

Fruits, Vegetables and their Management

DA - 281

Credit Hours: 3 (2+ 1)



AUTHORS

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PREFACE

This Course material is prepared as ready reckoner to the Teachers and Students of Agricultural Polytechnics. This is compiled from different sources of information including previous manuals of ANGRAU and PJTSAU, online resources, and textbooks for easy understanding with relevant photos. The authors are thankful to the content providers.

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AUTHORS

COURSE TITLE: FRUITS AND VEGETABLES AND THEIR MANAGEMENT**COURSE No.: DA-281 Credits: 3(2+1)**

Lec. No.	Title of lecture
1	Fruits - Importance of fruit crops growing- Nutritional aspects of fruits- Classification fruit crops
2	Points to be considered for Selection of site for establishment of orchard - Steps in establishment of orchard- Points to be considered while selection of saplings – High Density Planting
3& 4	Mango – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – Irrigation – Weeding – inter cultivation – inter crops - training and pruning – cropping – harvesting – yield – physiological disorders – pests and diseases
5	Banana – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – Irrigation – Weeding – inter cultivation – cropping – harvesting – yield
6	Grape – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – Irrigation –training and pruning - Weeding – inter cultivation – cropping – harvesting – yield- physiological disorders
7& 8	Citrus – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – Irrigation – training and pruning - Weeding – inter cultivation – cropping – harvesting – yield- physiological disorders
9	Pomegrante – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – Irrigation – training and pruning - Weeding – inter cultivation – cropping – harvesting – yield- physiological disorders
10	Papaya – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – Irrigation – Weeding – inter cultivation – cropping – harvesting – yield- papain extraction
11	Sapota – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – Irrigation – Weeding – inter cultivation – cropping – harvesting – yield
12	Guava – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – Irrigation – training and pruning – Flower regulation - Weeding – inter cultivation – cropping – harvesting – yield
13&14	Apple – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – training and pruning - Weeding – inter cultivation – cropping – harvesting – yield - physiological disorders
15	Strawberry – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – training – Weeding – inter cultivation – cropping – harvesting – yield
16	Vegetable - Importance of vegetables crops growing- in human nutrition – Classification of vegetables
17	Tomato – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation -- Weeding – inter cultivation – harvesting – yield - physiological disorders- pests and diseases – seed production – seed extraction

18	Brinjal – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield - seed production – seed extraction
19	Chilli– scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation - Weeding – inter cultivation – harvesting – yield - seed production
20	Okra - scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield - seed production
21 & 22	Peas and beans – Dolichos bean – Cluster bean – French bean – Cowpea – Pea - scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield - seed production
23,24 & 25	Cucurbits – Ridge gourd – Bitter gourd – Bottle gourd – Pumpkin – Snake gourd – Cucumber – Water melon- scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield - seed production
26	Onion – Garlic - scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield - seed production - physiological disorders
27	Potato - scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield
28	Cole crops – Cabbage - Cauliflower –scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield - seed production - physiological disorders
29& 30	Root crops – Carrot – Radish – Beet root - scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield - seed production - physiological disorders
31	Leafy vegetables – Amaranthus – Palak – scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield - seed production - physiological disorders
32	Drumstick - scientific name – family – origin – varieties – propagation – planting – manures and fertilizers – irrigation – Weeding – inter cultivation – harvesting – yield

Horticultural crops & Management

The term Horticulture first appeared in the writings of 17th century. The word is derived from the **latin** word 'Hortus' meaning **garden** and **cultura** meaning 'cultivation'. According to the modern world, horticulture is defined as the crop science which deals with the production, utilization and improvement of fruits, vegetables, ornamental plants, spices and plantation crops, medicinal and aromatic plants.

Divisions of Horticulture.

