

Tropical and Subtropical Fruits



3. TROPICAL AND SUB-TROPICAL FRUITS (HPH 201)

3(2+1)

Horticultural classification of fruits including genome classification. Horticultural zones of India, detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning. Management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards. Physiological disorders. Post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage of the following crops. Mango, banana, bael, grapes, citrus, papaya, sapota, guava, pineapple, jackfruit, avocado, mangosteen, litchi, carambola, durian and passion fruit. Bearing in mango and citrus, causes and control measures of special production problems, alternate and irregular bearing overcome, control measures. Seediness and kokkan disease in banana, citrus decline and casual factors and their management. Bud forecasting in grapes, sex expression and seed production in papaya, latex extraction and crude papain production, economic of production. Rainfed horticulture, importance and scope of arid and semi-arid zones of India. Characters and special adaptation of crops: ber, aonla, annona, jamun, wood apple, bael, pomegranate, carissa, date palm, phalsa, fig, west Indian cherry and tamarind.

Practical: Description and identification of varieties based on flower and fruit morphology in above crops. Training and pruning of grapes, mango, guava and citrus. Selection of site and planting system, pre-treatment of banana suckers, desuckering in banana, sex forms in papaya. Use of plastics in fruit production. Visit to commercial orchards and diagnosis of maladies. Manure and fertilizer application including bio-fertilizer in fruit crops, preparation and application of growth regulators in banana, grapes and mango. Seed production in papaya, latex extraction and preparation of crude papain. Ripening of fruits, grading and packaging, production economics for tropical and sub-tropical fruits. Mapping of arid and semi-arid zones of India. Botanical description and identification of ber, fig, jamun, pomegranate, carissa, phalsa, wood apple, West Indian cherry, tamarind, aonla, bael and annona

Horticultural classification of fruits including genome classification- by Dr. Kulapati Hipparagi

Classification of fruits

Classification is the system of grouping or placing of an individual 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 behavior.
- To know their compatibility & inter grafting ability.
- To know their adaptability to soil & climate.

Pomology

Pomology: Pomology is a branch of horticulture which deals with various aspects of fruits starting from rising of saplings, growing them properly and providing various intercultural operations, the term pomology is a combination of two Latin words pome-fruits and logos-culture.

“Poma” in Greek means fruits later subsequently transfer in to ‘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.

Classification of fruits based on climatic adaptability

Classification of fruits based on climate adaptability

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

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. E.g. apple, almond, peach, pear, plum, strawberry, apricot, persimmon, cherimoya, pecan nut, walnut, hassle nut, cherry, pistachios and kiwifruits etc.

Tropical fruits

- Tropical fruit plants are generally evergreen and are extremely sensitive to cold.
- The plants are generally grown in climatic conditions prevailing in the region between the tropic of cancer (23° (27) N latitude) and the tropic of Capricorn (23° (27) S latitude).

- 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 e.g; mango, banana, papaya, sapota, etc.,

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.,

- **Classification based on fruit morphology**

Based on Fruit morphology

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

2) Modified berry

Balusta	Pomegranate
Amphisarca	Woodapple, Bael
Pepo	Water melon
Pome	Apple, Pear, Loquat
Drupe (Stone)	Mango, Pear, Plum
Hesperidium	Citrus
Nut	Cashew, Litchi, Walnut, Rambutan

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

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

Classification based on rate of respiration

Fruits classified based on rate of respiration

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

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

Classification based on photoperiodic responses

Based on photoperiodic responses the fruits are classified as

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

Classification based on relative salt tolerance

Based on relative salt tolerance fruits are classified as

<i>Highly tolerant</i>	<i>Medium Tolerant</i>	<i>Highly sensitive</i>
Datepalm, Ber, Amla, Guava, Coconut, Khirni	Pomegranate, Cashew, Fig, Jammu, Phalsa	Mango, Apple, Citrus, Pear, Strawberry

Classification of fruits based on longevity

Based on longevity fruits are classified as

Very Long Longevity	>100 yrs	Datepalm , Coconut, Arecanut
Long Longevity	50-100 yrs	Mango, Tamarind
Medium longevity	10-50 yrs	Litchi, Guava, Pomegranate
Short longevity	-	Pineapple, Banana

Classification based on relative acid Tolerance

Based on relative acid Tolerance

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

Classification based on consumers preference

Based on consumer preference or weight of fruits

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

Botanical classification

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>	Musaceae	Berry	22,33,44
Pineapple	<i>Ananas comusus</i>	Bromeliaceae	Sorosis	50
Panaragh Palm	<i>Borvus 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>Ammona squamosa</i>	Annonaceae	Aggregate of berry	
Hannanaphal	<i>Ammona reticulata</i>	Annonaceae	Aggregate of berry	
Lakshmanaphal	<i>Ammona muricata</i>	Annonaceae	Aggregate of berry	
Ranphal	<i>Ammona cherimoya</i>	Annonaceae	Aggregate of berry	
Karonda	<i>Carissa carandus</i>	Apocyanaceae	Berry	
Kiwi fruit	<i>Actinidia chinensis</i>	Actinidaceae	Berry	
Durian	<i>Durio zibethinus</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>Emblica 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>Averrhoa carambola</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 unshu</i>	Rutaceae	Hesperidium	18
Rough lemon	<i>Citrus jambhiri</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 achras</i>	Sapotaceae	Berry	26
Phalsa	<i>Grewia subaenqualis</i>	Tiliaceae	Drupe	
Grape	<i>Vitis vinifera</i>	Vitaceae	Berry	38

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Lecture 2

Horticultural Zones of India/ Fruit Zones

Climate is one of the important complex factors which influences the fruit production is defined as the general temperature and atmospheric conditions of an area, over an extended period of time. Atmospheric conditions include rainfall, humidity, sunshine, wind and other factors. The fruit growing zones are classified based on the climate factors.

The fruit zones are classified in to four types.

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 100⁰F. The fruit plants of this zone need strong sunshine warm and humid climate and a very mild winter. They cannot stand against frost. Area 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 includes, 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 grow 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 conditions, 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, UP etc.

7. North- Western region: It is again classified in to 4 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, 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.

Refernces:

1. Commercial Fruits---S.P.Singh

2. A text book on Pomology Vol. 1. T.K.Chattapadhya

3. Tropical Horticulture-Vol.1-T.K.Bose,S.K.Mitra,A.A.Farooqui & M.K.Sadhu.

LECTURE 3, 4, 5 &6

MANGO

(*Mangifera indica*)

Family: Anacardiaceae

Chromosome Number: $2n=40$

Preamble:

Importance and use:

Origin and distribution:

Climate and Soil: Mango thrives well in tropical and sub tropical climate. It can be grown from sea level to an altitude of about 1400meters. The optimum temperature range is 24C to 27C. However, it can tolerate up to 48C during fruit development with regular irrigations, which improve fruit size, quality and maturity. Low temperatures (13C-19C) 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 soils with good depth and drainage except black cotton soils. Optimum PH is 5.5 to 7.0. It cannot tolerate saline conditions.

Cultivars:

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:

Manuring: 10 kg Fym, 2.5kg Bone meal ,1.0 kg pot sulphate for 1 year old plant and increased by 5 kg FYM, 0.5 kg bone meal and 0.4 kg pot sulphate per year till 10th year.

Bearing trees may be given 750g N, 200g P₂O₅ and 1150g K₂O/year/tree. It is better always to apply organic manures during October. Manures should be applied in a small trench dug from about 1.5-2m from the trunk up to the drip line. Watering should be done soon if no rains.

Irrigation :Irrigation should be according to the soil and weather conditions. Bearing trees should be irrigated regularly at 10-15 days interval from fruitset to maturity. plant should be given rest by stopping irrigations at least 2-3 months before flowering for maximum fruit bud development. Under drip, plants may be applied with 40 liters/tree twice a week.

Cultivation: Land should be ploughed to proper tilth. Pits of 90x90x90cm are dug at a spacing of 8-10M. Pits may be filled with FYM.

Planting: Planting is done during rainy season graft union should be kept at least 6 inch above the soil at planting staking should be done and watered soon after planting.

Intercultural: Intercropping can be done in prebearing period to keep the weeds under control and to get some additional income.

Phalsa, Papaya and Pineapple or Vegetables can be grown if irrigation facilities are available.

Cover crops like Sun hemp, Daincha, Cow pea, Cluster bean, etc, also can be grown during rainy season and ploughed into the soil before the end of the rains.

Land should be ploughed twice a year during June and October.

Weeds can be controlled by the application of 4kg/ha atrazine/oxyfluorfen(Goal)@800ml/ha as pre-emergence and application of 2liters/ha gramaxone(Paraquat)/as post emergence.

Weed Management:

Pruning and Training: Mango needs no regular pruning except removing dead and diseased branches. Young plants should be trained properly to have a good framework.

Flowering and fruitset: flower bud formation takes place 2-3 months prior to flowering. Flowering occurs from Nov-Dec to Feb-Mar depending upon locality 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 natural and is very high in mango specially during the first four weeks.

1. Soon after flower opening
2. After pollination and fertilization
3. At grain stage of the fruit.

This occurs as an adjustment to the resources available in the plant for the development of fruits and is natural. Drop of grownup fruits is a major problem. 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 avoided by regular irrigations during fruit development, application of optimum doses of nutrients effective control of pests and diseases and some hormonal sprays like 2,4-D (10-30ppm) NAA(5-50ppm), 2,4,5-T(20ppm) etc.,

Alternate Bearing

I. SOME FACTS AND MYTHS ASSOCIATED WITH MANGO TREES VIS-A-VIS BEARING PROBLEM.

Operation of 'on' and 'off' phases

The phrases 'on' year and 'off' year are used to refer to the years of 'normal' and 'sub-normal' or 'no crop' respectively. However, these phrases are in a way misnomers in so far as their reference to a given year is concerned since not hundred per cent of trees in an orchard would be either 'on' or 'off' in any year. In any given year, the 'on' or 'off' phases may be confined to individual trees or portion/branches of trees depending on the previous history of the given tree with regard to the magnitude of the crop load that had been carried in the previous fruiting season (Jan.-June). Further, a set of two identical adjoining trees may behave variably during flowering season of a given year: one of them may be in 'on' phase while the other may be in 'off' phase which is dependent on the magnitude of crop load harvested in the previous year. This fact therefore, rules out the role of climate in causing 'on' or 'off' phases in a given group of trees.

2. Variability in the expression degree of bienniality in different varieties

It is observed that the problem of bienniality in cropping is expressed in varying degree in different varieties and hybrids. In general, the choice varieties have recorded higher degree than the mediocre varieties. An analysis of 7-year yield data (Table 1 a & lb) of adult mango varieties and hybrids grown at Raichur (North Karnataka) has revealed that the highest degree of bienniality is expressed in choicest variety like Alphonso. The Cv. Baneshan, the most popular commercial variety of Andhra Pradesh, though not the choicest one, has recorded the weakest bienniality; the Cv. Neelum which has a claim as a 'regular bearer' in the common parlance was graded as 'moderately biennial' and the Cv. Totapuri, the other popular cultivar having the 'regular bearer' acclaim was observed to be weakly biennial. However, it is interesting to note that some of the hybrids having

Neelam in their parentage have recorded weak bienniality.

Thus, it appears that there exists no such variety as 'regular bearer' in its literary sense. According to Rao *et al.*, (1990), giving 'regular bearer' acclaim to some varieties like Neelam in common parlance may be an illusion since such varieties too in reality have recorded lower yields followed by year of higher yield. At best, they suggested that such varieties could be classed as weakly or moderately biennial types as against the strongly biennial types like Alphonso.

Table 1a : Yield potential and degree of bienniality in some mango varieties and hybrids

Variety/ Hybrid	Mean number of fruits/ tree/year	Bienniality	
		Deviation in successive croppings (43/0)	Class
Khadar	425	42	Moderately biennial
Neelum	644	40	Moderately biennial
Baneshan	697	22	Weakly biennial
Hyb. Neeleshan (Neelum x Baneshan)	1129	27	Weakly biennial
Hyb. AU-Rumani (Rumani x Mulgoa)	438	28	Weakly biennial
Hyb. Neelgoa (Neelum x Yerramulgoa)	773	38	Moderately biennial
Hyb. Neeluddin (Neelum x Himayuddin)	707	33	Moderately biennial

3. Degree of bienniality as related to yield potential and agro-climatic conditions

There is a contention that the high yield potential in certain varieties may be a factor in causing higher degree of bienniality. The basis for this contention is that higher yield causes over-exhaustion of tree and consequently the tree may not be able to restore its floriferous energy for cropping in the following year. This contention is, however, not tenable when yield data of different varieties and hybrids is considered. (Table-1a). A variety like Baneshan or a hybrid like Neeleshan have exhibited high yield potential but they are weakly biennial. Conversely, the varieties like Alphonso and Pains have exhibited lower yield potential but they are strongly biennial.

The mango is a tropical tree. As such, the varieties adapted to warm and dry regions have expressed higher yield potential with relatively lower degree of bienniality as seen in varieties of Andhra Pradesh as compared to those adapted to mild tropical rainy climate that exist in northern parts of Karnataka and Maharashtra varieties like Alphonso and Pain. It is interesting to note that Cv. Khadar which is a warm-region adapted eco-type of Alphonso

(Rao *et al.*, 1990 a: Rao *et al.*, 1993) has been recorded as moderately biennial (Table-2) as compared to Alphonso.

