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FUNDAMENTALS OF HORTICULTURE & PRODUCTION TECHNOLOGY OF FRUIT CROPS

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LECTURE -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 % 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 two **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*”.

Definition:

Horticulture is a science and technique of production, processing and merchandizing of fruits, vegetables, flowers, spices, plantations, medicinal and aromatic plants.

2. BRANCHES OF HORTICULTURE

- Horticulture is a wide field which 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.
 - Following are the branches of horticulture.
 - i. **Pomology** : study of fruit crops.
 - ii. **Olericulture** : cultivation of vegetables.
 - iii. **Floriculture** : cultivation of flower crops.
 - iv. **Plantation crops** : cultivation of coconut, arecanut, rubber, coffee, tea, etc.
 - v. **Spices crops** : cultivation of cardamom, pepper, nutmeg etc.
 - vi. **Medicinal and aromatic crops**: cultivation of medicinal and aromatic crops.
 - vii. **Post harvest technology**: deals with post harvest handling, grading, packaging, storage processing, value addition, marketing etc, of horticulture crops.
 - viii. **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 Solanaceae, 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 *w.r.t.* area and production contributing 13.38 % 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.

Differences between fruits and vegetables

Sl No.	Vegetables	X	Fruits
1.	Most of the vegetables are annuals	:	Fruit plants are perennial in nature
2.	Mostly majority of them are sexually propagated	:	Fruit plant are sexually and asexually propagated
3.	Cultivation of vegetable is seasonal and special techniques like pruning and training are generally not required	:	Fruit plants require special practices like training and pruning and are required seasonally.
4.	Vegetable plants are generally non-woody	:	Fruit plants are generally woody in nature
5.	All parts of the plant are edible	:	Only fruit is edible but sometimes false fruit also edible (eg. Fleshy thalamus of apple)
6.	Generally consumed after cooking	:	Mostly consumed raw after ripening

FLORICULTURE:

- In India, flower cultivation is being practiced 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 sectors contributing about Rs.7,500 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 9,500 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 IN GENERAL

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

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Lecture No.: 2**IMPORTANCE OF HORTICULTURE**

- Fruit crops cover an area of 4.96 m ha and vegetable crops 6.75 m ha. Accordingly, 49.29 m.ton of fruits and 101.43 m ton of vegetables are produced in the country annually (Indian Horticulture Database, 2005).
- To meet out the projected demand of population by 2020 AD about 50 mt of fruits and 143 m tons of vegetables would be required. Therefore by 2020 A.D. the production of fruits needs to be increased.
- Requirements of export and processing industry further add to the requirements of horticultural produce.
- In view of these, there is lot of scope of increasing production and potentiality of horticulture crops.
- Apart from fruits and vegetables, floriculture industry in India comprising of florist trade, nursery plants, potted plants, seed and bulb products is being observed as sunrise industry.
- There is roaring business of flowers in almost all metropolitan cities of the different states.
- The developed flower market in the country during 2005 is with area of 2.24 lakh ha with a production of 6.54 lakh MT loose flowers and 19,515 lakh cut flowers.
- The traditional flowers are grown on a large area on a commercial scale. These flowers are mostly grown for loose flower purpose.
- Area under cut flowers like rose, chrysanthemum, gladiolus, carnation and orchids is increasing day by day.
- Plantation crops are another potential sector with lot of opportunities for employment generation, foreign exchange earnings and overall supporting livelihood sustenance of mankind at large.
- These plantation crops form the mainstay of lively hood in coastal areas of the country where predominating stands of plantation crops are found.
- Coconut has so much importance in the country that the state Kerala receives its very name on the basis of coconut, the Malayalam name of which is *Kera*. These cover an area of 31.02 lakh ha with a production of 131.60 lakh MT.

Horticulture is important due to 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 - fruit crops requires 860 man days/annum as against 143 man days/annum for cereal crops where as the crops like grapes, banana and pineapple needs 1000-2500 man days per annum.
6. Effective utilization of waste land through cultivation of hardy fruits and medicinal plants.
7. As a substitute for family income being the component of home garden/ kitchen 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 the environment.
 11. Religious significance in the country.
- In short and sweet 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.
1. **Incentive for the farmer:**
 - The biggest incentive for the farmer is money.
 - Horticultural crops provide more returns in terms of per unit area of production, export value, value addition compared to agricultural crops.
 2. **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 from 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 lot of scope for horticultural crops.
 3. **Necessity:**
 - After having achieved the self sufficiency in food, nutritional security for the people of the country has become the point of consideration/priority.
 - To meet the 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.
 - 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 etc.,) 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.

4. Export value:

- Among fresh fruits-mangoes and grapes; in vegetables- onion and potato; among flowers, roses; among plantation - cashewnut, tea , coffee, coconut, arecanut, and spice crops like black pepper, cardamom, ginger, turmeric, chillies, etc., constitute the bulk of the export basket.
- *European and gulf* countries are major importer of horticultural produce.

Major countries for export of horticultural produce from India

Sl.No.	Commodity	Major importer	Share value (%)
1	Fruits and vegetables	United Arab Emirates	28.00
2	Flower crops	U.S.A	37.70
3	Processed products	Soviet Union countries	14.60
4	Spices	U.S.A	43.50
5	Cashew	U.S.A	40.00

- 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.

Reasons for scope of Horticulture in India are:

1. To exploit the great variability of agro climatic conditions in the country.
2. To meet the need for fruits, vegetables, flowers, spices, beverages in relation to population growth based on minimum nutritional security and for 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 avoid the problem of unemployment.
6. To protect environment.

Other importance:

1. Similar to forest trees these horticultural trees will maintain the ecosphere.
2. They help in transforming the micro climate.
3. Provides shelter to birds, reptiles and other micro organisms and add to the geo-ecological diversity on the land.
4. Provides thrust to the writers, poets, thinkers and analysts there by keeps their cultural impulse alive.
5. Adds to the survival of life-spheres of living entity.

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.
- Realizing the worth of fruits and vegetables in human health, Indian Council of Medical Research (ICMR) recommended the use of **120g fruits** and **280 g vegetables per capita per day**.
- 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,
2. Improves appetite and provides fibre to overcome constipation.
3. They neutralize the acids produced during digestion of proteins and fatty acids.
4. They improve the general immunity of human body against diseases, deficiencies etc.
5. They are the important source of vitamins and minerals for used in several bio-chemical reactions occur in body.
6. Fruits and vegetables 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	<ol style="list-style-type: none"> 1. Essential for growth and reproduction. 2. Helps in resistance to infections, increases longevity and decreases senility. 3. Deficiency causes, night blindness, xerophthalmia, retardation in growth, roughness in skin, formation of stones in kidney. 	<p><i>Mango, Papaya, Persimon, Dates, Jack fruit, Walnut, Oranges, Passion fruit, Loquat etc.</i></p> <p><i>Coriander leaves, Drumstick leaves, Fenugreek leaves etc.</i></p>
Vitamin – B ₁	<ol style="list-style-type: none"> 1. For maintaining 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. 	<p><i>Walnut, Apricot, Apple, Banana, Grapefruit, Plum and Almond</i></p> <p><i>Chillies, Colocasia leaves, Tomato, etc.</i></p>
Vitamin – B ₂	<ol style="list-style-type: none"> 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, and development of cataract, swollen nose and baldness. 	<p><i>Bael, Papaya, Litchi, Pomegranate, Wood apple and Pineapple.</i></p> <p><i>Amaranthus, Fenugreek leaves etc</i></p>

Vitamin – C	1. Deficiency causes scurvy, pain in joints, swelling of limbs, unhealthy gums, tooth decay, delay in wound healing and rheumatism.	<i>Barbados cherry, Aonla, Guava, Lime, Lemon, Sweet oranges, Ber, Pineapple and Pear.</i> <i>Chillies, Tomato, Coriander leaves, Drumstick leaves etc.</i>
Fat	Walnut, Almond, Avocado	
Fibre	Guava, Pomegranate, Aonla, Grape, Amaranth, Mustard, Beet leaf, Spinach etc.	

Minerals are essential for the growth and development for the human body:

Minerals	Deficiency causes	Sources
1. Calcium	Causes Rickets, Osteomalacia.	<i>Sitaphal, Ramphal, Fig, Phalsa, Citrus, Sapota, Grapes, West Indian Cherry etc.</i> <i>Curry leaves, Amarantus, Radish leaves, Fenugreek leaves etc</i>
2. Phosphorous	Essential for cell multiplication of bones and soft tissues. Helps in liberation of energy on oxidation of carbohydrates.	<i>Wood apple, Avocado, Dates, Pomegranate and Grape raisins.</i>
3. Proteins	Important for body growth, formation and maintenance of body tissues	<i>West Indian cherry, Avocado, Custrad Apple, Banana, Apricot, Guava, Grapes etc.,</i> <i>Peas, cowpea, Bean etc..</i>
4. Iron	Act as oxygen carrier in the body.	<i>Karonda, Date palm, Grape raisins, West Indian Cherry, Guava, Sitaphal, Avocado, Sapota, plum etc.</i> <i>Amarantus tender, Coriander leaves etc.</i>

- Fruits 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.

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Lecture No.3

SCENARIO OF HORTICULTURE**{Area, Production and Export –Import (EXIM) Trade}**

- India is one of the leading producers of horticultural crops in the Globe.
- Horticultural crops cover 13.08 % of the total area under agriculture and contribute to about 28 % of the GDP.
- These crops accounts for 37 % of the total exports of agricultural commodities.
- Due to planned emphasis laid on horticulture, India is accredited as the second largest producer of fruits and vegetables,
- India is the largest producer and consumer of cashew nut, tea and spices.
- Third largest producer of coconut.
- Fourth largest producer and consumer of rubber.
- Sixth largest producer of coffee in the world.
- India exports fruits, vegetables, processed products, flowers, seeds and planting materials, spices, cashew nut, tea, coffee etc.
- During 2005-06, the value of export material was worth Rs.1, 24,175 million. During the year, export of cashew nut was dominantly higher followed by spices, tea and coffee.

Fruits:

- India is the largest producer of mango, banana, grape and litchi. However, the bulk of the production is consumed domestically.
- Of the total global exports for fruits, India's share is only 0.3%.
- Fruits accounts for about 11% of total horticultural export from country.
- Grape and mango together constitute 60% of India's exports of fresh fruits.
- Citrus, banana, apple and papaya are other important fruits for export.

Vegetables:

- During the year 2005-06, the export of fresh vegetables was of the order of Rs 919.8 crore.
- Onion accounts for maximum share in exports trade.
- Other major vegetables are tomato, potato, bean, pea, mushroom, asparagus, capsicum and okra.

Floriculture:

- In floriculture, cut flowers alone account of 86% of the total trade in this sector.
- Dried flowers and other plant parts are other prominent commodities.

Processed products:

- Of the total horticultural trade, processed fruits and vegetables account for 20% and 17% respectively.
- Among the processed fruits, fruits juice and dried fruits contribute to 41% and 12% of trade respectively.
- Mango pulp, pickles and chutneys of various fruits remain in high demand in export trade.
- Among processed vegetables, mushrooms, gherkins, dehydrated onion and frozen pre-cut vegetables are important items.

Spices:

- World trade in spices has been estimated of the magnitude of 7.5 lakh metric tonnes valued at Rs 1650 million US\$.
- Indian spices command 43% share in volume and 31% in value of the world trade (2005-06).
- These commodities account for more than 5% of the total agricultural export earnings in the country.
- Value added spices are in large demand in export trade and their share is 60% of total export under spices.

Seeds and planting materials:

- The country exports seed and planting materials of fruits and vegetables.
- The export of these commodities was of the order of Rs.63 crores during the year 2004-05

Medicinal and aromatic plants:

- The country has its credits of exporting herbal material raw drugs to world market.
- Before 2005, Indian export of herbal material was worth Rs. 446 crore.
- China export in this regard has been worked out of the tune of Rs.18, 000-22,000 crore. Aloe veera, belladonna, acrus, cinchona, *Cassia tora*, dioscorea, senna, isbgol, etc., hold prominence in export trade under the sector.

Cashew nut:

- During the year 2004-05, cashew nut kernels worth Rs.2709 crore were exported.
- At present, the country exports about 1.27 lakh metric tonnes of cashew kernels worth Rs. 2500 crore.

Tea:

- Until 1987-88, India was dominant exporter of tea in the world market.
- The share of tea in total agricultural export was 20.7%.
- In view of stiff competition from Sri Lanka, Kenya, China tea export from the country has been divided down.
- At present share of tea in total agricultural export has been merely 5%.

Coffee:

- After petroleum, coffee is the second largest commodity in the world trade. From India, 70% of the total production of coffee is exported.

Coconut:

- The recent trends in the exports of coconut products witness decrease in export of copra and copra meal.
- There has been moderate increase in coconut oil, desiccated coconut and shell charcoal while
- There is significant increase in coco chemicals, activated carbon, coir and coir products.
- Coir and coir products are major coconut based commodities in the export basket.

Rubber:

- The country exports natural rubber.
- Under this sector, it accounts for 1.1% of the global share.
- The export of natural rubber rose from 6995 metric tonnes in 2001-02 to 75,905 metric tonnes during 2003-04.

Cocoa:

- India exports cocoa products.
- During the year 2005-06, India earned foreign exchange worth Rs.24.80 crore out of export of cocoa beans/products.

Imports

- There is rise in the imports of certain commodities.
- Commodities like dried pea, apples, apple juice, dried vegetable, black pepper, raw cashew nut, areca nut, cocoa etc., are important items imports by India.
- In spice sector, India is leading producer but bulk of its production is utilized domestically itself.
- In cashew nut production scenario, the country produces 5.4 lakh tonnes of raw cashew nuts, as against the requirement of 11-12 lakh tonnes per annum to feed out 1700 cashew processing units.

RESEARCH ORGANISATIONS IN HORTICULTURE

1. Indian Institute of Horticultural Research(IIHR), Bangalore
2. Indian Institute of Vegetable Research(IIVR), Varanashi
3. Indian Institute of Spices Research(IISR), Calicut, Kerala
4. Central Institute of sub-tropical Horticulture(CISH), Lucknow
5. Central Institute of Temperate Horticulture(CITH), Srinagar
6. Central Potato Research Institute(CPRI), Kufri, Shimla
7. Central Tuber Crops Research Institute(CTCRI), Thiruvananthapuram, Kerala
8. Central Plantation Crops Research Institute(CPCRI) Kasargod, Kerala
9. Central Institute of Arid Horticulture(CIAH), Bikaner, Rajasthan
10. Central Institute of Post Harvest Engineering and Technology(CIPHET), Ferozepur, Punjab
11. ICAR Research Complex for Goa, Ela, Old Goa
12. ICAR Research Complex for North Eastern Hill Region. Barapani, Meghalaya
13. National Research Centre for Banana. Trichirapalli, Tamil Nadu
14. National Research Centre for Citrus, Nagpur, Maharashtra
15. National Research Centre for Onion and Garlic, Pune, Maharashtra
16. National Research Centre for Grape, Pune, Maharashtra
17. National Research Centre for Medicinal and Aromatic Plants, Anand, Gujarat
18. National Research Centre for Mushroom, Solan
19. National Research Centre for Orchid, Gangtok, Sikkim
20. National Research Centre for Cashew nut, Puttur, Karnataka
21. National Research Centre for Seed Spices, Ajmer, Rajasthan
22. National Research Centre for Oil Palm, Eluru, Andhra Pradesh
23. National Research Centre for Pomegranate, Solapur, Maharashtra
24. National Research Centre for Makhana, Patna, Bihar
25. National Research Centre for Litchi, Muzaffarpur, Bihar
26. National Horticulture Board(NHB), Gurgaon, Haryana

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Lecture No.4

HORTICULTURAL ZONES OF INDIA AND CLASSIFICATION OF HORTICULTURAL PLANTS

- 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.
 - 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;
1. **Temperate:** Kashmir, Himachal Pradesh, North Uttaranchal, Sikkim and part of Arunachal Pradesh.
 2. **N.W. Subtropical:** Punjab, Haryana, Rajasthan, Central Uttar Pradesh and North M.P.
 3. **N.E. Subtropical:** Bihar, Jharkhand, Assam, Meghalaya, Nagaland, Manipur.
 4. **Central tropical:** South Madhya Pradesh, Chattisgarh, Gujarat, Maharashtra, Orissa and West Bengal.
 5. **Southern tropical:** Karnataka, Andhra Pradesh and Tamil Nadu.
 6. **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.

- Climate is one of the important complex factors which influence the fruit production.
- Atmospheric conditions include rainfall, humidity, sunshine, wind and other factors.
- The fruit growing zones are classified based on the climate factors.

FRUIT ZONES ARE:

1. Tropical fruit zone:

- This class includes fruit crops which are ever green unable to endure cool temperature but can tolerate warm temperature of about 100°F.
- The fruit plants of this zone need strong sunshine warm and humid climate and a very mild winter.

- They cannot stand against frost.
- Areas under this zone include West Bengal, Parts of Punjab, Haryana, Rajasthan Orissa, Maharastra, AP, Karnataka, TN and Kerala.
- Fruits crops: Banana, Pineapple, Sapota, Papaya, Cashew, Pomegranate.

2. Sub- tropical fruit Zone:

- This class includes fruit crops intermediate characters to tropical and temperatures.
- The summer is hot and dry and winter is less mild.
- They may be either deciduous or ever green & are usually able to withstand a low temperature but not the frost.
- Some require chilling for flower bud differentiation the fruits grow mostly in plains,
- The fruits include Citrus, Grapes, Phalsa, fig, guava, pomegranate, Banana etc.
- This fruit zone covers the plains of Punjab, UP, Parts of Bihar, MP, WB, Maharastra, Rajasthan, Karnataka, AP, TN, Kerala, Orissa. etc.

3. Temperate fruit zone:

- This class of fruits grows successfully in cold regions where temperature falls below freezing point during winter.
- During the cold season, the trees shed their leaves and go into rest period.
- For breaking the rest/dormant period, a definite chilling period is required. This chilling temperature helps the plants to put forth new growth, flowering and fruiting with the onset of spring season.
- The regions under this zone are J&K, Kuluvally, HP, Parts,
- Peaches, Plum, Cherries, Almond, Walnut, Strawberry, Apricot, persimmon, Pecan nut, Kiwi fruit etc.

4. Arid Zone:

- The arid zone has an extreme climatic condition, high temperature low humidity, rainfall is very low and its distribution is erratic, poor textured soil.
- The area of Rajasthan (62%) and Gujarat (20%) parts of the Punjab, Haryana, Karnataka & Maharashtra
- The crops are Phalsa, Date palm, Pomegranate, Ber, Custard apple, Tamarind etc.

5. Semi- arid zone:

- This region exhibits low and erratic rainfall, low humidity and high temperature
- Fruits of arid region can be cultivated in this zone also Mango, Sapota, Guava, Jack, Avocado, Ber, Pomegranate and Tamarind etc.

6. North- Eastern sub-Tropical zone:

- All tropical and sub-tropical fruits are grown in this region.

- The parts are Bihar, Assam, Meghalaya, Manipur, Parts of WB and UP etc.

7. North- Western region:

- It is again classified into 4 regions; temperate- low winter temperature, dry temperature- highly cold condition, Sub- Temperate- winter temperature & lesser cold, Low hill valley- low winter temperature & lesser cold.
- Parts of J&K, HP, hills of UP, South of Punjab and Haryana.

8. Central tropical fruit zone: This region covers Southern parts of MP, Maharastra Orissa, parts AP, WB, Gujarat etc.

9. South tropical fruit zone: Karnataka, TN, Kerala & AP

10. Coastal tropical fruit zone: Kerala, Goa, Diu-Daman, Tripura, Coastal parts of Maharastra, AP, WB, TN, Orissa, Karnataka.

11. Humid zone fruit crops:

- This region is characterized by low temperature and high humidity.
- The crops are Litchi, Strawberry, Avocado, Mangosteen, Passion fruit etc.
- Apart from these fruit zones, India has been classified in to 21 agro ecological regions based on the physiography of soils, bioclimatic types and growing periods.

CLASSIFICATION OF HORTICULTURAL PLANTS:

- India is endowed with rich vegetation wealth with rich diversity of plant wealth.
- About 9,500 species of ethno botanical interest have been recorded.
- Out of these, more than 50 types of fruits and vegetables, many individual types of spices, plantation crops etc. are under commercial cultivation in different parts of the country, under different sets of growing conditions.
- An attempt to deal with all these plants separately becomes tedious, cumbersome and infeasible and more so repetitive.
- To avoid these difficulties, it is better to classify the plants in groups, based on similarity or dissimilarity of attributes.
- Plants having similarity in either of the traits are placed under one group. Such type of grouping plants in different categories is referred to as classification.
- The overall objective of the classification is to systematize the presentation and make the remembrances of the plants easy and convenient.
- Generally based on botanical relationship, the plants are classified.

Different group of plants are classified based on the following criteria:

I. FRUITS:

1. Based on nature of growth
2. Based on climatic requirement
3. Based on continuation of growth
4. Based on types of fruit
5. Based on parts used
6. Based on botanical relationship
7. Based on salinity tolerance
8. Based on ripening behaviour
9. Based on ethylene evolution
10. Based on bearing habits
11. Based on photoperiodic requirement

II. VEGETABLES

1. Based on botanical relationship
2. Based on hardness or temperature tolerance
3. Based on tolerance to soil acidity
4. Based on tolerance to salt
5. Based on parts used as food
6. Based on methods of raising
7. Based on forcing
8. Based on rate of respiration
9. Based on pigmentation

III. FLOWERS

1. Based on season of growing
2. Based on colour of flower
3. Based on purpose of growing
4. Based on nature of growth
5. Based on mode of propagation
6. Based on growth behaviour
7. Based on photoperiodic requirement
8. Based on ability to grow

IV. SPICES

1. Based on completion of life cycle
2. Based on growth behaviour
3. Based on importance
4. Based on part used
5. Based on utility
6. Based on cultural management
7. Based on botanical relationship
8. Based on photoperiodic requirement

V. PLANTATION CROPS

1. Based on botanical relationship
2. Based on growth behaviour
3. Based on utility
4. Based on extent of growing
5. Based on intensity of cultivation

Lecture No.5

NURSERY

(Importance and Propagation Methods)

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

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
1. **Home nursery:** is the area where planting materials specifically grown or raised only to cater the needs of the growers garden.
2. **Commercial nursery:** Nurseries are larger in size and collection of plants. This is mainly concerned with economic returns from the investments

Factors affecting the establishment of a nursery:

1. Location and site- Topography, climate, reputation of locality for business and transport facility
3. Selection of soil
2. Water facility
3. Manures
4. 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.

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.**

Methods of Propagation

1. **Sexual Method of Propagation:** In this method the plants are raised from seeds.

Advantages: For evolution of new varieties through breeding, the hybrids are raised from seed.

1. In some fruit plants like papaya, this is the most popular method of propagation.
2. Seed propagated rootstocks are hardy and develop better root system.
3. Viruses don't transmit through seeds, thus mostly the seedlings are free from virus diseases.
4. Occurrence of polyembryony (more than one embryo in seed) in citrus and mango leads to the development of uniform seedlings as in asexual method.

Disadvantages

1. Seedlings have a long juvenile period and come into bearing later as compared to asexually raised plants.
2. Due to segregation of characters, the progeny is not true-to-type.
3. It is not economical to handle larger trees, as less number of trees can be accommodated per unit area and the cultural operations are difficult.

2. **Asexual Method of Propagation:** In this method of propagation the plants are obtained from a vegetative portion of the mother plant instead of seeds.

Advantages

1. In some fruit plants like banana, which do not bear seeds, this is the only method of propagation.
2. The plants are generally true-to-type, uniform in growth, yielding capacity and fruit quality.
3. Have short juvenile phase, thus come into bearing earlier than seedling plants.
4. The advantages of rootstocks can be obtained by budding or grafting susceptible varieties on resistant/ tolerant rootstocks.
5. Plants have restricted growth, thus cultural practices and harvesting are easy.

Disadvantages

1. New variety cannot be evolved by this method.
2. Plants are not so vigorous and long-lived as the seedling trees.
3. Germplasm conservation requires lot of space and is expensive as compared to storage of seeds.

i. Cutting:

Cutting is a method of asexual propagation in which plant part such as stem, root or leaf is cut from the parent plant and placed under favourable condition to form roots and shoots thus producing a new independent plant.

Advantages

1. It is the cheapest method of asexual method of propagation
2. It is used for clonal multiplication of root stocks.

Types of cuttings ; Stem cutting ; Root cutting ; Leaf cutting

ii. Layering

Layering is the development of roots on the stem while it is still attached to the parent plant. The rooted stem is then reached to become a new plant growing on its own roots. Such rooted stem is known as a layer. Stool layering is also used for clonal multiplication.

Types layering

- Simple layering ;Compound layering; Mound layering ;Air layering

iii. Grafting

- Grafting is the art of uniting or joining the parts of two independent plants in such a manner that they unite together and develop into a single independent plant.
- The part of graft which is to become the shoot system is termed as scion.
- The part which is to become the root system is called as root stock.

Types of grafting

- Approach grafting
- Side grafting
- Veneer grafting
- Epicotyl grafting(Stone grafting)
- Soft wood grafting

iv. Budding

Budding is also method of grafting wherein only one bud with a piece of bark, and with or without wood, is used as scion material. It is also called as bud grafting. The plant successful union of the stock and bud is also known as ‘**buddling**’.

Methods of budding

- T–Budding (Shield budding); Inverted T-Budding ;Patch Budding;Flute Budding ;Ring Budding; Chip Budding

PROPAGATION THROUGH SPECIALIZED VEGETATIVE STRUCTURES

There are certain plant modifications which are used for vegetative propagation of plants. These modified plant parts may be stem, root, or leaves and are usually specialized for food storage. Two principal methods are used for propagation of plants by using these modifications.

1. **Separation** : naturally detachable structures, such as bulbs or corms are separated and planted individually and
 2. **Division**: The plants modification such as rhizomes, tubers etc., are cut into sections to obtain new plants from each section.
1. **Bulbs**: Bulbs are produced by monocotyledonous plants in which the stem is modified for storage and reproduction. Bulb is a specialized underground organ consisting of a short freshly, usually vertical stem axis bearing at tip apex or growing points and enclosed by thick freshly scales. Bulb scales morphologically are the continuous sheathing leaf base. Growing points develop in the axils of these scales to produce miniature bulbs known as bulbets/ daughter bulbs. These daughter bulbs can be separated from the mother plant at the end of growing season and used as propagating material.

Ex: Tulip, Daffodils, Polyanthers (Tuberose), Onion, Garlic, (cloves)

2. **Tubers:** A tuber is the short terminal portion of an underground stem which has become thickened because of accumulation preserved food material eg: Potato. Propagation by tuber can be carried out either by planting the whole tuber or by cutting into sections each containing bud or eyes.
3. **Tuberous roots:** Certain herbaceous perennials produce thickened roots which contain large amount of stored food. The tuberous roots differ from the tubers in that they lack nodes and internodes. Adventitious buds are present only at stem end or proximal end; fibrous roots are produced towards the distal end. These fleshy roots are separated and used for propagation.
 - EG: Sweet potato, Dhahlia. Tapioca (Cassava).
4. **Rhizomes:** The horizontal, thick and fleshy or slender and elongated stem growing underground are known as rhizomes. Rhizomes have nodes and internodes and readily produce adventitious roots. The rhizomes are cut into pieces, each containing vegetative bud and transplanted.
 - Eg: Banana, Ginger, Ferns, Turmeric, and Cardamom.
5. **Corms:** A corm is solid underground base of a stem having nodes and internodes and is enclosed by a dry scale like leaves. After flowering one or more corms may develop just above the old one, which disintegrates. In addition several new corms called caramels develop below each new corm. These may be separated and grown for 1-2 years to reach flowering stage.
 - Eg: Gladiolus, Amor phophallus.
6. **Runners:** Runners are specialized arial stems (stolones) arising in the leaf axils of plant having rosette crowns. New plants arise from nodes at interval along these runners. From these runners more new runners may arise thus developing natural clonal multiplication methods. The typical runner producing plant is straw berry which is photo sensitive with regard to its runner production. Long days favour runner production where as short days prevent runner formation.
 - Eg: Strawberry.
7. **Suckers:** Adventitious shoot from the underground portion of the stem or from their horizontal root systems are known as suckers and when these strike roots, they may be utilized as propagation materials. Well developed suckers are dugout and separated from the mother plant and planted in the nursery for further growth. Suckers are usually treated like rooted layers.
 - Eg: Pineapple, Chrysanthemum, Curry leaf, Banana.
8. **Offsets/ offshoots:** An offset is a shoot or thick stem of rosette like appearance arising from the base of the main stem of certain plant such as date palm, pineapple etc.,
 - Date palm cultivars are propagated vegetative by separating away the offshoots and replanting them.
 - However these are girdled and layered for about a year prior to separation, because offshoots do not root easily when directly separated from the mother plant and planted in the field.

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Lecture No.6

PRINCIPLES OF ORCHARD ESTABLISHMENT AND MANAGEMENT

- ◆ 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

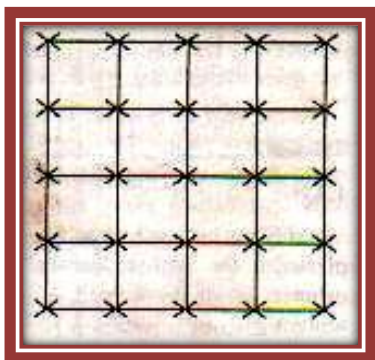
- For laying out an orchard, according to square system, a base line is first established and position of the trees is marked along this line by laying wooden stakes in the ground.
- Another base line at right angle to the first base line, is then marked along with the other edge of the field with the 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.

1. 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.

2. 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.

3. 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

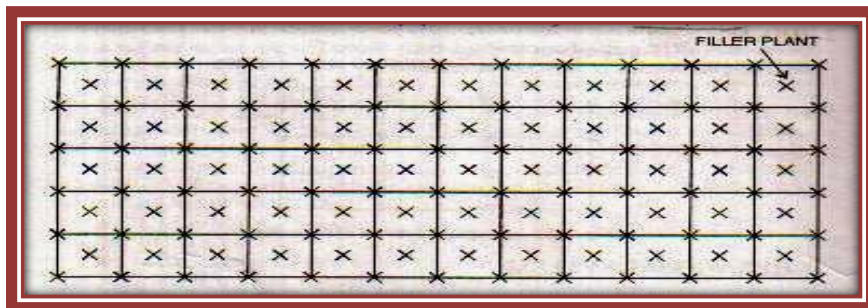
is costly and very fertile with ample provision of irrigation water.

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.

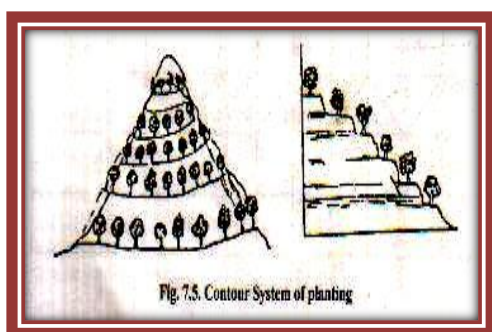
4. QUINCUNX SYSTEM



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.

5. 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

- 1) In this system, trees are planted as in the square system but the plants in the 2nd, 4th, 6th and such other alternate rows are planted midway between the 1st, 3rd, 5th and such other alternative rows. This system provides
- 2) Plants in alternate rows are off set half the space between plants in a row.
- 3) Result in 9 % fewer plants than square and rectangular system.
Eg : Amrapali – 1600 plants / ha.
4. More open space for trees and for intercrop.

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Lecture No.8

TYPES OF ORCHARDS

- 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.
1. **Orcharding:** refers to growing of fruit plants in an orderly manner and maintain them for successive economic returns.
 2. **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
 3. **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.
 4. **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. Orchard with single variety of a particular fruit crop.
2. Orchard with different variety of a fruit crop.
3. Mixed orchard with different fruit crops of almost equal life span.
4. Orchard with intercrops/intercropping.
5. Multistoried orchard.
6. High density orchard.
7. Dry land orchard.
8. Clonal orchards.
9. Homestead plantation
10. Nutrition /Kitchen garden.

1. Orchard 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+Pomegranate+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. Orcharding 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+Pineapple.

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 3x3m : 1111 plants ; 3x2m -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

9. Homestead Plantation

Plantation is done in the premises of the house/bungalow compound is referred a homestead plantations. It is a system of crop production for diverse uses of family members. Homestead plantation is very common in South-Indian state. Coconut-banana/cocoa-turmeric/ginger/cassava/pineapple etc. are planted in available land spaces in house compound

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LECTURE NO.10**SOIL AND ENVIRONMENT FOR HORTICULTURE CROPS****SOIL:**

- 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 has 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 chosen 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.

Grouping of fruits according to their tolerance to salinity:

- a. **High salt tolerance** : Date palm, Ber and Aonla.
 - b. **Medium salt tolerance** : Pomegranate, Fig and Grape.
 - c. **Low salt tolerance** : Apple, Orange, Almond, Lemon and Avocado.
- In making choice of soil for fruit crops physical properties should be emphasized, more as chemicals can be added from outside to improve nutrient status and chemical properties of the soil.
 - Generally the depth and the drainage-ability 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.***

CLIMATE

- Climate is the most important factor on which choice of the crop for a region depends and therefore, understanding about soil and climate and their 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 exerts considerable influence on flowering.

Based on the response by plants the major classes are following. However, fruit crops for such categories are not known.

- Long day plants:** Cabbage, Cauliflower, Onion, Beetroot, Radish, Carrot, Spinach, Potato, Dill and Plantago.
- Short day plants:** Strawberry, Pineapple, Chrysanthemum, Poinsettia, Aster, Balsam, Salvia, Euphorbia and Xanthium.
- 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.
- The growth of the plants depends primarily on temperature.
- 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 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.

Classification of vegetable and flower crops according to seasons

	Warm Season	Cool Season
Vegetables	Bottle gourd	Cabbage
	Water melon	Cauliflower
	Brinjal	Pea, Radish, tomato
	Tomato	Beans
	Clusterbean	Potato
	Okra	Onion
	Sweetpotato	Carrot
		Radish
Flowers		Tomato
	Marigold	Aster
	Zinnia	Poppy
	Chrysanthemum	Dianthus
	Sunflower	Dahlia
	Gomphrena	Salvia
	Gaillardia	Petunia
	Portulaca	Pansy
	Kochia	Phlox
	Amaranthus	Coreopsis
	Celosia	Verbena
	Coreopsis	Diamorphotheca
		Calendula

WATER

- Water is a transparent, odourless and tasteless liquid compound of hydrogen and oxygen (H₂O) 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, Banana, 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*, *SO₂*, *CO₂*, *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.

Classification of plants according to photoperiodic requirements.

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

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)
1. Mango	10	100
2. Citrus & Pomegranate	6	275
3. Grape	i) Head system ii) Kniffin system iii) Bower system	2.0x1.5 4.00x3.00 3.1x6.0
		3300 1100 550
4. Guava, Peach & Loquat	6.5	225
5. Litchi & Sapota	7.5-9.0	180-123
6. Ber & Pear	7.5	180
7. Date palm & Almond	6-7	275-202
8. Jamun	10-12	105-75

9. Phalsa & Papaya	1.5	4400
10. Banana i) Tall varieties	2.7x3.0	1210
ii) Dwarf varieties	1.8x1.8	3052
11. Pineapple	30x60x90 cm	43500
12. Custard apple	5	390
13. 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 i.e., 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.

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Lecture No.13

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;

- 1) Soil management
- 2) Water management
- 3) Nutrition management
- 4) Pruning and training (plant management)
- 5) Weed management
- 6) Plant protection against insect pests and diseases.
- 7) Bearing, fruitfulness and causes of unfruitfulness.
- 8) Maturity and harvest.
- 9) 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:

- 1) To create favourable conditions for moisture supply and proper drainage.
- 2) To maintain high fertility level and replenishment against losses.
- 3) To provide proper soil conditions for gaseous exchange and microbial activities through addition of organic matter.
- 4) To check or reduce soil erosion.
- 5) To ensure supply of nutrients for growth and development of plants.
- 6) To utilize vacant land for additional income because such a loss is inconceivable for small holders.
- 7) To reduce the cost of cultivation with high economic returns.
- 8) To suppress weed population.

Definitions of terms to be used in management of soil:

- 1) **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**.
- 2) **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**.
- 3) **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.

The 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) Type of 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:

- ✓ Removes competition of weeds for light, water and nutrients from crop and avoidance of alternate host for pests and diseases.
- ✓ Improves soil physical condition through better aeration by breaking clods.
- ✓ Helps in breaking hard top and abstractions in the infiltration of water.
- ✓ Improves soil biological activities through better aeration.

Disadvantages:

- Loss of organic matter.
 - Loss of soil through erosion even on flat lands through water and wind.
 - Loss of nutrient through excessive leaching.
 - Injury to roots and creation of entry points for pathogens.
- Due to several such disadvantages, clean cultivation is not advisable in fruit farming.

(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, and 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 interspace of perennials is called **mixed cropping**.
- The term **multi-storey 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.
 - ◆ Should not be tall growing and spreading type.
 - ◆ They should not be exhaustive.
 - ◆ Should not function as alternate host for common pests and diseases.
 - ◆ The water requirement schedule should match or phenology of crop should match so that operation could be synchronized.
 - ◆ 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 <i>Valeriana wallihi</i>
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	<i>Citrus medic</i> , 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 all over 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

1. Conserves moisture by suppressing weed growth, regulating soil temperature and protection from sun and wind.
2. Improves soil structure.
3. Reduces soil temperature fluctuations.
4. Increases soil organic matter level.
5. Controls erosion.
6. Improves water infiltration rate.
7. Improves nutrient availability through better soil condition micro flora.
8. Avoids competition for nutrient and moisture with main crop.
9. 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 <i>Sachrarum munja</i> 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 <i>bui</i> (<i>Aerva persica</i>).
14	Pineapple	Black polythene, Saw dust and Dry leaves.
15	Apple	Oak leaves, Black alkathene and Conifer leave.

