



HPSHIVA

Himachal Pradesh Sub-Tropical Horticulture, Irrigation and Value Addition Project

Financed by Asian Development Bank

FARMER'S TRAINING MANUAL



Prepared by
Dr. YSP University of Horticulture & Forestry
College of Horticulture & Forestry, Neri, Hamirpur
(CS-04 Package of HPSHIVA PRF)



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Important Notice

The information given in this compilation **Farmer's Training Manual** holds good only under optimum conditions. There may exist slight variation in some aspects due to several factors or can vary under different systems of management. Mishandling/negligence of the user can also result in damage/loss/non-reproducibility of results. In this regard, HP SHIVA team accepts no legal responsibilities.

FOREWORD

Himachal Pradesh is well endowed with natural resources and has made significant progress in horticulture development. The Himalayan ecosystem offers an enabling environment characterized with favorable microclimatic conditions for cultivation of a wide range of fruits. The state of Himachal Pradesh is characterized by a significant number of opportunities in high-value commodities. These include, most importantly, diversity in agro-climatic conditions, possibilities to produce for 'off-season' markets, relatively well-educated producers, and proximity to consumer markets. This characteristic has resulted in shifting of land use pattern from agriculture to fruit crops in the past few decades. Around 80,000 hectare area under subtropical fruit crops accounts for 36% of the total area under fruits whereas, total annual production of subtropical fruits is only 70,000MT thereby accounting for productivity of < 1.0 ha in comparisons to national average which is about 10.0 t ha.

The sub-tropical region in the state face multiple challenges in terms of climate change, rainfall uncertainties, water availability and low productivity of horticulture produce and income disparity, etc. The region also enjoys the rich diversity of agro-climatic conditions, topographical variations, and altitudinal differences and horticultural crop production has not gained sufficient momentum in the region because of majority of the farmers are small and marginal category, besides having the adherence to traditional maize-wheat and rice cropping pattern despite being uneconomic and have a limited scope of viability for future. Hence, emphasis must be on increasing productivity levels through modern horticultural intervention like high density plantations (HDP) and diversification of fruit crops. The orchardists thus, can get remunerative prices for their produce in the domestic and international market. There is also great scope for expansion of area under fruit crops for intensification of subtropical horticulture using comprehensive high density planting, drip and fertigation scheduling, mulching, raised bed technology, on spot advisory, genuine planting material and high yielding varieties having suitability for fresh consumption and processing purposes.

The farmer's training manual has prepared as part of CS04 package containing the latest and up-to-date procedures for various intercultural operations with suitable illustrations viz. laying out of an orchard, planting techniques, training and pruning, water & nutrient scheduling, plant protection, harvesting, grading & packaging of mandated crops of HPSHIVA project. I congratulate the team of national experts from College of Horticulture & Forestry, Neri (Hamirpur) under CS04 package (HPSHIVA) for preparing the farmers friendly training manual in a simple and easy-to-understand language with diagrammatic representations for the benefit of orchardists and field functionaries of the subtropical regions of Himachal Pradesh.


Sandeep Kadam, IAS
Director of Horticulture

Preface

The low hill and valley areas of Himachal Pradesh has an altitudinal variation from 390 to 1000 m above mean sea level and represent subtropical climatic conditions. This zone has tremendous potential for cultivation of subtropical fruit crops with a seasonal advantage from the adjoining states of northern plains.

The growth rate of subtropical Horticulture in Himachal Pradesh has been surprisingly slow. Many factors such as small and fragmented land holdings, poor soil nutrient and moisture levels, lack of irrigation facilities and most importantly reluctance of the farmers to shift from traditional rice -wheat-maize cropping pattern have been attributed to this lag in the growth of Horticulture in subtropics of the state. Thus, the farm income in subtropical areas is quite low which resulted in lack of interest in the farming enterprise especially among the rural youth.

The project HPSHIVA has been envisaged to improve this situation by adopting cooperative approach through cluster farming and enhance livelihood opportunities of rural households in Himachal Pradesh. The cultivation of fruit crops under high density planting system requires skill among extension functionaries as well the farming community. Readily available scientific information to the various stakeholders involved in production of fruit crops is an important pre-requisite for such a progression.

Although the information based on scientific knowledge pertaining to various technologies for production of the mandated fruit crops has been included in package of practices, the farming community requires an activity wise detail of the procedure to be adopted while carrying out operations such as layout of an orchard, planting, training and pruning, water and nutrient management, plant protection, harvesting, grading and packaging,.

The Farmer's training manual' prepared as part of CS04 package contains the latest information, details of the procedures to be adopted for various intercultural operations with suitable illustrations as a readily-usable information available on high density plantation of mandated crops of HPSHIVA project collated and compiled by the team of experts from national and international domains through the coordination of the stakeholders and Team Leader of HPSHIVA.

The Farmer's training manual' has been written in a simple and easy-to-understand language with diagrammatic representations so that the stakeholders of the subtropical regions of Himachal Pradesh can be benefitted to the maximum.



(Som Dev Sharma)

Team Leader

HPSHIVA CS04 Package

COHF (YSPUHF) Neri, Hamirpur

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Chapter-1

HORTICULTURAL TOOLS AND IMPLEMENTS



Sr. No.	Implement	Description and their uses
1.	Khurpi 	The khurpi is used for removing weeds. The tool is also used for breaking the surface layer and improve soil aeration.
2.	Pick Axe 	A pick axe, is a T-shaped hand tool used for prying. Its head is typically metal, attached perpendicularly to a longer handle, traditionally made of wood, occasionally metal, and increasingly fiberglass. It is used for digging hard, compact and stony soils.
3.	Kodali 	Kodali is more of a streamlined tool. The Kodali has a wide base which is makes the work easy and efficient as while digging it pulls out large chunks of soil from the surface.
4.	Spade 	It is used to lift and turn the soil. Also used for digging pits, preparing channels for irrigation and drainage.

5.	Fork 	A garden fork, also called a spading fork or digging fork, is a tool for digging. It is used for loosening soil. It is used similarly to a spade, but it can be pushed more easily into the ground. It does not cut through plant roots.
6.	Shovel 	A shovel is a tool for digging, lifting, and moving bulk materials, such as soil, coal, gravel, snow, sand, or ore.
7.	Rake 	A rake is a type of tool with a handle that ends in a head. It is used to rake for scooping, scraping, gathering, or leveling materials, such as soil, mulch, or leaves. Some rakes have flat heads; others have sharp metal tines that can break up compacted soil or rocks.
8.	Trowel 	A trowel is a small garden tool which is used for digging small holes or removing weeds from nurseries and also used for transplanting.

9.	Axe 	It is used to cut trees and branches.
10.	Budding Knife 	In this knife the apex of the blade is slightly curved which is used to make incision for bud on the rootstock. In some knives, on the rear side, a plastic blade is provided for opening the bark of the rootstock.
11.	Grafting Knife 	It is used to separate the scion branch, make the scion branch defoliate and make an incision on the rootstock.
12.	Scateur 	It is used for cutting of the unwanted branches or twigs of the orchard tree, vines, scion sticks, defoliation etc. They are strong enough to prune hard branches of trees and shrubs, sometimes up to two centimetres thick.

13.	Pruning Saw 	Pruning saws are used to trim shrubs and trees. There are many types of folding saws, each designed for a particular type of branch or stem. This tool is used to cut larger bushes and smaller tree branches.
14.	Hedge Shear 	Hedge shears look a lot like giant scissors with their long pair of straight blades. Their design lends itself to cutting as much of a plant as possible in one single sweep. When we use hedge shears to trim your bushes, they will create long sharp edges on anything you cut.
15.	Lopping Shear 	Loppers are a type of scissors used for pruning twigs and small branches, like pruning shears with very long handles. They are the largest type of manual garden cutting tool.
16.	Grafting Tape 	It is used to reinforce the union between the rootstock and the scion and protect the graft from the air and water, which cause dehydration. The wax actually replaces the paste which is usually applied after tying up the plants with a rubber or polyethylene tape. It protects the plant from dehydration.

17.	Measuring Tape 	A measuring tape is a type of hand tool typically used to measure distance or size. A tape measure will have imperial readings, metric readings or both.
18.	Shoes 	Garden shoes, boots and clogs help gardeners feet prevent injury from branches, rose thorns, stray gardening tools and wet feet.
19.	Watering Can 	A watering can is a portable container, usually with a handle and a funnel, used to water plants by hand.
20.	Knap Sac Sprayer 	Knapsack sprayers are used for spraying insecticides and pesticides on small trees' shrubs and row crops upto 2.5 m height. It consists of a frame on which fuel tank, engine and hose with cut-off mechanism are mounted.

21.	Foot sprayer 	The foot sprayer is one of the ideal and versatile sprayers used for multipurpose spraying jobs. The sprayer consists of a pump operated by the foot lever, suction hose with strainer, delivery hose, spray lance fitted with shut off pistol valve, gooseneck bend and adjustable nozzles.
22.	Hand Cultivator 	Hand cultivators are small, handheld gardening tools that are suitable for digging and breaking up the soil from the depth. It can be helpful to loosen the soil and remove weeds without putting much strain on back and arms.
23.	Wheel Barrow 	A wheelbarrow is a small open cart with one wheel and handles that is used for carrying things in the garden.
24.	Sickle 	Sickle is one of the most ancient of harvesting tools, consisting of a metal blade, usually curved, attached to a short wooden handle. The short handle forces the user to harvest in a stooped or squatting position. The longer-handled scythe, the user of which remains upright, evolved from the sickle.

25.	Tree Pruner 	Tree pruners, cut away dead or excess branches from trees or shrubs to clear utility lines, roads, and sidewalks.
26.	Gloves 	Hand gloves is a great way to keep your hands safe and protected from insecticide/fungicides, germs, or dirt. One can use them while cleaning, washing, gardening or using chemicals to prevent any hand injuries.
27.	Pegs 	Wooden pegs are generally used for marking the position on the ground while mulching layout for different orchards.
28.	Pruning Ladder 	A tripod orchard ladder is a portable, self-supporting ladder used in orchards and landscape maintenance, for tasks such as pruning and fruit harvesting.

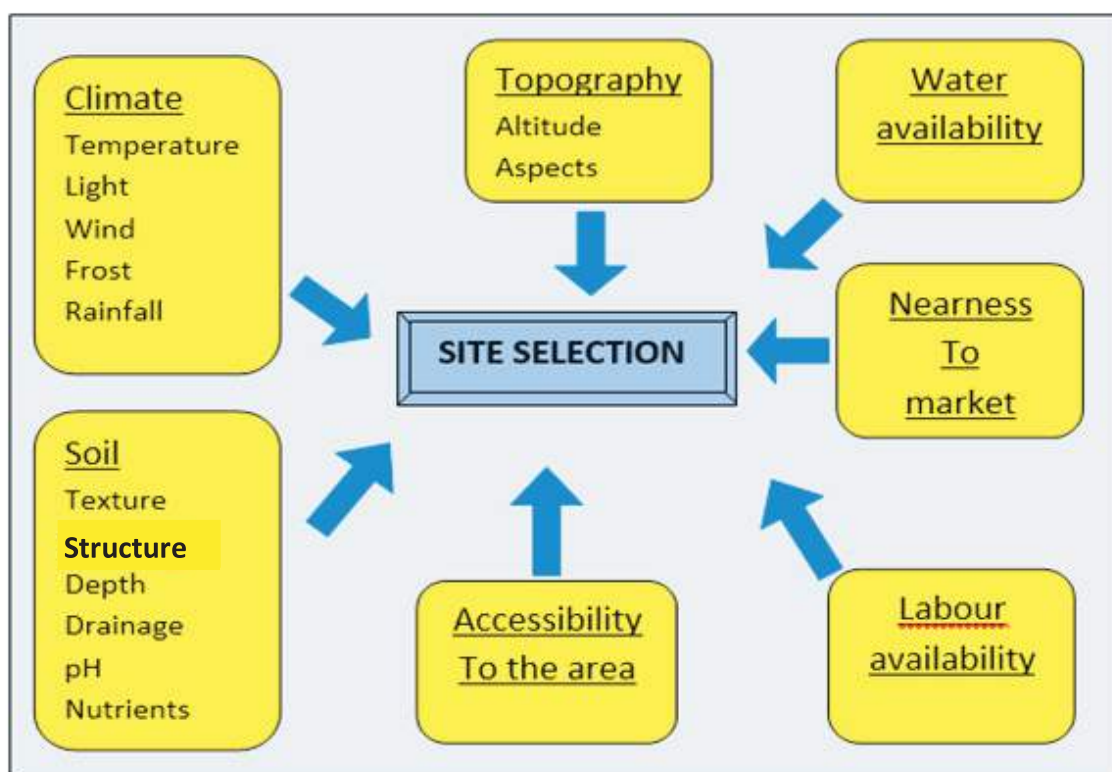
Chapter-2

ORCHARD PLANNING, LAYOUT AND PLANTING

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, 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.

Site Selection

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



Following factors should be considered before selection of a site for establishing a new orchard:

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 the orchard is a new venture or whether there are already other growers,
8. Availability of labour

1. Site Preparation

Fruit production development takes three to five years. During this period the orchard goes through different stages of development. The following table summarizes them a in stages of fruit orchard development:

Main Stages of Orchard Development

Time	Main stage	Sub-stage	Main activities
3-4 month before planting	Site preparation	Bush cleaning	Cleaning and weeding
		Land preparation	Loosening soil
			Ploughing
			Harrowing
			Leveling
			Terracing
			Bunding
			Fencing
		Orchard layout	Design pattern
			Establish row & plant distance
			Install irrigation system
			Digging holes
			Manure & fertilizer application
			Filling up and marking holes

Time	Main stage	Sub-stage	Main activities
			Sapling preparation
			Planting saplings
			Basin formation
			Staking

1 st to 3 rd year	Planting	Planting saplings	Mulching		
		Training fruit tree	Irrigation		
			Headback		
			1 st -3 rd years happing cut		
			Staking		
			Propping vs. trellising		
			Cloth pinning		
			Basin formation		
			Staking		
			Mulching		
			Irrigation		
			Nutrient management		
			Weeding		
			Pest & disease management		
4 th to 5 th year			Shaping fruit trees	4 th -5 th years happing cut	
				Staking	
				Propping vs. trellising	
				Cloth pinning	
				Basin formation	
				Staking	
				Mulching	
				Irrigation	
				Nutrient management	
				Weeding	
				Pest & disease management	
			5 th year onward	Main production period	Pruning
					Propping
					Irrigation
					Nutrient management
Pest & disease management					
Harvesting					

Orchard layout

Orderly and systematic arrangement of fruit plants on a piece of land is known as orchard layout.

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
- 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.

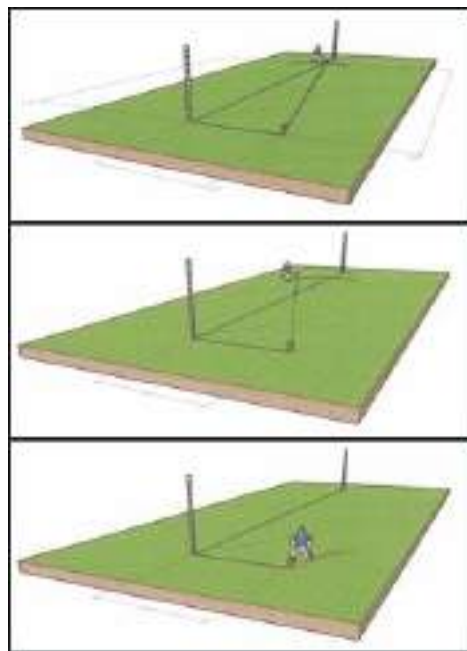
Basic measurement

The measurement of the future orchard depends on the type of fruit, the intensiveness of the production and the size of the matured tree (dwarf, semi-dwarf, etc.). According to these characteristics the population density varies for the same size of area.

Once you have determined the spacing for your trees, you may proceed with the orchard layout.

Establishing a Straight Line

1. The first target is to establish a base line. All other measurements will be conducted in relation to its position from the base line. The base line is a straight line between two opposite points on the field. The two points will be marked with two poles. (A and B)
2. A third pole (C) will be set on the line roughly one third of the way toward the in between the the first two poles (A and B).



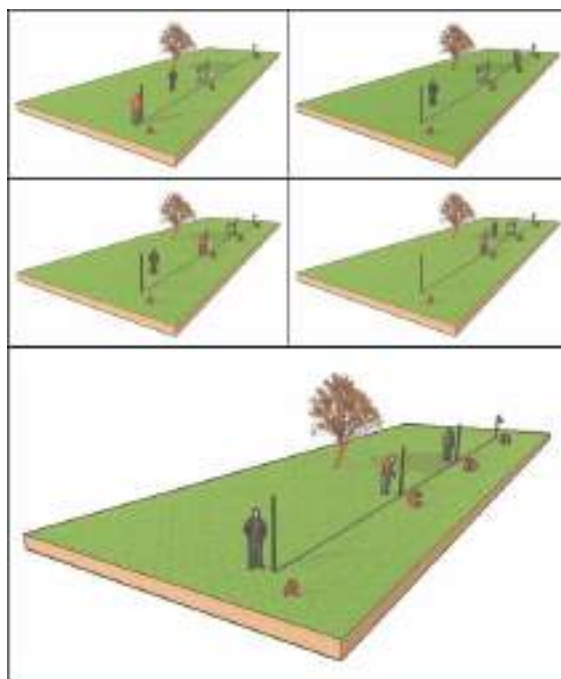
3. Finally a fourth pole (D) should be set on the line roughly half way in between the third (C) and second pole (B).
4. Return to the third pole (C) and correct its position on the line according the position of the first (A) and fourth (D) pole. Then go back again to the fourth (D) pole to correct its position according to the position of the third (C) and second (B) pole. This correction is repeated until all four poles are on a straight line between the two points on the field.

Establishing a Right Angle

3-4-5 Method

When the base line is set out in a satisfactory manner, the next step is to measure a right angle (90°) and form perpendicular lines.

1. From pole A measure 4m along the baseline and mark the point with a peg.
2. Next, tie a 3 m long string to pole A with a big nail or pointed stick attached to the other end.
3. Then draw a half circle in the soil with the nail/stick while making sure to keep the string constantly stretched.
4. Next, draw another half circle in the soil, from a string that is 5m long that will be tied to the peg.
5. Put another peg where the two circles cross each other. In reference to the newly formed triangle's dimensions, this method is called the 3-4-5 method.



Physical Layout

After the site has been prepared, the planting system for orchard establishment should be selected. The orchard layout depends on the slope of the land, the irrigation system, the drainage and the tree species to be grown.

The basic activities are the following:

- Establish a straight line (baseline) from the edge of the field, most commonly a road, hedge or fence.
- Mark the right angle
- The baseline forms a base row and the other line, running at a right angle to the first, forms the line at which the first tree in each row is placed.
- Using the baselines as reference points, at a point stretched along one line and pegs are put at the desired intervals of tree spacing.

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:



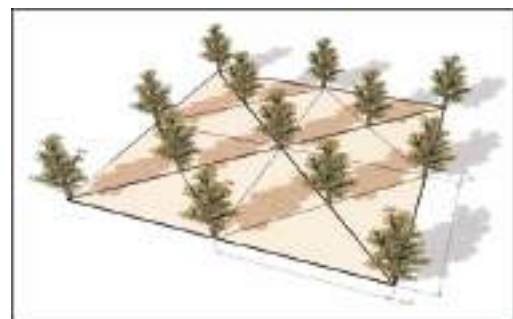
Triangular system



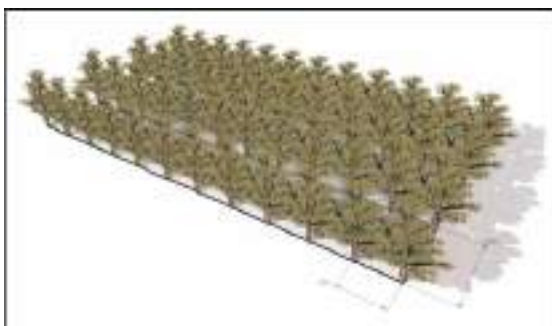
Square system



Rectangular system



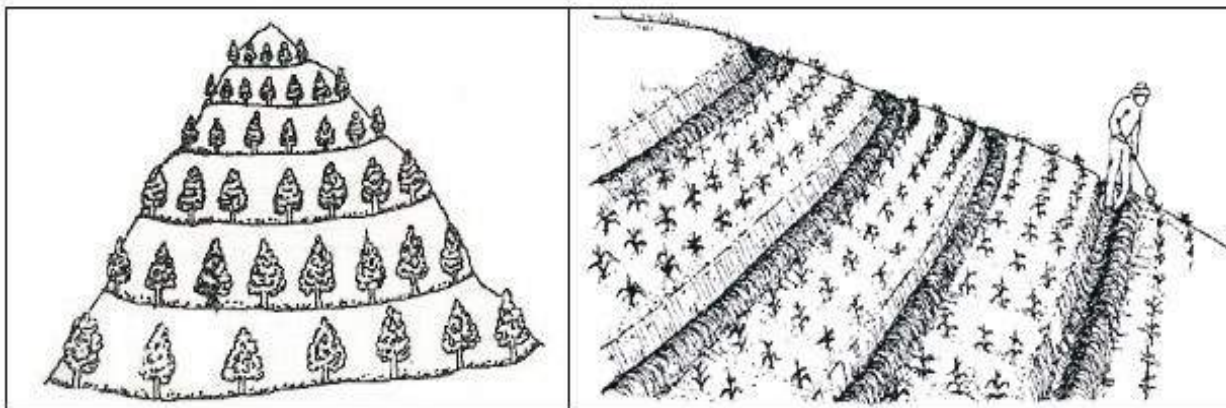
Quincunx system



Hedge Row system



Equilateral system for orchard layout



Contour/terrace system of planning in Hilly areas

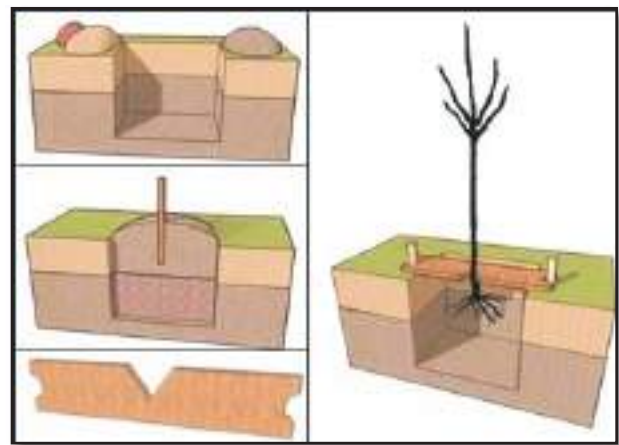
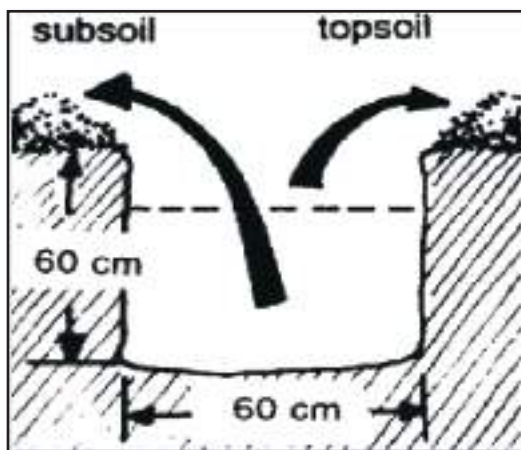
The most widely used planting systems in fruit crops under flat lands are square or rectangular and contour layout in hilly terrains. The orientation of planting should be North–South direction.

