Fundamentals of Horticulture

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Lecture No.1

INTRODUCTION

India is the seventh largest country in the world with a total geographical area of 328.73 m ha. and has second largest population 121crores (2011), after China. The total arable land available is 144 million hectare of which 70% is under rainfed cultivation. Around 55-60 per cent of the total population depends on agriculture and allied activities. Horticulture crops constitute a significant portion of total agricultural production in the country.

The term Horticulture is derived from the Latin words: "***hortus***" meaning **garden** and "***cultura***" meaning **cultivation**. In ancient days the gardens had protected enclosures with high walls or similar structures surrounding the houses. The enclosed places were used to grow fruit, vegetables, flowers and ornamental plants. Therefore, in original sense "Horticulture refers to cultivation of garden plants within protected enclosures".

At present the horticulture may be defined as the science and technique of production, processing and merchandizing of fruits, vegetables, flowers, spices, plantations, medicinal and aromatic plants.

Branches of Horticulture

Horticulture is a wide field and includes a great variety and diversity of crops. The science of horticulture can be divided into several branches depending upon the crops it deals with. The following are the branches of horticulture.

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1. Pomology: refers to cultivation of fruit crops.
2. Olericulture: refers to cultivation of vegetables.
3. Floriculture: refers to cultivation of flower crops.
4. Plantation crops: refers to cultivation of crops like coconut, arecanut, rubber, coffee, tea etc.
5. Spices crops: refers to cultivation of crops like, cardamom, pepper, nutmeg etc.
6. Medicinal and aromatic crops: deals with cultivation of medicinal and aromatic crops.
7. Post harvest technology: deals with post harvest handling, grading, packaging, storage, processing, value addition, marketing etc. of horticulture crops.
8. Plant propagation: deals with propagation of plants.

Fruit crops: India is the second largest producer of fruits after Brazil. A large variety of fruit crops are grown in India. Of these, mango, banana, citrus, papaya, guava, pineapple, sapota, jackfruit, litchi, grapes, apple, pear, peach, plum, walnut etc. are the important ones.

India accounts for 10 per cent of the total world production of fruits. It leads the world in the production of mango, banana, sapota and acid lime besides recording highest productivity in grape. The leading fruit growing states are Maharashtra, Karnataka, Andhra Pradesh, Bihar and Uttar Pradesh.

Vegetable crops: More than 40 vegetables belonging to Solanaceaeous, cucurbitaceous, leguminous, cruciferous, root crops and leafy vegetables are grown in Indian tropical , sub-tropical and temperate regions. Important vegetables grown in India are onion, tomato, potato, brinjal, peas, beans, okra, chilli, cabbage, cauliflower, bottle gourd, cucumber, watermelon, carrot, radish etc.

India ranks second in vegetable production next to China in area and production contributing 13.38 percent to the total world production. India occupies first position in cauliflower, second in Onion, third in cabbage in the world. West Bengal, Orissa, Uttar Pradesh, Bihar, Maharashtra, Karnataka are the important states for horticultural crop production.

Floriculture: Flower cultivation is being practiced in India since ages. It is an important/integral part of socio-cultural and religious life of Indian people. It has taken a shape of industry in recent years.

India is known for growing traditional flowers such as jasmine, marigold, chrysanthemum, tuberose, crossandra, aster, etc. Commercial cultivation of cut flowers like, rose, orchids, gladiolus, carnation, anthurium, gerbera is also being done. The important flower growing states are Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, West Bengal, Sikkim, Jammu &Kashmir, Meghalaya etc.

Plantation crops: This is one of the important sector contributing about Rs.7500 crores of export earnings. The major plantation crops include coconut, arecanut, oil palm, cashew, tea coffee, rubber cocoa, betel vine, vanilla etc. The leading states are Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra, Goa, Assam etc.

Spices: They constitute an important group of horticulture crops and are defined as vegetable products or mixture thereof, free from extraneous matter used for flavouring, seasoning and imparting aroma in foods. India is known as home of spices producing a wide variety of spices like black pepper, cardamom, ginger, turmeric, chilli, Coriander etc. Major spice producing states are Kerala, Andhra Pradesh, Gujarat, Rajasthan, Maharashtra, Karnataka, Orissa, Tamil Nadu etc.

Medicinal and Aromatic plants: India has diverse collection of medicinal and aromatic plants species distributed throughout the country. It has more than 9500 species with medicinal properties. Demand for these crops is increasing progressively in both domestic and export markets. Important medicinal plants are Isabgol, Senna, Opium poppy, Periwinkle, Coleus, Ashwagandha, etc. and aromatic plants are Japanese mint, Lemon grass, Citronella, Davana, Patchouli etc.

Features of Horticulture

1. Horticultural produces are mostly utilized in the fresh state and are highly perishable.
2. Horticultural crops need intensive cultivation requiring a large input of capital, labour and technology per unit area.
3. Cultural operations like propagation, training, pruning and harvesting are skilled and specific to horticultural crops.
4. Horticultural produce are rich sources of vitamins and minerals and alkaloids.
5. Aesthetic gratification is an exclusive phenomenon to horticultural science.

Importance of Horticulture

Horticulture is important for the following considerations:

1. As a source of variability in produce.
2. As a source of nutrients, vitamins, minerals, flavour, aroma, alkaloids, oleoresins, fibre, etc.
3. As a source of medicine.
4. As an economic proposition as they give higher returns per unit area in terms of energy, money, job, etc.
5. Employment generation 860 man days/annum for fruit crops as against 143 man days/annum for cereal crops and the crops like grapes, banana and pineapple need 1000-2500 man days per annum.
6. Effective utilization of waste land through cultivation of hardy fruits and medicinal plants.
7. As a substitute of family income being component of home garden.
8. As a foreign exchange earner, has higher share compare to agriculture crops.
9. As an input for industry being amenable to processing, especially fruit and vegetable preservation industry.
10. Aesthetic consideration and protection of environment.
11. Religious significance.

In short horticulture supplies quality food for health and mind, more calories per unit area, develops better resources and yields higher returns per unit area. It also enhances land value and creates better purchasing power for those who are engaged in this industry. Therefore, horticulture is important for health, wealth, hygiene and happiness.

Scope of Horticulture

Like any other things, scope of horticulture depends on incentive it has for the farmers, adaptability of the crops, necessity and facilities for future growth through inputs availability and infrastructure for the distribution of produce/marketing etc.

Incentive for the farmer: The biggest incentive for the farmer is money and horticultural crops provide more returns in terms of per unit area production, export value, value addition compared to agricultural crops.

Adaptability: India is bestowed with a great variety of climatic and edaphic conditions as we have climates varying from tropical, subtropical, temperate and within these humid, semi-arid, arid, frost free temperate etc. Likewise we have soils like loam, alluvial, laterite, medium black rocky shallow, heavy black, sandy etc. and thus a large number of crops can be accommodated with very high level of adaptability. Thus, there is good scope for horticultural crops.

Necessity: After having achieved self sufficiency in food, nutritional security for the people of the country has become the point of consideration/priority. Moreover, Indians are basically vegetarians, and to meet their nutritional requirement in terms of vitamins and minerals horticulture crops are to be grown in sufficient quantities to provide a bare minimum of 85 g of fruits and 200 g of vegetables per head per day with a population of above 120 crores. Continued increase in demand for horticultural produce provides tremendous scope for the growth of this industry.

Good land is under pressure for stable food, industry, housing, roads and infrastructure due to population explosion and only wasteland had to be efficiently utilized where cultivation of annuals is a gamble due to restricted root zone and their susceptibility of abiotic stress. These lands can be best utilized to cultivate hardy horticultural crops like fruits and medicinal plants.

At present our share in international trade of horticultural commodities is less than one per cent of total trade. Moreover, these commodities (spices, coffee, tea) fetch 10-20 times more foreign exchange per unit weight than cereals and therefore, taking advantage of globalization of trade, nearness of big market and the size of production, our country should greatly involve in international trade which would provide scope for growth.

In the recent past communication and transport system have improved, investment in food industry has increased which will support growth of horticulture through quick deliverance and avoidance of waste.

In brief it can be stated that horticulture has great scope for the following reasons:

1. To exploit great variability of agro climatic conditions.

2. To meet the need for fruits, vegetables, flowers, spices, beverages in relation to population growth based on minimum nutritional and other needs.

3. To meet the requirement of processing industry.

4. To substitute import and increase export.

5. To improve the economic conditions of the farmers and to engage more labourers to avert the problem of unemployment.

6. To protect environment.

Lecture No.2

Horticultural crops and Human Nutrition

Fruits and vegetables play an important role in balanced diet. These provide not only energy rich food but also provide vital protective nutrients/elements and vitamins. Comparatively fruits and vegetables are the cheapest source of natural nutritive foods. Since most of Indians are vegetarians, the incorporation of horticulture produce in daily diet is essential for good health. With the growing awareness and inclination towards vegetarianism worldwide the horticulture crops are gaining tremendous importance.

Functions of fruits and vegetables in human body:

1. Fruits and vegetables provide palatability, taste, improves appetite and provides fibre thereby the constipation can be overcome.
2. They neutralize the acids produced during digestion of proteins and fatty acids.
3. They improve the general immunity of human body against diseases, deficiencies etc.
4. They are the important source of vitamins and minerals for used in several bio-chemical reactions occur in body.

Fruits:-

Fruits provide higher energy value per unit area compared to cereals. Some of the essential nutrients provided by different fruits are:

Vitamins/ Minerals	Role in human body	Source
Vitamin-A	1. Essential for growth and reproduction. 2. Helps in resistance to infections, increases longevity and decreases senility. 3. Deficiency causes, night blindness, xeropthalmia, retardation in growth, roughness in skin, formation of stones in kidney.	Mango, Papaya, Persimon, Dates, Jack fruit, Walnut, Oranges, Passion fruit, Loquât etc.

Vitamin – B_1	1. Essential for the maintains of good appetite and normal digestion. 2. Necessary for growth, fertility, lactation and for normal functioning of nervous system. 3. Deficiency causes beri-beri, paralysis, loss the sensitivity of skin, enlargement of heart, loss of appetite and fall in body temperature.	Walnut, Apricot, Apple, Banana, Grapefruit, Plum and Almond.
Vitamin – B_2	1. Important for growth, health of skin and for respiration in poorly vascularised tissue such as the cornea. 2. Deficiency causes pellagra and alopecia, loss of appetite, loss of weight, sore throat, development of cataract, swollen nose and baldness.	Bael, Papaya, Litchi, Pomegranate, Wood apple and Pineapple.
Vitamin – C	1. Deficiency causes scurvy, pain in joints, swelling of limbs, unhealthy gums, tooth decay, delay in wound healing and rheumatism.	Barbados cherry, Aonla, Guava, Lime, Lemon, Sweet oranges, Ber, Pineapple and Pear.

Minerals are essential for the growth and development for the human body		
Calcium	Causes Rickets, Osteomalacia.	Sitaphal, Ramphal, Fig, Phalsa, Citrus, Sapota, Grapes, West Indian Cherry etc.
Phosphorous	Essential for cell multiplication of bones and soft tissues. Helps in liberation of energy on oxidation of carbohydrates.	Wood apple, Avocado, Dates, Pomegranate and Grape raisins.
Iron	Act as oxygen carrier in the body.	Karonda, Date palm, Grape raisins, West Indian Cherry, Guava, Sitaphal, Avocado, Sapota, plum etc.
Proteins	Important for body growth, formation and maintenance of body tissuess	West Indian cherry, Avocado, Custrad Apple, Banana, Apricot, Guava, Grapes etc.,

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ruits are also a good source of energy eg. Avocado, Olive etc.,

- Fruits are also a good source of enzymes which are helpful in metabolic activities leading to proper digestion of food. Eg. Jamun and Papaya.
- All fruits have one or the other medicinal value.
- They should be eaten in adequate quantity.
- Regular consumption of fruits reduces obesity, maintain health and increase the longevity of life.
- Fruits are attractive in appearance, delicious in taste and easily digestible.

Therefore ,they are liked by young and old alike.

Lecture No.3

Climatic Requirement

Climate is the most important factor on which choice of the crop for a region depends and therefore, understanding about climate and its requirement for different crops for optimum production on sustainable basis is important for horticulturists.

Climate is defined as the whole of average atmospheric phenomena for a certain region calculated for a period of thirty years. These phenomena are light, heat, water and air.

Light:

Electromagnetic radiation to which the organs of plant react ranging in wavelength from 4000 to 7700 angstrom units, and is propagated at a speed of about 540 kilometres per second. It is essential for the process of photosynthesis and therefore, for growth and development of plants. There are two aspects of light, its intensity and duration which are important for plant development. The light intensity can be estimated from the number of hours of bright sunlight or from the cloudiness of sky. Generally horticultural crops need a lot of light and must be grown in sunny climate, but there are some crops which can tolerate shade eg. turmeric and ginger. There are others like young mangosteen, coffee, cocoa and tea need shade during part of their development. A third group requires permanent shade like salak palm, duku, and carambola.

The duration of light for the time elapsing between dawn and dusk referred as **photoperiod or day length**.This exert considerable influence on flowering.

Based on the response by plants we classify plants in nine classes (Table 2.2) but the major classes are following. However, fruit crops for such categories are not known.

(i) Long day plants: Cabbage, Cauliflower, Onion, Beet, Radish, Carrot, Spinach, Potato, Dill and Plantago.
(ii) Short day plants: Strawberry, Pineapple, Chrysanthemum, Poinsettia, Aster, Balsam, Salvia, Euphorbia andXanthium.
(iii) Day neutral plants: Tomato, most fruit crops, Pepper, Cucumber, Snapdragon, Mirabilis and certain varieties of peas.

Heat:

Heat is a non-mechanical energy transfer with reference to a temperature difference between a system and its environmental surrounding. It is measured as temperature by thermometers. Daily, monthly and yearly averages as-well as, mean low and high temperatures and their extremes are computed. The yearly average at sea level on equator is 26-27°C and the range is small; it usually accounts to 2-3°C between months and 6-10°C between day and night. Further away from equator range increases and altitude also has the effect on lowering the temperature by 5-6^{o} C for every 1000 m. The growth of the plants depends primarily on temperature. This means a plant which grows normally at sea level will grow slowly in the mountains e.g. 'Lacatan' banana has a growth cycle of 13 months at sea level but takes one more month at 100m altitude. Availability of heat units decide the crop for a given place and the

average temperature of a place gives an idea about heat units available on the basis of which crop can be decided.

Temperate fruit crops like apple, pear, peach, plum and almond become dormant due to short day conditions in the region and need chilling of various lengths to break dormancy. Frost and chilling are harmful for tropical and subtropical plants. On the other hand extremely high temperatures found in arid region cause wilting, sunscald, necrotic spot and even death of plants.

Therefore, under such conditions appropriate choice of plants and provision of protection become important.

Based on the temperature variations on the surface of the earth we have the following climates.

- Tropical equable climate with no distinct winter.
- Subtropical Climate with distinct winter and summer.

Temperate: Distinct winter, summer and autumn with temperature below freezing during winter is common.

Tropical : Mango, Banana, Papaya, Sapota, Pineapple, Coconut, Cashew, Arecanut, Breadfruit, Jackfruit and Avocado.

Subtropical: Guava, Grape, Citrus, Date palm, Phalsa, Pomegranate, Litchi and Loquat.

Temperate: Apple, Pear, Peach, Plum, Quince, Apricot, Walnut, Almond, Strawberry and Cherry.

However, this choice is not very rigid as some tropical crops which can be grown in subtropics and vice versa. There are low chilling temperate crops which can be grown in sub-tropics like peach, pear, strawberry etc. Short duration crops like vegetables and flower crops are classified as warm season and cool season crops accommodated in various types of climates depending on temperature variations within a year. Flower and vegetable crops have been depicted in table 1 according to their season of growing. However, there are some plants which can grow under both the situations.

Table 1: **Classification of vegetable and flower crops according to seasons.**

	Warm Season	**Cool Season**

Vegetables	Bottle gourd	Cabbage
	Water melon	Cauliflower
	Brinjal	Pea
	Tomato	Beans
	Clusterbean	Potato
	Okra	Onion
	Sweetpotato	Carrot
		Radish
		Tomato
Flowers	Marigold	Aster
	Zinnia	Poppy
	Chrysanthemum	Dianthus
	Sunflower	Dahlia
	Gomphrena	Salvia
	Gaillardia	Petunia
	Portulaca	Pansy
	Kochia	Phlox
	Amaranthus	Coreopsis
	Celosia	Verbena
	Coreopsis	Diamorphotheca
		Calendula
		Brachycoms
		Candytuft
		Sweet allysum
		Antirrhinum
		Sweetpea

Water

Water is a transparent, odourless and tasteless liquid compound of hydrogen and oxygen (H_20) with 11.91% hydrogen and 88.81% oxygen. It is essential for plant growth and development as a substrate in photosynthesis, regulation of plant temperature, distribution of metabolites and nutrients. It comes through precipitation of rain and snow. Near equator the total rainfall is 2000 mm per year and away from it, which reduces but again influenced by a number of factors like mountain ranges. Water requirement of plant is dependent on soil type and evapo-transpiration rate. For crop production it is not the total rainfall but its distribution is more important and in Indian subcontinent we have rains mainly confined to June to September, thereby fruit culture in India had to be supported by irrigation or one has to select crop where fruiting is confined to water availability periods and trees remain dormant during stress.

Water is also present in the atmosphere as vapour and we call it as **humidity**. This atmospheric humidity also influences growth and development of plants. Low humidity has drying effects and enhances water requirement whereas high humidity favours fungal diseases. Plants liking for high humidity and low humidity are there:

High humidity: Sapota, **B**anana, Mangosteen, Jackfruit and Breadfruit.