Table 2: Comparative yield potential and degree of bienniality in synonym mango varieties — Alphonso and Khadar

Particulars	Cv. Alphonso	Cv. Khadar
7-year (1983-89) mean number of fruits per tree per year	437	425
Mean weight of fruit (g)	198	309
Estimated yield per ha (t)	5.9	8.9
Degree of bienniality (% deviation in year-to-year yield)	81.0	42.0

4. Degree of bienniality in hybrids having a 'regular bearer' in its parentage

On account of having 'regular bearer' acclaim, Neelum was invariably involved in developing 'regular bearing' hybrids. The inheritance studies in mango are quite meagre. Majumdar *et al.* (1972) have made only some preliminary studies. According to them Neelum has a typical phenotypic character in the behavior of fruited shoots which has relationship to annual bearing. It was inferred by them that the fruited shoots are capable of developing lateral shoots sooner after harvest of fruit in June in 'on' year and such lateral shoots are capable of attaining quicker physiological maturity. Consequently they differentiate fruit buds in the ensuing period (Oct.-Nov.) critical for fruit bud differentiation (FBD). Such differentiated shoots would develop crop in the following (second year) fruiting season (Fig. 8.2). Thus, according to them, any offspring expressing this phenotypic character would be a 'regular bearer' like Neelum. They indeed observed the expression of this character in Neelum x Dashehari cross that was later named as Mallika which was claimed to have a 'strong tendency' for regular bearing. However, later observations showed that Mallika did not turn out to be a regular bearer.

Moreover, when Neelum was observed at Dharwad and Raichur conditions, the said phenotypic character was only feebly expressed and not many such early produced laterals on fruited shoots showed capability for differentiating fruit buds (Rao *et al.*, 1990) for cropping in the following year. Thus, the phenotypic character as proposed by Majumdar *et al.* (1972) could not be taken as a reliable character in so far as their capability for developing flowers in the following 'off year' was concerned.

Under Raichur conditions, Cv. Baneshan and hybrid Neeleshan (Neelum x Baneshan) have maintained lower degree of bienniality (Table 3). Whether Neeleshan has inherited the weak bienniality character of its male parent Baneshan however, remains to be genetically assessed.

Table: Degree of bienniality in successive cropping in hybrid Neeleshan in relation to its parents - Neelum and Baneshan

Study period	Degree of bienniality (% deviation in year-to-year yield)		
	Cv. Neelum	Cv. Baneshan	Hyb. Neeleshan
8-year period	51.4	31.7	46.4
7-year period	56.0	32.7	39.8
6-year period	56.4	28.4	30.2
5-year period	46.2	24.0	23.2
4-year period	48.3	16.0	11.0
3-year period	36.5	21.0	15.5
2-year period	57.0	27.0	22.0
Mean of 7 years	50.2	25.8	26.9

Mango varieties are heterozygous. As such, it is doubtful whether the 'regular bearing' character, if any, gets inherited in off spring when crossed with choice varieties and at the same time retain the quality of choice variety in off-spring.

5. Degree of bienniality in relation to number of hermaphrodite flowers or sex ratio

Some workers hold the view that the yield potential and intensity of bienniality are related to number of hermaphrodite flowers and sex ratio. But data collected at Dharwar (Jyothi, 1955; Rao and Bhandary, 1975) do not support this view. Baneshan has lower number (73/panicle) of hermaphrodite flowers with a sex ratio of 6.8: 1 as compared to Neelum which contain higher number (231.7/panicle) of hermaphrodite flowers with a sex ratio of 3:1. But the yield potential of Baneshan is higher (697 fruits/tree) than Neelum (644 fruits/tree) and is weakly biennial (c f Table 1a & 1b) whereas Neelum is moderately biennial (Rao *et al.* 1990).

According to Singh (1954), the number of hermaphrodite flowers or the sex ratio is a varietal feature and the yield is determined by ultimate retention of fruits till maturity rather than the number of hermaphrodite flowers or the extent of fruit set. At Dharwad, one fruit per panicle norm has been observed to result in fairly higher yield in Alphonso.

Harvesting and yield: Stage of harvesting is very important, indicated by

- (1) Starting of Colour development
- (2) Falling of one or two fruits from the plant
- (3) 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 commercial yields can be had from 8-10 years 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 card board 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 5-14c and 90% RH for about 2-7 weeks depending upon the variety

Post harvest Handling and storage:

Physiological Disorders

Mango malformation

Production of thick vegetative shoots and transformation of floral parts into a compact mass of sterile flowers.

Two types: Vegetative and floral

Vegetative malformation resembles “bunchy top” which may dry and die in due course.

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 than in South. It may result in loss of about 50-60% crop. Krishnabhog, collector, Langra, Neelum are tolerant(seedling trees are found to be tolerant)

Virus, fungus, mites, nutrients, C/N ratio, carbohydrates, nucleic acids, amino acids, proteins, phenolic compounds, 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, Paclobutrozol, etc.
2. Deblossoming: 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.
2. Regularly inspecting the orchard
3. Regularly removing all malformation parts and
4. 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. Major causes for this are supposed to be:

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.

Presently the suggested measures to overcome biennial bearing are:

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

Black tip: Physiological disorder causing distal end of fruit to become black hard
Polluted atmosphere with smoke, carbon monoxide, carbon dioxide, sulphur dioxide, acetylene causes this disorder.

Spraying Borax 0.6% from fruit set at 10-15 days intervals controls this (Punjab, UP, Bihar, W,B)

Clustering(Jhumka) clustering of fruits without growth at the tip of the panicle caused by adverse weather (low temperature) during Feb-March. Most of the fruits drop+shrivelled 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 Ca deficiency causing breakdown of flesh towards the apex of the fruit before ripening.

Ref:1. Commercial Fruits---S.P.Singh

2. A text book on Pomology

Vol,1. T.K.Chattapadhy

3.Tropical Horticulture—Vol.1

-T.K.Bose, S.K.Mitra, A.A.Farooqui and M.K.Sadhu

Lecture 7, 8 & 9

BANANA

Botanical Name : *Musa paradisiaca* L / *M. cavendishi* L
Family : Musaceae
Chromosome No. : $2n = 22, 33, 44$

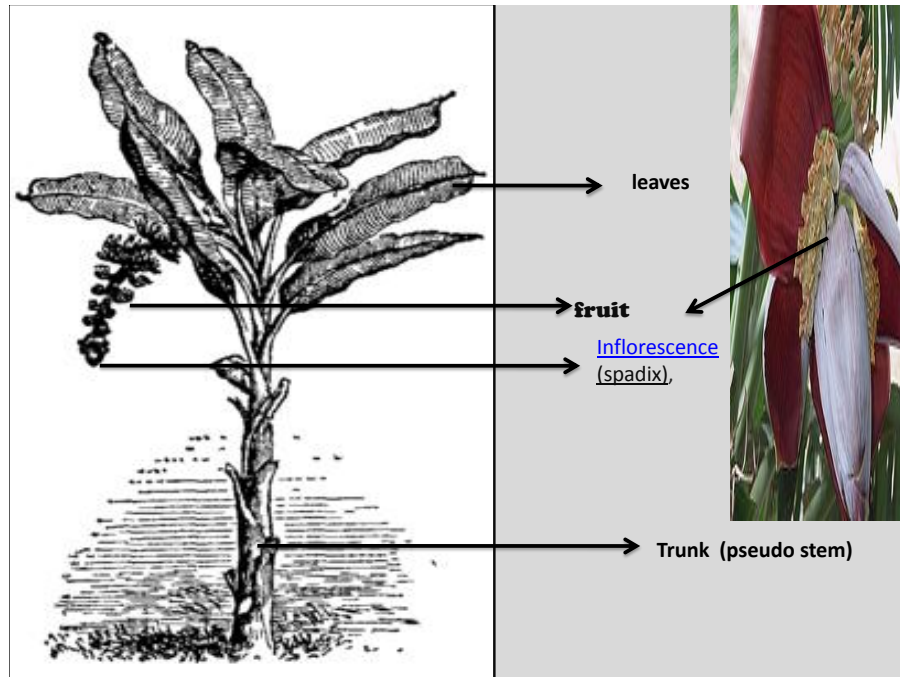


Fig. 1 a well developed Banana plant

Banana is an important fruit of tropics. The fruit is recognized as the fourth most important global food commodity. India's share is 32 per cent 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 has been cultivated since ancient times. Eve was said to have used banana leaves to covers 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 per cent moisture, 25-30 per cent carbohydrates, 1.4 per cent protein, 0.3 per cent fat, 0.5 per cent mineral matters (Ca, Fe, P,K) and Vit- C and K.



Fig. 2. Different bi products of Banana

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 germplasm, out of 600 reported worldwide. Edible Banana has arisen as a result of natural crosses between two wild progenitors viz., *Musa. paradisiaca* and *Musa. balbisiana*. Banana is being grown in many of the African countries between 30⁰ N and 50⁰ S latitudes. Important countries are India (1st place) with a total production of 17 million tons from an area of 0.50 million hectare, 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 per cent of the total area under fruit crops and 32 per cent 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.

- i. *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*: (n=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, ie., *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.	Pedicel	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 banana 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.



Musa 'Super Dwarf' Cavendish

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.



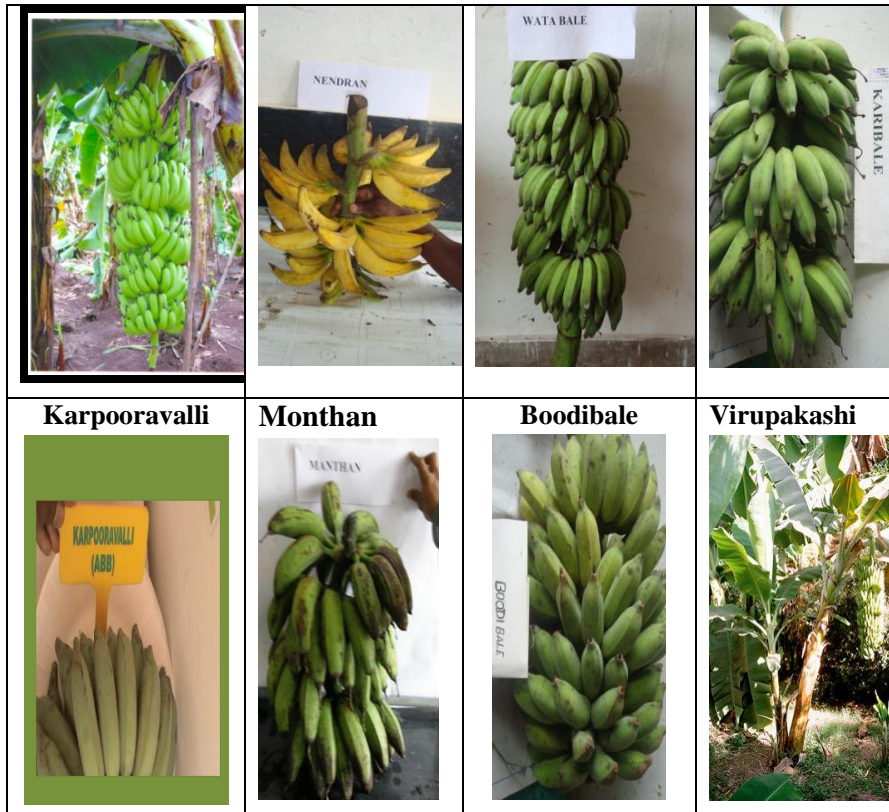
Mysore Sub-group

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
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Crop improvement

The commercially cultivated bananas are susceptible to pest and diseases. Also to increase the yield and improve the post-harvest quality of fruits, some of the national and international institutes are working out for improvement of banana crop.

International Network for Improvement of Banana and Plantain (**INIBAP**) - France.

International Institute for Tropical Agriculture (IITA) - Nigeria.

ICAR: Aduthurai-Tamil Nadu i.e NRC on banana & later it was shifted to Trichy.

FHIA. i.e Fondation Hondurena de Investigation Agricola, Handura released different banana hybrids.

Indian Institute of Horticultural Research (**IHR**), Bangalore, KAU, Kannara, Kerala, Fruit Research Station, Kavour, Andhra Pradesh. All these institutions have worked on collections, evaluation and improvement of banana germplasm for further breeding programme. All the cultivated varieties i.e, 303 cultivars, which are all natural hybrids between *acuminata* and *bulbisiana*. Cultivated and edible types belongs to pure *acuminata* (AA) family.

IC-1- The first hybrid between Gross michel x *Musa acuminata* sub species *Malacensis* developed in 1990 from IITA, Nigeria, resistant banana clone for wilt disease, which is similar to that of Gross michel, a premier cultivar in that zone. It was not accepted

because it produces small fruits. Also IC-2, 5-19 - none of them are better than Gross michel. Later,

FHIA-01: It is popularly known as Gold finger. It is the cross between a dwarf lady finger type ie., Dwarf prata x SH-3142. It is a desert banana, produces heavy bunch (20-25 kg) and has Apple flavour & suitable for export. It is resistant to black sigatoka & fusarium wilt race 1&4.

FHIA-03: GH-3386xSH3320-It is a Robusta, Disease resistant cooking banana.

FHIA-04: AVP67xSH3437-A French type hybrid, has very attractive golden coloured pulp, resistant to black leaf streak or black sigatoka resistance.

FHIA-17: high gate x SH-3362-Cavendish hybrid resistant to black sigatoka.

FHIA-21: AVP-67x SH3142 resistant to black sigatoka

The other hybrids are-FHIA-19,20,22

TNAU- C0-1: It is a multiple cross hybrid involved

Kallar laden x *M balbisiana* cv *savani*.

AA ↓ BB
F₁ AB x AA (Kadali)
 ↓
AAB - C0-1 also called H-135

H-135- it is a pome hybrid. It retains the typical virupakshi characteristics. However, the bunch is small in size.

H1-Agniswar x Pisang lilin – released by Kerala Agricultural University- resistant to leaf spot, fusarium wilt & burrowing nematode, yields 14-16 kg bunch

H₂- Vannan x Pisang lilin -tolerent to leaf spot & nematode, yields - 15-20kg.

Propagation:

Banana is traditionally propagated 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's to select the 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.

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 and immersed in cow dung slurry, 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.

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.

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 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				
Dwarfcavendish	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 at 4 leaves per 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 stunted ovaries and do not develop into 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 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 antheic 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, then 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 mature in about 4-5 months depending upon varieties, climate etc. Bananas 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 plump 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, 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 per cent 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 per cent) treatment can extend shelf life up to 3 weeks.

Bananas are not usually allowed to ripen on the tree; Smoking 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 indicate 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 - *Fusarium oxysporium* F.sp *cabens*

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. Some of the 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.

