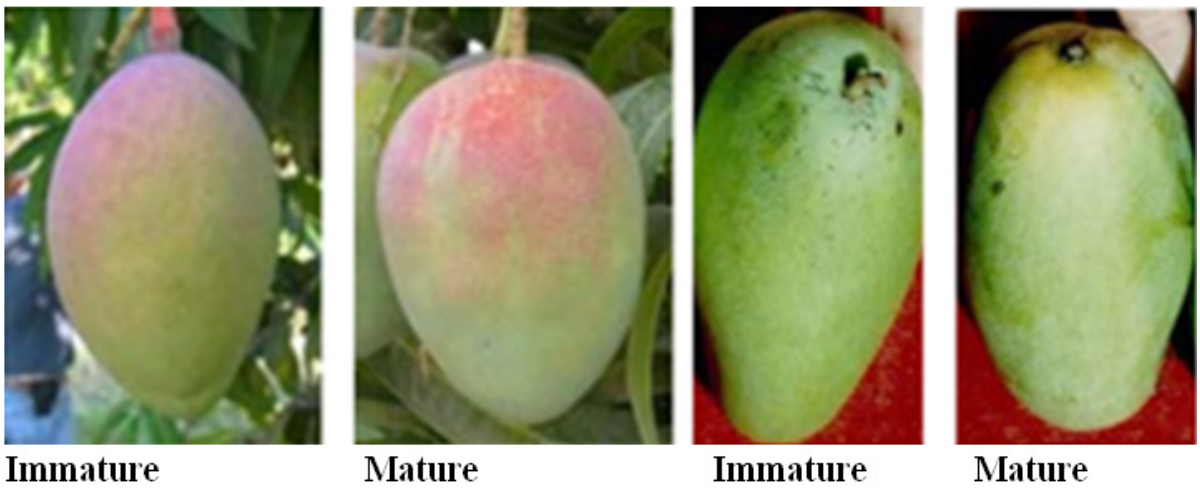


Figure 5.5 Fruit shape: fullness of cheeks, elevation of shoulders above the stem attachment

Mango harvesting

Mangos are harvested when mature, but not ripe. An old recommendation to judge the date of harvest was when the first fruit dropped, the fruits on the tree were ready to pick. Mango normally takes 90-120 days from fruit set to maturity. The mango is harvested by hand from the ground, wherever reachable, or from ladders and by the use of a long pole with a metal basket or a cloth bag (Fig. 5.6) to hold two or three large fruit. Harvesting is also done using two people, one on a ladder to cut the fruit and let it drop into the hands of the other on the ground.

Figure 5.6 Fruit picking tool with net at the end

Any form of bruising should be avoided during harvesting. Normally the fruit will be harvested with a 3–4 cm length of peduncle; the fruit are put under the shade of the trees either on the ground in small furrows or on a layer of sawdust or in specially designed boxes with the cut part of the peduncle pointing down for about 30 min until the sap flow stops. Grade standards are usually based upon size, color and freedom from injury and defects. Other requirements include full development, freedom from stains and firmness.

5.3 Papaya maturity determination

Common maturity indices for papaya include: days from flowering to maturity, fruit size, flesh color, skin color (Fig. 5.7), flesh firmness, and soluble solids content.

Figure 5.7 Papayas should be harvested at a minimum of ¼ yellow color (½ is better).
Source: Brecht, 2015

Observation and Expression of Results

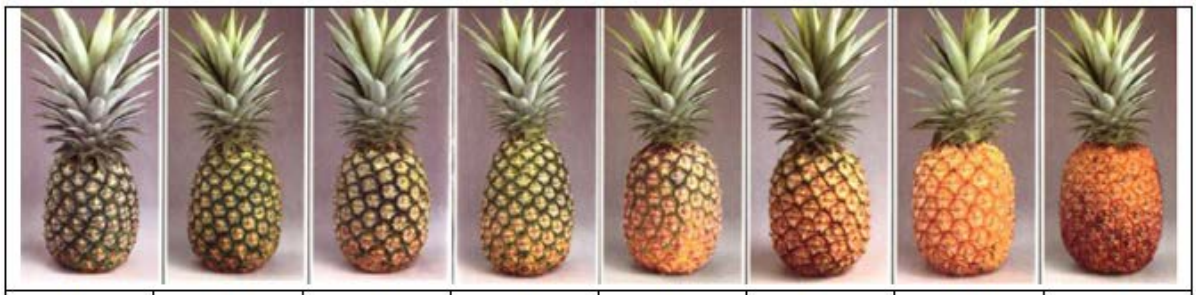
Take a random sample of five fruits, and record (1) the degree of change of skin color of fruit from green to pale green or yellowish, (2) whether the latex of fruits becomes watery, (3) soluble solids content. At the end of your observation, compare your results with standard maturity indices of papaya.

Papaya harvesting

Harvesting is easy when fruits can be reached by hand; as trees become taller some form of harvesting aid, such as poles and ladders, must be used. The harvested fruits are accumulated in a bucket, tray or cloth picking bag. These methods are possible only with the small 'Solo' fruit. When the container is full, it is emptied into padded or lined bins left on field roads.

5.4 Pineapple maturity determination

Common maturity indices for pineapple include: number of days from planting to maturity, color of lower portion of fruit (Fig. 5.8), nature and color of eye bracts, soluble solids content. Pineapple fruit should have a minimum of 12% soluble solids near the base and 10% near the top. This is determined by taking two cross sections of the fruit; one at the point of its largest diameter near the base and another in the upper third portion of the fruit, and squeezing a few drops of juice from each cross section onto the prism of a hand-held refractometer. The internal appearance of the flesh is also indicative of fruit maturity. Random samples of fruit should be sliced horizontally at the point of the largest diameter. Immature fruit has a white flesh color, while mature or ripe fruit has a yellowish-white flesh. The flesh also becomes slightly translucent in appearance at maturity. Fruits destined for the cannery are usually harvested at the half- to three-quarter-yellow stage. Fruit to be transported to distant fresh fruit markets is picked anywhere from mature green (no yellow color) to quarter-colored stage.



0	1	2	3	4	5	6	7
Full green	Slight color break	Less than ¼ gold	¼ to ½ gold	½ to ¾ gold	¾ to full gold	Full gold to ¼ reddish brown	More than ¼ reddish brown

Figure 5.8 Pineapple is a non-climacteric fruit and can be harvested as soon as it is ready for consumption. Maturity is determined by color and texture. At maturity fruits change color to yellow, orange or red and soften. Number 2, 3, 4 and 5 on the photos above are right stages for harvest. 0 and 1 are pre-mature, while 6 and 7 are over- mature.
Source:http://ssadp.com/wp-content/uploads/2017/04/Harvest-and-PostHarvest-Handling-of-Horticultural-Crops.pdf

Observation and Expression of Results

Take a random sample of five fruits, and record whether: (1) the color change of lower portion of fruit turned green yellow; (2) eyes on the fruit are smooth or flat and are bulged on the sides, (3) eye bracts are loose and turned brown in color. At the end of your observation, compare your results with standard maturity indices of pineapple.

Pineapple harvesting

Fruits are harvested by hand, and also harvested by pickers carrying large baskets on their backs. When the baskets are full, the fruits are dumped at the ends of the rows or at the side of field roads, to be later loaded into trucks or trailers. When the fruit arrives at the packing shed, it is unloaded by hand.

5.5 Guava maturity determination

Common maturity indices for guava include: number of days after flowering, fruit skin color, fruit softness, occurrence and shape of ridges on the fruit.

Observation and Expression of Results

Take a random sample of five to ten fruits from, at least, three different canopy locations, and record whether the: (1) fruit color changed from green to pale green or yellow (Fig. 5.9), (2) fruit became soft, (3) A slight depression developed near the stalk end, (4) Ridges on the fruit disappeared and it became round. At the end of your observation, compare your results with standard maturity indices of guava.

Figure 5.9. Pink guava (Psidium guajava L.). Appearance of whole fruits and cross sections at the different maturity stages (1= Immature to 4= fully mature/ripe stage).
Source: https://www.semanticscholar.org/paper/Carotenoid-Profile%2C-Antioxidant-Capacity%2C-and-of-L.-Rojas-Garbanzo-Gleichenhagen/d6271ed01d4cd675cdb742c892d7ff6a5baa96ee/figure/1

Guava harvesting

Guava fruits are harvested at their full yellow but firm for local market, whereas half yellow fruits should be picked for distant markets. The fruits are harvested selectively by hand along with the stalk and leaves. Hand-pulling is employed. Higher branches can be reached with a ladder. The fruits are collected in basket (or any other appropriate container). Picking is done 2 to 3 times a week during harvest season of 8 to 10 weeks (for most varieties).

Discussion

- Compare the results and observations with other groups and discuss accordingly.

Conclusion

- Summarize what have been observed from the session,
- Make a conclusion based on your observations and results.

Recommendations

Self-assessment

Assess yourself by considering the following points:

1. Distinguish among the different maturity indices of tropical fruits (climacteric, non-climacteric).

2. Enlist and describe maturity indices of the major tropical fruits and common harvesting tools for the students (peer-group members),
3. When and how are fruits harvested?
4. What sorts of containers are used for harvesting tropical fruits?
5. Describe the common harvesting tools and containers used in Ethiopia.

References

1. O'Brien, C.F. 1983. Principles and Practices for Harvesting and Handling Fruits and Nuts. AVI Publishing company, Inc. Westport, Connecticut, USA.

2. Thompson, A.K. 2003. Fruit and Vegetables: Harvesting, Handling and Storage. (2ndEdition)Blackwell Publishing Ltd., Oxford.

3. Kader, A.A. 1999. Fruit Maturity, Ripening, and Quality Relationships. In:Proc. Int. Symp. On Effect of Pre- and Post Harvest Factors on Storage of Fruit (Ed., L. Michalczuk).

4. Samson, J.A. 1982. Tropical fruits. Longman group Ltd., London.

PRACTICAL SESSION 6

Practical Session 6

Field Visit to nearby Fruit Farm, Agricultural Research Center and Agro-industry

Practical Session 6

Field Visit to nearby Fruit Farm, Agricultural Research Center and Agro-industry

Theory

A field visit is a journey made by a student or a group of students to a place away from their normal learning environment usually nearby tropical fruit Farm, Agricultural Research Center and agro-industry [1]. The basics of such a trip is mostly observation to broaden the students view about tropical fruit crops production and management detailed activities about tropical fruit nursery establishment and management, orchard establishment and management, harvesting, postharvest handling, grading, packaging and marketing. Such field visits not only do provide alternative educational opportunities for students, but can also benefit the community if they include some type of community service by the students [2].

Objectives

To enable students to:

- Gain real working experiences about fruit crops production and management
- Identify the major fruit crops grown and their constraints
- Familiarize with all activities in relation to research, production, postharvest handling and marketing of fruit crops

Materials

Procedure

1. Seek instructions about the proposed visit from the instructor (place of visit, date, schedule for departure and return, any special instructions) ahead of the visit date
2. Make sure all materials (notebook, checklist, pen pencil,..) are carried
3. Start the visit as per the instructions and follow all safety rules directed by the research center, farm or processing plantation
4. During the visit, follow the instruction given by the team leader throughout the day
5. Visit the fruit farm, agricultural research center, and agro industry areas only the management agrees
6. Critically observe all activities in nursery, orchard, pack house going on in the fruit farm, agricultural research center, and agro industry
7. Check that all work areas in the fruit farm, agricultural research centre and agro industry are kept clean
8. Return to your destination as per the schedule

Observation and Expression of Results

When writing your observation, consider the following issues:

- The session's topic and objective.
- Name of the fruit farm, Agricultural Research Center, agro-industry etc. visited.
- State the activities observed associated with all aspects of the fruit farm, Agricultural Research Center and agro industry activity.

Discussion

Discuss the activities you observed during the visit in accordance with the theory behind fruit propagation, nursery and orchard establishment, maturity determination, harvesting and postharvest handling dealt in the class. Any positive points that contribute to minimize those mistakes should also be highlighted corroborating scientific reasoning.

Conclusion

Based on your observation give a conclusion about the overall activities of the tropical fruit establishments visited

Recommendations, if any
Self-assessment

Assess the level of your understanding considering the following questions

- Do I understand the research activities carried in relation to fruit crops
- Do I can manage fruit crops production and management activities independently?
- Do I know the need of field visit in relation to fruit crop farms, research, production and management establishments?
- Do I need any additional knowledge/skill to take about fruit crops production and management? If so what sort of additional input is needed?
- What knowledge and skill I gained from the field visit?

References

1. Wikipedia, 2009. The Free Encyclopedia. The Wikimedia Foundation, Inc., a U.S. 501(c)(3) tax-deductible nonprofit charity. http://en.wikipedia.org /wiki/ Manioc (accessed on August, 2018).

2. http://www.informalscience.org/news-views/field-trips-are-valuable-learning-experiences (accessed on Dec.,2 2018)

Sub-tropical and temperate fruit crops production and management

Hort2121

Student's Practical Guidebook

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COURSE INTRODUCTION

Fruit plants are classified based on their climatic adaptability, which is mainly known as ecological classification. In horticultural point of view, this classification has got much significance in which fruit growers can select crops suited to a particular region. With such classification, fruit crops are categorized in to temperate, subtropical or tropical.

The main focus of this guidebook is on subtropical and temperate fruit crops. Sub-tropical fruit crops are fruits that require warm or mild temperature throughout the growing season but can tolerate light frost. Some of these fruits may require some winter chilling for maximum fruiting. They are adapted to a subtropical zone, with a mean temperature in the coolest month between 13 and 18 ^{o}C, a seasonal temperature range, a distinct wet and dry season, the possibility of slight frosts, and a minimum heat accumulation of about 2000 ^{o}C days. Some of the important subtropical fruit crops are citrus, avocado, persimmon, fig, pomegranate, etc. On the other hand, temperate fruit crops are fruits of the temperate zones that require a period of cold season followed by warm period to grow and set fruit properly. Their major common feature is that they need a cold dormant period to give a satisfactory yield. Some of the temperate fruit crops have also a minimum requirement for warm period to give more fruit yield. Some of the important temperate fruit crops are apple, grapes, pear, peach, plum, apricot, cherries, almond etc.

Both sub-tropical and temperate fruit crops production in Ethiopia is largely situated on mid to high land altitudes, which makes the growing of tropical fruits difficult with ownership of the smallholder farmers. Such fruit crops are typically cultivated to supplement household income from their main crops. Moreover, growers can enrich their diets with essential minerals and vitamins through home consumption of such fruit crops.

As the industry for such fruit crops is relatively new to the Ethiopian agriculture system, many of the crops are recently introduced, their crop husbandry for optimum production is not well understood and most farmers and experts are not knowledgeable as to how to handle them, it is expected that both farmers and experts faced many production and management constraints. Thus, this Student's Practical Guidebook on "Sub-tropical and Temperate Fruit Crops Production and Management", is prepared within the framework of nationally harmonized curriculum for horticulture Bachelor of Science (B.Sc.) degree students with a prime aim of providing relevant procedures for the students so they can easily understand the procedures and accordingly conduct the respective practical sessions indicated in the course.