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 taken up, 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

- (i) Cowpea/ clusterbean/Blackgram/Greengram /French bean.

Litchi Orchard

- (i) Cauliflower/Peas.
- (ii) Cucurbits / Greengram / Blackgram / Cowpea—Radish / Beat / Turnip / Carrot

Pomegranate Orchards

- (i) 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.

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 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, 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.

MULTISTORIED 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/Pineapple/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 with 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.
- 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.

Table 6: Recommended densities of some fruit species:

Fruit	Variety	Spacing	System of planting	Number of plants/ha
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 prior citrange as a rootstock	3025
		8 x 8 feet	Karna Khatta as rootstock	1780
		10 x 10 feet	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

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Lecture No. 14

WATER REQUIREMENTS AND IRRIGATION METHODS FOR HORTICULTURE CROPS

- 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:

- Topography and soil characteristics.
- Kind of plant (root depth, water absorption capacity, growth habit, etc.).
- 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. 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.

II. 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 retain 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 which results 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.

III. OVER HEAD OR AERIAL IRRIGATION:

- In this system, water is applied in the form of spray, 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.

IV. 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.

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Lecture No.15

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 shade the foliage.
- There are some weeds which are parasitic partially or completely on the host tree.
Ex : Striga and 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.
- Around 250 species are causing serious economic losses.
- i. **Monocot weeds (Narrow leaf/Grasses):** Cyprus, Cynodon, Poagrass, Rye grass, Quackgrass etc.
- ii. **Dicot weeds (Broad leaf weeds) :** *Dandelion*, *Chenopodium* spp., *Parthenium*, *Solanum*, *Euphrobia* spp., Ground ivy etc.

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
<i>Cyperus rotundus</i>	<i>Bactra verutana</i>	Insect (shoot boring moth)
<i>Echinochola spp.</i>	<i>Emalocera; Tripos spp.</i>	Insect (stem boring moth)
<i>Parthenium</i>	<i>Zygogramma bicollarata</i> <i>Epiblema strenerana, Conotrachelus spp.</i>	Leaf eating insect Stem girdling insect
<i>Orabanche</i>	<i>Sclerotinia spp. (Fungus)</i>	Plant pathogen
<i>Rumex spp.</i>	<i>Uromyces rumicis (Fungus)</i>	Plant pathogen
Mycoherbicides products	Content	Weeds controlled
De-vine	Liquid suspension of <i>Phytophthora pamivora</i> (Root rot of weed)	<i>Merrenia odorata</i> in citrus plantations
Bipolaris	Suspension of fungal spores of <i>Biopolaris sorghicola</i>	<i>Sorghum halepense</i>
Biophos	Microbial toxin produced as fermentation products of <i>Streptomyces hygroscopicus</i>	Non-specific can be used on general vegetation

Chemical control

- It refers to use of herbicide to suppress or kill weeds.
- 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).

I. **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.),

II. **Non-selective herbicide:** will indiscriminately kill all the plants that come in contact.

For ex. : Glyphosate, paraquat (destroy green tissue only).

III. **Systemic herbicides:**

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

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.

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Lecture No. 16**NUTRIENT MANAGEMENT**

- The Nutrients are chemical elements which are absorbed by the plants in more or less quantity to transform light energy into chemical energy and to keep up plant metabolism for the synthesis of organic materials.
- These materials constitute among other things, foods for humans and animals and a range of raw materials for various industrial uses.
- Feeding of plants with nutrients is termed as nutrition.
- Successful growth and production of the plants in general requires a proper supply of the 16 elements. These elements are regarded as essential to life in higher plants.

Allen and Arnon (1955) laid out following criteria for categorising nutrients essentiality to plants:

1. Complete or partial lack of the element in question must make normal plant growth impossible
2. Deficiency symptoms must be reversibly by the addition of the elements in question
3. The element must play specific role in the plant metabolic symptom

They are:

1. **Basic elements** : Carbon (C), Hydrogen (H) and Oxygen (O) (03)
2. **Macro elements** : Nitrogen (N), Phosphorus (P), Potash (K), Calcium (Ca), Magnesium (Mg) and Sulphur (S) (06)
3. **Micro elements** : Manganese (Mn), Molybdenum (Mo), Chlorine (Cl), Zinc (Zn), Boron (B), Copper (Cu) and Iron (Fe) (07)

Macro elements: The nutrients that are required in relatively large quantity are termed as macro elements.

Micro elements: are those required in relatively less quantity are termed as micro nutrients.

- Besides some nutrients like Aluminium (Al), Cobalt (Co), Sodium (Na), Silica (Si) and Vanadium (V) are not considered necessary always because either their essential character has been proved only in some plants or in certain metabolic processes that are not always necessary.

TYPES OF FERTILIZERS**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 ₂ O ₅ %	K ₂ O %
BULKY ORGANIC MANURES			
1. Cattle dung	0.40	0.20	0.17
2. Poultry manure	3.03	0.63	1.40
3. Farmyard manure	0.50	0.25	0.50
4. Rural compost	0.75	0.20	0.50
5. Urban compost	1.75	1.00	1.50
6. Vermicompost	3.00	1.00	1.50
CONCENTRATED ORGANIC MANURE			
1. Castor cake	4.37	1.85	1.39
2. Coconut cake	3.00	1.80	1.90
3. Neem cake	5.22	1.08	1.48
4. Blood meal	12.00	2.00	1.00
5. Groundnut cake	7.30	1.50	1.30
6. Pressmud	2.10	4.40	0.80

Composition of inorganic manures.

Fertilizer	Composition %		
	N	P ₂ O ₅	K ₂ O
1. Sodium nitrate	16	-	-
2. Calcium nitrate	15.5	-	-
3. Potassium nitrate	13.8	-	-
4. Anhydrous ammonia	82	-	-
5. Urea	46	-	-
6. SSP	-	16	-
7. Double SP	-	32	-
8. 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 Capsicum 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 exists. 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.



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:** Red gram and Black gram.
- **Fruits:** Banana, Mango, Orange, Pineapple, Passion fruits, Cashew nut 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:** Jiggery, Sugar, Tea, Coffee, Cotton and Textiles.

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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 inter-cultivation, 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.

1. Staking or supporting of vine like plants.
2. Training on pergola or trellis of vine type fruit plants or even indeterminate type tomatoes.
3. Nipping of apices for encouraging lateral growth to give bushy appearance or fulsome appearance in pot plants like aster, marigold and chrysanthemum.
4. De-shooting or removal of lateral buds for making single stem for large flowers as in chrysanthemum and Dahlia.
5. 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):



Fig. 7.1 Open centre system

- 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).

(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).

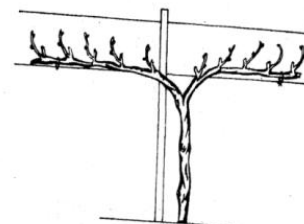


Fig 7.4 : Cordon (espalier) System

(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 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, and unclipped natural in fruits like guava, mango, sapota and citrus.

Details of Training:

1. 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.

- Low head:** 0.7—0.9 m. This is common in windy areas. Such plants are easy to maintain.
 - 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.
 - High head:** More than 1.2 m. Common in tropics in wind free areas. Operations under the canopy are easy to perform.
- 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.
 - 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:

1. To maintain the growth and vigour of the trees and to have a balance between the vegetative vigour and fruitfulness, so as to be conducive for production of optimum crop of best quality.
2. To shape the tree to make the best use of the space between trees while allowing the necessary access.
3. To regulate the size and quality of the fruits by way of proper distribution of the fruiting area.
4. To regulate the succession of crop and to have the crop where it can be managed easily and cheaply.
5. To spread the trees for economic orchard management.
6. To remove the dead, diseased and over aged wood.
7. For effective spraying of pesticides to the crop.
8. To minimize biannual bearing and consequent risk of die back.
9. To get maximum plagiotrophic shoots/stems.

10. Establishment of transplant where leaves/shoots are pruned to strike a balance between roots and shoot so that plants lose less water against restricted root system lost during lifting of plants.
11. Elimination of non-productive vegetative growth like water sprouts, suckers, dead and diseased wood.
12. 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.**

1. **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.
2. **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.
3. **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.
 - Time at which buds are differentiated in relation to blooming.
 - 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.

Principles of pruning:

1. Excessive pruning should be avoided as it affects the growth of the plant by dwarfening and may induce more of water suckers, fasciations (union of a number of parts side by side in a flat plane) and thus affect the bearing potential.
2. In pruning, only that wood which is not necessary for the tree should be removed.
3. Pruning of larger limbs should be avoided as far as possible.
4. Pruning of young trees should be done more carefully than the yielding trees, since severe pruning of young trees delays the cropping and much more of yield area will be removed than what is desired.

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 plantation /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.

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Lecture -

PLANTING SYSTEMS AND TRANSPLANTING OF HORTICULTURAL CROPS

- Planting and transplanting are the important horticultural operations of placement of a plant in the prefixed place.
- The word planting generally refers to transfer of a plant from a pot to its permanent place in the ground.
- The word transplanting on the other hand refers to transfer of plants originally raised in seed beds for early intensive care to their permanent place in the ground.
- In transplanting seedlings, particularly of annuals, one has to avoid bunching and haphazard distribution.
- If one needs only a few plants to be transplanted, thinning is the best method otherwise; transplantation can be done according to the grower's wish.
- The transplantation is beneficial to most plants whose seeds are very small and it also allows economy and convenience in the use of seeds. With normal care, a majority of the seedlings can be transplanted safely.

Season for planting and transplanting:

- The best season for planting and transplanting varies from place to place and species to species.
- Hot weather is generally avoided since there is a great risk about their establishment.
- In places where the rainfall is moderate, the beginning of the rainy season is best suited for transplanting.
- On account of the fear of water logging in heavy rainfall area, planting and transplanting operation are best postponed till about the close of the rainy season.

Transplanting seedlings – Annuals

- Once the seed germinates the seedlings emerge from the surface soil and it is ready for transplantation when the second pair of leaves emerges.
- A few annuals such as celosia, chrysanthemum and phlox need early transplantation i.e. within 15 days after sowing.
- Further, balsam, salvia and zinnia are usually transplanted when they are 21 days old.
- Some others such as amaranthus, hollyhock, snapdragon and verbena can be delayed up to 30 days.
- On the other hand seeds of flax and tuberose are sown.

In-situ

- The seed bed/seed pan should be soaked with water 1-2 hours before pulling the seedlings so that injury to the thin fibrous roots can thus be avoided.
- Seedlings are lifted with a ball of earth by using a trowel or any other short flat equipment and separated and planted in holes made by using dibbler or planted in places where they are to grow permanently by pressing in soil down gently but firmly round the collar of the seedlings.

- Seedlings are to be watered immediately after transplanting and protected against direct sun for a day or two.
- Watering usually done in the evening if the bed is to be filled with a single variety of ornamental or vegetables, they are best placed in triangular fashion in rows.
- Distance between seedlings varies with the species.

Transplanting and planting of shrubs and trees:

- In case of shrubs and trees raised from the seed stock, the seedlings are carefully transferred to polythene bags or pot of required sized, care should be taken to remove polythene cover at the time of transplanting.
- Later the plant is placed in a pit dug for planting and finally covered with soil.
- Earthen pots of 10 cm diameter and 20 cm height are used for raising seedlings individually and allowed to grow and later transplanted.
- After marking out of the positions for planting pits of appropriate size are opened well in advance at least a fortnight before planting, while digging the pits, the top soil which is generally good is kept on one side, unmixed with the rest of the soil.
- If the soil is bad below, it is replaced with a mixture of 3:2:1 part of manure, red earth and sand.
- If the soil is good it is mixed with manure alone. Sand is added to the soil if it is heavy.
- The top soil is used for filling up the upper portion of the pit.
- The pit is watered and gently pressed down a day prior to planting so that it would not further settle down after planting.
- While planting, a small hole is made in the centre of the pit which should be slightly larger than the ball of earth holding the roots of the plant.
- Before putting the plant in to the hole, all the damaged roots are pruned.
- The roots are spread out in the hole in their natural positions and covered with soil. The hole is then pressed down firmly.
- Care is taken to see that the plant is buried up to the point as existed in the nursery only.
- The plant is then thoroughly watered. In the absence of rain the plant is watered once in three days liberally.
- The new plant is protected against severe sun especially during summer and provided with stake to avoid its shaking due to heavy winds.

Transplanting corms, bulbs and tubers:

- During dormancy (resting period) the underground corms (caladiums and gladiolus), bulbs (amaryllis and lily) and tubers (Begonia and dahlia) are to be separated.
- Washed, treated with plant protection chemicals and stored in sand until the next season.
- Runners or suckers of chrysanthemum (Perennials) and ferns, when over crowded, can be transplanted by dividing the rooted side shoots to other pots especially in the beginning of the monsoon.

Lecture No. 18

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 other parts, wherein very low concentration causes a physiological response.
- The plant hormones are identified as promoters (auxins, gibberellin, and 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, 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 GA₃ is usually the 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 GA₃ 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 + GA₃), 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:** GA₃ 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+GA₃).
6. **Dwarf plant (genetically) to normal height:** GA₃.
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 cytokinin 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 N₂ 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.
- 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.

Gibberellic 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, cucumber 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 ethephal.

6. 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.

7. 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.

8. 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 ethephal or morphactin reduces the fruit load by 25-30 per cent.

9. 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 1-4 weeks.

10. 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.

11. 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.

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Lecture No.19

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.
1. **Fruit setting:** It refers to initial growth of ovary and its associated parts after blossoming and taking it to maturity.
 2. **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.
 3. **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).
 4. **Self fruitfulness:** Ability of a plant to mature fruits after self pollination.
 5. **Self fertility:** Capacity of a plant for the production of viable seeds after self pollination.
- The ability of a plant to produce optimum crop is **Fruitfulness**. Where as,
 - 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, they 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**. Eg. 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**. Eg. 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.

(ii) **Dichogamy:**

- When stigmatic receptivity period does not coincide 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.

(iii) **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.

(iv) **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 numbers 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 hermaphrodite 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.
 - Choice of the crop and variety should be made on the basis of climatic and edaphic conditions of the site of orcharding.
 - Provision of windbreak and shelter belts for areas prone to wind damage.
 - Before planting an orchard soil should be brought to optimum by incorporating organic matter, amendments and nutrients based on soil analysis.
 - 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).
 - 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.
 - The problem due to old age could be overcome by replanting or rejuvenation of old trees.
 - Problem due to overbearing can be managed through thinning at appropriate stage.
 - Irrigation management would be key role in situations with drought and waterlogged conditions.
 - Problem due to uneven distribution of flowers on tree should be managed through thinning and crop regulation.
 - Maintenance of critical nutrient status in tree leaves for optimum crop production by adopting correct nutritional programme based on plant and soil analysis.
 - In crops requiring regular pruning standard practices will have to be adopted based on crop, variety and its phenology.
 - Unfruitfulness due to pathogens should be managed through effective plant protection measures following integrated approach.
 - Problem of unfruitfulness due to tendency of alternate bearing should be overcome 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.

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GROWTH, FRUITING HABITS AND METHODS FOR INDUCING FRUITFULNESS IN HORTICULTURAL CROPS

- Every plant has two distinct phases of development namely vegetative and Reproductive.
- In the **vegetative** phase, the plant only vegetative growth i.e. leaves, shoots etc.,
- In the reproductive phases the plant produces reproductive growth i.e. flowers and fruits.
- In case of **annuals**, these phases occur for a short period, each phase occurring only once and that too within the same season.
- In the **biennials** also there is vegetative phase and reproductive phase.
- In **perennials**, the vegetative phase lasts for several years depending upon the variety and species. This is known as the **pre-bearing period**.
- Later the plant switches on to the reproductive phase and starts producing flowers and fruits.
- Once the perennial tree completes its pre-bearing period, the cycle of vegetative and reproductive phases might occur in each season or the reproductive phase may occur simultaneously along with vegetative phase without much distinction between the two.
- In certain trees the vegetative and reproductive growth may occur in alternate years which are known as **alternate bearing**.
- In some other trees, the vegetative growth may occur for two, three or more years followed by reproductive growth for one year and again vegetative growth for two or more years. This is known as **irregular bearing**.
- The growth of the plant, either vegetative or reproductive takes its origin in the buds which are situated on the stems.
- These buds are normally found towards the apex of the shoot and the axils of the leaves (single bud).
- But in some cases more than one bud is found in the leaf axils as in the case of peach, Japanese plum, grape etc. The extra buds are normally called as “**Supernumerary buds**” or **accessory buds**.
- Any bud on sprouting produces only a vegetative shoot is known as a **vegetative bud**, while
- The one which produces floral parts only or a shoot with flowers is known as **flower bud, fruit bud or the blossom bud**.
- In case the bud produces only floral parts, it is known as a **pure flower bud** and if it produces a shoot with flowers and leaves it is known as **mixed bud**.
- In early stages, all the buds are vegetative in character.
- In its youth every bud is potentially a flower bud. That is if favourable conditions are provided any bud can develop and gets differentiated into a flower bud, but after getting formed into floral bud it cannot revert to a vegetative bud again.
- The physiological and morphological changes that occur in a vegetative bud in its preparation to change over to the reproductive phase or to become a flower bud may be called as the “**flower bud initiation**”.

- Further developmental changes that occur in an initiated flower bud leading to the formation of the embryonic flower inside the bud are known as “**Flower Bud Differentiation**”.
- Both the steps of initiation and differentiation together referred as “**Flower Bud Formation.**”
- Depending upon species or variety or kind of fruit tree, there may be varying periods of interval between the formation of the flower bud and the actual production of flowers. For example, in grapes the period is 3-4 months and in citrus it is few weeks and in mango it is supposed to be few days.

FRUITING OR BEARING HABITS:

- If one observes a mango tree, he/she may find it does produce the fruits terminally on a shoot and in citrus he/she finds the fruits always produced laterally in the leaf axils.
- The manner or pattern in which a plant produces its fruit is known as **bearing habit or fruiting habit**.
- Bearing habits are specific to the kind of plant.

In determining the bearing habit of any plant three points are to be considered.

1. The origin or position of the flower or fruit bud which may be either terminal or lateral on a shoot.
 2. The nature of the bud, which may be either pure flower bud or a mixed bud.
 3. Position of flowers or fruits on the flowering shoots especially in case of mixed bud. The flowering shoot may end with the fruits or carry fruits laterally on it.
- Considering the above three points, the bearing habit of fruit plants are broadly classified into six groups.

Group I : Fruit bud terminal, pure flower bud producing only flower parts, e.g., mango, cashew.

Group II: Fruit bud terminal, mixed bud with flower parts situated terminally on the flowering shoot, e.g., apple, pear.

Group III: Fruit bud terminal, mixed bud, with flower parts situated laterally on the flowering shoot, e.g., guava.

Group IV: Fruit bud lateral, pure bud producing only flower parts, e.g., citrus, coconut, date, gooseberry.

Group V: Fruit and lateral, mixed bud, with flower parts terminally on the flowering shoot, e.g., grapes, cashew and Annonaceous fruits.

Group VI: Fruit bud lateral, mixed bud, with flower parts laterally on the flowering shoot e.g. fig, mulberry, ber etc.

- Of these six groups, the first three come under **terminal bears**, through we see fruits laterally on the flowering shoot in Group III.
- The other three groups are **lateral bearers** through we see fruits terminally on the flowering shoot in group.
- In addition to these six main groups we do find some different bearing habits in some plants which cannot be conveniently classified under any of these six groups.
- These are therefore classified into separate groups. They are;

Group VII: Flower buds borne sub terminally in the leaf axils, pure flower bud. This could be treated as a lateral bearer e.g., papaya and sapota.

Group VIII: Flower buds borne adventitiously on the main trunks or branches, pure flower bud, e.g., jack fruit and cacao.

Group IX: The growing apex (pseudo stem) ending in a flower which could be treated as a terminal bearer, e.g., banana and pineapple.

Group X: Fruit bud terminal or lateral, pure bud. These plants come under group I and IV and as such classified separately e.g., pomegranate.

- In case of these groups occasionally the plants may bear in different pattern also deviating from its own characteristic pattern but majority of its bearing will be always as per the classification.
- The knowledge of bearing habits will be of much importance for regulating the bearing of any plant by means of pruning, terminal bearers are not normally pruned.
- Whereas in case of lateral bearers pruning certainly increase the bearing, as it encourages the sprouting of lateral buds.

METHODS FOR INDUCEING FRUITFULNESS:

The fruitfulness of a tree is governed by various external and internal factors.

- The most important external factors are environment, insect pests, disease and nutrient supply to the plants.
- The important internal factors are sex distribution, heterostyly, dichogamy, aborted organs, non-viability of pollen, genetic incompatibility and nutritional status of the plant.

EXTERNAL FACTORS:

The environment comprises of temperature, rainfall, wind and light.

1. **Temperature** plays an important role in determining the fruitfulness.

- Chilling is required for breaking dormancy and lack of it during winter is responsible for low yields of an apple at Connor.
- Pollen of many deciduous fruit plants may germinate very freely at optimum temperature.

2. **Light intensity** also influence on fruit set to a certain extent

- Interior branches of a tree, which bear fewer fruits.
- In strawberry the flowers developed stamens when they are exposed to long daylight.

3. **Rainfall** also determines the extent of fruitfulness.

- The period of water stress appears to be a most potential factor for influencing flowering in tropical fruit trees.

4. **Infestation of Insect Pests and Diseases** also reduced the fruit set considerably.

- The best examples are mango-hoppers, malformation of mango inflorescence and anthracnose in grapes.
- By preventing the attack of these pests and diseases by suitable control measures in the beginning itself, one can actually increase the fruitfulness of these trees.

INTERNAL FACTORS:

- In some of the fruit plants, individual plants are self-unfruitful as their flowers are unisexual i.e., flowers of one sex may be present in one plant as in case of papaya, strawberry, fig and date palm.
- The fruitfulness of these plants can be improved by inter planting of the plant bearing opposite sex flowers.
- **Prevention of self pollination in perfect flowers** may be due to the difference in the time of maturing of male and female sex organs and this is known as **Dichogamy**, as found in Avocado.
- **Genetic incompatibility** is another cause of unfruitfulness. The pollen of some varieties are not capable of fertilizing the flowers of the same variety or certain other varieties as in the case of apple, sweet cherry, plum, pear, almond, mango, sapota etc, in such plants to improve the fruitfulness, certain suitable combination of varieties which would successfully cross pollinate each other should be planted.
- Fruitfulness of a tree is to a great extent determined by the **nutrient supply and the nutritional status of the plant**.
 - ✓ Application of manures and fertilizers a few days before blossom emergence is generally believed to increase the fruitfulness.
 - ✓ **Relationship between C/N ratio and fruitfulness:**
 - ✓ The fruit bud formation, setting of the fruit and its development mainly depends upon the requisite balance of nutrients in the branches of the trees at certain critical seasons.
 - ✓ Plants with plenty of nitrogen and high carbohydrate accumulation are found to make moderate growth and produce satisfactory crop. Whereas, plants with plenty of nitrogen and moderate carbohydrates are found to grow vegetatively, the expense of fruit production.

By adopting some of the horticultural practices like root exposure, root pruning, bending, girdling or ringing, notching and smudging, the plants can be made to accumulate more of carbohydrates at the desired positions of the plant and these make them more fruitful.

- For giving such treatment one should have the knowledge as to when the plant puts out new growth and flowers, when it takes rest or ceases to grow vegetatively and it matures its wood.

1. Root pruning:

- This is a recognized practice in the dwarf fruit tree culture.
- Every year a trench is dug a few centimeters away from the trench of the previous year.
- The trench is then filled with manures liberally and watered.
- As a result of this, circular mass of fibrous roots increases very slowly from year to year and the tree becomes short but stocky and well matured shoots will be rich in their reserve food material and will be more fruitful.

2. Root exposure:

- This is commonly practiced to force flowering and fruiting of **orange, guava and other citrus fruits** in the desired season. It is called as **Bahar Treatment**.

- ✓ About two months before the bloom, the soil around the tree is removed near the main roots from an area of 60cm radius.
- ✓ The fibrous roots are removed and the main roots are exposed to the sun.
- ✓ The trees are allowed to go dry until the leaves wither or even some of them fall. Time taken for leaf fall is 3-4 weeks.
- ✓ After this stage, the exposed roots are covered with a mixture of soil and manure and watered immediately.
- ✓ During this period of root exposure, the trees are forced to take rest since the upward movement of water is adversely affected.
- ✓ Within three weeks of covering the roots and watering, the trees burst into heavier bloom, and set a much larger crop.
- This treatment can be practiced only in orchards planted in retentive soils which remain moist for a long time and do not allow plants to take a post harvest rest even though watering is stopped.
- Now days this treatment is becoming up popular in view of the fear that it may adversely affect the performance of the trees in the long run.

3. Bending:

- This is widely practiced for increasing the fruit production in **guava**, especially in the erect growing varieties.
- The large branches in their erect and upright position have a natural tendency to produce fruit bearing shoots near about their ends, while the lower branches remain more or less dormant.
- When such large branches are bent and tied and pegs fixed in the ground in an arch fashioned way, the fruiting area is considerably increased due to the increased number of side branches produced on the lower parts of the main limbs.
- This practice is not necessary in spreading varieties like **Sardar guava (Lucknow- 49)**

4. Ringing or Girdling:

- This is one of the well known methods of increasing fruit bud formation.
- The operation consists of removing a strip of bark of a tree.
- It interrupts the downward movement of carbohydrates and thus causes them to accumulate above the ring or girdle.
- In India girdling is sometimes practiced on mango to force flowering in over vegetative trees, which normally do not bear satisfactory crops.
- The branches of 15 to 20 cm thick are girdled by removing a strip of bark about 2 cm wide all around at the base of the branch or little above the point where it joins another branch.
- In santra, saw passed round the branches is just enough to cause the ring.
- It is usually done between 15th of April and 15th of May.
- The healing of the ring and complete restoration of new bark on the girdled portion is highly imperative after fruits have set.
- The ring of bark removed should be such as not to injure the cambium.

- It is recommended to practice the girdling on the trees which are vigorous in growth. The exhausted trees should be avoided.

5. Notching:

- This is practiced in **fig**. This consists of **removal of the small narrow strip of bark just above a dormant bud**.

Notching affects the sprouting in three ways.

- ✓ Firstly, it prevents the inhibitory influence of certain compounds in the bud.
- ✓ Secondly, it cuts off the supply of carbohydrates synthesized from the leaves above and increased the supply of nutrients from below.
- ✓ Thirdly, the bud which was once one of the lower most of the branches becomes apparently the top most due to construction in the bark connection with the part of the branch above the notch. Notching can be given below bud also.

6. Smudging:

- This is **practiced for mango in Philippines to produce off season crop**.
- This consists of burning trash wood on the ground and allowing the smoke to pass through the crown of the tree.
- To direct the smoke to different parts of the tree, a cone shaped enclosure with a tall chimney at the top is built with wooden stakes and thin bamboo strips woven together.
- The tree will be smoked heavily and continuously for a week and then mild fire are made at regular intervals for about a month or till the tree comes into bloom or till the terminal buds start swelling and show the symptoms of sprouting.
- **Smoke is known to contain ethylene**, which is a **flowering hormone**.

INDUCTION OF FLOWERING:

- Length of the day and temperature are the two most important factors controlling this process.
- Plants can be made to flower or kept vegetative to the convenience and benefit of growers in important.
- Many of the cultivated varieties of pineapple are short day plants and flower in the month of November and do not synchronies their blooming and obviously ready for harvest at different times and some times interval between first and last picking will be few months and fruits so formed will considerably vary in size.
- However, plants promptly flower when about 0.5mg of NAA in aqueous solution is applied on the crown and this technique is being commercially exploited.
- Therefore, growth regulators may be employed to force a batch of plant to bloom and mature at once.

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CROPPING SYSTEMS IN HORTICULTURE

Systems of cropping are the way in which different crops are grown. Sometimes a number of crops are grown together or they are grown separately at short interval in the same field. The cropping systems may be broadly divided into, 1. Sole cropping; 2. Mono cropping ; 3. Mixed Intensive cropping.

I Sole cropping: One crop/variety grown alone is pure stands at normal density.

II. Mono cropping: This system is the repetitive growing of the same crop on the same land.

III. Mixed cropping: Mixed cropping is the process of growing two or more crops together in the same piece of land. This system of cropping is generally followed in areas where climatic hazards such as flood, drought, frost etc. are frequent and common. Besides to enhance the income or to meet the daily needs of marginal farmers.

Under mixed cropping, the time of sowing of all the crops is almost same. However, they may mature either together e.g., Tomato + Marigold, 2. Chilli +Tomato,

They mature at different times e.g.,

1. Chilli+Onion +cotton

Mixed cropping may be classified into the following groups, based on their method of sowing.

- a. **Mixed crops:** In this group the seeds of different crops are mixed together and then sown either in lines or they are broadcasted. This system is not scientific and it causes problems in performing all the cultural operations and harvesting of the crops.
- b. **Companion crops:** Under this system the seeds of different crops are not mixed together but different crops are sown in different rows e.g., between two rows of arhar two to three rows of groundnut are sown. This method of sowing facilitates in weeding, inter-culture, plant protection operation and even in harvesting.
- c. **Guard crops:** under this system of cropping the main crop is grown in the center, surrounded by hardy or thorny crops such as safflower around pea.
- d. **Augmenting crops:** When sub crops are sown to supplement the yield of main crops, the sub crops are called augmenting crops, such as Japanese mustard with be seem. Here the mustard helps in getting higher tonnage of fodder in spite of the fact that be seem gives yield in first cutting.

Principles of mixed cropping:

The most important point is the selection of crops. Crops which compete with each other should not be chosen. Therefore, the following points should be considered while selecting crops.

1. Legumes should be sown with non-legumes e.g., Beans with Chilli.
2. Tall growing crops with short growing crops e.g., Brinjal with onion.
3. Deep-rooted crops with shallow rooted crops.
4. Bushy crops with erect growing crops.
5. Crops being attacked by similar pests, insects and diseases should not be sown together.

Advantages of mixed cropping:

1. All the crops do not fail under adverse climatic conditions e.g. frost kills only legumes; flood kills only dicots and drought kills the monocots or shallow rooted crops. Thus the farmer gets some crop instead of losing the entire crops.
2. The epidemic attack of any pest, insect or disease kills only one crop without affecting the rest of the crops.
3. The farmers grow different crops which balance their daily need or demand for cereals, pulses and oil seeds.
4. Mixed cropping checks soil erosion, weed etc.
5. It improves or maintains the soil fertility.
6. Family labour and cattle are employed throughout the year.

IV. Intensive cropping:

- Intensive cropping is the process of growing a number of crops on the same piece of land during the given period of time.
- In other words, when the area is limited and the number of crops to be grown is increased within a definite period of time, this cropping method is termed as intensive cropping.
- The main objective is to increase the income per unit area within a specified period of time.

Pre-requisites of intensive cropping:

1. High yielding and short duration crop varieties.
2. Availability of inputs viz. labour, capital, irrigation etc.
3. Marketing facility
4. Better and efficient plant protection measures.
5. Excellent soil condition (leveled and fertile soils).

Methods of intensive cropping:

1. **Multiple cropping:** It may be defined as cropping systems in which two or more crops are grown in succession within a year.
 - a. **Relay cropping:**
 - Relay cropping is analogous in a relay race where a crop hands over a land to the next crop in quick succession.
 - The best examples of relay cropping are –Cluster bean – early potato-coriander.
 - b. **Overlapping system of cropping:**
 - In this system of cropping the succeeding crop is sown in the standing preceding crop.
 - Thus, in this system before harvesting one crop the seeds of the next crop are sown.
Eg. Potato – coriander.

2. Inter cropping:

- This is a process of growing subsidiary crops between two widely spaced rows of main crops.
- The main object of this type of cropping is to utilize the space left between two rows of main crop and to produce more grain per unit area. E.g., Maize intercropped with green gram, black gram or groundnut.

Groups under intercropping:**a. Parallel cropping:**

- Two crops are selected which have different growth habits and have a no competition between each other and both of them express their full yield potential. Eg. Tomato with coriander.

b. Companion cropping:

- In companion cropping the yield of one crop is not affected by the other.
- In other words, the yield of both the crops is equal to their pure crop.
- Thus, the standard plant population of both crops is maintained. E.g., chilli, onion, potato etc. with fruit crops.

c. Multistoried cropping:

- Growing of plants of different heights in the same field at the same time is termed as multistoried cropping.
- It is mostly practiced in orchards and plantation crops.
- Example: Eucalyptus + papaya + berseem; sugarcane + potato + onion (seed crop); sugarcane + Mustard + potato.

d. **Synergetic cropping:** Here the yields of both crops grown together are found to be higher than the yields of their pure crops on unit area basis. Example; sugarcane and potato.

e. **Row intercropping:** Growing two or more crops simultaneously where one or more crops are planted in rows. Often simply referred to as intercropping.

f. **Patch cropping:** The component crops are planted in patches.

g. Strip intercropping:

- Growing two or more crops simultaneously during the part of life cycle of each.
- A second crop is planted after the first crop has reached its reproductive stage of growth but before it is ready for harvest, often simply referred to as relay cropping.

h. Relay intercropping:

- Growing two or more crops simultaneously during the part of life cycle of each.
- A second crop is planted after the first crop has reached its reproductive stage of growth but before it is ready for harvest, often simply referred to as relay cropping.

i. Alley cropping:

- A farming system in which arable crops (crops which require cultivation) are grown in alleys formed by trees or shrubs established mainly to hasten soil fertility restoration and enhance soil productivity.

Lecture No. 20

CLASSIFICATION OF FRUITS

Classification is the system of grouping or placing of individuals according to nomenclature. It is very useful to the pomologist. It helps to:

- To identify and naming the crop.
- To study the close relationship.
- To know their hybrids and crossing behaviour.
- To know their compatibility & inter grafting ability.
- To know their adoptability to soil & climate.

POMOLOGY:

Pomology is a branch of horticulture which deals with study of various aspects of fruits like, rising of saplings, growing them properly and providing various intercultural operations.

- The term pomology is a combination of two Latin words ‘**Pome**’ means ‘**Fruits**’ and ‘**Logos**’ means ‘**study**’.
- “**Poma**” in Greek also meaning *fruits* later subsequently “**Pome**” in Latin word means *fruits, logos-study*.
- **Basic Pomology:** Study of basic aspects of fruit production like training, water management, use of PGR's.
- **Commercial Pomology:** It is concerned with commercial production of fruits.
- **Systematic Pomology:** It may be concerned with classification and nomenclature like kingdom, order, class, genus and species.

A. Classification of fruits based on climate adaptability.

In this classification, the fruits trees are categorized into three recognized groups.

i. Temperate fruits:

- Temperate fruit plants are exacting in their climate requirement.
- They are grown only in place where winter is distinctly cold, require as exposure of specific chilling temperature for certain period without which they do not flower.
- These fruit plants are generally deciduous and stand frost. Eg. Apple, almond, peach, pear, plum, strawberry, apricot, persimmon, cherymoya, walnut, peanut, hassle nut, cherry, pistachios and kiwifruits etc.

ii. Tropical fruits:

- Tropical fruit plants are generally evergreen and are extremely sensitive to cold.
- They do well under lesser fluctuations of diurnal temperature, light and dark periods they require a moist warm climate but are capable of withstanding dry weather in some cases Eg; mango, banana, papaya, sapota, etc.,

iii. Sub-tropical fruits:

- The fruit crops grown under a climatic condition between temperate and the tropical are known as subtropical fruit crops.

- They may be either deciduous or evergreen and are usually able to withstand a low temperature but not the frost.
- They are also quite adoptive to fluctuations of light and dark period during day and night.
- Some subtropical fruit plants require chilling for flower bud differentiation.
- Example; grape, citrus, durian, jackfruit, etc.,

B. Classification based on bearing habit:

On the basis of bearing habit, fruit trees are classified in to six categories to facilitate cultural operation like pruning, skiffing, heading back etc.

1. Fruit buds bore terminally and giving rise to inflorescence without leaves e.g. Mango, Cherry, etc.
2. Fruit buds borne terminally and unfolding to produce leafy shoots which terminate in flower clusters. e.g. Apple
3. Fruit buds borne terminally and unfolding to produce leafy shoots with flower or flower clusters e.g. Guava
4. Fruit bud borne laterally containing flower parts only and giving rise to inflorescence without leaves or leaves present, they are reduced in size., e.g. Citrus
5. Fruit bud borne laterally and unfolding to produce leafy shoots terminally in flower clusters this type of flowering is noticed in grapes and cashewnut.
6. Fruit buds borne laterally and unfolding to produce leafy shoots with flower clusters in leafy axils. eg.Fig.

C. Fruit morphology:

1) **Simple fruit - Berry:** Banana, Papaya, Grape, Sapota, and Avocado

2) **Modified berry-**

- i. **Balusta** : Pomegranate
- ii. **Amphisarca** : Woodapple, Bael
- iii. **Pepo** : Water melon
- iv. **Pome** : Apple, Pear, Laquat
- v. **Drupe (Stone)** : Mango, Pear, Plum
- vi. **Hesperidium** : Citrus
- vii. **Nut** : Cashew, Litchi, Walnut, Rambutan
- viii. **Capsule** : Anola, Carambola

3) **Aggregate fruits** : **Etario of berries** –Custard apple, Raspberry

4) **Multiple fruit** : **Syconus-** Fig
: **Sorosis-** Jackfruit, Pineapple, Mulberry

D. Based on rate of respiration:

Climacteric Fruits	Non-climacteric Fruits
Mango, Banana, Sapota, Guava, Papaya, Apple, Fig, Peach, Pear, Plum, Annona, Tomato	Citrus, Grape, Pomegranate Pineapple Litchi, Ber, Jamun, Cashew, Cucumber, Cherry, Strawberry.