Preparation of field

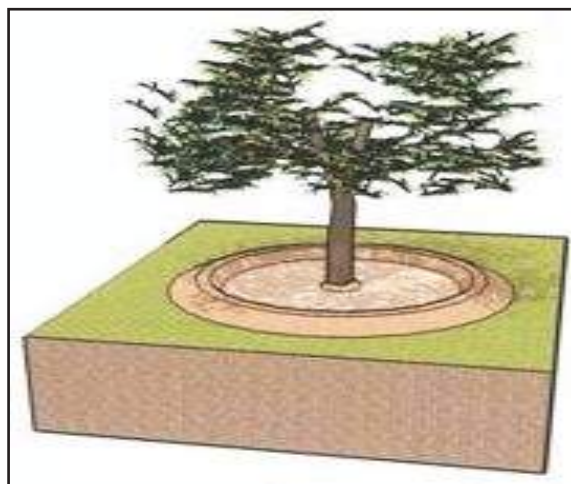
- Deep ploughing should be done and raised bed (2-meter-wide at bottom x 1.5-meter-wide at top x 45 cm height) should be prepared one month before planting.
- Where planting is to be done on steep sloppy sites, the soils are more prone to erosion and fast depletion of moisture, thus require frequent irrigation. On undulated, sloppy topography contour and terrace orcharding having about 1 m wide terrace is recommended for commercial high density orcharding.

Digging of pits and filling

Planting should be done in pits of 60 x 60 x 60 m³ size the pits are dug about a month prior to planting and are allowed to be disinfected by intense solar radiation. Compost and manure is an important part of the whole preparation, because additional organic matter content improves the soil's physical properties and provides valuable nutrients for the tree. Each pit should be filled with top soil mixed with farmyard manure (20kg), neem cake (1kg), and single super phosphate (500g) as depicted below. After filling the pit, watering is done to allow soil to settle down. Irrigation is provided immediately after planting .



Planting a sapling



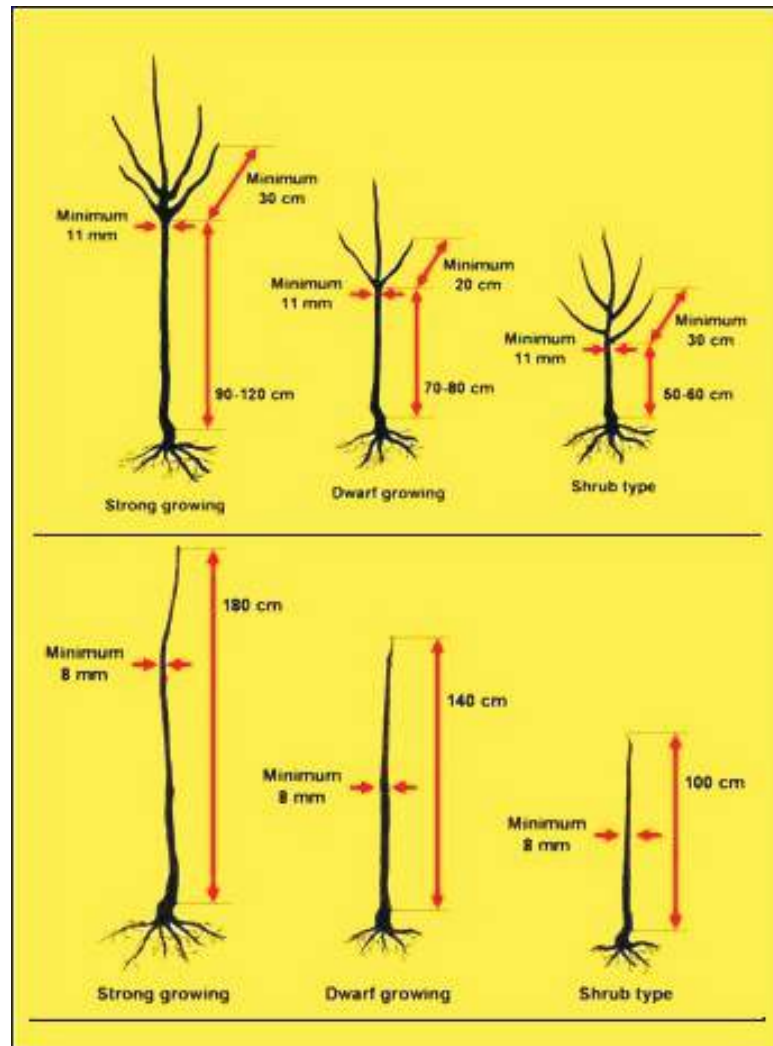
Basin Around the Tree

Planting Fruit Tree

Planting

- Place the tree in the hole so that the potting mix mark is slightly higher than ground level to allow for some sink. Fill the hole up to half level with soil and press it gently towards the root.
- Fill the hole with water and allow it to drain before completely filling the hole with soil. Do not place fertilizer in the planting hole as this can burn sensitive roots.
- Apply a layer of organic mulch in 1 m diameter around the trees.
- Planting should be done during spring season or rainy season depending on availability of irrigation water.
- Polybag raised plants can be planted without disturbing their roots.

- Staking should be provided to young plants to keep the plant straight and avoiding breakage of shoots by winds. Use 50-80 cm long wooden sticks and tie the main branches with strings. Wooden sticks should be treated with chloropyriphos 2 ml/litre for termite protection.



Standard for Sapling Quality

Chapter 3

PROPAGATION AND NURSERY MANAGEMENT

Planning and establishment of nursery

Establishment of nursery:

Nursery is developed gradually. The mother plants planted for vegetative and seed propagation and seed propagated plants are raised for sale simultaneously. Important factors considered for establishing a nursery are agro-climatic conditions, soil types, soil pH, location, area, irrigation facilities, communication, market demand, availability of germplasm or mother plants, skilled persons, etc.

Selection of site:

- The site selected for raising a nursery should preferably be located near marketing centres for the convenience of transportation of the products with minimum or no damage.

Topography of land

- The topography of land at the nursery site must be even. If it is undulating, it must be levelled. In hilly areas, it may be divided into levelled terraces

Soil

- The soil must preferably be loam or sandy loam with adequate organic matter content. The pH of the soil must be near neutral (6.5 – 7.5). It must have adequate water retention capacity and aeration.

Water

- The quality of water used in a nursery is important for the growth of plants. Saline and polluted water must not be used. It must be ensured that there is adequate water supply for irrigation. Besides, the nursery must be located near a water source .

Drainage

- The nursery site must have adequate drainage facility and be free from water-logging. Water should not stagnate at any time.

Transportation

- The nursery site must be accessible by road. It must not be far from potential markets so that there is no damage to the seedlings during transportation.

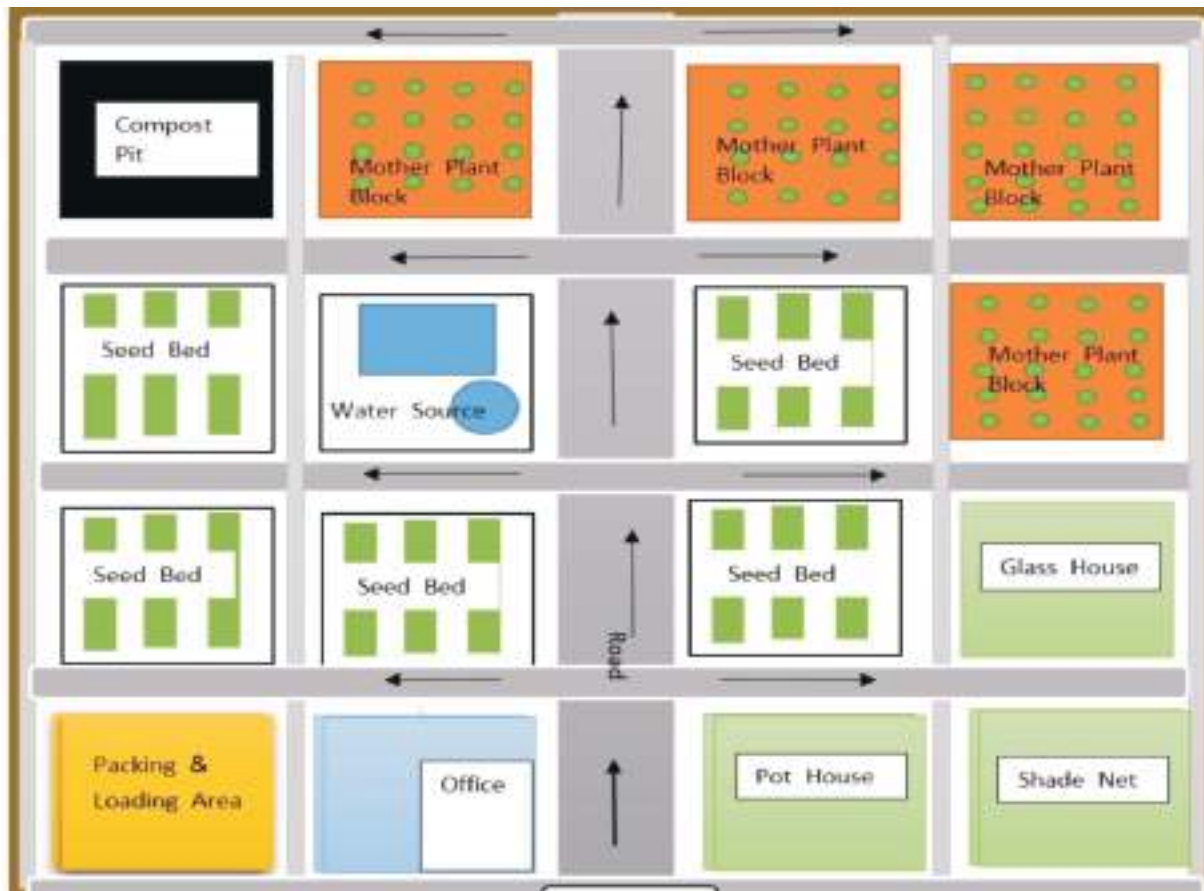
Labour

- As nursery work is labour-intensive, the nursery site must have enough number of labourers.

Protection from animals

- The nursery area must be protected by enclosures from the damage to the plants by stray animals

Layout of Nursery



Layout and Components of Nursery

1. **Fence:** Prior to establishment of nursery, a good fence with barbed wire must be erected all around the nursery to prevent trespass of animals and theft.
2. **Road and paths:** A proper planning for roads and paths inside the nursery will not add only beauty, but also make the nursery operations easy. This could be achieved by dividing the nursery into different blocks and various sections.
3. **Progeny block/Mother block:** the planting stock that is maintained as a source of commercial propagation is known as mother block. Once a superior type of material has been identified, it should be multiplied and maintained under conditions that prevent recontamination and allow detection of any significant change from the original source.
4. **Nursery office cum stores:** An office cum store is needed for effective management of nursery. The office building may be constructed in a place which offers better decorated with attractive photographs of fruit ornamental varieties propagated in the nursery with details of it. A store room of suitable size is needed for storing polybags, tools and implements, packaging materials, labels, pesticides, fertilizers etc.

5. **Sales area:** The nursery sales area should be clearly identified and located close to the nursery entrance. Customer parking for cars must be provided, and receiving trucks should be directed to the loading areas by signs so drivers can proceed without delay.
6. **Seed beds:** These components are essential to raise the seedling and rootstocks. These are to be laid out near the water source, since they require frequent watering and irrigation. Beds of a 1m wide of any convenient length are to be made. The working area of 60cm between the beds is necessary.
7. **Potting mixture and potting yard :** For better success of nursery plants, a good potting mixture is necessary. The potting mixture for different purposes can be prepared by mixing fertile soil, well rotten FYM, leaf mould, oil cakes etc. in different proportions.
8. **Compost pit:** Organic manure is an important and inevitable component for growing the nursery plants. It is essential for seed bed and potting compost. The compost pit should be constructed near the potting shed in order to facilitate the collection of compost materials for storage.
9. **Propagation area:** The propagation area is the heart of the nursery operation and must be located in an area accessible to the production and potting areas. A propagation area located close to the office helps in communication between the office staffs and the propagation managers who must make long range decision the number of specific plants to be produced .Propagation area, size and design are determined by production type number of plants and species produced and markets.
10. **Propagation structures :** there should be adequate provision for modern propagation structures like lath house ,cold frames ,hot beds , net house, mist chambers as these structures provide adequate conditions for seed germination and rooting of cuttings etc
11. **Irrigation system:** the irrigation lines from the source to the nursery/seed beds is generally located along the road between blocks and should be buried 30-36 inch deep.

Management of Nursery

- **Seedbed and nursery beds:** For raising seedlings, some permanent or temporary structures for seed bed may be prepared. These beds will be minimum 0.5 to 0.75 m high from ground level. The beds may be 0.75m to 1.00m in breadth and length may be as per the availability of land. The nursery beds will be prepared for storing of perennial plants or the plants that are to be kept for sale.
- **Collection and planting of mother plants:** The plantation of mother plants is an important work for developing a nursery. The mother plants must be true to the type and true to the variety. The plants should be properly labelled. The mother plants should be maintained properly for their vigorous growth; otherwise number of propagated plants will get reduced.
- **Storage of dried, cleaned soil and compost manure:** For raising seedlings during rainy or early winter season, the soil and compost would be stored during hot or summer

months. In rainy season, collection of dried soil and manure is very difficult. Without these, the seedlings cannot be raised during rainy season.

- **Production of seeds:** Production of seeds is highly specialized job. The seeds should be produced carefully. If the quality of seed is good, the percentage of seed germination, seedlings vigour, vegetative and reproductive growth of the crops will be good. After harvesting of quality seeds, germination percentage of seeds and seedling vigour should be checked before marketing of seeds.
- **Storage of propagated plants in nursery beds:** The propagated plants are planted in nursery beds for better growth or hardening the plants. In general, this type of nursery bed is prepared under partial shade.
- **Manuring:** Manuring is to be done very carefully. Vigorous growth of plant is always attractive to the buyer. Again, heavy manuring is not beneficial for storage of plants.
- **Watering:** Like manuring, watering is also important. Watering will be done according to need of the plant. The nursery should have a water source of its own.
- **Drainage:** For sufficient vegetative and reproductive growth of plants, good drainage system must be developed in between the beds and around the nursery. Adequately gentle slope in the surface is also desirable. It is extremely important to ensure that water logging does not occur in and around the beds.
- **Plant protection:** Keen observation on attack of different pests and diseases is required. If the mother plants are infected, the propagated plants will be infected also. Necessary control measures should be taken immediately on observation.

Propagation of mandated fruit crops

Mango

Propagation

Seedling rootstocks of mango are raised for grafting with the scions of desired commercial variety.

Raising of Rootstock

The current propagation practice by collecting pre-germinated mango stones (seeds) that fall under the tree, increase the risk of pests and diseases in the seedlings. Therefore the proposed improved practice for collecting mango stones and raising seedling rootstock should be followed.

Preparing the seed

Collect the best mango fruits from selected productive trees. It is essential to clean the mango pulp from the seed before sowing in the seed bed. Seed viability decreases with the delaying in sowing after extraction from the pulp.

- Wash the seed properly after extraction from the pulp.
- Seeds should be sterilized in plastic drum with 2.0 percent potassium nitrate solution for 24 hrs.

- The treated seeds should be sown in nursery beds and the layer of seeds should be
- Covered with well rotten FYM for better germination.

Planting the seed

- Sown seed should be covered with grass mulch.
- Maintain optimum moisture in the medium.
- Seed germination begins 10-14 days after sowing. Inspect seed regularly after sowing.
- Seedling should be transplanted 1 month after sowing, when the leaves turn dark green, into the polybags and should be lightly root pruned (leaving 2 inch taproot)
- About 8 - 12 months after transplanting, the seedling attains 30 - 40 cm height and 0.8-1.0 cm diameter (graftable thickness), and becomes ready for grafting with desired commercial cultivars.

Grafting

The most common grafting techniques are:

- Veneer grafting
- Wedge grafting

Recently wedge grafting has been demonstrated successfully by different institutes including COHF Neri. The time for propagation by this method is July-August and February-March (under protected conditions). Both the methods can be used for commercial propagation.

Preparing the scion

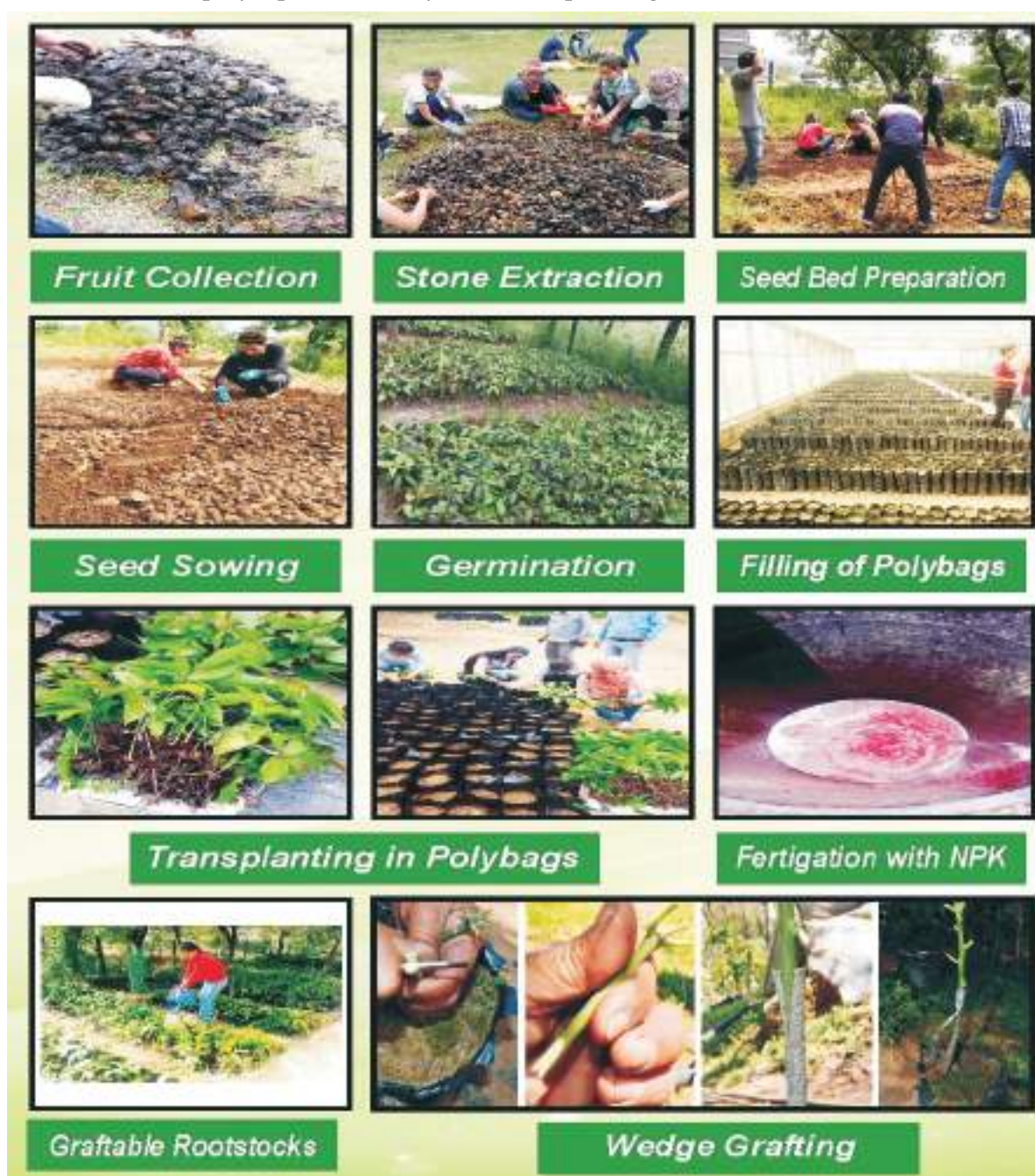
- Scion wood should be taken from terminal portion of mature stocks (3-4 months old) with visible buds from non-flushing and non-flowering shoot.
- Semi hard scion wood which bends a little upon applying pressure should be taken.
- Scion taken from young and soft portion will dry quickly.
- Remove leaves from scion 7 to 10 days before detaching from the mother tree, but keep the petioles to promote buds to swell in order to enhance the success rate of graft.
- Cut about 10 cm long top portion of the shoot with a diameter similar to that of the rootstock diameter (it can be thinner than the rootstock, but not thicker).
- The scions can be stored up to 1 week by placing them in a bucket of water. For transportation from distant places, scion should be wrapped in moist paper and kept in sealed plastic bag and don't let the scion to dry out.