LECTURE 10, 11 & 12

GRAPE

Botanical Name: *Vitis vinifera*

Family: Vitaceae

Chromosome Number: $2n=38$

Preamble: Grape is an important sub-tropical fruit crop in India. The average productivity of grape in India is 16.95 tonne/ha, the highest in the world.

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 are best suited. Optimum pH with good organic matter are 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 28-32⁰C.

Uses: Grapes are used for

(1) Table purpose

Table grapes are meant for use as 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 Humburg, 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 (Sultanina, 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

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. Venifera grapes have forked tendrils and shiny leaves.

Vitiis riparia, *rupestris*, *berlandieri*, *candicans*, *rufotomentosa* and *solanis* are popular rootstocks for phylloxera and nematode resistance.

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

Coloured seeded grapes:- B. 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	Pyriiform with long or short beak	Oblong without beak

Gulabi, Abyad- table, juice- early type.

Banaqui Abyad- table, wine- early,

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

Coloured Seedless: Beauty seedless (blue black) mid-season,

Krishmish Charni (brick red) Mid-season (sharad seedless).

Flame seedless (Purple) late.

White seeded:

Anab-e-shahi-late

Dilkush-clone of AES

Cheemashebi (Selection from Pandari sahebi) late.

White seedless: Perlette (Scolokertekhirolaynoje X Sultania marble)

Pusa Seedless: Superior than perlette- Mid.

Thompson Seedless mid- Tas-e-Ganesh, Manik Chaman, Sonaka are clones.

Arkavati- BlackChampaXThompson Seedless-late.

Delight-Sister seedling of perlette- early.

Homorod- ContarioX Sultania.

Propogation: Propagation by hard wood stem cuttings, Treating cuttings with IBA improves rooting. Single bud cuttings also can be rooted by keeping the base of the cutting at a constant temperature of 18-20⁰C 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. mataro*).

99- (*V. berlanderi* X *V. rupestris*).

Nemotode resistant rootstocks are:

Dogride- cultivars of *V. champin*.

Salt creek, 1613- 1616- (*V. solonis* X *V. paria*).

Telecki 5A- (*V. berlandarix* X *V. riparia* 5A 1616).

Solonis 1616- suitable for saline & wet soils.

Land Preparation:

Planting: Pits can be of 1 m cube and filled with mixture of soil and manure. One year old plants are planted pruning the stem to 2-3 buds. 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.

Manorial schedule for grapes is Anab-e-shahi:-

N-150kg /ha during April, 50 Kg (May) + 100 Kg (Oct) + 100 Kg (Nov) 100 kg (December). P-1200 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.

N. 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.

April Pruning:

Anab-e-Shahi-200:300:300kg/ha

Thompson Seedless-100:300:300 kg/ha

October Pruning:

300:200:700 kg/ha

200:200:700 kg/ha.

Application of fertilizers should be done starting from 1 month after pruning only as the roots will not be active till such time.

Foliar application of micronutrients specially Iron, Zinc, Boron, Manganese at Pre-bloom and bloom 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 improves the quality. Drip irrigation is becoming more popular.

Water requirements under drip are:

1-40 days after summer pruning -48000-60,000 liters/day

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 (7.5lit/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 CCC at 500PPM at five leaf stage after back pruning increases fruitfulness.

GA at 10PPM spray 22-25 days after for pruning elongates the clusters. dipping of clusters in 60PPM GA at bajra grain to red gram sized berries increases berry size. Girding the fruit bearing shoot also improves berry size.

1g grape production requires 16-26cm² leaf area.

Weed Management:

Training and Pruning

Training

The training of the vine depends on two fundamental factors namely, 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 Pandals. This system predominates in this State. Other systems of training are practically unknown to the commercial grape growers of this region. In some areas (Madurai district) live stakes of *Commiphora* species (*Kiluvai*) available in the forest areas nearby are used for erecting pandals. 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 form 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:

1. 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 1/2-5 months.
2. The crop gets enough sun shine uniformly for their proper development.
3. Plant protection measures are more effective in this system, especially against mildew.

To compare different systems of training, investigations were 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
Pnadal	268	27,952	13,427	179	124
Kniffin	806	18,407	20,392	119	188
Single	537	15,519	10,847	100	100

Training and Pruning

From the point of view of fruit production, the pandal system was 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	363
Single Stake	3 x 3	537	2,550	140
4-arm Kniffin	3 x 2	806	1,313	100

A similar trial was conducted at the Fruit Research Station, Periyakulam on the different training methods with the variety Pachadraksha. It was observed that the vines trained in pandal system of training recorded the maximum yield (3164 bunches weighing 675.4 kg per plot), followed by double horizontal cordon system (2,432 bunches weighing 526.5 kg). The head system of training recorded the minimum yield. With regard to the quality of the fruits the bunches from the pandal system of training recorded the highest total solid content.

Table: Yield (No. of bunches) in different sections of pandal in the variety *Anab-e-Shahi*

Section	Feet from center	I crop	II crop	Total	% of total
1.	0-8	31	19	50	7.58
2.	9-16	76	36	112	16.8
3.	17-24	115	77	192	28.8
4.	25-32	167	146	313	46.9
Total		389	278	667	100

In the pandal system, the productivity of the vine varies with the different segments on the arbour. Under the system of continuous pruning adopted by the growers in Tamil Nadu with no provision for found at in or back pruning, the bearing area is carried closer to the periphery leaving the center of the vine barren. In an experiment conducted on this aspect it was found that the productivity was the highest (47 per cent) in the last eight feet of the pandal in the peripheral side, when the vine had a spread of 32; on either side of the trunk. The first eight feet from the trunk accounted for only 7 per cent of the crop.

Bindra and Brar (1978) studied the yield and quality of Beauty Seedless as influenced by the various training systems. Six years studies revealed that the bower trained vines gave about three fold increased yield than those trained on head system. Kniffin and telephone systems were in between the two but kniffin trained vines out yielded the telephone trained vine. Bilateral cordons produced more yield as compared to unilateral cordons

especially in telephone system. Experiments carried out at Tamil Nadu Agricultural University, Coimbatore, Punjab Agricultural University, Ludhiana, and Haryana Agricultural University, Haryana to evaluate the suitability of different training systems of various commercial cultivars revealed the superiority of bower system over other systems of training. Experiments carried out at Tamil Nadu Agricultural University, Coimbatore with Muscat Hamburg on pandal (bower), telephone, kniffin and head systems of training revealed that pandal system was more economical with the highest cost benefit ratio of 1: 2.09 followed by 1:1.71 in telephone, 1:1.42 in kniffin and lowest being in head system with 1:0.05 (Anon. 1982).

Tolmer and brar (1982) studied the efficacy of four training systems viz. bower, telephone, kniffin and head in four cultivars namely Perlette, 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.

The 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.

The 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 tertiaryaries. 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 mast 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 to one 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. The following are some of the technical terms used:

- **Shoot:** Young growth of green stem of the current season, which bears the grape cluster.
- **Cane:** A well mature and ripened shoot of the past season or that of the previous year which gives rise to shoots.
- **Spur:** A portion of the cane or ripened shoot left behind on the plant after pruning.
- **Fruiting spur:** A cane or well ripened shoot leaving 304 buds, producing a bunch after pruning.
- **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.
- **Trunk:** Main stem of the plant.
- **Long spur:** A ripe shoot, carrying more than five buds. Normally it is 25-30 cm long with about 5-10 buds on it.
- **Medium spur:** It is a cane cut back keeping 3-5 buds.
- **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:

Harvesting and yield: Grape is a non climacteric fruit and has to be harvested at correct stage of maturity. Degree days from full bloom gives a correct indication of maturity. Early cultivars require about 1600-2000 degree days and late cultivars about 3000 or more. A cluster having underdeveloped 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 0-1⁰C.

Fruiting areas of different varieties

Bangalore Blue-3-5 buds, Bhokri-3to4 buds, Anab-e-Shahi-6-8 buds, Cheemasabebi- 5 to 8 buds Pusa seedless, Kishmish charmi, 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 spray 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.

Bud analysis:

Characteristics	Muscadina	Euvitis
1. Chromosome No(2n)	40	38
2. Nature of tendril	unforked	forked
3. Bark	tight	loose
4. Presence of lenticels	present	absent
5. Seed shape	break absent	breaked
6. Presence of diaphragm at the node of shoot,	Absent	present

Sampling is an important pre-requisite. A minimum of 20 buds is necessary for each bud position for estimating the cropping potential with a reasonably high degree of precision. In varieties like Muscat prediction of fruitfulness is not necessary because most of the buds are fruit full in these varieties. The number of bud position for which buds have to be collected should therefore be fixed according to the variety. In general, it is better to collect buds at least for the first ten bud positions. Thus a total of 200 buds have to be collected. The collection may be done at least from five randomly selected vines in each variety. In each vine, at least ten canes should be done roughly about 100 days after pruning i.e. a month or two prior to next pruning. Immature, green, disease infected and unhealthy canes have to be rejected. The buds in the axils are scooped out with a piece of wood of the stem and placed in glass vials containing FAA (Formalin Acetic Acid, Alcohol= 5:5:50).

The grape bud is a compound bud with two or three secondary buds, covered by a lignified protective scale. Under a sterio microscope, the protective scale and secondary buds are removed one by one. The scale & thick packed inter-woven tormentor's hairs are next removed carefully with a needle. The shoot primordial (differentiated bud unexpanded) can be seen in the centre of the bud. The bud that shows the inflorescence primordial as a closely packed miniature branch besides the leaf primordia is recorded as a "reproductive bud while the one locking this inflorescence (cluster) primordium is noted

as vegetative unproductive bud. The number of productive buds at each bud position is thus recorded from the first upwards on the cane. The bud fertility is expressed as a percentage on the number of buds examined and the percentage noted down for every bud position will reveal the most productive position of the cane. Pruning can be in the next season above the bud which records the highest percentage of fertility to obtain good crop.

LECTURE 13, 14 & 15

CITRUS

Botanical name: *Citrus* spp.

Family: Rutaceae

Chromosome no: $2n=18$

Preamble: 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.

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 $16-20^{\circ}$ C within a range of $17-40^{\circ}$ 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, Maltablood 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 group:Pummelo

C. grandis – Monoembryonic. Malaysia and Polynesia origin. Leaves pubescent in lower surface, fruits in clusters. Cultivars are kaopan of Thailand and Buntan of Formosa.

C. paradisi- 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 group:Lime

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. jambheri: 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- Trifoliolate orange, fruits inedible, Polyembryonic rootstock.

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

Intergeneric hybrids:

- Citrange- Trifoliolate orange x *C. sinensis*, cultivars are Troyer, Carriyo, Morton, Stonia, Rusk, Coleman.
- Citrange quat- Trifoliolate orange (*Poncirus x citrus*), citrange x fortunella- trigeneric hybrid (kumquat)
- Citrangedin: (*Poncirus trifoliolate x C. sinensis*) x *C. mitis* (calamondin) – bigeric hybrid.
- Citrangor- citrange x *C. sinensis*
- Cicitrange- citrange x *poncirus trifoliolate*
- 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. hindisi*

Limequat: *C. reticulata* x *F. japonica* x *F. margarita* .

Intragenic 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 Chittor 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 Jan-March or Sept-Oct.

Jatti Khatti (*C. jambheri* x Karnakatta (*C. karna*)) are popular 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.

As sweet orange shows deficiency symptoms of many micronutrients it is always better to give a composite spray of:

Zinc sulphate	-	2.25 kg
Copper sulphate	-	1.45 kg
Magnesium sulphate	-	0.90 kg
Manganese sulphate	-	0.90 kg
Ferrous sulphate	-	0.90 kg
Boric acid	-	0.45 kg
Slaked lime	-	4.0 kg
Urea	-	4.50 kg

Applied in 450 liters of water 2-4 sprays every year on the new flush of fully grown leaves.

Two sprays minimum during the new flush is recommended

1st spray-on new flush

2nd spray-after the leaves on new flush fully expand.

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 of the plants, vegetables other than solanaceous crops can be grown, taking care not to waterlog the soil around the trunks of the plants. Leguminous crops are the best Intercropping with 'pea' 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.

Weed Management:

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.

Flowering and Pollination:

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.

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 Bramhaputra 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).

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, obvate 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 obvate, base flattened, deep orange yellow, thin rind adhered to segments- irregular bearing, matures in mid January.

Propagation: By seeds using nuclear seedlings and by 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 an 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.

Weed management:

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 3 flowerings in a year during Feb (Ambebahar), June (Mrigbahar), and October (Hastabahar) of which Mrigbahar is preferred. So, 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.

Flowering and Pollination:

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 8-10⁰C and 85-90 % RH. Under room temperature, they can be stored well for 3-4 weeks.

CITRUS DECLINE: (Tristeza) very serious virus 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: Mandarins 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 Znso₄ + Cuso₄ mixture (0.5 %).

Decline: decline occurs in mandarin also.

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 20-30⁰C. 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-selfcompatible.

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 trifoliolate 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 Jan-September depending upon the locality for acid lime and May for lemons, 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.

No effective control: 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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Addition

- Citrus is micro-nutrient loving plant.
- Trifoliolate 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.

SPECIES

Lecture 16 & 17

PAPAYA

Botanical Name : *Carica Papaya L*
Family : Caricaceae
Chromosome No. : $2n = 18$



Papaya has long been known as wonder fruit of the tropics and 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 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, Maharastra, 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 38-44⁰C, but optimum range is 22-36⁰C, a day temperature of 35⁰C and 25⁰C night temperature are most suitable.

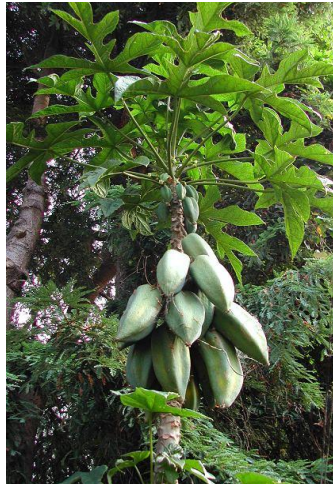
Papaya grows well under well drained soil with a pH range of 6-7. It prefers fertile soil, deep clayey and calcareous and rocky soils are not suitable.