(Climacteric fruits produce much larger amount of ethylene than non climacteric fruits)

E. Based on photoperiodic responses

Long day	Short day	Day neutral plant
Passionfruit, Banana, Apple	Strawberry, Pineapple, Coffee	Papaya, Guava

F. Based on relative salt tolerance

Highly tolerant	Medium tolerant	Highly sensitive
Datepalm, Ber, Amla, Guava, Coconut, Khirni	Pomegranate, Cashew, Fig, Jamun, Phalsa	Mango, Apple, Citrus, Pear, Straw berry

G. Based on relative acid Tolerance

Highly tolerant	Medium tolerant	Highly sensitive
Stawberry, Raspberry, Fig, Bael, Plum	Pineapple, Avocado, Litchi	-

H. Based on longevity:

- a) Very Long longevity - >100yrs- Datepalm, Coconut, Arecanut
- b) Long longevity - 50-100yrs - Mango, Tamarind
- c) Medium - 10-50yrs - Litchi, Guava, Pomogranate
- d) Short - Pineapple, Banana

I. Based on consumers preference or weight of fruits

- a) Very light - 50-100gm Grape, Ber, Banana
- b) Light - 100-150gm Sapota, Pomegranate
- c) Light medium - 150-300gm Mango
- d) Medium - 300-350gm Avocado
- e) Medium to heavy - 800-1000gm Mango
- f) Heavy - 1-5kg Bread fruit, Pineapple
- g) Very heavy - >5kg Jack Fruit

2. Botanical classification based on botanical relationship with genomes:**ANGIOSPERMS:**

COMMON NAME	BOTANICAL NAME	FAMILY	TYPE OF FRUIT	CHROMOSOME NO.
Monocotyledanae:				
Banana	<i>Musa paradisiaca</i> , <i>Musa sapientum</i>	Musaceae	Berry	22,33,44
Pineapple	<i>Ananas comusus</i>	Bromeliaceae	Sorosis	50
Panargh Palm	<i>Borassus flabellifera</i>	Palmae	Drupe	
Date palm	<i>Phoenix dactylifera</i>	Palmae	Drupe	36
Dicotyledanae:				
Mango	<i>Mangifera indica</i>	Anacardiaceae	Drupe	40
Pistachionut	<i>Pistachia vera</i>	Anacardiaceae	Nut	
Cashew	<i>Anacardium occidentale</i>	Anacardiaceae	Nut	
Custardapple/ Seetaphal	<i>Annona squamosa</i> , <i>A. gleabra</i>	Annonaceae	Aggregate of berry	
Hanumanphal	<i>Annona reticulata</i>	Annonaceae	Aggregate of berry	
Lakshmanphal	<i>Annona muricata</i>	Annonaceae	Aggregate of berry	
Ramphal	<i>Annona cherimoya</i>	Annonaceae	Aggregate of berry	
Karonda	<i>Carissa carandus</i>	Apocyanaceae	Berry	

Kiwi fruit	<i>Actinidia chinensis</i>	Actinidaceae	Berry	
Durian	<i>Durio zibetinus</i>	Bombaceaceae	Berry	28
Guava	<i>Pisidium guajava</i>	Myrtaceae	Berry	22
Jack fruit	<i>Artocarpus heterophyllus</i>	Moraceae	Sorosis	56
Bread fruit	<i>Artocarpus altilis</i>	Moraceae	Sorosis	56
Papaya	<i>Carica papaya</i>	Caricaceae	Berry	18
Aonla/Nelli	<i>Emblia officinalis</i>	Euphorbiaceae	Berry	28
Mongosteen	<i>Garcinia mangostana</i>	Guttiferae	Berry	24
Avacado	<i>Perisa americana</i>	Lauraceae	Berry	24
Tamarind	<i>Tamarindus indica</i>	Leguminosae	Pod	
West Indian cherry	<i>Malphigia punicifolia</i>	Malphigiaceae	Drupe	
Fig	<i>Ficus carica</i>	Malphigiaceae	Berry	
Guava	<i>Psidium guajava</i>	Myrtaceae	Berry	22
Jamun	<i>Syzygium cumini</i>	Myrtaceae	Drupe	
Roseapple	<i>Syzygium jambos</i>	Myrtaceae	Drupe	20
Olive	<i>Olea europaea</i>	Oleaceae	Drupe	
Carambola/ Star fruit	<i>Averova carmbola</i>	Oxalidaceae	Berry	24
Passion fruit	<i>Passiflora edulis</i>	Passifloraceae	Berry	18
Pomegranate	<i>Punica granatum</i>	Punicaceae	Balasta	
Ber	<i>Ziziphus jujuba</i>	Rhamnaceae	Drupe	
Loquat	<i>Eriobotrya japonica</i>	Rosaceae	Pome	34
Sweet orange	<i>Citrus sinensis</i>	Rutaceae	Hesperidium	18
Mandarin	<i>Citrus reticulata</i>	Rutaceae	Hesperidium	18
Mandarin	<i>Citrus unsu</i>	Rutaceae	Hesperidium	18
Rough lemon	<i>Citrus jambheri</i>	Rutaceae	Hesperidium	18
Lemon	<i>Citrus limon</i>	Rutaceae	Hesperidium	18
Bael	<i>Aegle marmelos</i>	Rutaceae	Amphisarea	
Wood apple	<i>Feronia limonica</i>	Rutaceae	Amphisarea	
Litchi	<i>Litchi chinensis</i>	Sapindaceae	Nut	30
Rumbutan	<i>Nephelium lappaceum</i>		Berry	
Sapota	(<i>Achras zapota</i>) <i>Manilkara</i>	Sapotaceae	Berry	26
Phalsa	<i>Grewia subenaequalis</i>	Tiliaceae	Drupe	
Grape	<i>Vitis vinifera</i>	Vitaceae	Berry	38

SCOPE AND IMPORTANCE OF FRUIT CROPS:

- Fruit growing is one of the important and age old practices, practiced in India since ancient times.
- Cultivation of fruit crops plays an important role in overall status of the mankind and the nation.
- The standard of living of the people of a country is depending upon the production and per capita consumption of fruits.
- Fruit growing have more economic advantages.

1. Economic importance:

- **High productivity:** high yield per unit area: From a unit area of land more yield is realized from fruit crops than any of the agricultural crops. The average yields of Papaya, Banana and Grapes are 10 to 15 times more than that of agricultural crops.
- **High net profit:** Through, the initial cost of establishment of an orchard is high; it is compensated by higher net profit due to higher productivity or high value of produce.
Eg. Wheat/ground nut/Ragi : Yield :3.0 - 4.0 tonnes/ha; 25000-00 to 35,000-00
Grapes/Mango/Banana 20-40t/ha ;1.5-2.5 lakh/ha.
- **Source of raw material for agro based industries:** Fruit farming provides raw materials for various agro based industries- canning and preservation (fresh fruits), coir industries (coconut husk), pharmaceutical industry (Aonla, Papaya, Jamun) Transporting and packaging industries etc.
- **Efficient utilization of resources:** Growing of fruits being perennial in nature, enables grower to remain engaged throughout the year in farm operations and to utilize fully the resources & assets like machinery, labour, land water for production purpose throughout the year compared to agronomic crops.
- **Utilization of waste and barren lands for production:** Although, most of the fruits crops require perennial irrigation and good soil for production, there are many fruit crops of hardy in nature, Mango, Ber, Cashew, Custard apple, Aonla, Phalsa, Jamun etc. which are grown on poor shallow, undulated soils considered unsuitable for growing grain/ agronomical crops.
- **Foreign exchange:** Many fresh fruits, processed products and spices are exported to several countries earning good amount of foreign exchange.

2. Nutritional importance:

Importance of fruits in human diet is well recognized. Man cannot live on cereals alone. Fruits and vegetables are essential for balanced diet and good health. Nutritionist advocates 60-85g of fruits and 360 gm. Vegetables per capita per day in addition to cereals, pulses, egg etc. fruits and vegetables are good sources of vitamins and minerals without which human body cannot maintain proper health and develop resistance to disease they also contain pectin, cellulose, fats, proteins etc.

Fruits- as sources of vitamins:

1. Vitamin-A- Mango, Papaya, Jack, Banana, Dates.
2. Vitamin-B- Cashew nut, Almond, Banana, Apple, Bale, Litchi, Papaya and Pomegranate.
3. Vitamin-C- Aonla, Citrus fruits, Pineapple, Ber, Guava, Strawberry, Tamarind etc.

Fruits as a source of minerals such as Ca, Fe, P- the fruits are- Almond, Cashew, Guava, Jamun, Fig, Karonda, and Mango.

Digestive enzymes- Papaya- papaine-9, proteolytic enzyme.

Fruits have medicinal value: The fruits like aonla pomegranate, Kokum, Jamun, Bael, Ber. etc, have great medicinal value,

1. Papaya reduces night blindness,
2. Citrus juice reduces acute diarrhoea.
3. Aonla triphala (chamanprash)- digestion.
4. Jack fruit (Jackoline) - prevents Aids.

Other importance: fruit growing in kitchen gardens helps to reduce family budget on purchase of fruits.

- Planting of fruits trees, maintains ecological balance and to increase precipitation of the locality.
- Fruit tree farming also reduces soil erosion, silting and air pollution.
- Generate employment being highly intensive & skillful enterprise generates employment even for trained persons.

LECTURE -21**MANGO***(Mangifera indica, Anacardiaceae; 2n=40)***INTRODUCTION:**

- Perennial tree of medium to large size with a symmetrical top.
- The flowers are produced in panicles which are about ten to twelve inches in length. The flower is hermaphroditic with male and female flowers in the same flower panicle.
- The fruit varies in size and has a fleshy pulp. The skin is leathery and varies in color from yellowish green to red. The seed is found in the center of the fruit.
- The fruit weighs about 1/4 pound to 3 pounds. Fruit may be round, ovate, or obovate depending on the variety.
- The immature fruit has green skin that gradually turns yellow, orange, purple, red, or combinations of these colors as the fruit matures.
- Mature fruit has a characteristic fragrance and a smooth, thin, tough skin.
- The flesh of ripe mangos is pale yellow to orange.
- The flesh is juicy, sweet, and sometimes fibrous.

IMPORTANCE AND USE:

Mangoes are full packed with vitamins, minerals and anti-oxidants and contain like all fruits very few proteins, fats and calories. They are perfect to replenish salts, vitamins and energy after physical exercise.

- It is a mineral packed chemical free food that has amazing benefits for our health.
- The mango-milk cure is an ideal treatment for loss of weight.
- Mangoes are thought to help stop bleeding, to strengthen the heart, and to benefit the brain.
- Taking Mango regularly makes the complexion fair and the skin soft and shining.
- Feeding the powder of dried kernel of Mango seeds with fresh water cures the habit of eating soil in kinds.
- Dietary fiber has a protective effect against degenerative diseases, especially with regards to the heart; may help prevent certain types of cancer, as well as lowering blood cholesterol levels.

ORIGIN:

- The genus *Mangifera* originates in tropical Asia, with the greatest number of species found in Borneo, Java, Sumatra, and the Malay Peninsula.
- The most-cultivated *Mangifera* species, *M. indica* (mango), has its origins in India and Myanmar.

DISTRIBUTION:

- *Mango is now cultivated throughout the tropical and subtropical countries for commercial fruit production, as a garden tree, and as a shade tree for stock.*
- In the Pacific region, all mangos were introduced from other parts of the world.
- The earliest recorded introductions into Hawaii were prior to 1825; however, most introductions to the Pacific islands have occurred over the past 100 years.
- Few other *Mangifera* species are found in the Pacific. *Mangifera geddebe*, *M. minor*, and *M. mucronulata* are found in the Solomon Islands and *M. minor* in Micronesia, but these either do not fruit or the fruit is inedible.

CLIMATE AND SOIL:

- Mango thrives well in tropical and sub tropical climate.

- It can be grown from sea level to an altitude of about 1400 m.
- The optimum temperature range is 24°C to 27°C.
- However, it can tolerate up to 48°C during fruit development with regular irrigations, which improve fruit size, quality and maturity.
- Low temperatures (13°C-19°C) are good for flower bud differentiation.
- It can be grown in areas with rainfall from 25cm to 250cm if no high humidity water stress or rest 2-3 months before flowering improves flower bud formation.
- Mango grows in all type of soils with good depth and drainage except black cotton soils. Optimum PH is 5.5 to 7.0. It cannot tolerate saline conditions.

CULTIVARS:

Chausa, Dusehri, Mulgoa, Langra Benarsi, Totapuri, Fajli, Alphonso, Amrapali, Badami, Banganapalli, Bombay Green, Chinna Rasam, Pedda Rasam, Roomani, Himsagar, Jehangir, Kalami, Kesar, Kishen Bhog, Komanga, Lalbaug, Maldah, Malgis, Mallika, Mankur (GOA), Neelum, Pairi, Rajapuri, Raspuri, Ratna, Safeda, Sammar Bahisht, Suvarnarekha, Vanraj, Alampur Baneshan, Nannari etc.

PROPAGATION:

- **Mango is commercially propagated by;** 1. Veneer grafting; 2. Approach grafting
3. Soft wood grafting
- June to Sept/Oct is best for grafting. Polyembryonic seedlings are best in providing uniform root stocks. Totapuri red small and Olour are dwarfing root stocks. Mango does not show significant variation on different rootstocks.

LAND PREPARATION:

- For backyard planting, prepare the land simply by digging a hole wide and deep enough to accommodate the ball of soil that goes with the planting material.
- This is recommended particularly in fertile, deep and friable soil. On poor soil, dig big, deep holes with a diameter of 30-50 cm. set aside the top soil to be used to re-fill the hole after planting or transplanting.
- For orchard planting in flat or slightly rolling terrain, plow the field as deep as possible and harrow the field twice until fine tilt is attained before the onset of the rainy season.
- To accommodate other cultural activities and to ensure straight alignment of trees, layout the field using the desired planting system such as, square, quincunx, or triangular system.

MANURING:

- 10 kg Fym, 2.5kg bone meal, 1.0 kg potassium sulphate for 1 year old plant and
- Increased by 5 kg FYM, 0.5 kg bone meal and 0.4 kg potassium sulphate per year till 10th year.
- Bearing trees may be given 750g N, 200g, 200g P₂O₅ and 1150g K₂O/year/tree.
- It is better always to apply organic manures during October.
- Manures should be applied in small trenches dug from about 1.5-2.0 m away from the trunk upto the drip line. Watering should be done soon if no rains.

IRRIGATION:

- Irrigation should be given according to the soil and weather conditions.
- Bearing trees need to be irrigated regularly at 10-15 days interval from fruit set to maturity.



- Plant should be given rest by withholding irrigations at least 2-3 months before flowering for maximum fruit bud development.
- Through drip irrigation the tree may be given @ 40 litres/tree twice a week.

CULTIVATION:

- Land should be ploughed to proper tilth and the pits of 90x90x90cm are dug at a spacing of 8-10m and then filled with well decomposed FYM.

PLANTING:

- Planting is done during rainy season; the graft union should be kept at least 6 inch above the soil. After planting staking should be given for support and watering have to be given soon after planting.

INTERCULTURAL:

- It should be done in pre-bearing period to keep the land free from weeds.
- Intercropping can also be taken with phalsa, papaya and pineapple or vegetables if irrigation facilities are available.
- Cover crops like sun hemp, daincha, cow pea, cluster bean, etc, can also be grown during rainy season and ploughed into the soil before the end of the rainy season.
- Land should be ploughed twice a year during April-May and October- November.

WEED MANAGEMENT:

- Weeds have to be controlled by the application Atrazine @4kg/ha /oxyfluofen (Goal)@800ml/ha as pre-emergent weedicide and application of Gramaxone (Paraquat) @ 2liters/ha as post emergent. Root zone of the trees must be kept weed free throughout the growth periods.

PRUNING AND TRAINING:

- Mango needs no regular pruning except removing dead and diseased branches.
- Young plants should be trained properly to get good framework.

FLOWERING AND FRUIT SET:

- Flower bud formation takes place 2-3 months prior to flowering.
- Flowering occurs from November-December to February-March depending upon region and variety and continues for about 2-3 weeks.
- Flowers are polygamous-sex ratio can be improved by application of NAA 200ppm at flower bud initiation stage.

FRUIT DROP:

- Fruit drop is a natural phenomenon and is very high in mango especially during the first four weeks.
 1. Soon after flower opening.
 2. After pollination and fertilization.
 3. at grain stage of fruit.
- This occurs as an adjustment to the resources available in the plant for the development of fruits.
- Sometimes we can notice the drop of the grownup fruits. This may be due to competition between developing fruits, drought or lack of irrigation, adverse weather conditions and incidence of serious pests and diseases.
- This can be minimized by regular irrigations during fruit development, application of optimum doses of nutrients, effective control of pests and diseases and by hormones sprays like 2,4-D (10-30ppm) NAA(5-50ppm), 2,4,5-T(20ppm) etc.,

HARVESTING AND YIELD:

- Stage of harvesting is very important, indicated by
- Starting of Colour development
- Falling of one or two fruits from the plant
- Specific gravity of 1.0 to 1.02 (more reliable)
- Mango normally takes 90-120 days from fruit set to maturity. Harvesting is done using pole harvesters without causing any damage to the fruit.
- Mango grafts come to bearing in about 2-3 years but economic yields may be expected after 8-10 years of planting and may continue up to 40-60 years.
- Average yield is 8 tones/ha and may vary according to variety and locality.

PACKING AND TRANSPORT:

Mangoes are normally packed in bamboo baskets using straw as the padding material. Wooden and cardboard boxes are also used. Wrapping fruits individually maintains the quality of the fruit. Waxing 3% with hot water treatment improves storage life mangoes can be stored at 5-14°C and 90% RH for about 2-7 weeks depending upon the variety.

PHYSIOLOGICAL DISORDERS

MANGO MALFORMATION

- Production of thick vegetative condensed bunchy top shoots and transformation of floral parts into a compact mass of sterile flowers is referred as malformation.
- **Two types:** Vegetative and floral malformation.
 1. **Vegetative malformation** - resembles “bunchy top” which may dry and die in due course.
 2. **Floral malformation**- results in enlargement of flowers with new flowers being produced even after fruit set but with less % of hermaphrodite flowers. Malformed panicles may be 1. loose 2. Compact.
- Malformation is serious in North India than in South India. It may result in loss of about 50-60% crop. Krishnabhog, Collector, Langra, Neelum are tolerant (seedling trees are found to be tolerant).

Causes for Malformation:

- Infestation of virus, fungus, mites, nutrients deficiency, C/N ratio, carbohydrates, nucleic acids, amino acids, proteins, phenolic compounds, and enzymatic activity in the plant, phytohormones and occurrence of malformation like substance are all supposed to be the probable causes for malformation.

Control measures:

1. Application of plant growth regulators and phenolic compounds (NAA, Ethrel, GA, Paclobutrazol, etc.
2. De-blossoming: at bud burst stage-ethrel
3. Use of antagonists and antimalformins: Glutathione, Ascorbic acid, Silver nitrate
4. Application of nutrients: High NPK added with FeSO₄, Cobalt sulphate
5. Pruning of malformed parts.



6. Application of pesticides: Parathion, Kelthane, Kerathane.
7. Covering panicles with polythene film to raise the temperature around the panicle. In spite of this, malformation is still a puzzling problem. It is therefore concluded that malformation can be kept under check by maintaining
 1. Orchards cleanly using disease free planting materials only.
 1. Regularly inspecting the orchard
 2. Regularly removing all malformation parts and
 3. Spraying of insecticides and after each pruning.

BIENNIAL BEARING IN MANGO:

Mango producing good crop one year and no crop or fewer crops in the next year is known as biennial bearing or alternate bearing. This is genetic and inherent in mango varieties.

CAUSES FOR BIENNIAL BEARING:

1. **Climatological factors:** Rain, high humidity, low temperature making on to off year
2. **Age and size of shoots:** Shoots of 8-10 months maturity will be productive.
3. **Carbon/Nitrogen ratio:** High carbon/moderate N encourages flower bud formation (30-40)
4. **Hormonal balance:** Higher levels of auxin and inhibitor like substance and lower levels of gibberellins like substances were found to be vital for a flowering shoot.

In spite of several studies, the biennial bearing is still an unsolved problem which is thought could be corrected by genetic engineering only.

SUGGESTIONS/ MEASURES:

1. Proper upkeep and maintenance of mango orchards.
2. Deblossoming in on year with NAA application.
3. Smudging and chemical regulation like application of paclobutrazol (5-10gm/tree), spraying 1-2% KNO₃, 6-8% CaNO₃, etc.
4. Pruning: Pruning of the fruited shoots to keep open the tree top properly.
5. Growing regular bearing cultivars: Bangalora, Rumani, Neelum and almost all hybrids.

BLACK TIP:

- The distal end of fruit become black and hard
- Due to polluted atmosphere with smoke, carbon monoxide, carbon dioxide, sulphur dioxide, acetylene.
- Spraying with Borax @ 0.6% from fruit set at 10-15 days intervals controls this disorder (Punjab, UP, Bihar, W,B).

CLUSTERING (Jhumka):

- Clustering of fruits without growth at the tip of the panicle caused by adverse weather (low temperature) condition during February-March leads to this disorder. Most of the fruits drop+shriveled and aborted embryos.

SPONGY TISSUE: Fruit appears normal externally but contains yellowish, sour spongy tissue inside. High temperature, convertive heat and exposing to sunlight after harvest are supposed to be the causes. Remedy lies in sod culture, mulching in the orchard and harvesting fruits at 3/4th mature stage only.

SOFT NOSE: Physiological disorder caused by calcium deficiency, causing breakdown of flesh towards the apex of the fruit before ripening leads to softness of the tissues.

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LECTURE- 26

BANANA

(*Musa paradisiaca* L / *M. cavendishi* L; Musaceae; $2n = 22, 33, 44$)



- Banana is an important fruit of tropics.
- The fruit is recognized as the fourth most important global food commodity.
- India's share is 32 % of the total fruit production.
- This is the only tropical fruit which is exported in large quantities and is leading fruit in the international trade.
- It is one of the oldest and commonest of the Indian fruits that have been cultivated since ancient times.
- Eve was said to have used banana leaves to cover her modesty in the garden of paradise.
- Banana is thus called apple of paradise.
- It is also known as "Adam's fig or tree of wisdom.
- It is used as staple fruit in most of the African countries and is used as ripe (table) or raw fruit (cooking).
- This fruit is available throughout the year.
- All the plant parts are being used.

USES AND COMPOSITION:

- Banana by virtue of its, multiple uses is popularly known as "Kalpataru" (a plant with virtue).
 - Usually banana is eaten when ripe as dessert / table fruit.
 - Plantain or cooking bananas are the staple food of people in many countries of central and western Africa.
 - Apart from fresh consumption, some types are also used for culinary purposes.
 - The flower bud and also the central core of the pseudostem are used to prepare tasty dishes.



- Banana leaf is used as plates for serving food, leaf sheaths are used as wrapping material and dry leaves as fuel, while, tender pseudostems, leaves, underground rhizomes are used as cattle feed.
- Various processed products like banana chips, toffee, puree, powder, flour, vinegar, jam, jelly and wine can be prepared from the fruit.
- Banana fiber can be made in to attractive napkins, table mats and carry bags.
- The fruits have a lot of medicinal properties and are used for treating various health disorders specially acidity, ulcer, joint pains, high blood pressure and heart diseases.
- Banana is rich source of energy (350 to 550 kilo joules/100g) and is a good source of minerals and vitamins.
- It contains 73 % moisture, 25-30 % carbohydrates, 1.4 % protein, 0.3 % fat, 0.5 % mineral matters (Ca, Fe, P, K) and Vit- C and K.

ORIGIN AND DISTRIBUTION:

- The origin of banana is believed to be in the hot, tropical regions of South-East Asia, stretching from India to Papua New Guinea, Malaysia and Indonesia.
- India has the second largest diversity of indigenous bananas in the world.
- India has more than 300 germplasms, out of 600 reported worldwide.
- Edible Banana has arisen as a result of natural crosses between two wild progenitors viz., *Musa paradisica* and *Musa balbisiana*.
- Banana is being grown in many of the African countries between 30° N and 50° S latitudes.
- Important countries are India (1st place) with a total production of 17 million tons from an area of 0.50 million ha and the other countries growing banana are Kenya, Uganda, Sudan, Fizi, Honduras, Hawaii, Canary Island, Philippines, Taiwan, Australia, Bangladesh, South Africa, Pakistan etc.
- In India, it is the 2nd major fruits, occupying about 20 % of the total area under fruit crops and 32% of total fruit production, Tamil Nadu (88,000 ha.), Maharashtra (59,000 ha.), Karnataka (61,000 ha.), Assam, Andhra Pradesh, Orissa, Gujarat and Kerala are the leading producers.
- Though, India is the leader in banana production, Indian export of fresh banana is meager (12 million tons).

SOIL AND CLIMATE

- Banana can be grown in almost all types of soil provided adequate soil moisture is available.
- Deep well drained, loamy soil with adequate organic matter is ideal for its cultivation.
- The plant has restricted root zone.
- It can grow well in slightly alkaline soils.
- Though banana requires large quantity of water, it cannot tolerate water stagnation.
- The optimum soil pH is 6.5-7.5.
- Banana being a tropical fruit crop, adapted to wide range of climatic conditions.
- It is grown up to an altitude of 1200 m from mean sea level.
- The temperature range is 13-40°C, but the optimum is 25-30°C for getting good yield, Heavy storms, frost, low temperature (Less than 10°C) or extremely high temperature are detrimental to plant growth which leads to abnormal or malformed condition.

SPECIES AND CULTIVARS:

- The family musaceae has two genera viz., *Ensete* and *Musa* with about 50 species.
 1. ***Ensete***- is an old genus, which probably originated in Asia and spread to Africa. It has about 6-7 species, of which *Ensete* and *Ventricosa* has been reported to be grown as a food crop.
 2. ***Musa*** –it is having 40-45 species, all the varieties under these species are under cultivation. The genus *Musa* is divided into following sections.

SECTIONS:

- Eumusa (2n=22):** This is the largest section with 13-15 species, all are cultivated forms; Pseudostem usually exceed 3m in height with pendent or semi pendent inflorescence, produces 10-25 nodes of flowers and covered with dull brown colour bracts, gives the edible cultivated parthenocarpic banana and are derived from 2 wild species. *Musa accuminata* (A) and *Musa balbisiana* (B).

- ii. **Callimusa (2n=10)** -It is having 5-6 species. Plants with less than 3 mtrs in height, suited as ornamental, parthenocarpy absent completely.
- iii. **Australimusa (2n=20)**- These fruits are parthenocarpic and predominantly female sterile; The fruiting bunch is erect and contains a red sap, the skin is orange in colour when ripe. eg-*Musa textilis* (Manila hemp).
- iv. **Rhodochlamys (2n=22)** -It is having 5-7 species, spreads from India to Indonesia, pseudostem less than 3m height with erect inflorescence, parthenocarpy absent eg-*M. ornate* & *M. velutina* are sometimes grown as ornamental plants.
- v. **Incertae sedis- (x=7; 2n=14)** - it is the largest among the Musaceae family, grows to a height of over 10m. eg-*M. ingens* & *M. beccarii* (x=9, 2n=18).
 - All the edible bananas are descendents by natural cross between 2 wild ancestors, i.e., *Musa acuminata* (A) and *Musa balbisiana* (B).
 - These edible bananas have 22, 33 or 44 chromosomes i.e., Diploids, Triploids and Tetraploids, respectively.
 - Triploid cultivars are generally numerous, diploids somewhat less and tetraploid forms are very rare. The basic haploid numbers is 11.

Simmonds and Shepherd (1995) have distinguished the major morphological characters of *M. acuminata* and *M. balbisiana*, which are as follows;

Sl. No.	Characters	<i>Musa acuminata</i>	<i>Musa balbisiana</i>
1.	Colour of pseudostem	Heavily marked with black or brown blotches	Blotches slightly or absent
2.	Peduncle	Usually downy or hairy	Glabrous
3.	Pedice	short	Long
4.	Ovules	Two regular rows in each loculus	Four irregular rows in each loculus.
5.	Bract curling	Bracts roll after opening	Bracts lift but do not roll
6.	Bract shape	Lancedote or narrowly ovate tapering sharply.	Broadly ovate not tapering sharply
7.	Bract apex	Acute	Obtuse.
8.	Bract colour	Red, dull purple or yellow outside, pink dull purple inside.	Brownish purple outside bright crimson inside.
9.	Male flowers colour	Creamy white	Variably flushed with pink.
10.	Stigma colours	Orange or rich yellow	Cream, pale yellow.

- The best known bananas all over the world belong to the pure *acuminata* (AAA) group.
- But the clones which are having both the parents is associated with the greater drought tolerance and resistance to diseases. Eg-AB, AAB, ABB, AA or AAA-suited for rainy condition.

Genomic constitution of different cultivars of Banana:

- In India bananas are distributed in southern, eastern, central and north eastern parts within 80° and 30°N latitudes. Major genomic groups and cultivars are AA group:
 1. AA- Anaikomban, Matti, Kadali, Tongat, pisanglilin.
 2. AB- Ney poovan (Elakki bale), Kunnan, Nathu Poovan. Thaen kunnan, Adakka Kunnan.
 3. AAB- Poovan, Rasthali, Pachanadan/Kaali/Galibale, Nendra paditha, Rajapuri, Virupakshi/Sirumalai, Nendran/Rajeli, Chinali.

4. AAA- Dwarf Cavendish/Basrai, Giant Cavendish, Robusta, Gross michel, Grand naine, William, Nagabale, Chenkadali/Red banana, Chakkarakeli, Amrit sagar.
5. ABB- Nalla Bontha, Monthan/Kanchkela, Keribontha, Peyan, Karpuravalli, Sugandhi.
6. AAAA- Bodles Altafort, IC-2.
7. ABBB- Klue Taparod
8. AABB- Kalamagol
9. AAAB- Atan, Goldfinger (FHIA).

Characteristics of important Banana varieties:



1. **Ney poovan/Elakkibale (AB):** It is commercially cultivated in Kerala and Karnataka. The plants are medium sized with slender, yellowish pseudostem, having reddish petiole margin. Small fruits flesh firm, sweet and highly fragrant. The average bunch weight is about 12 kg. It is tolerant to leaf spot and fusarium wilt, but susceptible to banana bract mosaic virus.

2. **Kunnans (AB):** It is a back yard cultivar of Kerala and Karnataka. The plants are medium sized and slender fruits with firm pulp with good taste. Mainly used as infant food after conversion into banana flour. It is tolerant to leaf spot and fusarium wilt.

AAA group: Cavendish sub-group;

3. **Dwarf Cavendish/Basrai (AAA):** It is the most important commercial cultivar of India the plant is dwarf, fruit large, curved, skin thick and greenish, flesh soft and sweet. Even after ripening the fruit is greenish in colour, but fruits ripening during winter season develop yellow colour. The keeping quality is not good; the average bunch weight is about 20kg and suitable for high density planting and susceptible to leaf spot disease.



4. **Gross Michel (AAA):** It is the main cultivar of this sub-group. Gross Michel was the leading cultivar in the world banana trade until the late 1950. The variety has lost its commercial status due to susceptibility to panama wilt.

Red Banana Sub-group



5. **Red Banana (AAA):** This cultivar is grown throughout the world. The colour of the pseudostem, petiole, midrib and fruit peel is purplish red. The fruit is of good size and has a characteristic aroma. The average bunch weight is 20 kg. It thrives well in humid tropics and at higher altitudes. It is highly susceptible to bunchy top, fusarium wilt and nematode.

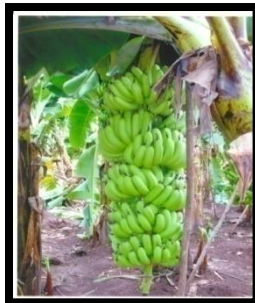
Silk Sub-Group:



6. **Rasthali (AAB):** it is one of the most popular commercial choicest table cultivar of West Bengal, Tamil Nadu, Karnataka, Andhra Pradesh, Kerala and Bihar. The plant is tall and can be easily identified by the yellowish green stem with brownish blotches. Reddish margins of the petiole and leaf sheath. The average bunch weight is about 12 kg. Fruits are medium, thin skin, yellow in colour flesh firm, sweet with a pleasant aroma. It has the disadvantage of longer duration, severe susceptibility to fusarium wilt, easy dropping of fruits from bunch. Susceptible to sun injury and formulation of hard lumps in the pulp.

MYSORE SUB-GROUP:

7. **Poovan/Champa** (AAB): The plant is tall, hardy and grows vigorously, one of the distinguishing characters of the plant is the rose pink colour on the outside of midrib, fruit is medium to small, yellow skin firm flesh with sub-acidic taste, good keeping quality, the average bunch weight is about 15kg. It is resistant to panama wilt and fairly resistant to bunchy top highly susceptible to banana bract mosaic and streak virus.

**Other varieties/Cultivars****Grand Naine****Nendran****Watabale****Karibontha****Karpooravalli****Monthan****Boodibale****Virupakashi****PROPAGATION:**

- Banana is traditionally propagated by vegetatively through suckers or rhizome or tissue culture plants.
- Sexual propagation is not possible due to Parthenocarpic nature of fruits.

Banana produces two types of suckers

1. Water suckers.
2. Sword suckers.

WATER SUCKERS:

- Water sucker is one which is characterized by broader leaves which do not produce a healthy banana clump, with slender pseudostem.
- Rhizome/corm is not well developed.
- It takes more time (more than 18 months) for yielding.
- Yield also less.
- These types normally develop from shallow buds away from pseudostem near the soil surface.

SWORD SUCKER:



- Sword sucker is one with well developed rhizome, well developed pseudostem with sword like leaves.
- It takes 12-13 months to yield and gives bigger bunches.
- Sword suckers are closely associated with the mother plant and therefore develop strong thick rhizomes of their own.

Important criteria for selection of suckers for planting:

- The orchard/mother block should be disease free.
- The weight of the suckers should be 1.0- 1.5 kg.
- The mother plant should be heavy yielder.
- Always select sword suckers for planting.
- Select the suckers free from rhizome weevils.
- Age of suckers: 3-4 months
 - The whole or split rhizomes can also be used when suckers are not available.
 - Bits of rhizomes may also be used as a planting material.
 - Tissue cultured plants were also used as planting material on commercial scale.

Preparation of suckers (Pairing & Prolinage):

- It is the removal of older leaves, roots, adhered soil and other particles on the surface of rhizome and top portion of the suckers leaving 15cm from rhizome should be removed.
- The suckers have to be immersed in cow dung slurry and sprinkle phorate granules @ 10-15 g/rhizome in order to avoid soil pathogen & rhizome weevils.
- Also rhizomes are dipped in fungicide solution by giving a slant cut.

PLANTING:

- Banana can be planted throughout the year except in severe winter and during heavy rains. In general, June-July is the most common season of planting.

1. Pit method:

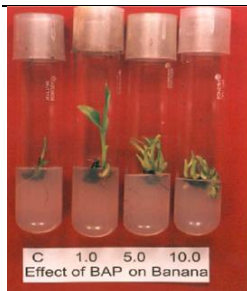
- Pit method and furrow methods are commonly followed.
- The pit size of 60cm³ should be opened at 1.8 x 1.8m or 2 x 2m (Tall varieties) adopting square system.
- These pits are filled with top soil with 20-30 kg.
- FYM should be applied at least 15-30 days prior to planting.
- During planting each pit will be supplied with 250gm neem cake and 50 gm of trichoderma to prevent nematode & rhizome rot problems.
- Planting of suckers at the centre of pit and irrigate immediately after planting.
- Spacing should be adopted variety wise.

2. Furrow method:

- This is the most common method of planting. Furrows of 15-20cm deep are opened at a regular distance and rhizomes are planted in the furrows.
- Paired row planting in tissue culture plants

Tissue culture plants:

- Banana is also grown commercially by using tissue cultured plants;
- These plants required much care throughout the growth period compare to suckers and
- Yields about 10-20 per cent more than suckers.



- In recent years the concept of high density planting (HDP) is being practiced, suckers are planted at closer spacing or planting two suckers per pit by accommodating more number of plants at specified spacing to get higher yield and reduced cost of production.
- The cultivar Robusta and Dwarf Cavendish spaced at 1.5x1.5m accommodates 4444 plants/ha is recommended by IIHR was recorded highest yield.

IRRIGATION:

- The soil in banana plantation should not be allowed to dry completely.
- Banana requires high amount of water ranging from 1800-2500 mm annually.
- About 40-45 irrigations are required from planting to harvest at 4-5 days interval.

NUTRITION MANAGEMENT:

- Banana is a heavy feeder, Due to shallow root system of the crop, it responds well to applied nutrients.
- The high fertilizers requirement of banana is mainly due to their rapid and vigorous growth and high fruit yield.

State	N	P	K	FYM (t/ha)
Karnataka				
Dwarf cavendish	540kg/ha	325kg/ha	675kg/ha	40
Robusta	405kg/ha	245kg/ha	507kg/ha	40
others	400kg/ha	240kg/ha	500kg/ha	40
Maharastra	600g/plant	720g/plant	600g/plant	100 carts/ha
Andhra Pradesh	200g/plant	-	200g/plant	40
Tamil Nadu	110g/plant	35g/plant	330g/plant	10kg/plant
Kerala				
Nendran	190g/plant	115g/plant	300g/plant	10kg/plant
Others	160g/plant	160g/plant	320g/plant	10kg/plant

- Fertilizers have to be applied before initiation of inflorescence in 3 splits i.e. 2nd, 4th and 6th months after planting.
- The fertilizers should be applied at 30-45cm radius from the plant by making basin and mix with the soil then irrigates the plant.

WEED CONTROL:

- In banana, weed is a problem at the early stage of growth, for conservation of moisture, proper utilization of nutrients as well as for effective control of pests and diseases weed free environment is essential in banana.
- Integrated weed management programme should include growing of cover crops, use of herbicides, inter cropping and hand weeding where ever necessary.
- Pre emergence application of Diuron at the rate of 4kg/ha controlled grasses and broad leaved weeds without affecting the yield and quality of banana or application of Glyphosate 2kg/ha followed by gramoxone 1.8kg/ha proved effective in controlling weed growth.

IMPORTANT CULTURAL PRACTICES:

DESUCKERING:

- Desuckering is done by cutting the pseudostem of sucker at the ground level followed by application of kerosene/2-4, D @ 0.5 per cent also the growth of suckers can be inhibited by damaging the cut end to prevent further growth.
- As banana produces number of suckers, if allowed, they compete for moisture nutrition with mother plant; one or two healthy sword suckers may be allowed to grow for ratoon crop.