PRACTICAL SESSION 1

Practical Session 1

Identification of Horticultural Tools, Equipments and Sub-tropical and Temperate Fruit Crops

Practical session 1

Identification of horticultural tools, equipments and sub-tropical and temperate fruit crops

Activity 1.1: Identification of horticultural tools and equipments

Refer activity 1.1 of Students' practical guidebook for tropical fruit crops production and management within this practical guidebook

Activity 1.2: Identification of subtropical and temperate fruit crops

Theory

The objective is to identify different subtropical and temperate fruits by using their morphological characteristics such us: leaf shape, leaf arrangement, growth habit, fruit shape, fruit color, edible portion and fruits can also be identified based on their climactic adaptation; fruits that do not require specifically cold but have slightly frost tolerant but they can be severely injured or killed in temperature less than 9.5^{o}C like avocado, citrus, fig, persimmon and pomegranate are known as subtropical fruits. Temperate fruits are grown in the temperate zone of the northern and southern hemispheres. They withstand very cold winter temperature. For example: Apple, peer, peach, plum, grape, strawberry etc. They require chilling temperature (0 – 10^{o}C) for a specified period for flower bud initiation and good productivity. Identifying the fruit can give information on how the fruit is best used, how long it can be stored, its resistance to a possible disease outbreak, growth habit and even how long the fruit tree can live. It can also give a bit of history about ones orchard and know the management aspect too. Temperate and subtropical fruit production is a major industry. The production and marketing of fresh fruits are much more labor-intensive than that of broad acre crops, so that the temperate fruit industry is a major source of employment. As a consequence of the high labor content of production, large-scale fruit production by major companies is tending to shift towards suitable regions with access to cheap labor [1].

Specific objectives

- To acquaint students with sub-tropical and temperate fruit (including their respective scientific names).
- To make the students familiar with the morphological structure (flower bud, flower) of sub-tropical and temperate fruits.

Material:

Equipments

- Flip chart

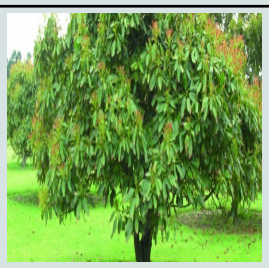
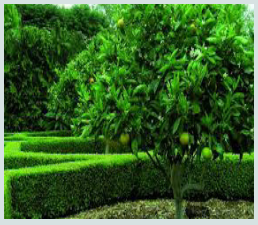
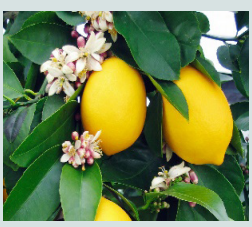
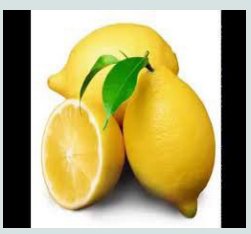
Consumables

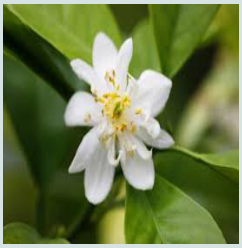
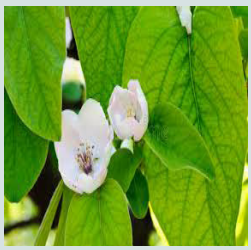
- Different fruits (plant and edible part) (if exist).

Procedures

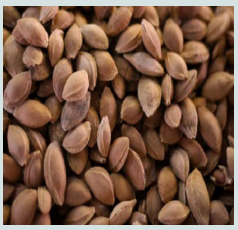
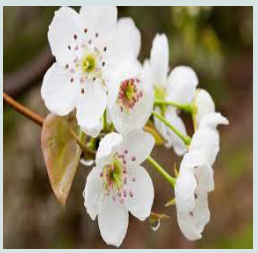
1. Observe the flip chart hanging in the class (Flip chart 1 &2); if an established orchard exist, visit the orchard.
2. Identify the fruits whether they are subtropical or temperate fruits based on your theoretical background.
3. Observe and name each fruit from the flip chart and the orchard (if exist).

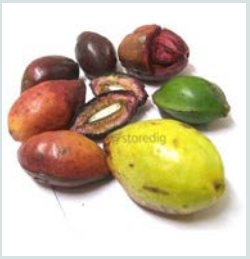
Flip chart 1.1 Pictorial presentation of subtropical fruit crops for trees, flowers, fruits and seeds

Fruit Type	Fruit trees	Flowers	Fruits	Seeds
Avocado [2] *(Persea americana*		 		
Lime [3] *(Citrus aurantifolia)*				
Lemon [4] *(Citrus limon)*				

Fruit Type	Fruit trees	Flowers	Fruits	Seeds
Sour Orange[5] *(Citrus aurantium)*				
Sweet Orange [6] *(Citrus sinensis)*				
Mandarin [7] *(Citrus reticulata)*				
Shadoke (pumelo) *(Citrus grandis)*				
Persimmon *(Diospyros kaki)*				
Fig (Ficus carica)				

Flip chart 1.2 - Pictorial presentation of temperate fruit crops for trees, flowers, fruits and seeds

Fruit Type	Fruit trees	Flowers	Fruits	Seeds
Apple [] *(Malus domestica)*				
Grape *(Vitis spp.)*				
Peach *(Prunus persica)*				
Pear *(Pyrus communis)*				
Strawberry *(Fragaria x ananassa)*				
Plum *(Prunus domestica)*				

Almond *(Prunus dulcis)*				
Apricot *(Prunus armeniaca)*				
Brazilian cherry *(Eugenia uniflora)*				

Observation and expected results

Write your evaluation on the following points:

1) Write down your observation in relation with morphological characteristics of the fruit (the plant and edible part).
2) Write the common name and scientific names of the fruit from the flip chart?
3) Write down the differences between temperate fruit and subtropical fruit based on climatic requirement, growth habit, and edible portion of the fruit.
4) Write a report by considering the morphological characteristics and the growth habit of the displayed fruits in flip chart and field (if available).

Discussion: discuss the different sub-tropical and temperate fruits based on the morphology and the growth habit of the fruit.

Conclusion: Write what you conclude from your observation.

Self-Assessment

1. Do I distinguish among the various sub-tropical and temperate fruits based on the observations (pictorial display/flip chart and live fruit plants)?
2. Do I name the major sub-tropical and temperate fruit crops grown in Ethiopia?
3. Can I write down common and scientific names of sub-tropical and temperate fruit crops from your filed observation?
4. Do I clearly and concisely explain the observed results to peer group and my instructor?
5. Have I acquired report writing skill based on the observations I made?

Table 1.1 Fill the Table (checklist) by observing the flip charts and live fruits (field visit).

No	Common Name	Scientific Name	If possible, its morphology
1			
2			
3			
4			

Recommendation: The instructor needs to facilitate active participation of students and supervise the session.

References

1) Smith. L.G. Somerset. S.M. (2003). Fruits of temperate climates and commercial and dietary importance, in Encyclopedia of Food Sciences and Nutrition (Second Edition).
2) https://www.google.com/search?q=avocado+fruits&rlz
3) https://www.google.com/search?q=lime+fruit&rlz
4) https://www.google.com/search?q=lemon+fruit&rlz
5) https://www.google.com/search?q=sour+orange++fruits&rlz
6) https://www.google.com/search?q=sweet+orange+fruit&rlz
7) https://www.google.com/search?q=mandarin+++fruits&rlz
8) https://www.google.com/search?q=diffrent+varity+of+shadok+citrus+fruits&rlz
9) https://www.google.com/search?q=persimmom+fruit&rlz
10) https://www.google.com/search?q=fig+fruit&rlz
11) https://www.google.com/search?q=pomegarante+fruit&rlz
12) https://www.google.com/search?q=apple+fruit&rlz
13) https://www.google.com/search?q=grape+fruit+bud+and+flower&rlz
14) https://www.google.com/search?q=peach++fruit&rlz
15) https://www.google.com/search?q=pear++fruit&rlz
16) https://www.google.com/search?q=strawberry+fruits+and+their+flower&rlz
17) https://www.google.com/search?q=plum+fruit&rlz
18) https://www.google.com/search?q=almond++fruits&rlz
19) https://www.google.com/search?q=apircote++fruit&rlz
20) https://www.google.com/search?q=brazilian+cherry+tree&rlz

PRACTICAL SESSION 2

Practical Session 2

Demonstration of subtropical and temperate fruit crops propagation

Refer practical session two of Student's practical guidebook for tropical fruit crops production and management and practical session three of Student's practical guidebook for sub-tropical and temperate fruit crops production and management within this practical guidebook.

PRACTICAL SESSION 3

Practical Session 3

Subtropical and Temperate fruit Nursery Establishment, propagation and management

Practical session 3

Subtropical and Temperate fruit Nursery Establishment, propagation and management

Theory

Fruit plants may be propagated directly from seeds or by vegetative means. Although seed propagation of fruit plants is the easiest, generally it is not the best, because it scarcely allows for maintenance of the characters of the original plant. In addition, plants grown directly from seeds are slow to come into production. Seedlings are normally grown as a rootstock onto which desired fruit cultivars are budded or grafted. A vegetative reproduction is the process of multiplication in which a portion of fragment of the plant body functions as propagules and develops into a new individual plant which involves the production of new plants without the act of fertilization or sexual union. It is accomplished entirely by mitosis, the cell division process by which the plant grows. Each daughter cell is an exact replica of its mother cell [1]. Thus, the major challenge is getting proper planting material in potential areas for the cultivation of subtropical and temperate fruits. They are usually propagated by either sexual means (seed) or vegetatively (asexually) by grafting or budding a desired variety onto a suitable rootstock. It is possible to grow subtropical and temperate fruits like citrus, avocado, peach and apple from seed, but they may not have the same characteristics as the parent plant, i.e. the new plant raised from the seed might taste and look different than the parent plant.
Seeds of some temperate fruit trees often do not germinate unless they are exposed to chilling temperatures [2]. This can be accomplished artificially by a practice called stratification [3]. Temperate fruit nursery plants require due care and attention after having either emerged from the seeds or have been raised from other sources like rootstock or through tissue culture technique. Thus, nursery management mainly includes all such operations right from excising the planting material from the mother plant and emergence of young plantlet till they are fully grown-up or are ready for uprooting and transplanting in the main fields. Several vegetative propagation methods are used to multiply subtropical and temperate fruit crops. Some of these include grafting, budding, cutting, layering, micro propagation or tissue culture.

Objectives

- To acquaint the students with procedures of seed extraction of selected subtropical and temperate fruit crops,
- To enable the students understand causes and avoidance mechanisms of seed dormancy of selected subtropical and temperate fruits.
- To train student about rooting of temperate fruit hardwood cuttings

Materials - Prepare all the equipment and consumables for the practical session

Equipment	Consumables
- Sharp knife (Stainless steel knife - Small wooden box/tin can - Plastic pot - One to two liter jug	- Mature & well ripe healthy fruits of citrus, avocado, apple, peach - Grapevine/apple cuttings - Glove

- 100 ml conical flask
- Juicer
- Sieve
- Fine plastic strainer.
- Refrigerator
- Water
- Charcoal
- Sphagnum moss
- Sawdust or peat moss
- Sterile potting soil

Procedures for propagation of rootstock and planting

Seedlings can be raised in the nursery beds or in polythene bags, however raising rootstocks in polyethylene bags is recommended due to better establishment of plants in the field on account of undisturbed tap root system. Moreover, rootstock raising in polyethylene bags is cost effective as it saves labor in weeding, watering, shifting and lifting of plants. Specifically, the instructor makes sure that

- Have sufficient quantity (depending mainly on the number of students) of sample fruits of locally available subtropical and temperate fruits one or two days ahead of the practical session day.
- Get a jug of water, tray and fruit cutting knife available in advance, and encourage the students to pass these materials to each other (whenever needed).
- Have students work individually or in small groups (4-6 students in a group).
- Guide students to take one or two fruits of any one or more of subtropical and temperate fruit crops, extract seeds and observe their physical characteristics (and also count and record number of seeds per fruit) as details shown for each fruit type below.
- Take seed samples of any one or more of subtropical and temperate fruits (commonly grown and available at your area) and demonstrate seed sowing procedure on seedbed and/or container.
- If established fruit saplings are available at nursery, encourage the students observe and distinguish among the saplings (seedlings and/or grafted/budded plants) of different fruit types.
- If available, show video about seed extraction, seed sowing etc. of any one or more of subtropical and temperate fruits.

I. Procedure for propagation of citrus by seed

Selection of seeds for rootstock

In citrus, cultivars have been identified, or developed through breeding programs, which may not have edible fruit, but are excellent rootstock plants, such as rough lemon, sour orange, Trifoliate orange, Carrizo citrange, Cleopatra mandarin, and other lesser used cultivars. For best results, seeds from one of these plants should be used. Criteria used for selection of the seeds include: ease of budding, vigor, pests and disease tolerance or resistance, adaptability to soil conditions (salinity, water-logged, etc.), the effect on the scion (fruit size, fruit quality etc.) and other desirable features.

Once the rootstock has been selected:

1. Collect fruits for seed only from the select trees in order to ensure that the seeds are not contaminated, and that they reflect to the characteristics of the rootstock species chosen. As a general rule, the fruit for seed must be picked directly from the tree. Fruits which have fallen to the ground are more subject to fungal infections (example, brown-rot and /or other) that may later contaminate the whole seedbed. When possible, mature fruit should be picked from vigorous

trees, which are 10 years old or more, and most importantly from those free of pest and /or diseases of economic importance.

2. After harvest, transport the fruit to the nursery within the shortest possible time.
3. Avoid leaving the fruit directly exposed to the sunlight and/or where water may accumulate, since fruits under such conditions are more susceptible to disease infection.

Extraction and treatment of the seeds

The extraction of seeds from the fruit must be done within one or two days after harvest. Waiting for a longer period, especially if some of the fruits rot, increases the chances of contamination by pathogens that may later infect the seedbed. To avoid introduction of any potential disease agent, fruit should be rinsed prior to seed extraction in diluted (20%) sodium hypochlorite (bleach).

1. Make a shallow cut (about 1cm deep) through the rind and approximately around the center of the fruit (Fig. 3.1a).
2. Twist, and separate the two halves (Fig. 3.1b). A deeper cut will damage some of the seeds (Fig. 3.1c).
3. Squeeze the cut fruit in to a sieve to collect the seeds. If large amounts of seeds of fruit are to be squeezed, a hand extractor or some low-speed mechanical extractors (if available) would be helpful.
4. Wash the seeds (remaining in the sieve) free of the pulp. A preliminary selection of the best seeds based on their potential viability may be done at this time, by placing the seeds in water. The undeveloped seeds and any remaining pulp will float, these are discarded.
5. Spread the seeds over newspaper, or over open screen boxes. They are then left to dry in the dark for no more than 24 hours. At the end of this time, it is advisable to treat the seeds with a fungicide to reduce, among other things, the possibility of mould infestation.