Wedge Graft

This technique is widely used and is easiest for mango propagation, if done well it produces a very strong joint and with stands in windy conditions.

- Two (2-3cm long) slanting cuts are given on each side of scion to prepare the wedge.
- Head back of rootstock about 30 cm above the surface of medium then cut a 2-3 cm long slit down the centre of stem.

- Wedge formed in scion should be slid into the slit cut of rootstock. Line up surface of scion and stock, or at least on one side so that the surface at the union of scion stock feels smooth.
- Wrap the graft with grafting/budding tape (12 mm wide), start from 1 cm below the bottom end of joint and move upward and be sure to completely cover upto 1 cm above the top of the joint. If necessary give a second wrap moving the tape downward along the joint.
- Place the newly grafted plants in a 50 percent shaded net.
- Wedge grafted plants of mango should be covered with polythene cap so as to improve graft success
- Remove the polycap immediately after bud sprouting.





Commercial wedge grafting under protected cultivation

Nursery raising of Mango

Veneer Grafting

- This method is used when the rootstock is quite thicker than scion.
- Make an incision sloping cut (2.5-3.0 cm long) about 20cm above soil level on one side of the rootstock. Keep the portion above this cut for some time.
- Cut a wedge on one side of the scion matching the length of the incision given on rootstock (2.5-3.0cm).
- The scion is inserted into the incision given in root stock with some pressure so as to line up the cambium layers. Head back the rootstock slightly above the joint.
- Wrap the joint using grafting tape.

Grafted Seedling Management

- Freshly grafted seedlings need 50% shade. Apply water to keep the soil moist. The grafting tape can be removed when the graft union has healed after 8-10 weeks of grafting.
- The shoots arising below the graft union should be removed regularly.
- The grafted plants become ready for planting in the field 6 months after grafting, when the plants attain a 1 m length of about. If the plants are flushing, wait to transplant until the new leaves are greener.



Saleable plants

Citrus

Propagation

Virus free planting material is of prime importance for successful citrus cultivation since it is susceptible to a number of viral infections. The quality of nursery plants has a major contribution in the productivity of citrus orchards.

Recommended Rootstocks

Citrus plants are very sensitive to various biotic and abiotic stresses, therefore, selection of an ideal rootstock is a continuing challenge for the citrus cultivation. For budwood, disease free mother plants developed from the elite progeny of known pedigree should be selected. Rough lemon is most suitable rootstocks for sweet orange varieties.

Rootstock Raising

Seed for raising rootstocks should be obtained from healthy fruits of rough lemon harvested from vigorous trees. The seeds of rough lemon are extracted in September and immersed in hot water at 52⁰ C for about 10 minutes to check Phytophthora infection. The seeds should be sown immediately after seed treatment with captan @ 1g per kilogram of seed. The seeds are sown in nursery beds of 2 m×1 m size and in rows 15 cm apart. The seed should be sown at a depth of 2.5 cm 10-12 cm tall, uniform seedling are transplanted to polybags. Spray of 19:19:19 15 g/litre of water solution on Jatti Khatti seedlings at monthly interval (March to December) increases the proportion of graftable plants.

Maintenance of Mother Trees

For the induction of more bud wood required for the nursery production, the mother trees of sweet orange should be planted at 2×2m spacing and pruned at 6 feet height from ground level along with topping of side branches during last week of January to first week of February. Bordeaux paste should be applied on cuts after pruning. The fruits should also be removed from the mother trees after fruit set in the month of April.



**Mother plant of citrus
under net house**

Budding

Primary nursery beds are prepared on light fertile soils or in the HDPE trays under shade net structures. The most commonly used method for propagation of citrus is T-budding. Budding should be done in month of July-August.

Pencil thickness seedlings are budded by inserting shield shaped bud into the slot cut in the bark of the seedling at 15-20 cm from the ground level. It can be made by first making a horizontal cut about 1.5-2.0 cm long according to the thickness of the stock. Another vertical cut, about 2.5 cm long, is made downwards from the middle of the horizontal cut to receive the bud shield. After the 'T'-cut has been made in the stocks, the bud is removed from the budstick and inserted into the slot and wrapped up with the plastic tape keeping the bud eye uncovered. The wrapping should be fairly tight, but not so tight as to girdle the stock. The sprouts of the stock seedlings below and above the bud union should be removed regularly.

T-budding in Citrus



Extraction Seeds and treatment with captan



Treated dried seeds should be sown within a week of extraction



Germination of citrus seeds



4-6 leaf stage seedling should be transplanted



Polybags filled with media ready for transplants



Seedling ready for budding/grafting



Collection of Scion wood



Extraction of budwood



Preparation of scion wood



Insertion of budwood on rootstock



Successful plants ready for transplanting to the farmer's field

Important Points to keep in mind:

- Always take bud wood from true to type and diseases free mother plant for nursery production.
- Use soil, FYM and cocopeat potting mixture (2:1:1) in polybags for containerized nursery production.
- Budding should be performed at 15-20cm above the ground level.
- Containerized nursery production helps in propagating plants in shorter time and reduces the incidence of insect-pest and diseases.

Litchi

Propagation

The most widely used and commercial method of propagation in litchi is air layering.

Air layering

The best time of the year to propagate litchi by air layering in Himachal Pradesh is July-August.

- Select a healthy terminal branch with a thickness of 1.2-1.5cm on a well developed tree.
- Remove the bark to make a ring of 2.5 cm width on the branch about 40-50 cm below the apical growth.

Air Layering in litchi



Removing of bark and cambium should be kept intact



Media preparation for layering



Air layering



Ditching air layer from mother plant



Removing of wrapping material of air layer



Drenching of air layered ball before shifting to polybags



Shifting air layer



Growing nursery



Saleable plants

- Rub off the cambium layer to expose the woody portion of the stem. Apply a paste of 2400 ppm (2.4 g/l) IBA to the exposed area and cover it with a layer of moist moss alongwith well rotten leaf compost and litchi orchard soil.
- Wrap the treated area with a piece of polythene sheet (20×25cm) and tie it well at both ends.
- The roots develop from the upper end of the ring after 45-60 days.
- Remove the layer by making a sharp cut about 5 cm below the lower end of the wrapped area.
- Before planting them in polybags, remove 50% of leaves, place the layers under shade for hardening and irrigate frequently.

Guava

Propagation

Wedge grafting technique has been standardized and adopted for commercial mass multiplication of guava in nursery with more than 95% success. The polybag raised, grafted plants have better success and growth on farmers' field.

Wedge Grafting

Raising seedling rootstocks

- Remove the seeds from ripe guava fruits during August-September. Wash the seeds thoroughly to remove the pulp from the fruit and dry the seeds under shade. Seeds can be stored in a sealed container for planting later.
- Guava seeds are placed in hot water for 5 minutes to break seed dormancy.
- Place the seed in potassium nitrate solution (2g/l) for three hours for enhancing seed germination rate.
- Fill the seedling trays with potting mixture and place two or three seeds in each cell, cover seeds slightly with the medium.
- Seeds can also be sown in raised beds under protected structure.
- Apply water until medium is wet. Place the seedling trays in warm covered place. Germination takes place in 2-4 weeks depending upon the temperature.
- Transplant to polybags when the seedlings have at least two sets of leaves (15 cm high).
- Root pruning of main secondary roots should be done at the time of transplanting for better establishment.
- A light fertigation should be done with NPK 19:19:19 (1.0g/l) as a starter solution immediately after planting.

Grafting

- Easiest method of grafting in guava is wedge grafting. It produces a very strong joint which can withstand under windy conditions. Grafting is easier than air layering.
- Scion should be one year old hard wood i.e. available at the base of guava shoot.
- Two (2-3 cm long) cuts are given on each side of scion to prepare wedge.
- Head back the rootstock 22-25 cm above the pot medium surface, then cut a slit 2-3 cm down the centre of stem.
- Wedge of scion should be slipped into the slit cut of rootstock. Line up the surface of scion and stock at least on one side so that the union of scion and stock feels smooth, if not possible on both the sides.
- Wrap the graft with grafting/budding tape (12 mm wide). Start from 1cm below the bottom end of joint and move upward, be sure to completely cover upto 1cm above the top of the joint if necessary give a second wrap moving the tape downward along the joint.
- Place the newly grafted seedlings in a 50 % shade net house.
- Put a polythene cap over the grafted plant. Two weeks after grafting the terminal bud will start growing. As leaves start to develop from scion bud, the cap should be removed.

Raising of seedling rootstocks



Seed extraction method



Layout of sheet for seed drying



Guava seed drying



**Seed treatment with
potassium nitrate**



Seed sowing on raised bed



Seed germination



**Seedling ready for
transplanting**



Root pruning of seedling



**Planting of seedling in the
poly bag**



Seedlings ready for grafting

Wedge Grafting



Heading back of seedling and preparation for wedge grafting



Preparation of scion wood



Preparation of 'V' shape cut on scion bottom



Insert scion on rootstock



Capping of polytubes



Successful Grafts

Wrapping of stock-scion union with polythene

Pomegranate

Propagation

Pomegranate plants are mostly multiplied through cutting however in southern parts of the country; pomegranate is propagated through air-layering. In North India, where pomegranate behaves as deciduous plant, it is propagated mainly by hardwood cuttings. Pomegranate plants multiplied through vegetative means *viz.*, stem cuttings and air layering are susceptible to challenging diseases and pests of pomegranate like bacterial blight, wilt and nematodes. Therefore, the production of quality planting material free from these maladies is of utmost importance. Nowadays, plant production through tissue culture technique has become more popular as the tissue cultured plants are uniform and free from insect-pest and diseases.



Pomegranate Cuttings



Root trainer raised cuttings



Pomegranate Nursery

Cuttings (Hardwood)

Pomegranate plants are successfully multiplied by hardwood and semi-hardwood cuttings under mist system. Semi-hard wood cuttings of 6 month to one year old, pencil thickness and 20-25 cm length perform better. Hardwood or semi-hard wood cutting planted during winter season gives higher success rate. Under North Indian conditions cuttings are planted in February and July under mist system. In July, cutting should not be taken from the lateral branches producing flowers and fruits.

Pomegranate cuttings dipped in IBA (2500 ppm) for 5 minutes produce fibrous root system, which helps in better establishment of plants under field conditions. Pomegranate cuttings planted in different media *viz.*, mixture of cocopeat and sand (4:1) or cocopeat alone promotes fast rooting and performs better. While planting, we should always treat and sanitize the cuttings with Antimicrobial compound 2-bromo-2-nitro-1,3-diol @ 500mg/litre (0.5g/litre) + carbendazim @ 1.0 g/litre for 5 minutes to reduce pests and disease infection.

Tissue culture

The demand of quality planting material of pomegranate is increasing day by day, for which large scale multiplication of pomegranate plants through tissue culture is required and it is highly successful in pomegranate. Tissues culture plants are free from all kind of infection (nematodes, wilt and bacterial blight) and are true-to-type. Synchronized flowering and fruiting make tissue cultured plants more suitable for mechanical cultivation which results in better quality and high yield. It provides disease-free planting material for introduction of pomegranate to non-traditional areas. Although, this technology requires high initial investment, more care and skilled man power.

Chapter-4

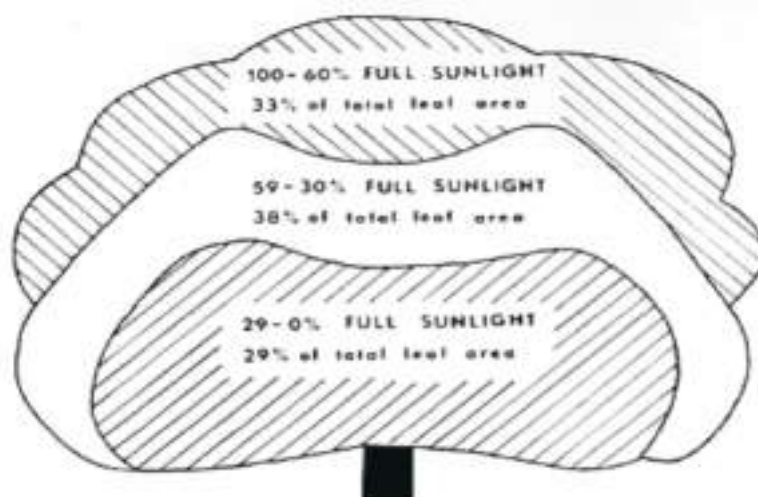
TRAINING AND PRUNING

Training

Training involves a physical technique that controls the shape, size and direction of plant growth. Training of young fruit trees is essential for proper tree development. The goal of tree training is to direct tree growth and minimize cutting. Training includes bending, twisting, or fastening of the plant to a supporting structure. A well-trained fruit trees will have strong branches with wide crotches.

Principles of training

- To develop strong framework of scaffold branches.
- To admit more sunlight and air to the centre of the tree.
- To expose maximum leaf surface to the sunlight.
- Maximum utilization of light.
- Avoidance of built-up microclimate congenial for diseases and pest infestation.
- Convenience in carrying out the cultural practices.
- Maximizing productivity with quality fruit production.
- Economy in obtaining the required canopy architecture
- To direct the growth of the tree so that various cultural operations, such as spraying and harvesting are performed at the lowest cost.
- To protect the tree from sunburn and wind damage.
- To secure a balanced distribution of fruit bearing parts on the main limbs of the plant.



Sunlight received in different parts of plant canopy

Pruning:

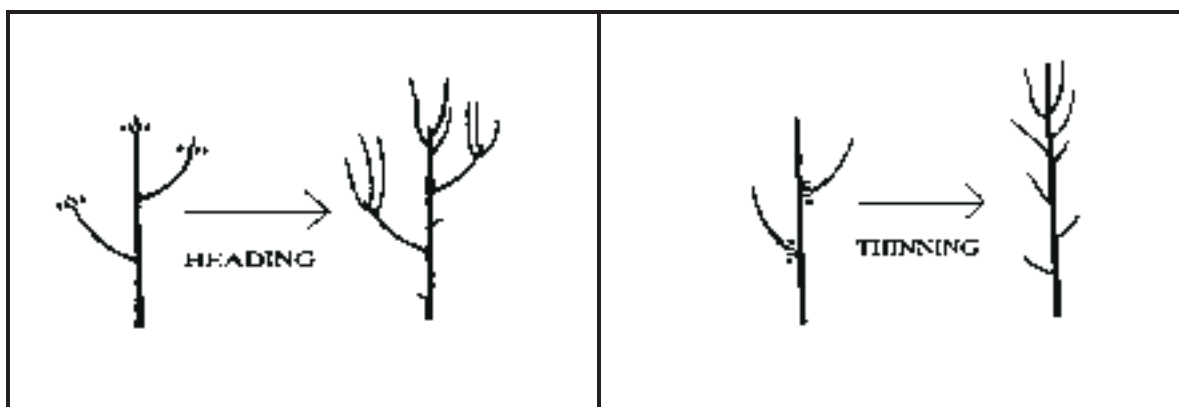
Pruning is the proper and judicious removal of plant parts such as shoots, spurs, leaves, roots or nipping away of terminal parts.

Principles and objectives

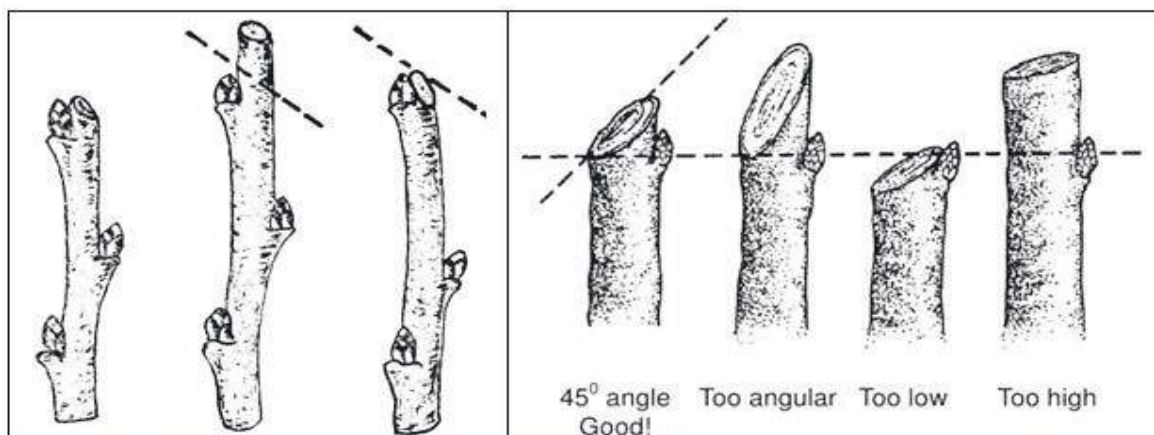
- To establish a balance between vegetative and reproductive growth
- To make the plant more productive and bear quality fruits.
- To increase longevity of the tree, make it manageable and to get maximum returns from the orchard.
- To control the size of the plant and the form (structural make up of the plant) which involves number, placement, relative size and angle of branches,
- To improve quality of fruits by better light distribution.
- To remove diseased, criss-crossed, dried and broken branches,
- To remove the non-productive parts in order to divert the energy into those parts that are capable of bearing fruits,
- To develop proper proportion of root- shoot ratio and regulate the fruit crop.

Types of pruning:**(1) heading back and (2) thinning out.**

Heading back: It consists of cutting back the terminal portion of a branch to a bud that is, the terminal portion of twigs, canes, or shoots are removed, but the basal portion is not. Heading back induces lateral shoot formation by inhibiting the effect of apical dominance.

**Thinning out:**

It is the complete removal of a branch i.e., the entire twig, cane, or shoot is removed. Thinning out corrects an overly dense area or removes unwanted branches, or undesirable growth such as upright branches that compete or interfere with the leader and branches that are structurally weak because of narrow crotch angles.



Ways of making pruning cuts

When do we manage the canopy?

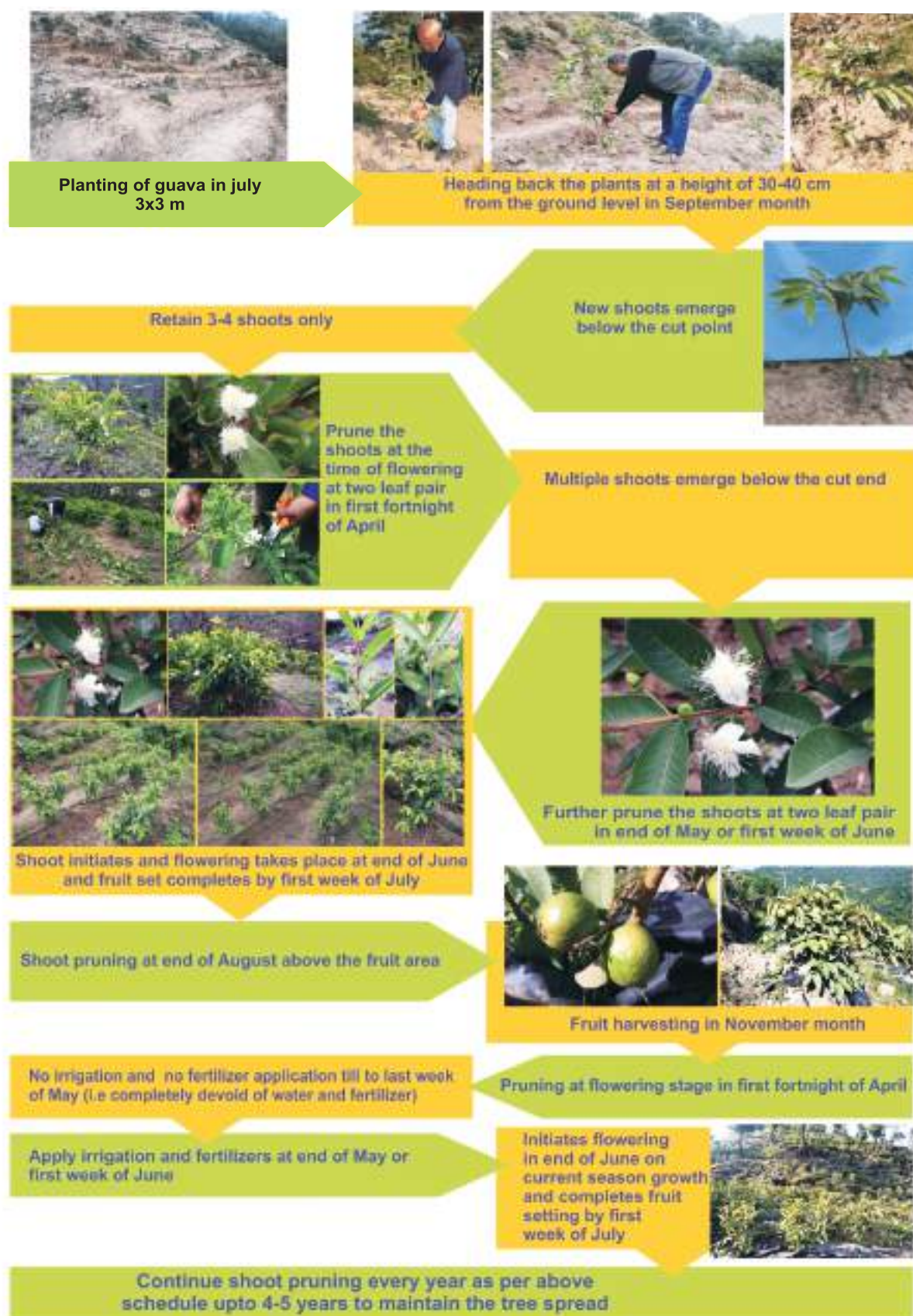
- It's best to prune a fruit tree during winter because the level of physiological activity is much slower and there is no crop on the plants. Summer pruning can also be done for controlling tree size and removal of water shoots, dead and diseased wood. Microorganisms (e.g. bacterial and fungal infections) are plentiful during the summer months. Pruning in the summer creates wounds that make trees more susceptible to infections

Pruning and training procedure of important fruit crops

Guava

In early years of planting properly strong framework of the plant has to be developed by allowing widely angled branches and removal of weak crotch angles. During training period heavy heading back cuts should be done to maintain vigour of shoots. Productive plants need pruning to maintain the appropriate size and shape. Proper management practices help to increase yield quality of the produce and reduce pests and diseases attack.