EARTHING UP:

- To prevent uprooting of plant by wind soil is mounded around the pseudostem during rainy season.

PROPPING:

- Providing support to the plant when it is at bunching stage.
- If dwarf variety and closed spacing no propping is required but for all tall varieties, it is required by using bamboo poles or any other supports.

DENAVELING:

- Removal of male buds after the last set of fruit. It increases the bunch weight/fruit weight and quality of fruits also.

THRASHING:

- A process of removal of old, dry, diseased and senescent leaves this could reduce the disease and facilitate better light, temperature and air.
- However, if leaves are pruned before bunch initiation, flowering is delayed and cycle time increased.
- A minimum of 12 leaves are required to be retained for maximum yields

BUNCH COVERING:

- Bagging of bunch with perforated polythene cover or dried leaves to protect against cold, sun scorching, attack of thrips and other scrapping insects, during bunch maturity stage, the bags may be coated with pesticides.



GROWTH AND DEVELOPMENT OF THE PLANT:

- During the life cycle, the plant produces 30-40 leaves @ 4 leaves/ month depending on variety.
- The last leaf produced at shooting which is small in size is called **flag leaf**.
- The first distinguishing feature between vegetative and reproductive phase is the production of bract primordium.
- The basal (proximal) nodes of the inflorescence bear female and the upper (distal) nodes contain male flowers.
- In between male and female buds, hermaphrodite flowers and have stunt ovaries and do not develop in to edible fruit.
- Banana fruit botanically known as **berry**.
- The edible bananas are vegetative parthenocarpic, the female sterility gene and lack of pollen due to triploidy causes seedless nature. While, the pollination is essential for fruit development in the wild seeded bananas.

USE OF PLANT GROWTH REGULATORS:

- The process of flowering governed by *Gibberlin* like substances helps in development of plant,
- Later on *antheclin hormone* inducing flowering of plant,
- Both combiningly called as “*Dual factors hypothesis*”.
- Spraying of NAA at 100 ppm after 5 and 7 months of planting markedly increases fruit size and yield.
- Spraying of 2-4 D@ 20ppm increased the quality of fruits.
- It is poured in the growing apex, than bunch will have more of female flowers/fingers.
- Application of GA₃ at 50mg/l resulted in maximum yield and required less number of days for fruit maturity in Giant Governor Banana.

FRUIT MATURITY AND HARVEST:

- Under favorable conditions, banana starts flowering in 9-12 months and
- Fruits matures in about 4-5 months depending upon varieties, climate etc.
- Banana are harvested at 3/4th maturity stage for distant markets or for chips making purpose while, for local markets are harvested at full maturity.
- The following are the indications of maturity of banana.
 - Drying of top leaves.
 - Changing of fruit colour from green to light green.
 - The floral ends of fruits are shed with slight hand touch at apices.
 - Fruit become plumpy and angles are filled & disappear.
 - One or two fruits ripe at the basal end (yellow colour).
 - Starch content of the fruit (22-25%).
- The bunches are to be harvested by leaving 2 ft of peduncle on the bunch.

MATTOCKING:

- It is the process of cutting the pseudostem after harvesting of bunches.
- After harvesting the pseudostem should be cut leaving a stump of about 0.6m high, the left over stump with its stored food material continues to nourish the daughter sucker (follower) till it withers and dries up.

YIELD:

- Yield of banana varies with variety and production practices.
- Tall cultivars usually yield 15-20 tones/ha.
- Cavendish group varieties yield about 40t/ha,
- Whereas the hill banana/cooking varieties yield about 11-15 tones/ha.

POST HARVEST MANAGEMENT:

- Banana can be stored at about 13⁰C with the Relative Humidity of 85-95 % for 3 weeks and is ripened in a week at 16.5-21.0⁰C.
- The fruits should not be stored / shifted under refrigerated condition.
- The storage life can be increased by keeping the fruits in high concentration of carbon dioxide and low concentration of oxygen.

- Also storing in sealed polythene bags containing ethylene absorbent like potassium permanganate.
- Shrink film wrapping or Waxol (12 %) treatment can extend shelf life up to 3 weeks.
- Bananas are not usually allowed to ripen on the tree;
- Smoking have to be done with straw leaves & cow dung in a closed chamber for 18-24 hours in summer and 48 hours in winter and later shifted to ventilated room for uniform ripening.
- The exogenous application of 100 ppm ethylene gas in an enclosed chamber for 24 hrs for will produce uniform colour and ripening.

RHIZOME AND SUCKER PRODUCTION

- The true stem of banana is technically tuberous rhizome.
- Botanical description of the bananas by various authors indicates that the banana stem should be regarded as a short rhizome.
- The mature rhizome is about 300 mm in diameter and has extremely short internodes covered externally with closely packed leafscars.
- The rhizomes should remain completely below the surface of the soil for stability of the plant.
- Production of banana suckers in large quantities is currently receiving attention in the wake of great demand for elite planting material.
- Besides, rapid multiplication of suckers in successful hybrids will enable their quick spread in short period.
- Suckers production in banana is influenced by a complexity of factors.
- Some authors reported that, the diploids ranked first in suckers production followed by triploid and tetraploid in the order.
- *Puer accuminata* diploids and triploids produced larger number of suckers than the *balbisiana* derivatives.
- The nutritional status of the mother plant has an overwhelming influence on sucker production.
- Among the cultivars, greater uptake of nutrients by a cultivar of the same ploidy level resulted in more sucker production.
- For instance, Anaikomban (AA among the diploids and Monthan (ABB) among the triploids showed higher uptake of nitrogen with resultant increase in the production of suckers.

PESTS AND DISEASES: Some of the important pests and diseases are listed here under.

PESTS

1. **Pseudostem borer**-most of the commercial cultivars are attacked by the borer. Exudation of plant sap is the initial symptom and blackened mass comes out from the holes bored by the larvae.
2. **Rhizome weevil**-Nendran is highly susceptible, damaged corms show feeding tunnels filled with mass of rotten tissues.
3. **Banana aphid**-vector of the virus disease bunchy top
4. **Fruit and leaf scarring beetle**-The beetle feeds on young leaves and skin of young fruits, occurrence is maximum in rainy season.

DISEASES

1. Panama wilt :

- Caused by *Fusarium oxysporium* F.sp *cubens*.
- It is the most severe and important disease of banana.
- Rasthali is highly susceptible cultivar.
- It is serious in poorly drained soil.
- Resistant varieties are Robusta & Dwarf Cavendish.

2. Leaf spot/Sigatoka :

- It is a fungal disease, initially presence of light yellowish spots on the leaves under severe condition formation of brown spots and later dies, turning light grey surrounded by a brown ring.
- The Gros Michel and Cavendish group are all (AAA) highly susceptible to sigatoka.
- While, all ABB clones are resistant.

3. Banana bunchy top virus (BBTV):

- Transmitted by aphid vector, *Pentalonia nigronervosa*.
- The dwarf banana cultivars are very susceptible.
- The leaves are bunched together like a rosette at the top, the margins are wavy and slightly rolled upward.
- Dark green streaks of the lamina or midrib.
- The plants are stunted and do not produce bunch of commercial value.

OTHER DISEASES ARE,

- Pseudostem heart rot,
- Diamond spot,
- Anthracnose,
- Cigar end tip rot,
- Crown rot,
- Bacterial soft rot,
- Bacterial wilt or moko disease,
- Banana streak virus,
- Banana bract mosaic virus etc., causing damage to banana plants.

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LECTURE -24**CITRUS***(Citrus spp.; Rutaceae; 2n=18)***INTRODUCTION:**

- Citrus is the leading tree fruit crop in the world. In India, citrus ranks second in area sharing 12.8% of the total area under fruit crops with 9.6% share in production. Under citrus group, mandarins are the most important, occupying 50% of the total area under citrus followed by sweet orange and limes.
- Citrus fruits are grown mainly in Maharashtra, Andhra Pradesh, Punjab, Karnataka and North-Eastern region.
- Citrus is micro-nutrient loving plant.
- Trifoliate orange: Resistant to Phytophthora and nematodes.
- “Limolin”: The glycoside which is responsible for bitter taste of citrus fruit juice.
- Nagpur mandarin was introduced in India in 1894 by Shriji Raja Bhosle.
- Kinnow can be grown in high density planting by using the cultivar “Troyer Citrange” as a root stock by spacing the plants at 1.8 x 1.8 m².
- Classification of citrus was given by Tanaka and Swingle.
- Grape fruit is also known as Forbidden fruit, breakfast food.
- Citron- Persian apple.

ORIGIN & DISTRIBUTION:

- South East Asia, tropical and sub-tropical regions of Indio-china.
- Major citrus growing countries are USA, Spain, India, Italy, Japan, Argentina, Mexico, Brazil, Morocco, Algeria, Greece, South Africa, Australia, Israel, Egypt, Jamaica, etc.
- Citrus trees are found growing in all the countries (30) between 40° N and 40°S latitudes. United States is the largest producer with 35-40% of world production.

CLIMATE AND SOIL:

- Grows well in dry semi arid climates producing good quality fruits.
- It can tolerate occasional light frosts.
- Optimum temperature range is 16-20°C within a range of 17-40°C.
- Annual rainfall of 500-775mm is optimum.
- Sweet orange can be grown in any well drained soils, sandy or clay loams are preferable.

SPECIES AND CULTIVARS

- The classification of citrus was done by two famous authorities on the subject.
- W.T. Swingle (USA) and T. Tanaka (Japan) are at two extremes.
- Swingle (1948) recognized only 16 species under the genus *Citrus* where as
- Tanaka (1954) described as many as 144 species. He failed to cover many forms of horticultural importance and many species of Japanese, Chinese and Indian origins have been denied.
- Swingle divided the genus *Citrus* into subgenera viz;
 - *Eucitrus* having 10 species and *Papeda* having 6 species.
- Tanaka's (1954) treatment although considered more comprehensive and detailed, contained excessive number of species, some of them being of doubtful validity.

- In the mandarin group alone, he described 35 species, resulting into much confusion and obviously to lesser practical utility.
- Tanaka divided the genus Citrus into two subgenera viz; Archicitrus having 98 species and Metacitrus with 46 species.
- Contrary to Swingle's opinion, citrus forms of hybrids and certain cultivars by Tanaka were questionable and might be avoided. It is accepted that the characters employed for identifying a valid species of citrus should be free from the environmental influence.

Major species of horticultural importance are:

1. MANDARIN GROUP:

Citrus reticulata: Chinese origin. Polyembryonic cultivars are Nagpur, Coorg, Khasi of India and Ponkan of China.

C. unshu: Japanese origin- seedless, cultivars are Satsuma mandarins of Japan and Owari, Kara, Silver hill.

C. deliciosa: Mediterranean origin- Polyembryonic cultivars- Willow leaf mandarin, Kinnow, King of USA and Blinda of Algeria.

C. nobilis: Indo-China origin, natural Tangor. Polyembryonic cultivars: Kunembo of Japan, King Orange of USA.

2. ORANGE GROUP:

C. sinensis: sweet orange Polyembryonic cultivars are Mosambi, Maltableed Red, Sathgudi, Valencia, Pineapple, Washington Navel Orange, Shamouti of Israel, Succari of Egypt, Dobra Fina of Spain, Mudkhed (bud mutant of Nagpur mandarin)

C. aurantium- sour orange.

3. GRAPE FRUIT AND PUMMELO GROUP:

- C. grandis* (*Pumelo*) – Monoembryonic. Malaysia and Polynesia origin. Leaves pubescent in lower surface, fruits in clusters. Cultivars are kaopan of Thailand and Buntan of Formosa.
- C. paradisica* (**Grape fruit**) South China origin, polyembryonic. Leaves non-pubescent, fruits solitary. Cultivars are Poser, Ruby, Marsh, Duncan seedless, Thompson, Red blush, Triumph, Sharanpur special.

4. ACID LIME GROUP:

- C. limon*: Lemon: weakly polyembryonic, cotyledons white. Cultivars are Eureka, Lisbon of USA, Feminello and Monactiello of Italy, Bernia of Spain. Lemon oil is very important.
- C. jambhiri*: rough lemon- polyembryonic Indian origin, cotyledons light green, popular rootstock, fairly tolerant to virus diseases.
- C. aurantifolia*: Acid lime or sour lime- Polyembryonic, cotyledons whitish- popular cultivar are Kagzi lime-susceptible to tristeza and canker.
- C. medica*: citron – Indian origin – Monoembryonic, Persisting style.
- C. karna*: Kharna Khatta- Popular rootstock, cotyledons white.
- C. limonica*: Rangpur lime-hardy- popular rootstock, tolerant to tristeza and also salt.

Other related wild species are:

- C. indica*- Indian wild orange with inedible fruits
- C. latipes*- Khasi papeda- cold tolerant.
- C. macroptera* – Melanasian papeda- has medicinal value
- C. ichangensis*- Ichang papeda- cold hardy, fruits inedible.
- C. assamensis*- Admajor (Gajanimbe)

Related genera:

Poncirus- **Trifoliate orange**, fruits inedible, Polyembryonic rootstock.

Fortunella: **Kumquat**- the species are margarita, japonica, errasiflora, hindsii- Polyembryonic plants ornamental with small oval fruits.

INTERGENERIC HYBRIDS:

- Citrange- Trifoliate orange x *C. sinensis*, cultivars are Troyer, Carriyo, Morton, Stonia, Rusk, Coleman.
- Citrange quat- Trifoliate orange (*Poncirus x citrus*), citrange x fortunella- trigenic hybrid (kumquat)
- Citrangedin: (*Poncirus trifoliata x C. sinensis*) x *C. mitis* (calamondin) – bigenic hybrid.
- Citrangor- citrange x *C. sinensis*
- Cicitrangle- citrange x *Poncirus trifoliata*
- Citrandarin- *P. trifoliata x C. reticulata* (mandarin).
- Citrumelo- *P. trifoliata x C. paradisi* (grape fruit).
- Citermon- *P. sp x C. aurantium*
- Citrumquat- *P. sp x C. japonicum x F. margarita* (kumquat)

Hybrids of fortunella (kumquat) are:

- **Procimequat**: *F. japonica x C. aurantifolia* (acid lime) x *F. hindsii*
- **Limequat**: *C. reticulata x F. japonica x F. margarita*.

INTRAGENERIC HYBRIDS:

- **Tangor** : *C. reticulata x C. sinensis*, cultivars are temple, clamentine, montreal, Umatilla, monoembryonic
- **Tangelo**: *C. reticulata x C. paradise*, cultivars are Orlando, Sampson, Seminole.
- **Lemonima**: *C. limon x C. aurantifolia*
- **Lemmonage**: *C. limon x C. reticulata*

SWEET ORANGE

- Second largest citrus fruit in cultivation and commercially grown in Andhra Pradesh (Ananthpur, Cudappah, Nalagonda, Mahaboobnagar and Chittoor district), Maharashtra- Marathwada, Ahmednagar, Pune and Nasik, Karnataka, Punjab, Haryana, Rajasthan.
- **CULTIVARS**: Blood red in Haryana, Punjab and Rajasthan-Jaffa, Hamlin, Pineapple- exotic, Mosambi in Maharashtra and Sathgudi in A. P

PROPOGATION:

- By budding (T or Patch) during January-March or September-October.
- Jatti Khatti (*C. jambheri x Karnakatta (C. karna)*) are popular root stocks for blood red in Punjab.
- Rangpur lime is popular rootstock for mandarins and sweet oranges.

LAND PREPARATION:**Planting:**

- Pits of 60 cm cube are dug and filled with soil + FYM + Carbofuron and planting is normally done during monsoon season, spacing is 6m x 6m.

Manuring:

- The bearing tree should be given the fertilizer dose at the ratio of 550gm: 370gm: 550gm NPK/plant/year, depending upon its performance.

- Graded dose of fertilizers can be applied from 1st year to 10th year.
- Fertilizers should be applied in a ring 30-40 cms wide just below the canopy of the tree at a distance of at least 1-2 m from the trunk.

IRRIGATION

- Irrigation requirements depend upon soil and weather conditions.
- Irrigations should be regular during fruit development.
- Water should never come in direct contact with the trunk of the tree; for this reason double ring or check bund method is best suited for this crop.
- Presently drip irrigation is becoming popular which helps in saving of irrigation water.
- Stopping irrigation 1 or 2 months prior to flowering is beneficial to the crop, till the tree withers and drops half of its leaves.

INTERCULTURE

- During the pre-bearing stage, vegetables other than solanaceous crops can be grown by taking care not to waterlog around the trunks.
- Leguminous crops are the best intercropping with 'peas' was found to improve the yield of sweet orange. Cucurbits also can be grown successfully.
- Weeds can be controlled with pre-emergence spray of diuron @ 3Kg/ha twice at 120 days intervals. Other weedicides used are simazine, atrazine, bromacil, 2, 4-D. etc.

PRUNING AND TRAINING:

- No regular pruning except removing dead, diseased and over crowding branches after harvesting of the fruit.
- Plants should be trained during first 3 years to have a well distributed frame work at 1mt height on a single trunk.

HARVESTING AND YIELD

- Sweet orange takes 9-12 months for maturity.
- Being non-climacteric should be harvested only after full maturity of the fruits.
- Harvesting seasons are Dec-Feb in North India, Oct-march in South India, Nov-Jan (Ambebahar), March-May (Mrigbahar) in central and western India.
- Yield varies from 500-2000 fruits/tree depending upon the variety, agro-climatic conditions and age of the tree.

POST-HARVEST HANDLING AND STORAGE

- Post-harvest handling consists mainly of washing, drying, storing, grading and wrapping in tissue paper and packing in corrugated boxes.
- Fruits can be stored for 20 days at room temperature by dipping in 500 ppm Benlate or 0.1 % carbendazim (Bavistin).
- Malta fruits can be stored for 2-3 months at 4.4⁰C Sathgudi for 4 months at 2⁰C and Mosambi for 3 months at 5⁰C and 85-90 % RH.

PHYSIOLOGICAL DISORDERS:

FRUIT DROP:

- Citrus drops flowers and fruits at different stages as a natural means of adjusting to its resources.
- These are normal and may not affect the yield.
- Pre-harvest drop of well grown fruits prior to maturity is a serious problem reducing the yield.

The main causes may be

- i. Climatic factors
- ii. Improper water management
- iii. Lack of nutrition
- iv. Relation of seed to fruit drop.

Control: Spraying 10 ppm 2, 4-D 2 months before harvesting. Fruit drop may be due to presence of pests and diseases also which can be controlled by spraying 1 % Bordeaux mixture.

2. MANDARIN:

- Mandarin occupies 50 % of citrus area in India.
- **Nagpur santras** are grown in satpur hills of central India, hilly slopes of Darjeeling and Coorg.
- **Kinnows**- Rajasthan, Punjab, Haryana, H.P, J & K and U.P, Wynad, Nilgiri, Palni and Shevoroy hills of South India, hills of Meghalaya, Mizoram, Tripura, Sikkim, Arunachal Pradesh and Brahmaputra Valleys.

CLIMATE AND SOIL:

- Mandarins grow well in frost free tropical and sub-tropical regions with an elevation of 370-1500m, average temperatures of 10⁰C-35⁰C and an annual rainfall of 100-1200 cms.
- Hot winds and severe heat during flowering and fruit set result in heavy loss of yields.
- Kinnow cultivar requires light chilling for good yields.

SOIL

- Mandarins grow in a wide variety of well drained soils but light loamy soils are best.
- It is grown in soil pH range of 4.5-9.0 depending upon region and type of soil, but 6.0-8.0 is an ideal pH.

CULTIVARS:

1. **Coorg:** Fruits medium to large, bright orange, oblate globose, base depressed, rind thin (matures during Feb-March) - Coorg and Wynad
2. **Khasi:** fruits depressed, globose to ovate, orange yellow to orange, smooth surface even based or short necked- grow in Assam, Meghalaya, and North Eastern states.
3. **Nagpur-** fruits medium, subglobose, coloured, smooth surface, base slightly drawn out (matures Jan-Feb) Nagpur is the most popular variety.
4. **Kinnow:** (King mandarin X William leaf) fruit medium oblate, base flattened, deep orange yellow, thin rind adhered to segments- irregular bearing, matures in mid January.

PROPAGATION:

- By seeds using nuclear seedlings and
- T budding on Rangpur lime, rough lemon, Cleopatra, Troyer Citrange, Kharna Khatta rootstocks.

PLANTING:

- Monsoon is the best season for planting.
- Pits can be of 50 cm cube.
- Spacing is 4-6m.
- Kinnow on Troyer Citrange can be planted at 1.8m spacing (3000 plants/ha).

MANURING:

- A fertilizer dose of 450 g of nitrogen, 450 g phosphorous and 900 g of potassium per plant in two split doses 1st dose in may and 2nd after harvest may be given from the beginning.
- As mandarin also shows micronutrient deficiencies, a composite spray of the following is recommended

Zinc sulphate	-	2.5 kg
Copper sulphate	—	1.5 kg
Magnesium sulphate	—	1.0 kg
Manganese sulphate	-	1.0 kg
Ferrous sulphate	—	1.0 kg
Boric acid	—	1.0 kg
Slaked lime	—	1.0 kg
Urea	—	4.5 kg

Dissolved in 450 liters of water and may be sprayed on new flush of growth once in a year.

IRRIGATION:

- Irrigations may be at 10-15 days in winter and 5-7 days in summer.
- Drip irrigation was found to be more beneficial.
- Water stress during growth, flowering, fruit set and development should be avoided.
- In south India, mandarins are grown under rainfed conditions in heavy rainfall areas.

INTERCULTURE:

- Pea, Cowpea, grams are beneficial intercrops for mandarins.
- Weeds can be controlled by application of diuron 5 kg/ha as pre-emergence and atrazine (5-6 kg/ha) as post emergence application.

TRAINING & PRUNING:

- Mandarins are better trained as low headed plants (50 cm) with single stem.
- Pruning in bearing trees is mainly to remove dead, diseased and overcrowding branches and water shoots and stock sprouts after harvest of fruits.

CROP REGULATION OR BAHAR TREATMENT:

- Under south and central Indian conditions, mandarin produces 03 flowerings in a year
 - February : Ambebahar,
 - June : Mrigbahar
 - October : Hastabahar
- Mrigbahar is preferred.
- Flower regulation is done by withholding water a month or two before flowering till the plants wither and drop some of their leaves.
- Then they are manured and irrigated which results in profuse flowering.

HARVESTING AND YIELD:

- Mandarin being non-climacteric should be harvested at right stage of maturity only.
- Mandarin starts bearing from 4 years but commercially yields can be obtained from 10-12 years.
- Harvesting season starts from August and extends upto April depending upon the locality and the variety grown.
- Yield may vary from 500-1000 fruits/plant. Dipping the fruits in 50 ppm ethrel develops golden yellow colour in 5 days.
- Mandarins can be stored for many months at 8-10°C and 85-90 % RH. Under room temperature, they can be stored well for 3-4 weeks.

CITRUS DECLINE:

- Tristeza a very serious viral disease causing various deficiency symptoms in leaves like leaf falling, root decay, dieback of shoots and finally the death of the tree.
- Trees normally produce heavy crops before dying.
- Citrus decline may advance in badly maintained orchards in ill drained soils and also due to malnutrition and insects and pests.
- Though, appropriate control measures are not available as a means of rejuvenating the declining plants, the following measures may be followed.
- Removing all dead wood before new growth starts and spraying Bordeaux mixture and covering all cut surfaces with Bordeaux paste.
- Applying more organic manures to the plants
- Regularly following the recommended plant protection and spraying 0.3 % zinc sulphate and B. M. whenever new growth appears.
- New plantations should be with plants grafted on Rangpur lime which is reported to be highly tolerant to tristeza.

GRANULATION:

- Mosambi, Hamlin and blood red cultivars are mostly affected by this disorder.
- Granulation is drying up, becoming hard with greyish colour and enlargement of the juice vesicles with increase in pectin, lignin, etc. resulting in reduction of the juice content.
- This occurs more in young vigorous trees than old trees.

Factors affecting granulation are:

- Climate (humid)
- Cultivars
- Rootstocks
- Mineral nutrition
- Enzymes and plant growth regulators
- Crop load

Control: no successful method, but the following can be tried as remedies.

- Spraying lime, ZnSO₄, Bordeaux mixture or ZnSO₄ + CuSO₄ (0.5%).
- Early picking
- Reduced irrigations
- Spraying 200-500 ppm lead arsenate

PHYSIOLOGICAL DISORDERS:

FRUIT DROP:

- A mandarin also drops the flowers and fruits at different stages adjusting to its resources.
- But preharvest fruit drop reduces the yield.
- It can be controlled by proper cultural management and treating with 2, 4-D (10ppm) or NAA (5ppm) or 2, 4, 5-T (5ppm) and Aureofungin 20 ppm to check any fungal diseases.

GRANULATION:

- A physiological disorder causing drying up, becoming hard with grayish color and enlargement of the juice vesicles with increase in pectin, lignin, etc. resulting in reduction of the juice content.
- This occurs more in young vigorous trees than old trees.
- It can be reduced by spraying lime, reducing irrigations and application of 2, 4-D (12ppm) or $ZnSO_4$ + $CuSO_4$ mixture (0.5 %).

DECLINE: It occurs in mandarin.

3. LIMES AND LEMONS

- India is the largest producer of acid limes in the world, but ranks fifth in the production of limes and lemons.
- Acid lime is the third important citrus fruit after orange and mandarins.
- It is cultivated in almost all states A.P, Maharashtra, T. N, Karnataka, Gujarat, Bihar and H.P, are the major ones.
- Lemons are commercial in Punjab, Rajasthan and Uttar Pradesh.

ORIGIN: Limes –India; Lemons –Malaya

CLIMATE AND SOIL:

- Acid lime grows well in areas which are free from frost, strong winds and are warm and moderately humid.
- Can grow upto 1000m elevation with annual rainfall not exceeding 750 mm.
- Sweet limes can tolerate frost better than acid lime.
- Rangpur lime grows well under areas with 20-30°C.
- Lemons can be grown in both humid and semi humid areas upto 1200m elevation and tolerate frost better than acid lime.
- Lime grows well in deep (2-2.5m) well drained soils rich in organic matter.
- Optimum pH is 6.5-7.0 it can not grow in water logged soils, alkaline soils with high lime content. Lemons grow better in shallow soils also if well drained.

LIMES

Varieties: Kagzi lime is the best most popular one. Some of the improved varieties of limes are: Pramalini, Vikram, Saisarbat- supposed to be canker free and prolific bearers.

- **Chakradhar:** seedless strain of acid lime, PKM-1 heavy yielder.
- **Selection 49:** tolerant to canker, tristiza and leaf miner. It is also a prolific bearer.

- **Seedless lime:** fruits are oblong-prolific bearer. Tahiti lime- plants nearly thornless, leaves much larger of different shapes- fruits also much larger- triploid.
- **Mithachikna (Thin rind) and Mithotra (Thick rind):** Two varieties of sweet lime with less acid, sweet fruits and are mostly used as stocks. Rangapur lime is grown for root stock purpose.

LEMONS

- **Eureka:** Fruit elliptic to oblong, base necked and heavy yielder.
- **Lisbon:** Fruits oblong, apex nipped
- **Villafranka:** Fruits oval-oblong, apex pointed, bear more seeds.
- **Lucknow seedless** (Assam lemon): Fruit oblong, apex nipped. seeds few or absent.
- **Nepali round:** nipple has a scar.
- **Kagzikalan:** fruit spherical, apex slightly nipped.
- **Plant lemon 1:** Selection of Kagzi kalan tolerant to canker tristiza and die-back-self compatible.

PROPAGATION:

- Acid lime is propagated by seeds selecting the nucellar seedlings.
- But budding on Rangpur lime preferable.
- Sweet limes can be propagated by sub-terminal stem cuttings or layerings or budding.
- Lemons by budding on trifoliate orange or Rangpur lime (*Citrus limonica*).

PLANTING:

- It can be done before or after rains during the rainy season depending upon amount of rainfall.
- Spacing should be 4-6m for limes, and 6-8m for lemons.
- Pits can be of 1 m cube and filled with mixture of soil and manure.

TRAINING AND PRUNING:

- Limes may be trained as low headed plants.
- Pruning is mainly to remove dried, diseased and overcrowding branches.
- Grownup lemons may be given light pruning every year to remove already fruited shoots.

MANURING:

- Fully grown lime may be given 5 kg FYM, 900g N, 250g P and 500g K per plant per year.
- Total P, half of N and total K after rains and remaining dose should be given after flowering.
- Organic manures are more preferable than chemical fertilizers.
- Lemons may be given 500g N/plant/year only.
- Composite spray of micronutrients as given for sweet orange may be given once a year on the new flush.

IRRIGATION:

- Limes require more water; irrigation may be given if top 25cm soil becomes dry.
- Check bund system is best as it will not allow the contact of water with the stem.
- Drip irrigation improves yield.

INTERCULTURE:

- Mulching basins will be very beneficial.
- Weeds can be controlled by using weedicides like Monouron, Diuron, Gramaxone, etc.

HARVESTING AND YIELD:

- Harvesting season extends from January-September depending upon the locality for acid lime and May for lemons and June-Aug for Rangpur limes.
- Lime yields 2000-5000 fruits/plant.
- Acid limes can be stored for 6-8 weeks at 8.3 to 10.0⁰C and 85.9 % RH and
- Lemons for 8-12 weeks at 7.2-8.6⁰C and 85-90 % RH.

CITRUS CANKER:

- A serious disease in acid limes caused by gram negative bacterium.
- The symptoms on the plants comprise water soaked patches appearing on all the parts, and finally ending in necrotic brown corky tissue.
- The disease spreads with the aid of leaf miner, rains and even wind.

CONTROL MEASURES:

- **No effective control only by** controlling the leaf miner reduces the spread.
- Pruning diseased parts and spraying Bordeaux mixture may be of some use.
- Streptomycin sulphate 500ppm or Streptocycline on new flushes will give effective control.

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LECTURE -28**GUAVA***(Psidium guajava; Myrtaceae; 2n= 22)*

- GUAVA (Amrud) is one of the most common fruits in India.
- It ranks 4th in area and production after mango, banana and citrus.
- It is a very hardy sub-tropical plant, prolific bearer. In India, it is commonly called as “poor man’s apple” widely naturalized in the country. Allahabad has the reputation of growing the best guava in the country as well as in the world.

COMPOSITION AND USES:

- The fresh fruits are very rich in vitamin C (100-260 mg/100g pulp). Vit-A, B₂, and minerals like Calcium, P, acidity 2.4 %, carbohydrates 9-10 %, TSS-13 %, pantothenic acid, riboflavin, thiamin and niacin, also rich source of pectin.
- The fresh ripe fruits are used as table/salad fruits.
- Fruits are rich in pectin. The best quality jelly can be prepared; fruits can be canned in sugar syrup or made in to fruit butter, juice preparation and in ice-creams.
- The leaves yield a dye and are used in dyeing industry and also have medicinal values for curing diarrhea.

ORIGIN AND DISTRIBUTION:

- A native of tropical America.
- Guava was spread rapidly throughout the world’s tropics by the Spanish and Portuguese.
- The major guava producing countries are South Asian countries, the Hawaii Islands Cuba and India.
- In India it is grown in 1.30 lakh hectares in Uttar Pradesh (largest area and production), Bihar, M.P, Maharastra and Andhra Pradesh.

SOIL AND CLIMATE:

- Being very hardy, is grown successfully in wide range of soil like light sandy loam, clayey, deep, rich alluvial with the pH of 4.5- 8.2.
- It is the fruit crop of sub-tropical region; the young plants are susceptible to drought and cold.
- The trees are very hardy and can withstand heat and prolonged drought.
- A cool winter induces heavy fruiting and produces good quality fruits.
- The rainfall of 100cm with uniform distribution is ideal for production.
- The optimum temperature lies between 23-28⁰C and can be grow up to 1500m above mean sea level.

SPECIES: There are more than 150 species available in guava and some of the important species are

1. *Psidium guajava*- It is the commercially cultivated species, rest of them do produce fruits but small size, inferior quality and with high acid content.
2. *P. guineense* – Guinea guava – has small fruit with poor quality.
3. *P. guajava* var. *aromaticum*- small scented fruits.
4. *P. pomiferum* – Fruits are round.
5. *P. pyriferum*- Fruits are pear shaped.
6. *P. cattleianum*- The strawberry guava with round red fruits.
7. *P. friedrichsthalianum*- Chinese guava with small and globose fruits having high acid content and resistant to wilt.

Varieties:

1. **L-49 (Lucknow-49)** : It is prolific bearer, greenish yellow with milky white sweet pulp and rough surface. Shell is fairly thick, contains fairly soft few seeds in inner portion of pulp. Since the number of seeds is less, keeping quality is medium; it is very popular in Maharashtra and Andhra Pradesh. It is suitable for table purpose and yields about 25t /ha.
2. **Allahabad Safeda** : This is the most famous variety grown in Uttar Pradesh for table purpose. Tree is medium in height (5.8-6.5m) with vigorous branching and dense foliage. Fruits are medium in size (180g), round in shape with few seeds. Fruit is white fleshed with good keeping quality.
3. **Chittidar** : The Chittidar is similar to the Safeda except that, it has many pinkish red dots of the pinhead size on the surface of fruit.
4. **Red Fleshed** : Tree attains 3-5m height. The branches are spreading with roundish oval fruit, which has yellowish skin with pink colour flesh.

**Hybrids:**

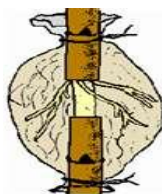
5. **Arka Mridula** : This hybrid was obtained by crossing of Seedless x Allahabad safeda. Plants are semi-tall in nature and spreading. Fruits are round in shape and weigh about 180g. Skin is yellow in colour and smooth. Flesh is white in colour. The TSS is around 12° Brix. Fruits are soft seeded and have a good keeping quality. It is good for processing due to high contents of pectin (1.041%).



Other hybrids released from Fruit research station, Sangareddy, Andhra Pradesh are

1. Safed jam- Allahabad safeda X Kohir
2. Kohir safeda- Kohir X Allahabad safeda

PROPAGATION: Commercially guava is propagated by grafting /Air layering/Ground layering.



Air layering in Guava

RAISING OF SEEDLINGS:

- Rootstocks are raised from the seeds extracted from healthy fruits and stored for 100 days by treating with ferulic acid at 10^{-3} Molar concentration.
- Potassium nitrate also used at 1 per cent to prolong storage of seeds.
- The seedlings will be ready for grafting in 45-60 days after sowing.
- The layers should be treated with IBA @ 10,000 ppm for better rooting.

PLANTING:

- Planting is done during monsoon at a spacing of 6m x 6m by opening 90cm³ pits
- Filled with 30-40 kg FYM, dried leaves and 1 kg SSP.
- After planting they are supported by stakes.

IRRIGATION:

- Immediately after planting, plants are watered.
- During summer and winter season orchard is irrigated at an interval of 4-6 and 10-15 days, respectively.

MANURING:

- The tree should be provided with 25kg FYM/plant, at the time of planting,
- the fertilizer dosage should be given based on the age of the plant.
- Following are the fertilizers recommended in major guava growing states of India.

State	N (g/plant/ year)	P (g/plant/ year)	K (g/plant/ year)	Fym (kg/plant/ year)
Karnataka	300	120	150	25
Maharashtra	600	300	370	12-15
Andhra Pradesh	210	160	300	60
Tamil Nadu	1000	1000	1000	50
Uttarpradesh	350	250	350	----

- Fertilizers are applied in 2 splits i.e. half of N and full of P and K during bahar treatment and remaining half of N 1-1½ month after first application.
- Foliar application of urea (3 %) along with Calcium, Phosphate and Muriate of Potash (KCl) at 1 per cent could increase the yield. The deficiency of micronutrients such as Zn and B are rectified by spraying with ZnSO₄ (0.3 per cent) and Boron – Boric acid (0.4 %) before flowering.

BRONZING:

- Fatio disease:** The leaves turn to pale or purple color, small size leaves, sparse flowering, death of growing tips, ultimately plant dies.
- It may be due to the deficiency of NPK, Zn, Mg and low pH, spraying of 0.5 % DAP and ZnSO₄ during Oct-Nov at weekly intervals.

INTERCROPPING:

- During pre-bearing age, some of the fruits and vegetables can be taken as the remunerative crops i.e., Leguminous vegetables or green manuring crops are grown during first 1-2 years.

WEED MANAGEMENT:

- Weed is a problem at the early stage of growth, for conservation of moisture, proper utilization of nutrients as well as for effective control of pests and diseases weed free environment is essential.
- Integrated weed management programme should include growing of cover crops, use of herbicides, inter cropping and hand weeding where ever necessary.

TRAINING & PRUNING:

- Training is done primarily to give form to the tree.
- For development of a strong framework, the first 60 to 90 cm from base of the trunk should be cleaned followed by 4 to 5 scaffold branches at an interval of 20-25 cm.
- When the plants attained a height of about 1.5m to 1.8 m, it is headed back to make the center open.
- In some parts of India (Maharashtra and South Bengal), the branches are bent down ward and tied to each other. Thus forcing the dormant buds to grow. This results in increased yields.
- The trees are rarely pruned in North India, but light annual pruning after harvesting to promote vegetative growth and flowering is desirable.
- All dead, diseased, crowded growth and suckers sprouting from the base and sides of the framework are pruned back annually.
- Pruned trees give larger fruits and early ripening.

FLOWERING AND FRUITING:

- Guava tree flowers throughout the year, but the peak flowering is observed in 2 season, rainy crop (April-May) and winters crop (Aug- Sept).
- Flowers are produced in leaf axils or in cyme the period of flowering varies from 25-45 days. Honey bees are the pollinators.

FLOWER REGULATION:

- Bahar treatment expand, root exposure, with holding water and also deblooming the rainy season crop due to insipid taste of the fruits and inferior quality.
- So winter crop is generally desirable.

FRUIT SET:

- Only 35-50% fruits are carried to maturity though initially 80-86% fruit sets.
- In seedless variety, it is as low as 6 %, to improve fruit set GA₃ at 200ppm.
- Fruits take 105-140 days to mature from fruit set.
- Spraying GA₃ at 1000-8000 ppm is suggested to improve fruit set.