- 1. Pomology:** Study or cultivation of fruit crops.
Ex: Mango, Sapota, Guava, Grape, Banana etc.
- 2. Olericulture:** Cultivation of vegetables.
Ex. Brinjal, Okra, Tomato, Pumpkin etc.
- 3. Floriculture:** Study of flower crops.
Ex. Jasmine, Rose, Chrysanthemum, marigold etc.,
- 4. Spices:** Used for food flavouring to aroma and flavour
Ex: Pepper, Cardamom, Clove, Nutmeg
- 5. Condiments:** Plants used to add taste only
Ex: Coriander, Cumin
- 6. Plantation crops:** Are those crops, which are cultivated in an extensive scale in large contiguous areas, owned and managed by an individual or a company and whose produce is utilized only after processing.
Ex: Arecanut, Tea, Coffee, Rubber
- 7. Medicinal plants:** are those plants, which are rich in secondary metabolites and are potential sources of drugs.
Ex: Periwinkle, Opium, Menthi, Cinchona, Dioscorea Yam, Belladonna, Senna, Tulasi etc.
- 8. Aromatic plants-** are those plants, which possesses essential oils in them. The essential oils are the odoriferous steam volatile constituents of aromatic plants.
Ex: Lemon grass, Citronella, Palmrosa, Vetiver, Geranium, Davanam, Lavendor etc.
- 9. Post-Harvest technology and Value Addition:** It deals with the processing and preservation of produce of horticulture crops.
- 10. Landscape gardening:** It deals with the planning and execution of ornamental gardens, parks, landscape gardens etc.
- 11. Nursery and seed production:** It deals with the production of seeds and planting material of horticulture crops on commercial basis.

Role of horticultural crops in human nutrition:

Fruits and vegetables are recognized as protective foods as they are the chief sources of vitamins, minerals, carbohydrates, fats, proteins etc necessary for the maintenance of human health.

- 1. Proteins:** These are body building foods.
Ex: Almond, Peas and Beans

2. Carbohydrates: Supply energy to human body.

Ex: Banana, Dates, Apple, Potatoes, Sweet potato, Beans, Peas etc

3. Lipids: It will give energy to the human body

Ex: Cashew nut, Avacado, Almond, Papaya

4. Minerals:

Calcium: It is essential for development of bones regulation of heartbeat, controlling blood clots

Iron: It is required for production of haemoglobin. Its deficiency causes anaemia, smooth tongue, pale lips, eyes and skin and frequent exhaustion.

Sources: Fruits- Custard apple, Guava, Pineapple, Straw berry, Grape, Black currents, dried dates etc. and vegetables like Carrot, Drumstick leaves etc.,

5. Vitamins

- **Vitamin-A:**The deficiency of this vitamin results in cessation of growth in young children, night blindness Ex: Mango, Papaya
- **Vitamin B: It ill gives energy to nervous system.** Its deficiency in human diet results Ber-beri. Ex: Almond, Onion, Carrot
- **Vitamin -C (Ascorbic Acid):** This vitamin promotes general health and healthy gums, prevents scurvy disease, bleeding of gums, tooth decay.
 - **Sources:** Amla, guava, citrus, Tomato, palak, green chillies
- **Vitamin-D:** This vitamin is necessary for building up of bones, preventing rickets All green leafy vegetables are rich in this vitamin.

Importance of Horticultural crops:

1. High productivity and profits
2. Fruits and vegetables are the richest source of minerals and vitamins
3. Generate employment
4. Source of raw material for agro based industries

Differences in between Field crops and Horticultural crops

S.No	Horticultural crops	Field crops
1	Horticultural crops are annual and perennials	Field crops are only annuals
2	These are highly perishable hence have shortest shelf life	These are not perishable hence have more shelf life
3	Technical skill and knowledge required for growing of these crops Ex: for doing training and pruning	Technical skill and knowledge not required for growing of these crops
4	Some of these contain medicinal values (Ocimum, aloe vera etc.,)	Do not contain any medicinal values
5	These can be used for preparation of many value added products	From these crops limited number of value added products prepared
6	These can be grown for ornamental purpose (ornamental crops)	Not suitable for ornamental purpose
7	Ex: Fruits, Vegetables, flowers, medicinal crops etc.,	Ex: field crops, oil seed crops etc.,

IMPORTANCE AND SCOPE OF FRUIT CROPS

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.

Fruits are good sources of vitamins and minerals without which human body cannot maintain proper health and develop resistance to disease they also contain pectin, cellulose, fats, proteins etc so these can be termed as Protective foods

Nutritional importance of fruits

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

Fruits- as sources of vitamins

- Vitamin-A- Mango, Papaya, Jack, Banana, Dates.
- Vitamin-B- Cashew nut, Almond, Banana, Apple, Bale, Litchi, Papaya and Pomegranate.
- Vitamin-C- Aonla, Citrus fruits, Pineapple, Ber, Guava, Strawberry, Tamarind etc.
- Fruits as a source of minerals such as Ca, Fe, P- the fruits are- Almond, Cashew, Guava, Jamun, Fig, Karonda, and Mango.
- Digestive enzymes- Papaya- papaine-9, proteolytic enzyme.