Pruning for winter crop of guava



TRAINING AND PRUNING HIGH DENSITY ORCHARD OF GUAVA

High Density Planting



**Field Planting
(3.0×3.0m)**



Heading back the trees at a height of 60 cm from the ground level after 3 months of planting



New shoots emerge below the cut point and lowermost shoot should be 30cm above the ground



Retain 15cm apart 3-4 shoots (equally spaced in all directions) 30 cm above ground level



**Prune the shoots after 3-4 months of shoot growth
(cutting back to 50% of their total length- shoot length should be 70-80 cm) i.e. 35-40cm heading back**



After winter (1st fortnight of February) Shoot pruning should be done by heading back to 50% of their total length- shoot length should be 70-80 cm)



During 1st fortnight of May Shoot pruning should be done by heading back to 25% of their total length- shoot length should be 70-80 cm)



For winter season fruiting, Shoot pruning at two leaf stage during 2nd fortnight of June to induce cropping



During end of August-1st fortnight of September pruning of non-bearing shoots to 25% of total shoot length and thinning out of crowding shoots should be done)



Continue shoot pruning (50%) during June every year for winter cropping and to maintain the tree shape and size

MANGO

Establishment of scaffold branches

First order (1st Order): Head back plants at 45-50 cm when they attain the height of 80-90 cm, this may reach within 3 month of planting.

Second order (2nd Order): As a result of head back new shoots emerge, 3-4 new shoots should be retained at least 30-45 cm above ground level.

- Ideal canopy can be developed by thinning out the shoots, so as to retain 3-4 shoots distributed evenly in all directions. These shoots develop as primary branches.
- As shoots become mature i.e. shoot colour changes from green to brown, second cutting should be performed. New shoots take about 4 months to mature.
- At this stage if new shoots are at smaller crotch angles, then increase the crotch angle by bending the shoot using rope/thread. Use a jute rope instead of nylon based/poly threads for binding.

Third order (3rd order): Heading back to 50 per cent should be performed on growing shoots when they attain 70-75 cm length. This will take 3-4 months to reach the stage for second cut to primary branches. This cutting also induces new growth.

- Crowding shoots should be removed so that 3-4 shoots are retained on each primary branch.
- New shoots emerge as a result of heading back and only 3 shoots are now retained in all directions.

Fourth Order (4th order): Heading back of 50 percent should be performed on growing shoots when they attain 70-75 cm length.

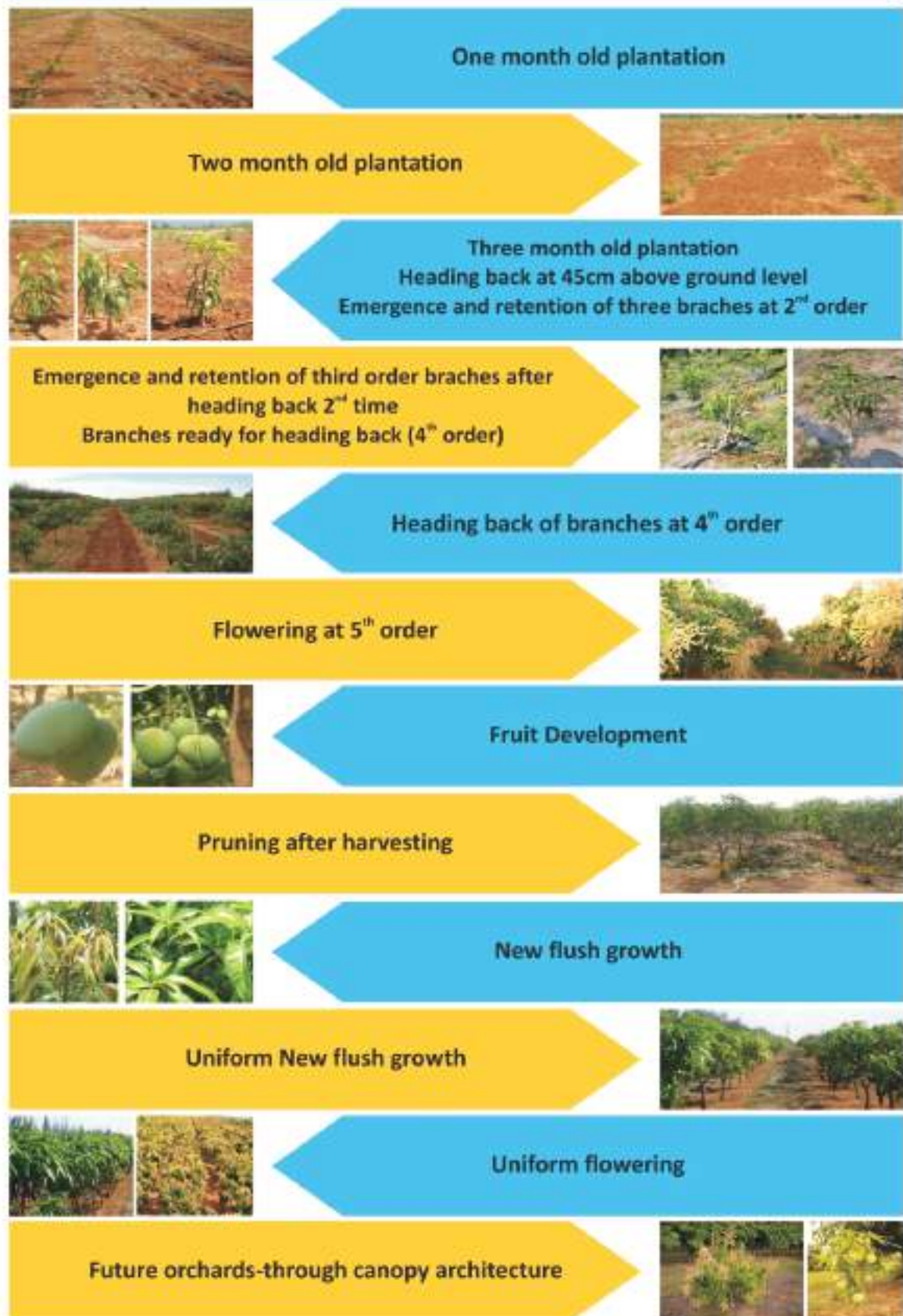
Fifth Order (5th order): Heading back to 50 per cent should be performed on growing shoots when they attain 70-75 cm length.

- Sharp secateurs should be used to ensure smooth sharp.
- This initial training creates open and spreading type canopy of trees.

Pruning

- Pruning is required to regulate the growth and fruiting of mango tree under HDP. Pruning should be done immediately after fruit harvesting i.e. July-August by heading back 25-50% branches particularly bearing twigs.
- The long-term sustainability of a mid-density orchard depends on an effective canopy management. In general, every pruned shoot produces three new shoot but occasionally more than three.
- Light or moderate pruning increases yields in mango orchards, while heavy pruning often inhibit fruit production for several seasons. However sometimes there is need to remove internal long branches affected by diseases or insect pests.

HIGH DENSITY PLANTING TECHNOLOGY OF MANGO FOR HIGHER PRODUCTIVITY & QUALITY



Citrus

Training

- Training operation to develop structural framework should start after 6 months of planting when the plants attain a height of 45-60 cm.
- All branches up to 30 cm height should be removed and first ring of branches should start 30cm above the ground.
- During the second phase, select 3-5 primary branches above 30 cm height in all directions. The selection of primary, secondary and tertiary branches should remain continuous during next year.
- The orientation of primary branches should be toward peripheral canopy at about 60° angle with stem and upright growing branches should be thinned out.
- During development of frame structure training should be done continuously for first two years.
- The maximum height of grown tree should not exceed 2.5 m and canopy should be developed in round dome shape.

Pruning:

Citrus trees may be pruned at any time, but it is better to avoid those periods when trees are in active growth. The best time for pruning the bearing trees is immediately after the harvest of the fruits. For getting better yield of high quality fruit, pruning of such branches is necessary to open up the tree for proper ventilation and provide more chances for inner wood to bear fruit. 10-15cm head back of one year old shoots should be done in bearing tree. Removal of dead and dried wood is necessary to check the further spread of diseases.

- Hard pruning of thick shoots should be discouraged.
- Removal of water sprouts and water shoots should be continuous except in May-July.
- Pruning of dried, intermingled and diseased branches should be done during winter months.
- Pruning should be done immediately after harvesting.
- Apply 10% Bordeaux paste on the cut end and spray with oxychloride 250g+ 20g streptomycin in 100ml water of plant after training and pruning.

LITCHI

Training

- Training of litchi tree in the initial stage is essential to provide the desired framework.
- Remove all branches below 30 cm to provide a wanted shape and induce the growth of the trunk and the crown of the tree;
- During the second phase, select 3-5 primary branches above 30 cm height in all directions. The selection of primary, secondary and tertiary branches should remain continuous during next three years.

- The orientation of primary branches should be towards periphery in all directions of the canopy at 60° angle with stem.
- Cut branches that compete with the central leader or are together or crisscross or the branches having less than 45° angle.
- The centre height of plant should be restricted at 3.0 m.

Pruning

- Pruning in litchi trees has been found effective in terms of increasing productivity. Pruning is necessary to correct or maintain tree structure and improve light distribution.
- Harvesting the fruit with the panicle along with 20 cm of twig induces new flush and improves the next year bearing.
- Besides bearing twigs, light pruning of other branches up to 20 cm heading back should be done just after harvesting.
- Pruning of centrally growing upright branches should be done periodically (Once in 2-3 years) to facilitate proper aeration and light penetration inside canopy which would help in production of better yield and quality fruits.

POMEGRANATE

Multi-stem training system

- Healthy saplings of 5-6 months age should be planted and trained in multi-stem training system (3-4 stems) to avoid losses of stems/plants by stem borer or any other disease.
- Training operation to develop structural framework should start after 3 months of planting, when plants attain a height of 45-60 cm.
- For multi-stem system, 3-4 healthy suckers should be allowed to develop and other suckers must be removed regularly.
- All the branches up to 30 cm height should be removed.
- During the second phase, select 3-5 primary branches above 30 cm height in all directions. The selection of primary and secondary branches should remain continuous during the next year up to February month.
- The orientation of primary branches should be toward peripheral canopy about to 60° angles with stem.



Multi-stem training system



Training of Bhagwa plants (8-9-month age)

Pruning

- Pruning should be done during winter months by removing dried twigs, inter-mingled branches, water shoots and sprouts.
- All upright growing shoots should be removed during growing period.
- Bearing to induce cropping, heading back of tertiary branches/shoots of 5 mm thickness should be practiced during winter season.
- Hard pruning of thick shoots should be discouraged.
- Major pruning is practiced during winter months and light pruning of new growth should be done during fruit setting by removing all the new water shoots and water sprouts.
- Immediately after training and pruning, apply Bordeaux paste on the cut ends (>10 mm thickness) of the plants.

PLUM

Training

- In general, open centre or modified leader system are adopted in plum which vary according to variety.
- In varieties with spreading type of growth habit open centre system (suitable for mid hills of Himachal Pradesh) should be followed.
- Whereas, modified central leader training of plant keeping 4-5 scaffold branches is considered better to avoid scorching summer sunlight.

Open Centre System

- Cut back the plant at 40 cm above ground level after planting. The tree produces 3-6 laterals in addition to the central leader.
- During the 1st winter allow growth of 3-5 scaffold branches with wide crotch and remove rest all branches including the central leader.
- The branches are then headed back to 1/4th of the growth
- 2-3 secondary branches should be retained on primary branches during 2nd dormant pruning. Care must be taken so that each secondary leader is placed at about 30-40 cm distance from each other.
- Leader branches are pruned more severely to maintain staggered height of secondary branches.

- Avoid overcrowding of branching by developing branch leaders at different heights through severe pruning of vertically growing branches.
- This completes the formation of a head (crown) and the selection of secondary branches.

Modified Leader System

- It takes 3 years in plum to train the plant on modified leader system.
- The transplanted plants (about 1.0 m high) should be cut back to 40-45 cm in the first half of the January, branches, if any on the main stem should also be pruned to short stubs.
- During the first dormancy select 4-5 branches at 15-20 cm vertical height from one another around central branch axis and remove all other branches from the axis which at this stage is allowed to grow as leader.
- First branching should be maintained at least about 30 cm above the ground.
- During second year the primary branches will produce secondary limbs, as the plant grows new branches will come out from the first year extension growth.
- With tree growth in 3rd year many new shoots arise from primary and secondary shoots.
- Keep only the wide angled shoots which are evenly spaced and remove all other branches.
- Head back the central leader adjacent to outward growing lateral branch, when a good framework of the plant has been developed at the end of the year.
- As a result a plant trained on modified leader system becomes ready to bear fruit.

Pruning

- In general, plum varieties bear fruits on spurs, while some fruiting takes place laterally on one year old shoot. The spurs bear for 5-6 years. So, it requires pruning in each year for promote spur renewal.
- To obtain proper fruiting the bearing, plum trees should grow 25-30 cm every year. For this head back to 50% and 25-30% thinning in Santa Rosa is done in Himachal.
- All the dried/dead, broken and diseased wood should be removed during pruning.
- The scaffold branches should start at least 30 cm above ground and other scaffold are kept at 15 cm away from each other in a spiral arrangement, branches with wide angle are retained others are removed.
- Head back the central leader in first dormant pruning allowing growth of scaffold branches which are pruned by removing 1/3rd growth. Other weak/unwanted branches arising from main stem are removed.
- 2-3 suitably spaced branches on primary scaffold are retained during second winter pruning which are pruned to 1/3rd-1/4th of their length.
- The undesired, weak and crowding branches are removed during pruning, besides water sprouts, dried/died, diseased and intermingling branches.
- A branch has to be maintained in vegetative and reproductive growth of the plant through pruning in bearing trees. Only light and corrective pruning is required during pre-bearing period.

- Heavy heading back encourages development of long upright water sprouts thus, should be avoided.
- Regularly remove all the water sprouts coming out from crown portion of the plant. Heading back of lengthy branches to 50% should be performed after cropping for 4-5 years.
- Bordeaux paste/paint should be applied on each cut which is thicker than pencil thickness (4-5mm).

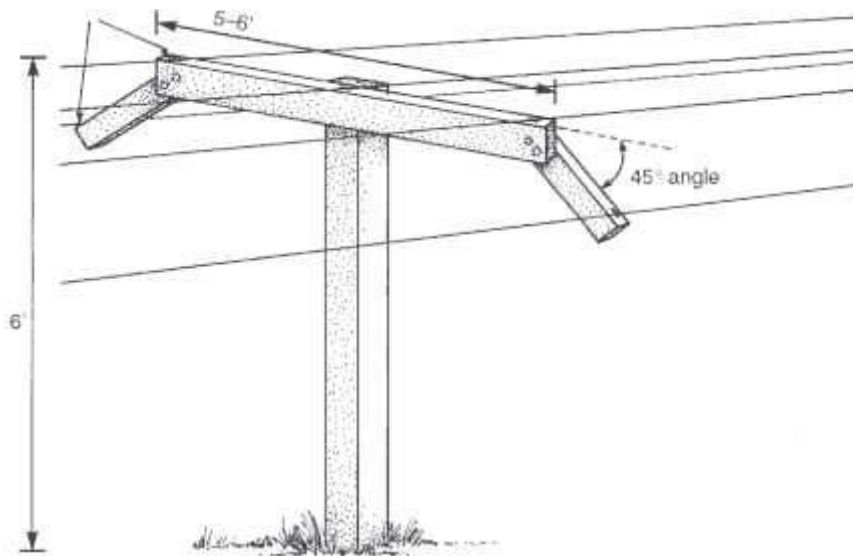
KIWI FRUIT

Training

- T-bar is the most common and preferred method for training of kiwifruit vines.
- In T-bar a spacing of 3 meters between rows and 5 meters between plants in each row is maintained for getting better fruit production of quality fruits.

Training on T-Bars

- In T-bar fence, the pillars of iron or concrete about 1.8 m in height above the ground level are erected at a distance of 5m from each other in a row.
- A cross arm (1.5m) is fixed on each pole, which carries outrigger wires.
- The laterals arising from the main branch are trained on these wires. A strongly growing shoot is selected as the main trunk to carry the vine up to the wire.
- The vine is staked to provide support and is tied at frequent intervals to prevent wind damage and to avoid the twisting of vine around the stake.
- As soon as the vine attains a height of 2 m or reaches the wire, one permanent leader/ arm is allowed to grow out in each direction along the centre wire.
- To achieve this, the leader is trained one way along the wire and a shoot slightly below the wire is selected and trained in the opposite direction as the second leader.
- Alternately, the main leader can be cut just below the wire to force the production of two leader growth, which can be trained as leaders in two opposite directions, along the wire.
- From the permanent leaders, fruiting arms 25-30 cm apart are selected at right angle along both sides of each leader.
- The first crop of fruit comes on these arms and later crop forms on laterals that develops from them.
- Fruiting arms should not be trained along outrigger wires, because shoots from then will compete with the fruiting arms which originate directly from the leader, result in a dense tangled growth which adversely affect management and performance of the vine.



Pruning

Kiwifruit vine bears fruit on current season's growth that originates from one year old wood. Only the basal buds at nodes 4 to 12 on the fruiting shoot produce fruits, so it requires open pruning, which allows access for pollinators during the flowering period, better penetration of sunlight and air movement around the vine.

The following principles should be kept in mind at the time of pruning kiwifruit vines:

- 1) The fruit is developed only on current season's growth arising from the bud developed in the previous year.
- 2) Only the basal buds of nodes 4 to 12 on current season's growth are productive.
- 3) Vine grows 2 to 3 m every year, which becomes overcrowded and trangled if not controlled by both summer and winter pruning.
- 4) The shoots developed on older wood by heading back will not fruit normally in the first season.

In the beginning, a lateral arising from main leaders is cut back in the winter so as to provide enough space for 4 to 5 fruiting shoots at an interval of 4-5 buds between two such shoots. Light summer pruning is done for shortening of fruiting arms, thinning out of criss-cross and shading shoots.

Dormant Pruning

- In dormant pruning, the fruiting lateral is cut back to two vegetative buds beyond the last fruit.
- In the second year, these vegetative buds will produce the fruiting shoots, which will be pruned again.
- The arms on lateral shoot are pruned and allowed to fruit for 3 and 4 years.
- After this the lateral is removed from the main branch and other laterals are selected and pruned accordingly so that the balance between vegetative and reproductive growth is maintained for the continuity in the fruit production.
- Dormant pruning is done during Jan-Feb. The cut portion of the shoots is pasted with Bordeaux paste.

- The shoots which grow from the first bud carries none or few flowers, thereafter, the number of flowers/shoot increases to a maximum of 4, 5, 6 which remain constant along the entire length of the left cane. The fruiting laterals which have lost their vigour and are overcrowded, are removed to encourage the development of new laterals.

Summer Pruning

- The summer pruning is done by shortening back of fruiting arms, thinning out of criss-cross tangled and shading shoots.
- The strong uprights or the shoots arising at undesirable points are pruned in spring when they have not grown too long.
- Summer pruning starts from spring continues throughout the growing season.

PERSIMMON

Training

- Persimmon is trained to modified central leader system
- The trees should be kept low headed by heading back at 45 cm from the ground while planting.
- Strong framework of 4-5 primary shoots with wide crotch angle should be developed around the trunk, above 30 cm from the ground.
- In the next two years secondary and tertiary branches should be developed.
- The plants should be staked to keep in a straight position, which helps in selecting the well-spaced laterals in the coming season.

Pruning

- The broken and interfering branches should be removed.
- After developing the proper framework of the tree, little or no pruning is needed except removing dead, diseased, broken and interfering branches.
- Old trees may be given severe pruning to regenerate new growth for regular production.
- Remove dried/diseased fruits and twigs regularly and burn them completely to reduce the disease and pest inoculum in the persimmon orchard.

PECANNUT

Training

- To get the proper shape and size, it is essential to carry out the training and pruning in pecan nut.
- In pecan nut, plants are generally trained to central leader system.
- The lowest branch should be kept to a height of 60 cm from the ground level.
- All 5-6 primary branches should be developed spirally at a distance 20-30cm from one above another.
- Wide crotch angle should be developed in between central leader and primary branches.
- During the initial 4 years of planting, frame work should be developed.

- After development frame work, light pruning on matured pecan nut trees should be done.
- Pruning should be done during winter months.
- Heavy pruning not recommended as it results in vigorous vegetative growth.
- Only damaged, dried and diseased wood should be removed.
- Overcrowded and intermingled branches should be thinned out.
- Central leader should be headed back at a 3 m height. Pecan nut is generally pollinated by wood.