HARVESTING:

- Guava, being a climacteric fruit, it ripens after harvesting;
- The fruits are harvested throughout the year (except during May and June) in one or the other region of the country.
- However, peak harvesting periods in north India are August for rainy season crop, November-December for winter season crop and March April for spring season crop.
- In the mid climatic conditions of other parts of the country, the peak harvesting periods are not so distinct.
- Change in colour of fruits from dark green to pale green is the indication of maturity;
- The fruits are harvested at their full yellow but firm for local market, whereas half yellow fruits should be picked for distant markets.
- The fruits are harvested selectively by hand along with the stalk and leaves.

YIELD:

- The tree reaches its peak bearing stage with in 15 to 16 years after planting.
- A mature tree yields about 90-150kg fruits or 10-15t/ha.
- Sardar variety gives about 25t/hectare.

POSTHARVEST HANDLING AND STORAGE:

- Because of their perishable nature, guavas are disposed off immediately after harvesting in the local market and a very small quantity may be sent to distant market if they are not kept in cold storage.
- However, the shelf-life of guava can be extended up to 20 days by keeping them at low temperature of 5°C and 75-85% RH.
- It can also be stored for about 10 days at room temperature (18° -23°C) in polybags, providing a ventilation of 0.25%.

IMPORTANT PEST AND DISEASES

PESTS:

1. **Fruit fly**- *Chaetodacus spp*- It is severe during rainy season crops
 2. **Mealy bugs**- *Cryptolems spp*.
- The other insect pests causes problems to this crop are scale insects, Tea mosquito, shoot & bark borer.

DISEASES:

1. Guava wilt - *Fusarium spp*.
2. Anthracnose - *Colletotrichum psidii*- It is also severe during rainy season crops.
3. Fruit canker - *Pestlotia psidii*.
4. Cercospora leaf spot - *Cercospora sawadal*

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LECTURE- 23

GRAPE

(Vitis vinifera; Vitaceae; 2n=38)

- Grape is an important sub-tropical fruit crop in India. The average productivity of grape in India is 16.95 t/ha, the highest in the world.
- The genus *vitis* is sub-divided into two sub-Genera, *Muscadinia* and *Euvitis*. The *Muscadinia* have 40 chromosomes while that of *Euvitis* have 38.
- *Vitis vinifera* is the most popular species of grapes grown in the world. *vinifera* grapes have forked tendrils and shiny leaves.
- *Vitis riparia*, *rupestris*, *berlandieri*, *candicans*, *rufotomentosa* and *solanis* are popular rootstocks for phylloxera and nematode resistance.

USES: Grapes are used for;

(1) Table purpose:

Table grapes are meant for fresh fruit consumption. These grapes are attractive in appearance and eating quality and with good shipping and keeping qualities. Most of the varieties grown in India are table fruits. The important table grape varieties are Muscat Hamburg, Cardinal, Perlette, Thompson seedless (Sultanina), Tokay, Concord, anab-e-shahi, pusa seedless, Delaware, Catawba, Ohanez, Red Malaga, Emperor, Italia, Muscat of Alexandria, etc.

(2) Raisin making

These are the grapes intended for making dried grapes. The raisin variety of grapes should have soft texture, seedlessness with good sugar content, marked pleasing flavour, large or very small size; and little tendency to become sticky in storage. The varieties most extensively used in the commercial production of raisin include Thompson seedless (Sultania, Oal Kishmish), Seedless sultana, Red Corinth, Cape Currant and Black Monukha.

(3) Juice making

The varieties of sweet juice grapes produce juice of acceptable beverage. The juice should retain the natural fresh grape flavour throughout clarification and preservation. In United States of America the Concord grapes are in general for Juice. The varieties White Riesling and Chasslas Dore are used for juice in the central Europe. The varieties Aramonand Carignan are utilized for sweet juice in France.

(4) Wine making and canning

Most of the vineyards in Europe, North Africa, South Africa, and South America, Australia and United States of America produce wine grapes. Wines are classified as table wines and desert wines. Table wines contain less than 14 per cent alcohol while the desert wines have more than 14 per cent alcohol, usually 17 to 20 per cent sugar acid ratio, total acidity and tannin content etc., will determine the wine quality. The varieties such as White Rieslin, Chardonnay, Cabernet Sauvignon, Tinta Maderi and Muscat Blanc (Muscat canelli) produce wines of high quality, outstanding in bouquet, flavour and general balance (Winker, et al. 1974).

(5) Canning Grapes

Seedless varieties like Thompson Seedless and canner are generally canned in combination with other fruits. The varieties grown in Tamil Nadu belong to 'table' grapes. Pachadraksha, Muscat ("Panneer"), *Anab-e-shahi* & Bangalore Blue are the main varieties

ORIGIN AND DISTRIBUTION:

- Asia minor- it is between Caspian & black sea.
- Major world producers of grape are Spain, Italy and France.
- In India, grapes are grown in about > 63,000 ha with a production of about 16.67 lakh tonnes.
- Major grape growing states are Maharashtra (21,000 ha), Karnataka (5500 ha), TN (2475), Punjab (2400), AP (2500), Haryana, UP & M.P.

SOIL AND CLIMATE:

- Can be grown in wide range of soils if climate is suitable.
- Sandy loam with good drainage, fairly fertile with good organic matter is best suited.
- Optimum pH with good organic matter is best suited. Optimum pH is 6.5-7.5.
- Heavy soils, very shallow soils, ill drained alkaline soils are not at all suitable.
- Grape grows well in all areas with warm to hot dry summers and cool winters.
- Showers or rain flowering is very dangerous to grapes and reduces yield to a greater extent.
- Optimum temperature range is 28-32°C.

Cultivars: There are thousands of cultivars of grapes. Most popular ones are:

Coloured seeded grapes: - Bangalore Blue - a cross between *V. vinifera* x *V. Labrusca*- table, juice, wine

Table: Characters of Vitis and Muscadinia

Characters	<i>Vitis</i>	<i>Muscadinia</i>
Shoots	Bark is longitudinally striate, fibrose	Tight bark, non-shedding, with prominent lenticels
Pith	Interrupted in nodes by a diaphragm	Without diaphragm
Tendrils	Forked	Simple
Flower clusters	Elongated	Short, small
Berries	Adhering to the cluster at maturity	Detach one by one they mature
Seeds	Pyriform with long or short beak	Oblong without beak

Kishmish charni, Black champa - processing & for hybridization purpose only.

Coloured Seedless: Beauty seedless (blue, black) for mid-season; Krishmish Charni (brick red) for mid-season (Sharad seedless); Flame seedless (Purple) - late cultivar.

White seeded: Anab-e-shahi-late; Dilkush-clone of AES; Cheemasahebi (Selection from Pandari sahebi) are late cultivars.

White seedless: Perlette (Scolokertekhirolaynoje x Sultania marble).

Pusa Seedless: Superior than perlette (Mid); Thompson Seedless- midseason, Tas-e-Ganesh, Manik Chaman, Sonaka are clones; Arkavati- BlackChampa x Thompson Seedless-late type; Delight-Sister seedling of perlette- early type; Homorod- Contariox Sultania.

PROPOGATION: Propagation by hard wood stem cuttings, cuttings treated with IBA improves rooting. Single bud cuttings also can be rooted by keeping the base of the cutting at a constant temperature of 18-20°C for 2-3 weeks.

While, using root stocks, grape can be propagated by chip budding or grafting.

Phylloxera resistant rootstocks are- Riparia Gloire - Selection from *V. riparia*; St. George - Cultivar of *V. rupestris*; 4x2 (Ganzian)- (*V. vinifera* (Aromon) X *V. rupestris* (Gonzin); 1202- (*V. rupestris* and *V. matoara*); 99- (*V. berlandieri* X *V. rupestris*).

Nemotode resistant rootstocks are: Dogride- cultivars of *V. champin*; Salt creek, 1613- 1616- (*V. solonis* X *V. paria*); Telecki 5A- (*V. berlandieri* X *V. riparia* 5A 1616); Solonis 1616- suitable for saline & wet soils;

CULTIVATION

LAND PREPARATION:

1. SOIL SOLARISATION:

- Soil solarization of the planned vine row can also significantly reduce weed populations. The soil must be moist and the width of the solarized area should be at least 6 feet. Bury all sides of the plastic to create a seal on the soil; this also helps to prevent the plastic from being blown away by wind. Machines that lay down the plastic are available to automate the process.
- Solarization must be done during summer and should be started at least by the beginning of August to have sufficient time (4 to 6 weeks) to complete the process. Clear plastic or a plastic with a coating that suppresses weed seed germination can be used. Black plastic suppresses weed seed germination but will not heat the soil sufficiently for solarization. Plastic mulches may not be successful in suppressing species like nutsedge.

2. MULCHES

- Mulches can also help with weed control in the vineyard. The mulch blocks light, preventing weeds germination or growth.
- Many materials can be used as mulches including municipal yard waste, wood chips, straw, hay, sawdust, and newspaper.
- To be effective, mulches need to block all light to the weeds; therefore different mulch materials vary in the depth necessary to accomplish this.
- Organic mulches must be maintained in a layer 4 or more inches thick.
- Organic mulches breakdown with time and the original thickness typically is reduced by 60% after one year. Cover crops can be grown in the middles; in the spring "mow-and-throw" the mulch in around the base of the vines.
- Weeds that emerge through the mulch can be controlled using an organic contact herbicide or with hand hoeing.
- Do not plant cover crops under the vine row because excess competition may occur, possibly reducing grape yields.

3. WEED MANAGEMENT:

- It is critical to have minimum or no weed competition at the time of planting new vines so weed control before planting is important.
- Take measures to deplete the soil weed seed bank. A summer fallow treatment of irrigation followed by tillage and then drying can reduce weed seed numbers in the soil. Repeat this cycle several times to further deplete weed seeds in the soil. Weed seeds located in the surface 4 inches of soil can be buried to depths where they cannot emerge with a soil-inverting plow such as a Kverneland plow; a moldboard plow will not sufficiently invert the soil to be effective.

HERBICIDES

- Several organic, contact-type herbicide products are registered for use.
- These soap-based (Scythe), clove oil based (Matran 2), or acetic acid based (All-Down) products all damage any green vegetation contacted, including the leaves and young stems of grape vines.
- Apply these products as directed sprays against woody stems and trunks. Because these herbicides only kill contacted tissue, good coverage is essential. Thus, adding an organically acceptable surfactant is recommended. Because these materials lack residual activity, repeat applications will be needed to control new flushes of weeds.

Planting:

- Pits can be of 1 m cube and filled with mixture of soil and manure.
- One year old plants need to be planted.
- Spacing varies according to the method of training and variety from 1.2 to 5.0 m x 2.5 to 6.6m.
- Pandal system requires maximum spacing.
- As the plant grows staking should be provided.
- Best time for planting is Jan-Feb for rooted cuttings and October for unrooted *insitu* planting.

Manuring: Average crop of grape removes 40-60Kg N, 10-15 Kg P and 50-70Kg K per ha from the soil.

Manurial schedule for grapes :**Anab-e-shahi:-**

- N-150kg /ha during April, 50 Kg (May) + 100 Kg (Oct) + 100 Kg (Nov) 100 kg (December);
- P-120 Kg/ha (April) 100 Kg (May) 200kg Oct. ;
- K -300 kg (June), 100 kg Oct, 200kg Nov, 200 kg December, 200 Kg January.

Thompson Seedless:

- N-100kg (April) + 100kg Oct+ 50 Kg (Nov)+ 50 kg December.
- P- 200 Kg (April) + 100 (May) + 200 Kg October.
- K-300 kg June+ 100 Kg Oct+200 Kg Nov+200 Kg December +200 Kg January.

North India:

- N-250 Kg Feb+ 350 Kg March + 100 Kg Oct/ha.
- P-800 Kg April + 400 Kg May.
- K-400 Kg May + 400 Kg June+200 Kg October.
- 60 g urea + 125g Mp are recommended for newly planted plants in April & June.

	<u>April Pruning:</u>	<u>October Pruning:</u>
• Anab-e-Shahi	200:300:300kg/ha	300:200:700 kg/ha
• Thompson Seedless	100:300:300 kg/ha	200:200:700 kg/ha.
<ul style="list-style-type: none"> • Application of fertilizers should be done starting from 1st month after pruning, because the roots will active after the pruning only. • Foliar application of micronutrients specially Iron, Zinc, Boron, Manganese at preblossom and blossom stage were reported to improve quality and quantity of yield. 		

IRRIGATION:

Grape requires less water during fruit bud formation and more water during berry growth. Reduced irrigations during ripening improve the quality. Drip irrigation is becoming more popular.

Water requirements under drip are:

- 1-40 days after summer pruning -48000-60,000 liters/day/ha
- 41-100- days after summer pruning-24000-32,000/litres/day
- 101-winer pruning days after summer pruning- 15000-20,000 liters/day
- 1-45 days after winter pruning 20,000-24,000 liters/day
- 46-75 days after winter pruning -20,000-24,000 liters/day
- 76-100 days winter pruning 48,000- 60,000 liters/day
- 101- harvest summer pruning 36000-48000 liters/day

INTERCULTURE:

- Daincha and sun hemp can be grown as intercrops to check weed growth. Paraquat (7.5 l/ha) as post emergence application controls weeds effectively.
- Pandal system discourages weed growth to maximum extent. Mulching with paddy husk will reduce weed growth, water requirement and improves the quality of yield.
- Spraying with CCC at 500ppm at five leaf stage after back pruning increases fruitfulness.
- 22-25 days after for pruning spray with GA₃ at 10ppm will elongate the clusters.
- Dipping of clusters in 60ppm GA₃ at bajra grain to red gram sized berries increases berry size.
- Girdling the fruit bearing shoot also improves berry size.
- For production of one gram of grape fruit 16-26 cm² leaf area is requires.

TRAINING AND PRUNING**TRAINING**

- The training of the vine depends on two fundamental factors viz.,
 - the growth characteristics of a variety and
 - the influence of the local climate on the growth of the variety.
- In addition, the training system selected should take cognizance of economic aspects also, such as the initial outlay on erection, subsequent maintenance and cost of production of the crop.
- Defective training may result in delayed bearing and irregular development of vines resulting in reduced yields.
- The reduction, in yield may also be due to the failure to utilize properly the full vigour of the vines.

Training system adopted widely in India is the **BOWER SYSTEMS**.

- Ever since the introduction of grapes in Tamil Nadu, the grape has been trained in overhead arbours or Pendants system.
- The height of the bowers is however very low and the root effect of the stakes is an objection. Recently, growers are going in for stone and cement pillars or even G.I. tubes.
- The overhead canopy is made of either thin bamboos (2 to 2.5 cm) or G.I. wires of different thickness, (8 to 16 in gauge).
- The cross piece connecting the pillars are made of thick bamboos or trek-wood or palmyra rafters or iron tubing.
- The wires are spaced (30 x 45 cm) or 30 x 30 cm. apart forming a network.
- The rooted cutting planted in the field reaches a height of 180 cm. (6 feet) in about three months.
- When the main stem is pinched at the top that is about 15 cm below bower.
- Two to four side shoots are allowed to grow and are trained on either side of the trunk or on four sides to from the arms subsequently.
- These side shoots or main arms as they are called are allowed to reach the periphery of the pandal and they are then tipped.
- On these arms secondaries are produced and allowed to grow on the main arms at intervals of 45 cm from each other alternately in opposite directions.
- These branches are trained to cover the framework uniformly.
- These secondaries in turn give rise to 'tertiaries' on which canes develop and produce the shoots carrying, bunches.
- Some growers allow only one arm to develop in one direction with the secondaries spaced at

convenient intervals.

- Many of the growers allow the arms to grow long and unchecked, twist them back so that the vine is full of wood of all kinds and it is difficult to train the vine properly.

The advantages of the Pandal system of training are as follows:

- The climate prevailing in India affords full scope for the vine to grow as luxuriantly as possible. Consequently, it facilitates harvests of a succession of crops at intervals of 4 $\frac{1}{2}$ - 5 months.
- The crop gets enough sun shine uniformly for their proper development.
- Plant protection measures are more effective in this system, especially against mildew.
- The comparative study was undertaken at the Agricultural College and Research Institute, Coimbatore and at Fruit Research Station, Periyakulam, with the varieties *Anab-e-Shah* and *Pachadraksha*.
- In the variety *Anab-e-Shahi* the pandal system produced maximum number of shoots per vine and per acre.
- The proportion of well-developed shoots to weak ones was higher in the pandal and the signal stake system than in the kniffin system.
- The vine vigour as shown by the weight of prunings per acre was the highest in the pandal system followed by the kniffin system.
- Pandal system produced more than three times as many fruiting canes per vine as other two systems:
- The percentage increase of fruiting canes over the single stake system, when calculated per acre, for the pandal and kniffin systems is 79 and 19, respectively as shown below.

Table: Effect of different systems of training on fruiting canes

System of training	Vine density per acre	Mean No. of spurs calculated per acre		% increase over single stake system	
		Fruiting	Renewal	Fruiting	Renewal
Pandal	268	27,952	13,427	179	124
Kniffin	806	18,407	20,392	119	188
Single stake	537	15,519	10,847	100	100

- From the point of fruit production, the pandal system is found to be superior both in vine yield and acre yield to the kniffin and single-stake systems and the single stake system was slightly more productive than kniffin system.
- The percentage increase of crop production over kniffin training is 263 for pandal and 40 for single-stake.
- It was also observed that the pandal system encouraged maximum development of berries, bunches and ultimately yield than the other systems.
- Fruit quality was not influenced by the system of training and the duration of the crop was also not changed by the system of training.

Table: Efficacy of different system of training on productivity of grapes

System of training	Spacing (m)	No. of vines per acre	Yield per acre (kg)	%. increase over kniffin system
Pandal	6 x 3	268	6,531	263
Single Stake	3 x 3	537	2,550	140
4-arm	3 x 2	806	1,313	100

- Thompson Seedless, Beauty Seedless and Himrod;- among the training systems, bower gave higher yield which was 146, 1.70 and 3.05 tonnes more than telephone, kniffin and head systems, respectively.

Chadha (1984) remarked that research on training in other country has been given a major emphasis, whereas in India only conventional systems are evaluated and no innovations in this regard have been tried. This aspect therefore needs priority attention and newer systems of training are required keeping in view the following points.

1. Adequate ventilation and light interception.
2. Orientation of the shoots either vertically or diagonally for greater exposure to light.
3. Economy and vine productivity.
4. High density planting.

DIFFERENT TRAINING SYSTEMS ARE DESCRIBED HEREUNDER.

SINGLE-STAKE SYSTEM

- A single shoot is allowed to develop from the vine of rooted cuttings and is trained vertically by staking to a support.
- When this shoot reaches a height of 120 cm it is tipped and allowed to produce 4 to 5 secondary branches or canes, which are pruned after every bearing season.
- The main stem and the primary laterals are supported by a bamboo post planted nearby.

FOUR-ARM KNIFFIN SYSTEM

- In this method, the vine is allowed to put forth a single shoot which is trained erect and tipped at a height of about 45 cm from the ground level.
- Only three shoots are allowed to grow from this point, all others being removed.
- Two of the retained shoots are trained horizontally and the remaining is trained vertically to a height of another 60 cm.
- When it is tipped to a height of another 60 cm.
- When it is tipped again to produce two more shoots, which are trained horizontally.
- All the four horizontal arms are supported by bamboo poles or wire tied horizontally to posts fixed at regular intervals of 3 metres.
- Primary laterals are allowed to develop from these four main arms at fairly regular intervals and these are pruned to produce the crop every season.
- For every fruiting cane, a renewal spur of 2 to 3 buds is left.
- Normally only four canes are allowed in the 4-cane kniffin system and 6 canes in the 6-cane system. Under tropical conditions it is possible to have doubled the number.

WIRE TRELLIS SYSTEM

- In this system two or three wires are strung in rows from vertical posts.
- A single stem in between the posts is trained as far as the top of the wire 2.1 m and two arms are allowed to develop along the wire on either side.
- Each arm will meet the arm from the adjacent vine and will have two arms with six teritaries.
- The spurs on the fruit bearing shoots growing on these canes are seasonally pruned for fruit every year.
- Because of its resemblance to the telephone pole with its flat topped pole bearing the supporting wires, this is called as **Telephone Trellis system**.
- In this system there is large flat-topped T-Trellis above ground level.
- The horizontal cross is 120 to 150 cm wide with wires strung on the top 30 to 45 cm apart.
- The vines are trained along the wire in the direction of the row.
- Steel angle iron or waste structural steel is used when available and the cross arm is welded to the upright.
- In a few vineyards the flat top is modified by bending each half of the mast upwards about 30° so that a trough shaped or 'H' shaped form is obtained.
- The disadvantage in this system is that there are no cross-supports to the rows to withstand strong winds.
- Cultivation and movement is limited tone direction. But they are provided with better exposure to light.

PRUNING

- The grapevine is a vigorous climber. If it is not properly trained and pruned, it does not bear fruit properly.
- Pruning is one of the most important operations in grape culture.

The objectives of pruning are as follows:

1. To reduce the amount of old wood in order to keep the vine within manageable limits.
 2. To secure fruit bearing branches in predetermined places.
 3. To expose the fruiting branches to sufficient sunshine.
 4. To reduce the excessive vegetative growth.
- It is essential that one should be familiar with the various parts of the vine and their functions for successful pruning.

Types of Pruning:

Back Pruning

Fore Pruning

Following are some of the terminologies are being used in grape cultivation:

1. **Cane:** A well mature and ripened shoot of the past season or that of the previous year which gives rise to shoots.
2. **Shoot:** Young growth of green stem of the current season, which bears the grape in cluster.
3. **Spur:** A portion of the cane or ripened shoot left behind on the plant after pruning.
4. **Fruiting spur:** A cane or well ripened shoot leaving 304 buds, producing a bunch after pruning.
5. **Foundation spur or Renewal spur:** A well-ripened shoot or cane bearing bud. This normally remains after the shoots are pruned in March-April or summer in Hyderabad. It is called a **foundation spur** as it forms the base of the foundation wood on which next year's canes and fruiting spurs are formed or on which both growth of the year are borne.
6. **Trunk:** Main stem of the plant.
7. **Long spur:** A ripe shoot, carrying more than five buds. Normally it is 25-30 cm long with about 5-10 buds on it.
8. **Medium spur:** It is a cane cut back keeping 3-5 buds.
9. **Spur:** It is cane pruned to 1-2 buds.
 - In India, being a tropical country, there is a marked apical dominance of growth of the vine, because of the failure of the most of the buds to sprout and grow after the pruning.
 - On the other hand, in temperate zones the Thompson Seedless when pruned to 15 buds, there is 60 to 100 per cent bud burst as against 6-9 per cent in India.
 - Therefore, the stimulus nearby pruning wound is the important factor in forcing bud burst.
 - Usually the only bud that may grow on a long cane of 6 to 15 buds is the bud left in the terminal position.
 - This factor of extremely low frequency of bud burst confined almost entirely to the terminal position.
 - The tendency of only the terminal buds to grow on the pruned canes has an important bearing on the form and eventually the cropping and longevity of the vine.
 - The problem of rapid elongation of the arms or other more permanent frame work of vine is of course most acute when one is forced to leave long canes to ensure that enough crop will be obtained, such as is necessary in *Anab-e-Sliah* and to a greater degree in Thompson Seedless.
 - In varieties such as Muscat Hamburg or Perlette, where the basal buds are often fruitful than that pruning will ordinarily not present this difficulty.

Flowering and pollination:

- Grape vines, like many other fruit types, are self-pollinated where the female and male parts needed for pollination are present on the same plant.
- If you can recall your biology lessons from school, you will remember that, there are certain things that need to be present for a flower to be a perfect flower.

Female part (pistillate)

This is the central part of the flower and consists of basically 3 parts

- Stigma – the soft tissue at the end of the pistillate, where pollen is accumulated
- Style – a tube where through the pollen will move to reach the ovary
- Ovary – the place where the fertilisation takes place

Male part (stamen)

This is the outer part of the flower, just underneath the petal and consists of basically 2 parts

- Anther – the place where pollen is produced
- Filament – a long stem that supports the anther at its tip
 - For your grape vine to pollinate, all of these parts must be present in a grape flower.
 - Certain wild grape varieties do not have male or female parts on their flowers and is called dioecian plants.
 - Cross pollination needs to take place for these grape vines to bear fruit.
 - Most of the commercial grape varieties used these days are self-pollinated and do not need cross-pollination in order to bear fruit.
 - During pollination, the pollen from the anther of the male part of the flower, falls on the stigma of the female part, and grows down the style until it reaches the ovary, where it will penetrate the wall of the ovary so fertilisation can take place.
 - Dramatic climate conditions (wind, rain, and extreme cold and extreme heat) can have a negative influence on how well pollination will take place.
 - Mild, sunny weather is ideal.
 - During poor pollination weather, you will notice that grape clusters will be straggly and very loose, with not many berries on the clusters and the opposite happens with too good pollination weather – the grape clusters are too compact, deforming and damaging nearby berries. This is often the starting point for secondary infection (botrytis or grey rot).
 - There isn't much you can do about straggling grape clusters, but in the case of compact bunches, you can thin out the bunches by removing berries by hand or blunt scissors.
 - DO NOT work with scissors in a bunch after the berries softened – you will damage the surrounding berries and this is where infection can start.
 - Try to thin out the bunches when berries are still green (the size of small peas)

HARVESTING AND YIELD:

- Grape is a non climacteric fruit and has to be harvested at correct stage of maturity.
- Degree days from full bloom give a correct indication of maturity.
- Early cultivars require about 1600-2000 degree days and late cultivars about 3000 or more.
- A cluster having under developed seedless berries known as “shot berries” or mummies. These will be very sweet in taste.
- Treating clusters with AVG (2 Aminoethyl Vinyl Glycine) 50-300 ppm 1-3 weeks before anthesis improves berry set.
- Cluster thinning also helps in improving the quality. 60-70 clusters/ vine spaced 3mx3m is best.
- Girdling the shoot one week after bloom, improves berry set, after berry set improves berry size and before veraison advances ripening and uniform coloration.
- GA (40ppm) Ethrel also can be used for improving yield and quality. Ethrel (250ppm) can be used for uniform colour development (5 weeks after anthesis, 4 weeks after berry set for colour).
- Balancing the canopy also plays an important role in improving quality and yield.

- Grape starts yielding from 2-3 years and continues for more than 20-25 years. Average yield will be about 25-30 tonnes/ha but higher yields of 60-75 ton/ha also possible with good management.
- Grapes are packed in corrugated fibre board boxes having grape guard (craft paper coated within layer of mixture of sodium bisulphate and a plastic polymer) improve their storage life.
- Grapes can be stored grape guard or for 7-12 weeks under controlled atmosphere with 15-25% CO₂ and at 0-1°C.

Fruiting areas of different varieties:

- Bangalore Blue - 3-5 buds,
- Bhokri - 3 to 4 buds,
- Anab-e-Shahi - 6-8 buds,
- Cheemasabebi - 5 to 8 buds
- Pusa seedless, Kishmish charmi and Gulabi-10 to 12 buds.

Post harvest Handling and storage:

Pests and diseases:

Pests:

1. Flea beetles- Spraying Malathion or carbaryl.
2. Thrips- spray Malathion or 0.5ml Phosphomidon or 1ml monocrotophos per litre of water.
3. Chaffer beetle- dusting any insectide in evenings.
4. Mealy bugs- Spraying Dich lorovas.
5. Scales
6. Nematodes- Use nematode resistant root stocks.

Diseases:

1. Anthracnose removing & burning, spraying BM, Benlate or Bavistin regularly or Ziram
2. Downy mildew sprays BM, or Mancozeb (2.5 gm/1 litre.)
3. Powdery mildew spraying or dusting sulphur or Neem products.

Physiological Disorders are:

1. Blossom a black suskan spot develops at the blossom end of the berry which later on spreads + water suncans and due to rot Calcium deficiency.
2. **Interveinal chlorosis:** Mn, Zn or Fe deficiency-0.2%.
3. **Stalk necrosis:** Calcium deficiency.
4. **Bud, flower and berry drop:** girdling 10 days before full bloom, 500PPM ethrel at ripening NAA 100PPM at 10 days before ripening, Reducing irrigation during bloom, Benzyl adenine 200ppm, 4-CPA 20ppm-for thinning.
5. **Bud killing:** Excessive nitrogen.
6. **Hen & Chicken** - Due to boron deficiency.

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LECTURE- 25

SAPOTA

(*Manilkara zapota*/*M.achras*/ *Achras sapota*; Sapotaceae ; 2n=26)

INTRODUCTION:

- In India, Sapota cultivation was taken up for the first time in Maharashtra in 1898 in a village named Gholkward.
- India is considered to be the largest producer of sapota in the world though.
- Sapota is considered to be a minor crop in India (65,000ha+5.7 lakh tones). Karnataka+6000ha.
- In India, Sapota is commercially grown in Karnataka, Gujarat, AP, WB, Maharastra and TN.

IMPORTANCE AND USES:

- Sapota is good source of sugars, protein, fat, fiber and minerals (Ca, P, Fe).
- Sapota is a delicious dessert fruit.
- The latex from stems and immature fruits is used in the preparation of chewing gum.
- Fruits can be dried and made into nutritious powder which can be used in Milk shakes and sweets.
- In countries (Indonesia) young leafy shoots are used in salads or as vegetable.
- Sapota is supposed to be medicinal also seeds as diuretic, bark as tonic, antipyretic, febrifuge and in curing biliousness and febrile attacks.

ORIGIN AND DISTRIBUTION:

- Sapota is native of tropical America and is believed to have originated in South Mexico or Central America.
- Cultivated in West Indies, Philippines, Malaysia, Indonesia, Srilanka and India.

Climate and soil:

- Sapota is a tropical fruit and can be grown up to 1200m.
- But at higher altitudes and in subtropics it produces only one crop an year with reduction in quality and quantity.
- Annual rainfalls 125-250cm are best.
- Optimum temperature range is 11⁰C to 34⁰C.
- High temperature 41⁰C causes drying of stigmatic surface.
- Dry and strong winds also damage Sapota.
- Sapota can be grown in a wide variety of soils.
- Deep Sandy loams or alluvial soils or medium black soils are best.
- Calcareous soils (pH 6-8) give good crops of Sapota.



Species, types and cultivars:

- Sapota cultivars are grouped into 4 types based on nature of branches and colour of foliage as follows.
 1. **Trees with erect growing habit:** Branches appearing in whorls, leafy dark green, broad and oval, fruits large and superior.
 2. **Trees with drooping habit:** Branches in whorls, leaves light green narrow and elliptical, fruit small, inferior.
 3. **Trees with spreading habit:** Branches irregular, leaves dark green, broad and oval, fruits medium to large, superior.
 4. **Trees with spreading habit:** but with inferior quality fruits.

CULTIVARS:

1. **Kalipatti**-commercially grown in Maharashtra, Gujarat, North Karnataka. Has spreading branches, oval shaped fruits, fruits appear singly-superior.
2. **Chhattri**: Similar to kalipatti with dropping branches in whorls.
3. **Dhola Diwani**: Whitish oval fruits with superior quality
4. **Long**: Has narrow and small leaves, fruits long poor bearer.
5. **Bhuri or Bhuripatti** Medium bearer, fruits large superior.
6. **Jingar**: Medium sized tree, small leaves, fruits in clusters.
7. **Vanjeet**: Slow growing, knots on stems shy bearer, superior.
8. **Pala**: Popular in AP and TN fruits small, oval, heavy bearer in clusters.
9. **Kirthibarthi**: Popular in AP. Fruits small to medium with 4-5 ridges, oval, superior, withstands long transport.
10. **Dwarapudi**: Popular in AP. fruits round like cricket ball, superior.
11. **Cricket ball**: Popular in TN, Karnataka, Maharashtra, WB AP. Fruits large, round, superior, shy bearer.
12. **Oval**: Fruits small to medium, oval, inferior shy bearer.
13. **Vanivalasa**: AP, fruits oval, medium sized, medium quality.
14. **Calcatta Round**: WB, Karnataka, AP fruits large, medium quality.
15. **Jonnaivalasa-1**: AP fruits medium, ovate, superior and no ridges
16. **Jonnaivalasa-2**: AP, fruits medium, ovate, depression at stalk end, whitish flakes on skin eight ridges superior.
17. **Baramasi**: WB, Bihar, UP fruits medium, round medium quality.
18. **Pot Sapota**: Fruits small, oval, superior, bears in pots itself
19. **Gavarayya**: AP, TN fruits small with varied shoulders 8-10 ridges, superior.
20. **Thagarampudi**: TN fruits medium sized, round or oval, superior, good for export.
21. **Ayyangare**: TN fruits medium to large, round or obovate rose scented, superior.

Sapota varieties/ hybrids developed in India

Variety	Parentage	Shape	TSS (Brix)	Fruit weight (g)
CO-1	Cricket Ball x Oval	Oval	18	125
CO-2	Clonal selection from Baramasi	Obovate to round	23	200
CO-3	Cricket Ball x Vanivalasa	Oval	24.2	-
PKM-1	Selection from Guthi	Oblong	NA	NA
PKM-2	Guthi x Kirthabarti	Obong	NA	NA
PKM-3	Kalipatti x Cricket Ball	Oblong	NA	NA
PKM-4	Clone of PKM	-	-	-
DHS-1	Kalipatti x Cricket Ball	Oblong	25	150
DHS-2	Kalipatti x Cricket Ball	Round	23	180

PROPAGATION:

- Commercially propagated by grafting on Rayan or khirni (*Manilkara hexandra*) root stocks.
- **Other root stocks used are:** 1.Sapota seedlings, 2.Adams apple (*M. kauki*), 3.Mahua (*M.latifolia*), 4. Mee Tree (*Bassia Longifolia*), 5. Star apple (*Chrysophyllum cainito*) and 6. Miracular fruit (*Sideroxylon dulcifieum*).
- Approach grafting during February (Jan-March) and soft wood grafting during: May-July ; Air layering using 10,000PPM (1BA+NAA) gives good rooting; Budding during May also gives success.

PLANTING:

- Spacing is 8-10m; 1m cube pits are dug. Pits are to be filled with mixture of FYM and soils with 1.2 kg of bone meal.
- High density planting with 5mx5m spacing improves yield.
- It is better to have a wind break around the Sapota plot.
- Best season is monsoon season.

Manuring:

- Bearing tree of 11 years is given 400gN, 260gP and 450gK per year in addition to 40kg FYM and graded doses are applied from the beginning according to the growth of the plant.
- Application of more 'N' is reported to increase the yield. Manuring should be done in 2 split doses coinciding with the mansoons.

Irrigation:

- Sapota can tolerate drought to some extent but irrigations help in improving the yield.
- Regular irrigations should be given from planting till the plant establishes well.
- Later irrigations may be according to need and soil and weather conditions.
- Insufficient irrigations result in dropping of flowers.
- Drip irrigation can be more useful.

Interculture:

- Intercrops like banana, papaya, leguminous vegetables can be grown profitably during the pre-bearing period.
- Weeding should be regular.
- Spraying SADH 100ppm gives good fruit set and (Planofix) NAA 300ppm gives fruit retention. Sprayings are done twice before flowering and again at pea stage.

Training and Pruning:

- Better to remove the lower most branches on the trunk up to 60-90cm as they will be touching the ground and mostly unproductive.
- Stock sports should be removed from time to time.
- No regular pruning is needed for Sapota.

Harvesting and yield:

- Sapota may start bearing 2nd or 3rd year but commercial yield can be obtained from 7th year onwards.
- Sapota takes about 7-10moths from fruitset to maturity depending upon the cultivar season and locality.
- Best symptoms of maturity are;
 1. Milky latex on scratching will be reduced & shows an yellow streak than green streak.
 2. Brown scaly material gets reduced.
 3. Dried stigma at the tip of the fruit drops easily.
 4. Develops dull orange or potato colour

- Fruits should be harvested with stalk intact.
- Peak harvesting periods are Jan-Feb and May-June in Maharashtra and March-May and Sept-October in Karnataka and AP.
- Sapota normally produces fruit throughout the year.

YIELD:

- 03 year old plants gives 100 fruits; 5 year-250 fruits; 7 year-700, fruits; 8 year-800 fruits; 10 year-1000 fruits; 11 year-1500 fruits; 15 year-2000 fruits; 30 year-2500-3000 fruits/plant/year.
- Large sized cultivars like Cricket ball, Calcutta round give lower number of fruits but will be sold at higher price. The average yield is 15-20 ton/ha.

POST-HARVEST HANDLING AND STORAGE:

Ripening and storage:

- Fruits ripen after harvest in about 4-13 days depending upon cultivar.
- Ripening can be hastened by treating with ethrel (250-750ppm).
- Between 12-14°C fruits ripen slowly and keep well for about 5 weeks
- Ripe fruits can be stored at 2-3°C and 85-90% RH for 6 weeks and firm fruits for 8 weeks at 3 to 5°C and 85-95% RH.

Pests and Diseases:-

1. **Stem borer (*Isocrata tetraonis*).** The grub of this small beetle bores into bark of the Sapota trunk and feeds on the living tissue inside the bark. The chewed bark is seen on the hole.
 - **Control measures:**
 1. Kill the insect by thrusting a stiff wire into the tunnel.
 2. Plug the hole with a wad of cotton in kerosene at 0.1 percent and plaster with wet mud. This treatment creates suffocation inside the hole or tunnel which results in death of the insect inside.
2. **Leaf minor:** The tiny caterpillar of a greyish moth mines into the surface of young leaves. Affected leaves curl up, mines are seen on the surface of leaves and sometimes caterpillars are found inside the mines. Later on, affected leaves get destroyed, dry up and fall.
 - **Control measures:** Spray once or twice Dimethate (30ml in 18 liters of water) or Malathion (30ml in 18 liters of water)
3. **Mealy bug: (*Phenacoccus icteroides*),** It is sucking insect. It is a small, oval in shape with a cottony white, waxy on the under surface of leaves and base of the fruit near the fruit stalks. They suck the sap and secrete large quantities of sugary sub stances. Leaves have a black coating which gives them a sickly appearance.