Low humidity (Dry): Ber, Grape, Date palm, Pomegranate, Citrus, Aonla and Guava.

Air

A mixture of oxygen, nitrogen and other gases that surrounds the earth and forms its atmosphere. It is also one of the climatic factors influencing plant growth. If its quality is polluted by the accumulation of gasses like hydrocarbons, SO_2, CO_2, CO, NO ethylene and methane the plant growth adversely affected but we are more concerned with the movement of air (wind) causing great damage to crops in deserts, coastal areas, valleys for which provision of windbreaks and shelterbelts are suggested and such situations sometimes have to be avoided for plantation.

Storm has a wind speed of 50/hr whereas, hurricane has a wind speed of more than 100km/hr.

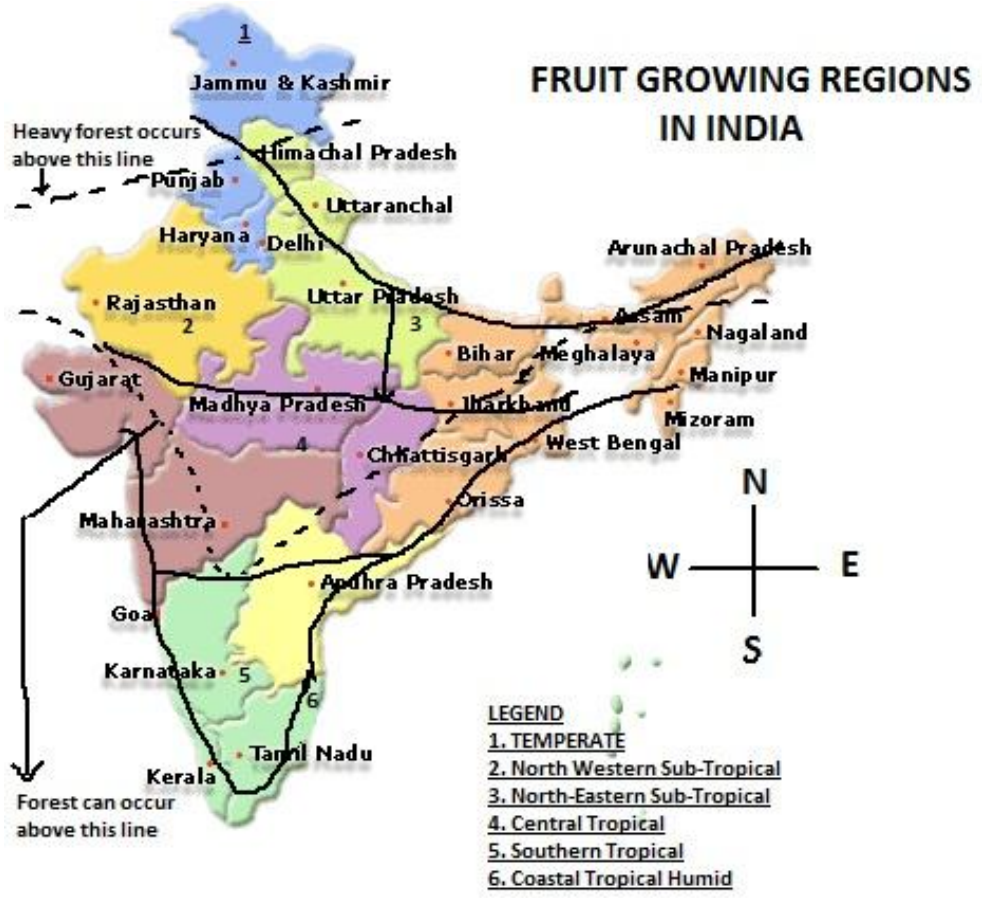
Table 2: **Plants according to photoperiodic requirements.**

1.	**Short-day plants**	Strawberry, Chrysanthemum, *Cosmos bipinnatus,* Aster, Poinsettia, *Impetiens balsamina* (Balsam), *Salvia occidentalis, Euphorbia pulcherrima, Xanthium pensylxanicum,* Rice, Some soyabean varieties and Tobacco.
2	**Long-day plants**	Spinach, Beet, Radish, Potato, *Hibiscus syriacus*, *Hyoscyamus niger*, *Anethum graveolens* (Dill), *Plantago* lanceolata and Wheat.
3	**Day-neutral plants**	Most of the fruit crops, Tomato, Pepper, Cucumber, *Mirabilis* (Four O Clock plant), Cotton, Certain varieties of peas, Buck wheat and Snapdragon.
4	**SL plants**	Strawberry, *Primula malacoides* and *Cineraria hybrid.*
5	**LL plants**	*Chrysanthemum leucanthemum, Silene pendula.*
6	**LS plants**	*Physostegia verginiana, Bottonia latisquama.*
7	**SS plants**	*Pharbitis nil, Cosmos bipinnatus and Glycine max.*
8	**LI plants**	*Phlox paniculata.*
9	**SI plants**	Late varieties of rice.
10	**IS plants**	*Chrysanthemum articum.*
11	**IL plants**	Spinach and Wheat
12	**II plants**	*Capsicum frutenscens* (Bell Pepper) and Early varieties of rice.

Lecture No.4

Horticultural Zones of India

The Indian subcontinent is bestowed with a great variety of climate and soil conditions. Broadly the country can be divided into tropical, subtropical and temperate regions. Within each broad category there are differences due to rainfall, humidity, altitude etc. And considering these aspects six different horticultural zones have been identified so that appropriate choice of the crops can be made and development is planned. They are:



(i)**Temperate:** Kashmir, Himachal Pradesh, North Uttaranchal, Sikkim and part of Arunachal Pradesh.

(ii) **N. W. Subtropical**: Punjab, Haryana, Rajasthan, Central Uttar Pradesh and North M.P.

(iii**) N. E. Subtropical**: Bihar, Jharkhand, Assam, Meghalaya, Nagaland, Manipur.

(iv) **Central tropical:** South Madhya Pradesh, Chattisgarh, Gujarat, Maharashtra, Orissa and West Bengal.

(v) **Southern tropical**: Karnataka, Andhra Pradesh and Tamil Nadu.

(iv) **Coastal tropical humid:** Konkan, Goa, Kerala, Western Ghats, Eastern Ghats in Tamil Nadu, Andhra Pradesh and Orissa.

To exploit the potential of a crop and its sustenance, right choice based on climate and soil is necessary otherwise the management of the crop becomes difficult and the cost of cultivation increases. To be precise, most adaptable crop should be chosen for sustenance.

Table 3: Climatic requirements for important fruits of India

Mango	:	Tropical and sub tropical.
Citrus	:	Subtropical but can be grown under temperate conditions.
Grapes	:	Temperate but can be grown under subtropical and tropical conditions.
Peaches	:	Temperate but low chilling varieties can be grown under subtropical conditions.
Sapota	:	Tropical but can be grown under subtropical conditions which are free from frost.
Papaya	:	Tropical and mild subtropical climate.
Banana	:	Tropical, can be grown under subtropical climate provided it is free from hot winds and frost.
Almond	:	Temperate but some low chilling varieties can be grown under subtropical climate.
Apple	:	Temperate but low chilling varieties can also be grown on lower hills.

Lecture No.5

Soil Requirement

Soil is the upper most crust of earth surface which supports plant growth. It is defined as a three phase system in which plants grow. These phases are solid, liquid, and gas and are essential. Solid part is frame which provides space for other two. This consists of minerals, clay minerals and organic matter.

The soil is also a living system with millions of microbes that breakdown organic matter and builds it again.Microbes are essential and survive only when soil is well aerated and rich in organic matter and devoid of waterlogged conditions.

Texture of soil depends on the size of solid particles and classified as gravel, coarse and fine sand, silt and clay. Soils are classified according to relative distribution of these particles and there are 12 textural classes.

Likewise, arrangement of these particles is referred as structure, and both texture and structure lend soil physical properties like water holding capacity, aeration and bulk density. Generally loamy soils and crumb structure are most preferred for fruit crops.

According to level of organic matter, soils are classified as mineral soil or organic soil and soil having more than 20% organic matter is organic soil like peat and muck.

Minerals and salts lend chemical properties to the soil like pH, alkalinity, sodicity, salinity and cation exchange capacity which influence the availability of nutrients in soil.

Therefore, for making choice for soil, soil analysis in terms of following criteria is essential to decide on land capability.

Criteria for land capability class:

(I) Slope and erosion hazard.
(ii) Soil depth .
(iii) Drainage.
(iv) Workability.
(v) Stoniness and rockiness.
(vi) Water holding capacity.
(vii) Permeability.
(viii) Nutrient availability.
(ix) Fertility status.
(x) Salinity, alkalinity and acidity hazards.

Based on these criteria there are 8 capability classes of which (i) to (iv) are suitable for cultivation and (v) to (viii) are not suitable for cultivation.

The soil provides support for the plant and act as storehouse of nutrients and water as well as oxygen for root growth. The ability of the soil to support plant growth is often referred to as its productive capacity which depends on fertility and physical condition. Therefore, the soil has to be a good soil.

A good soil is one which have the capacity to nourish and sustain plant growth by providing mineral particles (nutrients) in an available form to plants by their interaction with soil air, moisture, microbes and humus. Generally a loam soil is considered to be a good soil.

Generally fruit crops need porous, aerated, deep (2 m) uniformly textured soils and the pH of soil should be within range of 6-8. Soil with hardpan within 120 cm from surface, soil with

high clay content at surface and very less at subsurface or vice-versa are not suitable for fruit crops. Fruit crops are susceptible to waterlogged condition and growth is adversely affected by salinity, sodicity and alkalinity.

It is, therefore, important that soil be analyzed for its quality and then choice of the crop is made for sustainable production. If the soils are problematic like poor aeration or drainage, sodicity, alkalinity, acidity and salinity, they require improvement or reclamation before taking up crop production or the venture would fail. Alternatively tolerant or resistant crops can be choosen for different problems.

Salinity tolerant crops: Kair, Khirni, Woodapple, Date palm, Ber, Aonla, Fig, Sapota etc.

Sodicity tolerant crops: Ber, Tamarind, Woodapple, Date palm, Aonla, Karonda, Fig, Phalsa, Pomegranate, Guava, Bael and almond.

Drought tolerant crops: Ber, Aonla, Ahalsa, Lasoda, Kair, Custard apple, Karonda, Fig, Guava etc.

If we know the soil and the requirement of soil for the crops, then choice of the crop can easily be made. Let us examine the example of coconut plant for which the suitable soil is indicated below.

Soil characteristics for coconut:

Slope	0.02%
Drainage	good
Texture	Clay loamy-sand
CEC	Any
Base saturation	+ 20
EC	Any
ESP	Any

Grouping of fruits according to their tolerance to salinity:

(i) **High salt tolerance:** Date palm, Ber and Aonla.

(ii) **Medium salt tolerance:** Pomegranate, Fig and Grape.

(iii) **Low salt tolerance:** Apple, Orange, Almond, Lemon and avocado.

In making choice of soil for fruit crops physical properties should he emphasized, more as chemicals can be added from outside to improve nutrient status and chemical properties of the soil. Generally the depth and the drainability are very important for crop production.

To upkeep soils for sustainable production following things are to be done before and after planting a crop:

Soil analysis in terms of its physical and chemical attributes.

- Bring the soil to its optimum potential by applying organic matter, chemical fertilizers, micronutrient and amendments depending on soil analysis report.
- Adoption of soil conservation technique like green manuring on regular basis.
- Use of improved water management techniques like drip irrigation and check basin or Furrows.

- Incorporation of large quantity of bulky organic matter each year.
- Creation of appropriate drainage around the plot.
- Scrapping of salts, and reclamation of soil by application of gypsum, iron pyrites, press mud etc. On regular basis in case of salinity problem.
- Replenishment of nutrients harvested by the crop on regular basis by preparing a balance sheet for nutrients.
- Recycling of organic waste.

Soil is the most important natural resource for fruit culture and it needs to be protected and improved.

Lecture No.6&7

Importance of Nursery and its management

Nursery is a place where seedling, saplings or any other planting materials are raised, propagated, multiplied and sold out for planting.

The prerequisite of a successful and remunerative fruit production is the availability of good quality true-to- type and diverse plant materials. Setting up of a nursery is a long term venture and requires careful planning and expertise.

Importance of Nursery:

1. The young seedlings require special attention during the first few weeks after germination. It is easier and economical to look after the young and tender seedlings growing in nursery bed in a small area than in a large permanent site.
2. Majority of fruit crops are propagated by vegetative means. The propagules require special skill and aftercare before transferring them in the main field. In a controlled condition in nursery all these can be provided successfully by skilled labour.
3. Cuttings are best rooted and grafts are hardened in the mist house chamber which is an integrated part of a nursery.
4. Direct sowing method is not so successful in several crops when compared with transplanting of seedlings raised in nursery.
5. Plants hardened in the nursery are preferred for causality replacement in orchards.
6. Besides these, raising of seedlings or saplings in nursery provides more time for pre-planting operations/preparations.
7. Seasoning/hardening of seedlings against natural odds is only possible in nursery.

Classification of nursery:

Nursery can be broadly grouped into two on the basis of its site:

1. Home nursery 2.Commercial nursery

Home nursery: is the area where planting materials specifically grown or raised only to cater the needs of the growers garden. The area is small and the primary consideration is the raising of quality planting material. Costly methods of nursery practices are adopted.

Commercial nursery: Nurseries are larger in size and collection of plants. This is mainly concerned with economic returns from the investments and therefore, very expensive methods are avoided. This type of nursery can be divided into two based on location:

a. **Rural nursery** **b. Urban nursery**

Factors affecting the establishment of a nursery:

1.Location and site - a. Topography b. climate c. reputation of locality for business d. transport facility
2 Selection of soil
3 Water facility
4 Manures
5 Availability of labour

Components of nursery: A nursery should consist of the following components:

1. **Building structures:** This includes office, sale counter, packing shed, potting shed, store, implement shed and residential quarter.
2. **Progeny tree block:** The current choice of kind and variety of fruit crops and collection of true to type mother plants have strong bearing on the success and goodwill of a nursery industry. Suitable fruit crops should be selected to meet the demand of the customers. There should be a collection of good number of promising varieties of popular crops to make a wide choice. The progeny tree should be healthy, disease free, genetically true to type and free from pest attack. The pedigree of these plants should be known to the nursery man.
3. **Propagation structures:** structures like green house, glass house, poly house, hot bed, cold frames, lath house, shade house, mist house are used to create congenial condition for the propagation of plants.
4. **Nursery bed.**

Management of young nursery plants:

a. **Irrigation**: the young seedling should be frequently watered with low pressure. Excess and deficit of moisture is harmful. Proper care should be taken to avoid subsoil congestion through provision of proper drainage.
b. **Nutrition:** Proper nutrition has profound effect on growth. The growing media should have liberal dose of manures and decomposed organic manure. A light and frequent dose of nitrogen will boost the growth of young seedlings.
c. **Weed control:** The nursery should be kept weed free including roads and channel to avoid chances of further spread.
d. **Plant protection**: In the initial stages the seedlings are more prone for pest and diseases. Therefore, prophylactic measures should be undertaken.

Common pests: Ants, Snails, Rodents, Cutworms and sucking pests.

Diseases: Collar rot, Damping off, Nematodes, Wilt etc.

Lecture No.8 & 9

PLANNING OF ORCHARDS

Orchard is a long-term investment and needs lot of planning and expertise. While planning and planting a new orchard, one should give utmost attention and care to various aspects like selection of location and site, nature of soil and subsoil, planning of suitable kinds and varieties of fruits, proper planting distance and purchasing of plants from reliable nurseries.

Preparation of land

The land should be cleaned properly for free movement of men and machinery. All the trees, bushes and creepers should be removed. The soil of the area designed for growing fruit plants needs thorough preparation. A virgin land requires a deep ploughing and harrowing. The land should be repeatedly ploughed and bring the soil to a fine tilth.

Layout plan

The marking of position of the plant in the field is referred as layout. The layout plan of the orchard should be prepared carefully, preferably in consultation with horticultural experts. The orchard layout plan includes the system of planning provision for orchard paths, roads, water channels and farm building. A sketch of the proposed orchard should be prepared before the actual planting is taken up.

Method of layout

For laying out an orchard, according to square system, a base line is first established and position of the trees is marked along this line by laying 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 three metre distance from the corner along the first line and the tape is then stretched along the second base line for a distance of four metre. The diagonal distance between these two points should be five metre. The wooden stakes are put in the ground at the desired distance along the second line. All the four rows are thus established and staked. Three men, one putting the peg in the field and others correcting alignment while moving along the base line, can easily stake the whole field.

The marking of position of the plant in the field is called "**layout"**.

Aims:

1) To provide adequate space to plants.
2) To accommodate more number of plants.
3) Easy intercultural operations.
4) System of planting

The following are the important systems of planting generally followed on the basis of Agro-climatic conditions.to improve aesthetic view of the land.

Square system

It is the most commonly used method and easy to layout in the field. In this system, plant to plant and row to row distance is the same. The plants are at the right angle to each other, every unit of four plants forming a square. This system facilitates the interculture in two directions after the orchard is planted.

Advantage:

1) Most easy and popular one.
2) In this row to row and plant to plant distance is kept similar.
3) Plants are exactly at right angle to each other.
4) Interculture operations can be done in both the directions.
5) Adequate space for inter-cultivation of remunerative crops like vegetables.