Pruning Process

The pruning of fruit tree is one of the most important activities in determining the yielding capacity of the tree. Its importance relies on four aspects:

- To develop a strong and sturdy framework
- To maintain the desired shape of the tree for light interception, fruit development and easy operations
- To manage the balance between vegetative and generative growth of the tree
- To control pests and diseases

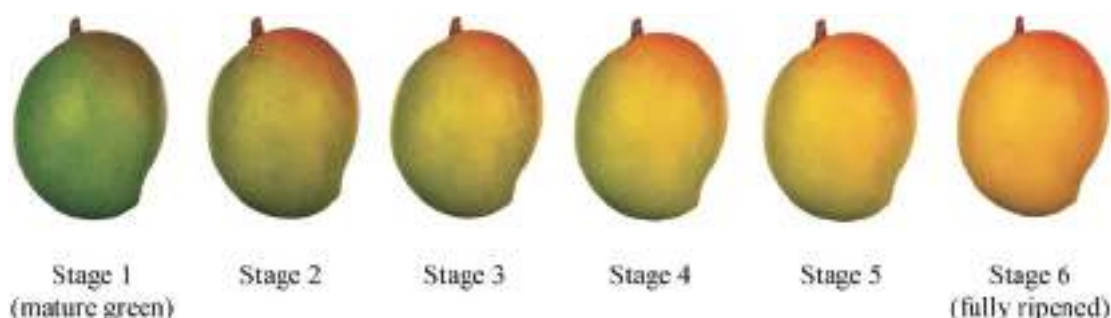
Chapter – 5

MATURITY INDICES, HARVESTING AND POST-HARVEST MANAGEMENT

MANGO

Maturity Indices

- Slight colour development on the shoulder
- When one or two ripe fruits fall from the tree naturally (Tapka stage)
- Specific gravity of the fruit should be in the range between 1.01 and 1.02
- White powdery like appearance on skin of mature mango.
- Change in fruit shape (fullness of the cheeks)
- Change in skin color from dark-green to light-green to yellow (in some cultivars)
- TSS 12-15 % is optimum.
- Change in flesh color from greenish-yellow to yellow to orange.



COLOUR CHANGES AT MATURITY

Harvesting

- Harvesting is done by hand picking
- For export, approximately 1.0 cm fruit stem/pedicel is cut along with fruit with the help of sharp scissors. Then fruits are kept upside down for two hours so that the latex flows out from the fruit completely.

Grading

The export quality mangoes are categorised into three grades:

- Category-I: 200-250g
- Category-II: 251-300g
- Category-III: 301-350g

Washing

Fruit should be washed and dipped in water containing fungicide for the control of post-harvest diseases.

Ripening

Mango does not normally need any post-harvest ripening treatment for local marketing. It is a general practice to harvest fruits early in the season (premature stage) to capture early market. These fruits do not ripen uniformly without ripening aid. Such fruits could be ripened uniformly using Ethrel in a ripening chamber.

Packaging

- CFB boxes of 5kg and 10kg capacity are used for packing and shipping of mango fruits for domestic markets as well as export purposes.
- Paper scraps, newspapers, are commonly used as cushioning material for packaging of fruits.
- Wrapping of fruits individually in honeycomb nets help in getting optimum ripening with reduced spoilage.



Storage

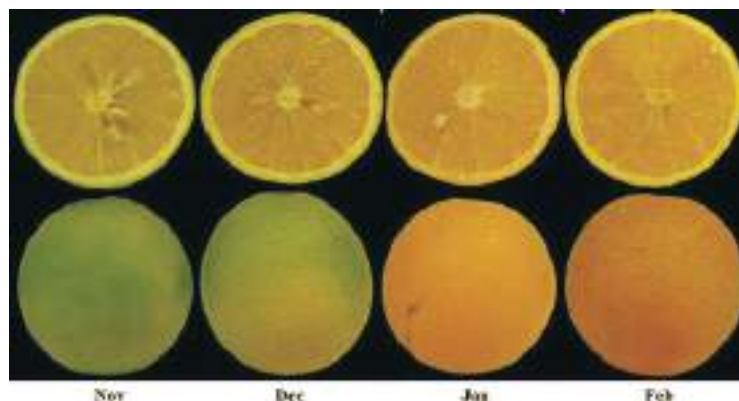
- The mature green fruits can be kept at room temperature for about 4-10 days depending upon the variety.
- For exports, harvested fruits are pre-cooled at 10-12°C and then stored at an appropriate temperature.
- The fruits of Mallika at 12°C, Langra at 14°C and Chausa at 8°C with 85-90% relative humidity can be stored for 3-4 weeks.

SWEET ORANGE

Maturity indices

- Sweet orange fruits should be harvested when they have attained adequate size and 12:1 (TSS: Acid ratio) in juice.
- The time for picking different cultivars varies from end of October to 1st week of February.

- In Mosambi, rind colour is pale yellow or whitish, while in Blood Red variety colour of rind is fully red & ratio is 10:1.



Maturity indices for Sweet Oranges

Harvesting

- Harvesting season varies within the states as well as locality and the cultivars.
- Harvesting is done with a clipper retaining a non-protruding short fruit stalk on the branch.
- Harvesting during early hours of the day when there is dew on fruits and harvesting immediately after rains should be avoided.
- The Light green colour of the rind should not exceed one fifth of the total surface area of the fruit for transportation to remote areas.

Grading

The sweet orange fruits are graded as per the size into small, medium and large grades depending upon the cultivars.

Packaging

Citrus fruits are packed in CFB. Corrugated trays quite effective as packaging material while transporting the fruits.



Storage

- Fruits treatment with Bavistin @ 100 mg/litre reduces post-harvest losses and extends the shelf life to 25-30 days at room temperature.

- The ideal storage temperature for sweet orange is 6-8⁰ C at 85-90% relative humidity.

Litchi

Maturity Indices

The litchi fruits must be harvested at appropriate maturity time for sending to distant and local markets. Litchi is a non-climacteric fruit and therefore it does not ripen after harvesting. The fruits harvested at immature stage do not ripen properly and develop insipid taste.

- Skin colour is the most reliable indicator for assessing harvest maturity. The fruit is said to be ready for harvesting when the pericarp becomes uniform red and the protuberances have become smoother.
- For local market, the fruits should be harvested at full maturity whereas for distant markets harvesting should be done when fruits start developing rose to pink colour.
- At maturity, the tubercles on litchi fruit become less pointed and the fruits attain maximum size.
- The ideal TSS: acid ratio for harvesting of the litchi fruits is 40 or above.



Harvesting

- The fruits are harvested in bunches along with twigs having leaves. This enhances storage life of the fruits.
- The harvesting time of litchi is during peak summer season therefore, the fruits are picked early in the morning after drying of the dew.
- The harvested fruits are stored in shade to avoid discoloration.
- Harvesting during the rains is avoided as the wet fruits are damaged early.

Grading

The quality of litchi for export should be:

- Fruit sound, fresh in appearance, clean, free from any visible foreign matter, free from pests and damage and abrasion.
- Should have minimum equatorial diameter of 23 mm.

Packaging

- The litchi bunch must include more than three attached and well-formed fruits. The branch must not exceed 15 cm in length.
- The fruits are packed in wooden boxes, baskets or cardboard boxes for sending to local or distant markets.
- Cardboard boxes are generally used for export of litchi fruits.
- The most commonly used packing size for litchi fruits is 10-20 Kg/ pack. Each bunch inside a box is packed separately.

Storage

- Litchi fruits can be stored at room temperature for 3-4 days, thereafter, the fruits start turning brown.
- The fruits can be stored for 3-5 weeks by packing in perforated polythene bags at 90- 95 % relative humidity.
- Fruits treated with 2.0% sodium hypochlorite can be stored satisfactorily in perforated polythene bags at 0-30⁰ C for 25 days.
- Controlled atmosphere storage (3-5% O₂ and 3-5% CO₂) reduces skin browning and slows down the losses of ascorbic acid, acidity, and soluble solids. Exposure to oxygen levels below 1.0 % and/or carbon dioxide levels above 15% may induce off-flavors and dull grey appearance of the pulp.

GUAVA

Maturity Indices

- TSS: acid ratio ranging from 26.0-36.0 with specific gravity <1.0 and light green to yellow colour depending upon variety.
- Harvesting should be done through hand picking with staggered harvest as per maturity of fruits.

Grading

The fruits are mostly graded as per the size and colour.

Packaging

- For local markets fruits are packed in baskets/crates, whereas for distant transportation fruit are packed in corrugated fibre boxes with proper cushioning using paddy straw/dried grass/guava leaves/rough paper etc.
- Being a delicate fruit, it requires careful handling during harvesting and transportation with proper ventilation.

Storage

- The shelf life of guava is short, therefore, proper storage for long distant market is required.
- Mature green and partially ripe guavas are stored at 8-10⁰ C for 2-3 weeks while fully ripe guavas can be stored at 5-8 ⁰ C for 1 week at 90-95% relative humidity.

POMEGRANATE

Maturity indices

Being a non-climacteric fruit, pomegranate fruits should be harvested after achieving proper maturity.

Maturity Indices	Attributes
Fruit Colour	Reddish with waxy shining surface
Shape of crown and fruit	The bud at the anterior end of the fruit gets curved inside and becomes hard and dry at maturity. The fruit shape becomes compact.
Sound	The fruit gives a metallic sound when tapped.
Scratch	Properly mature fruits are easily scratched with finger nails
Maturity Period	The fruits become ready for harvest in 170-180 days after full bloom.
Aril Colour	The arils attain deep intensity of colour (Dark red- Bhagwa) with high juice recovery
Juice Colour	Red colour of juice in Bhagwa
TSS	12-14° Brix
Titrateable Acidity	Below 0.8%
TSS/acid ratio	It is one of the most reliable maturity indicators. Mature fruit have TSS/ acid ratio between 25 to 40



Harvesting and packaging

- Secateurs are used for fruit harvesting at maturity.
- After harvesting, the fruits should be collected in plastic crates and should be pre-cooled to remove the field heat and enhance the shelf life. Then, the fruits are graded and packed in Corrugated Fibre Board boxes.

Grading

The fruits are graded on the basis of their size, external appearance and quality.

Size code	Weight in grams (minimum)	Diameter in mm. (minimum)	Skin Colour and quality
A	400	90	Good attractive bright red colour and no spots on skin
B	350	80	Attractive red colour and spot free
C	300	70	Bright red and spot free
D	250	60	Fully ripe bright red and spot free
E	200	50	Fully ripe bright red and spot free

Packing

The pomegranates fruits are packed in white or red colored CFB boxes having 3-5 plies for domestic markets. The cut pieces of waste of newspaper are used as cushioning material for the fruits.



Storage

Pomegranate fruit can be stored for 2-3 months successfully at a temperature of 5-7°C with 90-95% relative humidity. This temperature range needs to be kept throughout the transport and further storage. The temperature should never go below the 5°C, otherwise it will result in chilling injury.

KIWIFRUIT

Maturity Indices

- A maturity index of 6.2% total soluble solids is found satisfactory.

Days from full bloom to harvest (DFFB) for different kiwifruit cultivars are used to predict the optimum picking date.

Days from full bloom to harvest for different kiwifruit cultivars.

Cultivar	DFFB to harvest
Allison	193±4
Abbott	190 ± 4
Bruno	182±4
Monty	192±4
Hayward	202 ±4

- Besides this, at optimum maturity the hair present on the fruit skin can be removed very easily, which can also be used to judge the picking maturity.



Harvesting

- It takes atleast 4 to 5 years for a kiwifruit vine to start bearing worthwhile crop and about 8 to 10 years are required to reach full commercial production.
- Kiwifruit are readily harvested by snapping off their stalks at an abscission layer which forms at the base of the fruit. Fruit stalks remain on the vine.
- At least two pickings are normally made. The larger fruits are harvested first and the smaller fruits later having had the chance to improve in size and quality.
- The fruits are transported to the market in hard (High firmness) conditions which subsequently loose their firmness in about two weeks at room temperature to become edible.

Grading

- Kiwifruit is graded on the basis of fruit size and weight.

- In the international market, fruit weight of 70 g is minimum whereas, the fruit having 100 g weight are preferred.

Packaging

- Cardboard boxes of 3-5 kg capacity are used for packing of kiwifruit.
- For export, the fruits are wrapped in poly films, packed in trays.
- 33 fruits of uniform size weighing 100 -105 g are accommodated in a tray.



Storage

- Kiwifruit has a long shelf life which can be extended further with timely picking and good storage.
- The fruits can be stored up to 8 weeks in cool and dry place at room temperature.
- The fruits can be stored for 4 to 6 months at a temperature of 0°C and 90% relative humidity.



PERSIMMON

Maturity Indices

- Fruit skin colour changes from green to orange or to yellowish-green or yellow
- TSS should range between 18-19⁰ B.

**Harvesting**

- Clip the fruit with secateurs from the tree and calyx should remain attached to the fruit.
- The fruit must be harvested carefully to avoid blemishes and bruises, as they reduce the market value of the fruit.
- Fruits must be harvested in two to three pickings, depending upon the fruit size and colour.
- Persimmon can be harvested in the month of August to October depending upon the altitude.

Grade, sizes and packing

- An ideal size of persimmon fruit cultivar Fuyu ranges between 220-250 g and 150 g is minimum marketable size.

Fruit counts:

- Fruit counts range from 12 to 28 pieces of fruit per tray with most fruit packed to a count of 16 to 20 with an average weight of 3.5- 4.6 kg per tray. Larger fruit e.g. counts of 12 when packed into smaller tray will generally produce higher tray weights i.e., 4.6 kg.

Count sizes:

- 4.0 kg tray can accommodate - 12, 14, 16, 18, 20, 23, 25, 28 fruits
- Small sized fruits (25 or 28 per tray)
- Medium sized fruits (20 or 23 per tray)
- Large sized fruits (12 to 18 per tray)
- Smaller fruit are packed loose in 10 kg containers.

Storage

- Persimmon is sensitive to chilling at temperatures less than 5°C will shows flesh browning and softening.
- Persimmon fruits can be stored for 2-3 months at 0-2 °C temperature, with 90-95 % relative humidity.

Chapter-6

SOIL AND LEAF SAMPLING

- Soil samples to determine the availability of macro and micro nutrients and salt content can be taken any time of the year.
- Taking soil samples every year is usually adequate in high density plantation. In recently planted orchards, annual sampling may be done until the soil fertility program is established.
- To monitor available nutrients over the years, samples should always be taken during the same season.
- For soil nitrate analyses, samples should be taken in spring/early summer before the period of high nitrogen uptake by the trees.
- Samples need to be taken before fertilizer is applied.

Sampling procedure

- Divide each field into blocks based on soil survey data, slope, cropping history, variety, rootstock, age, growth pattern, or irrigation system.
- Plant residue from the sample spot is removed.
- Samples are best taken with a soil probe or auger.
- The sample is taken halfway between the trunk and the drip line and within the wetting zone of the sprinkler/emitter (Figure 1).
- Cores are taken from the entire area of the field or management area in a W-shaped sampling pattern or by walking a zigzag course around or through the orchard.
- Mix the cores thoroughly; remove large stones, pieces or roots and other foreign material.
- Sample by foot increments to a depth of 2 feet. When diagnosing a problem, deeper cores may be recommended.
- To obtain an accurate estimate of the nutrient availability, between 15 and 20 cores should be taken from each block for a composite sample.
- One sample per tree is generally taken. Within each block, make sure to sample different orientations relative to the trunk.
- Collect the samples in a clean plastic bucket. Galvanized or rubber buckets may contaminate samples with zinc.

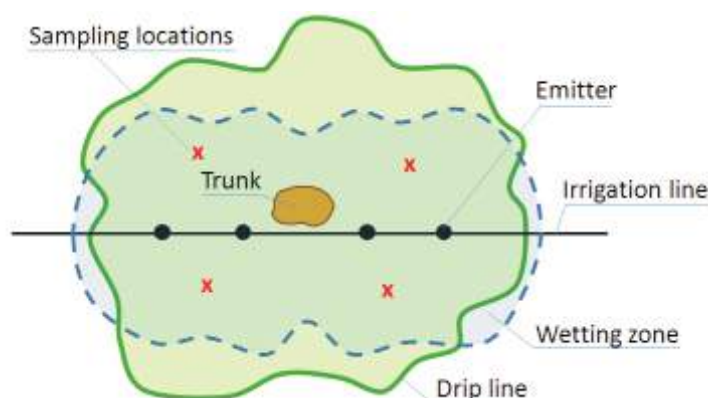


Figure 5.1: Bird's view of the optimal sampling location under orchard trees.

Sample handling

- When all the cores for an area are taken, mix them thoroughly.
- Very wet samples should be air-dried before packaging. Do not dry the samples in an oven or at abnormally high temperature.
- Put about 500 grams of soil in a clean bag and label it clearly. Follow the instructions of the laboratory that will do the analysis.
- To receive accurate fertilizer recommendations, the sample information sheet needs to be filled out carefully. Include the information sheet within the package submitted to the test lab.

Leaf tissue analysis

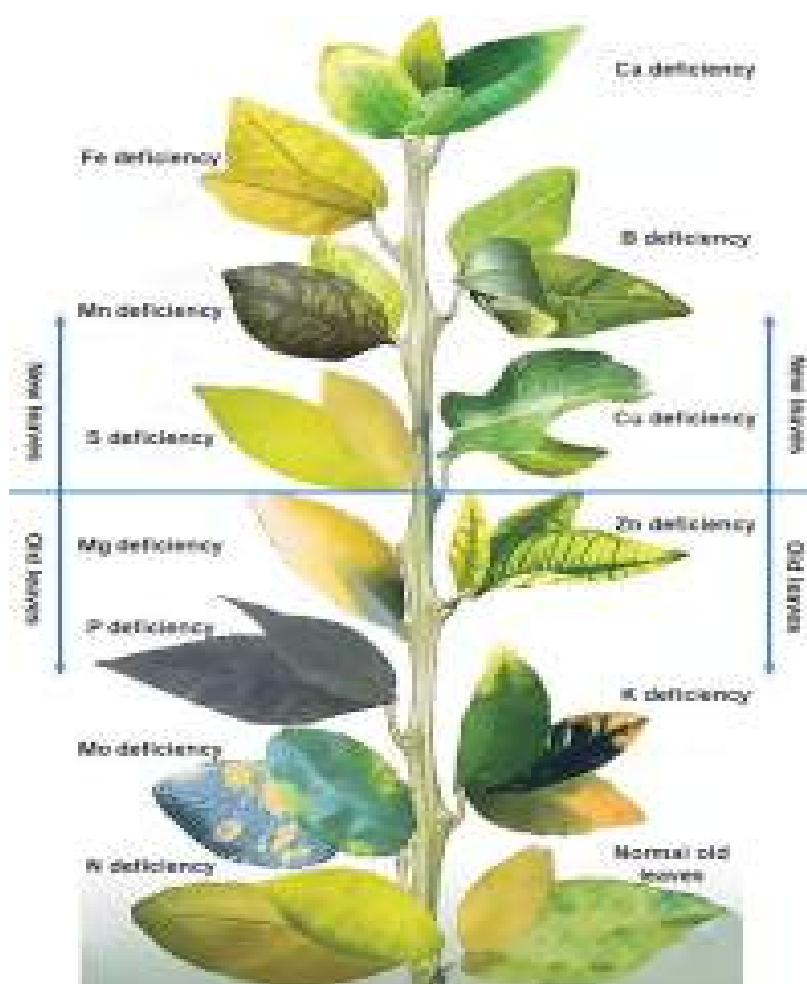
Analyzing leaf tissue is one of the most valuable and standardized tools to diagnose nutrients and/or monitor the nutritional status of any orchard. To effectively evaluate leaf tissue nutritional analyses, it is important to understand what it can and cannot tell us, and how to interpret results.

Generalized symptoms of nutrient deficiency and excess in fruit crops

Element/status	Visual symptoms
Nitrogen (N) Deficiency	Light green leaf and plant colour with the older leaves turning yellow, leaves that will eventually turn brown and die. Plant growth is slow, plants will be stunted, and will mature early.
Excess	Plants will be dark green in colour and new growth will be succulent; susceptible, if subjected to disease and insect infestation; and subjected to drought stress, plants will easily lodge. Blossom abortion and lack of fruit set will occur.
Ammonium toxicity	Plants fertilized with ammonium-nitrogen (NH ₄ -N) may exhibit ammonium toxicity symptoms, with carbohydrate depletion and reduced plant growth. Lesions may occur on plant stems, there may be a downward cupping of the leaves, and a decay of the plants under

	moisture stress. Blossom-end rot of fruit and Mg deficiency symptoms may also occur.
Phosphorus (P) Deficiency	Plant growth will be slow and stunted, and the older leaves will have a purple coloration, particularly on the underside.
Excess	Phosphorus excess will not have a direct effect on the plant, but may show visual deficiencies of Zn, Fe and Mn. High P may also interfere with the normal Ca nutrition, with typical Ca deficiency symptoms occurring.
Potassium (K) Deficiency	On the older leaves, the edges will look burned, a symptom known as scorch. Plants will easily lodge and be sensitive to disease infestation. Fruit and seed production will be impaired and of poor quality.
Excess	Plants will exhibit typical Mg, and possibly Ca deficiency symptoms due to a cation imbalance.
Calcium (Ca) Deficiency	The growing tips of roots and leaves will turn brown and die. The edges of the leaves will look ragged as the edges of emerging leaves stick together. Fruit quality will be affected with the occurrence of blossom-end rot on fruits.
Excess	Plants may exhibit typical Mg deficiency symptoms, and when in high excess, K deficiency may also occur.
Magnesium (Mg) Deficiency	Older leaves will be yellow in colour with interveinal chlorosis (yellowing between the veins) symptoms. Plant growth will be slow and some plants may be easily infested by disease.
Excess	Results in a cation imbalance showing signs of either a Ca or K deficiency.
Sulfur (S) Deficiency	A general overall light green colour of the entire plant with the older leaves being light green to yellow in colour as the deficiency intensifies.
Excess	Leaf tips and margins will turn brown and die.
Copper (Cu) Deficiency	Plant growth will be slow and plants stunted with distortion of the young leaves and death of the growing point.
Excess	A Fe deficiency may be induced with very slow growth. Roots may be stunted.
Iron (Fe) Deficiency	Interveinal chlorosis will occur on the emerging and young leaves with eventual bleaching of the new growth. When severe, the entire plant may be light green in colour.
Excess	Bronzing and tiny brown spots on the leaves.
Manganese (Mn) Deficiency	Interveinal chlorosis of young leaves while the leaves and plants remain generally green in colour. When severe, the plants will be stunted.