Control measures:

1. Spray dimethoate at the rate of 30ml in 18 liters of water.
2. Try to keep free sapota plantation from red ants because these help in distributing mealy bugs from one tree to another. Red ants are effectively controlled with a dusting of a mixture of BHC 5 percent with sulphur in the proportion of 2:1.

4. **Scale insects: (*Pulvinaria psidii*).** They suck the sap by infesting along the sides of midrib and surface of leaves and twinges. These scales are green or brown in colour and oval shaped.

Control measures: Spray Dimethoate or Malathion at 30ml in 18 liters of water.

5. **Fruit borer** (*Virachola isocrates*). Borer attacks on fruits and some times buds which can easily be detected by seeing the latex which comes out on the surface of the infested fruits, the latex later crystallizes.

Control measures:

1. Spray 0.05 Malathion
2. Spray 0.01% Fenvalerate/0.01% endosulfan.

Diseases:

1. **Leafspot:** (*Phoecophleospora indica*). The causal fungus results in dark brown, the adjacent spots on leaves. When infection is severe, the adjacent spots become large irregular whitish patches. In severe case, the defoliation of leaves may be noticed.

Control measures:

1. Spray -78 @0.2% at an interval of 30 days.
2. Grow resistant varieties like Co-1, Cricket Ball. The varieties Co-2 & Kalipatti are tolerant, but Calcutta round are susceptible.

2. **Sooty mould:** Sooty mould is incited by Capnodium: The causal fungal disease develops on the honey like excretion by scale insects and mealy bugs.

Control measures:

1. Spray Zineb @ 40 g in 18 liters water.
2. Spray starch solution (100 g M in 18 liters of water). Starch forms this flakes and drop.

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LECTURE -27

PAPAYA

(Carica papaya L; Caricaceae; 2n = 18)

- Papaya has long been known as ‘*wonder fruit of the tropics*’.
- It is one of the five major fruit crops of tropical world.
- Papaya fruits throughout the year and a remunerative fruit crop which is grown in almost every part of the country.
- It gives maximum yield per unit and income next to banana.
- It is generally grown as fruit plant in kitchen garden, home garden or nutrition garden and later as commercial fruit.
- It is also planted as a filler plant in a fruit orchard.

COMPOSITION AND USES:

- Papaya is a very delicious, wholesome, refreshing fruit with a unique food value.
- The ripe fruits are used for desert purpose, preparation of jam, jelly, soft drinks, ice cream, flavoring, crystallized fruits, canned in syrup, fruits salad.
- The unripe fruits are consumed as vegetables also as a contraceptive.
- The seeds also have medicinal properties.
- The milky latex which is obtained from immature fruits is known as papain, which is a proteolytic enzyme used in several ways.
- As a digestive aid and for the treatment of ulcer & diphtheria.
- In the industry of pre-shrinking of wool and degumming of natural silk and rayon.
- Tenderization of meat and it is used for tanning of leathers.
- Used in brewing industries as a clarifying agent for beer etc.
- Used in preparation of drugs for treating intestinal cancer, tape worms, round worms and kidney disorders.
- The carpaine alkaloid present in green parts and in seeds used as heart stimulant, as diuretic and for treatment of amoebic dysentery.
- Preparation of chewing gum, cosmetics, papers and adhesive materials.
- It is also be used for extraction of oil from liver of Tuno fish.
- Papaya is very nutritious, it contains high quantities of vitamin A and ranks second to mango in the content of vitamin-A (carotene), the vitamin A is associated with carotene but the yellow pigment of papaya is caricaxanthene.
- It also contains Vit. C, riboflavin, niacin, good source of Ca, P, Fe, fat and carbohydrates.
- Apart from papain, raw fruits can also be used for extraction of pectin.
- Pectin is generally extracted using alcohol precipitation method.
- It is used in food industry as flavouring extract and emulsifying agent.
- **Tutti frutti:** Papaya bits (immature) are first soaked in brine and boiled in sugar syrup and immersed in sugar syrup for 48-60 hours with permitted colours.
- The other products like, papaya jam, canned slice, papaya beverages, fruit bars/toffee bars, soft drinks etc, could be made out of the fruits.

ORIGIN & DISTRIBUTION:

- India is the second largest producer of papaya in the world after Brazil.
- It is a fruit native to tropical America and
- Commercially grown in many parts of the world viz., Australia, Hawaii, Taiwan, Puerto Rico, Peru, Florida, Texas, California, South Africa, Pakistan, Bangladesh and India.
- In India, it was introduced by Portuguese in 1611.
- It is grown in Karnataka, Bihar, Kerala, TN, Assam, Gujarat, Maharashtra, Andhra Pradesh, Madhya Pradesh etc.

CLIMATE AND SOIL:

- Papaya is tropical in its climatic requirement.
- It is susceptible to frost.
- It requires warm humid climate and can be cultivated up to an elevation of 1000-1200 m above MSL.
- It thrives well at temperature between 38-44°C, but optimum range is 22-36°C, a day temperature of 35°C and 25°C night temperature are most suitable.
- Papaya grows well under well drained soil with a pH range of 6-7. It prefers fertile soil, deep clayey and calcareous and rocky soils are not suitable.

SPECIES AND VARIETIES:

The genus *Carica* contains 48 species of which, only 3-4 species are important.

1. *Cariaca papaya* – It is a cultivated commercial species and polygamous in nature.
2. *C. monoica* - Monoecious and is suited for mild climate, found in Amazon basin.
3. *C. candamarcensis* – This species is known as mountain papaya is suited to cold climate.
4. *C. gracilis* – Ornamental
5. *C. pubescens* – Mountain papaya
6. *Carica dodecaphylla* – Jaracatia
7. *Carica goudotiana* – Papayuelo
8. *Carica stipulata* – Chamburo
9. *Carica quercifolia* – Oak Leaved Papaya
10. *C. stipulate etc.,*

Varieties/ cultivars:

1. **Honey dew:** it is dioecious with less per centage of male plant and breeds true to the type from seed, semi tall variety, bear fruits low on the trunk heavily. This variety is popular all over India, also known as Madhu Bindu.
2. **Sunrise Solo:** The variety is named 'solo' because one man can easily consume one fruit. This is gynodioecious variety from Hawaii with small sized fruits, pyriform and yellowish orange pulp and keeping quality is good.
3. **Coorg honey dew:** Selection from Honey dew at IIHR, Chethalli. This variety produces no male plants. The plants are either hermaphrodite or female. Fruits borne on female plants are almost seedless and are of excellent quality.
4. **Washington:** The plants are vigorous, stem and leaf stalks are with purple ting, fruits medium to large, round to ovate, sweet, pulp orange colour with good flavour.



The improved strains released from Tamil Nadu Agricultural University, Coimbatore

- **Co-1** It is a selection from variety Ranchi, dwarf type medium sized, spherical shape and greenish yellow fruits with golden yellow pulp good keeping quality, yield is about 100 –120 tons/ha
- **Co-2:** It is a dioecious, semi dwarf, medium tall type, very good for table and papain extraction. It yields 5-6g. of papain per fruit.
- **Co-3** : A hybrid between Co-2 x Sunrise solo. It is gynodioecious in nature, Tall vigorous plant with medium sized fruits. The pulp is attractively red coloured and is good for table purpose, Yields 100-220 tons/ha
- **Co-4:** A hybrid derivative from Co-1 x Washington. It is dioecious, medium- tall plant with large fruits (1-1.5kg) , Yields 100-220 tons/ha
- **Co-5:** Selection from Washington and the plants are exclusively selected for papain extraction and yields about 14-15 g. of papain/fruit, Yields 100-220 tons/ha.
- **Co-6:** Selection from pusa majesty, it yields about 80-100 fruits and also a high papain (7.5-8 g/fruit) yielder i.e., 890 kg of dry papain/ha, Yields 100-220 tons/ha
- **Co-7:** It is also a gynodioecious developed through multiple crosses CP-75 (Pusa deliciousxCo-3) and coorg Honey dew, yields 160-180 tone/ha.



PUSA, Bihar-released some improved varieties.

- Pusa delicious** - It is a gynodioecious with medium sized fruits (1.5kg) and high yielder, male has been eliminated genetically by sibmating with hermaphrodite.
- Pusa majesty:** A gynodioecious, medium round fruits with good keeping quality. Plants resistant to virus diseases. The fruit with stand long distance transport.
- Pusa giant-** Dioecious variety with big sized fruits (2-3.5 kg), plants are very vigorous and resistant to wind damage. The fruits are suitable for canning industries.
- Pusa dwarf:** The plants are dwarf and bears fruits at 38cm from the ground, they are dioecious and medium yielder, medium sized fruits, suitable for HDP and home gardens.
- Pusa nanha:** A dioecious dwarf mutant and well suited for kitchen garden, nutrition garden and pot cultivation. It yields about 60-65 tonnes of fruit/ha. It is developed by gama radiation, suitable for High density planting.

Varieties released from Pantnagar University- Pant-1, 2 & 3.

IIHR, developed some hybrids, they are

- IIHR-39- Sunrise solo x Pink Flesh Sweet.
- IIHR-57- waimanello x PPS.

Now a days Taiwan hybrids are grown on large scale – Red lady.

PROPAGATION:

- Papaya is usually propagated by seeds.
- The seeds should be collected from healthy ripe fruits essentially from the plants free from pest & diseases.
- The seeds should be rubbed with ash to remove mucilaginous coating (Aril/Sarcotesta) to facilitate better germination.
- However seeds can be stored for 45 days in an air tight container and stored at 10°C.
- Before sowing, soaking seeds in 100ppm GA solution to enhance germination percentage.

SOWING:

- Seeds may be sown in poly bags (22x15cm with 150 gauges) 6 weeks prior to transplanting.
- The media should be disinfected by using 2 % formalin solution,
- 4 seeds per polybag should be sown, if it is dioecious variety or
- 2 seeds, if it is hermaphrodite variety.
- Seeds also sown in raised nursery beds; about 350 g seeds are required to plant one hectare area.
- Germination will be observed in 2-3 weeks after sowing.
- About 6-7 weeks old seedlings will be ready for transplanting.

PLANTING:

- The pit size of 1-1.5 cubic feet should be dug at 1.8 x 1.8m or at 2.4 x 2.4m apart and filled with 30-40 kg FYM with 25gm aldrin 5 % dust will be added to the pits and filled with top soil.
- Planting is done during monsoon season.
- Due to sex variation more than one seedling are required per pit.
- In case of dioecious varieties Co-1 & Co-2, four seedlings are transplanted/pit,
- Whereas, two seedlings are sufficient in case of hermaphrodite types like solo, Coorg Honey Dew etc.
- After planting irrigate the pit & provide staking.



INTERCROPPING & INTERCULTIVATION:

- Different short duration vegetables can be profitably grown for about six months from planting;
- For control of weeds, weedicides like fluchloralin or butachlor at 2.0 kg/ha have to be applied.
- Post emergent herbicides - Glyphosate has also been found effective.

FLOWERING AND FRUIT SET:

- Papaya starts flowering in 5-6 months after planting;
- When the sex of the plant is identified, surplus male plants (plants with long 1-1½ meters flower stalk hang out with small tubular flowers contains stamens only), may be removed keeping one male plant for every 10 female plants, as pollinizers.

Thinning of Male plant:

- Removing of male plants by maintaining 1 male plant for every 10 plants after flowering.

Manuring: The recommended dosage of fertilizers for different states are given below and the fertilizers are to be applied in 4 splits at 1st, 3rd, 5th and 7th months after planting. While applying fertilizers it is not necessary to fertilize the male trees left as pollinizers as they will regularly put forth necessary male flowers without any extra manuring.

STATE	N (g/plant/year)	P (g/plant/year)	K (g/plant/year)	FYM (Kg/plant/year)
Karnataka	250	250	500	10-15
Maharashtra	100	-	-	40
Tamil Nadu	250	200	200	10
Uttarpradesh	150	80	100	-
West bengal	150	150	150	15

Irrigation: Papaya should be irrigated once in 8-10 days in winter and 6 days in summer by ring system.

Weed Management: Application of weedicide such as Fluchloralin or Butachlor at 2.0 kg/ha, Post emergent herbicides - Glyphosate has also been found effective.

Sex distribution in papaya:

- Papaya is a polygamous species; many forms of inflorescence have been reported by Frankel and Galun, 1977. In general there are 3 important types of flowers.

1. Staminate or male flowers:

- Splender spoon shaped buds with long, narrow tubular flowers on long peduncles, from leaf axil petals fused at base and contains stamens but no ovary, it cannot develop in to fruits



2. Pistillate/Female flowers:

- Large yellow, borne singly or in groups of three in the leaf axils, close to the trunk.
- These flowers have five large twisted and fleshy petals, surrounded ovary, which swells and develops in to a papaya fruits.



3. Hermaphrodite flowers:

- These are bisexual flowers, having both female and male organs, they are creamy white in colour, big sized flowers no peduncle.
- The bisexual flowers are also borne in the same manner as of female flowers i.e. closer to the trunk in leaf axils.



- In papaya change in the sex expression is influenced by environmental factors like, low temperature favoring production of perfect flowers on the male tree.
- It was observed that fertile hermaphrodite types had some pistillate flowers which showed male tendency in summer and female tendency in winters.
- Seedless fruits are developed from the pure female flowers which are not cross pollinated.
- After flowering the fruits mature within 5 months.
- Under adverse climatic condition flowers & fruit drop is very common, to avoid this problem spraying of planofix @ 1ml/liter.
- Fruit thinning is suggested to get good size and quality.

Harvesting Indices:

- Papaya comes to bearing with 10 months after planting.
- The economic life is only 3-4 years.
- Fruits are harvested when the fruit turn slight yellow in colour.
- While harvesting, fruit should not be damaged to prevent rotting.
- Manual harvesting is commonly practiced.
- Wash the fruits with water or fungicide *i.e.*, Benlate at 0.05 per cent and pack in boxes with cushioning materials.
- After harvesting in about 5-6 days fruit ripens depending upon room temperature.
- Fruits could be stored for more than 4-5 weeks at 0°C; also individual fruits are wrapped in the newspaper for ripening



YIELD: The average yield is 30-80 tons/ha.

PAPAIN EXTRACTION:

- Papain is a proteolytic enzyme extracted from the milky latex obtained from immature papaya.
- About 400 tons of papain is produced throughout the world.
- The USA and UK are the major consumers of papain.

PROCEDURE OF EXTRACTION:

- The immature fruits of 90-100 days old are used for extraction of milky latex by giving 4-6 cuts of about 2mm depth, the latex is collected from 5-6 tapping and sieved the latex and dried in sun or in vacuum shelf dryer.
- The quality and grade of papain is determined by colour and enzyme activity (Tyrosine unit).

Some of the important points to be considered while collecting the latex.

- ✓ Fruits of 90-100 days from fruit set are generally preferred.
- ✓ Oblong fruits relatively yield more yielder than round ones.
- ✓ Fruits set during July yield more papain.
- ✓ There will be a 4 fold increase in papain yield by using ethrel at 200 ppm.
- ✓ Always collect the papain in glass vessels or Aluminum trays.
- ✓ Use Potassium Metabisulphite (0.05 per cent) to extend the storage life
- About 450g/plant and 250-375 kg papain could be extracted from an hectare area. The varieties C0-5 and C0-2 are preferred for papain extraction.

POST-HARVEST HANDLING AND STORAGE:

- ✓ After harvesting the fruits are graded on the basis of their weight, size and colour.
- ✓ Fruits are highly perishable in nature.
- ✓ They can be stored for a period of 1-3 weeks at a temperature of 10-13°C and 85-90% RH.

Plant protection:-

Insect pests: Few insects like scales, mealy bugs, aphids and thrips have been reported infesting the fruit tree. Scale insects and mealy bugs on stem and leaves.

Mite incidence may be occasionally noted especially during summer.

Diseases:

- ✓ **Caller rot and wilt:** This occurs mainly due to the incidence of *pythium aphanidermatum* and *phytophthora palmivora*.
- ✓ **Anthraxnose:** (*colletotrichum gloesporioides*): The initial symptoms are small round water soaked area on fruits which later develop into sunken or concentric lesions. The disease also affects the petioles of lower leaves leading to their shedding.
- ✓ **Powdery Mildew:-** (*Oidium caricae*)- The fungus is found mostly growing on the upper surface of the leaves with drawing nutrients from the cells of the leaf surface. Under severe attack the top portions of the seedling may die.
- ✓ **Viral Diseases:**
 - 1) Mosaic
 - 2) Leaf curl
 - 3) Ring spot –
 - ✓ Of these, the papaya ring spot virus is common in North India, Karnataka and Andhra Pradesh and after it has become a major threat to papaya production in several tracts.
- ✓ **Nematodes:** Root knot (*Meloidogyne* Sp) - Affects the root systems and cause yield reductions.

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Lecture -29**PINEAPPLE**

(*Ananas comosus*/ syn. *Ananas sativus*; Bromeliaceae; $2n = 28/30$)

**INTRODUCTION:**

- Pineapple is considered as one of the most popular tropical fruit, and is known as “Golden Queen” all over the globe.
- It can be grown as mixed crop in most of the orchards and also as hedge plant and as a pure crop.
- It is drought tolerant and suitable for marginal lands.

COMPOSITION AND USES:

- Pineapple has been described as an excellent source of vitamin c and also good source of vit -A and B, Sugar 13 per cent, Acidity-0.6-1.0 per cent mineral matter-0.05 per cent, Fiber, 0.3 per cent, Ca, Fe, P. The fruit contains a protein digestive enzyme Bromelin.
- Fruits are relished as dessert in the form of slices either fresh or canned, preparation of juice, squash and jam and mixed jam. Candy is prepared from fruit core.
- Fruits are used in preparation of alcohol, vinegar, calcium citrate, citric acid, gum and pineapple flavors.
- The leaves yield silky fiber which is used for making a fine fabric known as Pina cloth in Philippines and Taiwan.
- The pineapple plants and the fruit residues after extraction of juice are used as cattle feed.

ORIGIN AND DISTRIBUTION:

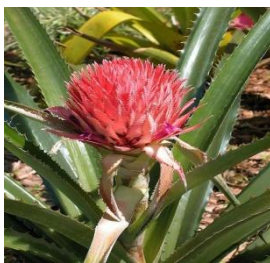
- It is believed to have originated from North Brazil from where it spread to other tropical parts of the world.
- The major pineapple growing countries are Tropical America, Mexico, Malaysia, Kenya, Taiwan, Australia, Srilanka, Singapore and India.
- Its cultivation is confined to high rainfall and humid coastal regions in peninsular India and to the hilly areas of North-Eastern region of the country.
- The important states are Karnataka, West Bengal, Maharastra, Tamil Nadu, Assam, Manipur, Meghalaya, Tripura, Andhra Pradesh and Orissa.

CLIMATE AND SOIL:

- Pineapple can be grown successfully from seacoast to an altitude of about 1500m above sea level. The optimum temperature is from 21°C-24°C.
- It can be grown in areas of 22°C-32°C with optimum rainfall ranges from 100-150cm.
- The higher temperature is beneficial for fruit development, low temperature is harmful and does not improve colour of fruits.
- The fruits grow well in sandy loam soil.
- Fruit size is larger on the heavier soil but flavor of the fruit is better when grown on lighter soil. It prefers soils which are acidic (pH 4.5-5.5).
- while high Mg and Mn content are injurious to the crop.

SPECIES AND VARIETIES:

- Smith (1979) established two genera, *Ananas* and *Pseudananas*,
 - *Pseudananas* at maturity bears a minute inconspicuous coma of bracts and plants produce elongated stolons and no slips,
 - Where as *Ananas* bears conspicuous coma of foliaceous bracts and plant produce slips but not stolons and a fruit remains seedless.
 - The genus *Ananas* has 8 species viz.,
1. *Ananas comosus*: The cultivated species with large fruits and a short thick spike.
 2. *A. monstrosus* : Crownless- There is no leaf formation on fruit.
 3. *A. bracteatus*: Has well developed, bright red flower bracts. Fruit is edible and relatively large.
 4. *A. fruitzmuelleri*: It bears pale green, developed bracts.
 5. *A. ananassoides* : With small fruits, erect leaves and a long fairly thin spike.
 6. *A. nanus* : A dwarf species.
 7. *A. parguazensis* : with curved leaves.
 8. *A. lucidus* : It has smooth (Spineless) leaves from which good quality fibre can be obtained.



- Only one species has been listed in *Pseudananas*-
- *P. sagenarius*

*Ananas comosus**Ananas nanus**Ananas bracteatus**Ananas parguazensis**Ananas ananassoides**Ananas lucidus*

VARIETIES: The varieties have been classified in to 5 groups.

1. **Spanish group:**

- Fruits are of 1-2 kg wt, globose in shape, fibrous, sub acid, spiny, resistant to mealy bugs.
- Eg: Mauritius Red Spanish, Singapore Spanish, Green Selangor, Castilla, P.R.1-67.



2. **Queen Group:**

- Conical fruits, spiny, deep eyes, low in fiber 0.5-1.1kg, sweet with yellow flesh.
- Eg: Queen, Mac gregor, Natal, Ripley and Alexandria.

3. **Cayenne group:**

- Cylindrical fruits with mild acidic, yellow (Spiny tip) 2-3 kg flesh sweet, suitable for sweet canning, low fibre.
- Eg: Cayenne, Baron, Rothschild, Smooth Guatemalan, Kew, Giant Kew and Typhone.



4. **Abacaxi group:**

- Conical fruits, pale yellow- white flesh, spiny 1.4 kg
- Sweet tender and juicy grown in Brazil.
- Eg: perola, Abakka, Sugar loaf, Papelon, Venezolana, Amarella.



5. **Maipure Group:**

- Fruits ovoid to cylindrical, sweeter, fibrous 1-2.5kg with yellow flesh, very juicy.
- Eg: Maipure, Bumuguesa, Rondon, Perolera, monte lirio.
- The cultivars grown commercially in India are Kew, Giant kew, Queen, Mauritius.
- Some of the indigenous cultivars - Jhaldeep (Sweet type) & Bakhat (Assam)-Sour Lakhat (Nagaland) and Baruipur local (West Bengal).

PROPAGATION:

- Pineapple is mainly propagated by vegetative methods viz., suckers, slips, crowns and stumps, among these suckers and slips and crowns are the three important parts used as planting.
- The suckers arise from the axils of the leaves below the ground level and come to flowering early (15-18 months) and
- The slips formed on the fruit stalk below the fruit are usually preferred for planting (15-18 months and 20-22 months after planting respectively, than the crowns (24 months).
- About 250-500 gm of suckers 250-450g slips and 40-45cm crowns are selected for planting.
- In some localities, butts- the stems of the plants already flowered, which are trimmed of roots, leaves and the peduncle are also used.
- The planting materials should be treated with mercurial fungicide.
- The planting materials should not be stored more than 14 days;
- Suckers production can be enhanced by giving additional nitrogenous fertilizers and more water, in recent years micro propagated plants are also available.



PLANTING:

- Planting is done during kharif season, before planting suckers or slips should be sun-cured,
- dry leaves and scales at the base should be removed basal end of planting materials
- Should be dipped in 0.4 per cent difolton and 0.05 per cent ekalux to avoid fungal & mealy bugs' infestation.

- The suckers or slips are planted in 10-15cm deep holes, while planting;
- The growing part should not be buried.
- Planting may be done in single or double row systems.
- In single row system we can accommodate about 15,000 -20,000 plants/ha – yields about 20t/ha
- In double row system (25x35x90cm) High Density Planting (HDP) is adopted in almost all pineapple growing region of India, we can accommodate about 64,000 plants and gives about 100-120t/ha of fruit yield.

MANURES AND FERTILIZERS:

- About 30 tonnes of FYM/ha/year, along with 500:140:560 kg NPK/hectare for 42,000 plants/ha whereas 600:200:600 kg NPK for 64000 PI/ha.
- Fertilizers should be applied at 3 months after planting in 4 split intervals. Foliar application of N (2-4%) is practiced.

MICRONUTRIENTS DEFICIENCY:

- Iron, zinc and copper deficiency are common in pineapple,
- The deficiencies can be corrected by spraying FeSO_4 (3 %), Zn SO_4 (1 %) as foliar spray.
- Copper deficiency can be corrected by drenching CuSO_4 (1.5-2.0 %) at 30-50 ml per plant.

IRRIGATION:

- Though, pineapple is a rainfed crop, 4-6 irrigations may be necessary during dry season at 20-25 days interval.

WEED CONTROL:

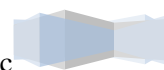
- Combination sprays of Bromocil and Diuron @ 2kg a.i/ha as pre-emergent herbicides can control weeds efficiently.

FLOWERING AND FRUITING:

- A pineapple plant generally attains flowering stage 11-12 months after planting by which time the plant should have produced atleast 40 leaves.
- Irregular flowering behavior is one of its major drawbacks.
- Flowering is not uniform in pineapple, to induce good and uniform flowering the following measures are to be taken,
 - Spraying of NAA 100-200 ppm *i.e.* pouring of 50 ml solution in to the center (heart) of plant to induce good flowering.
 - Also, etrel at 25ppm combining with Urea (2%) and sodium carbonate (0.04%) to induce good flowering.
 - This application has to be done, when the plants have 35-40 functional leaves and clear sunny days (one year old plants).
- Staggered planting to get fruits throughout the year, the plants generally gives out the inflorescence in 12-13 months after planting (Feb-April).
- Fruit takes $4\frac{1}{2}$ - $5\frac{1}{2}$ months from set to harvest (June –Aug).

HARVESTING AND YIELD:

- At maturity with a slight colour change at the base of fruit.
- The lowest eyelets have orange yellow colour and flattened. The bracts become loose & brown.
- The fruits should be harvested along with 5-7 cm stalk on full maturity because it is non-climacteric fruit



YIELD:

- The yield from a plant population of 35,000-40,000 per hectare is about 40-50 tonnes.
- The plant population of 43,000-50,000 per hectare normally varies between 50 and 60 tonnes.

STORAGE:

- At 10-13°C, the fruits stored for more than 20 days at 10-13°C, do not store at less than 8°C, since it results in browning of pulps.

RIPENING:

- Pre-harvest application of Ethrel at 500 ppm induces uniform ripening and colour development, but fruits will be acidic and lack flavour

RIPENING:

- Pre-harvest treatment of ethrel at 500ppm for uniform ripening & colour development, but fruits, are acidic and lack of flavour.

PHYSIOLOGICAL DISORDERS:

1. **Sunscald:** The cells under the fruit skin of exposed surface to sunrays get damaged; care should be taken to control lodging and fruit should be covered with dry straw or its own leaves during April-May.
2. **Fasciation and multiple crowns:** Multiple crowns may occur due to genetical factor as well as due to soil and environmental reasons. It is also due to excess Nitrogen. Fruits gets flattened and fasciated. In fertile virgin soil of warm areas, more abnormal fruits occur as compared to less fertile soil.
3. **Black heart:** It is also known as endogenous brown spot or internal browning, formation of brown spots at the base of fruitlets and further black discoloration of the centre core. Low temperature or exogenous application of GA₃ can induce this disorder. A fruit exposed to high temperature (40°C) for 24 hours reduces black heart in cold stored pineapple.

IMPORTANT PEST AND DISEASES

PESTS:

- Mealy bug- *Dysmicoccus brevipes*- Due to secretions of toxic substances the mealy bugs attracts and finally the plant get wilting. The comparatively resistant cultivars and species are Red Spanish, Pernambuco, Queen, *Ananas bracteatus*, *Pseudananas sagenarius*.
- Ants, Nematodes are also causes damage.

DISEASES:

- **Soft rot , Storage rot and Fruit rot-** *ceratostomella paradoxa* This disease is prevalent in the lower pulney hills of India causing sever loss in region with high rainfall and low temperature.
- **Heart rot and stem rot** - *Phytophthora parasitica*
- Leaf spot, Black spot, Sclerotium wilt.
- Pineapple wilt virus – transmitted by mealy bugs etc., also causes damage.
- **Ratoon management** – Single sucker/plant with regular package of practices can give normal yield of the crop.

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LECTURE -30

POMEGRANATE

(*Punica granatum* Lin. ;Punicaceae; 2n= 18;Origin: Iran.)

INTRODUCTION:

- Pomegranate is one of the ancient and important table fruit in tropical countries.
- It is grown on large scale in the Mediterranean countries such as Iran, Spain, Morocco and Egypt etc.
- It is grown all over India and commercially in Maharashtra (more than 60 %) followed by Gujarat, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu etc.
- The tree is deciduous in temperate countries, while it is evergreen in tropical and subtropical regions.
- The fruits are borne terminally on short spurs, arising from mature shoots.
- Tree is hardy and bushy having a tendency of developing multi-stems.

USES:

- The edible part of pomegranate is a juicy outgrowth of the seed called the aril.
- It is liked for the cool refreshing juice and also valued for its medicinal properties.
- The juice is useful for patients suffering from leprosy.
- The bark & rind of the fruit are commonly used in dysentery and diarrhea.
- The dried seeds of pomegranate give important condiment called 'Anardana.'
- Tannin is obtained from fruit rind leaves stem & root bark.
- The flowers yield red dye, which is used for dyeing cloth.
- One pomegranate fruit supplies about 40% of an adult's daily Vit-C requirement.
- It is also rich in Riboflavin, protein, fat, sugar, pectin, Ca & Iron content.

CLIMATE:

- The best quality fruits can be produced in areas of cool winters and hot & dry summers where rainfall is low.
- It can be grown in tropical to warm temperate climates and from plains to an elevation of about 1800 m.
- The tree require hot & dry climate during fruit development and ripening.
- It cannot produce sweet fruits unless the temperature is high for considerable period.
- The plant withstand considerable amount of drought but does well if provided with irrigation.

SOIL:

- Pomegranate can be grown on variety of soils.
- It can be grown in limy, alkaline and saline soils and also thrives well in shallow rocky gravel soils.
- However, the best yield & quality of fruits could be obtained in deep heavy, loamy and well drained soil with pH range of 5.5 – 7.5.

VARIETIES:

1. **Paper shell:** It is grown in South India. The fruits are medium to large size. The flesh is pinkish and the seeds are soft. The aril has good flavour with very high fruit bearing capacity.
2. **Alandi or Vadki:** It is commonly grown in Maharastra and Gujarat. Fruits are of medium size, blood reed or deep pink flesh with sweet, slightly acidic juice. The seeds are very hard.

3. **Ganesh:** It is a selection from 'Alandi' The fruit is medium in size. It has soft seeds. The aril is pink, high yielding, with average fruit weight of 325g, sweet and round fruit shape, TSS of 16.47 per cent, Acidity 0.42 per cent.
4. **Jyothi:** It is selection from Basin seedless variety developed by University of Agriculture Sciences, Bangalore; Fruits are bigger in size with attractive red colour, with soft seeded and more flesh and TSS of 16 per cent.
5. **Mridula:** It is a seedling selection from an open pollinated F₂ population of a cross Ganesh and Gul-e-Shan red. Fruits are red in colour and round shape with sweet aril soft seeded fruit.
6. **Jalore seedless** – It is a soft seeded variety developed and recommended by CAZRI, Jodhpur for arid regions as the fruit matures early and maximum fruit production is coincided with available soil moisture during monsoon, large fruits (200g) with pink to deep red skin, arils are pink to red having soft seeds with attractive overall appearance of fruit.
7. **Hybrid – Ruby:** (Ganesh x Kabul x Yercard) Developed by Indian Institute of Horticulture Research, Bangalore. The fruits resembles like Ganesh variety with reddish brown skin with green stripes on skin, soft seeded with bigger size and red coloured arils, heavy yielder (16-18 t/ha).
8. **Bhagawa (G-137): It is ruling variety.**

The other varieties popularly grown are – Dholka, Kandhari Kabul, Muscat, Jodhpur red, P-23, P-26,

PROPAGATION:

- Presently, pomegranate is successfully propagated by hardwood stem cutting and air-layering.

1. Stem cutting:

- Cuttings are collected from high yielding plants one year old & fully matured shoots.
- About 25-40cm long cutting should be planted by removing leaves and treating the bottom end of cuttings with rooting hormone (IBA - 2000ppm) and inserted in the soil.
- Plants will be ready in 55-60 days.

2. Air layering:

- Pomegranate may also be propagated by air layering.
- It should be done during rainy season.
- The bottom of the uppercut can be treated with IBA 10,000 ppm for better rooting.

3. Tissue culture: It is also standardized and commercially propagated by Jain Irrigation Company.

ESTABLISHMENT OF ORCHARD:

PLANTING:

- Land is prepared thoroughly during onset of monsoon.
- Pits of 60-75cm³ at a spacing of 5x2m.
- Planting should be done during monsoon season.
- Planting of 1-2 year old rooted cuttings in center of pits and provide support with staking.

IRRIGATION:

- Newly planted orchard requires frequent and regular irrigation, during flowering and fruiting, orchard should be irrigated regularly to avoid cracking of fruits and for better development of fruits.

INTERCROPPING AND INTERCULTIVATION:

- Leguminous vegetables and cereals can be taken during pre-bearing stage.
- Papaya can be taken as filler plant.
- Basins should be maintained free from weeds.
- Deep ploughing should be avoided as it damages the roots.

MANURE AND FERTILIZERS:

- Pomegranate is a hardy plant but it responds well to manure and fertilizers.
- About 20 - 50 kg FYM/tree for bearing trees/year, along with 400gN: 200g P: 200g K/tree.
- For pre-bearing plants full dose of P, K and $\frac{3}{4}$ th of N should be given at the time of bahar (flower induction) treatment, remaining $\frac{1}{4}$ th of N given at 1 $\frac{1}{2}$ months after fruit setting.
- At the age of 8-10 years this dose should be doubled.

TRAINING AND PRUNING

- Training of pomegranate plant is important to allow certain number of shoots/stems per plant.
 - It may be trained as multi-stemmed and single stemmed tree.
- Multi-stemmed tree:**
 - This method is preferred in Maharashtra, where in 3-4 stems are retained at a hill and remaining shoots are removed.
 - But yield has not been found to be affected. This will give a bushy frame work to the plant.
 - Single stemmed tree:**
 - Train the plants, remove all the side shoots upto 2-3 feet and single stem is left.
 - This operation begins at the time of planting.
 - The main stem is pinched at a height of 1m results in the formation of branches.
 - Only well distributed 4-5 branches on all sides are allowed to grow.
- Pruning of water shoots, weak crotches dead twigs, old spurs is done regularly.
 - After 10 years, old main stems should be removed by cutting back to make it more productive.

FLOWERING AND FRUIT SET:

- To obtain higher fruit yield during a particular period, the pomegranate plants are given a resting period.
- It is done by withholding of water for about 60 days in advance of the normal flowering;
- Roots are exposed and are known as **bahar treatment**.
- Flowering is noticed in almost round the year and
- There are 3 main seasons viz.,
 - Ambe bahar: Flowering** can be induced in **February -March** – This can be practiced in the areas where, enough water is available during hot weather.
 - Mrig-bahar: Flowering** can be induced in **June-July**, coinciding with the outbreak of monsoon; this treatment is taken in the areas where, water is scarce during the hot weather.
 - Hastha Bahar: Flowering** can be induced in **September – October**, where the trees have to be subjected to stress during August – September. This is rather uncertain because of the monsoon rains that occur during this period.

HARVESTING AND YIELD:

- The tree starts bearing fruits from 3-4th year and continues for about 25 to 30 years.
- Pomegranate fruits become ready for harvesting in 5-7 months after the blossoming.
- Mature fruits become slightly yellowish & further pink to red.
- On tapping, the fruits give metallic sound and when pressed they give a “Crunch” sound and flattened during maturity.
- Economic yield is generally obtained from 6th or 7th year onwards.

YIELD:

- The fully grown up tree of about 10 years old produces 80-120 fruits (16-20 Kgs)

PESTS AND DISEASES

1. Anar fruit fly/fruit borer- *Virachola isocrates*.- Affected fruits will rot due to insect bore & fall down
2. Bark eating caterpillar – *Inderbela tetraonis*- It bores in to the bark & tree becomes weak & do not bear fruits.
3. Stem borer: *Aleurodes* species.
4. Fruit rot – *Phomopsis* sp.
5. Leaf spot – *Colletotrichum gloeosporioides*

PHYSIOLOGICAL DISORDER

FRUIT CRACKING:

- It is common in pomegranate and is a serious disorder.
- This disorder is due to the prevalence of high temperature and moisture stress followed by rains cause fruit cracking during fruit development.
- In the young fruits, it could be due to boron deficiency.
- While in Mrigbahar (July) grown fruits, it might be due to sudden fluctuation in diurnal temperature.
- Also prolonged dry spell cause hardening of peel, if this is followed by heavy rainfall or irrigation then the pulp grows fast and results in cracking of pulp.
- The cracked fruits are also liable to be invaded by certain fungi and bacteria.
- The fruits lose their market value and become unfit for human consumption.
- The cultivars like ‘Bedana Bosek’ ‘Jalore seedless’ and ‘khog’ are comparatively tolerant to cracking.

CONTROL MEASURES:

1. Planting of varieties tolerant to fruit cracking.
2. Early harvesting of fruits immediately after maturity
3. Maintain optimum soil moisture during Mrig bahar fruiting
4. Spray calcium hydroxide on foliage after fruit set.
5. If boron deficiency – spray borax at 0.1 per cent to pl/20g/pl/year.
6. Spray GA₃ at 250ppm in June.
7. Plant windbreak around the pomegranate plantation.

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LECTURE- 31

FIG

(*Ficus carica* Linn; Moracea; $2n = 26$; Origin : S – E Asia – Eastern Mediterranean region.)

INTRODUCTION:

- Fig is an important and oldest fruit extensively used in fresh and dried form.
- Extensively cultivated in countries around the Mediterranean especially Italy, Spain, Turkey, Greece, Portugal, Algeria, California and Afghanistan.
- The main area of fig cultivation in India is Pune (Maharashtra), Srirangapatna, Raichur, Gulbarga and Chitradurga (Karnataka), Lucknow (Uttar Pradesh) and parts of Gujarat and Andhra Pradesh.
- *Ficus carica* is widely distributed in tropical and sub-tropical countries.
- The related genera with edible fruits are *Artocarpus*, *Cudrania* and *Morus* of family Moraceae.
- Some important species are *Ficus glomerata*, *Ficus benghalensis*, *Ficus religiosa*, *Ficus elastica*, *Ficus hispida*, *Ficus roxburghii*.
- Fig is a large shrub or low growing deciduous shrub with short and twisted trunk.
- Fruit solitary, axillary, green or yellow, pear-shaped.