Fruits have medicinal value

- The fruits like aonla pomegranate, Kokum, Jamun, Bael, Ber. etc, have great medicinal value,
- Papaya reduces night blindness,
- Citrus juice reduces acute diarrhoea.
- Aonla triphala (chawanprash)- digestion.
- Jack fruit (Jackoline)- prevents Aids.

Importance of fruits growing in national economy

India's diverse climate ensures the availability of all varieties of fresh fruits. It ranks second in fruits production in the world, after China. As per National Horticulture Database (Second Advance Estimates) published by National Horticulture Board, during 2020-21, India produced 102.48 million metric tonnes of fruits. The area under cultivation of fruits stood at 9.6 million hectares. Though

India's share in the global market is still nearly 1% only, there is increasing acceptance of horticulture produce from the country.

The major factors contributing to low productivity is described as below

- ❖ Traditional Methods of Cultivation
- ❖ Use of Traditional Varieties of Seeds
- ❖ Higher Input Costs
- ❖ Lack of Technological Advancement
- ❖ The Size of Farm Holdings
- ❖ Marketing Constraints
- ❖ Transport Difficulties
- ❖ Inadequate Marketing Intelligence
- ❖ Lack of Cold Storage Facility
- ❖ Lack of Processing Industry
- ❖ No Grading and Standardization
- ❖ Malpractices Adopted by the Middlemen:
- ❖ Improper Pre and Post-harvest Handling

Classification of fruits

- I. Classification Based on temperature requirements and response to different climatic conditions, horticultural crops have been classified in to three main groups and these are
 - a. **Temperate crops:** Temperate horticultural crops flourish well in temperate regions of the world. These plants can with stand with cold and needs chilling temperature. They go under rest or dormancy and sheds their all leaves during winter for examples: Apple, pear, walnut, almond, cherry, strawberry, plums,
 - b. **Tropical crops:** These plants need warm and humid climate with very mild winter. The plants cannot withstand with cold and can get frost injury if exposed to low temperature for example: Pineapple, banana, papaya, guava and sapota
 - c. **Subtropical crops:** These plants require warm and humid climate and can tolerate low temperature during mild winter for example: Mango, litchi, citrus, grape, pomegranate etc.,
- II. **Classification based on botanical description:** This classification was majorly done by family wise
 - a) **Monocots**

Bromeliaceae: Pine apple	Musaceae: Banana
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 - b) **Dicots**

Anacardiaceae: Mango	Caricaceae: Papaya
Rutaceae: Citrus	Vitaceae: Grape
Myrtaceae: Guava	Sapindaceae: Litchi
Punicaceae: Pomegranate	Moraceae: Jack fruit
Rosaceae: Apple, peach, pear, Almond, straw berry and wainut	

**Points to be considered for Selection of site for establishment of orchard -
Steps in establishment of orchard- Points to be considered while selection of
saplings – High Density Planting**

Establishment of an orchard is a longterm investment and deserves very careful planning. The selection of proper location and site, planting system and planting distance, choosing the varieties and the nursery plants have to be considered carefully to ensure maximum production.

Selection of site: The following factors are to be considered before selecting a site for an orchard.

1. Climate: The climate of the locality should be suited to the fruits, or the fruit chosen should be suited to the climate. Enquires should be made on the following points to assess how climate affects the fruits intended to be grown. 1) Experience of the fruit growers and research stations in the locality regarding the acclimatization of the fruits under consideration. 2) The seasons of heavy rainfall, hail storms and hot winds. 3) The seasons and intervals of cyclones, heat waves, gales and other catastrophic features

2. Soil: Soil samples must be analyzed to know the suitability of soil for growing fruit crops. Soil analysis gives information on the type of soil, its fertility; its pH value etc. As far as possible flat land should be selected. There should be no hard pan up to a depth of 2m.

3. Irrigation facilities: Most of the horticulture crops are raised under irrigation. So the water facilities should also be taken in to consideration (quantity and quality). Water table should be below 2 m depth.