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.*,



Carica monoica





Carica pentagona



Papayuelo - *Carica goudotiana*

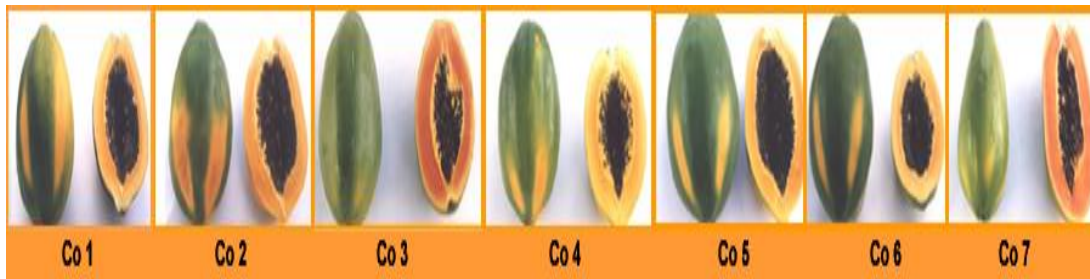
Varieties/ cultivars:

<p>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.</p>	
<p>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.</p>	

3. **Coorg honey dew:** Selection from Honey dew at IIHR, Chethalli. This variety produces no male plants. The plants are either hermophorodite 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.

- a. **Pusa delicious** - It is a gynodioecious with medium sized fruits (1.5kg) and high yielder, male has been eliminated genetically by sibmating with hermaphrodite.
- b. **Pusa majesty:** A gynodioecious, medium round fruits with good keeping quality. Plants resistant to virus diseases. The fruit with stand long distance transport.
- c. **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.
- d. **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.
- e. **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.

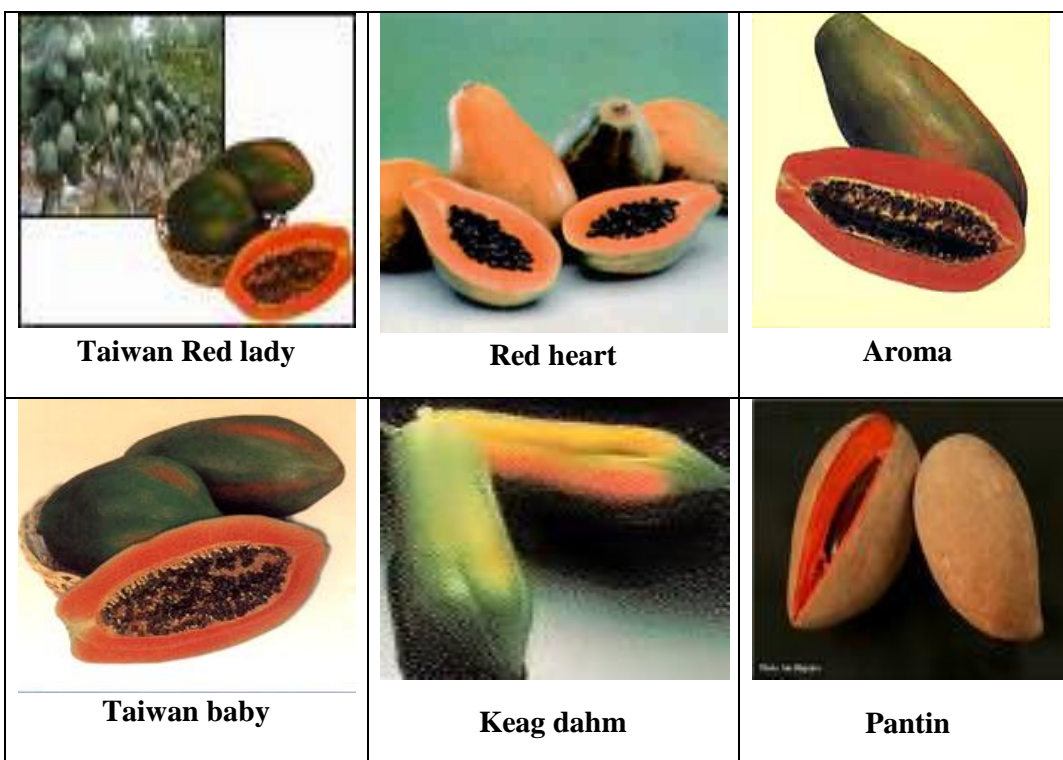
IIHR, developed some hybrids, they are

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.

Other varieties



Propagation: Papaya is usually propagated by seeds. The seeds should be collected from healthy ripe fruits essentially from of 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 a air tight container and stored at 10⁰C. Before sowing, soaking seeds in 100ppm GA solution to enhance germination percentage.

Sowing: Seeds to be sown in poly bags (22x15cm with 150 gauge) 6 weeks prior to transplanting. The media should be disinfected by using 2 per cent 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 per cent 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 seedlings 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.



Fig.1 Planting method followed in commercial papaya plantation.

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.

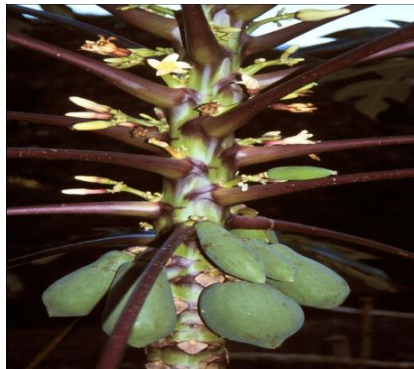
Sex distribution in papaya: Papaya is a polygamous species, many forms of inflorescence have been reported by Frankel and Galun, 1977. In general there are 3 important types of flowers.

Staminate or male flowers:

Spleder 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



Pistilate/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.



- **Hermophrodite 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 after flowering; 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% relative humidity.

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*.

Anthracnose: (*colletotrichum gloesporiodes*): 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.

LECTURE 18

SAPOTA

Botanical name : *Manilkara zapota*/*M.achras*
Achras sapota

Family : Sapotaceae

Chromosome number : $2n=26$

Preamble:

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.

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+5.7akh 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.

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 rainfall 125-250cm are best. Optimum temperature range is 11°C to 34°C . High temperature 41°C 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, Gujarath, North Karnataka. Has spreading branches, oval shaped fruits, fruits appear singly-superior.

2. Chhatri: 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 ,Karnatataka, Maharastra, WB AP. Fruits large,round,superior, shybearer.

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. Jonnavalasa-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)	Fr.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 Vanivallasa	Oval	24.2	-
PKM-1	Selecation 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 xCricket Ball	Round	23	180

Propagation:

Commercially propagated by grafting on Rayan or khirni (Manilkara hexandra) Stocks.

Other 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 dulcificum*).

Grafting time/period:

Approach grafting during: February (Jan-March).

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 8-10, 1m cube pits are dug Pits are filled with mixture of FYM and soils 1.2 Kg 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.

Weed Management:

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.

Flowering and Pollination:

Harvesting and yield: Sapota may start bearing 2nd or 3rd year but commercial yield can be obtained from 7th year onwards. Sapota takes about 7-10 months from fruit set to maturity depending upon the cultivar season and locality. Best symptoms of maturity are:-

1. Milky latex on scratching will be reduced & shows a 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 Sep-October in Karnataka and AP. Sapota normally produces fruit throughout the year.

Average yield will be;

3 year – 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 no of fruits but will be sold at higher price 15-20 tonne/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 12-14⁰C fruits ripen slowly and keep well for about 5 weeks, Ripe fruits can be stored at 2-3⁰C and 85-90% R.H. for 6 weeks and firm fruits for 8 weeks at 3 to 5⁰C and 85-95% R.H.

Pests and Diseases:-

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.

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)

Mealy bug: (*Phenacoccus icerjoides*), 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 substances. 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.

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.

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: 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 is susceptible.

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.

Lecture 19

GUAVA

Botanical name : *Psidium guajava*.
Family : Myrtaceae.
Chromosome No : $2n = 22$.



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 per cent, carbohydrates 9-10 per cent, TSS-13 per cent, 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 is used in dyeing industry and also has 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 are 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:

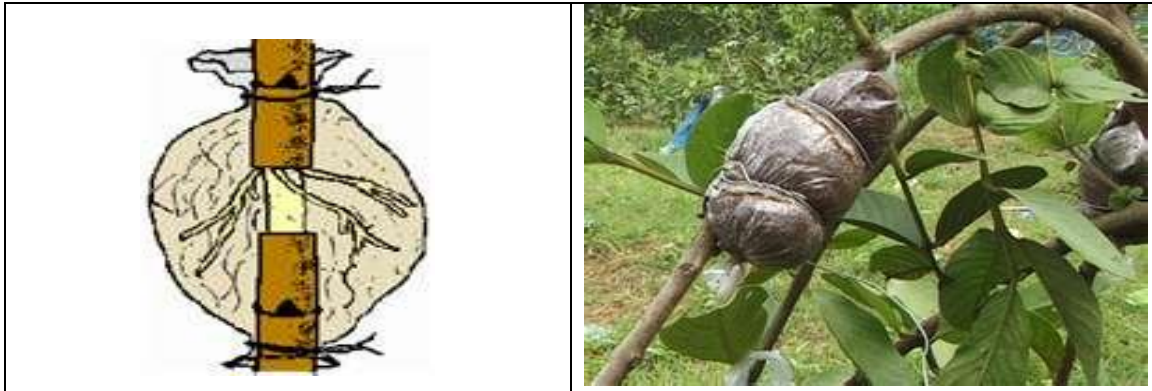
5. **Arka Mridula** : This hybrid was obtained by crossing of Seedless x Allahabad safeda. Plants are semi-tall in nature and spreading. Fruits are round in shape and weigh about 180g. Skin is yellow in colour and smooth. Flesh is white in colour. The TSS is around 12° Brix. Fruits are soft seeded and 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

Land Preparation:

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 1BA 10,000 ppm for better rooting.

Planting- Planting is done during monsoon at a spacing of 6m X 6m by opening 90cm³ pits provided 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
Maharastra	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 per cent) 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 $ZnSO_4$ (0.3 per cent) and Boron – Boric acid (0.4 per cent) 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 per cent DAP and $ZnSO_4$ during Oct-Nov at weekly intervals.

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

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 per cent to improve fruit set, GA_3 at 200ppm. Fruits take 105-140 days to mature from fruit set. Spraying GA_3 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 fifteen to sixteen 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 is sent to distant market, they are not kept in cold storage. However, shelf-life of guava can be extended up to 20 days by keeping them at low temperature of 5⁰C and 75-85% relative humidity. It can also be stored for about 10 days at room temperature (18⁰ -23⁰C) 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 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*

Lecture 20 & 21

PINEAPPLE

B.N : *Ananas comosus/ syn. Ananas sativus*
Fam: Bromeliaceae.
Chrom. No: $2n = 28/30$.



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, Maharashtra, 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 21⁰C-24⁰C. It can be grown in areas of 22⁰C-32⁰C 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 fruits 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 bracteatus



Ananas ananassoides



Ananas nanus



Ananas paraguayensis



Ananas lucidus

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

1. **Spanish group:** Fruits are of 1-2 kg in 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 - Jhaldheep(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 64000 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 pl/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 per cent), Zn SO_4 (1 per cent) as foliar spray. Copper deficiency can be corrected by drenching CuSO_4 (1.5-2 per cent) 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 spray 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 drawback. 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 ie. Pouring of 50 ml solution in to the center (heart) of plant to induce good flowering. Also, ethrel at 25ppm combining with Urea (2%) and sodium carbonate (0.04%) to induce good flowering. These application has to be done, when the plants have 35-40 functional leaves and a 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 4¹/₂-5¹/₂ 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 becomes 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 350000-40000 per hectare is about 40-50 tonnes and that from a plant population of 43000-50000 per hectare normally varies between 50 and 60 tonnes.

Storage: At 10-13⁰C, the fruits stored for more than 20 days at 10-13⁰C, do not store at less than 8⁰C, 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 flovour.

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 crown 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. Fruits exposed to high temperature (40⁰C) 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 saganarius*.

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.

LECTURE 22

JACK FRUIT

B.N. *Artocarpus heterophyllus* / *Astocarpus integrifolia*.

Fam: Moraceae

Chrom. No : $2n = 56$.



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.

Utility:

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 are 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.

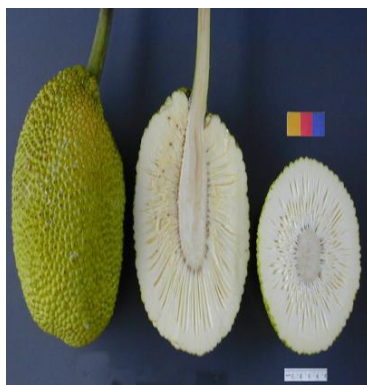
Species and varieties:

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 altalis



Artocarpus integer

Varieties: Though 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.



GKVK-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 GKVK-1 and Swarna with superior quality fruits were released from Karnataka and Gumless jack, Muttan Varica from Kerala also found to perform better.

The variety 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 1BA 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 1BA 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 takes 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: An 15 year old tree yields about 250 fruits, the individual fruit may weigh from 1kg to about 20 kg.

Storage: Fruits are stored for 2-3 months at 5⁰C with 85-90% relative humidity and 1 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.

Lecture 23

AVOCADO

Botanical name : *Persea americana*

Fam : Lauraceae

Chromosome No : $2n = 24$

Preamble:

Origin: Central America.

It might have been introduced into India from Ceylon about 50-77 years back.

It is being grown in hill slopes of TN, Kerala, Karnataka, and Maharashtra.

Leading producers of avocado are Mexico, USA, Dominican republic, Brazil, Columbia, Indonesia, Venezuela and South Africa.

Composition and Uses: One of the most nutritious fruits rich in fat, protein and minerals and low in carbohydrates. It can be safely eaten by diabetics.

Fruit is used as a dessert in salads, ice creams and milk shakes. Immature fruits may have a bitter flavour that may reduce on ripening; peel of avocado has 3 antifungal compounds.