COMPOSITION AND USES

- The fresh fruit contains 11.5 % total sugars, traces of iron, vit.-A, vit.-C, Protein, Fat, Calcium, Riboflavin, Thiamine, etc.
- The fruits are consumed as fresh, dry fruits are very delicious.
- It is also used for preparation of jam and jelly, preserved, candied or canned products
- Unripe fruits are used as vegetables after cooking.
- The fruits boiled in milk are repeatedly packed against swollen gums;
- The fruits are also used against tumor and other abnormal growth.
- The latex is widely applied on warts, skin ulcers and sores.
- A decoction of the fruits is gargled to get relief from sore throat.
- The leaf decoction is taken as a remedy for diabetes and calcifications in the kidneys and liver.
- Latex is used to coagulate milk;
- Leaves are used for fodder.
- In southern France, fig leaves are used as a source of perfume extraction called “Fig – leaf absolute”.
- The latex of unripe fruits and other part of the tree may be severely irritating to the skin and may cause hazard to the fig harvester, packers and also workers of food industries and to those who employ the latex to treat skin diseases.
- The edible fruit of fig botanically called as ‘**Synconium**’ which consists of hollow receptacle with a narrow aperture called as ‘**Ostiole**’ at tip and numerous small flowers lining the inner surface.
- The true fruit is tiny drupelets inside the cavity of the fused peduncle.

Caprification : The process of pollination in fig is caprification.



CLASSIFICATION:

- Based on pollination and horticultural importance, the fig is classified in to 4 classes viz.
1. **Common or Adriatic fig:**
 - The flowers of these figs are pistillate parthenocarpic fruits are developed on them.
 - In India, common (Adriatic) fig is cultivated and which is supposed to be hybrid between *F. carica* and Indigenous species.
 - The cultivated varieties in India are Pune, Bellary, Gangam Marseilles, etc.
 - They are medium sized, bell shaped and light purple with rosy flesh.
 - The other varieties are Trojano and Dottato of Italy, Brown Turkey, Frage and Lepe of Spain.
 2. **Capri fig:**
 - Capri fig is a primitive fig which has functional staminate flowers.
 - It bears non edible fruits, as the flowers are pollinated by a wasp *Blastophaga psenes* which are harboured in the fruits.
 - Some of the varieties are Stanford, Cordelia.
 3. **Smyrna fig:**
 - It is important in Europe and USA.
 - There will be fruit set only after pollination by Capri fig (Caprification).
 - The prominent cultivars are kadota, Bianco Grasso and Nutty Flavour.
 4. **San pedro fig:**
 - It bears two crops. The first crop is parthenocarpic, called as **breba** and
 - Second crop is like Smyrna fig which requires pollination (Caprification), if pollen is not affected the fruit will drop off.
 - The important varieties are Gentile, Blanguette, king, Dauphine, Lampeira, etc.
- Recently, Indian Institute of Horticulture Research has introduced few exotic cultivars, among these cultivars; Deanna, Conadria and Excel are reported to perform better.

CLIMATE:

- Fig is a subtropical fruit. It behaves as deciduous in temperate and subtropical and evergreen in Tropics, where temperature rarely goes below 4.5°C (South India).
- It withstands low temperature (12°C to 9.5°C) when it goes to dormancy.
- Best quality fruits are produced in the region with dry climate during fruit development and maturation,
- Fruits ripen prematurely if the temperature exceeds 38°C and such fruits have tough skin, less pulp with insipid taste, sun burn of fruit skin also take place.
- Good vegetative growth is observed at 15.5-21°C.

SOIL:

- Fig can be grown in a variety of soils.
- It is a deep rooted fruit plant, so it prefers deep soil, clay loam and non-alkaline, medium black soil with well drained and good water holding capacity.
- A good quality of fruit is obtained on heavy soils.

PROPAGATION:

- Fig is mainly propagated by hardwood stem cutting, air layering, budding and grafting.
- The rooted hardwood cuttings of 4 weeks old, are used for planting, IBA may be used for better rooting.
- Cuttings collected from base of shoots; root better than those collected from top or middle portion

PLANTING:

- Planting is done in early spring / monsoon – during August and September.
- The pit size of 60 cm³ with the distance of **3 x 3 m to 8 x 8m**.

TRAINING AND PRUNING:

- Fig can be trained on single stem or multistem but multistem is most commonly followed.
- Pruning of fig is important, fig generally gives two crops in a year, the first borne on previous year's growth is breba.
- The second crop on current season growth and therefore, pruning intensity and its type will depend on bearing habit and type of crop desired.
- Generally, the trees are headed back to about 2 buds of previous growth regularly, to keep them dwarf.
- This reduces the production but improves the quality of fruits.
- In some states, light pruning is practiced which gives higher production but poor quality fruits.
- **Notching** is also practiced to force new fruit bearing shoots from the lower portions of the branches. For this purpose, 0.5 cm wide notch of bark is removed above two buds on the middle portion of the branch in July.
- Application of HCN (Hydrogen Cyanamide) at 1.5-2.0 per cent advanced the date of bud burst.

IRRIGATION:

- Fig is fairly drought tolerant.
- But during summer, when the fruits are developing and ripening, irrigation is to be given twice a month.
- Excess of irrigation during ripening causes cracking of fruits; therefore, judicious watering is desirable for high quality crop.

NUTRITION:

- Fig responds to heavy manuring and application of 50-75 kg FYM for bearing plant.
- For 1 -2 year old plant about 75:50:50 g NPK is sufficient and should be doubled for the 3-5 years and 5th years onwards, a dosage of 300:200:200 g NPK/plant, gives good yield and quality fruits.

FLOWERING AND POLLINATION:

- In fig crop generally, three types of buds occur.
- Flower buds which are spherical, have 3-5 scales, these buds produce parthenocarpic fruits only.
- Mixed buds are conical, made up of 5-8 scales and these buds also produce fruits.
- Vegetative buds are made up of 3-5 scales which usually remain dormant and rarely produce shoots.
- Flower appears on the plants even at two years age, but considerable yield is obtained from 5th year onwards.
- In central and South India, fig bears fruits twice in a year viz., July - September and February – May.
- The fruits harvested during February-May are sweeter and of good quality and fetch premium price in the market.

- Parthenocarpy is favoured or inhibited in a given type by climatic condition of the place where it is growing.
- In Coeur, cultivars like black Ischia, Brown turkey and Pune are parthenocarpic.
- While the cultivars Turkish white has failed to set fruits without caprification in the said place.
- In Allahabad, the cultivated varieties, Pune and Black Ischia do not set fruit without caprification.

PESTS AND DISEASES:

Important Pests

1. Leaf eating caterpillar – *Oenaria varians* – Caterpillar feeds on fig leaves and cause damage
2. Stem borer – *Bactocera rufomaculata* -The grubs bore into the stem and branches.

Diseases

1. Leaf rust - *Cerotelium fici* – Affected plant show small, round brown spots on the leaves, small rusty, raised spots on the underside of the leaves. In severe case defoliation of leaves will be observed.
2. Leaf spot – *Cylindrocladium scoparium*
3. Anthracnose – *sphaceloma ficicuricae*
4. Fig mosaic – Viral disease transmitted by a vector fig mites *Aceria ficus* – Affected leaves show yellow – green spots, white mottle on leaves.

DISORDERS

1. **Sun burn** – Young plants and severely pruned plants show cracking and bark also some times get peel off.

Control measures

- Plant wind break at South Western side of plantation.
 - Light pruning to avoid exposure of main branches / trunk.
 - White painting of main trunk and branches.
2. **Fruit cracking / splitting** –
 - This malady is caused due to sudden change in atmospheric humidity or due to rain showers at the time of ripening or nutritional disorders.
 - This can be minimized by maintaining proper soil moisture.

HARVESTING AND YIELD

- For quality and flavour, pick the fruits when they are soft and wilt at neck exhibited by hanging down.
- Milky latex does not ooze out from the mature fruit stalk when cut fruits are picked at every 2-4 days intervals.
- The average yield is about 150 – 300 fruits / tree or about 8-12 tonnes / ha.
- The selected fruits can be stored for four weeks at 0°C and 90 -95 % RH with CO₂: O₂ ratio of 3.3:5.5. However, frozen figs can be hold for several months in cold storage.

DRYING:

- Sulphur fumigation followed by drying is commonly done in fig.
- First fruits are soaked in boiling salt water for a half a minute and are dried for a few hours under sun and for eight days under shade.

LECTURE -32

JACK FRUIT

(*Artocarpus heterophyllus* / *Astocarpus integrifolia*.; Moraceae; $2n = 56$).

- Jackfruit is a common and popular fruit crop of the low land tropics of eastern and southern parts of India.
- This fruit tree grows well without much care.
- It is the largest edible fruit (20-40kg), In Srilanka a fruit of about 120 kg was harvested and created the world record.
- The fruit is also called as poor man's fruits in eastern and southern part.
- The tree has considerable potential, but it is yet to receive due attention in India it is not generally cultivated in regular plantations and is mainly grown in homestead for domestic uses & as a shade tree in coffee or cardamom plantations.



USES:

- The immature tender fruits and the seeds of ripe fruits are used for culinary purposes.
- Ripe fruits are used for table purpose, nectars, dehydrated leathers, jelly and chips etc. Pickles from immature tenders fruits.
- The skin of the ripened fruits & other wastes of the fruits & leaves are the excellent source for cattle feeds.
- The flour of the seeds is mixed in poultry feeds.
- Produces valuable timbers- furnitures, Musical instruments, toys, carvings, crates.
- The ripe fruits are very nutritious. It contains fairly large amount of proteins (1.9%), Ascorbic acid, carbohydrates (19%), carotene pectin, P, Fe, K & Ca. The seeds contain 7.22% crude protein.

ORIGIN AND DISTRIBUTION:

- Jack fruit is indigenous to India, commonly grown in Sri Lanka, Malaysia, Brazil, Jamaica, Myanmar, Singapore, India,
- In India; it grows in a wild and semi-wild state in Assam, W.B, Tripura, Bihar, UP and Western Ghats.

SPECIES AND VARIETIES:

- The *A. heterophyllus* previously known as *A. integrifolia*. The other related jack fruit species are
- *A. altalis* - bread fruit- small sized round fruit, found in TN, Assam, Mah & Kerala.
- *A. lakoocha*- Monkey Jack- Small edible fruits- it grows wild in Assam, WB, UP & Western Ghats.
- *A. hirsute*- is a semi-wild edible species, native to India.
- *A. champeden*- edible fruit with strong odour like durian.



Artocarpus heterophyllus



Artocarpus altilis



Artocarpus integer

VARIETIES:

- Though there are no distinct type could be identified, the cultivated types are broadly classified into two groups.
- Those producing fruits with firm flesh and crispy in nature.
- Those bearing fruits with soft flesh and very juicy.



GKV-1



Ceylon Jack



Swarna

- Some types with local names like 'Gulabi' (rose scented), 'Champa', Hazari, Rudrakshi (small roundish fruits) are also available. A genotype (No.7) was selected from Uttar Pradesh, with moderate yields.
- A variety GKV-1 and Swarna with superior quality fruits were released from Karnataka and Gumless jack, Muttan Varica from Kerala also found to perform better.
- **Singapore or Ceylon Jack** is remarkable for its **early bearing in 2¹/₂ to 3 years**;
 - The fruits are medium in size (7-10 kgs).
 - The flesh is sweet and crispy.
 - The carpels are compacts, yellow and firm with strong aroma, the fruit contain about 80 seeds.

SOIL AND CLIMATE:

- Proper drainage is ideal for cultivation.
- The fruit tree is very well suited for dry land conditions.
- It can be grown under wide range of soils rich deep and well drained soil is good for its cultivation.
- The fruit tree comes up well under humid and warm climate of hill slopes, arid warmer plains of south India.
- It is grown up to 1500m from main sea level and sensitive to frost and drought.

PROPAGATION:

- The seedling trees may take 10 years to bear. In India most of the plantations are still raised by seeds. The seedlings can be raised in pots/poly bags which are ready for transplanting after one year. The freshly extracted seeds are sown for higher % of germination.

Vegetative methods:

- Presence of gum/latex – layering, building, grafting is difficult to carry out. Cuttings were found to root easily under mist by treating with IBA at 3,000ppm and ferulic acid at 200ppm also used.

- Recent years softwood grafting is commonly practiced, patch budding 100% success provided there must be sufficient sap present in scion and root stock.
- Air layering is the earliest vegetative propagation, pretreatment of stock plant with ethrel (250ppm) 15 days before the air layers preparation and treating the layers with IBA at 3000 or 5000ppm at the time of air layering caused 100% rooting.

PLANTING:

- Jack fruit is planted as a shade tree in coffee garden or as mixed plant, as avenue plant.
- To have a regular orchard like mango the spacing 10x10 m is followed.
- Pits of 1m³ is prepared, 20-30kg FYM, ½ kg SSP and phorate granules (10-20gm) are filled in pits and planted during June –July.
- During summer supplementary irrigation should be provided.

Manuring:

- For 1-3 years old tree- 200:60g NPK/plant/year
- For 4-6 years old tree- 400:240:120g NPK/plant/Year
- 7th year onwards 600:300:240g NPK/plant/Year

INTERCROPS - short duration vegetables, leguminous crops cowpea, horse gram, black gram etc.

FLOWERING:

- Flowering starts in December and continues up to March.
- It is monoecious plant with spike type of inflorescence.
- Male and female inflorescence present in same plant.
- The flowers are cross pollinated by honey bees.
- A multiple fruit, known as **sorosis** develops following pollination and fertilization.
- The pericarp around the seed and the fleshy perianth are edible.
- The fruits take about 90-110days after appearance of the spike, mature in June-July and are available almost throughout the year in Assam & South India.

HARVESTING:

- It is a climacteric fruit; harvesting is done by cutting the fruit along with stalk after developing sweet and good flavour.
- Change in fruit colour from green to light yellow.
- Harvesting is done by cutting off the stalk carrying the fruits.

YIELD:

- 15 year old tree yields about 250 fruits, the individual fruit may weigh from 1.0kg to about 20 kg.

STORAGE:

- Fruits are stored for 2-3 months at 5°C with 85-90% RH and 1.0 week under room temperature.

Pests and diseases:

Pests: Although a number of pests are known to attack jack fruit, the most important are Shoot and trunk borer- *Margaronia caesalis*, brown weevil, mealy bug, Jack scale etc. are found to attack jack fruit which can be controlled by use of suitable contact insecticide.

Diseases:

Stem rot, male inflorescence rot, pink diseases & soft rot are the important diseases.

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Lecture-33

TAMARIND

(*Tamarindus indica*, Linn.; Leguminosae Sub. Fam: Caesalpiniae ; 2n = 24; Origin: Tropical Africa)

INTRODUCTION:

- Tamarind is one of the most popular tree found cultivated throughout India as stray plantation or avenue, common crop in waste land,
- It is a good wind break. Though tamarind is very popular, its large scale production is not common. However, at several places its regular plantations are being initiated under Agro-forestry systems.
- The tree is large 40-60 feet high, evergreen, but in hot and dry areas it sheds its leaves in April – May.
- India is the only country to exploit tamarind extensively.
- Annual production of pulp in India is over 3 lakh tones, of which 4,000 tonnes are exported to Europe and North America and the rest is locally consumed.
- Nearly 20,000 t. of tamarind seed powder is produced annually in India.

ORIGIN AND DISTRIBUTION:

- Tamarind is indigenous to tropical Africa and some part of South India.
- It is widely cultivated in tropical and Sub-tropical regions of the Africa, Asia and America.

COMPOSITION AND USES:

- The fruit pulp is very popular acidulant in Indian curries especially in South India.
- Immature fruits are used for chutney and ripe fruit pulp is an important ingredient in South Indian dishes to induce sourness.
- In India, the fruit is used mainly for culinary purposes, while in other countries; the fruit is processed into nectar, fruit punch, juice, crystallized fruit and concentrates.
- The pulp is used to season foods viz., curries, preserves, confectioneries, ice-cream and syrups; chutneys, pickles,
- Pulp is mixed with Jaggery and made into tamarind balls (sweet meat).
- The unripe fruits are the rich source of tartaric acid.
- The tender leaves, flowers and young seedlings eaten as vegetable.
- Seeds are rich in pectin.
- Tamarind seed kernels are eaten by the poor during times of scarcity and famine in South Central India.
- The Kernel of seeds are roasted and eaten like groundnut.
- The Kernel contains a polysaccharides – jellose, the jellose can replace starch in the cotton and jute industries.
- The bark and leaves are used for tanning.
- The wood is used for tools, furniture, fuel and makes a charcoal used in gun powder, tools and agricultural implements – mallets, planks, rice ponders.
- It is believed that continuous use of tamarind in daily food reduces the chances of stone formation in urinary system.

COMPOSITION:

- Fruit is a pod and comprises of 55 % pulp, 20.6 % water, 3.1 % protein, 0.4 % fat, 70.8 % carbohydrates, 3 % fibre and 10 % tartaric acid. Seeds have 63% starch, 16% protein.

CLIMATE:

- Tamarind is a hardy tree, which grows well under warm climatic conditions of tropics and subtropics, wherein summers are hot and dry and winters are mild.
- It is drought tolerant, but sensitive to frost.
- Fruits do not ripe properly in cold weather.

SOIL:

- It is self-sown in forest and waste lands, can grown in poor soils.
- Since, it has deep tap root system and long life span therefore deep loamy soils with adequate moisture would be the best for its growth.

Cultivars: Since cultivation has been through seeds no standard cultivars are available, but there are some selections based on

I. Fruit size and shape. Baily recognized 2 types.

1. East Indian type – having long pods with 6 – 12 seeds.
2. West Indian type – having shorter pods with 1-3 seeds.

II. Based on the pulp colour

1. **Yellow or brown pulp** type – turning dark brown on storage it is harvested after full maturity.
2. The **reddish pulp type** – locally known as **Raktichinch**.
3. **Yogeshwari** – A high yielding red type released by Marathwad Agriculture University, Parbhani, Maharashtra.

III. Based on organoleptic taste: The cultivated types could be broadly classified in to 2 groups they are

1. **Sweet type:** The ripe fruits have sweet pulp coupled with less acidity; fruits are used for desert purpose.

Varieties : Makham, Waan, Secthong, Manila sweet
Pratisthan – Released by the fruit Research Station, Aurangabad.

2. **Sour type** – The ripe fruits have sour pulp with more acidity.

Varieties – No. 263 – Fruit Research Station, Aurangabad, Urigam, Cumbum.
PKM-1 – Released by Hort. Research Institute, Periyakulam, Tamil Nadu – Best for HDP (160 plants / acre).
DTS – 1 and DTS – 2 : Released by UAS, Dharwad, (Dharwad Tamarind Selection)

PROPAGATION:

- Tamarind is propagated mainly by seeds, budding, cuttings, layering, approach grafting, and the most appropriate technique (in-situ soft wood grafting on 1 year old rootstock).
- To raise seedlings for 1 hectare – 2.0 – 2.5 kg seeds is needed.

PLANTING:

- Seedlings ready for planting in July – August planting is done in 75 cm³ pits, the tap roots are trimmed at the time of planting,
- It should be planted at 4 x 4 / 5 x 5 m at beginning, which remains after thinning twice or thrice 12 x 12 / 15 x 15 m.

Inter crops - During pre-bearing period – it is preferred to grow some of the annual fruits, vegetables and leguminous crops.

Nutrition – Being a leguminous tree, may not require nitrogenous fertilizer. However, P & K application might prove advantageous. Application of compost/FYM at 40-50 kg / tree / year would suffice the most need of nutrients.

Irrigation – Once the plant has established it hardly needs any irrigation. However, water harvesting in rhizosphere during rainy season would be advantageous.

Fruiting –

- Seedling tree of tamarind comes to bearing in 10 – 14 years after planting, whereas,
- Vegetatively propagated tree requires 7- 8 years.
- Flowering starts from April – June and pods ripen from Feb – April.
- The productive life of tree remains up to 60-70 years.

HARVESTING:

- Both immature and mature fruits are harvested depending upon demand and their uses.
- Harvesting is done by collecting individual fruits with fruit picker or some times a man can climb on the tree and shakes the branches.
- The exocarp of mature fruit gets hardened and gets separated from the pulp.
- A fully developed tree can give about 200 – 250 kg fruits / year.

POST HARVEST HANDLING:

- After harvest the fruits are allowed to dry and their hard shell is removed.
- Some times the seeds are also taken out and fruits are made in to tamarind bells and marketed.
- Under ordinary conditions the pulp remains good for about a year provided it is kept in dry condition.

Pests: Tamarind is not harmed by many pests. However, a few pest cause damage.

1. Scale insects – *Aonidiella orgetalis*

Damage to tender shoots by sucking the sap

2. Tamarind beetle – *Pachymerus gonagagra*

Beetle feeding inside the ripening fruits

Disease:

Saprot	– <i>Nylaria euglossa</i>
Brownish saprot	– <i>Polyporus calcuttensis</i>
White rot	– <i>Trametes flouose</i>

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ANNONA (SUGAR APPLE)

(*Annona Squamosa* Linn.; Annonaceae ; $2n = 14$; Origin: Tropical America – Peru)

INTRODUCTION:

- The custard apple has been growing in India from time immemorial.
- It is found growing wild in sub-tropical and tropical parts of India.
- The edible part of anona is areoles.
- It has about 120 species, five of them having pomological significance and 4 of the 5 species are important in the commerce and are originated in South America and one seems to have originated from Eastern Africa.

The first group includes –

1. *Annona cherimola* – Cherimoya/Lakshmanphal
2. *A. muricata* – Soursop/ Mullu Ramphal/Mamphal
3. *A. reticulata* – Bullock's heart/Ramphal
4. *A. squamosa* – Custard apple/Sitaphal/Sweet Sop/Sugar apple
5. *A. glabra* – Pond apple/Hanumanphal/Monkey apple

The African species *A. senegalensis* – wild soursop

- *A. atemoya* – Atemoya is a cross between *A. squamosa* x *A. cherimola*. Annonaceous fruits have morphological affinity for each other, but each type is unique in its taste, flavor, colour and texture.
- Custard apple is cultivated mainly in Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh, Uttar Pradesh, Bihar, Assam and Orissa.

USES AND COMPOSITION:

- The custard apple fruits are mostly used as table fruits or pulp is mixed with milk or ice-cream.
- It is rich in CHO's and provides good amount of proteins and minerals.
- It is a good source of Vit-A and C.
- Its calorific value ranges from 822 to 1050 K Cal/kg (as compared to 741 K cal/Kg of mango).
- The different parts of plant are widely used in folk medicine because of bioactive compounds, mainly acetogenine, alkaloids, flavonoids found in leaves, roots, fruits and seeds.
 - Acetogenins are potential anticancer property compounds as they have cytotoxic effect.
 - Flavonoids found in seeds, roots, bark, stems are potential chemopreventive agents, given evidence that they decrease tumour incidence.
 - Ethanol extracts of cherimoya seeds are used as insecticides and antiparasitic properties.
 - The roots are used to treat acute dysentery, depression and spinal marrow diseases.

SOIL AND CLIMATE:

- Custard apple grows well on sandy, rocky gravel, even on heavy soils.
- It does not require deep soil, but drainage should be proper.
- Soils with rich in organic matter with a pH of 6.0 – 6.5 are ideal.
- Custard apple is a hardy plant, prefers dry climate with mild winter and very sensitive to frost.
- The tree goes to dormancy in November-January after harvesting.
- The tree can be grown successfully 1000m from mean sea level.
- Moist climate is favourable for proper growth and development of fruits.
- The plant can tolerate extremes of heat but the yield goes down as shedding of flowers occurs above 39°C.

PROPAGATION:

- It is commercially propagated by grafting.
- Also propagated by sexual methods. Since the seeds loose viability; they should be sown, after removal from ripe fruits.
- The seeds of cherimoya treated with 10000ppm GA₃ significantly increased germination by 70%.
- It is propagated easily by budding.

VARIETIES

1. **Balanagar:** It is a popular variety of Andhra Pradesh, grows to a height of 3.5 to 4.0 m tall. The yield potential of this variety is very high with the fruit size of 350-450g with less number of seeds (40-80), pulp is white buttery sweet with TSS of 29 percent, acidity of 0.24 percent.
2. **Mammoth:** This is a high yielding variety with prolific bearer, fruits are irregular in shape. The average fruit weight is about 180-200g. The areoles are medium to big in size, very smooth and round. The mesocarp is white in colour small to medium segment. The number of seeds is less (15-30 seeds/fruit). The fruit has a good keeping quality.
3. **Red sitaphal:** The fruits are medium in size (170-250g) the rind is pink, slightly acidic and sweet, TSS-25 percent with good quality fruits, acidity 0.21 percent with small size seeds.
4. **Barbados:** The fruits are of small to medium in size (170-200g), fruits are spherical in shape. The mesocarp with medium areoles with creamy white pulp, moderately sweet, with the TSS of 24 percent acidity of 0.21 percent. This is a high yielding variety.
5. **British Guinea:** This is high yielding variety; the fruits remain green at ripening, medium in size (170-340g). The mesocarp is white and soft, pulp is white, moderately juicy and sweet with 25 percent TSS.
6. **Islander:** Large fruit (410g), TSS 26 percent with less seeded.
7. **Atemoya:** Hybrid between *A. squamosa* x *A. cherimoya* – sweet pulp, with few seeds.
8. **Arka Sahan:**

PLANTING:

- Planting of seedlings is done during monsoon; about 6-12 months old seedlings and grafts are selected for planting.
- The pits of 45-60 cm³ are dug and filled in with a mixture of good soil and compost, planting is done at different spacing based on varietal requirement.
 - Cherimoya – 6.0 x 4.0 to 8.0 x 6.0m
 - Custard apple – 3.0 x 3.0 to 5.0 x 5.0, 5.0 x 7.0m
 - Sour sop – 4.0 x 4.0 to 8.0 x 8.0m
 - Bullock's heart – 5.0 x 5.0m

MANURE AND FERTILIZERS: Green manure crop like moong and other leguminous crops can be raised. Application of caster cake and bone meal, in 2:1 ratio is found beneficial. Application of 250:125:125g NPK in two splits along with 50 kg FYM/Plant/Year.

IRRIGATION: Custard apple is mainly grown as rainfed fruit crop in India. This crop is benefited from the rainfall that is received during the fruiting season. One or two irrigations during fruit development improve the size and quality of fruits.

TRAINING AND PRUNING: Newly planted seedlings/grafts are supported with wooden sticks. Generally, pruning is not recommended in custard apple. Fruits are borne on old as well as current season

growth. Light pruning helps in inducing better branching. Where pruning can be done to avoid over crowding or remove dead/diseased wood.

FLOWERING AND FRUITING:

- Annona plants starts bearing from 3 years of planting and economic yields starts from 5-6 years after planting. Flowering periods extends from spring to the end of the rainy season.

Factors affecting fruit set

1. Failure of many flowers to form fruits due to lack of pollination.
2. It is desirable to set fruits early in the season, but in India the early flowers produce no pollen and hence natural pollination is difficult. Hand pollination gives about 85 percent fruit set compared to natural pollination (30 percent).
3. **Dichogamy:** The stigmas are not receptive when the pollen is shed and the **receptivity** also remains for a short period. Some custard apple trees shed pollen on the morning and others in the afternoon. Increase in fruit set is possible by application of NAA at 20ppm during flowering for 3-4 times at 8-10 days interval and spraying with GA₃ at 50ppm.

Mealy bug: *Planococcus pacificus*

Sometimes, new growth of custard apple tree during spring is severely affected by Aphids and Jassids – these pests are effectively controlled with the spray of Monocrotophos at 0.2% or Rogar at 0.1% concentration.

Diseases

1. **Collar rot and Root rot:** *Pithium* sp., *Phytophthora* sp. – The seedlings are affected, incidence is more severe when there is problem with drainage.
2. **Anthraxnose:** *Glomerella cingulata* – It affects on fruits, infections start at blossom end and later spreads on entire fruit surface, affected fruits may fall down from tree.
3. **Leaf spot:** *Cercospora anonae* – Brown spots on leaves, under severe condition leaves fall down.
4. **Fruit rot:** *Phomopsis anonacearum* – Rotting of fruits in storage condition.

HARVESTING AND YIELD:

- Custard apple matures/ripens during October-November/December in dry region, whereas in humid areas harvesting is done during August.
 - Custard apple fruits are climacteric, therefore they are harvested when they are mature, firm and plumpy, on maturity, fruit turn light green.
 - The inter aereolar space widens the fruits turn creamy white, the skin between the segments or tubercles turn into light yellow colour.
 - For transporting over distant market, the fruits are to be picked before full ripening and are packed in single layer, well ventilated wooden boxes with soft cushioning material.
 - A good bearing tree gives about 100-150 fruits i.e., about 8-10 tonnes/ha.
 - The fruits are highly perishable and cannot be stored for long duration.
 - It can be stored in good condition up to 7 days by treating them with 8% wax emulsion.
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WEST INDIAN CHERRY/BARBADAS CHERRY

(*Malphigia punicifolia*: Malphigiaceae; Origin: Tropical America)

The West Indian Cherry is a very important fruit, because of its high ascorbic acid content (10-33g/kg edible pulp). It is widely distributed throughout tropical America, Africa and west Indies. It is also called Acerola, Cereza in Puertorico, Barbedas cherry in Florida and Texas.

The plant is ornamental and when laden with clusters of its crimson fruits, presents a very attractive appearance. It is a medium sized shrub and can serve as ornamental trees on account of their fruits, flowers, foliage and the drooping branches.

Composition: It is an excellent source of Vit. C (1-4 per cent), Maleic acid, Glucose, Fructose, Sucrose, Calcium, P, Fe, Na & K in trace quantities. Because of its high vit-C content, the fruit of west Indian cherry can be rightly called as the “pill of natures” Vit-C. Eating one or two fruits every morning will meet the daily requirement of Vit. C. The fruit also contains protein, carbohydrates, fibre, carotein, thiamine, riboflavin etc.

Uses: There is good potential in the form of processed produce and also for the food and pharmaceutical industries. The fruits are eaten as fresh; it can be juiced for punch for jellies and in the preparation of gelatin desserts, salads or for fortifying other juices with low in Vitamin C.

The fruit is used to cure of throat pain, diarrhea, the bark extract (26 per cent Tannin) used for leather conditioning and for colouring silk and woolen cloths.

Soil: It can be grown in wide range of soil with good drainage. The soil pH should be 5.0 – 6.5.

Climate: It is a tropical plant, thrives well in warm low land climates. The number of flowering cycles depends upon temperature and the rainfall pattern. A well distributed average rainfall of about 175cm is good for growth and fruiting. It cannot withstand low temperature (less than 5°C) for longer period.

Cultivars and species: The genus *Malphigia* mainly having 2 related species – *Malphigia coccijera* and *Malphigia urense* yields edible fruits.

The cultivated types are grouped into two:

1. Acid types – These are generally better yielders with more desirable form. The vitamin C level is excess, these fruits are considered acceptable in many countries where fruit is used fresh or blended to fortify other juices low in Vit.C

Varieties – Maunawik, J.H. Beanmont, C.F. Rehnong, F. Haley, Red jumbo.

2. Sweet type: These cultivars were developed for general home planting and for potential use in baby foods and products requiring minimum acidity.

Varieties: Manoa sweet, Tropical Ruby, Hawaiian Queen, Florida sweet

Other varieties – A-14, 12, B-6, 7,8,15 and 17 grown in Puerto Rico.

Propagation: It is propagated both by seeds and vegetative means. Seed propagation is done primarily to produce seedlings for selection purposes or for rootstocks. Due to the high hetero-zygosity, seedlings are not recommended for production purposes. Seeds loose their viability quickly, and to be sown immediately for good germination. It takes about 10-12 days for germination and 6-8 months old seedlings are used for transplanting.

Vegetatively it can be multiplied by hardwood cutting, air layering, budding, commercially air layering is

followed during rainy season. Hardwood cuttings treated with IBA at 2500ppm give better rooting,

Planting: Planting is done in 1 m³ pits at a spacing of 7x7m for general cultivation and at 3x3m for hedge purpose.

Manuring: About 40-50 kg compost/plant/year should be applied in 2 splits.

Training and pruning: The plants are trained to a single stem with scaffold branches produced at a height of about 60-90cm above ground, to facilitate for easy cultural operations. Since the fruit bears only on current season growth, light pruning is necessary to encourage new growth.

Flowering: The flowering starts after two years and generally commences with onset of monsoon (May to August). Flower-bud production appears to occur between 15 and 18 days after pruning.

Harvesting and yield: The fruiting starts from second year after planting. The fruits are harvested at different stages of maturity based on purpose of use. Half to fully ripe fruits can be utilized for various purposes. Mature green fruits are suitable for Vit. C, extraction. All fruits may not ripen at a time. Hence repeated harvesting is required. The fruit is thin skinned, delicate and highly susceptible to bruising. An average yield of 2 kg/plant could be obtained from four-year-old trees.

JAMUN Gulab Jamun / Java Plum

(*Syzygium cuminii* Skeels; Myrtaceae; Origin – India; 2n = 40)

Jamun is one of the most popular minor fruit of India, grown throughout the country. It is more popular as an avenue tree and for wind break. The trees of this species are also found in Srilanka, Thailand, the Philippines, Madagascar, West Indies, East and West Africa, Algeria and Israel. In India, It is grown in the Indo-Gangetic plains, lower ranges of the Himalayas and Tamil Nadu.

The genus *Syzygium* is having about 400 – 500 species of which a few provide edible fruits like

1. *S. Jambos* (Rose apple or safed Jamun): The tree is ornamental; the fruits are light yellow – white in colour. The seeds are polyembryonic. It is grown in Assam, Bihar, Andhra Pradesh, Tamil Nadu, West Bengal, and Maharashtra & Gujarat.
2. *S. frutescens* – The trees are suitable for wind break, fruits are edible, small in size.
3. *S. Javanica* (Water apple): This species is found in South India and West Bengal.
4. *S. densiflora* – It is used as a root stock for *S. cuminii*. It is resistant to attack of termites.
5. *S. uniflora* (Surinam cherry or pitanga cherry): It is small tree bears small sized, bright red with aromatic flavour fruits.
6. *S. Zeylanica* – Small tree, bears edible fruits in Western Ghats of India.

Uses and composition

Fruits are eaten when fully ripen, processed in to beverages, jellies, jam, squash, vinegar, pickles and wine. The fruits are good source of sugar, protein (0.7%), fat (0.1%) carbohydrates (19.7%), Iron and other mineral matters. Jamun juice mixed with mango juice is very good for diabetics. The extracts from bark, seeds, leaves and fruits are used against diabetics and also moderately antibacterial.

Jamun vinegar is good for curing stomach disorder. The fresh bark / stem extract is used for prevention of dysentery by mixing with other concentrate and used as good animal food. The wood (Timber) is used for railway sleeper equipment. The flowers are an important source of honey.

Climate: It is grown under tropical and sub-tropical climate, also found growing lower ranges of Himalaya up to an altitude of about 1300 m. It prefers dry weather at flowering and fruiting. Early rains are better for proper growth, development and ripening of fruits, and annual rainfall of 350 mm is good for Jamun.

Soil: Jamun grows well in deep, loamy and well drained soils. It is sensitive to sodium. It can also be grown under saline and water logged conditions.

Varieties / Cultivars – There is no named varieties and lot of variation exist in this fruit. However, local types at several places are superior. A large fruited local types in Gujarat is known as ‘Paras’. The most common cultivars grown are

- 1) **Ra Jamun** – The fruit length from 2.5 – 3.0 cm. and dia. 1.5 – 2.0 cm. with oblong shape, deep purple or bluish black in colour, with light pink or grayish pulp which is juicy and sweet.
- 2) **Other strains are ;**
 - a. NDUA & T – Narendra Deva University of Agriculture & Technology – Faizabad – Fruit weight is more and high pulp: Seed ratio
 - b. Gujarat Agriculture University – Paras
 - c. PKV – 15, 4, 14 and 13.
 - d. Konkan Krishi Vidyapeet – Seedless, Gokak – Konkan Krishi Vidya Peet,
 - e. KRC – KJS – 20 – College of Horticulture, Arabhavi

Propagation: The Jamun is propagated by seeds and vegetative methods as well.

Seed: Fresh seeds can be sown within 3-4 weeks and germinated in 10 – 15 day, seedlings are ready during February to March

Vegetative Methods:

Budding: It is done on one year old seedling stocks during July to August in low rainfall area.

Air Layering: It is done in spring – about 60% rooted air layers are obtained when 500 ppm IBA in lanolin paste is used.

Cuttings: Cuttings treated with 2000ppm IBA gave higher rooting.

In grafting or budding, *S. densiflora* is used as root stock to impart resistance to termite attack.

Planting: Pits of 1 m³ size are opened at a distance of 10 x 10 m. for grafts and 12 x 12 m. for seedlings – done during March – May and planting is done during monsoon.

Manuring: About 20 kg FYM/Plant every year. This much quantity of organic matter suffices the requirement for growth, flowering and fruiting.

Irrigation: Jamun is a hardy plant, usually 8 – 10 light irrigations are required during the early age of the plant. Bearing trees should not be given irrigation in Sept – Oct to encourage fruit bud formation. Similarly withholding irrigation in Feb – March enhances flowering & fruiting depending upon climatic condition.

Inter & Mixed cropping: Upto pre-bearing period fruit crops like Guava, Kagzilime & Fig can be grown as filler crop. Legumes, onion, peas, gram, mung, etc. are good inter crops.

Pruning & Training: It is always better to keep 4-5 m of main trunk without any lateral branches, bearing tree does not require any pruning except removal of dry, diseased, criss-cross branches.