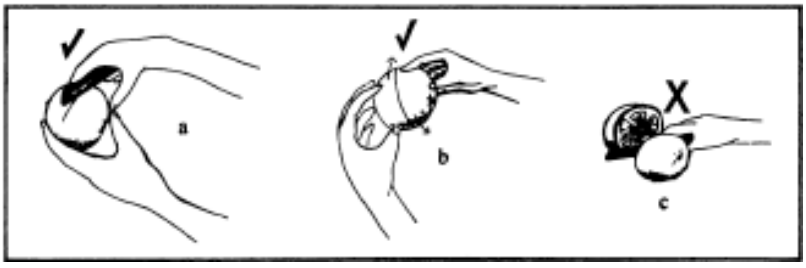


Figure 3.1 When cutting the citrus fruits for extraction of the seeds: (a) A shallow cut is made through the rind around the center of the fruit, (b) The two halves are then twisted and separated, (c) The fruit should not be completely cut across the center, otherwise many seeds will be cut in pieces.
Source: Marte, 1987

Planting the seed

Seeds should be planted at a depth of 6 to 12 mm in suitable pots or flats containing sterile potting medium. Removing the seed coats, or soaking seeds in aerated water for about eight hours just prior to planting, can reduce the time required for germination and seedling emergence. Under ideal conditions (sunlight, warm soil, and sufficient moisture), emergence will occur within 2–3 weeks after planting. Plants should be trained to a single stem (no branches within 15–20 cm of the soil).

Most citrus species used as rootstocks are polyembryonic. Often producing 2 and 3 seedlings from one seed, theoretically therefore, we should expect more seedlings than the number of seeds planted

Since some seeds fail to germinate and many seedlings have to be discarded, as a general rule we should plant 2 to 3 times as many seeds as the number of seedlings required for budding.

II. Procedure for propagation of avocado by seed

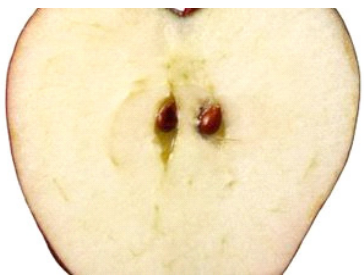
Avocado seed can be planted directly in the field in nursery rows, and later transferred to a container, or directly planted in a container. Direct planting in the field in nursery rows requires special care and does not permit culling weak and off type seedlings without leaving blank spaces. In addition, sprouting will be slow with some seeds, causing an irregular stand.

Remove the seed (pit) from the avocado carefully (without cutting it), and then washing it clean of all the avocado flesh. Be careful not to remove the brown skin on the pit (that is the seed cover). Some avocado seeds are slightly oblong, whereas others are shaped almost like perfect spheres – but all avocado seeds have a 'bottom' (from where the roots will grow), and a 'top' (from which the sprout will grow). The slightly pointier end is the top, and the flat end is the bottom.

Avocado seed should be planted with the large flat end down, leaving the tip flush with the soil surface. That is, the seed has to be correctly oriented as it hangs on the tree: the embryo shoot is toward the stem end, the root toward the bottom of the fruit. Be sure the soil makes firm contact with the seed. Spread a layer of clean sand, sawdust, or any other appropriate media-mix over the beds, deep enough to cover the seeds 6 to 12mm. This will avoid forming a crust over the soil after irrigation and will protect the seeds from drying. Provision should be made to shade beds during hot weather to avoid burning the tender sprouts as they emerge. Germination can be hastened by cutting a thin slice off the tip and base of the seed. This is not considered necessary when seed is planted immediately after removal from the fruit. Seedlings that are to be transplanted to the nursery bare root are planted at 5cm intervals in the bed. If they are to be removed with soil around their roots, they are planted at 10cm intervals to permit easy digging. However, in recent years instead of using a seedbed, most growers commonly plant the seeds in polythene bags, with perforated bases for drainage.

III. Temperate fruit Seed Stratification procedure (eg., peach and apple)

1. Cut the fruit in half: Cut a matured fresh peach/apple in half using sharp knife and pull the two pieces apart. Pull out the center stone with your fingers.



2. Soak and Clean the Peach Stone: Rinse the stone with water and remove any pulp that's stuck in the grooves. Fill a small bowl with room-temperature water and soak the stone for about 30 minutes.

Note: For apple allow the seeds to air dry after removing them from the fruit but avoid excessively prolonged drying.

3. Begin Cold stratification: Remove the stone from the water (for peach) or use air dried apple seed and place them in a moist fine sand and place them in a closed container (ziplock bag) in the refrigerator for at least 60 days. Place the plastic bag in a refrigerator to rest at temperatures between 0 and 4.5°C for about eight weeks without disturbing it.

Note: plan the time of stratifying the seeds in such a way that they will be ready for planting in time for spring.

4. End Cold Stratification: Remove the plastic bag from the refrigerator after eight weeks and let the stone rest outside the cold environment while preparing the planting soil.

5. Prepare a pot or garden bed of soil: Moisten sterile potting garden bed soil with clean water until it feels like a damp sponge. In case of potted plants, add the moistened soil to seed-starting pot.

6. Plant the Seed: After seeds have been stratified in the refrigerator, plant them during spring. Plant the seeds in well prepared soil (Step 5) as deep as 1 to 2 times the longest dimension of the seed and pushing it to make it firm. Cover the hole lightly with soil.

7. Situate the Pot: Set the pot in a warm area with a temperature of about 21°C and filtered or indirect sunlight.

8. Check the Soil Moisture: Keep the soil consistently moist but not wet, i.e. avoid saturating the soil to prevent the seed from rotting.

9. Transplant the Seedling: Transplant well-rooted seedling to a new pot having bottom drainage holes when there are at least five leaves on the stem. Finally, transplant the young tree to a sunny spot in spring following the last frost.

Source: [3]

IV. Rooting of Temperate fruit hardwood cuttings (eg., Grapevine/apple)

1. **Selecting the mother tree:** select disease-free and vigor mother tree for propagation.
2. **Time for Cuttings:** Collect the cuttings from well matured (one year old) mother plant during the dormant season for peach or late spring for apple.
3. **Making the Cuttings:**
   - For grapevine: prepare cuttings from the previous year's growth of one- year-old wood having at least 3 buds, but not more than 6–7 buds (35–40 cm) (Fig. 3.2). Trim off all leaves, make a slanted cut at the top and a straight cut across the bottom.
   - For apple: Trim off all leaves and buds that will be below the soil. The cut ting should be around 38 to 50 cm long, and at least three inches should be below the soil. Leave at least one or two leaves.

Figure 3.2 Cuttings with 5-6 buds for ideal propagation

4. Storing the Cuttings (grapevine): Store the cuttings at cold place at temperatures slightly above freezing (0-4°C). Tie the cuttings in bundles and moist it using moist wood shavings, sawdust, or peat moss. First, moist them well and then drain them enough to remove excess moisture.

Note: To differentiate the distal and proximal end of the cutting, make a diagonal or slanted cut at the top (distal) and a straight cut across the bottom (proximal). At this time, all tendrils and lateral shoots should be removed.

5. Removing the Cuttings from Storage (grapevine): In the spring after the soil shows signs of warming, above 12°C, cuttings can be placed in the nursery.

Note: At no time should cuttings be allowed to dry out.

6. Planting in the Nursery:

- Grapevine: plant the cuttings in the nursery when the temperature is warm enough for them to be planted in the nursery. Cuttings should be soaked in water for a several hours before placing them in the nursery. It is not necessary to use any type of root-promoting substance since grapevine cutting is easy to root.
- Apple: Dip the end of the cutting into a rooting hormone.

Plant the cuttings in prepared soil in rows in the nursery at a depth of at least 7.5cm. Rows should be spaced far enough (25cm apart) in the row, making sure cuttings have the slanted cut up. Give cuttings adequate moisture so as to assure good rooting.

Note: In case of grapevine the cutting can be planted directly in the main field and used as main vain yard establishment

Source: [3]

Observations and Expression of Results

- Guide students to share their findings to other groups or the entire class.
- Ask questions (and lead discussion based on what students share) as to whether the students have understood distinguishing characteristics of seeds of each fruit type; germination percentage of seeds and rooting success of cuttings; distinguishing between monoembryonic and polyembryonic seeds; Explain the possible causes of seed dormancy in subtropical and temperate fruits, such as citrus, avocado and apple, and ask the students to explain mechanisms of overcoming seed dormancy.

- Encourage the students write a complete session report (individually or in group) and submit to the instructor.

Discussions: encourages students to discuss their observations.

Recommendations - facilitate active participation of students and supervise the session.

Student Assessment

- Test knowledge and skill levels of students by asking questions focusing on seed extraction procedures, distinguishing characters of monoembryonic and polyembryonic citrus seeds, seed dormancy and purpose of stratification, procedures of germination and rooting of cuttings, etc).
- Students will be assessed out of 5 % based on the practical session report they submit.

Procedure for propagation of selected subtropical and temperate fruits by vegetative means

Objective

- To acquaint the students with the basic principles and common methods of propagation of subtropical and temperate fruit crops by vegetative means.

Materials - Prepare all the equipment and consumables for the practical session

Equipment

- Grafting/budding knife,
- Hammer (or Mallet),
- Cooler box (to collect scion-wood, optional),
- Fine tooth saw,
- Pruning shears

Consumables

- Root stock (Inter stock may also be required in some cases),
- Scion (scion-wood),
- Plastic bag to collect scion or wet newspaper,
- Tying Materials: tape, rubber strips,
- Grafting wax,
- Sterilizer such as spirit/ alcohol

I. General procedure

1. Select the scion wood from healthy, disease free, true to type mother trees.
2. Collect the scion wood from one year old shoots having at least 2 or 3 buds and packed in moist sawdust (moist sand or any other appropriate material), after proper labeling of the variety.

For grafting: When you are ready to make scions, cut off and discard the tip and base of the shoot. Buds near the tip of the shoot are often flower buds, and those near the base are often weak buds.

For Budding: Collect “budsticks” of the cultivar to be propagated from vigorous current season growth when the bark on the stocks peels easily. (Irrigate if dry; bark will then slip in a few days.)

3. Store the bundles of scion wood in shady place till required for grafting/ budding.
4. Perform grafting (Fig. 3.3A) /budding (Fig. 3.3B) on rooted seedling (section B) during February to March.

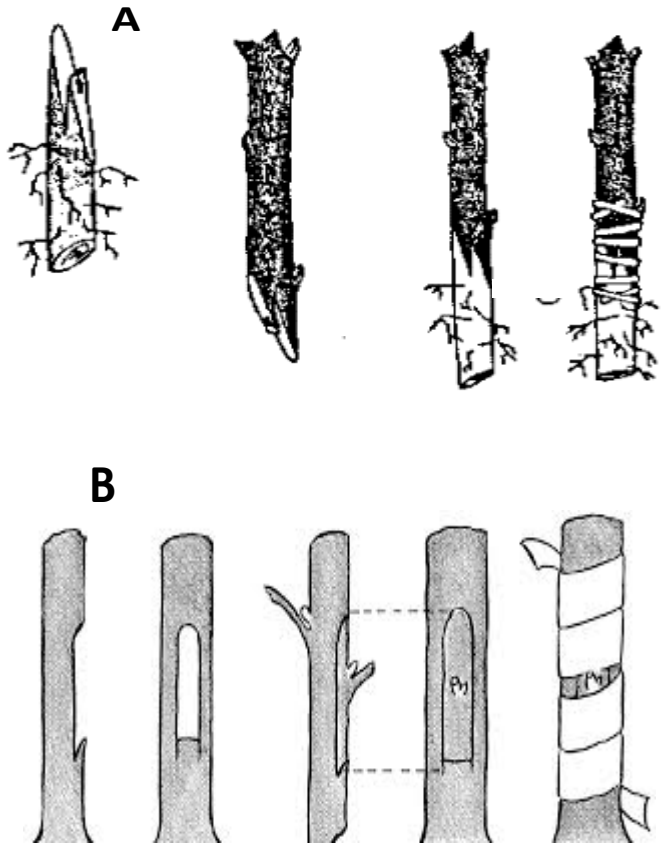


Figure 3.3 Grafting (A), and budding (B)
Source [4]

5. Grow the grafted/budded plants in the nursery till the graft union is well formed for a period of 1-2 months.
6. Plant the grafted/budded trees in the open field following the winter season (December to January)

II. Procedure for propagation of citrus

Selection of the bud-wood

There are two types of citrus bud-wood: The round bud-wood, from hardened twins, which is usually preferred by propagators, and the "angled" bud-wood, which comes from less mature twigs (Fig. 3.4).

The latter is more used in the "micro-budding" of small citrus seedlings. The bud-wood should be used immediately after it is collected, and must not be allowed to dry out.

One should remember that the propagation tool e.g. knife, secateurs, must always be sterilized using appropriate chemical (sterilant) every time the propagator moves from one tree to another.

Buds should be collected from healthy, disease free trees of the desired cultivar. This is usually done by collecting twigs from the next to last growth flush (the wood behind the current growth flush) or from the current growth flush after it has begun to harden or mature. Bud-wood should be round (not angular as is young wood), relatively straight and have well formed buds in the leaf axils (Fig. 3.4). Often, the presence of a few longitudinal gray lines on the green bark indicates the proper stage of maturity. Whenever possible, bud-wood should be approximately the same diameter as the rootstock stem to be budded.

After bud-wood is cut from the tree, the undesirable wood and/or growth flush should be discarded and the remaining bud-wood trimmed to 20-25cm lengths. Leaves should be cut off leaving a stub of the petiole about 3mm long to protect the bud. The petioles provide convenient handles that can be used to hold a bud when it is cut from the bud-stick. Trimmed bud-sticks should be labeled as to cultivar, date, and bud-wood source and used immediately, or placed in suitable storage.

Scion bud-sticks should consist of tree branches less than one year old and less than 6mm diameter (Fig.3.4). Bud-sticks should have dormant buds; buds that have sprouted and are actively growing are not suitable. Bud-wood should also be healthy; buds from sick trees may not be successful.

Some of the most important aspects to consider when selecting a citrus tree for bud-wood are the following: (1) Choose disease-free plants for bud-wood source, (2) Avoid taking bud-wood from plants which show abnormal growth, or abnormal fruits, (3) Only select trees with a record of good yields, and proven high quality fruits, (4) Avoid taking bud-wood from plants with excessively vigorous growth. Do not choose bud-wood from vigorous or extremely thorny suckers or water sprouts that arise from the tree trunk or limbs. If possible, give preference of mature trees (10 years and older) and reject any thorny bud-wood.