Soil and climate: Prefers well drained and well aerated acidic soils of sandy to clay loams with 4.5 to 5.5 pH.

West Indian race can tolerate pH of 7.6 to 7.9.

Uniformity of the subsoil texture is very important. Cannot tolerate any water logging. Climate requirements varies depending upon the race of Avocado.

Mexican is more cold tolerant. Guatemalan is intermediate and West Indian is most tropically adopted.

Fruits are very sensitive to freezing temperature; flowering is very much influenced by temperature, optimum being 28-31⁰C. Strong winds are very dangerous as the wood is soft and brittle.

Cool moist subtropics are best for maximum production.

Cultivars: Avocado has “3 races namely.

1. West Indian: No leaf scent, medium to large fruits, large seed, loose cavity, matures in 6 months. Varieties: Pollock, Simmond, Black Prince, Peterson, Waldin, Purple green.
2. Guatemalan: No leaf scent, moderate to large fruits, smaller seed, tight cavity, skin course materials in 9 months. Varieties: Taylor, Linda, Queen, Itsamma, Benik.
3. Mexican:- Leaves scented, small fruit, large seed matures in 6 months. Varieties: Gott fried, Duke, Pernod.
Fuerte:- is a cross between Mexican x Guatemalan- pear shaped.

Avocado cultivars dichogamous and are of two types namely.

A= Flowers functionally female in the morning and male in the next afternoon

B= Flowers functionally female in the afternoon and male in the next morning.

Propagation: By grafting. Mexican stocks are best and dwarfing in effect.

Persea schiediana is a vigorous stock. Popular Root stock selections are duke-6, Duke-7, G-6, Huntalas, Dusa and Latas.

Mexican race can be propagated by cuttings of young plants also.

Planting: Spacing 5-6 m Different Races with overlapping blooming periods should only be planted together. High density plantings of 800 trees/ha gave double yield than normal planting of 400 plants/ha.

Manuring: Bearing trees of 10 years may be given 200g N, 45gP and 165gK in addition to 50kg FYM. Graded doses can be given from early stages depending upon the growth of the plant. Fertilizer should be applied 30cm away from the trunk only.

Irrigation: Irrigation at 2% days interval will be optimum. Sprinkler irrigation to keep the top 60Cm soil moist is the best.

Weed Management:

Training & pruning: Better to train the plants to Pyramidal form. Regular pruning may be done to remove overcrowding, damaged & unproductive branches only.

Flowering & Fruit set: Avocado flowers are entomophilous. Higher relative humidity may help in prolonging receptivity of stigma and retain viability of pollen. Temperature,

rainfall, humidity, nutrition (N,ca) and hormone levels in the plant affect fruit growth and development.

Harvesting of yield: season in South India. Fully mature fruits only should be harvested. Maturity can be known by change in colour size of fruit and reduce of glossy shine of the fruit.

Average yield 100-500 fruits per tree.

Ripening & Storage: Mature avocados ripen in about 5-10 days at 15-21°C. Ripening can be hastened with ethrel treatments.

Mature avocados can be stored in controlled atmosphere with 9% CO₂ & 1% O₂ at 10°C for 60 days.

Physiological disorders:

1. **Tip burn:-** Chloride toxicity- necrosis of leaf and edges and fall. Heavy irrigation at end of winter, deep ploughing, addition of organic matter may control this.
2. **Gray Pulp:** Mainly due to warmer temperatures which reduce the moisture content of the fruit below 80%.

MANGOSTEEN

Botanical name	:	<i>Garcinia mangostana</i>
Family	:	Guttiferae
Chromosome No	:	2n = 88 / 90

Mangosteen plant and fruits

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 flavored fruits of the temperate zone.

Composition and uses:

The fruit is a rich source of 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 during early growth stage. It cannot tolerate temperature below 5⁰C or above 38⁰C. 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. hanburyii*- 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.



Garcinia mangostana



Garcinia hombroniana



Garcinia hanburyii



Garcinia xanthochymus



Garcinia cymosa



Garcinia gardneriana

Propagation: Mangosteen is mainly propagated by apomictic seeds (non zygotic) such seeds produce plants true to type, hence seed propagation is commonly practiced since the seed loose viability very quickly. also propagated by grafting budding or air layering,

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 70g N, 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 withstand water logging but not drought. Stress followed by irrigation is required to induce flowering.

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.

Removal of male plants : Dioeciousness is a major problem in mangosteen cultivation. At present, no method is available to detect the sex of the plants in seedling stage. About 7-8 years after planting the sex of the seedling plant is known. The male plant serves as pollinizers and hence it would be adequate to keep 10 per cent male plants well scattered in the orchard. After commencement of flowering, all the male plants other than those left for pollination should be removed or converted into female trees by side grafting.

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 areas. The trees tend to bear in alternate years. The trees bear 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: Seedling mangosteen plants require 7-8 years to bear while grafted plants start bearing at the age of 4-5 years. About 30-50 kg fruit can be obtained from well maintained orchards of 15th year onwards.

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).

Pests and diseases:

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.

Cankers on stems/ branches, *Zingarella garcineae* the affected part should be cut and burn.

LECTURE 25

LITCHI

Botanical Name:	<i>Litchi chinensis</i>
Family:	Sapindaceae
Chromosome. No:	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 per cent), acid (0.2-0.6 per cent), protein- 0.7 per cent, fat-0.3 per cent minerals -0.7 per cent, TSS-20-30 per cent vit-C-64mg/100g, pectin-0.4 per cent 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 Karanataka.

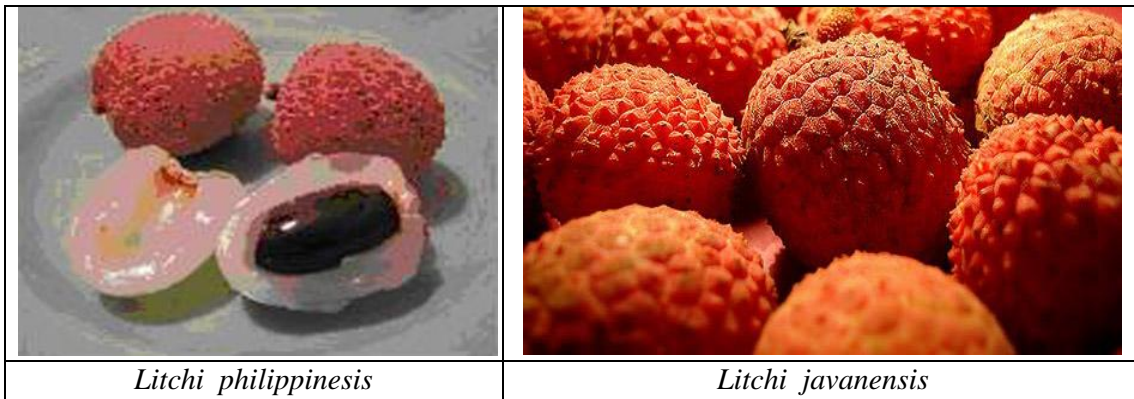
Climate: It is a sub-tropical fruit, high Relative Humidity is desirable, while hot winds are not favourable for this plant. However, the rain fall during flowering reduces fruit set. Successfully grown up to an elevation of 1000m from Mean Sea Level. The maximum temperature during the flowering period varies from 21⁰C to 38⁰C.

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 sub family 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
 - i. *Euphoria longana*- Langan/Anshpal-Small fruits, inferior quality.
 - ii. *Nephelium lappaceium*- Rambutan- hairy fruits.



Varieties: There is large number 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, , 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)	
1 st year	75	25	75	+30-40 Kg FYM/tree/Year Fertilizers are to be applied in 2 splits 1 st during monsoon & 2 nd after monsoon.
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 15-16⁰C for 2 months is essential to induce flowering and for vegetative growth the ideal temperature is 30⁰C. 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 week s 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 is 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 conditions and the economic life of the crop maybe over 100 years. It takes about 55-60 days from flowering to harvest. The fruits are harvested during May and June. The maturity indices are flatness of tubercles and smoothness of epicarp and colour development (Green-Pink). 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 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, Boron deficiency 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 per cent) reduces fruit cracking.

Plant protection

Pests

Mites- *Eriophyes litchi*

Symptoms: Curling of leaves.

Catterpillar: *Inderbella tetroanis*:

Diseases: Storage rot- *Geotrichum candidum*

LECTURE 26

CARAMBOLA (Star fruit)

Botanical name : *Averrhoa carambola*
Family : Oxalidaceae
Chromosome no. : 2n=24.

Origin: Malaysia, Popular in China, Taiwan, Malaysia, Thailand, Pakistan, Indonesia and India. Distributed within 30° N and south of equator..

Importance and uses: Carambola is good source of vitamin A,B & C, minerals specially Fe, K, Mg and P. It is used as a dessert fruit or for preparing juice, jam, jelly and pickles. It has medicinal value also. Ground leaves and shoots for chicken pox, root extract as antidote for poisoning and pulp of immature fruits for cleaning brassware. It is used as an alternative to tamarind in cooking.

Climate and soil: Carambola grows well in both tropical and subtropical climate free from frost. But it prefers warm and moist conditions optimum temperature range is 21-32 °C, 1800- 2500mm annual rainfall is best. It can be grown upto 1200m.

It can be grown in any type of soil. But well drained, deep clay soils are preferable optimum p^H is 5.2 to 6.2. Calcareous soils are not suitable. It can not with stand water logging.

Species and cultivars: No specific cultivars but 2 types namely sour and sweet are grown in India.

A). Sour type: 1% acid Var:Goldstar, 1 carambola.

B). Sweet type: 0.4% acid Var: Goldstar.

Florida- Goldenstar Fwang tung, Dahpon.

Teanma, Artin, Maha, Starking.

Thaiknight, wheeler, New comb.

Singalopre: Lengbak, Turong

Taiwan: Intho, Cheng, Tyeyi Dahpon, Erlin soft sih.

Malaysia: B1, B2, BA, Bb, BB, B102, Bill.

Australia: Giant siam, Jungle gold, BCP-1 Hosie.

Thailand: Fwang tung, Thai Knagut.

Propagation: By seeds. By grafting, budding and layering. M-18960 as stock is best for calcareous soils. Seeds should be sown immediately as they lose viability at a faster rate.

Micro propagation is also being attempted.

Manuring: 1 tonne carambola fruit is reported to remove 1.28 kg N; 0.12 kg P, 1.58 kg K.

No recommended fertilizer dose is available. Addition of 'N' fertilizer improves the yield.

Normally organic manures are only applied.

Irrigation: irrigations are given during fruit development only if the weather is dry. Trees may be provided 200 litre/ tree/ week in dry periods. Mulching will be very helpful in reducing weed growth and irrigation needs.

Planting: Spacing 7-9m x 5-7m or high density planting with 7x3m or 4.2x 3.6m is also practiced in some countries depending upon the cultivar. 1 m cube pits are dug and filled with mixture of soil and manure. Planting can be done throughout the year but monsoon season is best for good establishment.

Weed Management:

Pruning and training: Plant should be trained to have four to six main scaffold limbs from suitable height on the trunk. Pruning back old branches will improve quantity and quality of the fruit.

Flowering and Pollination:

Harvesting and yield: Carambola produces fruit on both young and old branches and even on trunks in clusters. Grafts start bearing within a year but good yields can be had after 3 years. Seedlings take 4-5 years to come to bearing.

Carambola being non-climacteric should be harvested at proper stage of maturity only, i.e. when 50% of fruit becomes yellow. On ripening fruit develops orange tinge.

Yield varies from 20-50kg/tree in the early stages and a grown up tree may give 400-500 kg/tree.

Carambola produces fruit throughout the year but peak seasons of harvest are Jan-Feb and Sept-Oct. Carambola takes about 3-4 months from flower to maturity.

Post harvest handling and storage:

Ripening and storage: Carambola is excellent in its keeping quality. Even under room temperature they store well for many weeks. They can be stored at 5⁰ C for 12 weeks.

Pests and diseases: Fruit fly, borers, fruit piercing growth, aphids, mealy bugs, scales.

Leaf spot and anthracnose- any fungicide can be used.

DURIAN

Botanical name : *Durio zibethinus*
Family : Bombaceae
Chromosome no : 2n = 56.

Preamble:

The durian is an important fruit in several parts of the tropics and the famous fruit of the far east, which is widely cultivated throughout Malaysia. The term durio is Malaysian word duri- thom and zibethinus is the Italian word Zibetho means strong smelling. Thus, this is a fruit characterized by a greenish, hard theory, thick rind outside and a yellowish sweet flesh with strong odour. The fruits are nothing but with seeds covered with cotton like fibre.

Composition: the fruits are rich source of food energy (124 cal) CHO's (28.89), ca (20.0mg), P(63mg), Fe, Vit.A, ascorbic acid protein (2.5g), fat, etc.

Uses: The fresh fruits used for table purpose. The rind is slit longitudinally along the grooves and the inner segments of flesh are taken out to be served as dessert or preserved with salt or made in to a sauce.

Also used in making durian paste, sweet durian candy or confectionary, preparation of ice-cream. The seeds roasted and eaten.

Medicinal importance: As aphrodisiac, the boiled decoction of roots used to relieve fever in Malaysia. Leaves used for curing jaundice. Durian shell placed under beds to discourage bed bugs.

Origin and distribution: It is indigenous to Malaysia i.e. S-E-Asia and distributed in Malaysia, Indonesia, Philippines, Thailand, Singapore, Kampuchia, Myanmar, India, Srilanka.

Soil and climate:

Durian trees can grow in deep well drained, sandy clay or clay loam soils rich in organic matter with a pH of 5.0-6.5.

It requires abundant rainfall (200-300 cm) equally, distributed throughout the rainy season. High humidity and high temperature with only a short dry season 24-30°C is ideal. Grows up to 800m. near equator, 30-50% shade is required for young trees.

Species and cultivars- The genus durian has 27 spp. 6 spp produce edible fruit, they are.