4. Nearness to the market: Saves the overhead charges in transport and gives close touch with market tastes. In most cases a large percentage of the retail price of fruits is accounted for by transport charges.

5. Transport facilities: Fruits being perishable cannot be moved for long distances without quick and refrigerated transport. So; the orchards must be located where there is quick transport, preferably a refrigerated transport system.

6. Power (electricity) supply: It would be a great advantage if electric power lines are running in the proximity of the area as it can be tapped easily.

7. Proximity to established orchards: It is an added advantage if the site is in proximity to the already established orchards because of compactness of areas of production facilitates provision of transport and storage facilities.

8. Availability of labour: Large orchards are started often in out of the way places and forest areas away from populated centres. It would therefore be necessary to ensure that adequate labour is available for orchard operations.

9. Social factors: These assume importance when large contingents of labour and managerial staff are to be employed as plantations or large orchards. They should be provided with medical and educational facilities, so that, they are content and stick onto the jobs.

10. Presence of nurseries close by: It is an advantage if the nurseries are close by to the selected site for selecting the plants for the orchard after studying the scion parents personally. It will also help to get cheap and quick transport of plants which will ensure better establishment.

11. Cost of the land: Cost of the land comes up for consideration when all the other requirements listed above have been satisfied.

Points to be considered while orchard establishment

The following general principles may be borne in mind while drafting a plan and as many of them as possible should be fulfilled. It should be recognized that not all of them can be adopted in every case.

- If the entire area is not of the same type of soil, each fruit should be allocated to the soil type it prefers.
- The irrigation sources should be marked and channels indicated along gradients with a view to achieve most economical conduct of water.
- Tall wind breaks should be planted especially on the sides from which high winds are expected. There should be adequate clearance between the wind breaks and the crop.
- Roads should be planned to occupy the minimum space consistent with economy of transport of orchard requisites and produce.
- The space between the wind break and the first row of fruit trees may often be utilized for roads and canals etc. with advantages.
- Drains should follow the gradient of the land, should be as straight as possible and concealed from the visitors, if possible.
- When varieties with pollen preferences are planted they should have the pollenizer in an adjacent block or in alternate rows so as to ensure good crop set.
- Fruits which ripen at the same time should preferably be grouped together to facilitate easy watching and harvesting.
- Assign rear areas for tall trees and the front for shorter ones will besides facilitating watching, also improves the appearance of the orchard.
- The spacing adopted should be the optimum.

Points to be considered before establishment of an orchard

1. It is of great advantage to prepare a plan of the orchard in advance, be it a home or market garden or a commercial orchard. A detailed survey of the site is carried out including the levels and a good map to scale is drawn.

The guiding principles in the preparation of plan are:

- a. The orchard should be managed most profitably
 - b. It should present as attractive look as possible.
2. The existing vegetation is to be cleared. Standing trees, shrubs, bushes etc. should be cut down and uprooted along with the stumps are removed and levelling should be done.
 3. Fencing is necessary to protect trees from stray cattle, human trespassing and also for attractiveness. The fence may be of stone, barbed wire or live fence (Agave, Karonda). Maintain the distance of 10-15mts in between the fence plants and orchard trees.
 4. Wind breaks are provided at south-west direction to resist the velocity of wind which causes loss of bloom, wind erosion and evaporation of moisture and to keep the orchard warm by checking frost and cold waves. The beneficial effect of wind break is felt up to a distance equal to 3 times its height. Casuarina, Jack fruit, Sapota, Cashew nut, Tamarind, Mulberry trees used as wind breaks.

Systems of orchard plating

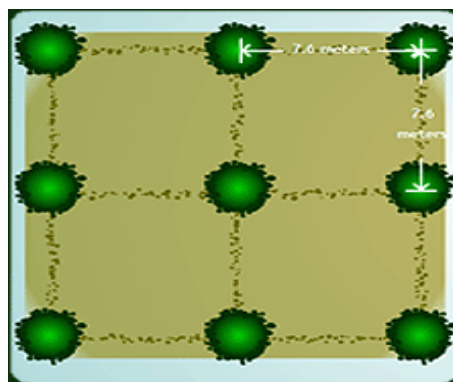
The arrangement of plants in the orchard is known as lay-out. The following points need to be considered before choosing a system of planting.