Flowering and Fruiting: Seedling trees comes to flower at 8 – 10 years and grafted trees in 6-7 years.

Flowers are borne in the axils of leaves on branchlets, flowering starts from March to April. The hermaphrodite flowers are light yellow in colour. Anthesis and dehiscence occurs between 10 am to 12 noon. Stigma receptivity is maximum one day after anthesis. Honey bees, house flies and wind are responsible for cross pollination.

There is a heavy drop of flowers and fruit (50-60%) within 3-4 weeks of flowering. A large number of fruits drop off at very young stage during 5-8 weeks after blooming. The flower and fruit drop can be reduced with the help of two sprays of GA₃ @60 ppm first at full bloom and second spray, 15 days after initial setting of fruit.

There are 3 phases of fruit growth and development i.e. I phase from 15 to 52 days after fruit set, having slow growth of fruit.

The II phase from 52 to 58 days after fruit set having fast growth and the III phase and last phase from 58 to 60 days after fruit set, having slow growth.

Harvesting: The ripe fruits change their colour in to deep red or violet. Fully ripe fruits are plucked singly or in bunch by hand from the tree. Since all the fruits are not ripe at a time, 3-4 harvesting are needed.

Yield: The fully grown seedling Jamun tree produces on an average 80 -100 kg fruits. Whereas, it is about 60-70 kg from vegetative propagated tree.

Post harvest handling and storage

The fruits of Jamun are highly perishable in nature, fruits are generally harvested daily and sent to market on the same day. They cannot be stored more than 3-4 days under ordinary conditions. However, pre-cooled fruits packed in perforated polythene bags can be stored well upto 3 weeks at low temperature ($9 \pm 1^{\circ}\text{C}$) and 85-90% RH.

Pests

1. Leaf eating caterpillar – *Carea subtilis*

Caterpillar attacks the leaves and tree become defoliated.

Management: Spray Rogar 30 EC @ 0.1 % or Malathion @ 0.1%

2. Fruit fly – *Dialeurodes eugenia*

Affected fruits get wormy appearance on the surface

Management: Destroy the maggots and pupae hibernating in the soil around the tree trunk by digging up the soil around the tree trunk and pluck all affected fruits and destroy them.

Diseases

1. Anthracnose – *Glomerella cingulata*

Affected leaves show small scattered spots, light brown or reddish brown fruits show small circular lesions ultimately fruit rot.

Management: Spray the tree with Dithane Z – 78 at 0.2% or Bordeaux mixture (4:4:50)

Wood apple

(*Feronia limonica*: Rutaceae; Origin: India and Ceylone)

Wood apple is a thorny tree commonly found in dry deciduous forests and cultivated in many parts of India for its fruit. It is one of the hardy and drought tolerant crops. Extensive root system and synchronization of its reproductive phase with high moisture availability made it suitable crop for arid zone. It is also called as an elephant apple, monkey fruit, curd fruit, katu bael, etc.

Composition: The ripe fruit contains sour, sweet, aromatic pulp which is about 70 per cent of total weight. It contains protein (7.19), sugars (7.2%), and acidity (2.3%) and is rich source of riboflavin (0.17mg). the pulp contains 3-5% pectin. The seed contain non-bitter, oil, high in unsaturated fatty acids.

Uses: The rind must be cracked with a hammer. The scooped out pulp though sticky, is eaten raw with or without sugar, or is blended with coconut milk and palm sugar syrup and drunk as beverage or frozen as an ice cream. It is also used in preparation of chutney, jelly and jam.

The fruit shell is fashioned into snuff boxes and other small containers. The trunk and branches exude a white, transparent gum used as a substitute for or adulterant of gum Arabic and is also used in making artists water colour, ink, dyes and varnish. The wood is very hardy, durable and valued for construction. Agricultural implements, rollers for mills, carving and fuel.

Medicinal uses: The fruits much used in India as a liver and cardiac tonic and when unripe as an astringent means of halting diarrhoea and dysentery and effective treatment for cough, sore throat and diseases of the gums.

The juice of young leaves is mixed with milk and sugar candy and given as a remedy for biliousness and intestinal troubles of children. The powdered gum, mixed with honey is given to overcome dysentery and diarrhea in children.

Leaves, bark, roots and fruit pulp are all used against snakebite.

Species and Cultivars.

It is a monotypic genus of the only species *Feronia limonica* and has $2n=18$ chromosomes. There are no named or standard cultivars of this fruit. The available types grouped into two forms, one with large sweetish fruits another forms, one with small, acidic fruits. The Marathwada Agril. Univ. Parbhani, Maharashtra has released a type called HB-10 having large sized fruits with an average weight of 350 g and pulp of 222g.

Soil: Being a hardy crop, it can grow in a wide variety of soils including degraded soils of arid region and can tolerate salinity to certain extent. It comes up well under black cotton soils. It can be grown successfully in marginal lands.

Climate: It grows in a dry region of subtropical and tropical regions of the country. It does not grow well above 150m the mature plants can tolerate low temperature (0-15°C) as well as a temperature as high as 47.5°C. The warm season appears conducive for the initiation of floral buds. The tree sheds its leaves and the branches are bare for a short period in the cold season during January and flowering starts in February-march.

Propagation: It is generally propagated by seed though seedlings will not bear fruit early. Seeds should be sown freshly to get higher germination. Polyembryony to the extent of 63% is observed in wood apple. Polyembryonic seedlings are vigorous in growth and true to type.

Vegetatively it can be propagated by cuttings, budding and grafting. Softwood grafting is highly successful with eight to ten months old seedlings.

Cultivation:

For regular plantations, the spacing of 8 to 10 m should be followed. The best time for planting is July-august.

Training and Pruning: Trees are allowed to grow freely on central leader with well spaced branches in all directions. It does not require regular pruning.

Irrigation: It is a crop of dry region and once the plants are established, they hardly need any irrigation. However, conservation of run-off rain water in root zone will enhance the productivity of the crop.

Manuring and Fertilization: Manuring is not practiced but it will be benefited with increased fruit size and quality by regular application.

Flowering: The flowering occurs from February to May. The flowers are mainly staminate and hermaphrodite. It is highly cross pollinated crop and un pollinated flowers failed to set fruits.

Harvesting: The matured fruits are available from October to March. The stage of harvest is determined by the purpose of using the fruit. For chutney, immature but fully developed fruits are preferred. For squash and jelly, fully matured fruits are desirable.

Harvesting should be done carefully without any damage/crack which leads to grip of the fruit stalk is loosened and the fruit is detached from the tree without any efforts which otherwise is difficult in unripe fruit.

An average yield of 200 to 250 fruits per annum from grown up trees can be obtained fruits can be graded based on size and then marketed. Fruits have a good post harvest storage life because of its hard outer shell and it can withstand transport better.

Pests and Diseases: There are no serious pest and diseases recorded on this crop. However, these attack on citrus are also known to attack on this crop viz., Anar butterfly, castor slug, etc. Xanthomonas bilvae-bacterial disease.

Research requirements

1. Survey, evaluation and commercial types should be exploited.
2. Wood apple based products are required to be developed to support production in arid region and on wasteland
3. Horticulture techniques and management practices are required to be standardized.

BAEL

(*Aegle marmelos*; Rutaceae; 2n=18; Origin –India; Fruit: Hard shelled berry)

It is cultivated throughout the South East Asia and East Indian Archipelago (small islands). It is a hardy fruit tree and can be grown successfully in dry areas. It is often cultivated in garden and temple compounds. The tree is deciduous and medium sized. It has characteristic trifoliate aromatic leaves which are divided into three leaflets. There is complete defoliation of leaves during the month of April (time of ripening of fruits). The new leaves and shoots appear at the end of April the fruits are of various shapes such as spherical flat, oblong and pear shaped. The fruit is hard and filled with soft, yellow and orange, very fragrant and pleasantly flavoured pulp. Due to mucilaginous texture and numerous seeds in its pulp, bael is not popular as a fresh fruit.

Uses and Nutritive value: Bael tree has both mythological and medicinal significance. It adores almost every temple. Bael leaves are used for sacred offering to lord shiva. There is mention of bael in our ancient literature. Bael fruits (green) are good for stomach ailments when used after preparing preserve. Ripe fruit is a tonic, laxative and good for heart and brain. Fruit is a rich source of riboflavin (Vitamin B12) and carotene. Marmelosin – active ingredient present in bael, extracted from bark.

Soil and climate: Bael tree can be grown in poor soils. It can be grown in acidic, alkaline and stony soils having pH range from 5-10. Bael tree grows even in poor clayey soils where other trees fail to grow.

Climate: Bael tree can withstand maximum temperature of 46.6°C and minimum of 6.6.

Cultivars: The genus consists of 2 to 3 species. It is found in UP, Bihar and WB some important types selected in different regions are UP, NB1, NB5, NB6, Bihar, Etawah Kagzi, Seven Large, Mirzapuri and Deoria large, Basti No. 1, Kagzi Gonda

Etawah Kagzi: It is mid season ripening cultivar and bears heavily. Fruits are big, spherical, smooth, brown coloured with thick skin. Pulp is hard, brown, sweet scented and slightly fibrous keeping quality of fruit is good.

Deoria large: Mid season cultivar with medium fruit keeping quality. Fruits are largest among all the cultivars. Pulp is soft, sweet scented and yellow-coloured. Fruits are of very good quality as the fruits have less mucilaginous substances.

Kagzi Gonda: It is the best cultivar in UP having large sized fruit within rind and soft yellow pulp of excellent flavour. Besides, it has excellent keeping quality of the fruits.

Mirzapuri: Excellent keeping quality. Rind is smooth, thin, dark and yellow coloured. Pulp is soft, brown coloured, sweet scented and contains little fibre.

Propagation :

Sexual propagation: common method of propagation of bael is by seeds which are sown in the month of June and seedlings become ready for transplantation after a year. (No true to type).

Vegetative Propagation :

T-budding, patch budding, chip budding are successful. The bael fruit can also be grafted on to a number of related plants viz., *Aegle fraglegabonensis*, *A. chevlieri*, *A. paniculata* and *Swinglea glutinosa*

Air layering: On 15 year old trees, air layers can be prepared during the month of August. Top working can also be practiced in bael. Top worked trees started fruiting after 5 years.

Planting: In 1x1x1 m size pits bael planting should be done during (July-September)

Pruning and training:

In young plants, training should be done for imparting proper shape to the tree. Pruning of dried and dead shoots should be done during April-May and August.

Irrigation: In the initial years, plants require frequent irrigation. Once plants are established it does not require irrigation as trees are tolerant to drought conditions. During summer, when the trees shed their leaves, requirement of irrigation is considerably reduced.

Nutrition: 60g N, 40g P and 60g K and 10 Kg FYM for one year plant. This dose should be doubled as the years advance. For control of Zn deficiency, foliar application of Zinc sulphate neutralized with unslaked lime should be made preferably during July, October and December

Flowering and Fruitset

The flower buds appear in the month of May and flowers start opening from the middle of May.

Fruit setting takes place by the third week of May and continues up to July. Fruiting occurs on one year old shoots.

Harvesting and storage: To avoid dropping of the fruits, harvest the fruits carefully retaining stalks at the time of harvesting. (January) for uniform ripening fruits can be treated with the application of etrel @1000-1500 ppm keeping the fruits at 30°C.

Ripe bael fruits can be stored for 2 weeks at 27-32°C. Fruits below 9°C temperature are greatly injured and brown spots appear on the fruit surface.

Yield: Commercial bearing starts after 7 to 8 years of plantation in seedling bael trees as compared to 4 to 5 years in budded trees. The yield increases with the age and size of the tree. 10 to 15 years tree gives 200 to 400 fruits/year.

MANGOSTEEN

(*Garcinia mangostana*; Guttiferae; 2n = 88 / 90)

The mangosteen is one of the finest fruits of the tropic. It is a sweet, soft and delicious fruit with exciting flavour. It can be compared with the most delicately flavoured fruits of the temperate zone.

Composition and uses:

The fruit is a rich source of vitamins vitamin-C (66mg), (A, B12) minerals (Ca,P,Fe), Carbohydrates (19-8g) protein (0.5g), citric acid, fibre, fat (0.6g), phytin (0.68 Percent). The delicate aril flavour is due to hexyl acetate and cis-hex-3-enyl acetate and Cis-hex-3-eno and 6 sesquiterpenes have also been identified.

Mangosteens are usually eaten fresh as dessert. It serves as topping for ice-creams, canning, acid fruits for preserving, jam. The seeds sometimes eaten after boiling or roasting.

The twigs are used as chewstics in Ghana. The fruits contain 7-14% catechin, tannin and rosin and are used for tanning leather in China. It also yields black dye. The rind and bark are used in traditional medicine. The wood is dark red, coarse and strong and can be used in carpentry works. The bark extract & rind powder called as "amibiasine" used to treat amoebic dysentery and diarrhea.

Origin and distribution:

It is native of Malayan Peninsula, Mainly cultivated in Malaysia, Indonesia, Thailand, Srilanka, Myanmar, India, Vietnam, Philippines, China, California etc., In India, its cultivation is mostly confined in the lower slopes of the Nilgiris. Limited cultivation is also noticed in Kerala, Karnataka and West Bengal.

Soil and climate: The tree grows on a wide range of soils, deep clay loam or silt loam with good drainage is suitable. Sandy alluvial soils are unsuitable.

The fruit tree requires a tropical climate with high humidity, high temperature and abundant rainfall, shade environment is required at early growth stages as well as shady, environment during early stage of growth. It cannot tolerate temperature below 5°C or above 38°C. It grows up to an elevation of 1500m above mean sea level.

Species: The important species of genus *Garcinia*. spp are.

1. *G. mangostana* is only cultivated plant and may be allopolyploid hybrid, between *G. hombroniana* (2n=48) and *G. malaccensis* (2n=42).
2. *G. cowa*- available in the tropical forests of Assam, Bengal, Orissa and Andaman, Fruits are edible.
3. *G. schomburgkiana*- fruits are used as a preserve.
4. *G. hanburyi*- Gum resins used for aolouring.
5. *G. xanthochymus* fruits are edible young shoots & mature fruits as vegetables.
6. *G. dulcis*- Grown as a fruit tree in Southern part of Thailand.
7. *G. indica* Kokum found in tropical forests of India, gives acidic sweet fruits, mainly used as a souring agent for vegetable curry and dal.

Propagation: Mangosteen is mainly propagated by apomictic seeds (non zygotic) also by grafting budding or air layering, such seeds produce plants true to type, hence seed propagation is commonly practiced since the seed loose viability very quickly.

Planting: planting is done at 7x7m to 10x10m depending on location and fertility of the soil. The seedlings of 2 ft ht are planted during monsoon. The young trees should be provided with shade to protect from direct scorching sun.

Manures & fertilizers: About 20-25 kg FYM/tree/year is to be applied. The young trees receive 70gN, 6g P & 50g K/plant/year for 15 years onward about 2.7 kg complete fertilizers (10:10:19)/ year/tree is required.

Irrigation: The trees can with stand water logging but not drought. Stress followed by irrigation is required to induce flowering.

Weed Management:

Pruning: The regular pyramidal crown and slow overall growth limit pruning, dead branches, base suckers, water sprouts, small inner branches should be pruned, to open the canopy.

Flowering and fruit set: Flower initiation is noticed at the tip swellings. It takes 25 days from bud stage to anthesis. Fruit development takes in 100-120 days from anthesis. It may take 180 days in cooler area. The trees tend to bear in alternate years. The trees fruits in May-July under low elevation and during Sept-Oct in high elevation. Under Indian conditions flowering occurs twice a year i.e Monsoon, July-October and summer from April-June.

Fruit set is not a problem, however, when 10-15% of flowers are set, they may inhibit the remaining buds to flower, leading to conversion of those buds to vegetative development.

Harvesting: Fruits are picked at green mature stage; soft and dark red/purple patches on the skin of fruits, fruits are harvested with attached peduncle.

Yield:

Postharvest handling and storage:

Storage: The presence of yellow dried latex oozed from the latex vessels on the fruit skin is known as Gamboge, it may be scrapped off. Thick fruit wall hardens as the fruit ripens and the fruits are dipped in fungicides, and fruits can be stored at 8-10°C upto 8 weeks.

Yield: The plants yield upto 200-2000 fruits/tree or 20-25 kg/tree (4-5t/ha).

Plant protection: Few insect pests have been reported, possibly due to the bitter sap. Mites attack the fruit surface and make it unattractive.

Caterpillars and grasshoppers cause leaf damage.

Diseases: Cankers on stems/ branches, *Zingarella garcineae* the affected part should be cut and burn.

BER**(*Zizyphus mauritiana*) (Indian ber; Rhamnaceae)**

Ber is an ancient fruit crop of India and is relished for its sweet and sour fruits. It is an ideal fruit tree for arid and semi arid regions in tropical and subtropical climate. It is highly suitable for marginal land and hot arid region. It is mainly grown in India, different countries in central Asia, China and Taiwan. It has been truly called as poor man's fruit/poor man's apple.

Ber can suitably be grown almost in all the parts of north Indian plains, in UP, Haryana, Punjab and Rajasthan. Seedling ber trees are found extensively growing widely in arid and semi arid areas.

Composition:

The ripe ber fruits are rich in nutritive value, containing high amount of vitamins like C, A and B complex. It contains 20 to 28 per cent sugar, 0.3 to 2.5% acid, 2.9 per cent protein etc. It was observed that vitamin C was found in the fruit flesh near the seed than near the skin of the fruit. The ber seed, roots and stem bark also contain some alkaloids.

Uses: Mainly eaten fresh and also used as dried candid, pickled and other products like squash or juice and ber butter can also be prepared.

The ber extract said to be a blood purifier and also helps in digestion. The powder and decoction prepared from the roots are effective in case of fever, ulcers and old wounds. The stem bark is said to be remedy for diarrhoea. The leaves are used as fodder in the dry regions, the stem gives as quality wood which is used for making various agricultural implements. The wood is used as a valuable timber and also makes excellent charcoal. The thorny branches are used for fences. The tree is a host plant for rearing of the lac insect.

Species and Varieties:

The genus *Zizyphus* consists of 40 species in tropical and subtropical regions.

Zizyphus jujuba (Cheneese ber) and *Z. mauritiana* (Indian ber) are the two species grown widely in temperate, tropical and subtropical regions of the world respectively.

The important species of *Zizyphus* in India are as follows

Species	Natural distribution or cultivation	Economic use
<i>Z. mauritiana</i> , <i>Z. jujube</i>	Native of China, now cultivated in Punjab, UP, Bihar and Rajasthan	Edible fruits, bark for tanning and leaves for fodder
<i>Z. nummularia</i> / <i>Z. rotundifolia</i>	Found in north-west India and AP	Edible fruits, bark for tanning

<i>Z. oenoplia</i>	Found in north and peninsular India	Edible fruits, bark for tanning
<i>Z. rugosa</i>	Found in UP, Bihar, MP and western peninsular	Edible fruits
<i>Z. sativa</i>	Found in Punjab and Bengal	Edible fruits
<i>Z. xylopyrus</i>	Found in MP	Lac host and for tanning

Other Zizyphus species are *Z. fumiculosa*, *Z. spina*, *Z. glabrata* and *Z. oxyphylla*

Cultivars: There are more than 125 cultivars grown in India. These have been developed by selection in different regions. The same cultivar is known by different names in different regions. Eg. Umran which has come from Alwar in Rajasthan is known as Katha, Kotho in Maharashtra, Ajmer, Chameli, Katha, Bombay etc. in different names such as DetriGola, Narik, akrota, Seo. Laddu etc.

Commercial cultivars in different ber growing states of India are given below

State	Early	Mid-season	Late
Haryana	Gola, Safeda, Sandur, Narnaul, Seo, Choncahl	Kaithli, sanaur-5, muria, mahrara	Umran
Maharashtra	Shamber, Badami, Manuki, guli	Mehrun, darokhi, kharki	-
Punjab	Nazuk, Noki, Seo, Rohataki, Gola, Selected safed, Sandhura, Narnaul	Banarasi, dandan, kaithii, sanawe-2, walaiti, thornless	Umran, ilichi, pathini, 2G2 2G3
Rajasthan	Gola, Seb, Seo	Jogia, mundia, tikadi	Katha, maharavali, bagawadi
UP	Narma varnasi, Delhi, gola, Banarasi Gola	Banarasi karaka muthiya, muriya, pewandi, meharun	Jogia, aligan
Gujarat	-		Ajmeri, chameli, randeri

Pakistan: LR-9, LR-11, LR-13, Hagnawaz, cantonment, Golan, Lalwali,
Azerbaijan: Akhmedi, nasimi, ulduz, azeri, irada, arzu, khajari, ordubadi

Soil: Because of its hardy and taproot system, it can be grown in a wide range of soil including porous and infertile soils unsuitable for major fruits and other crops. It grows well in sandy loam soils with neutral or slightly alkaline reaction. It also grows satisfactorily in saline soils.

Climate: It prefers hot and dry climate for quality fruits and production. It can be grown upto an altitude of 1000 m from MSL. Tree growth, flowering, fruit development and maturity seem to be more or less correlated with temperature and thus vary.

Propagation: Existence of old orchard in India is slightly difficult due to the hard endocarp and requires about three to four weeks to germinate. The germination time can be reduced to one week by cracking the endocarp carefully. The seedlings raised are mainly used as rootstocks. Commercially ber is propagated by budding. The time of budding depends mainly on temperature, humidity and availability of budding material. In dry areas, in-situ budding is highly successful.

Cultivation: A plant spacing of 6mX6m is followed for ber. Monsoon period June-July (in south India) and August-September in north India is preferable period of planting

Training: Unless ber trees are trained, the trees become bushy, unproductive and hinder all intercultural operations. To establish a strong frame work, the tree is trained to a single stem upto a height of 75 to 90 cm in the first year. Later, three to five main branches widely spread at all directions may be encouraged. The

same process should be repeated to develop tertiary branches as secondary shoots. Final balancing and correction of frame work should be done in the third year.

Pruning: Pruning keeps the trees productive and improves fruit size, weight and quality. The fruits are borne in the axils of leaves on the young shoots of current season. Therefore, a regular annual pruning in ber is very much necessary to induce a good and healthy growth which will provide the maximum fruit bearing area on the tree. Some thinning out of branches is also necessary to avoid too much crowding which helps in reducing the incidence of pest and disease.

The best time for pruning is after the harvest during the hot and dry season or when it sheds its leaves and become dormant. Dry, dead and diseased wood, criss-cross branches and weak crotches are removed at the time of pruning. After the establishment of the frame work, pruning should be continued every year. For optimum yield and good quality fruits, 25% of one year old shoots should be headed back. Drastic thinning and severe pruning should be avoided, which affects the growth of plant and gives poor yield.

Irrigation: Since it has very deep tap root system and xerophytic nature and is very hardy, once gets established, needs little care and irrigation. It prefers dry period during flowering and needs irrigation for November-February for better fruit development.

Manuring: Deficiency of N, P and K was found to inhibit shoot length, leaf number and axillary branch production. The following was also reduced and the plants failed to set fruits. So, regular application of manures and fertilizers is necessary. For leaf analysis, 5th and 6th leaf from the secondary shoots should be collected for nutritional diagnosis.

Flowering: Time and duration of flowering varies with cultivar and location. Flowering starts from July and extended upto November in different regions of the country. In south India, flowering starts from July and continues to September with major fruit set in august itself. It is cross pollinated crop and prominent pollinating insect agents are honey bees, houseflies and yellow wasp. The fruit set ranges from 6.19 to 8.16%. However, under controlled cross-pollination, it ranges between 26 and 46%. Spraying of GA₃, 2,4,5-T is found to improve the fruit set and reduces the fruit drop.

Fruit growth of ber followed a double sigmoid curve with three distinct phases i.e. and early phase of 45 days after fruit set (DAFS), middle phase, 45 to 90 DAFS and final phase, 90 DAF to maturity (185 days). The growth patterns of fruits and seeds were similar.

Harvesting: To get quality fruits, fruits should be harvested at correct stage of maturity. Under ripe fruits do not ripen properly and never attain the desired quality. Over-ripe fruits, on other hand, lose their attractive colour and become soft. Such fruits have less storage life and deteriorate in quality.

The maturity indices are attainment of full size of a particular cultivar with softening of pulp and development of characteristic yellow or golden yellow colour. Picking is done manually and sorted in different groups as over – ripe fruits, unripe fruits, damaged fruits, etc., the correct matured fruits are graded as per size, i.e. large, medium and small and marked after proper packing.

Yield: 80 to 200 kg per tree from 10 to 20 years old tree.

Dropping the ber fruits in waxol six percent solution is observed to be effective in reducing the fruit weight loss and decay loss. The ripening is also delayed by this.

Storage: Treating the fruits with wax emulsion and keeping them in perforated papers and polythene bags with wax emulsion treatment could extend the storage life of ber fruits. Under cold storage of 3°C and 85% RH, the fruits could be stored upto 30 days.

AONLA OR INDIAN GOOSE BERRY OR AMLA

(*Emblica officianalis* / *Phyllanthus emblica*; Euphorbiaceae)

Aonla or Indian gooseberry is also known as Indian amla. It is an important crop of Indian origin which is grown throughout North West Indian plains. It is very rich from nutritional point of view being next to Barbados cherry in terms of vitamin C content (500-750mg/100g pulp) which is not oxidized due to presence of tannins and even it is least destroyed during storage. Besides, it has an excellent medicinal value. It can be grown successfully in arid climate and in the soils of higher pH and poor fertility wastelands.

Tree is hardy and of medium height. However, seedlings tree can attain height up to 30m. it is evergreen, however, leaf shedding takes place during February-March. Tree trunk is smooth and whitish which resembles guava.

Uses and nutritive value

Aonla fruit has special significance in view of its high nutritive value and is the treasure house of medicinal properties. Bark, leaves and fruits are used for tanning. Its fruits are also a rich source of pectin which is used for preparing jelly, dried aonla fruit is useful for the treatment of dysentery, jaundice, dyspepsia and cough. It is also good for eyes and stomach ailment. Aonla fruit is also important ingredient of Chyawanprash which is an ancient well known ayurvedic medicine. Aonla is also used for manufacturing hair oil and shampoo. Fruits are also utilized for preparation of preserves and pickles.

Aonla is valued as an anti-scorbutic, diuretic, laxative, alterative and antibiotic. It is being used to treat respiratory and cardiac problems, rheumatism, scurvy and ageing ailments. If consumed regularly it improves immunity and vigour (kayakalp). Apart from chayavanaprash, a large number of medicines are being prepared from aonla viz., Triphala, amrit kalash, Trilax, Amla plex, Neutrale, Tylophora plus, etc.

Processing industry: The processing potentiality of aonla fruits is yet to be fully tapped. The fruits are made into preserves (morabba), candy, dried chips, tablet, jellies, pickles, powder etc., aonla can be a substitute for habitual gutka user. Aonla supari can easily replace pan gutkha, which is good for health.

Soils and climate:

Sandy loam soils are the best suited for aonla cultivation. Soil should be atleast 2 m deep, otherwise, plant will not prolong beyond 12 years in fruiting

Its cultivation is more successful in subtropical regions. It can be grown successfully up to the elevation of 1800 m from sea level. It can also be grown in semi-arid to arid regions.

Cultivars

Aonla cultivars are mostly known on the basis of size, colour or after the name of the places. Banarasi, bansi red, francis and chakiya are the known aonla cultivars.

Banarasi: an early bearer and bears good crop of quality fruits having good keeping quality. The fruits are medium to large roundish, six linear grooves extending from the base to apex, stone is lightly embedded in flesh, dull green and hexagonal with six small elliptical seeds. TSS-13%, acidity 2.34%, total sugars 8%, seed pulp ratio is 1:21

Chakiya: it is a hardy cultivar with very heavy bearing habit. It is a mid season cultivar having very good keeping quality. It is the most established cultivar has comparatively small sized fibrous fruits with a tendency to bear in alternate years. Segments are 6-8 in number, flesh soft, fibrous and adhered to stone. TSS 9.0%, acidity 2.17%, total sugar 9.6% and seed/pulp ratio is 1:17. It is a good pollinizer.

Hathijhool: late bearing, heavy bearer and has poor keeping quality. Fruits are large, oval roundish, short stalked with six linear grooves. Skin is thin, light green, flesh is firm, slightly fibrous, firmly adhered to stone. TSS 11.5%, acidity 2.5% and total sugars 7.3%. Stone is small, flattened and dull green.

NA-4 I(Kanchan), NA-5 (Krishna), NA-6, NA-7 and NA-10 showed promising response and were later release for commercial cultivation

Variety	Striking features
NA-4 (Kanchan)	Preferred by industry for pulp extraction and preparation of various products. It has adopted well in arid and semi-arid region of Gujarat and Maharashtra
NA-5(Krishna)	An early maturing variety low fibre content. Ideal variety for preparing preserve, candy and juice.
NA-6 (Chakiya)	Excellent, prolific bearing assumes good tree shape, fruits attractive in appearance and due to fibre suitable for making preserve candy and jam.
NA-7 (Amrit)	It is precocious and prolific bearer, well suited for making chavanprash, chutney and squash. It has adopted well in Rajasthan, Bihar, Madhya Pradesh, AP and TN

Propagation: Aonla can be propagated both by seed as well as vegetative methods. Seeds are extracted from the fruit after ripening are dried in shade. The seeds which float in the water are discarded and settled seeds on the bottom are taken for sowing. According to Bhujbal, 1975, dipping of seeds in GA₃ 500 ppm for 24 hr gave maximum seed germination. Seeds are sown in the nursery either during march or June-July. The seedlings plants after attaining proper stem girth are budded during June-August. Shield, forkert and patch are more common methods of budding. Cutting and layering are successful in aonla.

Establishment of orchard:

Planting is done during rainy season (July-August). However, it can also be done during March-April. Planting can be done at a spacing of 8-11 m apart which may vary according to soil and climatic conditions and growth habit of a particular cultivar.

Pruning and training: Aonla trees do not require special pruning and training. However, during the initial years. Pruning should be done to have balance training of the plant. In addition dried branches should be removed periodically.

Irrigation

During active growth period from March to June, trees are required to be irrigated at weekly interval to severe higher fruitset and reduce fruit drop. During October-December, irrigation at 20 days interval may help in better fruit development. Water should not stagnate in the orchard during rainy season.

Nutrition:

Nutrition plays an important role in aonla cultivation. 180-360 N, 540-1080 p and 180-360 S kg/tree/yr has been recommended. Application of fertilizers increased female flower ratio compared to male flowers, increased fruit size and TSS and also reduced fruit drop. P and K improve Vit. C content and boron helps in flowering and also in improving TSS and vit.C. content. Foliar spray of 0.6% borax solution thrice at 10-12 day interval during September– october will control internal necrosis.

Flowering and fruitset: Flower bud differentiation in Banarasi aonla was observed during the first week of march and flowers started opening from the last week of march. There is no self incompatibility in aonla due to high percentage of staminate flowers. The fruits remain in dormancy for about three and half months in cv. Banarasi dormancy discontinues from last week of July 10th first week of august and fruits start developing gradually in the initial stage but rapidly during the month of September.

Flowers open in the morning whereas dehiscence of pollen grain occurs in the evening between 4 and 6 pm. Only 30% pollens are viable in cultivar Banarasi and at room temperature these become non-viable within 10 days. Stigmatic receptivity starts after three days of opening of female lowers and stigma remains receptive only for 18 hr. pollination occurs through wind as well as by honeybees.

Diseases : Aonla rust, fruit rot, internal fruit necrosis.

Insects: mealy bug, caterpillars

Harvesting and storage:

Fruits become ready for harvesting by November-December and can be harvested up to February. The colour of fruits starts turning to light yellow at maturity stage. While harvesting, fruits should not drop down on the ground.

Fruits can be stored for 7-8 weeks keeping temperature at 32-35°F and R.H of 85-90%

Yield: Desi aonla starts bearing fruits after 10 years of plantation, whereas budded or grafted trees start bearing after 6-7 years from 10-15 years aged trees, approximately 200 kg fruit yield can be obtained /year/tree.

The average yield is about 125q/ha. An income of Rs. 12,500/ha can be obtained.

LITCHI

(*Litchi chinensis*; Sapindaceae, ;2n = 30)

Litchi is a popular subtropical evergreen fruit; the white translucent flavored aril is liked very much and is used for table purpose in India. The fruits are available during May –June in northern India.

Uses and composition:

Litchi is commonly consumed as a table fruit, but in China it is very popular in dried (litchi nut) or canned, which is famous among Chinese foods. A highly flavored squash is also prepared from the fruits. The Chinese use the leaves for making **poultice**; the seeds are used for treating skin disorders. Flowers, bark and roots decoction are used for gargling of throat infection.

The fruits are rich in sugars (10-22 percent), acid (0.2-0.6 percent), protein- 0.7 percent, fat-0.3 percent minerals -0.7 percent, TSS-20-30 percent vit-C-64mg/100g, pectin-0.4 percent etc.

Origin and distribution:

Litchi is a native of southern China (Oman). It is cultivated in India, Myanmar, West Indies, Australia, South Africa, Hawaii, Thailand, Mauritius and Hong Kong. India is the largest producer of litchi in the world after China and is grown in an area of more than 12,000 ha, area and the important states growing litchi in India are Bihar, West Bengal. Uttar Pradesh, Punjab, Haryana, Assam, Tripura, Orissa, Tamil Nadu and Karnataka.

Climate: it is a sub-tropical fruit, high Relative Humidity is desirable, while hot winds are not favourable for this plant. However, the rain fall during flowering reduces fruit set. Successfully grown up to an elevation of 1000m from Mean Sea Level. The maximum temperature during the flowering period varies from 21°C-38°C.

Soil: It can be grown on a wide range of soils i.e, acidic to alkaline soils. Acidic soils produce good quality fruits. The pH range is 5.5-7.0 with adequate soil depth.

Species and varieties:

The family sapindaceae and subfamily Nephelaeae has about 125 genera and more than 1000 species. The genus Litchi has two species.

1. *Litchi. philippinesis*- It is a wild type mostly used as root stock
2. *Litchi. chinensis*- It is a commercial important species. The other members of the sub family are
 - *Euphoria. longana*- Langan/Anshpal-Small fruits, inferior quality.

➤ *Nephelium. lappaceium*- Rambutan- hairy fruits.

Varieties: There are large numbers of litchi cultivars grown all over India. The important cultivars recommended for different states are.

Bihar: Sahi, China, Purbi, Rose Scented, Kasba.

Uttar Pradesh: Dehra Dun, Muzaffarpur, Saharanpur.

Punjab & Haryana: Saharanpur, Dehra Dun, Calcutta, Mazaffarpur, seedless late, rose scented.

West Bengal, Bombay, China, Bedana, Elachi

Haak yip, Tai so, Wai chee, Brewster, Gee Kee etc.

Propagation: Commercially propagated by grafting or air layering (500ppm IBA), stem cutting, semi-hard wood cuttings, stooling are also practiced.

Wind break: The growth of litchi plant is adversely affected due to hot wind in summer and cold waves in winter. It is advisable to plant suitable wind breaks around the boundary.

Planting: Planting is done in rainy season or even just after the monsoon. The litchi trees are planted by following square system at 8x8m or 10x10m apart in 1m³ pits. Each pit provided with 30-40 kg FYM + 2 kg bone meal + 300 g MOP.

Irrigation: The plant is highly sensitive to moisture stress, supplementary irrigation is provided in hot season & mulching also practiced.

Manuring and fertilization: The nutrient requirement of litchi is very high. The deficiency of N, P and K results in stunted growth and may even stop floral initiation. Therefore, suitable application of nutrients will ensure better production. The recommended dosages of fertilizers are,

Age of tree	N(g/pl)	P(g/pl)	K (g/pl)	+30-40 Kg FYM/tree/Year Fertilizers are to be applied in 2 splits 1 st during monsoon & 2 nd after monsoon.
1 st year	75	25	75	
2 nd year	100	25	100	
3 rd year	150	50	150	
4 th year	250	75	250	
5 th year	600	200	600	

Training & Pruning: Modified central leader system of training is followed and pruning is not done in litchi, except removing dried, diseased and criss crossed branches.

Flowering: The grafted or layered litchi tree comes to bearing in 3-4 years, while the seedlings take 8-12 years to flower. Flowering starts from Jan-Feb and fruits ripen in April & May. Temperature has direct relation on flowering, night temperature of 15-16°C for 2 months is essential to induce flowering and for vegetative growth the ideal temperature is 30°C. Flowers are terminal and appear on current season wood. Fruit set is very low and flower drop is also common due to water stress, Fruit drop occurs 4 weeks after fruits set which may be due to failure of fertilization, embryo abortion, high temperature and low humidity. To control fruit drop NAA at 20-30ppm, GA₃ at 20-50ppm or 2-4-D-20ppm, to be applied before flower opening. Apart from this girdling and centering also increases flowering.

Harvesting and yield

Litchi is non-climacteric fruit and harvesting to be done at full mature stage. The tree starts bearing from 3-4 years after planting with proper care and management under suitable environmental condition and the economic life of the crop maybe over 100 years. The fruits are harvested during May and June. The maturity indices are flatness of tubercles and smoothness of epicarp and colour development (Green-Pink). It takes about 55-60 days from flowering to harvest. The whole bunch is harvested manually.

Yield: About 80-150 Kg of fruits/tree in Indian conditions.

Storage: The fruits cannot be stored for more than 2-3 days under room temperature. It can be stored for 5 weeks at a temperature of 1.6-7.2⁰C in perforated polythene bags. Dipping of fruits in 250ppm ethrel a improves the fruit colour.

Physiological disorder

Fruit cracking: The whole fluctuations in diurnal temperature, heavy irrigation/rain after prolonged dry spell, hailstorms during fruit development causes injury to the fruit skin.

To avoid fruit cracking: The field to be irrigated during fruit growth and in early summer. Spraying with 2, 4, D (10ppm), GA₃ (20 ppm) and Boron (0.4 percent) spray reduces fruit cracking.

Plant protection

Pests

Mites- *Eriophyes litchi*

Symptoms: Curling of leaves.

Catterpillar: *Inderbella tetroanis*:

Diseases:

Storage rot- *Geotrichum candidum*