Rectangular system

In this system, the plot is divided into rectangles instead of squares and trees are planted at the four corners of the rectangle in straight rows running at right angles. Like square system, this system also facilitates the interculture in two directions. The only difference is that in this system more plants can be accommodated in the row keeping more space between the rows.

Advantages:

1) Lay out in rectangular shape.
2) More space between row to row.
3) Inter-cultural operations can be done in both the ways.
4) Plants get proper space and sunlight.

Hexagonal system

In hexagonal system, the trees are planted in the corners of equilateral triangles. Six trees thus form a hexagon with another tree at its centre. This system, though a little difficult for

execution but accommodates 15 percent more plants. Cultivation of land between the tree rows is possible in three directions with this system. This system is generally followed where the land is costly and very fertile with ample provision of irrigation water.

Advantages:

1) Accommodates 15 % more plants than the square system.
2) Plants are planted at the corner of equilateral triangle.
3) Six trees are planted making a hexagon.
4) The seventh tree is planted in the centre and called septule.
5) This requires fertile land.

Disadvantage:

- Lay out is difficult and cumbersome.

Fig: Hexagonal system of planting.

Quincunx system

This system is exactly like the square system but one additional tree is planted in the centre of each square. The number of plants per acre by this system is almost doubled than the square system. Fruit trees like papaya, kinnow, phalsa, guava, peach, plum etc. can be planted as fillers in the permanent trees provides an additional income to the grower in the early life of the orchard. The filler trees are uprooted when the main orchard trees start commercial fruiting.

Contour system

This system is usually followed in the hilly areas with high slopes but it is very much similar to the square/rectangular system. Under such circumstances, the trees may be well planted in lines following the contour of the soil with only a slight slope. Irrigation and cultivation are then practiced only across the slope of the land as this practice reduces the chances of soil erosion. In this system layout is done as in square/rectangular system, first by establishing the base line at the lowest level and then marking for the trees should be done from the base to the top. Bench terraces are used where the slope is greater than 10 per cent.

Triangular system

In this system, trees are planted as in the square system but the plants in the 2^{nd}, 4^{th}, 6^{th} and such other alternate rows are planted midway between the 1^{st}, 3^{rd}, 5^{th} and such other alternative rows. This system provides more open space for the trees and for intercrop.

Lecture No.10

ORCHARD

Orchard refers to an area where intensive cultivation of fruit crops is done. **Or** it is an area where fruit crops like mango, citrus, papaya, banana etc. are cultivated. **Or** it is an enclosed area where a fruit /group of fruit trees are grown.

Orcharding: refers to growing of fruit plants in an orderly manner and maintain them for successive economic returns.

Garden: The term garden refers to fruit farm, where sophisticated agro-techniques are employed for commercial cultivation.

Eg: Grape garden.

Specific crops: 1. Vineyard/vinery—grape garden

2. Pinery- Pineapple

3. Orangery—Orange garden

Plantation: refers to a fairly large area where cultivation is done with a particular type of fruit crop.

Eg: Mango plantation, apple plantation, coconut plantation etc.

Estate: refers to large area (more than 1000 acres) of sole crop cultivation. This terminology was used in earlier days (British empire).

Eg: Coffee estate and Tea estate.

Types of Orchards.

There are various types of orcharding

1. Orcharding with single variety of a particular fruit crop.
2. Orcharding with different variety of a fruit crop.
3. Mixed orchard with different fruit crops of almost equal life span.
4. Orcharding with intercrops/intercropping.
5. Multistoried orchard.
6. High density orchard.
7. Dry land orchard.
8. Clonal orchards.

9. Nutrition /Kitchen garden.

1. Orcharding with single variety of a particular fruit crop:

Eg: Mango orchard exclusively Alphonso variety.

Pomegranate orchard of Kesar variety.

Guava orchard of Sardar variety.

Advantages:

1. Purity of the variety can be maintained.
2. Convenient for planning and management.
3. All the trees come to harvest at the same time.

Disadvantages:

1. The variety may be incompatible (which leads to poor fruit set).
2. The variety may be susceptible to pest and diseases.
3. The variety may be irregular like Alphonso variety.
4. The variety may not satisfy all consumers.

2. Orcharding with different variety of fruit crop:

Eg: Mango orchard - Alphonso+ Kesar+Pairi.

Sapota orchard - Cricket ball+ Kalipatti.

Grape - Thomson seedless+ Sonaka +Sharad seedless.

Advantages:

1. If one variety fails for some reasons other variety will give some returns/income.
2. Problem of self incompatibility can be overcome.
3. It can help in supply variety of fruits during different periods and to cater the needs of different customers.

Disadvantages:

1. Purity of variety may be affected.
2. Management and harvesting varies.

3. Mixed orchards with different fruits of equal life span.

3. Mixed orchard with different fruit crops of almost equal life span.

Eg: Mango+Sapota+Guava.

Tamarind+Ber+Annona+Aonla.

Fig+Pomegrante+Ber+Lime.

Papaya+Banana+Pineapple.

Advantages:

1. More than one crop may be available on the same piece of land.
2. If one crop fails other crop will come to rescue and maintains continuity of income.
3. Year round income.

Disadvantages:

1. Management becomes very difficult.
2. Problems of pest and diseases.

4. Orchrding with intercrop:

This system involves incorporation of another species (fruit/vegetable) in between the interspaces of main crop. This system uses the open space available during pre-bearing period of main crop. The intercropping is discontinued once the main crop completely covers the canopy. The intercrop selected should have the following characters.

1. Should be compatible with main crop in their water, nutrient and soil requirement.
2. Compact stature and should not compete with main crop.
3. Short duration when compared to other perennial crops.
4. Should not act as an alternate host for pest and diseases.

Advantages:

1. Helps in getting additional income from the orchard during pre-bearing stage of main crop.
2. It also acts as a cover crop and prevents soil erosion.
3. Suppress the weed growth in open space.
4. Efficient land utilization.

Eg: Banana, Papaya, Pineapple, Guava, Phalsa, Fig, Beans, Cowpea, Dolichos, Marigold, Gaillardia, Aster etc.

5. Multistoried orchard:

Eg: Coconut+Black pepper+cocoa+pineapple.

Arecanut+Vanilla+Banana+Pinapple.

The principle involved in multistoried orchard is harvesting light at different height/story. The planting should be such that sunlight is harvested by different crops at different stories/levels/height and there won't be any competition for soil nutrients, moisture and sunlight because the spread and distribution of roots at different crop component is distributed in different layers of the soil profile.

6.High density orchard:

High density aims at increasing the productivity per unit area by increasing plant population/unit area by closer spacing. This has been successfully done in several temperate fruit crops like apple, pear, peach etc. where there is availability of dwarfing rootstocks and plant response for training and pruning and chemical regulation of size.

Eg : Apple 3X3 ---1111 plants.

3X2 ---1666 plants.

Limited success of high density is noticed in tropical and subtropical fruit crops because of

1. Non availability of dwarfing rootstocks.
2. Vigorous growth throughout the year.
3. Poor response for training and pruning.

High density orchard was tried in mango with dwarfing variety like Amrapali and with the use of dwarfing rootstock like Olur, Vellaikollamban.

Different types of high density planting followed in fruit crops:

Bush orchard, Pyramid orchard, Tatura trellies, Meadow orchard, Hedge row system etc.

Advantages:

1. High returns per unit area.
2. Maximum use of resources.
3. Possibility of adopting mechanization.

Disadvantages:

1. Competition in later years.

2. Pest and disease problems.
3. Cultural operation is difficult.

7. Dryland orchard:

Growing of fruit plants in drylands like arid and semiarid zones as rainfed crop. This concept is gaining importance as several fruit crops have been identified for cultivation in arid and semi arid regions.

Eg: Ber, Aonla, Datepalm, Tamarind, Fig, Phalsa etc.

With the advancement of irrigation technology and efficient water harvesting and conservation some of high value fruit crops are also being grown in arid and semiarid/rainfed regions.

Eg: Mango, Grape, Pomegranate etc.

8. Clonal orchard:

Orchard established from plants derived from single individual mother plants through vegetative means.

Eg: Clonal orchard of mango var. Alphonso.

Advantages:

Plants will be uniform in growth, bearing habit and management practices

Lecture No.11

Kitchen garden

Fruits and vegetables play an important role in the balanced diet of human beings by providing not only the energy rich food but also promise vital protective nutrients. In order to make available the requisite quantity and kind of fresh fruit and vegetables every day to a family, it is better to have a nutrition garden to grow them in the house premises. Fruits and vegetables obtained from market lack freshness and deteriorate in the food value besides their exorbitant price. Therefore, the best quality of the fresh produce can be had from one's own nutrition garden as the time interval between the harvest and the consumption becomes the least. Working in a garden becomes a pleasure, an inspiration, a means of recreation and a possible family enterprise in which all members have due share to spend the leisure hours. The whole family can be engaged in it, where no great technical skill is required. The land available within the compound of the residential building can be utilized for laying out a nutrition garden, which would help in taking proper care, harvesting, irrigation and other operations. Big trees should be planted towards the northern side of the garden as they will not only shade the vegetables but the roots may compete for moisture and nutrition if planted in between.

A model nutrition garden generally consists of growing vegetables and fruits either separately or in combination. Thus the plan of growing vegetables and fruits has to be integrated in a most beneficial manner.

The size of the garden may depend on the area available in the compound, the time available for its care and daily requirement of fresh fruits and vegetables of a family. To meet the demand of vegetables for an average family of 5 to 6 members, an area of 200 square meters will be sufficient. To produce 300g of vegetables per day, all the year round, about 50 square meters of area is required. Depending on the space available and the family size the planning may be done either for a big or a medium or a small size garden.

Guidelines/Principles in planning nutrition garden:

1. It is convenient to layout rectangular plot than a square plot.
2. Garden should be well protected with suitable fence.
3. Perennial vegetables like curry leaf, drumstick and quick growing fruits like papaya, banana and lime should be planted along the border.
4. Perennial vegetables like coccinia, chow-chow, etc., which require support should be planted at the rear end of the garden.
5. Long duration vegetables like tapioca, elephant foot yam, etc., may be planted together.
6. Suitable short duration companion crops such as radish, beetroot, carrot, etc., can be grown with the long duration crops. These crops can be grown on the bunds.
7. Crop rotation should be followed in such a way so that each plot will be planted with leguminous vegetable crop at least once in two years and also see that at least 4-6 kinds of vegetables are always available.
8. One plot should be kept reserved for raising nursery seedlings.
9. Knowledge of planting season is essential in planning the cropping pattern.

10. The entire plot should be divided into a number of small plots (sub plots). The size and number of sub plots can be decided based on area available (family size) and crops chosen with convenience.
11. One or two compost pits may be dug in the shady corner of the garden.
12. The plot should be provided according to convenience using minimum space.
13. Creeping vegetables like gourds and others may be trailed on the fence or erected pendals.
14. The area in between the perennial plants may be utilised for short duration shallow rooted annual vegetables or spices like garlic, coriander, etc.
15. If the land is limited preference can be given for growing those vegetables which are costly, highly perishable, not easily available in the market and which can produce maximum edible vegetables per unit area.

The irrigation channel from the water source and path should be so planned and prepared that it covers the whole area of the garden for easy operation

Lecture No.12

Digging and filling of pits

Marking of pits and planting should always be done with the help of planting board. The guide pegs are installed at both the ends. One meter deep pits of one meter diameter should be dug. Top 30 cm soil should be kept on one side, which is used for refilling the pits as it is fertile soil. Bottom 70 cm soil should be kept on other side, which is discarded. The pits should be left exposed for a few days before actual planting. These pits should be refilled with mixture of topsoil, 2-3 baskets of silt and 2-3 baskets of well-decomposed farmyard manure. The refilled pits should be watered a few days before planting the tree. To each pit add carbofuron (25g) for control of white ants.

Method of planting

Bore holes of suitable size are made in the centre of the filled pits with the help of planting board. Place the earth ball of a plant in it in such a way that the upper surface has the same level as ground. Fill loose earth around the ball and press it firmly with the handle of a spade or khurpi. Apply water soon after planting the plants in the pits.

Planting distance of fruit plants:

The spacing given to the fruit trees is generally governed by the different factors like climate and soil, choice of varieties, growth habit of tree, rootstock used, nature of irrigation and pruning technique followed. The spacing may vary according to different systems of planting. Provision of optimum spacing to fruit trees is one of the most important aspects of successful fruit culture. Optimum spacing regulates the proper utilization of sunlight, avoids competition in the uptake of nutrients caused by the collision of root systems and facilitates proper irrigation. The latest technology on high-density plantation system where trees are planted at critical spacing for maximum utilization of space is becoming popular. It will be very difficult to suggest exact spacing for fruit trees, which will suit every locality or soil.

Given below is the spacing of some of the important fruit plants, which serve as basic guideline for establishing a new orchard.

Name of fruit tree	Planting distance (m)	Number of plants/ha (square system)
Mango	10	100
Citrus & Pomegranate	6	275
Grape i) Head system ii) Kniffin system	2.0X1.5 4.00X3.00	3300 1100

iii) Bower system	3.1X6.0	550
Guava, Peach & Loquat	6.5	225
Litchi & Sapota	7.5-9.0	180-123
Ber & Pear	7.5	180
Date-palm & Almond	6-7	275-202
Jamun	10-12	105-75
Phalsa & Papaya	1.5	4400
Banana i) Tall varieties ii) Dwarf varieties	2.7X3.0 1.8X1.8	1210 3052
Pineapple	30X60X90 cm	43500
Custard apple	5	390
Jack fruit	10	100

Planting season:

The planting season of different fruit crops vary on the basis of their evergreen or deciduous nature.

Evergreen fruit plants: There are two planting times for evergreen fruits ie., beginning of monsoon and end of rainy season in heavy rainfall areas. The fruit plants such as citrus, mango and litchi should preferably be planted during September or in the beginning of October when the weather becomes mild and more favourable and there is enough moisture in the soil. Guava can also be planted bare-rooted during February-March or August-September. The plant should be defoliated and the roots covered with moist material.

Most of the sub-tropical and tropical evergreen fruit plants are suitably transplanted during the rainy season when the atmospheric humidity is high and sufficient supply of soil moisture is obtained. During this active period of growth, the plants easily penetrate their roots in the soil and get established. High atmospheric humidity during the rainy season helps them to minimize the transpiration loss.

The evergreen plants can also be transplanted during the onset of spring with equal success provided an ample quantity of irrigation water is available. Early regeneration of rootlets due to high temperature and available moisture during this period helps in early establishment of the plants in most of the cases.

Deciduous fruit plants: The deciduous fruit plants are planted during winter when they are dormant. Their planting must be completed before the start of new growth i.e., up to middle

January in case of peach and plum and up to middle of February in case of pear and grapes. The bare rooted ber can also be planted during January and up to middle of February.

It would be wise, if the planting operation in deciduous fruit plants could be done well before the dormancy is broken and the plants start their growth afresh during subsequent period.

Planting should be avoided during hot and dry spells of weather. The fruit trees should preferably be planted in the afternoon and on cloudy and humid days rather than in bright sunshine and dry weather.

Lecture No.13&14

Orchard Management

Orchard is an area, often enclosed, devoted to the cultivation of fruit trees and as a unit it encompasses various resources like land, water, trees and external inputs. All these resources have to be well utilized to the best advantage for higher production per unit area on sustainable basis without adversely affecting the quality of environment. We should also understand that a good manager is one who gets maximum out of various inputs consistently without any loss of fertilizers and manure, plant, plant protection chemicals, produce etc. Therefore, one should understand the management of these qualities of both resource and output. Various resources are soil and water.

Resources for better comprehension of orchard management are:

(I) Soil management
(ii) Water management
(iii) Nutrition management
(iv) Pruning and training (plant management)
(v) Weed management
(vi) Plant protection against insect pests and diseases.
(vii) Bearing, fruitfulness and causes of unfruitfulness.
(viii) Maturity and harvest.
(ix) Post harvest handling, utilization and marketing.

Soil management/Floor management:

Soil management aims at maintaining soil in good condition, or improving the condition if necessary. This includes protection from direct sunlight and from the impact of rainfall and wind erosion. In annual crops like vegetables and flowers which do not leave vacant space. There is no such problem except that one has to replenish nutrients harvested by crops and leached out but in tree crops, wherein, it is usually several years after planting before a tree which form such an extensive canopy that it can provide adequate protection to the soil, the vacant space needs to be productively utilized and protected through different management practices like intercropping, cover cropping, cultivation, sod culture, mulching, rotation, high density planting..

Objectives of soil management:

(i) To create favourable conditions for moisture supply and proper drainage.
(ii) To maintain high fertility level and replenishment against losses.
(iv) To provide proper soil conditions for gaseous exchange and microbial activities through addition of organic matter.
(iii) To check or reduce soil erosion.
(v) To ensure supply of nutrients for growth and development of plants.
(vi) To utilize vacant land for additional income because such a loss is inconceivable for small holders.
(viii) To reduce the cost of cultivation with high economic returns.
(vii) To suppress weed population.

Definitions of terms to be used in management of soil:

Intercrop: Any crop other than main crop grown between the rows of perennial tree crops is known as **intercrop** and the cultivation there of is **intercropping.**

Green manure crop: The crop other than main crop grown for the purpose of enriching the soil for organic matter is called **green manure crop**.

Cover crop: The crop grown to provide a cover to soil to protect it from erosion. It may be green manure crop also.

Methods of Soil Management:

Appropriate soil management method is important for the control of weeds, incorporation of organic and inorganic fertilizers and to facilitate absorption of water in soil. Common soil management practices are (1) cultivation (2) sod culture (3) mulching and (4) rotation.