- It should accommodate maximum number of plants per unit area.
- It should allow sufficient space for the development of each tree.
- It enables equal distribution of area under each tree.
- The intercultural operations such as ploughing, spraying etc are easily carried out.
- It makes supervision more easy and effective.

Descriptions of the different systems:

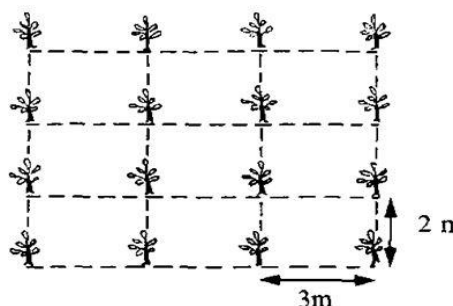
(1) Square system:

- In this system a tree is planted at each corner of a square what ever may the Planting distance.
- The distance between row to row and plant to plant is same
- The plants are planted exactly at right angle at each corner.
- Thus, every four plants make one square



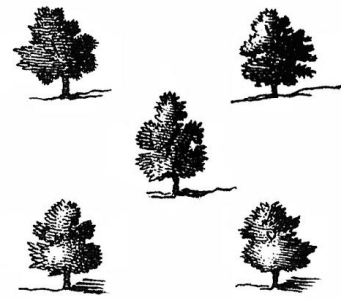
(2) Rectangular system:

- Similar to square system, except that the distance between plants in the row and distance between rows is not the same but different.
- Row to row distance is more than that from plant to plant in the row



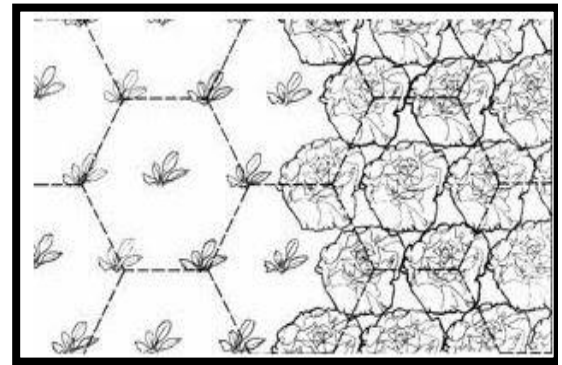
(3) Quincunx or filler system:

- This is also known as filler or diagonal system.
- This is the modification of a square system of layout distinguished to make use of the empty space in the center of each square by planting another plant is called filler tree. Generally the filler tree will be precocious and shorter duration and not be of same kind as those planted on the corner of the square.
- Guava, phalsa, plum, papaya, peaches, kinnow are important fillers.
- They yield some crop before the permanent trees come into bearing.



(4) Hexagonal system:

- ✚ This is also called as equilateral system. Sometimes a seventh tree is planted in the centre of the hexagon, and then it is called septule system.
- ✚ In this system the trees are planted in each corner of the equilateral triangle.

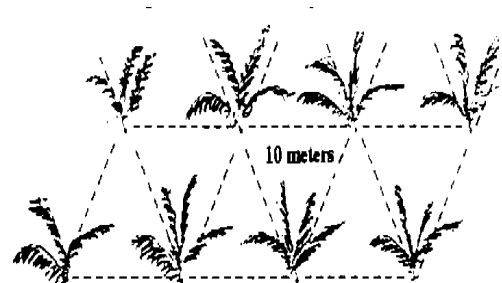


- ✚ This system differs from the square system in which the distance between the rows is less than the distance between the trees in a row, but the distance from tree to tree in six directions remains the same.
- ✚ This system is usually employed, where land is expensive and is very fertile with good availability of water.



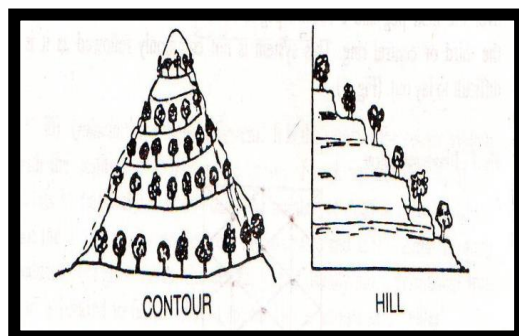
(5) Triangular system:

- The trees are planted as in square system but the difference being that those in the even numbered rows are midway between those in the odd rows instead of opposite to them. Triangular system is based on the principle of isosceles triangle.
- The distance between any two adjacent trees in a row is equal to the perpendicular distance between any two adjacent rows.