Excess	Older leaves will show brown spots surrounded by a chlorotic zone and circle.
Molybdenum (Mo) Deficiency	Symptoms will frequently appear similar to N deficiency. Older and middle leaves become chlorotic first, and in some instances, leaf margins are rolled and growth and flower formation are restricted.
Excess	Not of common occurrence.
Zinc (Zn) Deficiency	Upper leaves will show interveinal chlorosis with an eventual whiting of the affected leaves. Leaves may be small and distorted with a rosette form.
Excess	Fe deficiency will develop.



Visual symptoms of some important physiological disorders

Leaf sampling technique

Various techniques like visual symptom logy, leaf analysis, soil testing etc. are being used to determine the nutritional requirements of fruit trees in different fruit growing zones. It is very difficult even today to calculate the requirement of fertilizers/micronutrients in different fruits at different ages and productivity levels.

Leaf analysis has several advantages over other methods:

- The leaf analysis gives an exact picture of the nutrient content at given time, from which a relationship with production can be drawn.
- All the essential nutrients act in definite equilibrium in a fruit. Individual nutrient's presence or deficiency may not be related to the total quantity of that particular nutrient in the fruit tree.
- Leaf analysis help in understanding the internal functions of nutrients in a given fruit crop.
- It confirms the deficiency detected by visual symptoms.
- One can distinguish nutrients which have similar deficiency symptoms. Leaf analysis helps in ascertaining that applied nutrient have entered in the plant system or not. It helps in the determination of toxicity of some nutrients.

Procedure for collection of leaf samples:

Leaf tissue sampling has been identified as the most validated indicator of tree fruit nutrient status and cost effective, having the best compromise between sensitivity and stability for most mineral elements. The most stable nutrient concentration has been determined to be on recently mature leaves from nonbearing spurs or new shoots, obtained between the end of active shoot growth and nutrient relocation to shoots and roots.

Make sure to collect enough samples that represent the area that you want to analyze. The general recommendation is 50 leaves in a maximum of two hectares if the block is fairly homogeneous. Do not mix different species, cultivars, young and old blocks. Do not sample from too old or too young leaves, too vigorous or weak shoots, or dirty tissue that show things like insect or bird droppings. Samples should be collected at least 15 days after a foliar nutrient spray, or take into account the latest spray application when interpreting the results. In addition, some pesticides or protectants might contain mineral elements such as Zn, Cu, S, Ca and/or B. If it is not possible to avoid recently sprayed leaves make sure the laboratory knows about the condition, so they pay extra attention in processing the sample and keep it in mind when interpreting the results.

Samples should be collected in paper bags to avoid condensation. Keep cool before sending to the laboratory. Label each sample properly according to the laboratory requirements and submit within 24 hours of sampling. The accuracy of leaf analysis depends upon the leaf age, its position and time of sampling. Some specific guide lines for individual fruits have been worked out for different fruits as given below:

Sr. No.	Crop	Plant part, and growth stage	Sample Size (Number of Leaves)
1	Mango	4-5 months old leaves petiole from middle of shoot.	50
2	Citrus	3 to 5 months old leaves from new flush.	50
3	Guava	Third pair of recently matured leaves with the petiole from the end of the branch.	50
4	Litchi	Second pair of leaflets from tip from autumn flush 6 th month-old.	100
5	Pomegranate	8 th leaf pair from apex.	100
6	Plum	Mature leaves from mid-shoot of current growth	50
7	Kiwifruit	10 th to 14 th week after flowering.	50
8	Persimmon	Mature leaves from mid-shoot of current growth. The standard leaf sampling period is February/March.	50
9	Pecan nut	Collect at least 100 middle pairs of leaflets from the middle leaf of the current growth.	100

Chapter-7

IRRIGATION AND FERTIGATION

In high density plantations, orchard needs to be equipped with a drip irrigation system. By using a drip irrigation system, we can irrigate the trees as per requirement. This saves 50% of water and 30% savings in fertilizers. It saves electricity, labor and reduces the impact of weeds. Irrigation is required in varied amount at different stages of plant growth. High density fruit trees need to be irrigated as per irrigation scheduling procedure to thrive well and bear fruits every year. The need for water varies according to the type of soil, climate, age of the tree, and growth stage of the tree. Therefore proper water management is needed.

- Therefore, it is better to irrigate by drip irrigation method when required and as much as needed. When water is given by the drip irrigation method, moisture remains in the soil for a long time. So the plant grows well.
- When water is given by drip irrigation system, water particles move vertically than horizontally; hence root zone of plants remained moist always, or the root zone part of the soil is always at field capacity, which is necessary for the growth of plants.
- A drip irrigation system provides controlled watering as per the requirement of the plant; This saves 50% of water and electricity, and labor.
- Applying fertilizer through drip irrigation through fertigation tank/venturi saves up to 30% of fertilizer quantity.



Nutritional disorders generally cause a reduction in yield, fruit quality, or both before visible symptoms develop. An effective fertility management program involves preparing the site

before planting and monitoring the nutritional status of the orchard throughout its life to detect nutrient deficiencies, toxicities, and imbalances before they become yield- or quality-limiting. It should include all of the following:

- Do routine sampling on orchards to detect trends in the nutrient content of the trees.
- Troubleshoot – Sample suspected problem areas separate from routine areas to help confirm or deny nutritional disorders. Collect separate samples from affected trees and unaffected trees of the same age, variety, and rootstock for comparison.
- Keep good records on yield and quality. Be sure to include information on the amount and analysis of fertilizer applications.
- Observe leaf color and the amount of vegetative growth may be indicators of potential problems. If you observe differences, be sure to mark problem trees to enable you to find them when you come back to take leaf samples.

High density fruit trees need to be fertilized round the year to thrive and bear fruits every year. Depending upon the age of the crop, organic manure (FYM) and chemical fertilizers should be applied. Therefore proper nutrition management is needed. While planting, a basal dose is given when the pits are open. Fertigation is a suitable method of fertilizing high density orchards. This saves water, labor, and fertilizers and makes it possible to increase production through effective and efficient use. The application of fertilizers at different stages of crop growth increases the yield. Fertigation with water-soluble fertilizers has a good effect in different stages of the plant. Fertilizers do not degrade, waste, or evaporate when applied by the fertigation mechanism.

A. Procedure to calculate the amount of the pure element. Example: Nitrogen

- Quantity of pure nitrogen per month: 50 kg per hectare.
- Total days in the month: 30 days.
- Quantity of pure nitrogen per day: $50/30 = 1.66 \text{ Kg/ha/day}$

B. Procedure to calculate how many liters of liquid fertilizer will be needed

- For 100 liters of final mixture (water and fertilizer) 20 Kg of urea or ammonium nitrate equivalent, 27.8 Kg are dissolved.
- That amount of urea or ammonium nitrate represents 9 Kg of pure nitrogen ($20 \text{ Kg} \times 45\%$, or $27.8 \times 33\%$).
- If in 100 liters of liquid fertilizer there are 9 Kg of pure nitrogen, it follows that 1 (one) kg of pure nitrogen equals 11.1 liters of the mixture ($100/9 = 11.1$).
- Size of the plot to be irrigated: 20 hectares.
- Total injected liquid fertilizer every day will be:
- Total hectares $\times$ kg of pure nitrogen in irrigation $\times$ liters of fertilizer per kg of pure nitrogen = $20 \text{ ha} \times 1.66 \text{ kg N per irrigation} \times 11.1 \text{ liters} = 368 \text{ liters of fertilizer per irrigation}$.

C. Required duration of irrigation

- Daily evaporation rate as Class "A" is 8 mm.
- Replacement coefficient (K_c) = 0.8
- Amount of water to irrigate per day = $8 \text{ mm} \times 0.8 = 6.4 \text{ mm}$ or 64 m^3 per hectare.
- Run time per day = Total water to irrigate in mm / irrigation/Hourly capacity in mm / hour = $6.4 \text{ mm} / 1.0 \text{ mm per hour} = 6 \text{ hours } 24 \text{ minutes}$.
- However, as it is irrigated every other day, irrigate duration should be set for 12 hours and 48 minutes.

D. Required injection time

- In this example, the fertilizer injector is capable of injecting 100 liters per hour.
- Total fertilizer to be injected is 368 liters (step B).
- Time to be injected: $368 \text{ liters fertilizer} / 100 \text{ liters per hour} = 3.68 \text{ hours}$ (3 hours and 40 minutes).

Chapter-8

OPERATION AND MAINTENANCE OF IRRIGATION & FERTIGATION SYSTEM

Drip irrigation is application of water in small quantity at the rate of mostly less than 4-5 lph as drops to the zone of the plants through a network of plastic pipes fitted with emitters. Drip irrigation in its present form has become compatible with plastics that are durable and easily moulded into a variety and complexity of shapes required for pipe and emitters.

Merits

- Increased water use efficiency
- Better crop yield
- Uniform and better quality of the produce
- Efficient and economic use of fertiliser through fertigation
- Less weed growth
- Minimum damage to the soil structure
- Usage in undulating areas and slow permeable soil
- Low energy requirement (i.e.) labour saving
- High uniformity suitable for automization

Demerits

- Clogging of drippers
- Chemical precipitation
- Salt accumulation at wetting front

Components and its selection for a typical drip irrigation

1. Water source tank

The capacity of the tank is calculated from the water requirement of the crop, dripper capacity, type of soil etc.

2. Pump/Overhead Tank:

It is required to provide sufficient pressure in the system. Centrifugal pumps are generally used for low pressure trickle systems. Overhead tanks can be used for small areas or orchard crops with comparatively lesser water requirements.

3. Filters:

The hazard of blocking or clogging necessitates the use of filters for efficient and trouble free operation of the micro-irrigation system. The different types of filters used in micro-irrigation system are described below.

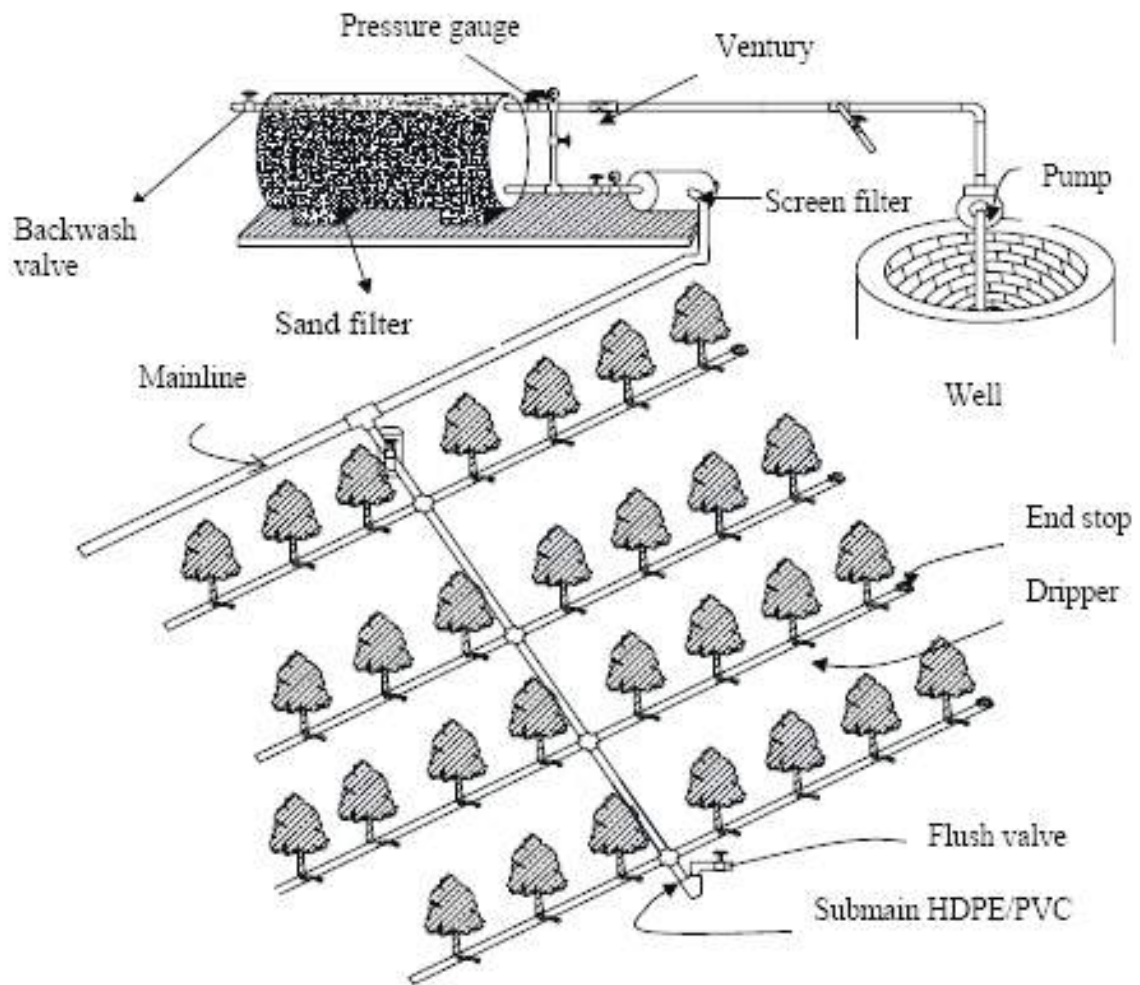


Fig. 1.1 Components of Microirrigation System

a) Gravel or Media Filter:

Media filters (gravel or sand) are necessary for any surface water source. This filter includes a flushing system for washing the gravel or sand and returning the dirt to the water source. Media filters consist of fine gravel or coarse quartz sand, of selected sizes (usually 1.5 – 4 mm in diameter) free of calcium carbonate placed in a cylindrical tank. These filters are effective in removing light suspended materials, such as algae and other organic materials, fine sand and silt particles. Water is introduced at the top, while a layer of coarse gravel is put near the outlet bottom. Reversing the direction of flow and opening the water drainage valve cleans the filter. Pressure gauges are placed at the inlet and at the outlet ends of the filter to measure the head loss across the filter. Fig. 1.2 shows different types of media filters.



Fig. 1.2 shows different types of media filters.

- b) **Screen Filters:** Screen filters are always installed for final filtration as an additional safeguard against clogging. The screen filter, containing screen strainer, which filters physical impurities and allows only clean water to enter into the micro irrigation system (Fig. 1.3). The screens are usually cylindrical and made of non-corrosive metal or plastic material.



Fig.1.3 Screen filter showing steel wire mesh strainers

- c) **Centrifugal Filters:** Centrifugal filters are effective in filtering sand, fine gravel and other high density materials from well or river water. Fig.1.4 shows different types hydro cyclone/centrifugal filters.



Fig.1.4 Centrifugal filters

- d) **Disk Filters:** Disk filter (Fig. 1.5) contains stacks of grooved, ring shaped disks that capture debris and are very effective in the filtration of organic material and algae. Back flushing can clean disk filters.



Fig.1.5 Disk filter showing stacks of discs

4. Pressure relief valves, regulators or bye pass arrangement:

These valves may be installed at any point where possibility exists for excessively high pressures, either static or surge pressures to occur. A bye pass arrangement is simplest and cost effective means to avoid problems of high pressures instead of using costly pressure relief valves.

5. Check valves or non-return valves:

These valves are used to prevent unwanted flow reversal. They are used to prevent damaging back flow from the system to avoid return flow of chemicals and fertilizers from the system into the water source itself to avoid contamination of water source.

6. Distribution Network:

It mainly constitutes main line, sub-mains line and laterals it drippers and other accessories.

- a) **Mainline:** The mainline transports water within the field and distribute to submains.
- b) **Sub-mains:** Submains distribute water evenly to a number of lateral lines.
- c) **Laterals:** Laterals distribute the water uniformly along their length by means of drippers or emitters.

- d) **Emitters/Drippers:** They function as energy dissipaters, reducing the inlet pressure head (0.5 to 1.5 atmospheres) to zero atmospheres at the outlet. The commonly used drippers are in-line drippers. These are fixed along with the line, i.e., the pipe is cut and dripper is fixed in between the cut ends, such that it makes a continuous row after fixing the dripper.

Water quality for drip irrigation

- The quality of water for irrigation relates to the parameters required to maintain the crop's health and the integrity of the irrigation system. Every type of pressurized irrigation system requires attention to the water quality to avoid clogging of the irrigation components in order to enable orderly long-term irrigation according to the irrigation program.
- Water quality will dictate filtration requirements, chemical injection requirements, and management of the irrigation systems to prevent dripper clogging.
- Causes of dripper clogging in systems may be chemical (precipitates or scale), physical (grit or particulates such as sand and sediment) or biological (such as algae or bacteria).
- The quality of the water is determined by a wide variety of parameters (measured or calculated) affecting the crop, the soil and the irrigation system. Some of them are listed below:

EC (electrical conductivity)	Alk (alkalinity)	Mn (manganese)
pH (level of acidity or alkalinity)	Cl (chloride)	TSS (total suspended solids)
Ca (calcium - hardness of the water)	SO₄ (sulfate)	TDS (totally dissolved solids)
Mg (magnesium)	PO₄ (phosphate)	Turbidity
Na (sodium)	N-NH₄ (nitrogen-ammonium)	Algae and Chlorophyll
K (potassium)	N-NO₃ (nitrogen-nitrate)	BOD (biochemical oxygen demand)
HCO₃ (bicarbonate)	B (boron)	COD (chemical oxygen demand)
CO₃ (carbonate)	Fe (iron)	VSS (volatile suspended solids)

Fertigation:

Fertigation involves the application of fertilizers with irrigation water at a slow and controlled rate to meet nutritional requirements at different stages of crop growth. Fertilizers are used accurately and efficiently. Under this system, the fertilizers can be applied in splits and thus

such applications result in increased crop yields with substantial savings in fertilizer and irrigation water. The application of liquid fertilizers makes the nutrients continuously available to the plants. Water soluble fertilizers should be applied to avoid precipitation, clogging and damage to the components of the system.

1. **Mixing and dissolving the fertilizer:** When applying a liquid fertilizer, it is not necessary to stir it or mix it. Most solid fertilizers, on the other hand, need to be mixed with water to become a liquid fertilizer and if necessary, need to be separated to prevent problems such as precipitation.
2. **Controlling the amount of fertilizer:** It is necessary to control the dosage when applying the fertilizer, the appropriate concentration of fertilizer should be about 0.1% of the irrigation flow. If the irrigation flow is 50 m³ per 1000 m², then the amount of fertilizer use should be about 50 liters per 1000 m²; excessive use of fertilizer may cause the crops to die and lead to environmental pollution.
3. **The fertigation process can be broken down into three stages:** In the first stage, the soil is moisturized with unfertilized water; in the second stage, a liquid fertilizer is added to the irrigation flow and irrigation begins; in the third stage, the irrigation system is cleaned with unfertilized water.
4. **Standard procedure for assessing performance**
 - Check installation according to approved design layout
 - Start the pump
 - Flush the filters
 - Allow the drip system to be loaded with water for 10 min.
 - Note the pressure from the pressure gauge at the inlet and outlet of sand and screen filters
 - Record the dripper discharge as per the format
 - The discharge and pressure readings have to be taken in the below mentioned locations
 - First, Middle and Last Dripper of a lateral
 - For laterals at beginning, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and end of sub main
 - Laterals on anyone side of the sub main can be selected in case of plain land or alternative laterals on either side in case of slight slope in the direction along the lateral
 - Measure the pressure at start and end of laterals
 - If the Emission Uniformity is less than 85 % then the issue has to be taken up with the Drip Irrigation System Designer
 - Modifications have to be taken accordingly.

Maintenance of drip irrigation system

The maintenance of drip irrigation system is very essential for its successful functioning.

Sand filter: Backwash the sand filter to remove the silt and other dirt accumulated. Backwash allows the water to come out through the lid instead of backwash valve. Stir the sand in the filter bed upto filter candle without damaging them. Whatever dirt is accumulated deep inside the sand bed, will get free and goes out with the water through the lid. Backflush sand filter every day before starting the system and possibly before stopping irrigation

Screen filter: Open the flushing valve on the filter lid so that the dirt and silt will be flushed out. Open the filter and take out the filter element. Clean it in flowing water. Take out the rubber seals and clean them from both sides. Care should be taken while replacing the rubber seals, otherwise they might get out.

- a. Clean screen filter everyday
- b. Open the drain valve to remove impurities before cleaning
- c. Use thin water jet / nylon brush to clean the filter element
- d. Do not use stones to rub the screen surface
- e. Check for any mechanical damage
- f. Never use the system without filter element inside filter

Daily Maintenance:

- a. Clean the sand and screen filters for 5 minutes before starting the system
- b. Ensure all drippers are working properly without any leakage
- c. Before stopping irrigation, backwash the sand filter for about 5 minutes

Weekly Maintenance:

- a. Clean the sand filter by hand
- b. Flush the sub main by opening the flush valve for 5 minutes
- c. Flush laterals for 5 minutes at a time

Monthly maintenance:

Chemical treatment: Clogging or plugging of drippers may be due to precipitation and accumulation of certain dissolved salts like carbonates, bicarbonates, iron, calcium and manganese salts. The clogging is also due to the presence of microorganisms and the related iron and sulphur slimes due to algae and bacteria. The clogging is usually avoided/cleared by chemical treatment of water. Chemical treatments commonly used in drip irrigation systems include addition of chloride and/or acid to the water supply.

Acid treatment: Hydrochloric Acid (HCl) is injected into drip systems. The acid treatment is performed till a pH of 4 is observed and the system is shut down for 24 hours. Next day the system is flushed by opening the flush valve and lateral ends.

Chlorine treatment: Chlorine treatment in the form of bleaching powder is performed to inhibit the growth of organisms like algae, bacteria. The bleaching powder is dissolved in water and this solution is injected into the system for about 30 minutes. Then the system is shut off for 24 hours. After 24 hours the lateral ends and flush valves are opened to flush out the water with impurities. Bleaching powder can directly added into the water source at a rate of 2 mg/litre or through venturi assembly.