Choice of the system is determined by many factors as mentioned below:

(i) Crop
(ii) Rooting depth of the crop
(iii) Slope of the soil
(iv) Rainfall of the area
(v) Climatic condition of the place
(vi) Economic condition of the farmer

1. Cultivation:

Cultivation in context with soil management refers to working of the soil by ploughing, harrowing, disking or hoeing. It is essential for removal of weeds, incorporation of manures and fertilizers, green manuring and to facilitate water and nutrient absorption through better aeration. Depth of tillage and areas are determined by root depth and spread of the canopy of the tree. In cultivation different modifications are made under specific conditions.

(i) Clean cultivation: In this method of soil management the space between plants is kept clean by tillage and removal of weeds.

Advantages:

(a) Removes competition of weeds for light, water and nutrients from crop and avoidance of alternate host for pests and diseases.
(b) Improves soil physical condition through better aeration by breaking clods.
(c) Helps in breaking hard top and abstructions in the infiltration of water.
(d) Improves soil biological activities through better aeration.

Disadvantages:

(a) Loss of organic matter.
(b) Loss of soil through erosion even on flat lands through water and wind.
(c) Loss of nutrient through excessive leaching.
(d) Injury to roots and creation of entry points for pathogens.

Due to several such disadvantages, clean cultivation is not advisable in fruit farming, perhaps just before planting. Even so, it will seem inconceivable to most small holders not to use good land whenever possible and intercrops involving short duration crops and nitrogen fixing annual crops are preferred. If it should be, cultivation should be shallow and infrequent and should be stopped at flowering time.

(ii) Cultivation and cover crops: In areas where soil is eroded during rains and drainage is poor, soil is cultivated and cover crops are grown between the rows during rains. The crop may and may not be turned into soil. These crops not only increase water retaining capacity of soil and biological complex of the soil but also add organic matter when ploughed in besides checking erosion. As cover crops, legumes should be preferred because they add extra N in soil through fixation of atmospheric-N in their nodules. They also suppress weeds during rainy season. Crops like greengram, blackgram, cowpea, cluster bean, soybean should be preferred during kharif season while pea, fenugreek, broad bean and lentil can be preferred in winter season as cover crops.

Advantages:

(a) Adds organic matter in soil.
(b) Improves soil condition.
(c) Improves soil fertility.
(d) Increases water retention capacity of soil.
(e) Increases biological complexes of soil.
(f) Checks soil erosion.
(g) Checks nutrient losses through soil erosion.
(ii) Cultivation and intercropping.

In this case of orchard soil management, cultivation is done for the purpose of raising intercrops. Intercropping is growing of two or more crops simultaneously on the same field so that crop intensification occurs in both time and space dimensions, and there is intercrop competition during all or part of crop growth. This can be mixed strip or relay cropping.

In context of an orchard or a plantation of perennial fruit trees, however, the practices of growing annuals or relatively short duration crop in the interspace during their formative years is referred to as **intercropping** and the growing of perennial in the interspacing of perennials is called **mixed cropping.** The term **multistory cropping** refers to a multispecies crop combination involving both annuals and perennials with an existing stand of perennials.

Purpose of intercropping: Intercropping is intended to maximize land and space use efficiency to generate supplement income, particularly during the initial unproductive phase of the orchard. To protect the inter space from losses through weeds, erosion, impact of radiation, temperature, wind and water, and enriching it by nitrogen fixing leguminous crops.

Disadvantage:

If the main plantation is not given proper care, serious losses may occur as a result of root restriction, damage and infection, undue exhaustion of the soil, perpetuation of viral, fungal and nematode infection. Intercrops should therefore, receive secondary importance and fulfill the following criteria.

(a) Should not be tall growing and spreading type.
(b) They should not be exhaustive.

(c) Should not function as alternate host for common pests and diseases.
(d) The water requirement schedule should match or phenology of crop should match so that operation could be synchronized.
(e) Should be compatible with main crop.

Besides, it is necessary that separate provision for nutrients should be made for intercrop to avoid competition. Normally if one selects intercrop on the basis of agro-climate, resource, market and compatibility of crop with perennial plantation it should be a successful choice. Annual crops particularly legumes and shallow rooted vegetable crops like tomato, onion, beans, radish, spinach, etc. are preferred.

Some perennials like pineapple, phalsa, banana, papaya are also taken as intercrops and popularly referred as **filler crops**. Based on experience and experimental evidences some recommendations for intercropping in young orchards exist. They are being presented in Table 4.

Table 4: Intercrops in different orchard crops.

Sl. No.	Crop	Duration for intercrop	Recommended Intercrops
1	**Apple**	4 years	Tomato, Cabbage, Beans, Strawberry, Early potato, Peach and *Valeriana wallihi*
2	**Banana**	5 months	Green gram, Cowpea, Cauliflower, Cabbage, Yam, Elephant foot, Onion, Black gram, Turmeric, Brinjal, Colocasia, Dioscoria, Chillies and Okra
3	**Ber**	2 years	Green gram, Moth, Cluster bean, Cowpea, Cumin and Chillies
4	**Citrus**	4 years	Beans, Carrots, Tomatoes, Berseem, Senji, Onion, Potato, Chillies, Pulses, Cucurbits, Okra, Gram, Peas, Potato and Cabbage
5	**Date palm**	5 years	*Citrus medic* , Guava and Sapota
6	**Grape**	1 year	Vegetables relevant to area.
7	**Guava**	3 years	Cauliflower, Peas, French bean, Cowpea, Cluster bean, Black gram, Green gram, Okra, Onion, Turmeric, Garlic, Cabbage, Chillies and Papaya
8	**Litchi**	7 years	Turmeric, Ginger, Pointed gourd, Sweet potato, Tomato, Radish, Cabbage, Turnip, Brinjal, Cucurbits, Green gram, Black gram and Cowpea.
9	**Mango**	5 years	Phalsa, Papaya, Guava, Banana, Peach, Strawberry, Pineapple, Cowpea, Cucurbits,

			Okra, Cabbage, Knolkhol, Beet, Onion, Carrot, Cauliflower, Tomato and Cluster bean.
10	**Papaya**	6-9 months	Cabbage, Cauliflower, Chillies, Radish and Tomato.
11	**Peach**	3-4 years	Soyabean, Pineapple, Cowpea and Turmeric.
12	**Pomegranate**	4 years	Berseem, Luceme, Cowpea, Green gram, Cucurbits, Cabbage, Cauliflower, Bean, Peas, Tomato, Carrot, Onion, Potato and Brinjal.
13	**Sapota**	7 years	Banana, Papaya, Pineapple, Broad bean, Tomato, Brinjal, Cabbage and Cauliflower

Minimum tillage

In this method inter space is maintained without any traditional soil tillage like ploughing, disking, harrowing, etc. This is receiving widespread adaptation in uneven topography. Here sod, weeds, cover crops and other vegetation are killed by herbicides in springs which forms a layer of dead plant material on soil surface. This controls erosion, conserve moisture and release nutrients.

Sod culture

In this system, in the space between trees, grasses are allowed to grow without tillage or mulching. Sometimes cover is mixed with grasses to improve fertility such as grasses are simply mowed and the surface is kept neat and tidy. This system is commonly followed in temperate region of Europe and America for apple and pear orchards and does not exist in tropical and subtropical region of India due to scarcity of available nutrients and soil moisture in most part of the year. It is the best system for the control of soil erosion and maintenance of soil organic matter and soil structure. In this case manures and fertilizers are not applied individually to trees but provided with sod allover the field and the system is satisfactory for deep rooted crops.

Modifications in Sod System

(i) Grasses are allowed to grow without cutting is not desirable because organic matter is lost.
(ii) Grasses are grown cut as required and removed for making hay not desirable because organic matter is lost here also.
(iii) Grasses are grown cut and left behind to decompose.
(iv) Grasses are grown and pastured i.e., animals are allowed to graze.
(v) Temporary sod. Sod is allowed for two years or so, then soil is ploughed, cultivated and sod is reseeded.

Sod is not being followed in India due to lack of cool and moist weather. Lack of aeration, rat holes in sod prove harmful and trees die. Nutrient deficiency is also common especially of potassium.

Mulching

Mulching is the practice of covering the soil around the plants to make conditions more favourable for growth and conserve the available soil moisture. In this management system the open soil is put under loose cover of straw, hay, crop residue, leaves, saw dust and plastic. It is essentially a surface barrier against evaporation and checks weed growth reducing competition for nutrients. This is one of the important soil management practices adopted in certain countries in orchards. It offers a number of advantages at the same time suffer from disadvantages too.

Advantages

(a) Conserves moisture by suppressing weed growth, regulating soil temperature and protection from sun and wind.
(b) Improves soil structure.
(c) Reduces soil temperature fluctuations.
(d) Increases soil organic matter level.
(e) Controls erosion.
(f) Improves water infiltration rate.
(g) Improves nutrient availability through better soil condition micro flora.
(h) Avoids competition for nutrient and moisture with main crop.
(i) Controls weed growth.

Disadvantages:

(i) High cost.
(ii) Transportation.
(iii) Disease and pest infestation through dead plant material.
(iv) Fire hazards .
(v) Roots grow shallow due to the effect through soil temperature and moisture.
Therefore, in first year mulching may not be advisable.

Among all the mulching materials, plastic mulches are becoming popular especially black polythene mulch, where weed control is desired. Mulching is common in tropics especially in crops like banana, citrus, pineapple. Some of the recommendations made for different crops are being presented in Table 5.

Table 5: Recommended mulches for different fruit crops.

Sl No.	Crop	Mulch material
1	**Banana**	Polythene, Straw mulch, Banana trash and Sugarcane trash.
2	**Mango**	Straw mulch especially effective against spongy tissue.
3	**Pomegranate**	Sugarcane trash, Paddy husk and Groundnut husk.
4	**Ber**	Sugarcane trash, Wheat straw, Black polythene, Trash of *Sachrarum munja* and Local grasses.

5	**Sapota**	200 gauge black polythene.
6	**Grape**	Black polythene.
7	**Acid lime**	Dry leaf mulch.
8	**Strawberry**	Black polythene, Cut grasses and Pine needles.
9	**Guava**	Organic mulches.
10	**Lemon**	Dry grasses and Black polythene.
11	**Coorg mandarin**	Dry leaf mulch and Weed scraping.
12	**Sweet lime**	Dry grasses.
13	**Date palm**	Local weed *bui* (*Aerva persica*).
14	**Pineapple**	Black polythene, Saw dust and Dry leaves.
15	**Apple**	Oak leaves, Black alkathene and Conifer leaves.

Rotation:

Planting of different crops in a regular sequence on a given piece of land is referred as **rotation**. When this technique is used for soil management, it is necessary that sequence in the year or the rotation includes legume as one of the crops. Even in plantations of perennial fruit crops like papaya, banana, pineapple, after clearing of fields, these crops should be followed by leguminous green manure crop before planting them again. Choice of the legumes can be decided on the basis of climatic region. Generally sesbania, crotolaria, cluster- bean and cowpea, are preferred as they add higher quantities of organic matter and nitrogen.

Advantages

(a) Helps in controlling insect pests and diseases.
(b) Helps in equalization of available nutrients.
(c) Avoids bad effects of continuous mono-culture through elimination of build up of toxins, diseases and pests.

Some of the recommendations are as under:

Banana — Crotolaria or Sesbania or Cowpea.
Papaya — Crotolaria or Cowpea.
Pineapple — Sesbania or Glyricidia.

Besides in young orchards when intercrops are takenup, some of the recommended rotations of intercrops are as under**:**

Citrus Orchard

Cowpea / Moong / Urd/Cucurbits / Turnip / Cauliflower /Carrot / Radish /Pea

Mango Orchard

(i) Brinjal — Cowpea
(ii) Tomato — Clusterbean

(iii) Tomato — Cowpea—Soybean—Coriander
(iv) Soybean — Pea — Cowpea — Palak — Chillies.

Banana Orchard

(i) Moong — Toria
(ii) Cowpea — Radish
(iii) Moong —Turmeric
(iv) Ragi — Bean
(v) Groundnut — Bean

Guava Orchard

Cowpea/ clusterbean/Blackgram/Greengram /French bean.

Litchi Orchard

Cauliflower/Peas.
Cucurbits / Greengram / Blackgram / Cowpea—Radish / Beat / Turnip / Carrot

Pomegranate Orchards

Cowpea/Green gram — Beans/Peas/Tomato/Carrot/Onion/Radish

Legumes should be included in rotation and crops like papaya, banana, pineapple and vegetables should be preferred for higher returns.

(should it be here?)**Agro forestry Systems**

It is sufficiently clear that any increase in food production has to come primarily from raising the productivity of existing agricultural land rather than bringing more area under agriculture or horticulture. Therefore, agro forestry should become an important land use system, even in degraded soils, so that we not only meet the food and wood requirement of the people, but also protect this good earth from environmental hazards.

In agro forestry systems, many options are available combining horticulture like agri -horti, horti—silvi, horti—pasture which combine horticultural crops with trees, pasture and agricultural crops. Among these horti-silvipastoral system appears to be one of the most efficient system for soil management. This encompasses any and all techniques that attempt to establish or maintain forests, horticultural crops, forage trees and pasture grasses on the same piece of land. It aims at systematically developing land use systems and practices where the positive interaction between trees and crops is maximized and seeks to achieve a more productive, sustainable and diversified output from the land than is possible with the conventional mono-cropping systems. In this system fruits and vegetable crops provide seasonal revenue, while forest trees are managed at 5 to 10 years rotation to give returns from timber, fuel wood and fodder. Horti-silvipastoral land use is considered to be an effective method of soil management satisfying multiple needs of farm families.

It offers a number of advantages:

(i) This system has higher employment potential being labour intensive.
(ii) As a conservation farming system can help in the control of erosion in catchment.
(iii) It is an excellent substitution for shifting cultivation in vogue in north-east region.
(iv) Degraded lands can be renovated by this integrated management system.
(v) It has potential to increase productivity under rainfed condition and provides stability in income.

(vi) Inclusion of drought hardy fruit tree component can ensure regular income in drought prone area.

In this system ber, pomegranate, aonla, mango, annona, jamun, tamarind, gonda, mahua and karonda as fruit trees; *Acacia tortalis, Albizia amara, Leucena leucocephala, Eucalyptus spp.* as forest trees and *Cenchrus ciliaris, Cenchrus setigerus and Stylosanthes hamata* as grass component have been found highly useful under rainfed semi arid conditions. In this case plantation of ber, mango and guava using staggered contour trenches, with forest spp. like *Leucaena leucocephala* and eucalyptus in highly degraded soil with *Cenchrus ciliaris* on gully rim and vegetable crops like cowpea, okra, clusterbean and brinjal in interface between fruit trees have been quite successful under rainfed conditions of Panch Mahal district of central Gujarat.

Some of the other successfully tested agro forestry systems including horticulture like peach with turmeric, Eureka lemon with chillies and mandarin with ginger in Doon Valley; aerable crops with mango, guava, cashewnut, acid lime and sweet orange in Andhra Pradesh; eucalyptus with aonla, ber and guava in Faizabad (U.P.); 'Coorg' mandarin with Casurina and paddy in Karnataka; pastoral system under apple, almond, pear and plum with *Festuca pretense*, *Dactylia glomerata* and red and white clover in J and K and pineapple with *Alnus nepalensis and Stylosanthes hamata* in Shillong have been found successful. All these systems need large scale testing for soil management strategy and value addition to degraded areas before adoption.

Multistory Cropping System:

In this system of agro forestry which suits well to small holders, different multispecies are grown which form a multilayer or multistory. This is most common in coconut based farming system in Kerala to meet the diversified needs of the farming community for fodder, food and fuel besides increasing net return from a unit area. This system involves growing of annuals and perennial in different tiers by exploiting soil and air space more efficiently. It has been demonstrated that inter cropping and mixed cropping with compatible component crops in coconut do not have any adverse effect on the yield of main crop while increasing net returns for the farmers.

Some common systems in vogue are -

(i) Coconut/Cocoa/Ppineapple/Pepper
(ii) Coconut/Hybrid napier and legume (Stylosanthes grandis).
(iii) Coconut/Arecanut/Cocoa/Black pepper/Pineapple.

This system is becoming most popular being efficient for effective utilization of solar energy and soil management.

High Density Plantation:

Planting density in general depends on kind of fruit tree, its growth habit, rootstock utilized, pruning and training needs and rainfall of the area and soil type. However, recommended planting densities in fruit crops results in under utilization of interspace during early stage of orchard's life. This makes orcharding unattractive, particularly on small holdings because of long gestation period before giving returns and soil management problematic for vacant space. Therefore, high density planting, planting more than optimum number of plants per unit area, is being-considered as soil management strategy for making maximum use of land to achieve high yields in the early periods of orchard life along with ease in its management. This has been successful in fruit crops like apple, pear, banana, pineapple, mango, guava, citrus, ber and pomegranate. This can be achieved through the use of one of the following factors like dwarf

genotypes, dwarfing rootstock, interstock, pruning and training, use of retardants, adjustment of planting geometry and induction of viral infection.

Table 6: Recommended densities of some fruit species.