1. Durian- *Durio-zibethinus*- widely cultivated spp.
2. Lai- *D kutejensis*- vey good fruits with good flavour.
3. Karatogan- *D oxleyanus*.
4. Tabelak- *D graveolens*

5. lahong- D dulais
6. Munjit- D Grandiflorus.

Cultivars: The selection programme in Thailand and Malaysia involved in evolving > 100 cultivars and few cv are recommended, Chance, deception, frog, Gibbeon, Golden Pillow, grown in Thailand Monthong, Kan yao, Luang, kradum thong- Malaysian cvs.

Propagation

Mostly propagated by seeds. Vegetative propagation by budding, grafting, air, layering and cuttings is also possible. Patch/cleft budding. The chance root stock resistance to root rot is commonly used in Thailand.

Land Preparation

Planting: Plants are spaced at 10-12 m, apart in orchards and more than one clone or cultivars should be planted for cross pollination.

Manures and Fertilizers: (During 1st 5 years)

1st year- 1.7:0.4:0.4kgNPK/ha

2-4 years- 23:6:13kg NPK/ha

>5 years- 38:8:21kg NPK/ha.

Irrigation: Irrigation is essential if the dry period extends up to 3 months or during flowering & fruit development. In case of chance cv mild stress is required to initiate flowering and is reported to require low amount of irrigation.

Weed Management:

Pruning: is done to remove laterals & water shoots leaving central leader, it is done after harvesting and propping is provided for heavy cropped trees.

Flowering & fruit set: Flower clusters arise from the laterals main branch and occasionally on tree trunk; Produces about 20,000-40,000 flowers/tree during dry period (Mar-April /Sept-Oct) self incompatibility is common & cross pollination is required; Pollination is by nectarivorous, bats & moths at night when bees are not active. Application of GA3 to durian pedicels at 6 weeks after anthesis reduces fruit drop & increases fruit size.

The fruits are ovoid or ellipsoid capsule derived from single ovary, fruits weighs up to 8kg with 30cm long & 20cm diameters.

Harvesting: climacteric to prevent natural fruit abscission fruit may be tied to the limb or harvested at maturity i.e. hollow sound when tapped with finger, harvest the fruit by picking.

Yield: commercial yield starts at 12-15 years old tree about 500-1000 fruits/tree/year. Fruits stored at 15⁰C

The aril pulp is dehydrated and sold as durian cake' boiled with sugar.

Postharvest handling and storage:

Physiological disorders:

LECTURE 28

PASSION FRUIT

Botanical Name : *Passiflora edulis*
Family : Passifloraceae

Origin: Brazil: Commercial in S.Africa, Srilanka, Kenya, Cameroon, Hawaii, Zimbabwe and Australia. In India, it is growing wild in Nilgiris, Wynad, Kodaiknal, Coorg and Malabar. It is being cultivated in H.P. Nagaland and Mizoram.

Composition and Uses: A rich source of Vit A & contains fair amounts of sodium, magnesium, sulphur and chlorides.

Gives a very good squash and is used in jam jelly, nectar and ice cream making.

Soil & Climate: Can be grown in infertile soils also. Deep, well drained fertile loamy soils are best for good yields. Optimum pH is 5.5 to 7.5, Cannot tolerate water logging over long periods.

Passion fruit cannot tolerate frost. Can be grown up to 2000m. purple one does well at higher altitudes and yellow one at lower elevations. Optimum temperature range is 20⁰C-30⁰C. Below 15⁰C growth and flowering is restricted and above 32⁰C vegetative growth increases at the cost of fruiting.

Species and cultivars: About 60 sps of *Passiflora* produce edible fruits. *P. edulis* is most popular.

Cultivars: *P. edulis*- Purple susceptible to diseases.

P. edulis- var *Flavicarpa* – Yellow

Tolerant to diseases.

Var Noels special- golden, early bearing, self incompatible.

Kaveri: purple yellow- tolerant to diseases and high yielding.

Australian Varieties: Purple gold, Lacey, E-23 Black beauty.

Propagation :(seeds) cuttings and grafting on resistant stocks.

P. incarnata, *P.coerulea*: Cold, Disease tolerant stocks and for breeding.

Planting: Spacing is 2m X 3m wider spacing between plants improves yield. Monsoon is best for planting. Passion fruit plants can be retained for 3-6 years only.

Manuring: 100g N, 50gp, 100gK. per vine/year in two splits for purple variety.

110gN, 60gP, 100gK per vine/year in 2 split doses for Kaveri (hybrid)

Irrigation: Irrigation should be regular keeping the soil at field capacity to a depth of about 60cm. Water stress during growth and development reduces quality and yield to a greater extent.

Interculture: Weeding should be regular. Oxyfluorfen 1.92 lit/ha, can be effectively used for controlling the weeds. Maintaining be hives helps in improving fruit set specially in golden-passion fruit as it is self incompatible.

Weed management:

Training & Pruning: Passion fruits are trained on to well built kniffin system trellis (2 arms). Two leaders are trained on either side of the vines from the main stem. Laterals on these leaders are allowed to hang freely. These are pruned systematically to encourage new fruit bearing shoots. Pruning is done after harvesting in April and November-December.

Harvesting & yield: Passion fruit takes 60-90 days from fruitset to maturity. Plants produce fruit from 10th month but good yields will be given from 16-19 months. Main seasons of fruiting are Aug-Dec and March-May. Passion fruit does not ripen well after harvest.

Yield will be 8-10 Kg/vine for Kaveri variety. On an average 12-20 tonnes/ha/year can be obtained.

Grading & Packing: Passion fruits are graded by size and colour. Normally packed in cartons or polythene bags.

Storage: Can be stored for a few days only at room temperature as they start loosing moisture and become shrivelled. They can be stored for 4-5 weeks at 5⁰C and 80-90% relative humidity keeps the quality well for 15-30 days.

Post harvest handling:

LECTURE 29

RAINFED HORTICULTURE

Rainfed horticulture may be defined as the cultivation of fruit, vegetable, flower crops and plantation crops taking the advantage of monsoon and adapting dry land technology principles for harvesting rainfall and conservation of moisture in order to get satisfactory yield and returns.

Dry climate/Arid climate: It is a climate in which a deficiency of moisture restricts, but not necessarily inhibit plant growth. Water is always a limiting factor in this climate. Water deficiency is taken as the sum of the monthly differences between precipitation and potential evapo-transpiration in the months receiving lower rainfall than the normal. On the basis of rainfall, it has been defined to be a scanty rainfall area with 0-250 mm rainfall/annum.

In arid zone/dry climate rainfall is very low and is continued to 2- 4½ months and remaining dry months. The rains are also erratic and often come in a few big storms of short durations which result in great sum off losses instead of charging the soil profile resulting into soil as well as atmospheric water stress during major part of the year.

Soils in dry land or arid areas are coarse and structure less with very low water holding capacity. Thus, dry regions have peculiar eco-climatological features and they can exist in tropics, subtropics as well as temperate zones of the world.

Important arid fruit crops for different arid fruit species of our country.

- | | |
|------------------|-------------------------------|
| 1. BER | – <i>Zyzyphus mauritiana</i> |
| 2. POMEGRANATE | – <i>Punica granatum</i> |
| 3. AONLA | – <i>Emblica officinalis</i> |
| 4. CUSTARD APPLE | – <i>Annona squamosa</i> |
| 5. GUAVA | – <i>Psidium guajava</i> |
| 6. DATE PALM | – <i>Phoenix dactylifera</i> |
| 7. FIG | – <i>Ficus carica</i> |
| 8. PHALSA | – <i>Grewia subinaequalis</i> |
| 9. TAMARIND | – <i>Tamarindus indica</i> |
| 10. LOSODA | – <i>Cordia myxa</i> |
| 11. JAMUN | – <i>syzygium cumnii</i> |
| 12. KARONDA | – <i>Carissa carands</i> |

13. BEAL	– <i>Aegle marmelos</i>
14. WOOD APPLE	– <i>Feronia limonia</i>
15. MULBERRY	– <i>Morus spp.</i>
16. KHER	– <i>Cappris apphylla</i>
17. PILU	– <i>Salvadora oleoides</i>
18. ROSE APPLE	– <i>Eugenia jambos</i>
19. LAKOOCH	– <i>Artocarpus lakoocha</i>
20. CARAMBOLA	– <i>Averrhoa carambola</i>
21. WEST INDIAN CHERRY	– <i>Malpighia glabra</i>
22. MANGOSTEEN	– <i>Garcinia mangostana</i>

Importance and scope of arid and semi arid zones of India

About 1/3rd land surface of the world is in the grip of Arid zone & hot deserts. The man made desert alone covers 910 m.ha area. The scope of the growth of dry land fruit industry shall be determined by

- Incentives for farmers.
- Necessity
- Adaptability of the crops and
- Future scope for expansion depending on the availability of inputs, infrastructure for distribution.
- Marketing system and industrial support.

1. Nutritional significance: The importance of fruits in providing valuable nutrients, particularly vitamins and minerals in human diet is well known, and according to dietary standards an individual must consume 85g fruits/day. After writing off 20 to 25 percent as post harvest losses and inedible portion of the fruits, the availability is estimated at 46 g/day, which is one of the lowest in the world.

To bridge this gap of demand and supply the production will have to be raised through increasing orchard efficiency and by bringing more area under fruit crops.

People inhabiting in dry land areas are known to suffer from a number of nutritional disorders owing to lower intake of protective foods like fruits & vegetables. Growth of fruit industry in such areas shall definitely increase their intake and helps in improving health hazards.

Nutritionally arid/arid fruit crops are highly significant and comparable with major crops. Following are the mineral composition of different minor/arid fruit crops.

Nutritional value of arid fruits/100g edible portion.

Sl. No.	Fruit crops	Calories	P (%)	Ca (%)	Fe (%)	Vit A (IU)	Thiamine (mg)	Vit.C. (mg)
1	Aonla/Amla	59	0.02	0.05	1.2	-	30	600
2	Bael	23	0.01	0.09	0.6	240	-	-

3	Ber	129	0.05	0.03	0.3	186	12	15
4	Bullocks heart	91	0.01	0.01	0.6	Trace	-	-
5	Custard apple	105	0.04	0.02	1.0	Trace	-	-
6	Dates	283	0.08	0.07	10.6	600	90	Trace
7	Fig	75	0.03	0.06	1.2	270	-	-
8	Jamun	83	0.01	0.02	1.0	-	-	-
9	Karonda	364	0.06	0.16	39.1	-	-	200-550
10	Pomegranate	65	0.07	0.01	0.3	-	-	16
11	Rose apple	43	0.03	0.01	0.5	-	-	-
12	Wood apple	97	0.11	0.13	0.6	-	-	-

2.Commercial importance : The organized establishment of orchards with these fruit crops can offer better return and yield, which also helps in assured supplemented income to farmers, particularly the marginal farmers.

Eg. Ber a wild fruit a decade back has gained commercial importance in Rajasthan, Gujarat, Haryana & Punjab gives a net profit of Rs.10,000/ha, like wise Aonla – Rs.20,000/ha even in drought years when other crops fail.

1. The sick saline and alkaline soils, which can't be put under cereal crops owing to greater sensitivity, can be successfully used for fruit crops like ber, date pomegranate and aonla and even their tolerance can be raised by using resistant root stocks.
2. Growing of arid fruit crops ensures proper utilization of marginal land where growing of food/fruit crops is not remunerative and can help in employment generation.
3. Ecological imbalance is a striking feature of Indian arid zone growing arid fruit crops in such areas shall not only provide sustained economy but help in improving the environment and strike an ecological balance.
4. The need for adoption of a multiple land use system involving cultivation of multipurpose trees/shrubs along with agricultural crops provides food, fodder, fiber or fruits (**4F's**) which can provide alternatives and a basis for sound farm economy.
5. Provide raw materials for processing and pharmaceutical industries.

The processed products viz., Jam, Jelly, Juice, wine etc., have got international market and make a satisfactory contribution in the national economy with a annual turnover of several million dollars. These industries provide job opportunities & extend the export potentiality of the country.

6. They also serve as a good source of organic matter/manures and also fuel – Eg- Ber, Cashew, Jack, Tamarind.
7. Intercropping can also be possible in dry land horticulture due to wider spacing.
8. Establishment of dry land orchard on rainfed areas serves as insurance against total or partial crop failures.

Reasons for causing dry land areas.

1. Deforestation – indiscriminately felling of trees.
2. Adaptation of inappropriate cropping systems & Agronomic practices.
3. Over grazing of Grassland & trees indiscriminately by the cattle.
4. Over exploitation of ground water resources & in-equitable distribution of surface irrigation are some of the important reasons for increased area in arid & semiarid regions.

Characteristic features of dry land areas

- These area are prone with high temperature (>40°C in summer)
- Delayed & erratic rainfall.
- High wind speed & hot wind
- Occurrence of drought & soil erosion frequent
- Deep water table
- Soils of dry land are very shallow & low in water holding capacity & fertility also.

Characteristic features of Arid /dry land horticultural crops

1. Dryland crop should be deep rooted & perennial crops.
2. Dry land crop should be of low water requirement crop.
3. The crop should have thick & small leaves & should be shiney.
4. Crops should be hardy & tolerant to rigorous monsoon
5. Crops should shed their leaves during summer & put forth flowering & fruiting during rainy season.

Run off water harvesting and recycling techniques for establishment of arid orchards.

In India, about 70% of cultivated area is under rainfed 12% arid & 48% semiarid (60%).

For successful dry land/arid horticulture, besides planting, adoption of proper soil and water conservation techniques is of prime importance following techniques are adopted.

1. Fall ploughing of land prior to onset of monsoon ploughing of land across the slope prior to onset of monsoon specially during summer helps in better infiltration of rainwater, conservation of moisture and also in reducing the intensity of weeds.
2. Formation of bunds/terraces: In order to conserve top soil, reduce run off of water and help in conservation of moisture, bunds/terraces may be formed across the slope depending upon the gradient. This may be done before taking up planting or even in the existing plantations if the lands are sloppy. The terraces check the runoff water within the block/terrace, thus helping in better infiltration and conservation of water. On steep & undulating slopes, formation of crescent bunds at the lower side of pit-half moon shaped bund formation towards the slope.