Chapter-9
INSECT-PEST MANAGEMENT
Insect-Pests of Mango



Mango Hopper

Symptoms and Nature of Damage:

During flowering, the hoppers develop enormously in number, suck juice from the inflorescence and other tender plant parts reducing the vigour of the plant leading to reduction in fruit set and even premature fruit fall.

The infestation also leads to development of sooty mould on the honeydew excreted by the insects.



MANAGEMENT

- Keeping orchard clean.
- Avoiding overcrowding and water logging.
- Proper pruning of the tree after harvesting to facilitate proper sunlight and air that minimises hopper population.

Spray schedule is recommended as follows

- At flower bud initiation, imidacloprid (0.25 ml/l or metasystox (1ml/l or Cyantraniliprole @ 0.2ml/l or Acetamiprid @ 0.5ml/l At emergence of inflorescence stalks and before flower opening (anthesis), thiamethoxam @ 1ml/l or Chlorantraniliprole @ 0.25 ml/l
- During anthesis and pollination, insecticides should not be sprayed. In case of very high population of hoppers at this stage, imidacloprid @ 0.25ml/l is recommended
- When fruits are of pea size, spray Adding sulphur 3.5g/l to the insecticide based on need to check mites and sooty mould, *Capnodiummangiferum*
- Directing the spray first to stem/ trunk, then branches, twigs, leaves and finally inflorescence is a recommended method.

Mango fruit fly *Bactrocera dorsalis* (Tephritidae :Diptera)

Host :

- It is one of the major pests of mango in India. It also infests guava, peach, citrus, ber, banana, papaya etc.

Symptoms & Damage:

- Semi ripe fruits with decayed spots.
- Dropping of fruits. Damage to semi ripe fruits is caused by both maggot and the adult.
- The oviposition punctures made by the female serves as entry for fermenting organisms.
- Maggots feed on the pulp and convert the pulp into bad smelling discoloured semi liquid mass, unfit for use.
- The fruits develop brown rotten patches on them and fall to the ground eventually.





Management:

- Collection and destruction of fallen, rotten fruits.
- Raking under the trees to expose the pupae.
- Mixing of carbaryl 10D in soils @ 50-100 g/tree.
- Install pheromone traps.
- Foliar spray with spinosad (0.2ml/l + gur (20g/l) a month before harvesting the fruit crop repeated after 15 days.
- Post-Harvest Control (Heat treatment techniques):
- Hot water treatment: Submerging fruits in hot water at 43 to 46.7°C for 35- 90 min.
- Double dip method: Immersion of mango fruits in water at 40°C for 20 minutes, followed by 10 minutes at 46°C to get 100 per cent mortality of *Bactrocera dorsalis* eggs.
- Spray Spinosad @ 0.2ml/l or Chlorantraniliprole @ 0.25ml/l before ripening (walnut stage) and 15 days after first spray.



MANGO MEALYBUG *Drosicha mangiferae* (Pseudococcidae: Hemiptera)

Host:

- It is one of the major pests of mango in India. It also infests guava, banana, papaya etc.

Symptoms & Damage:

- Both nymph and adults suck sap from other tender plant parts thus reducing the plant vigour.



Management:

- Deep summer ploughing up to base of the tree trunks, after harvesting to expose eggs of mealy bugs.
- Dusting methyl chlorpyrifos 5D or Malathion 5D around tree and incorporating in to the soil.
- Spraying with acetamiprid (0.5ml/l or imidachloprid (0.25 ml/l or Cyantraniliprole (0.025ml/l), when severe mealybug infestation noticed on the twigs.

- Wrapping 25 cm wide, 400 gauge polythene sheets on the tree trunk 30 cm above ground level and pasting grease over it to prevent migration of freshly hatched first instar nymphs during winter (Nov-Dec) from soil to trees, one week before their emergence.
- Crawlers collecting beneath the polythene sheet may be scraped with a knife.



MANGO SHOOT BORER *Chlumetia transversa*
(Noctuidae:Lepidoptera)

Host: Mango

Symptoms & Damage

- Damage results in withering and drying of new terminal shoots.

Management

- Clipping off and destruction of affected shoots.
- Foliar spray with Spinosad @ 0.2ml/l or flubendimide (0.05 ml/1%) or Chlorantraniliprole @.005 ml/l or Cypermethrin @ 1ml/l at the time of new flush.



MANGO STEM BORER *Batocera rufomaculata* Cerambycidae:
Coleoptera

Host: It is a polyphagous pest, infesting mango, apple, fig, mulberry, Eucalyptus, jack fruit, papaya etc.

Symptoms of Damage :

- Masses of frass and sap exuding from the bore holes.
- Leaves of damaged branches dry and fall.
- Branches collapse, tree succumbs in severe cases.



Management :

- The affected portions with grubs and pupae should be removed and destroyed, if branches are affected.
- The bore holes are traced and opened. A swab of cotton wool soaked in chloroform or petrol 5ml or methyl parathion @ 4ml/l or kerosene oil or Lambda cyhalothrin @ 4ml/l inserted in to the hole and sealed with mud.
- Methyl parathion 1 ml/l poured in to the hole or tablet of aluminium phosphide inserted into the hole to kill the grub.
- When burrows are superficial, extract the grubs with stiff hooked wire and paint bordeaux paste.

Mango Shoot Gall Psylla, *Apsylla cistellata* Buckton Hemiptera : Psyllidae

Host: Mango

Symptoms & Damage

- Feeding of nymphs and subsequently secretion of certain chemicals through the saliva results in the formation of conical galls in place of apical and axillary buds.
- The gall formation is caused by this pest only after tree start flowering and fruiting.
- Absence of gall formation of twigs with no eggs.



Management:

- **Cultural control:** Practice of removal of eggs bearing leaves from a shoot during March last week which decreases number of shoot gall formation.
- **Mechanical control:** Pruning of shoots upto 30 cm which bears galls during September to check further spread of incidence.
- **Chemical control:** Spray imidacloprid @ 0.5ml /l which is having ovicidal action during second week of March.
- Spray with metasystox (0.5ml/l or Chlorantraniliprole @.0.3 ml/l during middle of August. If needed repeat the spray with same chemical.



Pomegranate butterfly/Anar butterfly *Deudorix isocrates*
(Lycaenidae: Lepidoptera)

Host:

- It is the most important and destructive pest of pomegranate and distributed throughout the country, also infesting guava, annona, apple, ber, citrus, litchi, tamarind, wood apple, soap nut, etc.

Symptoms & Damage:

- Offensive smell and excreta of caterpillar at the entry hole.
- The affected fruits ultimately falling down.
- The fruit appears healthy but the caterpillar inside feeds on pulp and seeds just below the rind. It is only when the grown up caterpillar comes out, a round hole is seen through which juices come out.
- Feeding injury also causes rotting of the fruits. Up to 50% fruit damage is observed.

Management:

- Destruction of fallen infested fruits checks the spread.
- Removal of flowering weeds especially of Compositae family.
- Though expensive, bagging of fruits with polythene or paper bags or cloth bags soon after the fruit set prevents the pest attack.
- Initiate the spray schedule with the onset of flowering with any of following insecticides:
- cypermethrin @1ml/l or spinosad @ 0.2ml/l flubendimide (0.25ml/l or Lambda-cyhalothrin @ 0.25ml/l
- Repeat the spray at 15-20 day interval.
- About 3 to 4 sprays are needed for effective control of the pest, as it continues to attack flowers (flowering in pomegranate remains for a longer time).



Citrus Butterfly: *Papilio demoleus*, *Papilio polytes*, *Papilio helenus*
(Papilionidae: Lepidoptera)

Host:

- It infests almost all citrus varieties though Malta (*Citrus sinensis*) is its preferred host.
- It can feed and breed on all varieties of cultivated or wild citrus and various other species of family Rutaceae. Besides citrus, it also attacks ber, wood apple, curry leaf.
- *P. demoleus* is a big beautiful butterfly with yellow and black markings on all the four wings, having wing expanse of about 50-60 mm. Its hind wings have a brick red oval patch near the anal margin and there is no tail like extension behind though common in Papilionidae.
- *P. polytes* males are black and females vary in form.
- *P. helenus* has black wings with three white distal spots.
- **Symptoms and Damage:**
Leaves fed up to midribs.



Management :

- In small orchards and nurseries with mild infestation, hand picking and destruction of various stages of the pest.
- Natural enemies enumerated below suppress the pest population
- Egg parasitoids: *Trichogramma evanescens*; *Telenomus* sp.
- Larval parasitoid: *Distatrix papilionis*; *Brachymeria* sp.
- Pupal parasitoid: *Pterolus* sp.
- Spraying of spinosad @ 0.2ml/l or cypermethrin (1ml/l When the caterpillars are small. *B. t.* formulation HALT at 9 g/l is also recommended.

Citrus leaf miner *Phyllocnistis citrella* (Gracillariidae: Lepidoptera)**Host :**

- It attacks all species of citrus but prefers sweet oranges. It also infests Ponagamia, jasmine etc.

Symptoms & Damage:

- Characteristic silvery white zigzag galleries below the epidermis of tender leaves.
- Serious infestation causes retardation in growth. The infestation predisposes the leaves to canker growth.



Management :

- Pruning of affected parts during winter and burning of them
- Spraying of Neem cake solution 5% or Neem oil 5% or imidacloprid (0.25ml/l or Cyantraniliprole (0.3 ml/l or chlorantraniliprole (0.3ml/l, twice at 10 days interval at every new flush time i.e. during June – July, Sep – Oct, Dec – Jan.
- Drenching of tree basins with imidacloprid @ 0.25/l

Citrus psylla *Diaphorina citri* (Psyllidae: Hemiptera)

Host: Citrus

Symptoms & Damage

- The damage is caused by the nymphs which crowd on the terminal shoots and buds and suck up the juice which results in Curling and cupping of leaves.
- Defoliation and death of young shoot in severe infestation and
- The fruits turning undersized and juice content reduced.

**Management :**

- Spraying of methyl demeton (1ml/l or cypermethrin (1ml/l) or imidacloprid (0.25ml/l seedling stage on fresh foliage, twice at 10 days interval.

INSECT-PESTS OF LITCHI

Litchi fruit borer *Conopomorpha sinensis* Bradley (Gracillariidae : Lepidoptera)

Host: Also known as the litchi stem-end borer in China and the lychee fruit borer in Thailand is the major pest in most seasons.

Symptoms & Damage:

- Litchi fruit and shoot borer causes losses to fruit and shoot, to the tune of 24-48% and 7-70% respectively.
- The insect damage the newly emerged shoot during the Sept-Oct resulting in failure of shoot to bloom.
- Female moth laid eggs on shoots, flowers buds , calyx and newly emerged caterpillar enter inside the fruit through peduncle and in shoots through bcortex region of the new shoot.



Management :

- Bearing trees should be inspected during early flush development and sprayed if necessary. The leaf flush before flower initiation is very important as it supplies the carbohydrates needed for fruit development. If 30 to 40 percent of the larvae are parasitised, spraying is not recommended. Young, non-bearing trees do not need to be sprayed either. This also allows the parasitoids to build up in the orchard.
- Spray with spinosad (0.2ml/l or cypermethrin (1ml/l or flubendimide (0.25ml/l or Lambda-cyhalothrin (0.3ml/l at pre bloom stage.
- Repeat the spray at an interval of 15 days with any of the abovementioned pesticides.
- 3-4 sprays are needed for proper management of the pest

Erinose mite *Aceria litchii* (Keiffer) Acari : Eriophyidae

Host : Litchi

Symptoms & Damage:

- The mites attack new leaves causing a felt-like erineum to be produced on the under-surface.
- This forms as small blisters but may eventually covers the entire leaf, causing it to curl.
- In severe cases, whole terminals may be deformed.
- The young erineum is silver-white, changing to light brown and dark reddish-brown, and eventually black.
- The greatest numbers of mites are found in the intermediate stages.
- Many leaves are ruined if infestations are severe. This generally causes no problems in established trees, but can debilitate young orchards. There can also be a problem if the mite moves from leaves onto the developing flowers and fruit. Fruit set can be disrupted or the fruit deformed. Such fruit are unmarketable.



Management:

- Numerous species of predatory mites, particularly those from the Phytoseidae, have been recorded with *A. litchii*.
- Branches infested with the mite should be cut off and burnt.
- The mites can be controlled by applying insecticides when they move from the older leaves to a new flush. The leaves should be checked regularly for symptoms over summer and autumn.
- Chemicals recommended include magister @0.5ml/l or fenazaquin (0.5 ml/l) or propargite (1ml/l fenpyroximate(0.05ml/l) and spiromesifen @ 0.025 ml/l

Preparation of field concentrations of insecticides

The success of spray application for the control of the insect pests depends upon the use of accurate quantities of insecticide solutions per unit area. For field application of insecticides, the solutions are prepared generally from the formulations. The formulations are also the concentrated products of insecticides though contain lower quantities of active ingredients than their respective technical products. These are diluted before use in the field for the control/management of the pest. The applicator must determine the quantity of the formulation to

be added into the tank to ascertain the correct recommended dosage. For the purpose, the following formulae are given:

A. FOR EMULSIFIABLE CONCENTRATE (EC) AND WETTABLE POWDER (WP) FORMULATIONS:

Formula:

F = Quantity of formulation required (ml or g)

S = Total volume of spray solution to be made (litres)

C = Concentration (%) of the solution to be prepared

a.i.= Active ingredient (%) in the given formulation

Exercise 1. How much spray fluid of carbaryl 0.1% concentration can be prepared from 125g of Sevin 50WP?

Solution : In the present exercise we are given;

$$F = 125\text{g}$$

$$S = ?$$

$$C = 0.1\%$$

$$\text{a.i.} = 50\%$$

Applying the formula :
$$F = \frac{SC}{\text{a.i.}} \times 1000$$

$$125 = S \times 0.150$$

$$S = \frac{125 \times 50}{0.1 \times 1000} = \frac{6250}{100}$$

$$S = 62.5 \text{ litres}$$

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$$S = \frac{125 \times 50}{0.1 \times 1000} = \frac{6250}{100}$$

$$S = 62.5 \text{ litres}$$

Exercise 2. Calculate the quantity of Cythion 50 EC required for preparing 50 litres of 0.1 % spray solution of malathion for the control of fruit flies in mango orchards.

Solution: In the exercise we are given;

$$S = 50 \text{ litres}$$

$$C = 0.1\%$$

$$\text{a.i.} = 50\%$$

$$F = ?$$

Applying the formula :
$$F = \frac{SC \times 1000}{\text{a.i.}}$$

$$F = \frac{50 \times 0.1 \times 1000}{50}$$

$$F = \frac{50 \times 1 \times 1000}{500}$$

$$F = 50 \times 1 \times 2$$

$$F = 100 \text{ ml}$$

Exercise 3. For the control of fruit borer of litchi, 500ml of Cymbush 25 EC is added in 250litres of water. Find out the concentration of cypermethrin the spray solution.

Solution: According to the question we are given;

$$F = 500 \text{ ml}$$

$$S = 250 \text{ litres}$$

$$C = ?$$

$$\text{a.i.} = 25\%$$

Applying formula
$$F = \frac{SC}{\text{a.i.}} \times 1000$$

$$500 = \frac{250 \times C \times 1000}{25}$$

$$C = \frac{500 \times 25}{1000 \times 250}$$

$$C = \frac{1}{20}$$

$$C = 0.05\%$$

Exercise 4. How much volume of spray solution can be prepared from 250g Sevin 50 WP for spray of carbaryl @0.1% to control the defoliating beetles in apple orchards?

Solution: From the exercise we have;

$$F = 250$$

$$S = ?$$

$$C = 0.1\%$$

$$\text{a.i.} = 50$$

Applying formula $F = \frac{SC}{\text{a.i.}} \times 1000$

$$250 = \frac{S \times 0.1 \times 1000}{50}$$

$$S = \frac{250 \times 50 \times 10}{1000}$$

$$S = 125 \text{ litres}$$

Exercise 5. 500ml of formulation is added in 250 litres of water to prepare a spray solution containing 0.1% a.i. Find out the active ingredient in the formulation.

Solution: From the exercise we have;

$$F = 500 \text{ ml}$$

$$S = 250 \text{ litres}$$

$$C = 0.1\%$$

$$\text{a.i.} = ?$$

Applying formula; $F = \frac{SC}{\text{a.i.}} \times 1000$

$$500 = \frac{250 \times 0.1}{\text{a.i.}} \times 1000$$

$$\text{a.i.} = \frac{250 \times 100}{500} \times 1000$$

$$= \frac{25000}{500} = 50$$

Active ingredient (a.i.) in the formulation is = 50%

FOR GRANULAR AND DUST FORMULATIONS:

Formula: $C_1V_1 = 100RA$

Where

C₁ = Concentration (%) of the given formulation
V₁ = Amount / Quantity(Kg) of formulation required
R = Recommended rate of application (Kg/ha)
A = Area of be treated (ha)

Exercise 6. Calculate the amount of Furadan 5 G required for application in an 1000m² against the leaf miner of citrus applied @0.25Kg a.i. Carbofuran/ha.

Solution:

In the present exercise we are given;

C₁ = 5%
V₁ = ?
R = 0.25Kg
A = 0.1 ha

Applying $C_1V_1 = 100RA$
 $5 \times V_1 = 100 \times 0.25 \times 1$

$$V_1 = \frac{100 \times 25 \times 0.1}{5 \times 100} = 0.5$$

Hence V₁ = 0.5kg

Exercise 7. If 5Kg of granular formulation is applied for treating 1 hectare area @ of 0.25kg a.i/ha, find out the per cent active ingredient in the formulation.

Solution:

In the present we are given;

C₁ = ?
V₁ = 5Kg
R = 0.25Kg a.i./ha
A = 1ha

Using the formula: $C_1V_1 = 100RA$

$$C_1 \times 5 = 100 \times 0.25 \times 1$$

$$C_1 = \frac{100 \times 0.25 \times 1}{5 \times 100} = 5.0$$

$$C_1 = 5\%$$

Exercise 8. 10Kg of chlorpyrifos 5% granules are used to treat 5000 m² area for the management of white grubs in an apple orchard, find out its rate of application.

• Solution:

In the exercise we are given;

$$\begin{array}{rcl} C_1 & = & 5.0 \\ V_1 & = & 10\text{Kg} \\ R & = & ? \\ A & = & 0.5\text{ha} \end{array}$$

According to the formula; $C_1 V_1 = 100 R A$

$$5 \times 10 = 100 \times R \times 0.5$$

$$R = \frac{5 \times 10}{100 \times 0.5} = 1.0$$

$$R = 1.0\text{Kg} / \text{ha}$$

TYPES OF SPRAYERS:

1. Knapsack Sprayer: Knapsack sprayer consists of a pump and a air chamber permanently installed in a 9 to 22.5 liters tank. The handle of the pump extending over the shoulder or under the arm of operator makes it possible to pump with one hand and spray with the other. Uniform pressure can be maintained by keeping the pump in continuous operation.



2. Foot Sprayer: The foot sprayer is one of the ideal and versatile sprayers used for multipurpose spraying jobs. The sprayer consists of a pump operated by the foot lever, suction hose with strainer, delivery hose, spray lance fitted with shut off pistol valve, gooseneck bend and adjustable nozzles. The pump barrel is mounted on a steel frame, which provide it stability when placed on the ground. It has a provision of two strong springs, which retract the foot lever to its original position after each pumping stroke. The sprayer does not have inbuilt tank, therefore an additional storage device or container is required to store the spray liquid in which the strainer (f suction hose remain submerged. It has provision for the two discharge lines, which increases its versatility and field capacity. The plunger pump being a positive displacement pump, builds up a high



pressure to throw spray liquid to larger distances with a suitable boom. The pump barrel, lance and the spray nozzle are made from brass alloy. For operation the inlet pipe is placed in the storage container and one person continuously operates the pump by foot lever. There is a provision for the operator to hold the sprayer at the top by V-type fixture. The other person directs the lance to the target. For spraying tall trees up to a height of 10 m, a high jet or bamboo lance can be used.

3. Power Sprayer: Power sprayers are used for developing high pressure and high discharge for covering large area. These sprayers are either operated by auxiliary engines or electric motors. Most of these sprayers are hydraulic sprayers and consist of power unit to drive the pump, pump unit which employs piston or plunger pump, piston (1 to 3), pressure gauges, pressure regulators, air chamber, suction pipe with strainer, delivery pipes fitted with lance, gooseneck bend and nozzles. The portable sprayers use petrol engine so that these can be easily taken to the spray sites. The complete assembly is mounted on the stretcher type frame or on wheel barrow for easy transportation. The number of lances may vary from 1 to 6 depending upon the model. In some models there is a built in storage tank of fibreglass having capacity of 100 litres, while in others a separate storage tank is required in which the suction pipe of the sprayer remains submerged. For operation, the shut off trigger valve of the lance is closed and the engine/ electric motor is started to actuate the pump. The pump draws the spray liquid from the tank, imparts pressure energy and sends it to the delivery line/lines. The operator directs the lance towards the target and operates the trigger/shut off valve. Adjusting the nozzle or selecting the appropriate nozzle, adjusts the spray pattern. For delivering the spray liquid to large distances/ height a bamboo lance can also be used.



4. Tree Sprayers: The tree sprayer is an ideal sprayer for spraying tall fruit trees in the orchards. It consists of a 4- stroke petrol/ kerosene engine to drive the fan, a centrifugal fan which produces stream of high volume and velocity, a micronizer nozzle for producing uniform and fine droplets of spray liquid in the range of 150-200 microns, plastic tank for storage of spray liquid, rotary pump to draw the spray liquid from the tank and to feed it to the nozzle and a fibre glass casing. All these



components are joined and mounted on the stretcher type of frame. The sprayer can be carried by two persons to the place of spraying. For operation, the tank is filled with spray liquid and the engine is started by cranking with the rope, to drive the fan and the rotary pump. The control valve is opened to adjust the rate of flow. The sprayer is placed under the tree and manually moved around it to complete the spraying operation.