Fruit	Variety	Spacing	System of planting	Number of plants
Mango	Amrapali	2.5 x 2.5 m	Triangular system	1600
	Dashehari	3.0 x 2.5 m	Rectangular	1333
Citrus	Kinnow	6 x 6 feet	Square system using trior citrange as a rootstock	3025
		8 x 8 feet	Karna Khatta as rootstock	1780
		10 x 10 feett	Soh Sarkar as rootstock	1111
Banana	Cavendish group	1.2 x 1.2 m	Square System	6944
		1.0 x 1.0 x 2.0 m	Paired row system	6666
Pineapple		25 x 60 x 75 cm	Double row system	63000
Apple	Spur type on rootstock MM 111, MM 109	4 x 4 m	Square system	625
	Non spur type MM 106, MM 109	5 x 5 m	Square system	400

	Spur type on MM 106, M7	3 x 3 m	Square system	1111
	Non spur type on M9	2 x 2 m	Square system	2500
Guava	Aneuploids	3 x 3 m	Square system	1111
	Lucknow-49	6 x 2 m	Square system	833
Papaya	Pusa Nanha	1.25 x 1.25 m	Rectangular system	6400
Acid lime	Kagzi	4.5 x 4.5 m	Square system	484

Soil is an important but finite natural resource on which agriculture based. It is necessary to maintain this in optimum state of productive capacity and put in appropriate use for sustainable crop production. Therefore, appropriate (strategy) of management should be adopted depending on crop, climate, topography, resource and socio-economic condition of the farmer. In any case management system should be such that quality of this resource is improved for which right decisions are necessary after proper evaluation of all the factors involved.

Lecture No. 15 & 16

Water management

Water is one of the most important inputs essential for the production of crops. Plants need it continuously during their life and in huge quantities. It profoundly influences photosynthesis, respiration, absorption, translocation and utilization of mineral nutrients etc. Both its shortage and excess affects the growth and development of a plant directly and consequently its yield and quality.

Soil needs the application of water to :

- Remove stress condition.
- Release nutrients in the soil solution for absorption by plants.
- Leach or wash out injurious salts from the soil.
- Preparation of land for raising crops.
- To maintain the temperature and humidity of the soil micro-climate and the activity of soil microbes at optimum level.
- For the normal aeration and functioning of roots and shoots of the plants.

- Excess water needs to be removed for the normal aeration and functioning of roots and shoots of the plants

- Excess water creates unworkable soil condition.

Irrigation: It is defined as the artificial application of water to the plants in the event of shortage of natural rains in order to obtain rapid growth and increased yields. It is an essential item in the cultivation of crops. Success in gardening depends on how efficiently irrigation is provided to gardens because it is governed by many factors such as frequency, duration, intensity , source and method of supply.

Factors affecting the supply of irrigation water to plants:

1. Topography and soil characteristics.

2. Kind of plant (root depth, water absorption capacity, growth habit, etc.).

3. Weather condition.

When to irrigate?

The time when a plant needs irrigation can only be judged by a keen observing eye. The plants need water when their new leaves begin to show a wilting appearance. A little before the trees show the sign of wilting. The shedding of broad leaves in orchard shows distress symptoms.

How much to irrigate?

If water supply is limited, only a light irrigation can be given at a time with higher frequency of irrigation. If water is available in plenty, the irrigation may be heavy with longer intervals between successive irrigations. However, inadequate irrigation reduces the growth and fruiting of the trees while, over irrigation serves no useful purpose and it may even prove to be harmful. It may create water logging, the nutrients may get leached and fruits may become watery and develop poor quality. Plants which have

suffered from drought should not be given liberal doses of irrigations all at once. That may result in the splitting of fruits and even the splitting of bark of the branches and trunk.

Systems of irrigations:

Different systems of irrigation are followed in different parts of the country. The best system is the one which meets the moisture seepage and evaporation. Principally, irrigation systems can be divided under three broad headings:

I. **Surface irrigation:** a. Flooding b. Basin type c.Furrow type d.Ring type
II. **Sub-surface irrigation:**a. a.Trench method b. Through underground pipelines
c. Perforated pipelines.
III. **Overhead or aerial irrigation :** a. Sprinkler b.Revolving nozzles
IV. Drip or trickle irrigation

I. Surface irrigation:

a. **Flooding:** When the land is flat, letting in water from one end floods the entire area. This system is commonly practiced in canal or tank bed areas. It is the easiest method and permits the use of bullock drawn implements in the orchards. But in this there is wastage of water and leads to soil erosion also. It encourages growth of weeds and spread of diseases like gummosis in citrus and collar rot in papaya.

b. **Basin system:** In this system, circular basins are provided around the trunk of the tree. The basins are inter-connected in series and are fed through the main channel running perpendicular to the tree rows. When compared to flooding, this system minimises the loss of water. In this system of irrigation, the water close to trunk may bring about certain diseases like gummosis and nutrients are likely to be carried over from one basin to the other.

c. **Furrow system:** Unlike the flood system, here the entire land surface is not covered with irrigation water. The furrows are opened in the entire orchard at 4" or less apart, depending upon the age of the trees. Water is let in these furrows from the main channels. In orchards, two furrows on each side of the rows are generally made. It is suited to such lands , which have a moderate slope to the extent of 1-2% if the water is to run freely and reach the ends of the furrows. Where the slope is sharp, the furrows are made to follow the contour more or less closely. This method has disadvantage of excess of water penetration at the head than at the farther end, which may result in variation in vigour and growth of trees.

d. **Ring system:** this is an improvement over the basin system. In this system, a ring is formed close and around the tree and water is let into the basin .This method is recommended for citrus trees thereby reducing the chances of collar rot to which these trees are often susceptible.

The size of the ring will increase as the tree grows .In this system, the spread of diseases like collar rot, etc., are prevented. However, it involves more labour and capital and it does not permit uniform distribution of water throughout the bed or basin as in the basin system of irrigation.

1. Sub-surface irrigation:

This system consists of conducting water in number of furrows or ditches underground in perforated pipelines until sufficient water is taken into the soil so as to retained the water table near the root zone. In limited situation, this may be a very desirable system of irrigation. In general, however, it must be used with great caution because of the danger of water logging and salt accumulation. If the sub-strata are so slowly permeable that practically no water moves through, water added may stand in soil sufficiently for long time resulting an injury to the plant root due to poor aeration. Where irrigation water or the sub-soil contains appreciable amount of

salt, sub-soil irrigation is usually not advisable. Land must be carefully levelled for successful subsoil irrigation so that raising the water table will wet all parts of the field equally.

2. **Over head or aerial irrigation:**

In this system, water is applied in the form of spring, somewhat resembling rainfall. This is accomplished by pumping water from original source into the main supply line from where it is distributed to perforated pipes, which operate at low pressure (80 to 120 lb per square inch) and supply the water in a fairly uniform rectangular pattern. They have a high rate of application, usually 1"/hour or higher. Because of the high application rates, their use is restricted to soils with high infiltration rates, such as sandy or gravelly. Revolving nozzle is also at times used, which operated on either low or high pressure. Usually the rate of application followed in the rate of 0.2" to 0.3" per hour.

Sprinkler irrigation:

May have definite economic advantages in developing new land that has never been irrigated, particularly where the land is rough or the soil is too much porous, shallow or highly erodable. It is quite useful where only small streams are available, such as irrigation wells of small capacity. It is helpful in irrigating at the seedling stage when the furrowing is difficult and flooding leads to crusting of soil. Fertilizer materials may be evenly applied by this method. This is usually done by drawing liquid fertilizer solutions slowly into the pipe.

It has several disadvantages like high initial cost, difficult to work in windy location, trouble from clogging of nozzle, interference in pollination process and requirement of more labours while removing or resetting. In general, this system is best adopted for areas where ordinary surface systems are inefficient.

3. **Drip or trickle system:**

This is the most recent system of irrigating the plants. It is usually practise for high value crops, especially in green houses and glass houses. There will be an installation of pipelines with nozzles very close to the soil. The nozzle is fitted in such a way that water is dripped almost in the root-zone of the plants. Water is allowed to move in pipes under very low or no pressure and it drop at regular interval.

This system of irrigation has advantages like no disturbance of the soil; soil moisture is maintained, lesser leaching of nutrients from the soil.

Lecture No. 17&18

Manures and manuring

The perennials are different from annuals in their nutritive requirements. The annuals require fewer nutrients when gradually falls as the crop matures. Whereas, in pernnials ther are often two or three peak period of uptake owing to the occurrence of more than one vegetative flush and crop. Manaurial requirement of perennials gradually increased with the age of the tree till the trees reach their full growth and thereafter remins constant. Depending upon the requiremnets, we may have to supplement by applying manures and fertilzers at the appropriate time.

Inorganic fertilizers

- Industrially manufactured chemicals.
- Contains higher nutrient than organic manures.
- Nutrient input is lost through leaching, runoff, volatilization, fixation by soil or consumption by weeds etc.

Organic fertilizers

- These are plant and animal wastes that are used as nutrients after decomposition.
- Improves the soil tilth, aeration, water holding capacity and activity of micro-organism.

WHERE TO APPLY THE MANURES?

- In fully grown trees, the manures and fertilizers should be given over the area, where their active roots are spread.
- Fertilizer should be given in restricted area i.e., in the surrounding area of about 1 to 1.5 m away from the trunk of the trees.

TIME OF FERTILIZER APPLICATION

- It must be applied when the plants need it.
- Timing depends on the type of fertilizer and climate.
- Fruit trees require more nutrients at the emergence of new flushes and differentiations of floral buds.
- Utilized more during the course of fruit development.
- Nutrients should be available to them in February –March.
- So, it would be better to apply them in October-November to be available to the trees in February to March.

NUTRIENT CONTENT OF ORGANIC MANURES

ORGANIC MANURE	N %	P_2O_5 %	K_2O %
Bulky organic manures			
Cattle dung	0.40	0.20	0.17
Poultry manure	3.03	0.63	1.40
Farmyard manure	0.50	0.25	0.50
Rural compost	0.75	0.20	0.50
Urban compost	1.75	1.00	1.50
Vermicompost	3.00	1.00	1.50
Concentrated organic manure			
Castor cake	4.37	1.85	1.39
Coconut cake	3.00	1.80	1.90
Neem cake	5.22	1.08	1.48
Blood meal	12.00	2.00	1.00
Groundnut cake	7.30	1.50	1.30
Pressmud	2.10	4.40	0.80

Composition of inorganic manures.

Fertilizer	Composition %		
	N	P_2O_5	K_2o
Sodium nitrate	16	-	-
Calcium nitrate	15.5	-	-
Potassium nitrate	13.8	-	-
Anhydrous ammonia	82	-	-
Urea	46	-	-
SSP	-	16	-
Double SP	-	32	-
Triple SP	-	46-48	-

Methods of fertilizer application:

Broadcasting:

- Fertilizer in solid state or granular or dust are spread uniformly over the entire field.
- Leaching loss may be more.

Disadvantages:

- Some of the elements like phosphorous and potash do not readily move in the soil. Therefore, surface application may not be available to the trees especially in drier tracks.
- Leads to accumulation of potassium in surface soil beyond detrimental levels causing injury to plants.
- Surface application always stimulates weed growth.

Band placement:

- Application of fertilizer on the sides of rows.
- Fertilizer in solid and liquid forms can be applied.
- Quantity of fertilizer may be economised.

RING PLACEMENT:

- Commonly followed in fruit trees.
- Fertilizers are applied in a ring encircling the trunk of the trees extending the entire canopy.
- It is more labour intensive and costly.

FOLIAR APPLICATION

- Fertilizers are applied in liquid form as foliar sprays.
- They are easily absorbed by leaves.
- Fertilizers are applied in a very low concentration tolerable to the leaves.
- Recommended when the nutrients are required in small quantity.

STARTER SOLUTION:

- Liquid form of fertilizer application.
- Seedlings and propagules are kept emerged up to their root system for varying duration in starter solution.

- The starter solution is prepared either by dissolving concentrated fertilizer mixture at a concentration not exceeding 1%.

FERTIGATION:

- Application of fertilizers in irrigation water in either open or closed systems.
- Nitrogen and sulphur are the principal nutrients applied.
- Phosphorous fertigation is less common because of formation of precipitates takes place with high Ca and Mg containing water.

Advantages :

- Nutrients especially nitrogen can be applied in several split doses at the time of greatest need of the plant.
- Nutrient is mixed with water and applied directly near the root zone, as such higher use efficiency.
- Cost on labour is saved.

Best results of fertigation are noticed when the fertilizer is applied towards the middle of the irrigation period and applied towards the middle of the irrigation period and their application terminated shortly before completion of irrigation. Use of soluble fertilizer improves use efficiency.

Note: The grower must consider the economics and advantages before deciding for using fertigation.

Fertigation is used extensively in :
Cut flower production in green houses.
Fruit crops – Grapes, Papaya, Banana and Pomegranate.
Vegetables- Tomato and Capscicum under poly/green houses.

TREE INJECTION:

- Direct injection of essential nutrients into the tree trunk.
- Iron salts are injected into chlorotic trees that are known to suffer from iron deficiency.

FEEDING NEEDLES:

- Several types of feeding needles or guns are available.
- With these fertilizers either in dry form or in water solution placed in holes.

Factors favouring nutrients absorption and transport:

- High humidity, proper temperature and incident radiation.
- Good CHO supply and vigorous growth.
- Chemical and physical properties of nutrient spray solution.

- Leaf characters like leaf thickness, hairyness and wax coating on the leaf.
- Generally more vigorous plant and young growing leaves have good capacity to absorb nutrients.
- Nitrogen- applied in the form of urea (1%) is readily absorbed.
- Sodium and potassium (Kcl) - readily absorbed by leaves and they are among the highly mobile Elements.

Note:

- Foliar application proves to be most effective where problems of nutrient fixation in soil exits. So far the most important use of foliar sprays is in application of micronutrients.
- Foliar sprays should be applied either with pressure sprayer or with specially designed spray guns. The trees should be sprayed until the nutrient solution begins to drip from the leaves.
- Foliar application of urea has been found effective in many fruit crops like citrus, guava ,apple, etc.
- Potassium spray (3-5g/lit)- Papaya, Pineapple, Citrus and Guava.

Precaution:

- While applying foliar sprays, care should be taken to ensure correct concentration of spray solution.
- Apply in the morning or evening hours on a clear sky day.

Lecture No. 19

WEED MANAGEMENT IN ORCHARDS

Weeds in orchards reduce crop yields by competing for moisture, nutrients, light and space. They also harbour insect pests and diseases. When they become large they interfere with orchard operations. Some of weeds climb on the trees and produce shade on the foliage. There are some weeds which are parasitic partially or completely on the host tree.

Examples : Striga on sorghum (add example of horticultural crop), loranthes on mango.

Commonly noticed weed species in fruit orchards:

There are more than 30,000 species of weeds distributed world over, out of which 18,000 are noxious and cause serious losses.

Note: Around 250 species are causing serious economic losses.

Monocots (Narrow leaf/Grasses): Cyprus, Cynodon, Poagrass, Rye grass, Quackgrass etc.

Dicot weeds (Broad leaf weeds):*Dandelion, Chenopodium* spp., Parthenium, *Solanum sp, Euphrobia spp*., Ground ivy etc.(many are medicinal, pl. check)

Methods of weed control in orchards:

Broadly classified as:

1. Cultural methods
2. Biological methods
3. Chemical methods
4. Integrated weed control
5. Soil solarisation

Losses caused by weeds (Harmful effects):

1. Weeds compete with fruit crops for nutrients, moisture, air and light.
2. They increase the cost of production.
3. Reduction in crop yield.
4. They impair the quality of crop.
5. Weeds harbour pests and diseases.
6. They bring problems in irrigation, drainage etc.
7. Weeds reduce human efficiency through allergism and poisoning.

Cultural or mechanical control includes:

1. Hand weeding
2. Tillage operation
3. Growing of intercrops
4. Use of mulching

Biological methods

It involves the use of natural enemies of the weeds which includes fungus, bacteria, insects, fish, animals and plants (through competitive replacement **eg**: *Cassia spp*. replacing parthenium).

Characters of successful bioagents:

1. Host specific.
2. Easily adjustable to new environment.
3. Rapid destroyer of the target weed.
4. Easy to multiply.
5. Effective against several kinds of weeds.
6. Should not affect other cultivated species.

Insects as bioagents:

Weed	**Bioagent**	**Kind of bio-agent**
Cyprus rotundus	*Bactra verutana*	Insect (shoot boring moth)
Echinochola spp.	*Emalocera* *Tripos spp.*	Insect (stem boring moth)
Parthenium	*Zygogramma bicollarata* *Epiblema strenerana* *Conotrachelus spp.*	Leaf eating insect Stem girdling insect
Orabanche	*Sclerotinia spp. (Fungus)*	Plant pathogen
Rumese spp.	*Uromycis rumicis (Fungus)*	Plant pathogen

Mycoherbicides products	**Content**	**Weeds controlled**
De-vine	Liquid suspension of *Phytopthora pamivora (*Root rot of weed)	*Merrenia odorata* in citrus plantations
Bipolaris	Suspension of fungal spores of *Biopolaris sorghicola*	*Sorghum halepense*
Biolophos	Microbial toxin produced as fermentation products of *Streptomyces hygroscopicus*	Non-specific can be used on general vegetation

Chemical control

It refers to use of herbicide to suppress or kill weeds. A herbicide is any chemical that has phytotoxic properties. Herbicides include wide variety of compounds classified on the basis of :

1. Chemical structure.
2. Selectivity (selective and non-selective).
3. Contact or translocated (systemic).

Selective herbicides are those which kill certain kind of specific weed without causing any significant injury to others. **For example:** 2, 4-D (controls herbaceous dicot weeds), MCDA (controls *cyperus rotundus, plantago spp*. etc.), whereas **non-selective herbicide** will indiscriminately kill all the plants that come in contact. **For example:** Glyphosate, paraquat (destroy green tissue only).