(6) Contoursystem:

- It is generally followed on the hills where the plants are planted along the contour across the slope.
- It particularly suits to land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult.



- When the slope is <10% contour bunding is practiced and if the slope is >10% contour terracing is practiced.

Points to be considered while selection of plants from the nursery

Generally, the plants are purchased from the nursery well in advance. The grower should visit the nursery and select the plants. Plants are selected on the basis of certain characters of the plants.

- **Branching:** The main branches on the young plants become leaders on a grown up tree. These branches arise on a plant at an angle (crotch). This crotch should neither wide nor narrow but it should be medium i.e. 40-50°.
- **Growth of the plant:** The plants should be uniform in growth and is determined by uniform length of internodes.
- **Age of the plants:** Growers generally prefer older plants believing that these plants come to bearing early. For this there is no experimental evidence. Younger plants make up in a few years and become equally vigorous and out grow older plants.
- **Pests and diseases:** Plants should be free from pests and diseases like scale insects, mealy bugs, aphids, nematodes etc and diseases like canker, and viral diseases.
- **Lifting and packing:** Before lifting of plants from the nursery the nursery is thoroughly irrigated. Then the plants are lifted carefully along with a ball of earth attached to the root system. The roots are wrapped in straw or grass or covered with a gunny cloth and placed in a basket or a wooden crate for packing.
- **Season of planting:** In tropical climate, most trees are planted between July and December and few days in January also. Planting should be done on cloudy days and preferably in the afternoons rather than in the morning.
- **Planting:** The plants should be set in the soil to the same level as it was in the nursery. The bud / graft joint should not be covered with soil. Plants should be irrigated once copiously to get the soil particles to closely adhere to the roots and also to drive away the air around the roots completely. The plants should be staked with a straight bamboo piece or other twig.

→ **Heeling inn:** If the plants after transport are not directly planted in the field, they may be kept in shade in a slanting position along the side of a trench moistening the ball of earth. They may be left in this position till active growth commences by which time they should be planted in the field. This process is known as healing inn.

High density planting

High density planting: Planting of fruit trees rather at a closer spacing than the recommended one using certain special techniques with the sole objective of obtaining maximum productivity per unit area without sacrificing quality is often referred as 'High density planting' or HDP.

This technique was first established in apple in Europe during sixties and now majority of the apple orchards in Europe, America, Australia and New Zealand are grown under this system.

Based on plant population HDP is termed as

- Low HDP with less than 250 trees/ha.,
- Higher HDP with 500-1250 trees/ha and
- Ultra HDP with more than 1250 trees/ha.
- Super high density planting system has been also established in apple orchards with a plant population of 20,000 trees per ha. Still dense population of about 70,000 trees/ha is followed in certain orchards and this system of planting is referred as meadow orcharding as practiced in apple.
- ☛ HDP is one of the improved production technologies to achieve the objective of: enhanced productivity of fruit crops.
- ☛ HDP aims to achieve the twin requisites of productivity by maintaining a balance between vegetative and reproductive load without impairing the plant health.
- ☛ In India, HDP has been proved useful in many fruit crops e.g. Pineapple, banana, mango, apple and citrus.

☛ **Principle of HDP**

To make the best use of vertical and horizontal space per unit time

To harness maximum possible returns per unit of inputs and resources.

☛ **Factors Affecting HDP**

- Cultivar (species, variety, rootstock)
- System of Planting
- Cost of planting material
- Nutrition and moisture
- Economics of production
- Agro-techniques adopted for a particular crop

Advantages:

1. It induces precocity/precocious bearing
2. Higher yields. The average yield in apple is about 5.0 t/ha under normal system of planting and it is about 140.0 t/ha under high density planting.

3. Higher returns per unit area
4. Early returns
5. Easy management of orchard tress
6. Reduces labour cost resulting in low cost of production
7. Enables the mechanization of fruit crop production and facilitates more efficient use of fertilizers, water, solar radiation, fungicides, herbicides and pesticides.