Figure 3.4 The bud-stick at left is the best, the middle one can be used with good technique, but the one at right is too angular.
Source: https://aggie-horticulture.tamu.edu/citrus/budding/budding.htm

Storing bud-wood (bud-stick)

Bud-wood should be used as soon after its collection as is practical. However, it can be stored for up to 2-3 months under proper conditions. When storage is required, prepare the bud-wood as normal, clipping off leaves and thorns. The bud-wood should then be cut in appropriate lengths (15 to 20cm), arranged in small bundles, labeled, and sealed in polythene bags. They should then be put in a refrigerator at 10 to 130C. If refrigerator is not available, the bud-sticks should be kept in sterilized sawdust, and maintained in a cool, dark area. Do not put water or wet packing material into the storage bag as this will cause the bud-wood to mold or decay. Inspect bud-wood every two to three weeks for the presence of mold, or excessive moisture inside the bag. Lightly molded bud-wood should be carefully washed in cold, mild soapy water, rinsed and stored in a clean bag. Bud-wood which is excessively moist should be lightly blotted with paper towels. Shriveled, darkened, or heavily molded bud-wood should be discarded and any unaffected bud-wood should be washed and returned to storage in a clean bag. Stored bud-wood should remain moist and cool, but not wet. It is best not to remove bud-wood from storage until a couple of hours before its use.

T Budding (Inverted T Budding)

T budding is a relatively simple procedure and is recommended over chip budding for the inexperienced nursery person (budder). Some growers propagate citrus trees by the inverted T (⊥) bud procedure. T budding may be conducted whenever the rootstock plant has attained suitable size, its bark is slipping (the bark separates easily from the wood underneath), and suitable bud-wood is available.

All thorns, stems and leaves should be removed from the area to be budded. The preferred budding height is approximately 15cm above the soil surface. A very sharp knife is used to make a vertical cut in a smooth area of the rootstock stem about 2.5-3.5 cm long completely through the bark. A sharp knife will allow the propagator to cut into the wood smoothly and with minimal force. When a dull knife is used, the knife cut may be jagged, reducing the chance for bud survival. More importantly, excessive force must often be used with a dull knife, leading to loss of knife control and the possibility of injury. A horizontal cut is made through the bark at top (regular T) or the bottom (inverted T) of the vertical cut. The cut is made at a slightly upward angle, again cutting completely through the bark. The point of the knife can be used to lift the bark along the vertical cut.

Remove buds from the bud-stick while holding the apical end (tip) of the bud-stick away from you. With the knife blade almost parallel to the axis of the bud-wood, begin the cut about 12mm above the bud removing a shield-shaped piece of bark and wood about 19mm to 25mm1 long with a flat, smooth cut surface. Cut only deep enough to remove a thin sliver of wood under the bark. The bud should not be scooped out because too much wood will be removed with the bud.

Avoid touching the cut surface of the bud shield by holding it between the thumb and knife blade, or by carefully using the leaf petiole stub as a handle. The bud should be immediately inserted into the stock, not allowing the cut surface of the bud to dry. Slide the bud shield (the bud with associated bark and wood) under the bark flaps of the rootstock with the cut surface flat against the wood of the rootstock plant (Fig. 3.5A-D; Fig. 3.5B). The bud shield should be completely enclosed in the T incision; if part of it

protrudes beyond the incision, cut it off. Buds should be wrapped immediately following their insertion into the rootstock. Wrap buds with budding tape (polyethylene strips about 12mm wide by 15-25cm long). Begin wrapping below the bud with 3-4 turns and finish with several turns above the bud covering all exposed surfaces of the bud with tape. The end of the tape is secured beneath the last circular turn. The wrap should be firm without being excessively tight. Wraps should be removed after 14 to 21 days and should not be left on more than 30 days. If a successful union has formed between the bud and the rootstock the bud will be green and show no signs of shriveling or drying. Callus formation should also be evident around the edge of the bud.

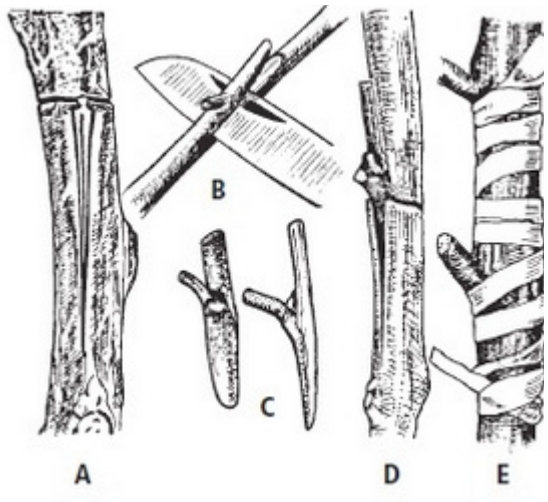


Figure 3.5A T-budding. A. Rootstock with T-shaped cut. B. Cutting bud from bud-wood. C. Buds ready for insertion. D. Bud inserted into the cut. E. Graft wrapped with budding rubber.

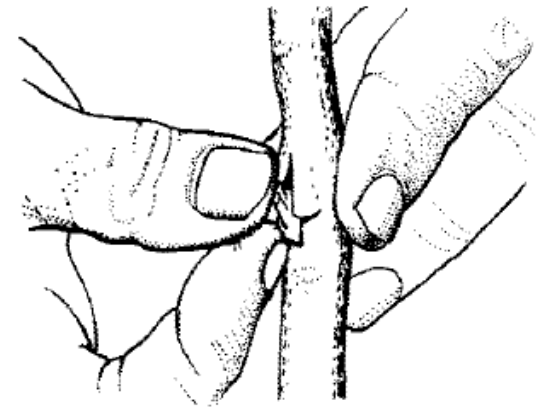


Figure 3.5B. During inverted T budding, the bud is slipped under the bark flaps created by making the inverted "T" (□) incision on the rootstock.

Source: Williamson and Jackson, 1994

The wrapping should be performed from the bottom upwards, to avoid the penetration of water through the edges. Several types of material of different colors are used for wrapping, but the most common is the clear polyvinyl chloride tape. The clear tape, as opposed to the colored, allows one to see at any time whether the bud is still alive.
Under tropical conditions (like in Ethiopia), unwrapping is carried out from 12 to 30 days after budding. Normally, the younger the stock, the shorter the time required. After unwrapping, the stock is bent or cut to force the bud to grow. All emerging shoots within 2.5cm above and below the new bud should be removed by hand as soon as they appear.

If the bud remains alive, but no shoots appear, then the bud must be forced artificially. Three methods are common. The best method is to make a shallow horizontal cut in the bark about 12mm above the inserted bud (Fig. 3.6A). This should favor shoot growth from the bud at the expense of competing shoots. An alternative is to bend the root-stock just above the inserted bud (this procedure is known as lopping) (Fig. 3.6B). If neither of these two methods works, the rootstock branch should be cut off about 2.5cm above the living bud.

Figure 3.6 Forcing scion bud (A. Bud forcing by notching, B. Bud forcing by lopping)
Source: https://aggie-horticulture.tamu.edu/citrus/budding/budding.htm

III. Procedure for avocado wedge grafting

Select the rootstock according to these criteria:

1. Suitable variety; but if not available chose a seedling from a local avocado tree that grows well in the area.
2. Healthy, strong and free of pests.
3. About 6 months old (which should be at least 20-30 cm tall) with a stem as thick as a pencil (Fig. 3.7).

Figure 3.7 Avocado sapling (rootstock) ready for grafting

Preparing rootstock for wedge grafting

1. The process begins with the cutting of the rootstock at the height of 15 to 20 cm, and the cut of the base of the scion should be wedge-shaped,
2. Make a vertical incision in the center of the rootstock (3-4 cm down from the centre of the stub).

Preparing scion wood for wedge grafting

Cut grafting-wood (scion-wood) from branches that have demonstrated high production of true-to-type fruit, on healthy, vigorously growing trees. The best wood is on young

trees, or on older trees that have been cut back severely to force strong upright new growth. However, extremely vigorous stems are more likely to have central soft pith that makes a scion more subject to desiccation.
Select graft-wood (about 8-12mm in diameter) that is firm and not rubbery or pithy. It is defoliated and disinfected prior to grafting. The scion may be of the same or smaller diameter than the rootstock.

Undersized buds are less likely to survive and grow. However, extra-large buds and plump buds may be flower buds, which produce weaker vegetative shoots or none at all. Buds that are slim and elongate, often with tiny leaf-like feathery tips, are not dormant; they will not store well and will take less successfully even when used fresh. Such immature buds have cambium that is more active and so might be considered better for propagation, but they are more vulnerable to desiccation. Therefore, avoid the rubbery stem ends of current growth.

Each scion cut should have at least two, preferably three or four sound dormant buds. The best buds are large and plump, with a healthy green color. The base of the scion is cut with an equal-sided wedge. The scion with the basal end in the form of a wedge is ready for insertion.

Cut the scion long enough so that at the actual grafting time you can remove both deteriorated ends. Re-cut the apical end to just above a bud. The ideal bud-wood (bud-stick, graft-wood) has three or more buds concentrated toward its upper end, with no side buds in the longer basal portion to cause irregularity in the grafting-cut edge. Bud-stick lengths vary with the type of graft, but should rarely be less than about 7.5cm or more than about 20cm. A stem section ending in a terminal bud can make a satisfactory scion if well hardened; it would then be re-cut only at the basal end. After cutting a bud-stick, immediately clip off the attached leaves to minimize desiccation. The handiest tool for cutting and trimming graft-wood is a pair of pruning shears.

Early morning is usually the ideal time to cut graft-wood, in terms of both weather and tree physiology. Avoid periods of high heat, strong wind, or drought to minimize desiccation during the gathering process and a somewhat desiccated condition of the tree. After such drying adversity, wait a few days for good tree recovery. Conversely, avoid harvesting graft-wood during rainy weather to minimize disease infections.

Storing scion/graft-wood

Avocado wood is probably best used immediately after cutting, but often it must be stored. Cutting a large quantity of wood at one time may be most efficient. The optimum time for bud collection may not coincide with the optimum time for grafting, or the only bud-wood available may be far from the grafting site, or unfavorable weather may interfere, or illness or some other unforeseen snag may occur.

The bud-sticks can be stored for two or three months at about 4 - 4.5°C in sealed, medium weight polyethylene bags. With thinner polyethylene or for longer storage, use double bags. Graft-wood storage life can be extended by using a mild fungicidal dip, or by lowering the temperature slightly, but be sure that normal storage temperature fluctuations do not reach the freezing point. You can provide some added protection against brief freezing by wrapping the bagged wood in newspaper or ordinary paper bags, since the life processes in the living wood release a bit of heat. The maximum desirable number of bud-sticks in each bag is about 50.

In the absence of suitable refrigeration, larger grafting wood has been successfully stored for months in a cool, shaded outdoor area, in a box lined with several layers of wet newspaper and covered with a wet blanket or similar material (jute bag). Check the wood at least weekly, depending on the weather, and keep it moist

Preparing the scion for wedge grafting

1. The terminal current season's shoot in active growth of a desirable clone, about 8-12mm in diameter, is selected as scion material. It is defoliated and disinfected prior to grafting. The scion may be of the same or smaller diameter than the rootstock.
2. The base of the scion is cut with an equal-sided wedge. The scion with the basal end in the form of a wedge is ready for insertion.

Join rootstock and scion

1. The scion is inserted into the split of the rootstock so that at least one side of the cambia of the rootstock and the scion is in intimate contact.
2. The scion and the rootstock are tied firmly in position with a clear polythene strip.
3. Fix both the scion and rootstock in place by covering the point of union until it is healed (Fig.3.8). To do this; (a) Hold the union carefully with one hand, (b) With your other hand, wrap the grafting tape or the polythene strip tightly around the union and knot or inter-loop the two ends of the tape/strip, (c) Make sure that the wrapping is tight enough and that the scion does not move out of the union while wrapping.

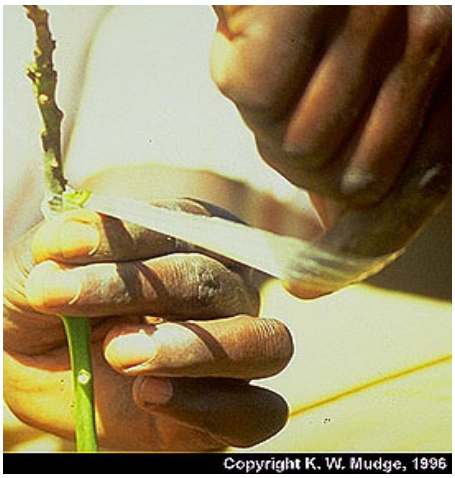


Figure 3.8 Stock and scion are tied together with plastic strip or a budding rubber

4. Bag the graft with transparent polyethylene to prevent dehydration and increase the success percentage (Fig. 3.9).

Figure 3.9 Bagging the grafted avocados to prevent dehydration and increase the success percentage

5. After the graft has healed and the terminal bud of the scion begins to sprout, loosen the polythene strip to allow the shoot to grow normally to avoid girdling.