Systemic herbicides

They are also referred **as translocated herbicides**; they are absorbed by leaves, stems or roots of treated plants. Translocated through either phloem or xylelm.

For example: Atrazine, Simazine, Diuron, Alachlor.

Guidelines for use of herbicides:

1. Use correct recommended concentration.
2. Sprayers should be properly calibrated; nozzles should be directed towards the target weeds away from the fruit tree trunk.
3. Young weeds are killed easily than older ones or established ones.
4. Application should be avoided during raining or windy situations.
5. Wetting agent should be added to facilitate spreading of herbicide more uniformly on leaf surface.
6. If the leaves of fruit trees are accidentally sprayed the sprayed portion should be immediately be cut off.

Note: The efficiency of weedicide is good, when it is used on weeds with new

sprout/growth.

Integrated weed management:

This is a weed management system that suppresses weeds by combining two or more weed control methods. IWM seems to be best suited for control of weeds in tropics or in fruit orchards.

Practices:

1. Deep ploughing during summer.
2. Repeated tillage and hand weeding/use of chemicals.
3. Intercultivation/cover cropping, intercropping etc.
4. Organic mulching in basins.
5. Use of herbicides—2-3 times per year.
6. Use of bioagents whenever possible.

7. Proper regulation of irrigation.
8. Use of drip irrigation.

Lecture No. 20,21 ,22&23

Training and pruning

Horticultural plants are grown for their produce like fruits, vegetable, flowers, medicinal components, spices (oleoresins), aromatic (essential oils) etc. Therefore, these plants should be managed in such a way that human desires for the purpose of growing them are fully satisfied in terms of quality and quantity of produce. This demands direct manipulation of plant growth itself or plant environment through various inputs. In manipulation of plant development, training and pruning are important for which our knowledge about plant development and its phenology has to be complete. These practices
are important in fruit crops.

Training
Definition:

Physical techniques that control the shape, size and direction of plant growth are known as training **or** in other words training in effect is orientation of plant in space through techniques like tying, fastening, staking, supporting over a trellis or pergola in a certain fashion or pruning of some parts.

Objectives:

- To improve appearance and usefulness of plant/tree through providing different shapes and securing balanced distribution.
- To ease cultural practices including intercultivation, plant protection and harvesting.
- To improve performance like planting at an angle of 45° and horizontal orientation of branches make them fruiting better.

Methods of Training

Method of training of a plant is determined by the nature of plant, climate, purpose of growing, planting method, mechanization, etc. and therefore, intelligent choice is necessary.

Training in herbaceous annuals and biennials:

These plants are usually grown without any attempt to alter their growth patterns because even if useful not practical being in large number in field. However, for some of ornamental value and creeping nature following types of training is affected.

(i) Staking or supporting of vine like plants.
(ii) Training on pergola or trellis of vine type fruit plants or even indeterminate type tomatoes.
(iii) Nipping of apices for encouraging lateral growth to give bushy appearance or fulsome appearance in pot plants like aster, marigold and chrysanthemum.
(iv) De-shooting or removal of lateral buds for making single stem for large flowers as in chrysanthemum and Dahlia.
(v) Staking with bamboo sticks and tying together various shoots in potted chrysanthemum.

Training of woody perennials:

The woody perennials, which are widely spaced and remain on a place for a long duration, are trained for develop strong framework for sustainable production of quality produce and for ornamental beauty in different shapes (topiary). In these plants following types of training are followed.

(i) **Open centre system (Vase shaped):** In this system the main stem is allowed to grow to a certain height and the leader is cut to encourage lateral scaffold from near the ground giving a vase shaped plant. This is common in peaches, apricots and ber (Fig. 7.1).

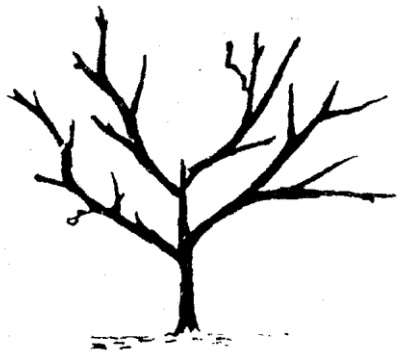


Fig. 7.1 Open centre system

(ii) **Central leader system (closed centre):** In this system the central axis of plant is allowed to grow unhindered permitting branches all around. This system is also known as **closed centre system** and common in use in apple, pear, mango and sapota (Fig.7.2).

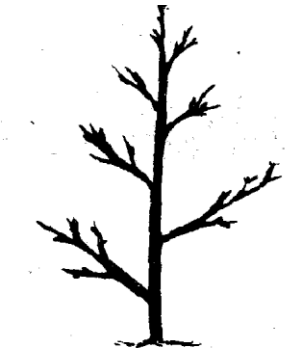


Fig. 7.2 Central leader system

(iii) Modified leader system

This system is in between open centre and central leader system wherein central axis is allowed to grow unhindered upto 4—5 years and then the central stem is headed back and laterals are permitted .It is common in apple, pear, cherry, plum, guava (Fig.7.3).

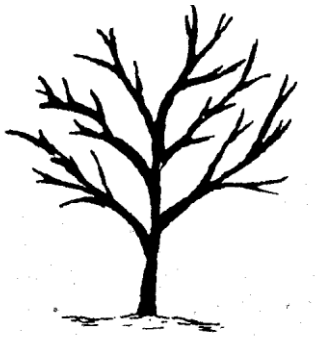


Fig. 7.3 Modified leader system

iv**) Cordon system :** This is a system wherein espalier is allowed with the help of training on wires. This system is followed in vines incapable of standing on their stem. This can be trained in single cordon or double cordon and commonly followed in crops like grape and passion fruit (Fig. 7.4).

(v) **Training on pergola:** To support perennial vine crops pergola is developed by a network of criss-cross wires supported by RCC/angle iron poles on which vines are trained. This is common for crops like grape, passion fruit, small gourd, pointed gourd and even peaches.

(vi) **Training in different shapes**: Generally ornamental bushes are trained in different shapes for the purpose of enhancing beauty of places. These shapes could be vase, cone, cylindrical and rectangular.

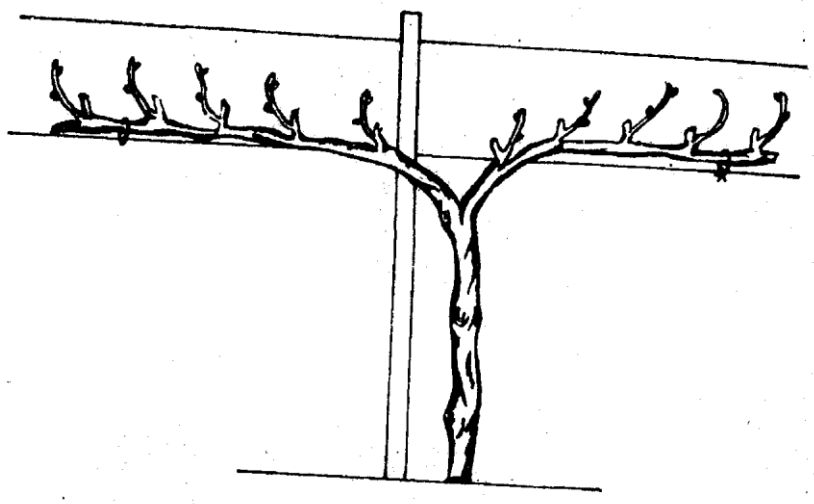


Fig 7.4 : Cordon (espalier) System

box, flat and trapezoid. Presently for the convenience of mechanization these shapes are being utilized in fruit trees. Such shapes are given to adjust the geometry of plantation like hedge row system, box, unclipped natural in fruits like guava, mango, sapota and citrus.

Details of Training:

(i) **Height of the head**: This is the height from ground to first branching or scaffolding. **Depending on the height the trees could be divided in three groups.**

(a) **Low head** : 0.7—0.9 m. This is common in windy areas. Such plants are easy to maintain.

(b**) Medium head** : 0.9—1.2 m. This is the most common height which combines both effects, ability to stand against wind and easy management.
(c**) High head:** More than 1.2 m. Common in tropics in wind free areas. Operations under the canopy are easy to perform.
(ii) **Number of scaffold branches:** It refers to allowing of number of scaffolds on the primary axis of the tree which vary from 2 to 15 but extremes are undesirable. In fruit trees 5 to 8 scaffolds are preferred to make the tree mechanically strong and open enough to facilitate cultural operations.
(iii) **Distribution of scaffolds**: Scaffolds should be distributed in all the directions spaced at 45-60 cm allowing strong crotches through wide angles of emergence.

A well trained tree is an asset to the farmer and therefore, efforts should be made for training trees appropriately in formative years for sustainable production. In fact the process should have begun from nursery itself.

Pruning

Definition:

It refers to removal of plant part like bud, shoot, root etc.. to strike a balance between vegetative growth and production. This may also be done to adjust fruit load on the tree.

Objectives:

(i) To control plant size and form.
(ii) For plant performance like
(a) Establishment of transplant where leaves/shoots are pruned to strike a balance between root and shoot so that plants lose less water against restricted root system lost during lifting of plants.
(b) Improvement in productivity and quality by regulating the load of the crop and extent of flowering.
(c) For flower and fruit quality.
(d) Elimination of non-productive vegetative growth like water sprouts, suckers, dead and diseased wood.
(e) In case of forest trees production of knot free timber.

Types of pruning:

Basically there are three types of pruning with definite purposes.
(i) Frame pruning.
(ii) Maintenance pruning.
(iii) Renewal pruning.(i) **Frame pruning**: This pruning is done to provide shape and form to a plant in its formative years so that tree develops strong framework and a shape for ease of operations. This process begins from nursery itself and continues up to fruiting stage. This is done continuously irrespective of the season.
(ii) **Maintenance pruning**: To maintain status- in production level and for uniform performance this pruning is done. In some plants like grapes, apple, pear, peach etc. (deciduous trees) it is an annual feature and in others (evergreen like mango, sapota) it is rare confining to removal of water sprouts and unproductive growth and opening of the tree.
(iii) **Renewal pruning**: This pruning is done in old trees like mangoes which shows decline . In this case severe pruning is required.

Factors to be considered in pruning:

In some of the tree species pruning as a regular feature in bearing trees is done to strike a balance between vegetative growth and production so that farmers get sustained production uniformly with optimum quality of produce. To achieve this one should consider the following factors.

(i) Time at which buds are differentiated in relation to blooming.

(ii) The age of the wood that produces the most abundant and highest quality of fruit buds.

In consideration of these factors our knowledge about bearing habit of the tree/plant should be complete. Bearing habit means relative position of a fruit with reference to its potential bud giving rise to flower or inflorescence in the shoot. This habit varies from plant to plant.

(add principles of pruning)

Lecture No. 24 &25

Kinds of flower bearing shoots (can it be clubbed with pruning in last chapter?)

Depending on the position of fruit bud and the kind of flower bearing shoots it produces, fruit trees can be classified into following eight groups. Basically there are two types of flowering: **terminal** and **lateral** and within each category there is variation depending on flower shoot**: pure or mix, terminal or lateral** (Fig. 7.5).

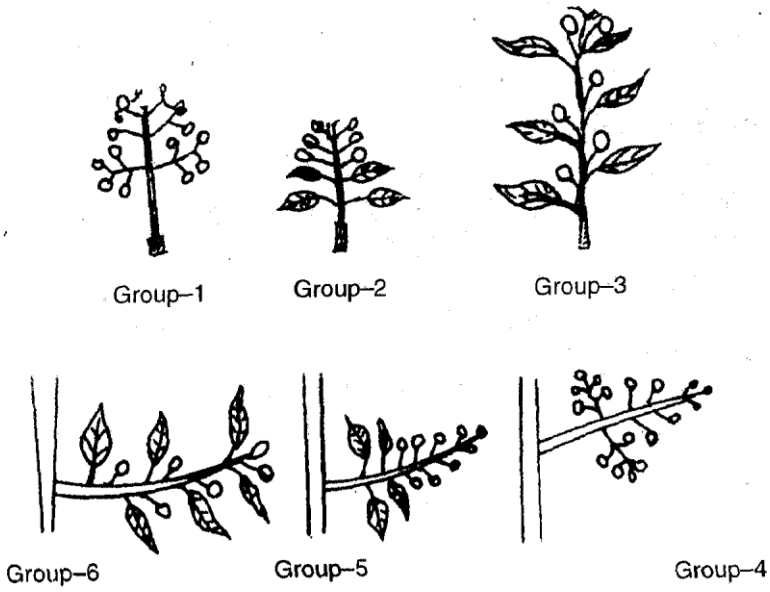


Fig. 7.5 : Kinds of flower bearing shoots

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Group-1: Fruit buds borne terminally and unfold to produce inflorescence without leaves. **E.g.** mango.

Group-2: Fruit buds borne terminally unfolding to produce leafy shoots hat terminate into flower clusters **e.g**. apple and unfolding to produce leafy shoot with flower cluster in the leaf axils. E.g. Fig and Avocado.

Group—3: Fruit buds borne terminally unfolding to produce leafy shoots with flowers or flower cluster in the axil of leaf. **E.g.** Guava

Group-4: Fruit buds borne laterally unfolding to produce flowers without leafy parts.
E**.g**. Sitrus, Coconut, Papaya and Coffee.

Group-5: Fruit buds borne laterally unfolding to produce leafy shoot terminating in flower clusters**. E.g**. Grapes.

Group-6: Fruit buds borne laterally.

Group-7: Fruit buds borne both terminally and laterally but unfolding to produce inflorescence terminally. **E.g.** Walnut.

Group-8: Fruit buds always borne adventitiously in old trunk or shoots.
E.g. Jackfruit, Cocos, Indian star goose berry.

Season of pruning

Generally pruning should be done in such a time that physiology of plant is disturbed to the minimum and it should not interfere with the principal function of the plant. Thus,

(i) Fruit trees are pruned for fruiting when dormant i.e. late winter in case of temperate fruits and soon after harvest in evergreen if required. Some times the trees are subjected to stress to induce dormancy before pruning as in bahar reatment.

(ii) Pruning for structural adjustment is done when plant is making growth i.e. summer pruning.

Generally pruning is regularly done in temperate fruit crops like apple, pear, peach, plum, cherry, walnut, apricot, grape and subtropical crops like pomegranate, lemon, ber, guava.

Evergreens like mango, sapota and litchi are rarely pruned except thinning of branches to avoid overcrowding and removal of deadwood. However, now this concept is under change.

Pruning Technique:

Basically there are **two techniques** which could be utilized individually or in combination depending on the need of the crop.

(i**) Heading back**: It is cutting back of terminal portion of a branch to a bud. This encourages spreading of growth, bushiness and compact plant. It is also called **pinching.**

(ii) **Thinning out**: It means complete removal of a branch to a lateral or main trunk. This makes the plant open, large tree or plant. Thinning out of growing wood is also called **deshooting.**

The table indicates pruning time and technique in different fruit crops.

Table 7: Pruning time and techniques in important fruit crops.

Sl. No.	Crop	Time	Technique
1	**Apple**	Late winter	Light thinning coupled with heading back.
2	**Peach**	Late winter (Dec-Jan)	A combination of thinning out and heading back.
3	**Plum**	Late winter (Dec-Jan)	A combination of thinning out and heading back.
4	**Grape**		
	North India	Late winter (Jan)	Heading back of cane.
	South India	Summer pruning (Aug)	Heading back to one or two buds which is almost thinning out.

		Winter pruning (Sept-Oct)	Heading back to cane.
5	**Mango**	After harvest	Thinning.
6	**Phalsa**		
	North	Late winter early spring	Heading back.
	South	Dec-Jan	Heading back.
7	**Ber**	Summer (April-May)	Heading back and thinning out of old branches.

Other important considerations:

(I) Use good and sharp equipment.
(ii) Cut should be small, smooth and slanting so that water does not accumulate on cut end.
(iii) Large wounds should be treated with antifungal chemicals like Bordeaux paste.
(iv) Shoots from rootstock should be removed regularly.
(v) Removal of deadwood, parasites (loranthus), epiphytes (ferns), climbing vines and nests of bees, wasps, ants, termites should also become part of pruning.

Besides pruning and training plants can also be managed through biological and chemical methods:
I. Biological control: In this method following techniques could be utilized.

(a) Use of rootstock: Use of dwarf, vigorous and semi vigorous rootstocks can alter plant size. **E.g.** M IX for dwarfing of apple and trifoliate for dwarfing of citrus.
(b) Phloem disruption (Ringing): can be utilized for regulating flowering and fruiting.
(c) Hardening : By subjecting plants to low temperature, high heat or stress , the plant size can be altered.

(ii) Chemical control : There are a number of plant growth regulators like inhibitors, retardants, gibberellin, auxins and ethylene when applied to plant modify plant growth and development and they can also be utilized for managing plant and its performance. Some of the useful responses are being mentioned below:
Rooting - Auxins enhance rooting. **E.g.** IBA, NAA Bolting, GA enhances while MH reduces bolting.
Modification of flower sex- Ethylene for the induction of femaleness and gibberellins for maleness
Flower induction - Auxin and ethylene in pineapple, cultarr in mango have positive role, gibberellins may help delaying flowering. Fruit set - Auxins and gibberellins in seedless fruits have positive role.
Control of fruit drop : Auxins check fruit drop

Thinning - Auxins in higher concentration and phenols can be utilized to thin crop.
Regulation of ripening - Ethylene enhances whereas auxins, kinetin and gibberellins delay ripening.
Pinching - Methyl ester
Disbudding - NAA
Sprout control - NAA
Abscission Enhancement by ethylene and check by gibberllins and auxins.
Storage disorder - pro-phenyl amine reduces storage disorders.