3. Opening of catch pits: Opening of catch or soak pits of size (1.5m length, 1.0m width and 1.0m depth) wherever land is sloppy and gully formation occurs, has been found to help in better conservation of soil and moisture resulting in better growth & establishment of the plants. After filling the pits with organic matter are removed and applied to the plants after monsoon.
4. Formation of farm ponds and re-cycling: Formation of farm ponds for collection of excess rain water (monsoon) and subsequent re-cycling (summer) has been found to be a suitable technique in most of the dryland areas.
5. Preparation of wider basins: Immediately after the onset of first shower, preparation of wide basins, would help not only better harvesting of the rain water but also in better infiltration of rain water, conservation of moisture.
6. Providing mulch and shade: Mulching (5cm thickness around the plant) with locally available materials like dry leaves, grasses black polythene film etc., will not only help in conservation of moisture and suppressing weeds but will also minimize soil erosion. Providing shade during summer in the initial years will also help in minimizing the mortality of plants under rainfed conditions.
7. Timely planting – Planting during monsoon by taking the advantage of rainfall is advisable.
8. Selection of grafted plants for planting.
9. Planting of trees along the contours/trenches/terraces.
10. Raising wind breaks around the borders of plantation with fast growing species like casuarinas, silveroak etc. will help in creating suitable micro climate for growth of crops inside the farm.

Planting techniques in Arid/dry land orcharding

- a. Selection of crops: Selection of suitable horticultural crops depends upon different agro-climatic conditions – In Karnataka – 3 categories of areas are prevailing.
 - i. Maidan- The crops are Jack, Tamarind, annona, ber, Jamun, wood apple Amla, Fig, Phalsa etc.,
 - ii. Malnad – Early varieties of ramphal, sitaphal, Jamun, Jack etc.
 - iii. Coastal – Early varieties of Karonda, Jamun, Jack, bread fruit, butter fruit, Cashew, apple etc.
- b. Wind breaks: like casuarinas, Silver oak help in demarcating the boundaries & also provides timber.
- c. System of planting: Depending upon the level and slope of the land system of planting – Square, triangular, rectangular or contour systems of planting could be adopted.
- d. Planting of rootstocks & in-site grafting: In rainfed areas it is always desirable to plant seedlings and to take up in situation grafting in subsequent season, helps in better establishment.

The unexploited fruit plants for watershed areas are – Tamarind, ber, karonda, pomegranate, Jamun, Jack, Aonla, Fig, Phalsa, Wood apple, Custard apple etc.

Distribution of Arid & Semi arid /Dry land regions or zones in India

The climatological data of the arid and semi arid regions of India have been analysed by Sarkar & Baswas (1980). The entire dry farming areas have been divided into four zones. Zone –D, E, F & G.

Zone-D: This zone has the lowest crop potential. It occurs at three places.

The first starts from the Jamnagar district of Gujarat to Ferozpur in Punjab. The second includes part of Ahmadnagar, Pune, Satar, Solapur and Sangli districts of Maharashtra.

The third includes portions of Bijapur, Raichur and Bellary districts of Karnataka and Karnool & Anantpur districts of Andhra Pradesh.

ZONE – E: This area extends from Rajkot in Gujarat along with east of Zone-D up to Punjab through Rajasthan and Haryana. This area also extends from Ahamadnagar (Maharashtra) to coastal areas of Cadappah(Andhra Pradesh) through Stara, Pune, Solapur & Sangli districts of Maharashtra and Bijapur, Bellary & Tumkur districts of Karnataka.

ZONE-F: This zone is confined to two localities in the country. In the north, it comprises vast areas of Gujarat, Rajasthan, Uttar Pradesh and a portion of Haryana and Punjab. In the South, this zone stretches from the Nasik district of Maharashtra to Kanyakumari of about 1/3rd land surface of world is in the grip of Arid zone and hot desserts. The man made desert alone covers 910m ha area.

Tamilnadu. A large portion of Karnataka and Andhra Pradesh also fall within this zone.

ZONE G: This zone has the highest crop potential. This area consists of small portion of UttarPradhesh, Madhya Pradesh, Gujarat & Tamil Nadu and considerable parts of Maharashtra and Andhra Pradesh. A part of Tamil Nadu receives the North east monsoon and the growing season, therefore differs significantly from the rest of localities.

Distribution of dry zone/Arid zone in India.

The Arid zones are characterized by sparse scattered and highly variable precipitation, extreme variation of day and night temperature and high evaporation. In India the arid regions occupy nearly 12% of the land surface comprising 317000 km² (39.54m.ha – 31.71m.ha in hot arid and 7.83 m.ha in cold arid region) in the states of Rajasthan, Gujarat, Andhra Pradesh, Punjab, Haryana, Karnataka & Maharashtra.

Statewise areas of arid zones of India

State	Area under Arid Zone (m/ha)	% age area out of total and zone.
1. Rajasthan	19.61	62
2. Gujarat	6.22	20
3. A.P.	2.10	7

4. Punjab	1.45	5
5. Haryana	1.20	4
6. Karnataka	0.86	3
7. Maharashtra	0.13	0.4

Thus the area in the arid zone, N-W India constitutes almost 90% of the total arid zone in the country.

Extent of arid region in India

Regions	Area (m.ha)	Important districts represents
A. Hot arid region	31.71	
a) North-West India	28.56	
- Western Rajasthan	19.61	Bikaner, Barmer, Jaisalmer, Jodhpur, Ganganagar, Churupali, Jalore, Nagor, Ajmer Sikar, Jhunjhanu
- North – Western Gujarat	6.22	Kutch, Amreli, Jamnagar Surendranagar, Jungadh Banaskantha, Mehsana
- South-Western Punjab	1.45	Ferozpur, Bhatinda
- South – Western Haryana	1.28	Hissar
b) Southern India	3.15	
- Andhra Pradesh	2.16	Anantapur, Kurnool & Cuddapah
- Karnataka	0.86	Dharwad, Chitradurga, Bellary and Raichur
- Maharashtra	0.13	Dhulia, Nasik, Sholapur and Satara
B. Cold arid region	7.83	
- Jammu & Kashmir	7.00	Leh, Kargil, Ladakh
- Himachal Pradesh	0.83	Kinnaur, Chamba,
Total	39.54 m.ha	

ANNONA (SUGAR APPLE)

B.N. *Annona Squamosa* Linn.

Family: Annonaceae

Chromosome No. : $2n = 14$

Origin: Tropical America - Peru



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 and 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, through shield, patch, chip budding in early spring on the commencement of sap flow or in the autumn.

Varieties

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.

Mammoth: This is a high yielding variety with prolific bearer, plant is dwarf compare to other varieties. 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.

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.

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.

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.

Islander: Large fruit (410g), TSS 26 percent with less seeded.

Hybrids

Atemoya: Hybrid between *A. squamosa* x *A. cherimoya* – sweet pulp, with few seeds.

Arka Sahana- It is progeny of island gem (*Annona atemoya*) x mammoth (*A. squamosa*). Fruits will mature in the month sep-oct. Matured fruits weigh 210g and take 6-7 days to ripe. The skin has a waxy bloom, light green in colour with creamy white flesh which is juicy with pleasant aroma. An average of about 12 tonnes of fruits can be harvested /ha

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.

Maturity indices:

Custard apple fruits are climacteric, therefore they are harvested when they are mature, firm and plumpy, on maturity, fruit turn light green. The inter areolar 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.

Introduction

ANNONA (SUGAR APPLE)

Botanical name	: <i>Syzygium cumini</i> Skeels
Family	: Myrtaceae
Chromosome No	: 2n = 40
Origin	: India

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 but not in . It is also known as jambolin, black plum, Indian black cherry, Java plum, jambul, rajaman, kalajam and phalinda.

Introduction

- Jamun is native to India. 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.

Introduction

- 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 per cent), fat (0.1 per cent) carbohydrates (19.7 per cent), Iron and other minerals. Jamun juice mixed with other fruit juice which is very good for diabetics. The extracts from bark, seeds, leaves and fruits are used against diabetes 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 making seating arrangements in railway coaches. The flowers are an important source of honey.
- 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, Maharashtra & Gujarat.
 2. ***S. fruiticosum*** – 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. cumini*. It is resistant to attack of termites.
 5. ***S. uniflora (Surinam cherry or pitanga cherry)***: It is small tree bears small sized fruits are bright red colour with aromatic flavour.
 6. ***S. zeylanica*** – Small tree, bears edible fruits in Western ghats of India.

Climate and soil

- 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 ideal for Jamun. Jamun grows well in deep, loamy and well drained soils. It is sensitive to sodium, but can be grown under saline and water logged conditions.

Species and Cultivars

- There is no named variety and lot of variation exists 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 greyish pulp which is juicy and sweet.
 2. Other strains are
 - NDDUA & T – Narendra Deva University of Agriculture & Technology – Faizabad – Fruit weight is more and high pulp: Seed ratio
 - Gujarat Agriculture University – Paras
 - PKV – 15, 4, 14 and 13.
 - Konkan Krishi Vidyapeet – Seedless
 - KJS – 20 – KRC College of Horticulture, Arabhavi

Propagation

Propagation

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

Seed:

- Fresh seeds can be sown within 3-4 weeks after extraction and will germinate in 10 – 15 days age of seedlings are ready during February to March

Grading and Budding

Grafting

- Jamun can be propagated by inarching, where seedlings are used as rootstock and June-July is the best time for inarching. Veneer grafting has also been successful if done in July with the spring flush.

Budding:

- It is done on one year old seedling stocks during July to August in low rainfall area. It is done in spring – about 60% rooted air layers are obtained when 500 ppm IBA in lanolin paste is used. 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.

Intercropping and intercultural operations

Intercropping and intercultural operations

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

Pruning & Training

Pruning & Training

- It is always better to train the plant without laterals upto a height of 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

- A Seedling tree comes to flowering 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. Stigma receptivity is maximum one day after anthesis. Honey bees, house flies and

wind are responsible for cross pollination.

- There is heavy drop of flowers and fruits (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 ie., at full bloom and second spray at 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 and Yield

Harvesting:

- On attainment of maturity fruits change their colour from green 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 harvestings 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 a temperature of $9 \pm 10\text{C}$ and 85-90% relative humidity.

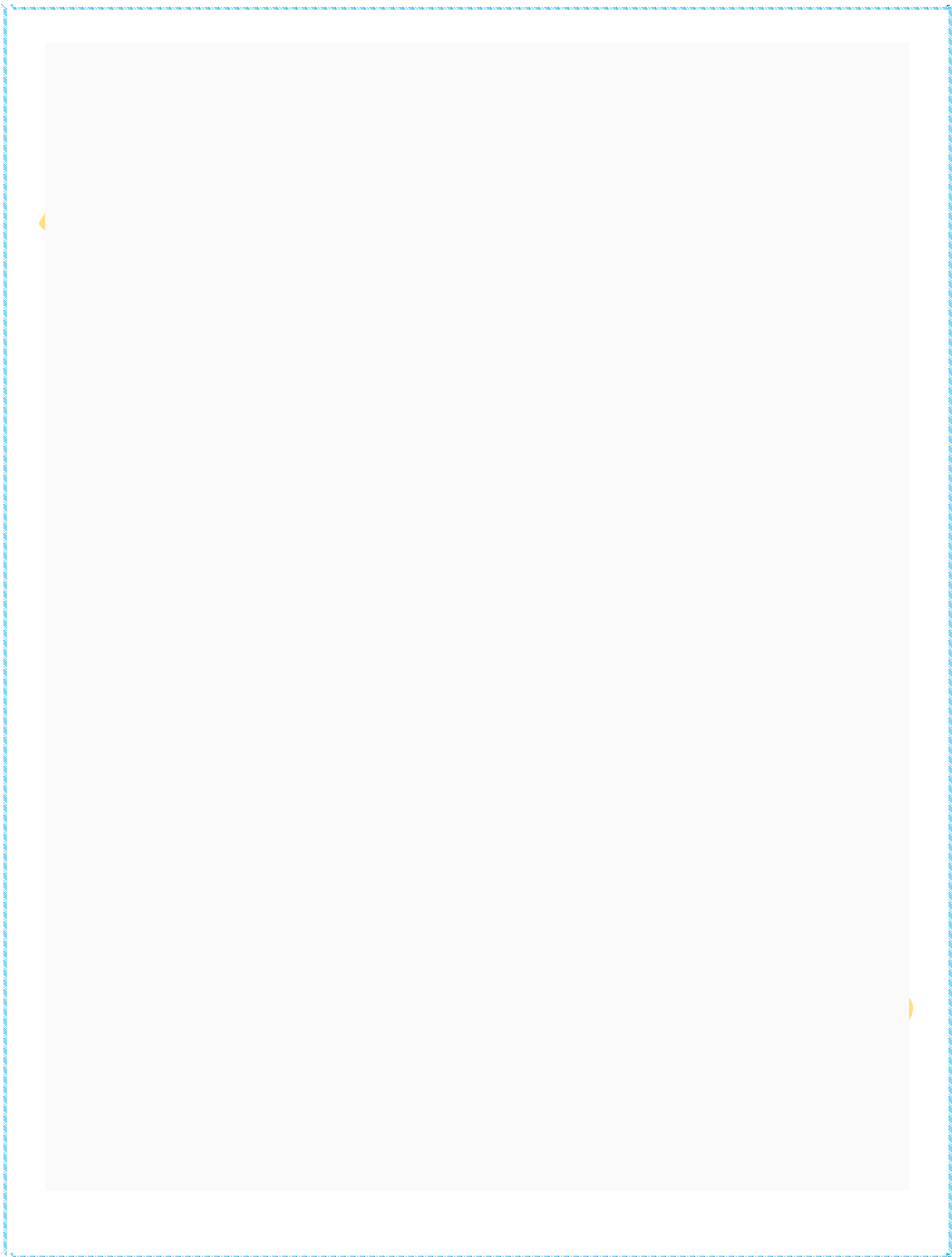
Pest and Diseases

Pests

1. **Leaf eating caterpillar** – *Carea subtilis* Caterpillar attacks the leaves and tree become defoliated.
2. **Fruit fly** – *Dialeurodes eugenia* Affected fruits get wormy appearance on the surface

Diseases

- **Anthraxnose** – *Glomerella cingulata* Affected leaves show small scattered spots, light brown or reddish brown fruits show small circular lesions ultimately fruit rot.