IV. Procedure for propagation of apple by layering, wedge grafting and T-budding

Rootstock preparation:

1. Once seedlings emerge and develop to an appropriate size, possible to carryout vegetative propagation (stooling and layering) as follows (Fig. 3.10)

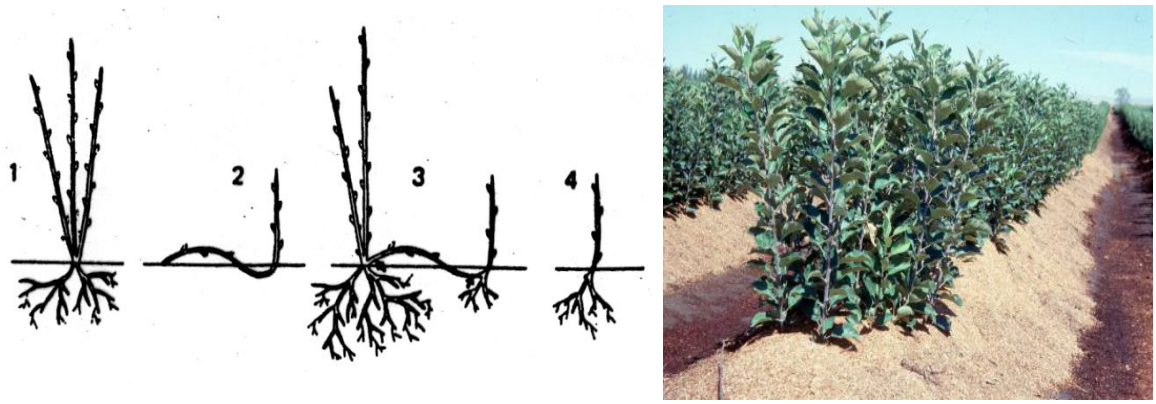


Figure 3.10 Steps showing layering (A) - 1) well developed stool, 2) one shoot is bending to the soil while the others might be harvested, 3) the bending shoot starts to root while the harvested one re-grow and 4) the bending shoot become independent from the original, and stooling (B)

2. the harvested shoots will be planted in the nursery at 20 - 30 cm distance apart

Scion preparation:

1. Select one year old shoots during dormancy (Fig. 3.11)

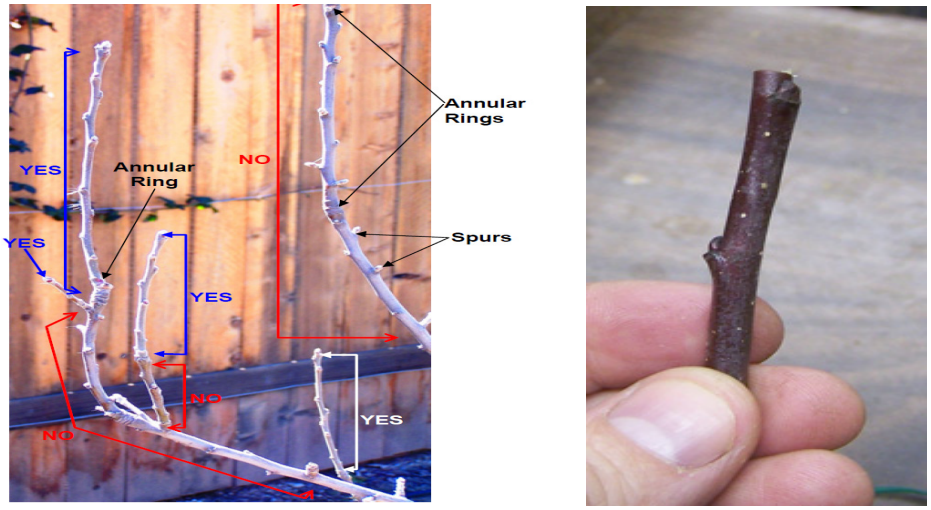


Figure 3.11 Apple scions to be selected for grafting and/or budding (shoots marked with blue are selected while shoots marked with red are not selected)

2. Scion preparation for wedge grafting (Fig. 3.12)

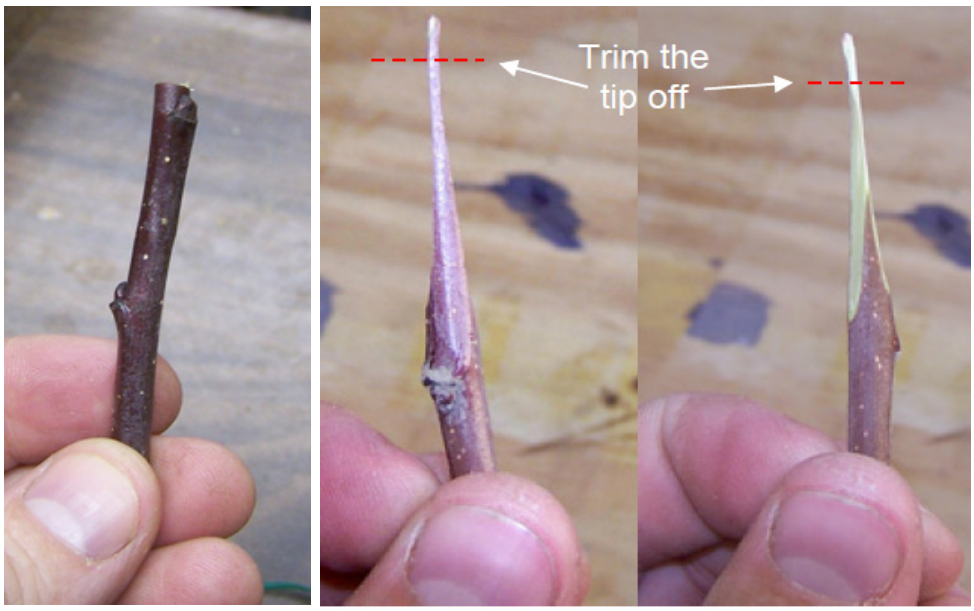


Figure 3.12 Scion preparation for wedge grafting

3. join between vascular cambium of scion and rootstock (Fig. 3.13)

Figure 3.13 Joining of the prepared scion with that of the rootstock

4. Scion and rootstock preparation for T-budding (Fig. 3.14)

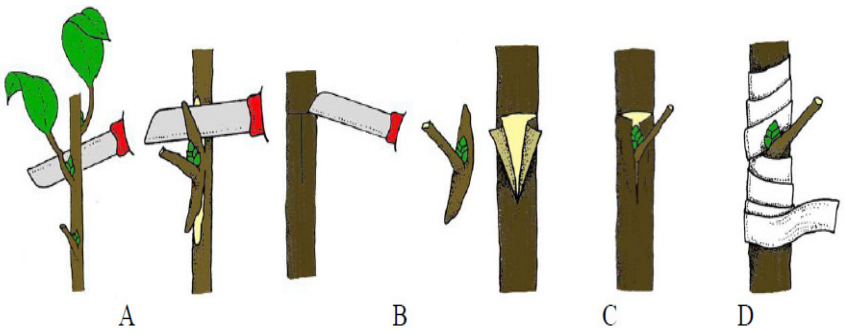


Figure 3.14 Steps showing T-budding (A) a shoot with matured buds and removed of a single bud, (B) make an opening in the rootstock, (C) fixing the bud in the rootstock, and (D) tying with polythene strip

Observations and Expression of Results

Write your observation based on your activity conducted for different techniques used for plant propagation by grafting and/ or budding.

Discussion

- Discuss each method of grafting and/ or budding briefly.

Conclusion

- Write what you conclude based on your observations and results.

Recommendation

Self assessment

- Define asexual propagation.
- How does vegetative propagation differ from sexual propagation?
- Distinguish between different propagation methods commonly used for propagation of citrus, avocado, apple and grapevine.

References

1. Hartmann, H.T., D.E. Kester, and F.T. Davies. 1990. Plant Propagation: Principles and Practices. Prentice-Hall, Inc., New Jersey. p. 647.
2. Baskin, J.M. and Baskin, C.C., 2004. A classification system for seed dormancy. Seed science research, 14(1), pp.1-16.
3. Griesbach, J., 2007. Growing temperate fruit trees in Kenya. World Agroforestry Centre.
4. Campoy, J.A., Ruiz, D. and Egea, J., 2010. Effects of shading and thidiazuron+ oil treatment on dormancy breaking, blooming and fruit set in apricot in a warm-winter climate. Scientia horticulturae, 125(3), pp.203-210.
5. Stoltz, L.P. and Strang, J., 2005. Reproducing fruit trees by graftage: budding and grafting. Un of Kentucky–college of agriculture, 10.
6. Marte R.1987, Citrus Propagation Manual, Miscellaneous Publication Series, No. A2/BB-87-004. Bridgetown, Barbados
7. Nicholas PR, Chapman AP, Cirami RM 1992. Grapevine propagation. In: Coombe BG, Dry PR eds. Viticulture, Vol. 2, practices. Adelaide, Winetitles. pp. 1–22.
8. Williamson and Jackson, 1994.Citrus Propagation, Florida Cooperative Extension Service, Fact Sheet HS-86, University of Florida. http://ufdcimages.uflib.ufl.edu/IR/00/00/23/80/00001/XC00400.pdf

PRACTICAL SESSION 4

Practical Session 4

Orchard establishment and management Theory

Practical session 4

Orchard establishment and management

Theory

An orchard is a farm land assigned for growing of fruit trees. As orchard establishment is a long-term investment, usually taking 3-4 years to bear a commercial crop and then continuing economic production for another 15 to 30 years, it needs thorough and careful planning for optimum production, high returns, and long tree life. Any mistake committed during planning reflects greatly on the orchard performance or efficiency. Thus, during establishing an orchard, site selection and land clearing, layout and spacing and digging planting holes and planting trees need adequate attention. Moreover, tree management (after care) plays a key role in the economic success of an orchard. Though the site, soil and climate conditions chosen for the species and the variety to be grown set the foundation for an orchard, tree management can compensate for less than ideal soil or climate conditions and the opposite is also true; improper tree management can render the best soil and climate conditions of little value. Major tree management practices for subtropical and temperate fruit crops include irrigation, fertilization, mulching, training and/or propping and pruning, dormancy management, pollination and pollination management, fruit thinning, and pest and disease management, among others.

Objectives

- To familiarize students with the principles and factors considered while planning, site selection and establishing an orchard for subtropical and temperate fruit crops
- To acquaint students with the impact of climatic, edaphic, and other factors on subtropical and temperate fruit crops production, and
- To equip students with practical skills and knowledge of husbandry of subtropical and temperate fruit crops.

Overall procedures

Activity 4.1: Site selection and land clearing

Specific objective: students able to

- understand and justify why planning prior to planting is more important to fruit crops than grain and vegetable crops.
- describe major climatic, edpahic and other factors to be considered while evaluating a site for subtropical and temperate fruit crops orchard
- understand the importance of land clearing from perennial weeds, undergrowth trees, stumps, roots, trash and debris, and leveling of very sloppy and shallow lands prior to laying out the planting field of an orchard

Material: Prepare all the equipment and consumables for the practical session

Equipment

- Agro-ecological zone charts with climatic and topography data
- Soil maps with soil physical and chemical properties
- Irrigation water sources and water quality data
- Different sizes hoes (dual purpose fork hoe, garden hoe, pick and mattock), rakes, spades/shovel
- Dozers and farm tractors with implements like moldboard, disc, offset disk harrow and bed former with rotary tiller (rotavator) if it is a large orchard

Procedures

1. characterization of the site in terms of its climatic (temperature, rainfall, relative humidity, wind, hail) and elevation
2. appraisal of nearness to market, labor availability, irrigation water sources and water quality and accessibility to transport of the area
3. characterization of soil physical and chemical properties by digging soil profile from representatives areas
4. land - crop suitability matching (considering the climatic and edaphic data of the land and the specific fruit crops requirements)
5. evaluate the site in terms of its land clearing, leveling, terraces, windbreaks, fencing conditions

Observation and expected results

Write your evaluation on the following points:

1. the agro-ecological zone of the site including its altitude, topography, slope, aspect, etc
2. long term climatic data like temperature, rainfall, solar radiation, relative humidity, wind, hail, chill units and frost
3. availability and potential market, labor, water for irrigation and access to transport
4. soil physical (texture, depth) and chemical (pH, organic carbon, EC, CEC, total nitrogen, available phosphorus, $CaCO_3$) properties
5. land clearing, leveling, terraces, windbreaks, and fencing conditions, and
6. overall land and/or area suitability of the existing fruit crops and/or other subtropical and temperate fruit crops to grow there, by considering your evaluation 1 - 5.

Discussion: elaborate and discuss with your classmates about the appropriateness of the site as an orchard for subtropical and temperate fruit crops. Moreover, discuss the importance of site selection and land clearing prior to laying out and planting field of an orchard.

Conclusion: write what you conclude about the site as an orchard for subtropical and temperate fruit crops.

Recommendation

Self-assessment

1. Do I understand the importance of planning prior to planting is more important to fruit crops than grain and vegetable crops?

2. Do I understand the basic considerations for establishing an orchard?
3. Can I list the important factors to be considered while evaluating a site for an orchard?
4. Can I do site evaluation for orchard of subtropical and temperate fruits crops independently?
5. Do I know the important farm tools used for land clearing and levelling an orchard?
6. Do I understand the importance of land clearing and leveling prior to laying out the planting field?

Activity 4.2: Layout, digging holes and planting

For the details, you may refer procedures 4. 2 - 4.4 of students' practical guidebook for tropical fruit crops production and management within this practical guidebook; but specifically it is presented as follows:

Specific objectives: students will be able to:

- understand the importance of layout and digging holes for fruit orchard prior to planting and make layout of an orchard,
- explain factors considered while laying out an orchard,
- understand that different subtropical and temperate fruit crops require different planting layouts and spacing,
- understand the precautions required during planting and immediately after planting different subtropical and temperate fruit crops.

Materials: Prepare all the equipment and consumables for the practical session

Equipment
- Ropes
- Spades
- Measuring tape
- Hammer

Consumable
- Grafted trees
- Pegs and stakes
- Paper, pencils and markers
- Water

Procedure: here it is possible to consider two different scenarios

I. Procedure for evaluation of existing nearby campus orchards layout and spacing - advice students

1. *check whether the orchard has a detailed layout plan on paper or not*
2. *if a layout plan exists, check the locations/positions of each and every orchard component (planting rows, windbreaks, fencing, irrigation systems, compost area, roads and paths, permanent buildings, etc) on the plan*
3. *check whether the layout plan is properly executed on the orchard*
4. *observe the type of planting systems or layouts of planting (square, rectangular, hexagonal (equilateral triangle), triangular, quincunx, contour and double row planting) and distance between trees and rows used for each fruit species and/or varieties.*

II. Procedure for sketching of hypothetical orchard layout and spacing, digging holes and planting of major subtropical (avocado and citrus) and temperate (apple, peach and grapes) fruits - instruct students

1. sketch a layout on a paper showing location of fruit species and/or cultivar names of each fruit species to be planted, location of windbreaks, fencing, irrigation system and compost preparation area, within orchard roads and paths, packing, shade and any other permanent features such as storages for inputs, produces, implements and guards houses.

2. decide the type of specific planting layout for each fruit crops in the orchard (square, rectangular, triangular, hexagonal, quincunx, contour and double row planting systems)
3. decide distance between trees and rows of each subtropical and temperate fruits considered and calculate the number of trees required for each species of fruit crops and/or varieties based on the specific planting layout system as follows [1]:

    i. Square and rectangular systems: -

    $$\text{Number of fruit plants} = \frac{\text{Area in m}^2}{\text{row to row distance in m} \times \text{plant to plant distance in m}}$$

    ii. Triangular system: - Number of fruit plants in square system minus one plant in every second row
    iii. Hexagonal (equilateral triangle) system: - Number of plants in a square system plus 15 per cent more plants than the square system
    iv. Quincunx system: - Number of fruit plants in square system plus additional plants of (number of rows lengthwise - 1) squared

4. to arrange planting places in a such a way that trees will well aligned in all directions for ease in orchard operations, pollination as well as for general appearance
5. to use carpenters triangle or Pythagoras theorem (3:4:5) to define rows and planting distances and mark accurately the spot where each hole is to be dug starting from a base line parallel to the road or fence or the boundary of the orchard.
6. to dig planting holes deep and wide enough (50 cm^3 to 1 m^3, depending on the soil type and the fruit crop) to accommodate the root systems in their natural position without bending.
7. to keep topsoil and subsoil separately while digging the holes as shown (Fig. 4.1).