Dis advantages of high density planting:

1. HDP results in overcrowding, over lapping not only in the tops, but also in the root system and heavy competition for space, nutrients and water
2. More important is build-up of high humidity, lack of cross ventilation in the orchard, which is more conducive for build up of pests and diseases
3. Reduction in yield in the long run after 10-12 years of age
4. Production of small sized fruits and poor quality fruits.

Lec: 3 & 4

Mango

Scientific Name: *Mangifera indica* L.

Family: Anacardiaceae.

Origin: Indo Burma region

- Mango is the most important among the tropical fruits of India and it is very popular and considered to be the choicest of all fruits grown in India. It is known as the, “**king of fruits**”.
- Total cultivated area in India under mango was: 1.25 million hectares
Production: 11 million metric tonnes
- Mango occupies 40% area under production among all the fruits and contributes 63% share among total fruit production. Mango thus deserves to be **the national fruit of India**.
- Leading mango growing areas: AP, UP, Bihar and West Bengal.
- Ripe mango is exceedingly refreshing to eat and is an excellent source of Vit-A and C.
- The immature and green fruit is used in various ways in curries, pickles and chutneys.
- Ripe mango slices and pulp can be preserved and canned for use when the fresh fruit is out of season.
- The important mango growing districts in AP are Krishna, W.Godavari, Vishakapatnam, E.Godavari, Vigayanagaram, Srikakulam, Chittoor, Kadapa and Khammam districts. In AP maximum area is in East Godavari followed by Khammam and chittoor districts.

Varieties:

Classification varieties based on utility:

1. **Table varieties:** Baneshan, Neelum, Bangalora, Rumani, Alphonso, Mahamooda and Goa bunder.
2. **Juicy varieties:** Chinnarasam, Peddarasam, Cherukurasam, Kothapallikobbari, Panchadarakalasa. Panakalu, Phirangiladdu.
3. **Table and juicy varieties:** Chinnasuvarekha , Peter.
4. **Off-season Varieties:** Neelum, Bangalora, Baramasi, Rumani, Royal special, Alipasand.
5. **Pickle varieties:** Acharpasand, Tellagulabi of Nuzivid, Alipasand, Guddemar (Hamlet)
6. **Varieties for preservation:** Baneshan and Bangalora.

Climate:

Although, it is a tropical fruit, the mango equally grows well under semitropical conditions. Mango can grow from sea level to an altitude of about 1500 meters provided.

The temperature between 24 and 27°C is ideal for its cultivation. Higher the temperature during fruit development and maturity gives better quality fruits. Regions having bright sunny days and moderate humidity during flowering are ideal for mango growing.

Soils:

Mango can be grown on a wide variety of soils, ranging from alluvial to lateritic, provided it is deep (2.0-2.5m) and well drained. Suitable pH for mango is 5.5-7.0 .

A soil with good drainage, permeability, a fair water holding capacity and ground water at a depth of 3-4m are features of an ideal soil for mango. Very poor, shallow, alkaline, rocky and calcareous soil should be avoided.

Propagation:

- Mango is a highly heterozygous and cross pollinated crop. There are two types i.e., Monoembryonic and Polyembryonic.
- Polyembryonic varieties can be propagated through seed because they produce true to type seedlings where as the monoembryonic varieties need to be propagated vegetatively.
- Cuttings do not root successfully in open. There is limited success under constant growth regulators.
- Air layering with use of growth regulators is also reported to be of some success but did not reach commercial exploitation.
- **Inarching or approach grafting** is the principal method of propagation followed by veneer grafting.

Planting:

- ➔ Different systems of planting like square, rectangular and hexagonal are followed but square system is most popular.
- ➔ Normally spacing adopted for grafts is 10 X 10 m and for seedlings and in very fertile soils it is 12 X 12m.
- ➔ For dwarf varieties high density planting is considered. The spacing adopted under high density planting is 5X3 / 5X2.5 / 4x4 / 3x2.5 2.5x2.5m.
- ➔ Planting should be done during rainy season in pits of size 1m³.
- ➔ Sometimes wood is also burnt in the pits. Application of nitrogen to young plants hastens growth and before filling the pits 50 kg. of well-decomposed FYM, 2 kilograms of super phosphate are added. If white ant problem is there 100 to 150 grams of polydol powder should be added per pit. Cow dung if applied produces too much heat and attracts white ants and hence should not be applied where white ants are a serious problem.
- ➔ While planting grafts, the graft joint or the union should be 20 cm above the soil surface to prevent entry of disease carrying organisms in to the graft joint. 12 to 18 months old grafts are used for planting.
- ➔ Immediately after planting plants are watered and staked.