All these techniques individually or in combination can be utilized for the management of tree and its productive functions. However, they need to be utilized after proper testing for their concentration, timings, and combinations.

Lecture No. 26

Top Working

It is a technique or method of rejuvenation where in the objective is to upgrade seedling plantations of inferior varieties with superior commercial cultivars or hybrids suitable for domestic or export market or the desired variety of the grower.

The technique involves grafting with procured scions of desired variety on shoots emerged on pruned branches by adopting softwood grafting during monsoon season (Season of top working slightly varies from species as it also depends on availability of good shoot and scions). The scion shoots and the emerged shoots should be of same thickness.

Advantages of top working:

1. Increase the tree productivity /orchard productivity.
2. Conversion of old and senile orchards into productive orchards.
3. Conversion of seedling or inferior variety plantaion /orchard into new orchard with desirable variety or varieties through top working.
4. Possibility of grafting several varieties on the same plant.
5. Increasing the fruit set of orchard by grafting few shoots with polliniser varieties.
6. Additional income by selling the pruned wood during non bearing season or period.

Disadvantages:

1. Chances of death of plant if not done properly or on severe pruning.
2. Need good management post pruning period.
3. Loss of crop for 2-3 years
4. Chances of pest and disease occurrence (stem borer, anthracnose etc.).
5. Needs skilled labour for thinning of shoots, removal of side shoots etc.

Top working technique can be successfully followed in crops like mango, sapota, aonla, cashew, guava, tamarind, jackfruit, etc.

Lecture No. 27&28

Problem of Unfruitfulness

In an orchard all the fruit trees do not bear equally or regularly and sometimes fail to flower and fruit under similar conditions where another fruit tree bears heavily. This failure to set fruits may be attributed to unfruitfulness. To understand the problem of unfruitfulness in orchards a familiarity with following terms is necessary.

Fruit setting: It refers to initial growth of ovary and its associated parts after blossoming and taking it to maturity.
Fruitfulness: It is the state of plant when it is not only capable of flowering and fruit setting but also takes these fruits to maturity and inability to do so is unfruitfulness or barrenness.
Infertility: Ability of a plant not only to produce fruits but develop viable seeds and the inability to do so is referred as sterility or infertility. All fertile plants are fruitful but all fruitful plants are not fertile (Seedless fruits).
Self fruitfulness: Ability of a plant to mature fruits after self pollination.
Self fertility: Capacity of a plant for the production of viable seeds after self pollination.

We have known that ability of a plant to produce optimum crop is **fruitfulness** and the inability to achieve this is referred to as **unfruitfulness**. This unfruitfulness is one of the serious problems of many orchards and its causes need to be understood properly for effective control and obtaining economically acceptable production level. The causes to this problem can be many and they have been broadly grouped into **two categories**

(A) Internal factors
(B) External factors.

(A) **Internal factors associated with unfruitfulness**: There are a number of internal factors which are associated with unfruitfulness or sterility. They have further been categorized into three major categories, those are
1. Evolutionary tendencies.
2. Genetic influence.
3. Physiological factors.

1. **Evolutionary tendencies**: In the process of evolution, a number of situations may lead to imperfect flowers or varied developmental periods leading to unfruitfulness unless suitable measures are adopted.
(i) Monoecious and Dioecious nature: A plant with stamens and carpels in different flowers on the same plant is **monoecious. E.g.** Coconut, Arecanut, Pecan nut, Capri fig and Hazel. In monoecious fruit plants in general there is no or very little problem of pollination, fruit setting and fruitfulness. Nevertheless, pollinators need to be ensured.

Plants which bear male and female flowers on different plants are known as **dioecious. E.g.** Papaya, Date palm and Strawberry. Likewise a few varieties of plum produce too little pollen to call them bisexual. Profuse flowering without fruit set in ornamental pomegranate is a result of their being unisexual. A number of sex forms have been reported in papaya by different

scientists. In case of figs two types of flower clusters are borne namely staminate and pistillate flowers. In Capri fig staminate flowers are borne near the eye and pistillate flowers are borne near the end. To ensure good fruit set, retention of a few staminate trees (9:1) is essential as pollinizers.

(ii) Heterostyly: A condition in the flower where length of the style, relative to other parts of the flower, differs in the flowers of different plants. In this case in some flowers styles are short with long filaments and in some of the flowers of some species or varieties styles are long with short filaments. Thus styles and stigmas at different height prevent self pollination.

In case of brinjal there are 4 types of flowers according to their length of style i.e. long, medium, pseudo short and true short. Out of these pseudo short and true short do not produce any fruit. Similarly in delicious group of apples extreme upright positions of the stamens accompanied by spreaded petals do not permit bees to do pollination while collecting nectar. When the pistils of heterostyled plants are pollinated with pollen from the same flowers or from other flowers containing stamens of an equal height the union may be fruitful but it is likely to be of varying degree of sterility. Here arrangement for cross pollination needs to be created.

(iii) Dichogamy: When stigmatic receptivity period does not coincides with pollen viability in monoecious plants it is known as dichogamy. In dichogamy self pollination is prevented in perfect flowered plants, due to maturity of two sex elements at different times. If the stamens ripe before the stigmas become receptive the flowers are known as **protoandrous** and if stigmas become receptive before the stamens produce viable pollens it is known as **protogynous**. This results in low production of fruits. Protogyny is present in monoecious plants like walnuts, hazels, etc. whereas protandry is present in many coconut varieties. Majority of dioecious plants are also protogynous.

(iv) Abortive Flowers or aborted pistils or ovules: This occurs in the developing flower's pistils and stigmas of many species and is responsible for failure in fruit setting. Abortion of partially developed flower buds is common. Setting and maturity of two sexes depend on the erosion of two properly formed sex cells. Any interference with their development and functioning may lead to sterility or unfruitfulness; such things can be observed in some grape varieties and tomato varieties. The late flowers of strawberry cluster are always abortive. This is more common in indeterminate type of plants. Degeneration of pistils takes the form of abortion and it is more common in ornamental pomegranate. Certain olive varieties have 10-60% abortive embryos. It is also common in some apple varieties. Embryo sac abortion becomes a cause of seedlessness in certain instances than fruitfulness.

(v) Impotence of pollen - Many varieties of grapes produce non viable or impotent pollens though they appear as perfect flowers. Sterility in grape varieties was the result of impotent pollens. Sterile pollen in the grape results from degeneration processes in the generative nucleus or arrested development prior to mitosis in the microspore nucleus. This is also common in 'J.H. Hale peach, Washington Navel orange and 'Tahiti' lime.

2. Genetic influences

Self sterility is a condition determined by the inheritance received but can develop in favourable environment. Self sterility affects it's off springs as well as hybrids .

(i) Sterility and unfruitfulness due to hybridity:

Generally wider the crossing, greater is the degree of sterility encountered. The cross between peach and plum bears abundance of flowers but they are without pistils with malformed stamens. Flower characteristics were constant sterile and barren. A hybrid between the pear and the quince was seedless. Most of the citranges (cross between sweet orange and *Citrus trifoliata*) produce no fertile female gametes. Seedlessness in most of the banana and pineapple varieties is due to hybrid nature of their ancestors. Most of the triploid apple varieties produce aborted pollen. A number of hybrids between *Vitis rotundifolia* and Euvitis are completely sterile. Similar was the case with hybridization of *Vitis vinifera* and *Vitis rotundifolia*.

(ii) Incompatibility - One of the most common causes of self unfruitfulness and self sterility is due to incompatibility between the pollen and ovules of the same plant or of the same variety. Pollen and ovules are fertile but they fail to affect conjugation. In apple, pear, plum and aonla self incompatible varieties require another pollinizer varieties for fruit setting. Self incompatibility has been reported in some of the mango varieties like 'Langra', 'Dashehari' and 'Chausa'.

Self sterility and self unfruitfulness has been reported in apple, pears, plums, almond, apricot, the Clementine' mandarins, may be attributed to incompatibility where normal processes of fertilization fails somewhere between production of functional gametes and the fusion of sex cells.

3. Physiological influences:

(I) Slow pollen tube growth:

Slow growth of the pollen tube results in unfruitfulness. Differences have been found in the rate of growth in selfed and crossed apples, pears, cherries and certain citrus fruits. This may be considered one type of incompatibility due to chemotropic or hormone influences.

Besides this, fertilization should take place within a short time failing which abscission will take place at the base of the style, ovary pedicel or peduncle and fruit setting does not take place.

(ii) Premature or delayed pollination:

Premature or delayed pollination leads to unfruitfulness. Tobacco flowers are very susceptible to injury from premature pollination. When mature pollen grains are applied to immature pistils they germinate, penetrate the style, enter the ovule and if the ovules are not ready for fertilization the flowers fall. However, in case of oranges premature pollination did not have any deleterious effect whereas some injury was noticed in tomato. Lower setting due to premature pollination was noticed in persimmon, Pear, plum and peach.

Similarly, if pollination is delayed the flowers fall without setting. Delay in pollination for 1 or 2 days did not affect fruit set. However, further delaying may result into polyembryonic seeds in some species.

(iii) Nutritive Condition of Plant:

Nutritive condition of plant just before or at or and just after the time of blossoming is an important factor determining the percentage of flowers carrying for setting and for maturity. It may affect the pollen viability or fertility of pistils.

a. Effect on pollen viability - There was significant difference in germination percentage of pollen collected from old apple trees and from strong young trees of the same variety.

b. Effect on defectiveness of pistils: Exhaustion of tree by over bearing, drought or poverty of soil leads to production of defective pistils. Over bearing weakens the fruit tree and in coming season production is adversely affected. Close correlation was reported between defective pistils and unfruitfulness in American plums.

In case of *Vitis vinifera* carbohydrate deficiency is the common cause of flower drop. Due to carbohydrate deficiency flower abortion and ultimately unfruitfulness also occur in green house grown tomatoes.

(iv) Fruit setting of flowers in different positions:

Fruits borne on terminal growth have more competition in many fruit crops and mature and set under normal nutritional conditions but percentage of set is small. This positional competition takes place between fruits and branch as well as between different fruits influencing fruitfulness.

Strong and weak spurs - Nutritional condition of spurs has positive correlation with fruit setting in apple. Spurs on vigorous limbs with large leaves set more fruits than those borne on weak limbs. More flowers ultimately lead to more fruit set and more flowers are generally borne on strong limbs. Likewise flowers borne singly set fruits and mature as fruit and majority of those borne in clusters drop down.

Ringing or girdling also lead to accumulation of an extra store of food material leads to fruitset and develop parthenocarpically.

In the process of fruitifications the embryo is more important for development i.e. if nutritive condition is favourable, it accompanies the development of the seed coat and fruit wall, if not, only the latter portions are in high degree retardation in development. Under insufficient nutrient supply the number of seed forming ovules are diminished and under extreme nutrition deficiency both fruit wall and large number of ovules are diminished leading to enabling to form seed.

In case of green house cucumbers, nutritional deficiency leads to arrest of growth of growing fruits depending upon the position of the fruits and time of pollination. If a few of the cucumbers are harvested remaining fruits resume growth.

In case of strawberries producing bisexual flowers may lead to produce pistillate flowers if nutritional deficiency was observed.

However, nutritive condition has indirect influence on compatibility.

B. Unfruitfulness associated with external factors

1. **Nutrient supply**: In certain families like graminae, cruciferae and leguminaceae sterility normally occur due to over feeding. 'Jonathan' apple self sterile in rich soil becomes self fertile in poor soils. High fertility level is generally associated with good pistil development and low level with poor pistils and good stamens in grapes. In olives low fertility leads to partial or complete degeneration of pistils.

2**. Pruning and Training**: Pruning tends to produce more true hermophrodite condition in grape variety 'Hope'. If pruning is not done the variety tends to remain sterile and produces aborted pistils.

3**. Locality**: Jonathan apple which is sterile in one location is reported to be self fertile in another location.

4. **Season:** Hybrid grape 'Ideal' is self impotent early in season but becomes self potent later on.

5. **Temperature**: High temperature at flowering dries up stigmatic secretion and prevents pollination. Tomato varieties grown at high temperature do not produce any fruit.
6. **Light**: Exposure of strawberry plants to long photoperiod results in development of stamens and pistils in strawberry flowers.
7. **Pests and diseases**: Mango hopper, powdery mildew, etc. adversely affect the fruit set and development in mango and grape.

Spraying the trees when they are in bloom i.e. spraying at flowering reduces fruit set. Some of the fungicides gave inhibitory effect on pollen grains i.e. copper fungicides at 200 to 10000 ppm prevent the germination of pollen grains on the stigma.

Steps to overcome the problem of unfruitfulness:

Having known that there could be many reasons for unfruitfulness, it is necessary to make necessary corrective measures which should begin from planning level and extend to an established orchard.
(i) Choice of the crop and variety should be made on the basis of climatic and edaphic conditions of the site of orcharding.
(ii) Provision of windbreak and shelter belts for areas prone to wind damage.
(iii) Before planting an orchard soil should be brought to optimity by incroporating organic matter, amendments and nutrients based on soil analysis.
(iv) In case of problems of pollination due to heterostyly, dichogamy incompatibility, sterility, embryo abortion, hybridity, etc. a mixture of varieties should be grown by introduction effective pollinizer varieties and pollinators (Honey bees).
(v) Unfruitfulness due to slow growth of pollen tube, premature and delayed pollination, use of plant regulators can be affected after standardization in terms of chemical concentration and timing of application.
(vi) The problem due to old age could be overcome by replanting or rejuvenation of old trees.
(vii) Problem due to overbearing can be managed through thinning at appropriate stage.
(viii) Irrigation management would be key role in situations with drought and waterlogged conditions.
(ix) Problem due to uneven distribution of flowers on tree should be managed through thinning and crop regulation.
(x) Maintenance of critical nutrient status in tree leaves for optimum crop production by adopting correct nutritional programme based on plant and soil analysis.
(xi) In crops requiring regular pruning standard practices will have to be adopted based on crop, variety and its phenology.
(xii) Unfruitfulness due to pathogens should be managed through effective plant protection measures following integrated approach.
(xiii) Problem of unfruitfulness due to tendency of alternate bearing should be over come through replacement of regular bearing varieties and crop regulation.

It is important to analyse the problem and then corrective measures should be suggested. Basically the planning should be so done that future is problem free and then should be followed by adoption of correct package of practices.

Lecture No. 29

Organic farming

Green revolution has brought spectacular increase in production as well as productivity of crops in our country. But after the initial success, it had shown the symptoms of fatigue evident from the undesirable side effects on natural resources, such as soil, water and biodiversity and thus human health. The vast areas of soils once fertilizer was degraded due to soil erosion, salinisation or general loss of soil fertility. Water resources have been over-exploited and polluted due to excessive requirement of irrigation water for high yielding varieties and intensive use of agro-chemicals. Many plants and animal species were wiped out and are endangered. Residues of harmful pesticide in food and drinking water endangered both farmers and consumer health point of view and thus excessive use of external inputs consumes a lot of energy from non-renewable resources.

Organic farming is a way of conserving the soil and maintaining the fertility, protect soil flora and fauna/diversity. It has lesser effect on pollution either of ground water, lakes and rivers. Organic agriculture does not utilize non-renewable external input and energy. Since no chemical or pesticide is used in crop production, there is very low chance of pesticide residues in food. At the same time the organic products are healthier and have better product quality like taste, aroma and storability. Input cost is drastically reduced in organic cultivation but the market price leading to higher income for farmers.

Aims of organic production and processing:

- To produce sufficient quantities of high quality food, fibre and other products.
- To work compatibly with natural cycles and living systems through the soil, plants and animals in the entire production system.
- To recognise the wider social and ecological impact of and within the organic production and processing systems.
- To maintain and increase long-term fertility and biological activity of soils using locally adopted cultural, biological and mechanical methods as opposed to reliance on chemical inputs.
- To maintain and encourage agricultural and natural biodiversity on the farm and surroundings through the use of sustainable production systems and protection of plant and wildlife habitats.
- To maintain and conserve genetic diversity through attention to on-farm management of genetic resources.
- To promote the responsible use and conservation of water and all life therein.
- To use, as far as possible, renewable resources in production and processing systems and avoid pollution and wastes.
- To foster local and regional production and distribution.
- To create a harmonious balance between crop production and animal husbandry.
- To provide living conditions that allows animals to express the basic aspects of their innate behaviour.

- To utilise biodegradable, recyclable and cycled packaging materials.
- To provide everyone involved in organic farming and processing with a quality of life that satisfies their basic needs within a safe, secure and healthy working environment.
- To support the establishment of an entire production, processing and distribution chain which is both socially and ecologically responsible.
- To recognise the importance of, and protect and learn from, indigenous knowledge and traditional farming systems.

Organic food products exported from India:

- **Organic cereals:** Wheat, Rice and Maize or Corn.
- **Pulses:** Redgram and Black gram.
- **Fruits:** Banana, Mango, Orange, Pineapple, Passion fruits, Cashewnut and Walnut.
- **Oilseeds and oils:** Soybean, Sunflower, Mustard, Cotton seed, Groundnut and Castor.
- **Vegetables:** Brinjal, Garlic, Potato, Tomato and Onion.
- **Herbs and spices:** Chilli, Peppermint, Cardamom, Turmeric, Black pepper, White pepper, Amla, Tamarind, Ginger, Vanilla, Cloves, Cinnamon, Nutmeg and Mace.
- **Others:** Jaggery, Sugar, Tea, Coffee, Cotton and Textiles.