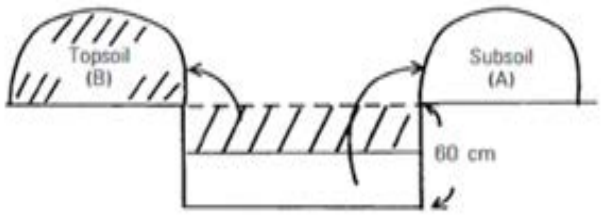


Figure 4.1 Pit (planting hole) digging; place the top soil (1/3) and subsoil (2/3) separately.

8. to leave the planting holes exposed for a few days before actual planting.
9. to water and gently press down the planting holes a day prior to planting so that they will not further settle down after planting.
10. to inspect trees during planting - the varieties/rootstock and number of the trees should be checked and discard the weak, diseased and trees with poor stock-scion combination

11. do not place the trees in the sun as the roots could be burnt even before planting.
12. to prune any damaged or curled roots back beyond the damaged or the curled area and head back them to about 70 cm long.
13. to soak roots in water for some hours before planting
14. to make a small hole in the center planting hole which is slightly larger than the ball of soil holding the roots of the fruit tree while planting
15. to place the tree in the hole at the same depth it was growing previously in the nursery, i.e., keep the graft union well above the ground level about 15 - 20 cm. If holes are deeper, backfill with enough soil to hold the tree slightly higher
16. to start filling the hole with mixture of the topsoil (B) and well-decomposed farmyard manure (C) and before the hole is completely filled with soil add some water and then fill it with the subsoil (A) and well-decomposed farmyard manure (C) completely after the water soaks in around the root system as shown (Fig. 4.2)

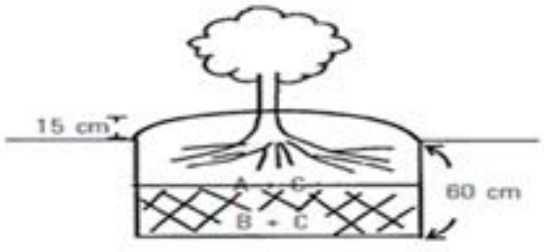


Figure 4.2 Refilling of the pit (planting hole); start with the top soil mixed with compost and followed by the sub soil mixed with compost.

17. once the tree is planted, the soil must be firmly tramped down and support the trees with sturdy props/stakes as soon as possible after planting
18. to make a basin/ring for irrigation as close to the newly planted trees as possible and lightly irrigate to help settle the fill soil. Irrigate again the following day to seal any cracks in the soil.

Observation and expected results

Write your evaluation on the following points, if orchard plan exists

1. whether the plan was well illustrated, clear and easy to understand to you or not
2. whether the layout plan is properly executed on the orchard or not and its appropriateness considering the relative location of each components on the orchard
3. the type of planting systems and distance between trees and rows used for each fruit species and/or varieties used.

Write your evaluation on the following points for the orchard you planned:

1. importance of layout an orchard on a paper before the actual planting,
2. materials and equipments required for layout an orchard,
3. merits and demerits of specific planting layout systems of an orchard,
4. importance of digging planting holes sometime before the actual planting,
5. rational for separating top- and sub-soils while digging planting holes,
6. precautions required during planting and immediately after planting of fruit trees.

Discussion: elaborate and discuss about the importance of layout and digging planting holes before the actual planting of fruit trees with your classmates. Moreover, discuss pros and cons of the different planting systems and care required while planting fruit trees.

Conclusion: write what you conclude about layout an orchard on a paper, digging holes and planting subtropical and temperate fruit crops in an orchard.

Recommendation

Self-assessment

1. Do I understand the importance of layout on paper prior to the actual planting of fruit trees in an orchard?
2. Do I know the important materials and equipments required for layout, digging holes and planting fruit trees in an orchard?
3. Can I do layout, digging holes and planting different subtropical and temperate fruits crops alone?
4. Can I list the important factors to be considered while selecting a specific planting system for subtropical and temperate fruit crops in an orchard?
5. Do I understand the precaution and care required while planting fruit trees?

Activity 4.3: Watering and fertilizing subtropical and temperate fruit crops

For the details, you may refer procedures 4.6 (specifically 4.6.1 and 4.6.2) of instructor's practical guidebook for tropical fruit crops production and management within this practical guidebook; but specifically it is presented as follows:

Specific objectives

- to acquaint students with the principles and essentials of water and fertilizer application in subtropical and temperate fruit crops,
- to acquaint students with the practices of water and fertilizer application for subtropical and temperate fruit crops.

Materials:

Equipment

- Sensitive balance
- Small cups
- Hand gloves
- Watering hose/cans

Consumable

- Water
- Different fertilizers (urea, DAP, blended fertilizers)

Procedures

1. determine the total amount of water required for the specific fruit crop at hand based on crop water requirement calculations and type of irrigation systems (flood, furrow, basin, modified basin, sprinkler and drip systems)
2. determine the amount and irrigation schedule for specific growth stages of major subtropical (avocado and citrus) and temperate (apple, peach and grapes) fruit crops
3. start irrigation based on the schedule (never apply water against stems of fruit trees; apply at least 50 to 100 cm away from the trunk up to the peripheral leaf; avoid water stagnation near the fruit trees)
4. observe possible nutrient deficiency symptoms in standing fruit trees
5. determine the type of fertilizer, rate, time of fertilizer application and method of fertilizer

application (band placement, foliar application, fertigation) to be used for the specific fruit crop at hand based on visible nutrient deficiency symptoms, growth stages and/or soil and plant tissue analyses (if present)

6. start fertilizing based on the rate, time and method of application determined (never apply fertilizers against stems of fruit trees; apply at least 50 to 100 cm away from the trunk up to the peripheral leaf)
7. every fertilizer application must be followed by a light and controlled irrigation.

Observation and expected results

Write your evaluation on the following points:

1. factors considered in determining the amount of water and irrigation scheduling for subtropical and temperate fruit crops
2. merits and demerits of different systems of irrigation commonly adopted for fruit crops
3. factors considered in choosing fertilizer type, fertilizer requirements and method of application for subtropical and temperate fruit crops
4. major water stress and nutrient deficiency symptoms seen in the fruit crops before the application of irrigation water and fertilizer.

Discussion: discuss the importance of irrigation and fertilization for successful subtropical and temperate fruit crops growing. Moreover, elaborate factors to be considered while selecting methods of irrigation and fertilization of subtropical and temperate fruit crops. Conclusion: write what you conclude about the essentials and practices of irrigation and fertilization of subtropical and temperate fruit crops in an orchard.

Recommendation

Self-assessment

1. Do I understand the essentials and practices of irrigation and fertilization of subtropical and temperate fruit crops?
2. Do I know the important factors to be considered while determining the amount of water, irrigation scheduling and method of irrigation for subtropical and temperate fruit crops?
3. Do I know the important factors to be considered while determining type and amount fertilizer and method of fertilization for subtropical and temperate fruit crops?
4. Can I describe the major water stress and nutrient deficiency symptoms to be seen in subtropical and temperate fruit crops?
5. Can I apply water and fertilizer at the right time, in proper amount and in a right manner for different subtropical and temperate fruit crops in my own?

Activity 4.4: Training and pruning

Specific objective

- to acquaint students with knowledge and skills of training and pruning of subtropical and temperate fruit crops.

Materials: Prepare all the equipment and consumables for the practical session

Equipment	Consumable
- Carpenters saw	- Staking poles
- Pruning shear	- Ropes/Wire
- Hatchet	
- Pruning saw	
- Pruning knife	

Procedures - guide and/or instruct students to follow the following procedures while executing training and pruning for subtropical and temperate fruit crops

I. Training

1. **Central leader system** - common for apple trees. This system involves keeping trees conical-shaped somewhat like "Christmas trees". The main trunk is allowed to grow without disturbed while orient branches sidewise and arranged in separate layers separated by open areas of canopy as shown in Fig. 4.3 below [2]; follow the following steps to do this
   (a) allow the central leader to grow
   (b) head back the first vigorous side shoots that grow upright and compete with the central leader; with this you create the first layer
   (c) at the end of the first dormant season after planting, head back the next upper vigorous side shoots that grow upright, approximately 70 cm above the first layer, and compete with the central leader; with this you create the second layer
   (d) with this you may continue till the intended maximum height of the fruit tree

Figure 4.3 A tree trained in a central leader system

2. **Modified central leader system** - common for apple. Like that of the central leader system the trunk will grow but headed back at about 70 cm height; lateral branches are also allowed to grow and headed back as shown in Figures 2-5 below [2]; specifically, follow these steps:

I. First year training - at planting time

(a) If the plant is a single whip at planting (Fig. 4.4), it should be headed back to a height between 70 - 100 cm

(b) If the young tree is branched at planting, the center leader should be headed back as in (a) while three options exist for laterals: (1) Newly formed laterals may be completely removed if improperly positioned or their crotch angle is narrow. (2) Laterals may be pruned back to l/3 or 1/2 its length, thereby diminishing competition with the central leader for dominance. (3) Very short, favorably positioned laterals located some distance from the apex of the central leader may be entirely saved except for the terminal which should be removed.

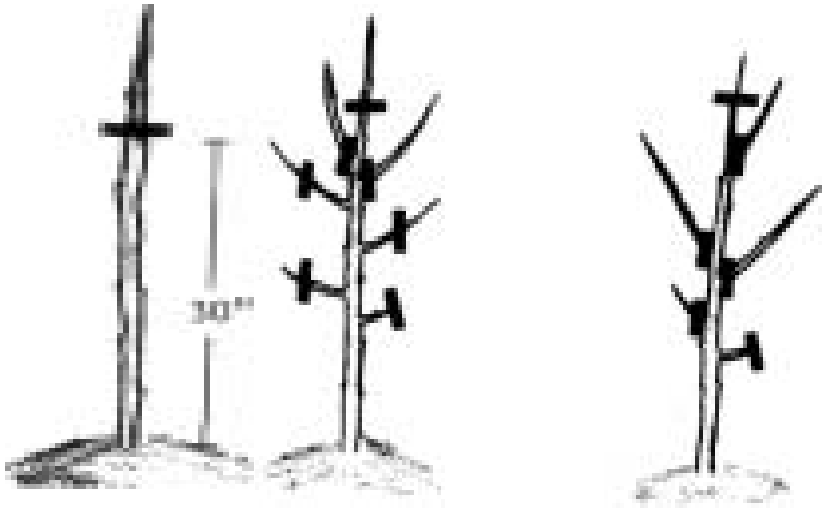


Figure 4.4 A single whip tree headed back to about 75 cm (a); branched trees with undesirable crotch angles thinned out and branches with desirable crotch angles partially headed back (b & c). (= pruning cut).

II. Second year training - one year after planting time

(c) training one year after planting time is similar to during the planting time training in that a leader is selected and headed back approximately 30 cm above the point where new laterals are desired (Fig. 4.5); Lateral branches to become scaffold limbs should be selected and headed back to 1/2 to 1/3 their length.

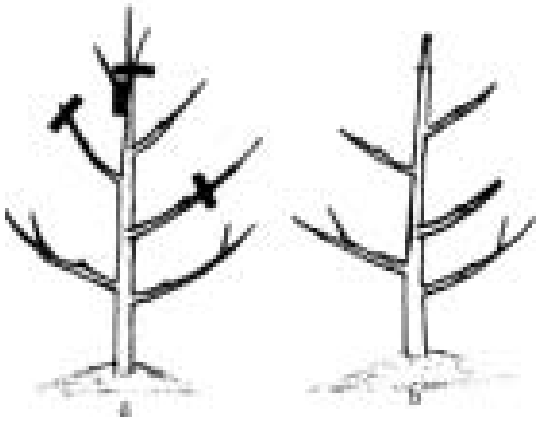


Figure 4.5 Before (a) and after (b) first dormant pruning just one year after planting. (= pruning cut).

III. Third year training - two years after planting

(d) same criteria used for training during the third year as the second year; to have several good scaffold limbs, head back the main central leader (Fig 4.6); if four to seven good scaffold limbs already exist, then simply remove shoots in competition with the main central leader. Scaffold limbs should be headed back if: 1) More secondary laterals are desirable on them, 2) there is a risk that a scaffold limb may overtake the central leader as the main leader, 3) the tree is out of balance because of preferential growth of one scaffold limb over the others.

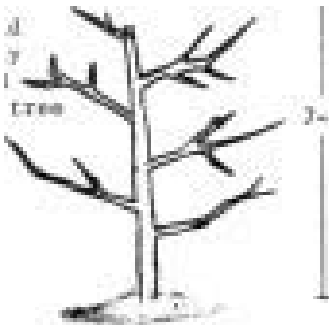


Figure 4.6 A tree properly trained to a modified central leader after third year training

IV. Fourth year and future trainings - three years after planting and onwards

(e) from this on, heading back vigorous shoots, selective thinning of small branches near the center of the tree, crossed branches, diseased or severely damaged limbs and water sprouts, as the framework has been developed by this time (Fig. 4.7); avoid heavy pruning since it will delay bearing.

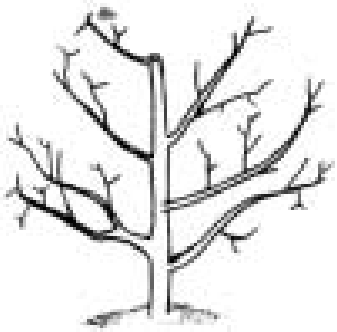


Figure 4.7 A bearing tree trained with modified central leader and with a proper tree framework

3. Training to multiple leaders - common for apple. Unlike to that of the central leader system, multiple leaders are allowed to grow here as shown below (Fig. 4.8) [2].

Figure 4.8 A bearing tree trained to a multiple leader training system

4. Open-center system - this is mainly commonly used for peaches and nectarines [2]; specifically, follow these steps

I. **First year training** - at planting time

(a) Trees may receive from the nursery either as whips or with several branches and needs heading back to about 75 cm as shown (Fig. 4.9 a-c).

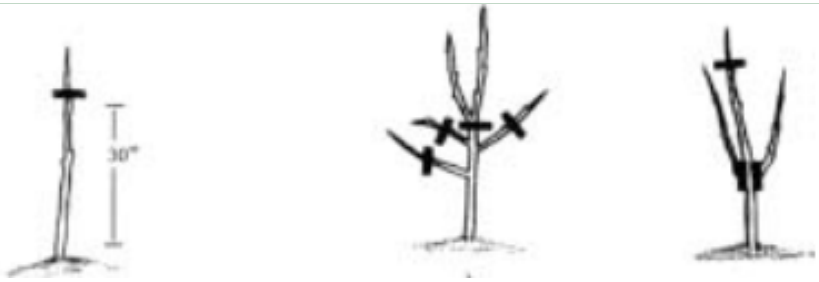


Figure 4.9 A single whip tree (a) and branched trees (b & c) as received from the nursery with their possible pruning cuts. (= pruning cut).