5. Power Tiller / Tractor Mounted Orchard Sprayer: It consists of an HTP (horizontal triplex piston) pump, trailed type main chassis with transport wheels, chemical tank with hydraulic agitation system, cut off device and boom equipped with turbo nozzles. It is fitted with turbo nozzles. It generates droplets of 100_150 micron sizes. Depending upon the plant size and their row spacing, the orientation of booms can be adjusted. The spray booms are mounted behind the operator. These are used to apply pesticides, plant growth regulators and foliar nutrients to orchard trees. It is a power tiller / tractor mounted equipment suitable for large area land.



OPTIMUM DROPLET SIZES FOR DIFFERENT TARGETS:

Target group	Droplet size (microns)
Flying insects (drift)	10-15
Crawling and sucking insect (drift)	30-50
Plant surfaces (limited drift)	60-150
Soil application (no drift) as in case of herbicide application	250-50

CALCULATION OF PESTICIDE / FUNGICIDE DOSES:

A. If the concentration is given in % a.i./ litre

Parameters required:

1. Spray volume required
2. Desired concentration in a.i. %
3. Concentration of commercial product in a.i. %

The dose will be calculated by following formula:

$$\text{Quantity required (g/ml)} = \frac{\text{Desired concentration} \times \text{Volume required (l)} \times 1000}{\text{Concentration of commercial product in a.i.\%}}$$

For example:

Calculate the quantity of Bavistin 50WP required for a 100 litres spray volume @ 0.05% a.i.

$$\text{Quantity of Bavistin 50WP required (g)} = \frac{0.05 \times 100 \times 1000}{50}$$

$$= 100 \text{ g}$$

Calculate the quantity of Spinosad 45 SC required for 200 litre spray volume @ 0.05 % a.i.

$$\text{Quantity of Spinosad 45 SC required (ml)} = \frac{0.05 \times 200 \times 1000}{45}$$

$$= 222.22 \text{ ml}$$

B. If concentration is given in % only

Parameters required:

1. Desired Concentration
2. Desired volume in litres

The dose will be calculated by following formula:

$$\text{Quantity required} = \frac{\text{Desired concentration (\%)} \times \text{Volume required (litres)} \times 1000}{100}$$

For example:

Calculate the quantity of carbendazim (Bavistin 50WP) required for a 100 litres spray volume @ 0.05%.

$$\begin{aligned} \text{Quantity of Bavistin 50WP required (g)} &= \frac{0.05 \times 100 \times 1000}{100} \\ &= 50 \text{ g} \end{aligned}$$

C. When recommendation is in kg a.i. / ha

Parameters required:

1. Recommended rate (kg a.i.)
2. Area to be sprayed (ha)
3. Concentration of commercial product in a.i.\%

The dose will be calculated by following formula:

$$\text{Quantity required (kg)} = \frac{\text{Recommended rate (kg a.i.)} \times \text{area (ha)} \times 100}{\text{Concentration of commercial product in a.i.\%}}$$

For example:

Calculate the quantity of Bavistin 50WP required for a 2 ha area @ 0.5 kg a.i./ha

$$\begin{aligned} \text{Quantity required (kg)} &= \frac{0.5 \times 2 \times 100}{50} \\ &= 2 \text{ kg} \end{aligned}$$

DO OR DON'TS WHILE HANDLING PESTICIDES

Do:

- Read the pesticide label carefully prior to purchase of pesticide
- Choose the appropriate pesticide keeping in view the target pest / pathogen
- Transport the pesticides safely away from children, groceries and animal feed
- Read the label carefully again before opening the container and follow all precautions mentioned on the package
- Use proper safety equipment and protective clothes as per the label recommendations
- Apply proper dose as advised
- Wear safety goggles, masks and gloves while handling and applying pesticides
- Keep all records of pesticide applications and environmental conditions at the time of application
- Rinse all the tools and equipments at least thrice and throw rinse water as per the label recommendations
- Wash clothing worn at the time of pesticide application separately from other clothes
- Follow instructions marked on the label in case of eye contact or ingestion of pesticide accidentally
- Call a doctor immediately in case of accidental exposure
- After usage, store the pesticide securely in original containers tightly closed and labeled
- Dispose the unused or expired pesticides properly

Don't:

- Purchase extra quantity of pesticide
- Handle pesticides when you are not feeling well
- Smoke or eat anything while applying pesticides
- Inhale pesticide dusts, sprays or vapours
- Mix or throw the pesticide near a natural water source
- Use excess quantities of pesticides to avoid environmental degradation
- Use on non target pests
- Allow children or pets to touch the pesticides
- Allow people or pets to enter the pesticide application area
- Dispose the waste or unused product in the drain, sink or toilet
- Reuse pesticide containers as these may be dangerous
- Transfer pesticides to any other containers especially the containers of eatables
- Store pesticides with or near food, animal feed or medical supplies or in the areas where flooding is possible
- Touch any of your body part while spraying pesticide without washing hands properly with soap

DISEASE DIAGNOSTICS AND MANAGEMENT

1. Mango:

i) Anthracnose:

- Oval or irregular, greyish-brown spots are seen on leaves which may coalesce
- On floral organs, minute, black dots are found in humid weather which are basically acervuli of the fungus.
- The ripened fruits show typical symptoms of anthracnose in the form of black spots on skin of the affected fruits gradually becoming sunken and coalesce



Mango Anthracnose

ii) Powdery Mildew:

- Whitish or grayish powdery growth on inflorescence and tender leaves which is the most common stage of this disease
- On leaves and shoots symptoms of the disease are quite common.
- Severely damaged infected floral parts drop off.
- Number and size of flowers is reduced leading to less yield.
- Fruits become malformed and off coloured and drop at premature stage



Mango powdery mildew

Mango Malformation:

- Bunchy top phase
- Floral malformation and
- Vegetative malformation



Floral malformation



Vegetative mango malformation

iii) Die Back and Gummosis / Decline complex:

- Twig Blight
- Die Back
- Gummosis
- Bark Splitting.



Mango Gummosis

iv) Bacterial Blight / Canker / Black Spot:

- Black angular spots are raised and appear on leaf lesion, which develop greasy margins and leaf venation. These are surrounded by a chlorotic (yellow) halo.
- Symptoms on fruits begin around lenticels as small irregular water-soaked specks or as small star-shaped lesions.



- With the progress of the disease, lesions blacken, develop greasy raised which later develop cracks.

Citrus

i) Anthracnose:

- Symptoms appear on leaves as black sunken spots which causes shedding of leaves and dieback of twigs leading to defoliation which ultimately leads to drying of tips.
- On fruits, light green spots appear turn brown after some time.



Dieback/Citrus Anthracnose

ii) Citrus Canker:

- Yellowish brown to green raised margin and watery yellow halo surround the rough lesions on leaves
- On fruits, symptoms same as that of leaves occurs but yellow halo is not visible and the crater like depression in the centre is more prominent
- Symptoms on stem are same as on leaves except that no yellow halo is present, bark eruption takes place, bacterial ooze is seen from cracks during warm rainy season.



iii) Citrus Gummosis :

- Yellowing of leaves, followed by cracking of bark and profuse gumming occur on the surface.
- Rotting of the bark and drying of tree leads to girdling effect.



- There is heavy blossom prior to death, but fruits die prematurely.
- Foot rot or collar-rot occurs

Citrus Gummosis

iv) Root and Collar Rot:

- Water-soaked, dark, usually sunken and greasy spots appear usually at the graft between the scion and rootstock or at soil level.
- Leaves turn yellow, dry and fall, and branches die back as root and collar rots progresses.
- The tree dies if the rot circles the trunk



Root and Collar Rot

v) Sooty Mould:

- Black encrustation covers the leaves which affect the photosynthetic activity.



vi) Citrus Tristeza:

- Pits in the wood can be observed ranging from short and narrow to elongated and deep when the bark is peeled away; sometimes gum is associated with the pits.
- Severely affected trees are chlorotic, stunted, and generally have a low yield of poor quality fruit.



Citrus tristeza

vii) Citrus Greening:

- Leaf chlorosis is the main symptom which resembles the zinc deficiency
- A characteristic feature of greening is that the yellow areas are surrounded on one side by the mid rib and on the other side by lateral veins. The yellowing expands towards the margins
- The size of leaves is also reduced
- The leaves are thicker than normal and usually remain erect



Greening symptoms in sweet orange

Litchi

i) Leaf, Panicle and Fruit Blight

- Symptoms appear as light brown to dark brown necrosis on the tip of the leaf
- Later, the necrosis advances towards both the margins of the leaf and the affected leaves dry up completely
- Blighting of panicles and fruits occurs.
- Panicles shrivel and dry up as a result of necrosis, while necrosis of the pedicel lead to complete drying of the rind of developing fruits.



Litchi leaf blight



Litchi panicle blight



Litchi fruit blight

ii) Twig Blight and Anthracnose:

- Necrosis of leaves on new shoots, foliar blight and tip dieback are major symptoms
- On fruits brown pinhead lesions appear that later turn to circular dark-brown to black sunken lesions on mature fruits



Litchi twig blight



Litchi anthracnose

iii) Fruit Rot:

Symptoms are seen on injured portion of the fruits. The decayed areas get depressed and rot gradually penetrates deep into the pulp. Fruits emit an odour of fermentation



iv) Root Rot and Wilt:

- Wilting of branch occurs followed by the decline of new growth on the affected branch in sometime. Tips may die without wilting.



2. Guava

i) Fruit Canker:

- Scabby, minute, brown or rust- coloured lesions of 2 to 4 mm diameter appear on the fruit, which are unbroken and circular and later tear open the epidermis in a circinate manner.
- These scabby lesions later develop raised margins and cankerous spots develop in great numbers.



ii) Styler End Rot:

- Initial symptoms of the disease appear as circular, water soaked lesions at styler end
- Numerous closely aggregated small, white or light grey pycnidia develop on infected area



Styler end rot

iii) Red Rust / Algal spot:

- Spots on leaves may be scattered or crowded, numerous or few and vary from mere specks to big patches
- The fruit lesions are dark green to brown or black in colour and smaller than leaves



3. Pomegranate

i) Bacterial blight:

- On leaves one to several small water soaked, dark coloured irregular spots appear leading to premature defoliation in severe cases.
- Girdling and cracking of nodes occur on the stem following the brown to black spots around the nodes
- Dark brown, irregular slightly raised spots with oily appearance are formed on fruits, which split open with L-shaped cracks under severe cases



ii) Cercospora Leaf and Fruit Spot:

- On leaves and fruits, light zonate brown spots appear.
- These leaf spots are minute, brown in colour with yellow halo.
- Spots are scattered, circular or irregular and become dark brown with age.



Cercospora Leaf and Fruit Spot

iii) Anthracnose:

- Symptoms appear as small regular or irregularly shaped light violet or black leaf spots with yellow halos.
- Both young and mature fruits develop spots which are initially circular, turning irregular with sunken centres, brown to dark brown and cover the fruit partly or completely.
- Minute, black dots representing acervuli are clearly visible on the fruits



iv) Fruit spot and rot

- On fruits, small reddish-brown circular spots appear. As the disease progresses, these spots coalesce to form larger patches and the fruits start rotting.
- The arils get affected which become pale brown to black and become unfit for consumption.



Alternaria fruit spot and rot

4. Persimon

i) Bitter rot / Anthracnose:

- Spots appear both on leaves and fruits and result in early dropping of leaves and fruits



PREPARATION OF BORDEAUX MIXTURE AND BORDEAUX (PRUNING) PASTE

1. Bordeaux mixture:

- i) For the preparation of 1% Bordeaux mixture we need following components:

Copper sulphate	1 kg
Lime	1 kg

Water 100 litre

ii) For the preparation of 0.8% Bordeaux mixture we need following components:

Copper sulphate 800 g

Lime 800 g

Water 100 litre



Copper sulphate



Lime

Steps:

- Dissolve required quantity of copper sulphate and lime each in 20 litre of water separately in two different plastic buckets



- Keep the two solutions dissolved overnight
- Now, take a third plastic or non-metallic container and pour the two solutions together or one by one in the third container.
- Mix these solutions gently with a wooden, plastic or glass stick and pour more water to the solution to make the final volume to 100 litres



- Mix gently and the Bordeaux mixture is ready to use
- Before use, check the solution for phytotoxicity

Phytotoxicity test:

- Dip an iron rod / blade in the solution for 10-20 seconds and take it out
- Check whether there is any deposition of rusty layer on the rod or not.



Phytotoxicity test

- If there is deposition of rusty layer on the rod, add more lime to the solution until the rusty layer disappears

Precautions:

- Do not use metallic container for its preparation
- Both the constituents should be first mixed in lesser quantity of water and final volume should be made in the last step
- Always pour copper sulphate solution into lime solution and not the *vice versa*

2. Bordeaux paste:

It is actually 10 % Bordeaux mixture. The composition is as follows:

Copper sulphate	1 kg
Lime	1 kg
Water	10 litre

The steps in its preparation are same as in Bordeaux mixture. 1 kg each of copper sulphate and lime are mixed in 5 litres of water separately and finally mixed together to make the consistency of a paste.

3. Bordeaux paint:

- For the preparation of Bordeaux paint, we use monohydrate copper sulphate.
- For this, prior to use, copper sulphate is heated so as to evaporate its water molecules and it gets converted into a white coloured powder.
- Normally we take 2 kg of copper sulphate with 3 kg of lime to make this paint.

- After converting copper sulphate into monohydrate form, the two components are mixed together to get a fine white powder.
- Linseed oil is then added to the mixture so as to get the consistency of a paint.
- This paint can be applied to the tree trunks so as to avoid the attack of pathogens

YEAR ROUND OPERATIONS OF DIFFERENT CROPS

1. Mango

Month	Group	Operations
January	Diseases	• De-blossom the new flower buds or panicles to manage the malformation • Spray the infected trees with potassium metabisulphite (KMS) @ 0.06 % (0.6 g/l) or NAA (200ppm, 200mg/l) to manage the malformation
February	Diseases	• Three sprays of Wettable sulphur (2g per litre of water) or carbendazim (1g/liter) or hexaconazole (0.5ml/liter) which include first spray as preventive spray is applied when the size of panicle is 8-10 cm. Second spray is done after 10-15 days of first spray and third spray is need based which is done after 10-15 days of second spray.
March	Diseases	• Third spray of Wettable sulphur (2g per litre of water) or carbendazim (1g/liter) or hexaconazole (0.5ml/liter) if required • If symptoms of anthracnose are visible, spray the foliage with carbendazim (1g/l) or copper oxychloride (3 g/l)
April	Diseases	• Spray the anthracnose affected foliage and panicles with carbendazim (1g/l) • If Alternaria infection is also mixed with anthracnose then spray with carbendazim (1g/l) + mancozeb (2g/l)
May	Diseases	• One or two sprays of thiophenate methy (1g/l) or carbendazim (1g/l) are effective to fight latent infections, if any • To manage bacterial canker, spray the crop with streptocycline (10g/100 litre)
June	Diseases	• To manage bacterial canker, spray the crop with streptocycline (10g/100 litre)

		After harvest, dip the fruits in ethrel solution (700ppm) for 5 minutes for uniform ripening of fruits. Addition of carbendazim (0.5g/l) to this solution helps to manage the fruits from post harvest fungal diseases
July	Diseases	Spray the crop with copper oxychloride (3g/l) to manage from anthracnose and red rust
August	Diseases	Repeat two sprays at 10-15 days interval with copper oxychloride (3g/l) to manage the crop from anthracnose and red rust
September	Diseases	If anthracnose or red rust symptoms are visible on leaves, spray the crop with copper oxychloride (3g/l)
October	Diseases	- Spray the infected trees with potassium metabisulphite (KMS) @ 0.06 % (0.6 g/l) or NAA (200ppm) to manage the malformation - If symptoms of die back are visible, prune the infected branch and apply Bordeaux paste - Spray the crop with copper oxychloride (3g/l) to manage from die back or Phoma blight - If gummosis symptoms are visible, then scrap the bark of affected portion and apply Bordeaux paint
November	Diseases	- Repeat two sprays of copper oxychloride (3g/l) at 10-15 days interval to manage from die back or Phoma blight - If gummosis symptoms are visible, then scrap the bark of affected portion and apply Bordeaux paint
December	Diseases	De-blossom the new flower buds or panicles to manage the malformation

2. Citrus

Month	Group	Operations
January	Diseases	- Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) for the management of foot rot / gummosis - Spray with streptocycline (10g/100litre) to manage citrus canker
February	Diseases	- Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) for the management of foot rot / gummosis and anthracnose - Spray with streptocycline (10g/100litre) to manage citrus

		canker
March	Diseases	- Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) for the management of foot rot / gummosis and anthracnose - Spray with streptocycline (10g/100litre) to manage citrus canker
April	Diseases	Spray of copper oxychloride (3g/l)
May	Diseases	Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) or carbendazim (1g/litre) to avoid scab
June	Diseases	Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) or carbendazim (1g/litre) to avoid scab
July	Diseases	Spray the crop with copper oxychloride (3g/l) + streptocycline (10g/100litre) to manage from anthracnose and canker
August	Diseases	Spray the crop with copper oxychloride (3g/l) + streptocycline (10g/100litre) to manage from anthracnose and canker
September	Diseases	-
October	Diseases	Spray the crop with copper oxychloride (3g/l) + streptocycline (10g/100litre) to manage from canker
November	Diseases	Spray the crop with copper oxychloride (3g/l) + streptocycline (10g/100litre) to manage from canker, pruning of affected portion and apply Bordeaux paint
December	Diseases	- Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) for the management of foot rot / gummosis - Spray with streptocycline (10g/100litre) to manage citrus canker

3. Litchi

Month	Group	Operations
January	Diseases	Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) for the management of leaf blight
February	Diseases	-
March	Diseases	If symptoms of leaf and panicle blight or twig blight and anthracnose are visible, spray the foliage with carbendazim (1g/l) or copper oxychloride (3 g/l)
April	Diseases	If symptoms of leaf and panicle blight or twig blight and

		anthracnose are visible, spray the foliage with carbendazim (1g/l) or copper oxychloride (3 g/l)
May	Diseases	Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) or carbendazim (1g/litre) to avoid scab
June	Diseases	Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) or carbendazim (1g/litre) to avoid scab
July	Diseases	- Spray the crop with copper oxychloride (3g/l) to manage from anthracnose - Apply castor cake or neem cake as manures along with biocontrol agents like <i>Trichoderma harzianum</i>, <i>T. viride</i>, <i>Pseudomonas fluorescens</i> etc. - Drench rhizosphere soil with hexaconazole (1ml/litre) or carbendazim (1 g/litre) if the symptoms of root rot are visible
August	Diseases	- Spray the crop with copper oxychloride (3g/l) to manage from anthracnose - Drench rhizosphere soil with hexaconazole (1ml/litre) or carbendazim (1 g/litre) if the symptoms of root rot are visible
September	Diseases	-
October	Diseases	-
November	Diseases	-
December	Diseases	Spray of Bordeaux mixture (1%) or copper oxychloride (3g/l) for the management of leaf blight

4. Guava

Month	Group	Operations
January	Diseases	Spray of Bordeaux mixture (1%) or copper oxy chloride (3g per litre) or Pyroclostrobin + metiram (Cabrio Top) @ 1g/litre of water for the management of styler end rot and fruit canker
February	Diseases	-
March	Diseases	-
April	Diseases	-
May	Diseases	-
June	Diseases	Spray of Bordeaux mixture (1%) or copper oxy chloride (3g per litre) or Pyroclostrobin + metiram (Cabrio Top) @ 1g/litre of water for the management of fruit canker
July	Diseases	Spray of Bordeaux mixture (1%) or copper oxy chloride (3g

		per litre) or Pyroclostrobin + metiram (Cabrio Top) @ 1g/litre of water for the management of fruit canker
August	Diseases	• -
September	Diseases	• Spray of Bordeaux mixture (1%) or copper oxy chloride (3g per litre) or Pyroclostrobin + metiram (Cabrio Top) @ 1g/litre of water for the management of fruit canker
October	Diseases	• Spray of Bordeaux mixture (1%) or copper oxy chloride (3g per litre) or Pyroclostrobin + metiram (Cabrio Top) @ 1g/litre of water for the management of fruit canker, if prevalent
November	Diseases	• Spray of Bordeaux mixture (1%) or copper oxy chloride (3g per litre) or Pyroclostrobin + metiram (Cabrio Top) @ 1g/litre of water for the management of fruit canker, if prevalent
December	Diseases	• Spray of Bordeaux mixture (1%) or copper oxy chloride (3g per litre) or Pyroclostrobin + metiram (Cabrio Top) @ 1g/litre of water for the management of styler end rot and fruit canker

5. Pomegranate

Month	Group	Operations
January	Diseases	• -
February	Diseases	• -
March	Diseases	• -
April	Diseases	• -
May	Diseases	• Spray of carbendazim (0.5g/l) + streptocycline 50g/100litre) to manage leaf spot and bacterial spot in the 1st week • Spray the crop with copper oxychloride (3g/l) + streptocycline (50g/100litre) to manage from bacterial blight in the third week
June	Diseases	• Spray of carbendazim (1g/l) or mancozeb (2.5g/l) or to avoid different leaf spots and repeat after 15 days
July	Diseases	• Spray the crop with copper oxychloride (3g/l) + streptocycline (50g/100litre) to manage from bacterial blight in the first week • Spray with carbendazim (1g/l) or hexaconazole (0.5ml/l) for

		fruit rot and anthracnose
August	Diseases	• Carbendazim (1g/l) or difenconazole (0.5ml/l) or mancozeb (2.5g/l) for the management of fruit rot
September	Diseases	• -
October	Diseases	• -
November	Diseases	• -
December	Diseases	• -

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