Lecture No. 30,31&32
PLANT GROWTH REGULATORS

The quantitative increase in plant body such as increase in the length of stem and root, the number of leaves etc., is referred to as plant growth, whereas, the qualitative changes such as germination of seed, formation of leaves, flowers and fruits, falling of leaves and fruits is referred as development.

The two sets of internal factors, viz**., nutrition** and **hormone** control the growth and development of the plant. The raw material required for growth is supplied by nutritional factors which include the minerals, organic substances the protein, carbohydrates, etc. Utilization of these substances for proper development of the plant is regulated by certain "chemical messengers" called **plant growth substances** or **plant growth regulators**, which in minute amounts increase or decrease or modifies the physiological process in plants.

Phytohormones:

These are the hormones produced by plants which in low concentrations regulate plant physiological process. These usually move within the plants from a site of production to a site of action.

Plant growth regulators:

These are organic compounds other than nutrients, which in small amounts promote, inhibit or otherwise modify any physiological process in plant.

Or It may be defined as any organic compounds which are active at low concentrations (1-10 ml) in promoting, inhibiting or modifying growth and development in plants.

The naturally occurring (endogenous) growth substances are commonly known as **plant hormones**, while the synthetic ones are called **growth regulators.**

Plant hormones:

It is an organic compound synthesized in one part of plant and translocated to another parts, wherein very low concentration causes a physiological response. The plant hormones are identified as promoters (auxins, gibberellin, cytokinins), inhibitors (abscisic acid and ethylene) and other hypothetical growth substances (Florigen, death hormone, etc.).

Auxins:

Auxin is a **greek** word derived from **Auxin** which means to **increase.** It is a generic term for chemicals that typically stimulate cell elongation by loosening cell wall but auxins also influence a wide range of growth and development response. The chemical isolation and characterization was done by **Kogi *et al.* (1934).** Auxins are the first identified hormones of which IAA seems to be the major naturally occurring endogenous Auxin in plants and crops. Besides IAA, plants contain three other compounds which are structurally similar and elicit many of the same response as that of IAA, 4, Chloro indole acetic acid (CIAA), Phenylacetic acid (PAA), Indole butyric acid (IBA).

Site of Auxin synthesis: Auxins are synthesized in stem tips and in young tissues and move mainly down stem (Basipetal movement) i.e from shoot tip to root.

Synthetic compounds are classified into five major categories:

1. Indole acids
2. Napthalene acids
3. Chlorophenoxy acid
4. Picolinic acid.
5. Derivatives.

Role of Auxin:

1. **Cell division and enlargement:** IAA + GA, example - cambial growth in diameter.
2. **Tissue culture:** Shoot multiplications (IBA and BAP), callus growth (2, 4-D), root multiplication IAA and IBA (1-2 mg).
3. **Breaking dormancy and apical dominance (inhibition of lateral buds):** NAA
4. **Shortening internodes:** Apple trees (NAA) dwarf branch fruit.
5. **Rooting of cutting:** (10-1000 ppm-NAA, IAA, Phenyl acetic acid)
6. **Prevent lodging:** NAA develop woody and erect stem.
7. **Prevent abscission:** premature leaf, fruit and flower fall (NAA, IAA and 2,4-D).
8. **Parthenocarpic fruit:** Grapes, Banana and Orange (IAA).
9. **Flower initiations:** Pineapple uniform flowering and fruit ripening (NAA) and delay flowering (2, 4-D).
10. **Weed eradication:** 2, 4-D.

Gibberellins:

It is the active principle isolated from the soil borne fungus *Gibberella fujikuroi*. The concentration of GA_3 is usually highest in immature seeds, reaching up to 18 mg/kg fresh weight in Phaseolus species, but it decreases rapidly as the seeds mature. In general, roots contain higher amounts of GA_3 than shoots. Gibberellins have also been found effective in overcoming both kinds of dormancy in buds as well as seeds.

Role of Gibberellins:

1. GA : Synthesis in leaf and induce shoot elongation (IAA + GA_3), by effecting cell elongation or cell division or both.
2. **Enhance metabolic activity:** Mobilization of reserved food material, promote growth and height, increase root activity and kinetin production in root- translocate to growing bud.
3. **Shoot elongation:** GA_3 spray increases height of seedlings.
4. **Delay senescence:** Increase photosynthetic and protein synthesis so decrease abscission.
5. **Increase cambial growth and differentiation:** Induce flower and fruit set (IAA+GA_3).
6. **Dwarf plant (genetically) to normal height:** GA_3.
7. **Promote flowering in Long Day Plants**: Substitute for long day condition and cold treatment (vernalization).
8. **Induction of parthenocarpy in grapes**: Three physiological events: Rachis cell elongation, flower thinning and berry enlargement.

9. Breaking dormancy and leaf expansion.

Cytokinins:

First endogenous cytokinin was isolated from maize kernels named as **zeatin.** Germinating seeds, roots, sap streams, developing fruits and tumor tissues are rich in cytokinins. Cytokinins imbibed seeds germinate better in dark than unimbibed lettuce seeds. Similarly cytokinins together with gibberellins effectively breaks the photodormancy of celery (*Apium graveolens*) seeds.

Synthetic cytokinins are: Kinetin, Benzyladenine and Ethoxy ethyladenine.

Role of cytokinin:

1. Cell division, elongation and enlargement.
2. Tissue culture morphogenesis.
3. Induction of flowering and fruit development.
4. Parthenocarpy.
5. Apical dominance overcoming.
6. Breaking dormancy.
7. Delay senescence.
8. Improves N_2 metabolism.

Ethylene:

Neljubow (1901) is credited with having identified the active growth regulating component of the illuminating gas as **ethylene.** Ethylene is formed naturally in plants in amounts sufficient to bring about regulatory effect and it might be considered as plant hormones. Ethylene may be active in alleviation of secondary dormancy also. (Ross, 1984).

Recently a synthetic chemical known as ethrel, ethephon, chloroethyl phosphonic acid (CEPA) has been reported to release ethylene when applied to plants.

Role of Ethylene:

1. Breaking dormancy.
2. Induce ripening of fruits.
3. Induce abscission of leaves.
4. Inhibit elongation and lateral bud growth.

Growth retardant:

The term growth retarding chemical or growth retardant is that chemical slows cell division and cell elongation of shoot tissues and regulate plant height physiologically without formative effects.

E.g: AMO 1618, Phosphon-D, CCC, Chloromequat and Alar.

These do not occur naturally in plants and acts in retardation of stem elongation, preventing cell division.

Plant growth retardants are defined as synthetic organic chemicals that cause a retardation of cell division steps in pathways of hormone biosynthesis without evoking substantial growth distortions.

Inhibitors: These suppress the growth of plants. There are phenolic inhibitors and synthetic inhibitors and abscisic acid(ABA).

Phenolic inhibitors: E.g. Benzoic acid, Salicylic acid, Coumaric acid and Chlorogenic acid.

Synthetic inhibitors: E.g. Maleic hydrazide, Tri-Iodobenzoic acid(TIBA), SADH etc.

An inhibitor from young leaves of *Betula sps.* prevent the growth of apical buds .

E. g. ABA and Dormin.

Role of Abscissic acid (ABA): should appear as 5th growth regulator in the group; add introduction to ABA; take this before growth retardant

1. To stop elongation.
2. Induce dormancy.
3. Delay germination.
4. Inhibit growth process.

Add method of preparation of growth regulator formulations

Methods of Application:

Growth regulators can be applied in different ways like:

1. Spraying method.
2. Injection of solution into internal tissues.
3. Root feeding method.
4. Powder form.
5. Dipping of cuttings in solution.
6. Soaking in dilute aqueous solution.

Various uses of plant growth regulators:

1. **Propagation of plants:**

A number of plants are propagated by stem, leaf cutting and by layering. For promotion of rooting, the most commonly utilized hormone is IBA followed by NAA.

Gibberllic acid causes inhibition of root formation in cutting. Cytokinins also help in quick and profuse root formation in cuttings and layers. By use of auxins, profuse root formation is observed in cuttings of guava, fig, pomegranate, crotons, rose, hibiscus, etc.

2. **Seed germination:**

Many seeds have natural dormancy which can be got over by dipping the seeds in auxins. Soaking seeds of french beans and peas in 10-20ppm solution of GA for 12 hours before sowing, significantly improves the yield and quality. Dipping sweet potatoes in 5ppm GA solution for 5minutes before sowing increases sprouting and yield of potatoes.

3. **Control of plant size :**

In fruits and vegetables, application of higher doses of nitrogenous fertilizers spraying cycocel (growth retardant), the superfluous growth of leaves is checked. By spraying 10ppm solution of morphactin in potato, the growth of plant is reduced and thereby the size of tubers is increased.

The growth retardants are useful in checking the growth of hedges in ornamental gardens there by reducing the cost of trimming the hedges.

4. **Regulation of flowering:**

In Pineapple, due to later flowering the fruit get ready in rainy season. This deteriorates the quality of the fruit. This difficulty can be overcome by spraying 5-10 ppm solution of NAA before flowering. Application of 100-200 ppm GA in Dahlia plants induces early flowering.

Sometimes, it is necessary to delay flowering. E.g. Crossing of varieties which do not flower simultaneously. Hence, the crossing becomes difficult.

5. **Control of Sex expression:**

In number of cucurbits, such as ridgegourd, bittergourd, watermelon, cucmber and pumpkins which have proportion of male flowers is more than female flowers. For better yield, it is necessary to increase the number of female flowers. This can be achieved by application of auxins which increases the number of female flowers and decreases the number of male flower. The commonly used auxins are NAA and ethrel.

5. **Control of fruit set and growth of fruit:**

Spraying NAA, TIBA, and PCPA on flowers increases the fruit set. Dipping of grape bunches (young fruits) in GA solution increases the berry size in Thompson seedless grape.

6. **Control of fruit drop:**

In Nagpur Santra, the fruit drop can be controlled by spraying 10-20 ppm NAA or 10 ppm 2,4-D after fruit set. The fruit drop in mango can be controlled by these two auxins.

7. **Thinning of fruits:**

Sometimes it is necessary to thin the fruits so as to bring a balance between the supply of nutrients and development of fruit. In such cases spraying with mild solution of ethrel or morphactin reduces the fruit load by 25-30 per cent.

8. **Early ripening and development of fruit colour:**

If the fruits could be brought in the market in early part of the season, they fetch good price. Spraying with 2,4,5-T and B-9 hastens maturity of apples by 1-4weeks.

9. Prevention of sprouting:

In potatoes and onions, after harvest, in storage, the buds start sprouting which makes them unfit for cooking. Spraying of malic hydrazide(MH) solution before storing, prevents sprouting and these can be stored safely for 6 months.

10. Control of weeds:

The conventional method of controlling the weeds is to remove them by uprooting manually. Successful control of weeds is obtained by spraying 2,4-D in many crops.

Lecture No. 33, 34 &35

Maturity indices for fruits

Maturity (Commercial or Horticultural maturity): refers to the stage at which the produce is optimally accepted to the consumer.

Maturity index: The maturity at harvest determines the quality and post- harvest shelf-life of the fresh fruits. The study of *maturity* indices helps to harvest the crop at right time.

Judging maturity: There are various means of judging maturity but they vary according to the kind of fruits, local soil and climatic conditions, but generally farmers follow visual means (appearance). But this is not a perfect method, many a times it may mislead the farmers.

There are certain limitations for all maturity indices due to variation in nutrition of the crop, fruit shape, size, climate, seasonal factors, moisture, pruning method, use of hormones and other chemicals. We can use various indices to judge maturity.

Mango:

1. Slight colour development on the shoulders.
2. When one or two ripe fruits fall from the tree naturally (tapka method).
3. Skin colour changes from dark green to olive green.
4. Counting of the days from fruit set to maturity.
5. When the specific gravity of fruits ranges between 1.01 to 1.02.
6. Flesh firmness.
7. Lenticels become more prominent and waxy bloom gradually disappears.
8. When the TSS reaches 11-15^{o} Brix.
9. The first and second methods are not of much help since these are not representative of the fruit maturity of the entire tree and the fruits harvested do not ripe uniformly.

Banana:

The fruits are harvested at different maturity level based on distance of transport.

For long distance transport 75-80% maturity and for short distance transport 90-100% maturity fruits can be harvested.

1. When the pulp peel ratio reaches 1.2 - 1.6.
2. Days taken from shooting, i.e., 3.0-3.5 months.
3. Disappearance of angularity of the fingers.
4. Brittleness of floral ends.
5. Drying of leaves in some varieties.

Guava:

1. Guava fruits generally take about 17-20 weeks from fruit set to reach maturity.
2. When the colour changes from dark green to light green.
3. When the specific gravity is one (1.0).

Grape :

Grape is harvested when they reach a TSS of 16 to 24% depending on variety.

Bangalore blue : 12-14%

Anab-e-Shahi and Selection-7 : 16-18%

Thompson seedless : 20-22%

Besides TSS, the following physical characteristics are also useful in judging maturity.

Texture of pulp (softness).

Peel colour (light yellow).

Easy separation of the berries from the bunch.

Development of characteristic flavour and aroma.

Papaya:

1. **For local market:** When skin colour changes at the apical end of the fruit.
2. **For long distance transport:** When the skin colour changes from green to yellow to the extent of 6%.
3. When the latex of the fruit becomes almost watery.

Pineapple:

For local market: When 25% of surface changes to yellow colour.

For long distance: When all the eyes are still green and have no trace of yellow colour (75-80%maturity).

In India:

1. Pineapples are harvested when the colour changes from green to greenish yellow.
2. The fruit develops a smooth surface around the eyes.
3. The flattening of eyes.
4. **TSS:**acid ratio of 21 to 27 and specific gravity of 0.98 to 1.02.

Jackfruit:

1. A dull, hollow sound is produced when the fruit is tapped by the finger.
2. The last leaf of peduncle turns to yellow.
3. Fruit spines become well developed and widely spaced.
4. An aromatic odour develops.

Pomegranate:

1. The fruits are ready for harvest between 135-170 days after anthesis.
2. The fruit colour changes in summer to dark yellow and in winter to dark red.
3. The persistent calyx at the anterior end of the fruit curves inward and become hard and dry at maturity.
4. Rind is very hard.

Sapota:

1. The peel shows a dull orange or potato colour with a yellowish tinge when scraped.
2. The scurf content on the surface of the fruit will be minimum and easily fall off.
3. The content of milky latex drops to almost zero.

Citrus :

1. Maturity indices differ among the citrus species/varieties.
2. **Mandarins**: When the rind colour changes from green to orange colour.
3. **Sweet orange:** When the rind colour turns to yellow.
4. **Limes:** When the rind colour changes to light green to yellow colour.

The International Standards Organization has set in minimum juice content of citrus as follows:

- Washington navel oranges 30%
- Other orange varieties 35%
- Grape fruit 35%
- Mandarin orange 33%
- Lemons and limes 25%
- For processing total juice content of the fruit is important.

Fig :

1. When fruits become soft and wilt at neck.
2. Fruits hanging down from their own weight.
3. No milk exudation from the stem when the fruit is pulled off.

Custard apple:

1. When the fruit turns to light green colour.
2. Development of yellowish white colour between the carpels.
3. Initiation of widening the gap between carpels or segments.

Ber :

1. Attainment of full size of particular cultivar with softening of pulp.
2. Development of characteristic yellow or golden yellow colour.
3. Days to mature the fruits.

   Ex: In Delhi cv. Gola took only 150 days where as Tikadi requires 173 days to mature.

4. In cultivars like Gola, Kaithli and Umran , there was an increase in reducing and non-reducing sugars, total sugars and TSS.

Date palm:

It can be harvested at 3 different stages.

Sl. No.	Stage	Characteristics
1	Doka (khalal)	Fruit becomes hard, yellow or pink or red, TSS- 30 to 45%, astringency present or absent depending on cultivar and edible stage.
2	Dang (rutab)	Softness starting at tip of fruit, tannins and astringency disappears, lose weight and moisture content is about 35 – 40% and edible stage.
3	Pind (tamur)	Fully ripe fruit, lose weight, TSS- 60 to 84 % and edible stage.

Lecture No. 36

Marketing of fruits (can this be dropped?)

Marketing is as crucial to better performance as production. It comprises all the operations and actions involved in the movement of commodities from the producer to the ultimate consumer

Richard Kohls (1958) has defined marketing as "Marketing is the performance of all business activities involve in the flow of goods and services from the point of initial agricultural production until they are in the hands of the ultimate consumers".

Price stability and equitable distribution of goods and services cannot be achieved without an organized, well equipped and efficient marketing system.

Some of the objectives of fruit marketing are:

1. To link the producers and consumers by bringing the products from the producing centres and offering them to the consumers.
2. To fetch a profitable but reasonable selling price for the producers.
3. To keep the price of the commodities within the reach of the consumers.
4. To present the commodities in a saleable, readily consumable and attractive form with minimum deterioration in form, quality and taste.
5. To keep the cost of marketing as minimum as possible to maintain the interests of both producers and consumers.
6. To keep the demand and supply in balance.

Factors affecting rate of market development:

1. Nature of demand.
2. Nature of products.
3. Transportation and communication facilities.
4. Quantum of supply and demand.
5. Public policies.

Marketing Channel:

The route through which the goods and services move and reach the hands of final consumer is known as **marketing channel**. There are number of intermediaries who perform the various services and are parts of marketing channel.

The most common and widely used marketing channel in fruit marketing is:

Grower---- Pre harvest contractor---- Primary wholesaler---- Commission agent---- Secondary wholesaler ----Retailer-----Consumer.

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