II. Second year training - one year after planting

(b) remove unwanted scaffold branches which have developed during the previous summer and all branches arising above the permanent scaffold branches (Fig. 4.10).

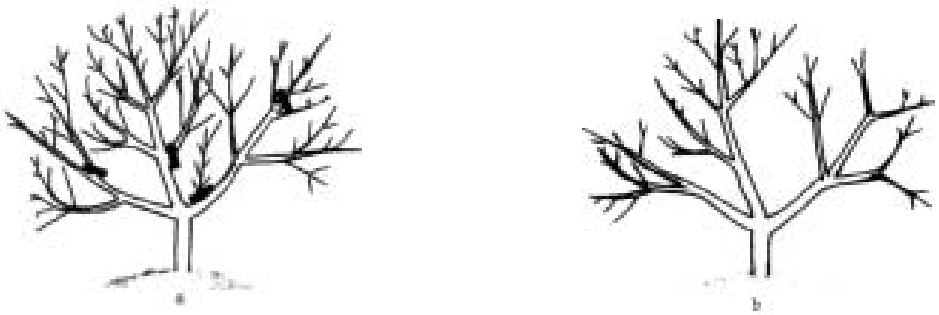
(a) (b)

Figure 4.10 Before (a) and after (b) first dormant pruning of peach, just one year after planting. (= pruning cut).

III. Third year and future pruning

(c) thin out inappropriately placed branches as shown (Fig. 4.11)

(d) remove older than one year, diseased and damaged woods; this should continue every year to maintain production of vigorous fruiting wood and good quality fruit.



(a) (b)

Figure 4.11 Before (a) and after (b) first dormant pruning of peach, just one year after planting. (= pruning cut).

5. Head system - this is mainly used for grapes [3].

- *first year* - one shoot is trained straight upward, supported by the planting hole and then topped at one meter above the ground level as shown below (Fig. 4.12)

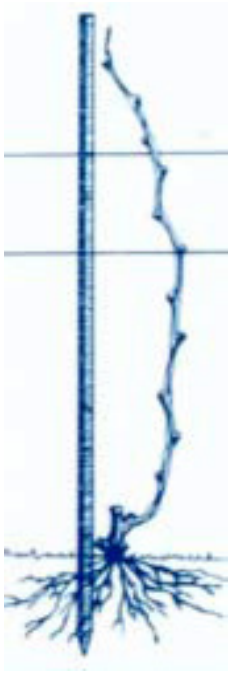


Figure 4.12 Heading back and supporting with a stick for a newly planted grape fruit trees.

- second year - three lateral shoots are encouraged to grow from the head region and such laterals are topped between 2nd and 3rd node;
- third year - on each of the three laterals, two new laterals are allowed to grow and on each arm 2-3 canes are developed to give rise to spurs that bear fruits

6. **Trellis system (cordon)** - this is also mainly used for grapes
   - first year - same as head training
   - second year and onwards - then lateral shoots start to grow bilaterally, as shown below
   -

II. Pruning

1. prune following the proper angle as shown (Fig. 4.13)

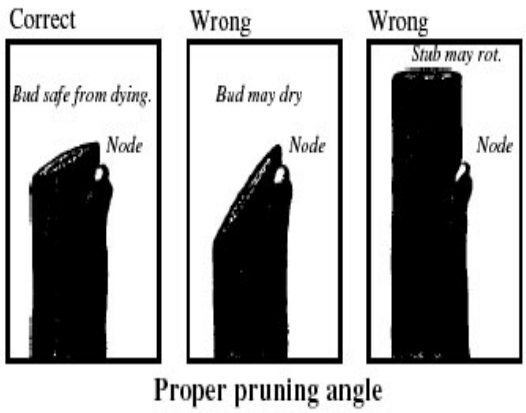


Figure 4.13 Pruning following proper angle of buds

2. cutting off part of a branch or shoot (heading pruning) as shown (Fig. 4.14)

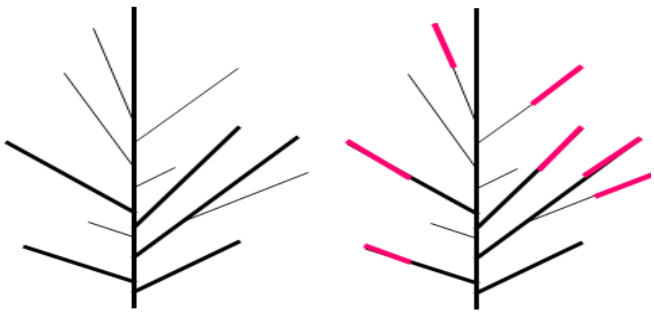


Figure 4.14 Heading pruning

3. cutting out a whole branch or shoot back to its origin (thinning out) as shown (Fig. 4.15)

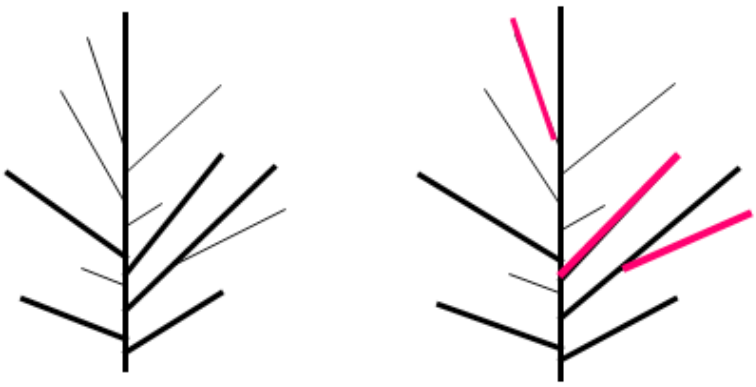


Figure 4.15 Thinning out pruning

4. care should be taken to ensure that the cut is made flush with the main branch or trunk in the case of thinning outs, or just above a bud, in the case of heading cuts. If this is not done, stubs are left which do not heal & are a potential source of infection; for heading cuts, the direction that this bud is pointing will be the direction in which the new shoot growth will grow

5. in any case of the pruning systems, the following are priority plant parts to be pruned as shown below (Fig. 4.16)

A) suckers
B) stubs or broken branches.
C) downward-growing branches
D) rubbing or criss-crossing branches
E) shaded interior branches
F) competing leaders
G) branches with narrow crotches
H) whorl

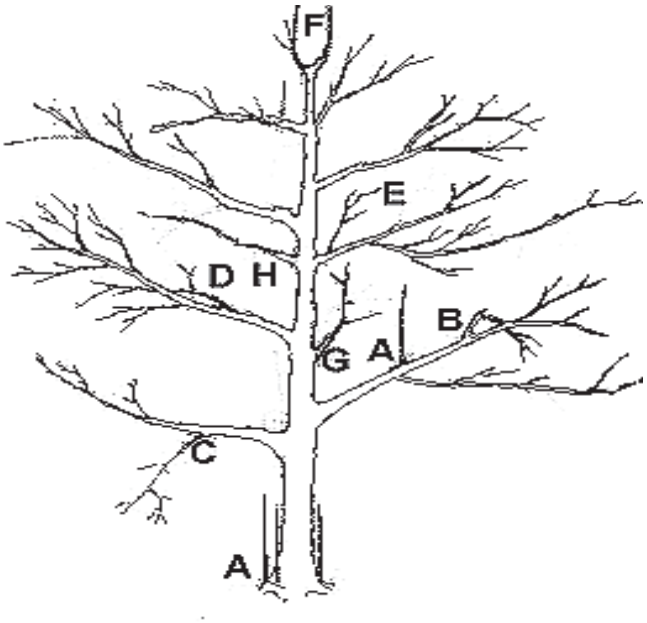


Figure 4.16 Letters showing plant parts to be pruned

Observation and expected results

Write your evaluation on the following points

1. the basic principles of training subtropical and temperate fruit crops for form and framework capable of supporting large yields of high-quality fruit when the trees reach bearing age
2. responses of the whole tree to pruning and the reactions of its component parts, such as twigs and young fruiting branches
3. the periodical (winter and summer) pruning considered more useful to temperate fruits crops than subtropical fruits crops

Discussion: discuss the essentials and practices of different training and pruning techniques as pomological husbandry for successful production and productivity of subtropical and temperate fruit crops. Moreover, discuss important features to be taken in consideration before training and pruning of subtropical and temperate fruit crops and why the training and pruning operations are not similar for all subtropical and temperate fruit crops.

Conclusion: write what you conclude about the principles and practices of different training and pruning operations for subtropical and temperate fruit crops.

Recommendation

Self-assessment

1. Do I understand the purposes of training and pruning operations for subtropical and temperate fruit crops?
2. Do I know what is meant by pruning and when and where is it done appropriately?
3. Can I distinguish clearly between training and pruning?
4. Do I know the main factors which decide the time and extent of pruning?
5. Can I differentiate between heading back and thinning out pruning types?
6. Can I perform training and pruning operations at the right time for different subtropical and temperate fruit crops in my own?

Activity 4.5: Dormancy management

Specific objective

- to acquaint students with the dormancy development, depth of dormancy and dormancy breaking in subtropical and temperate fruit crops
- to provide students an understanding of chilling requirements of different fruit crops
- to acquaint students with methods for calculating chilling accumulations of fruit crops

Materials:

Equipment

- Temperature data
- Pictures showing bud's developmental phases during dormancy
- Pruning shears
- Growing trays

Consumable

- Apple one year old shoot cuttings
- Water

Procedures

1. observe main symptoms (bud formation, leaf color change, defoliation) of dormancy
2. observe dormancy progression using shoot cuttings - sampled one-year-old, unbranched 10 - 20 cm length shoots randomly from different trees at 2-3 weeks interval during the winter season (Nov - Feb).
3. based on the available temperature data, calculate the possible chilling accumulated in the fruit trees in an orchard with different models [4] (Utah, Mean temperature, South African (Infruitec), daily positive chill units)

Observation and expected results

Write your evaluation on the following points

1. visible symptoms seen during dormancy entry and exit
2. the vegetative vigor of the tree, orientation of branches, early versus late growth of shoots, time of leaf drop and type of bud, and their respective depth of dormancy
3. amount of chilling calculated from the temperature data using the different models
4. dormancy development along shoots situated at different positions

Discussion: discuss the relationship between growth features of the trees and depth of dormancy; suitability of the different chilling accumulation models to the prevailing condition; amount of chilling accumulated with the different models and the requirements of the planted cultivars from the literature

Student assessment

1. Test knowledge and skill levels of students by asking their understanding on:

Conclusion: write what you conclude about concepts of dormancy, development and depth of dormancy and its management for subtropical and temperate fruit crops.

Recommendation

Self-assessment

1. Do I differentiate the symptoms to be seen during dormancy entry and exit in temperate fruit crops?
2. Can I mange to calculate the amount of chilling from different temperature data using different models?
3. Can I execute and manage dormancy progression experiments using one-year old cutting shoots independently?

Activity 4.6: Pollination and pollination management

For the details, you may refer procedures 4.7 of students' practical guidebook for tropical fruit crops production and management within this practical guidebook; but specifically it is presented as follows

Specific objective:

- to acquaint students with the importance of pollination and pollination management in respect to subtropical and temperate fruit crops production and productivity

Material:

Equipment

- fruit trees at an orchard

Procedure

1. check whether for self-incompatible fruit crops like apples that compatible pollen donor cultivars ('pollenizers') are included in the orchard or not
2. check whether for fruit crops with unique flowering behavior like avocado (protogynous diurnally synchronous dichogamy) more than one cultivar of which some are 'Type A' and others are 'Type B' are included in the orchard or not.
3. closely observe the flower features of 'Type A' and 'Type B' avocado cultivars as shown Fig. 4.17

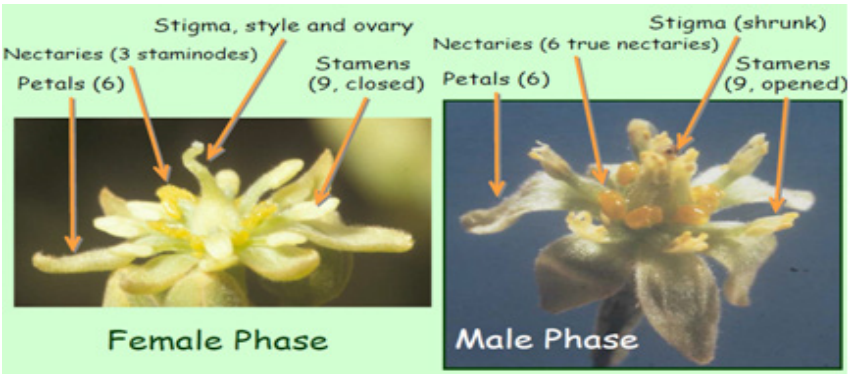


Figure 4.17 Flower features of 'Type A' and 'Type B' avocado cultivars

4. check orchard structure in respect to placement of pollenizers and spacing of pollenizer trees and synchronicity
5. check whether managed honey bee colonies were in the orchard for pollination purpose

Observation and expected results

Write your evaluation on the following points

1. compatibility of cultivars, placement and spacing of pollenizers and their synchronicity
2. time of hives introduction, hives placement, stocking rates and colony hygiene with respect to promoting pollination
3. importance of planting more than one cultivar of a given subtropical or temperate fruit crop
4. contribution of managed honey bee colonies in production and productivity of subtropical and temperate fruit crops
5. favourable floral features of different subtropical and temperate fruit crops for pollinators to promote pollination

Discussion: discuss the features behind flower morphology, pollinators' foraging behavior, pollination requirements (i.e. compatibility) and pollination in respect to subtropical and temperate fruit crops production and productivity

Conclusion: write what you conclude about the importance of pollination and pollination management for the production and productivity of subtropical and temperate fruit crops

Recommendation

Self-assessment

1. Can I make correct decisions about the need for multiple cultivars for any given subtropical and temperate fruit crop?
2. Can I differentiate clearly 'Type A' and 'Type B' avocado cultivars at an orchard during flowering time?
3. Do I understand the role of managed honey bee colonies in improving the production and productivity of subtropical and temperate fruit crops?

Activity 4.7: Fruit thinning

Specific objective:

- to acquaint students with the principles and practices of fruit thinning as one of the most important orchard operations

Material:

Equipment

- flowering fruit trees at an orchard
- secateurs/pruners or long and sharp scissors

Procedure

1. thin as early as practical, but generally only after the first self fruit drop
2. shake the branches lightly to dislodge some of the fruits which are likely to drop off naturally
3. if there are still excess fruits, then start thinning from top to bottom of the branches by holding the stem of the fruit to be removed between thumb and second finger/forefinger and pull, twist or pinch it off gently; it is also possible to use secateurs/pruners or long and sharp scissors to cut away the fruits.