Pomegranate

Botanical name: *Punica granatum* Lin.

Family: Puniceaceae

Chromosome No. : 2n= 18

Origin: Iran.

- 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 Iron, Spain, Morocco and Egypt etc. It is grown all over India and commercially in Maharashtra (more than 60 per cent) followed by Gujarat, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu etc. Besides,
- 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.

- 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

Soil and Climate

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 plants withstand considerable long period. The plant withstand considerable amount of drought but does well if provided with irrigation.

Soil

- Pomegranate can be grown on soils-which are considered unsuitable for most of other fruit crops.
- It can be grown in limy, alkaline and saline soils and also thrives well in shallow rocky gravel soils.
- However 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

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.

Alandi or Vadki: It is commonly grown in Maharashtra and Gujarat. Fruits are of medium size, blood red or deep pink flesh with sweet, slightly acidic juice. The seeds are very hard.

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.

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.

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.

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.

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).

G-137, Bhagawa: The other varieties popularly grown are – Dholka, Kandhari Kabul, Muscat, Jodhpur red, P-23, P-26,

Propogation and planting

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

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.

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 10,000ppm for better rooting

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.

Manures and Fertilizers

Pomegranate is a hardy plant but it responds well to manure and fertilizers. Following are the fertilizers recommended in major pomegranate growing states of India.

State	N/year	P/year	K/year	FYM/year
Karnataka	200 kg/ha	300 kg/ha	100 kg/ha	12.5 t/ha
Maharashtra	625 g/tree	250 g/tree	250 g/tree	----
Tamil Nadu	600 g/tree	500 g/tree	1200 g/tree	30 kg/tree

Rajasthan	230 g/tree	200 g/tree	-----	50 kg/tree
Gujrath	500 kg/ha	250 kg/ha	500 kg/ha	50 kg/tree

The full dose of P, K and 3/4th of N should be given at the time of bahar (flower induction) treatment, remaining 1/4th of N given at 1 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

M.C.Q.

Flowering- To obtain higher fruit yield during a particular period, the pomegranate plants are given a resting period. It is done by with holding of water for about 60 days in advance of the normal flowering; Roots are exposed and is known as bahar treatment. Flowering is noticed in almost round the year and there are 3 main seasons viz.,

Amba bahar – Flowering can be induced in February -March – This is taken 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.

The tree starts bearing fruits from 3-4th year and continues for about 25 to 30 years. Economic yield is generally obtained from 6th or 7th year onwards.

Harvesting and yield

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

Pests and diseases

- Anar fruit fly/fruit borer - *Virachola isocrates*

Rotting of fruit & affected fruits fall down

- Bark eating caterpillar – *Inderbela tetraonis*

It bores in to the bark & tree becomes weak & do not bear fruits.

Stem borer : *Aleurodes species*.

Fruit rot – *Phomopsis sp.*

Leaf spot – *Colletotrichum gloeosporioides*

Physiological disorder

Fruit cracking

- It is common in pomegranate and also serious. 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 loose 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

- Planting of varieties tolerant to fruit cracking.

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



Fig (Anjur/Anjir)

Botanical name : *Ficus carica* Linn.

Family: Moraceae

Chromosome Number : $2n = 26$

Origin – South East Asia, Eastern Mediterranean region.

- 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 bengalensis*, *Ficus religiosa*, *Ficus elastica*, *Ficus hispida* and *Ficus roxburghii*.
- Fig is a large shrub or low growing deciduous tree with short and twisted trunk. Fruit solitary, axillary green or yellow, pear-shaped.

Composition and Uses

- The fresh fruit contains 11.5 percent total sugars, traces of iron, Vit. A, Vit. C, Protein, Fat, Calcium, Riboflavin, Thiamine, etc. Dry fruits are very delicious. It is also used for preparation of Jam and Jelly. Figs boiled in milk are repeatedly packed against swollen gums; The fruits are also used against tumor and other abnormal growth. Leaves are used as fodder. In southern France, fig leaves are used as a source of perfume extraction called “Fig – leaf absolute”.
- The fruits are consumed as fresh, dried, preserved, candied or canned products. 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, unripe fruits are used as vegetables after cooking.
- The latex of the unripe fruits and also any 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 living the inner surface. The true fruit is tiny drupelets inside the cavity of the fused peduncle.

- **Caprification**

The process of pollination in fig is known as caprification. Based on pollination behavior, the figs are grouped in ti four groups viz.,

Cultivars

Some of important characters of few cultivars grafted on Brown Turkey root stock

Characters	Poona	Deanna	Conadria	Excel
Plant height (m)	1.80	1.56	0.90	1.38
Plant canopy (m ³)	3.42	3.52	0.78	1.17
Earliness	Late	Early	Early	Early
Av. Fruit wt. (g)	38.5	61.5	38.5	34

Fruit shape	Pyriiform	Pyriiform	Pyriiform	Ovoid
Skin colour	Light purple	Lemon-yellow	Green	Yellow
Pulp colour	Strawberry	Light yellow	Pink	Pink-yellow
Flavour	Distinct	Very mild	Mild	Mild
TSS (OB)	22	21	20.5	21
Seeds	Few	Many	Many	Few
Taste	Sweet acidic	Sweet	Sweet	Sweet to slightly acidic
Tolerance for splitting	Very poor	Good	Good	V. good
Susceptibility to rust	Moderate	Susceptible	Moderate	Moderate
Fruit Yield (Kg/tree)	2.69	3.94	1.87	1.75

Soil and Climate

2024

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 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 above 38°C and such fruits have tough skin and aslo fruit skin may show sun burns, less pulp with insipid in taste, 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, non-alkaline, medium black soil with well drained and good water holding capacity. A good quality of fruit is obtained on heavy soils.

Propogation and planting

Propagation

- Fig is mainly propagated by hardwood stem cuttings, 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.
- The Kithur Rani Channamma College of Horticulture, Arabhavi, developed the CMS-closed Media Sachet technique where in the rooting media is filled in the polythene bag and planted the required numbers of cuttings, after watering the mouth of Sachet/bag is closed, until rooting is observed and planted the cuttings for further growth.
- Air layering is also successful.

Training and Pruning

- Fig can be trained on single stem or multistem, multistem is most commonly followed.
- Pruning of fig is important, fig generally gives two crops in a year, the first borne on previous years growth is breba and the second crop on current season growth and therefore, pruning intensity and its type will depend on bearing habit and type of crop desired. 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 Tamil Nadu and Maharashtra (Pune), 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 Cyanide) at 1.5-2.0 % advanced the date of bud burst.

Irrigation and Nutrition

3.

Irrigation

- Fig is fairly drought tolerant, but during summer, when the fruits are developing and ripening, irrigation 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 50-75 kg. FYM for bearing plant is recommended.
- For 1-2 year old plant about 75:50:50 g NPK is sufficient and should be doubled 5th year onwards, a dosage of 300:200:200 g NPK/plant, gives good yield and quality fruits.

Flowering and pollination

- In fig, three types of buds occurs. Flower buds which are spherical, have 3-5 scales and 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., once in July – September and in February - May, Indian figs develop fruit without pollination. The fruits harvested during February-May are sweeter and of good quality and fetch premium price.
- **Parthenocarpic** 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 – *Oeinaria 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 – *Cylindrocadium scoparium*
3. Anthracnose – *sphaceloma ficuricae*
4. Fig mosaic – Viral disease transmitted by a vector fig mites
5. *Aceria ficus* – Affected leaves show yellow – green spots, white mottle on leaves.

Disorders

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

- 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 OOC and 90 -95 % Relative Humidity 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 minute and are dried for a few hours under sun and for eight days under shade.

Tamarind

Botanical name: *Tamarindus indica*, Linn.

Family: Leguminosae; Sub. Fam: Caesalpiniae

Chromosome number: 2n = 24

Origin: Tropical Africa



- 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.
- 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. 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.

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

Soil and Climate

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 also of long life span life-span is long therefore deep loamy soils with adequate moisture would be the best for its growth.

Cultivars

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.

II. Based on organoleptic taste

The cultivated types could be broadly classified in to 2 groups they are

- **Sweet type:** The ripe fruits have sweet pulp coupled with less acidity, fruits are used for desert purpose, important varieties are Makhham, Waan, Sechhong, Manila sweet

Pratisthan – Released by the fruit Research Station, Aurangabad.

- **Sour type** – The ripe fruits have sour pulp with more acidity, important varieties are 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 Dharwad Agricultural University,

Propogation and planting

Propagation

- Tamarind is propagated mainly by seeds, budding, cuttings, layering, approach grafting, 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.

- **Intercrop, Nutrition and Irrigation**

Intercrops: 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, harvesting and Post harvest handling

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.

Tamarind / Indian date/Imli- *Tamarindus indica*

Family: Leguminosae, $2n=24$, origin=Tropical Africa

It is the most popular tree found cultivated throughout India as stray plantation or avenue. Regular orcharding is wanting but common in waste land. The wood is used in cart wheels, rice pounders. Oil mills, etc. the bark is used in tanning, the tender leaves and flowers are eaten as a vegetable. The pulp of fruit is used for culinary purpose. The seeds are rich in pectin. India is the major producer and consumer of this fruit in the world.

Uses and composition

- This tree is generally grown for its fruits which are used mature or not. Immature fruits are used for chutney and ripe fruit pulp is an important ingredient in south Indian vegetable dishes to induce sourness. Continuous use of tamarind in daily food in urinary system of human beings. It is an important condiment and refreshing acid drink and syrup are also made. Seeds are eaten roasted or boiled.
- Acidity is due to tartaric acid. Pulp is 55% of pod. Seeds have 63% starch.

Climate

- Semi arid tropical and subtropical region but can be grown in monsoon region with good drainage. It prefers warm climate.

Soil

- Self sown in forest and wastelands. A compost of fibrous loam and sand suits very much.

Cultivars

- No standard cultivars are available. Some selections have been reported from Rahuri and Tamil Nadu.
- The genus Tamarindus is a monotype one containing the only species indica belongs to sub family Caesalpiniaceae of the family Leguminosae.

On the basis of fruit size and shape

Baily recognized two types of tamarind

1. East Indian type having long pods with 6 to 12 seeds.
2. West Indian type having shorter pods containing 1 to 4 seeds.

Paulos (1975) recognized a tamarind type known as 'Valakatchi'- which bears long and rectangular pods.

On the basis of pulp colour:

1. The yellow or brown pulp type, turning dark brown on storage. It is harvested after full maturity.
2. The reddish pulp type is locally known as 'Raktichinch'
3. A high yielding Red type (Yogeshwari) has been released by Marathawada Agriculture University, Parbhani.

On the basis of organoleptic taste

The cultivated types could be broadly classified into two groups viz., sweet and sour types.



- **Sweet type:** The ripe fruits have sweeter pulp coupled with less acidity and fruits are mainly used for dessert purpose. Makhham Waan, Seethong, Maniliasweet are few cultivars found mostly in South East Asia (Thailand)Cultivar 'Pratistan' released by FRS, Aurangabad is a sweet type (61%).
- **Sour type:** No. 263 has been released by MAU, Parbhani. Urigam+higher pulp seed ratio and cumbum (good yielder) are popular in Tamil Nadu. PKM-1 (Periyakulum-1) has been released from HRS, Periyakulam. Suitable for high density orcharding (160 plants/acre against 40 plants/acre under conventional planting.).

Genotypes: T-9, T-10, T-11, T-12, No. 5, No. 48, No. 65, No. 67, No. 68, No. 96 and No. 109.

Propagation

- Seed propagation is common. Budding is also successful. Cuttings also root easily during rainy season. Air layering/mound layering, approach grafting, veneer grafting and softwood grafting. For arid region, in situ soft wood grafting on one year old seedling when new growth on one year old seedling when new growth takes place for which activated scion should be employed.

Planting

- 12 X 12m, 10 X 10m, 5 X 5m latest pit size: 13 m – planting is done in the beginning of monsoon. No pruning is required.

Nutrition

- Being a leguminous tree, it may not require nitrogenous fertilizer. Phosphorus application at pit filling will be advantageous.

Irrigation

- Once the plant has established it hardly needs any irrigation. In heavy rainfall areas proper drainage would be essential.

Fruiting

- Flowering takes place in May to June and the fruits are available in February to March.
- A seedling tree takes 13 to 14 years for first flowering but a vegetatively propagated plant takes 7 to 10 years.
- Productivity increases and continues to be productive for more than 60 years.

Harvesting

- When harvested the fruits are almost semi-dried and do not spoil due to high acidity. A fully developed tree can give production of 200 to 250 kg per annum.

Post harvest handling

- After harvest the fruits are allowed to dry and their hard shell is removed.
- Tamarind pulp is also exported to Europe and America for preparing chutney and meat sauces.
- Under ordinary conditions the pulp remains good for about a year provided it is kept in dry conditions.

Problems

- The tree is affected by a number of rots, such as Saprot, brownish saprot and white rot.

Pests

- Scales, mealybug, white grubs, leaf eating caterpillars, black citrus aphids. White flies, thrips, cowbugs, bud and flower pests, fruit borers.

- West Indian Cherry

Introduction

Botanical name: *Malpighia punicifolia*

Family: Malpigiaceae

Chromosome No: $2n = 20$

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 Puerto Rico, 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 tree on account of their fruits, flowers, foliage and the drooping branches.

Composition and uses

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, carotene, 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 and climate

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 5oC) for longer period.

Cultivars

Cultivars and species

- The genus Malpighia mainly having 2 related species – Malpighia coccifera and Malpighia urens, yields edible fruits.

The cultivated types are grouped into:

1. Acid types

- These are generally better yielders with more desirable form with more vitamin C, 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. Beammont, C.F. Rehn bong, 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.

Propogation and planting

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

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.

V.C.S.



V.C.S.G.College of