4. while thinning, focus on the undersized, misshapen/malformed, poorly positioned, insect or disease infected ones as shown (Fig. 4.18)

Figure 4.18 Fruit thinning; red arrows showing fruit lets to be thinned out.

Observation and expected results

Write your evaluation on the following points

1. number of flowers open vs. number of fruit matured naturally in a fruit tree
2. overall fruit quality of thinned vs. un-thinned fruit trees
3. biennial bearing vs. fruit thinning

Discussion: discuss the importance fruit thinning in respect to overall fruit quality and productivity of subtropical and temperate fruit crops

Conclusion: write what you conclude about the relationship between fruit thinning and overall fruit quality and productivity of subtropical and temperate fruit crops

Recommendation

Self-assessment

1. Do I understand the role of fruit thinning in improving fruit quality and productivity of subtropical and temperate fruit crops?
2. Do I understand why fruit thinning is practically executed after the first self fruit drop?
3. Can I manage to thin fruits on my own?

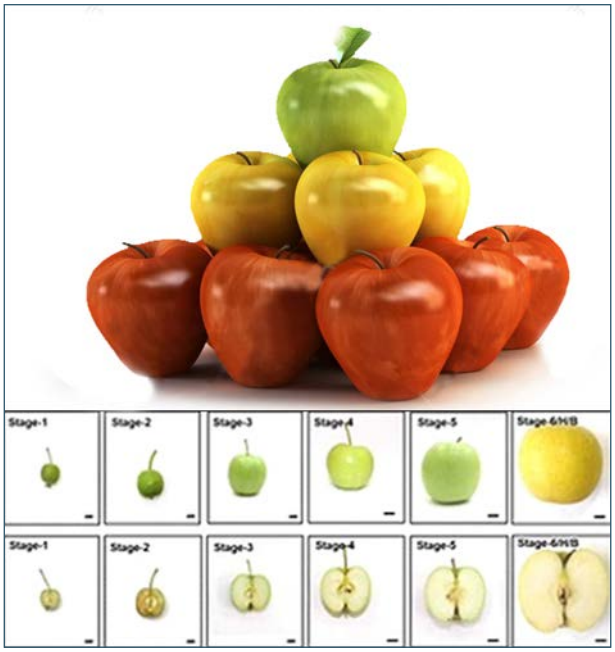
Activity 4.8: Pest and disease management

You may refer procedures 4.9 of student's practical guidebook for tropical fruit crops production and management within this practical guidebook.

References:

1. Derbew, B. and Jeong Cheon (2014) Fruit production in Ethiopia. Soon, Seung Ho, Shin Publishers, KNU Press, Korea, 519 pp.
2. Missouri State University (1984) Training and pruning deciduous fruit trees. Bulletin No. 40.
3. Christensen (1998) Training table grapes vineyards. Pub. TB11-98
4. Allan (2004) Winter chilling in areas with mild winters: its measurement and supplementation. Proc. VIIth IS on TZFTS. Acta Hort. 662.

PRACTICAL SESSION 5



Practical Session 5

Maturity determination and harvesting

Practical session 5

Maturity determination and harvesting

For the theory, objectives and materials, you may refer practical session five of student's practical guidebook for tropical fruit crops production and management within this practical guidebook; but the specific procedures for some specific subtropical and temperate fruit crops, it is presented as follows:

Procedures

5.1 Citrus maturity determination

Some markets require that citrus fruits meet specific maturity standards before being sold. These standards are most commonly described as a ratio of sugar, expressed as total soluble solids (TSS) to acid and sometimes percent juice [1].

Observation and Expression of Results

The main maturity determination procedures for citrus are as follows [1].

5.2 Avocado maturity determination

It is important to pick avocados when they are mature, as immature fruit will shrivel and not ripen properly. Several indices may be used to determine avocado fruit maturity, mainly skin texture and appearance, color and seed coat color is an indicator of harvest maturity in most avocado cultivars.

Observation and Expression of Results

The main maturity determination procedures for citrus are as follows [1].

Determining juice content (% juice) - The juice content of fruit increases as they mature. However when fruits are over-mature their juice content often decreases.

1. Take a sample of 10 - 20 pieces of fruit representative of the fruit (the more fruits tested the more accurate the test results).
2. Place the container that fruit will be weighed in onto the scales and tare to zero.
3. Place fruit into the container and weigh the fruit sample. Record weight in grams.
4. Extract and strain the juice through a fine sieve from the fruit.
5. Place the container that will hold the juice on the scales and tare to zero.
6. Pour the juice into the container.
7. Weigh the juice and record weight in grams.
8. % juice = juice weight ÷ fruit weight x 100.

Total soluble solids (TSS) or Degrees Brix (° Brix) - TSS refers to the total amount of soluble constituents of the juice. These are mainly sugars, with smaller amounts of organic acids, vitamins, proteins, free amino acids, and essential oils. Approximately 85% of the total soluble solids of citrus fruit are sugars – so TSS is an excellent guide to the sugar content of fruit. Fruit sugar levels generally increase as the fruit matures; however levels can decrease when fruit are over-mature.

Determining °Brix using a hydrometer

1. The fruit sample should be a minimum of 10 fruit.
2. Cut each fruit in half (at right angles to fruit axis).
3. Juice fruit and strain through a fine sieve (1–2 mm). Put aside some juice (10 ml) for the titration (acidity) test.
4. Place a few drops of juice onto the stage of the refractometer, as shown in (Fig. 5.1) and take the °Brix reading and record.

Figure 5.1 Determining °Brix using a refractometer

5. Between samples clean the refractometer with distilled water and dry.
6. For hand-held refractometers, periodically (i.e. every ten readings) check that the baseline is set to zero.

Determining acidity (titration)

1. Put 10 ml (for lemons you can use 5 ml) of the juice into a conical flask as shown (Fig. 5.2).

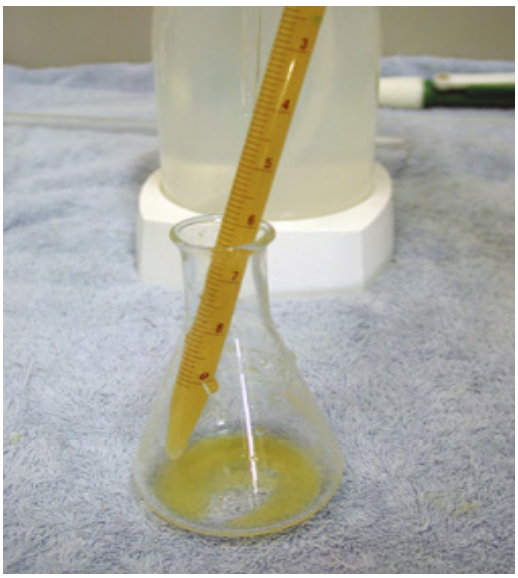


Figure 5.2 Placing of 10 mls juice in a flask

2. Add 5 drops of phenolphthalein solution indicator as shown (Fig. 5.3).

Figure 5.3 Adding 5 drops of phenolphthalein solution

3. Fill a burette with 50 ml of 0.1% sodium hydroxide.
4. Slowly add the sodium hydroxide solution drop by drop to the flask and swirl, until the colour goes a persistent pink (Fig. 5.4) for at least 30 seconds (~pH 8.2).

Figure 5.4 Slowly add sodium hydroxide solution until color change

5. Record the amount of sodium hydroxide solution used in ml.
6. Acidity = 0.064 (or 0.128 for lemons when using 5 ml of juice) x ml of sodium hydroxide used.

Citrus harvesting

- Citrus is best to harvest on a clear, sunny day with low humidity. The fruit should be harvested as soon as the dew has evaporated. On a cloudy day, the fruit should be harvested in the afternoon. Fruit should not be harvested at all on a rainy day.
- o prevent physical damage to the fruit, the worker should trim his/her finger-nails, wear gloves, and use special harvesting scissors with rounded ends to cut the fruit.
- To harvest the fruit, it should be held in one hand, and the other hand used to cut the fruit stem together with a few leaves.
- Then the fruit is brought close to the chest and the rest of the stem is cut off smoothly, close to the fruit.
- The container used for newly harvested fruit should be solid made of wood or bamboo, with good ventilation. The bottom of wood or bamboo containers should be lined with newspapers, a paper bag or a fertilizer sack. It is important to move containers as little as possible, and not to leave them standing in the sun
- Citrus are graded by size, using by hand or by machine.

Figure 5.4 Mechanized grading of fruit by size, using different types of revolving drum

5.2 Avocado maturity determination

It is important to pick avocados when they are mature, as immature fruit will shrivel and not ripen properly. Several indices may be used to determine avocado fruit maturity, mainly skin texture and appearance, color and seed coat color is an indicator of harvest maturity in most avocado cultivars.

Observation and Expression of Results

Skin texture - As fruit approach maturity, they develop a smoother skin surface. Also, the glossiness or shine of the skin becomes duller as the fruit reaches maturity.

Color - The fruit color of many cultivars changes from green to light green with maturity. Reddish streaks may also appear at the stem end of certain deep green-skinned cultivars when the fruit mature.

The area of the stem nearest the fruit changes from a green to brown or black color when the fruit is mature and ready for harvest

Seed coat color - An internal fruit characteristic indicative of harvest maturity is the color of the seed coat. The seed coat typically turns brown when the fruit is sufficiently mature for harvest.

Avocado harvesting

- Avocados should be harvested with sharp clippers by severing the stem slightly above the fruit shoulder.
- Fruits should never be pulled off the tree since the stem needs to remain attached. The stem length should be 1 cm (0.4 in) or less, in order to avoid puncture damage of adjacent fruit in the harvest container.
- Avocados should be harvested carefully as even small cuts, scratches and abrasions can spoil the appearance of the fruit and lead to decay.
- The use of gloves reduces the likelihood of skin damage during harvest. Where fruit cannot be reached by standing or climbing, a picking pole can be used to harvest the fruit.
- A cutting device is put at the end of the pole, with a catching bag below. The bag should be made from a soft fabric to prevent damage to the fruit.
- The harvested fruit should be carefully put into paper-lined or padded field crates, or picking bags.
- Picking bags are either strapped around the waist or hung over the shoulder and made with a quick opening bottom.

5.3 Apple maturity determination

Apple fruits should be harvested at their proper picking maturity, depending whether they are meant for distance markets (harvest them in advance to their full maturity) and home consumption and markets (properly matured fruits are harvested). Generally, mature apples are firm, crisp, juicy, well-colored, and good flavored.

Observation and Expression of Results

Time taken from full bloom to maturity - though this may vary from growing condition to condition, Red Delicious may be picked after 133-139 days from full bloom; Golden delicious 148-154 days after full bloom and Granny Smith 176-182 days after full bloom[2].

Color - The fruit color of many cultivars changes from green to yellowish indicating fruits are ready for harvest; however, fruits of green variety are judged by taste [2].

Apple harvesting

Apple fruits harvested too early are astringent, sour, starchy, and poorly flavored, while apples harvested too late are soft and mealy. As apple fruits do not ripe at a time on the tree more than one picking is required. When harvesting apples, pick and handle the fruit carefully by grasping in the palm of the hand and removed from the spur with a quick upward twist of the wrist to prevent unnecessary damage. Start picking the fruits of apple with the lower branches and advancing to the top.

5.4 Grape maturity determination

Grape is harvested when it is fully ripe as it is a non-climacteric fruit. There are several tests [2] that can be used to monitor the changes that occur during the maturation process of grape berries as presented in the observation and expression of results below.

Observation and Expression of Results

Color - Depending upon the variety color changes from green to yellow on golden yellow or black or pink. Easy separation of barriers indicates harvesting stage.

Sugars - The concentration of sugars, expressed as either oBrix or % SS, increases during maturation and can be measured with a refractometer or a hydrometer.

Initial Juice pH - During maturation, juice pH increases and is measurable with a pH meter. Juice pH is important because wine balance or the perception of sourness or tartness, aroma, microbial stability, and physiochemical stability of the wine.

- Titratable acidity (TA) - During maturation the organic acids in the juice decline, and this can be measured as titratable acidity. Titratable acidity is expressed as either the percentage acidity (% TA) or grams of acid per liter where 1 % TA is equivalent to 10 g/liter TA.

- The oBrix, initial juice pH and TA are measurable indicators of maturity and when used together, provide good guidance in determining when to harvest.

- Grape harvesting

- Being non – climacteric, grapes are harvested when they are fully ripe. While harvesting the clusters should be removed from the vine by cutting with a sharp knife near its attachment to the cane. Handle the cluster by the stem.

References

1. Sandra H. and Sabderson G. (2010). Citrus maturity testing. Available at: www. dpi.nsw.gov.au/primefacts

2. Bal J.S. (1997). Fruit growing. Kalyani publisher, New Delhi, India.

3. ---------- Grape maturation and ripening; available in: https://c.ymcdn.com/sites/mngrapegrowers.site-ym.com/resource/resmgr/Growing_Grapes_in_MN_Best_Practices/Chapters/Ch_15_Grape_Maturation.pdf

PRACTICAL SESSION 6

Practical Session 6

Field visit to the nearest Farm, Agricultural Research Center and agro-industry

Refer and follow practical session six of student's practical guidebook for tropical fruit crops production and management within this practical guidebook.

Fruit Production and Management Practical Guidebook

Successful and sustained fruit production needs knowledgeable, technically-competent and skilled human resource in all segments of the industry. In connection with this, the higher learning institutions that are involved in training agricultural professionals in various disciplines are expected to produce competent graduates to satisfy trained human resource needs of the agriculture sector in general and horticulture subsector in particular of the country.

This Practical Guidebook has been developed within the framework of nationally harmonized curriculum for horticulture Bachelor of Science (B.Sc.) degree students, and it comprises of two parts: (I) Tropical Fruit Crops Production and Management, and (II) Sub-tropical and Temperate Fruit Crops Production and Management. The Guidebook broadly covers six practical sessions (in the respective parts) including: Session (1) Identification of horticultural tools, equipments and major fruit crops in Ethiopia, (2) Propagation of Fruit Crops, (3) Nursery Establishment and Management, (4) Orchard Establishment and Management, (5) Maturity Determination and Harvesting, and (6) Field Visit to nearby Fruit Farm, Agricultural Research Center and Agro-industry.

The Practical Guidebook has been developed by a team of instructors from four Ethiopian public Universities (Bahir Dar, Hawassa, Jimma and Mekelle Universities) in collaboration with Horti-LIFE project of SNV. A prime aim of preparing this guidebook is to provide relevant procedures (both for instructors and students) on how to properly conduct the above indicated practical sessions designed for the Tropical, as well as Sub-tropical and Temperate Fruit Crops Production and Management courses. This practical guidebook therefore is believed to enormously benefit not only B.Sc students attending the horticulture program of the nationally harmonized curriculum, but also B.Sc and/or Diploma students taking fruit crops production and management module, and instructors who are handling practical sessions of this course.

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