Weeding:

Removal of weeds is required at least twice a year either by manually or mechanically. Application of weedicides like Atrac 800g/240 lit water For monocot weed control glyphic or Round up @ 8ml/lit

Inter crops:

- Vegetables like bhendi, cowpea, potato, cucurbits and leguminous crops like groundnut and bean, dwarf banana and cover crops like sesbania and *Crotalaria juncea* can be raised and buried in the soil for green manuring.
- Often young plants produce flowers. These are pinched off during first 3-4 years. Otherwise the vigour of the plant is lost.
- Mango requires no pruning except removal of dead, diseased and dried parts and branches arising within 3 feet above the ground level. This will help in easy cultivation.

Irrigation:

So far, the water requirements of mango have not been worked out. The water requirements mainly depend on the age, soil type and climate. However young plants up to 2 years of age should be watered daily. The newly planted plants require about 30 litres of water every week. Bearing plants are often given irrigation but irrigation from flowering to harvest time reduces fruit drop and produces larger fruits.

Irrigation should be stopped at least before flowering to induce flowering. It is better to avoid irrigations before harvesting for better quality of the fruit. Basin system of irrigation is generally followed to economize water. The basins may be connected in series or to a channel dug in-between rows.

Manuring:

Mango orchards are not generally manured. But if manured, the yield will be more. The chief requirements during pre-bearing age are rapid growth and the development of strong framework. Good cropping, regular bearing and high fruit quality are the prime objectives of bearing trees.

- ☞ For non-bearing trees liberal doses of Nitrogen, phosphorous and reasonable amounts of potassium are to be applied.
- ☞ During non-bearing stage nitrogen is particularly needed in heavy quantities to support healthy and fast growth.
- ☞ Phosphorous is needed for the development of roots, respiration and translocation of carbohydrates.
- ☞ Application of potassium will help in development of fruit, increases fruit quality and control of fruit drop.

During bearing age

- ☞ At this stage manuring programme aims to secure sufficient vegetative growth early in the season for the next year's growth and to ensure regular bearing with superior quality.

☞ This can be achieved by heavy dose of nitrogen a little earlier than flowering in the on year to initiate vegetative growth and suppression of bud differentiation.

Manurial schedule:

Age of the plant	FYM (Kg)	N (g/plant)	P ₂ O ₅ (g/plant)	K ₂ O (g/plant)
1-3 years	5-20	50-100	40-80	100-200
4-6 years	25-50	100-200	80-100	200-400
7-9 years	60-90	200-250	120-160	400-600
10 years & above	100	250	160	600

- ☞ The manures and fertilizers are applied in a shallow ring dug around the base of the tree in young orchards.
- ☞ In old bearing orchards, they are broadcasted under the canopy of the plant leaving 30-60 cm from the trunk and thoroughly mixed into the soil.
- ☞ In A.P. the manures and fertilizers are applied in two split doses. First dose is given during June-July, consisting of complete Nitrogen with half potash at the onset of monsoon.
- ☞ The second dose is applied during September-October with FYM, super phosphate and remaining half of potash.

Foliar application: To promote growth, improve fruit set, yield and quality Foliar spray is given immediately after the harvest of the crop with urea @ 1-2% and another after flowering and at marble stage to improve fruit set and to reduce fruit drop.

Training: The training of mango plants in the initial stages is very essential to give them proper shape. Specially, when the graft has branched too low, the process of training becomes very important. At least 75cm of the main stem should be kept free from branching and the first leader of main branch should be allowed after that. The main branches should be spaced in such a way that they grow in different directions and are at least 20-25cm apart. Otherwise there is every chance of breakage due to smaller crotch angles and heavy top.

Pruning: Proper pruning of mango trees after the harvest gives the best results in terms of disease and pest management, diversion of food materials to the productive shoots, increased photosynthetic activity and increased carbohydrate and starch content, early production of new flush that bear the crop in the next season. Pruning also helps in increased cytokinin, Ascorbic acid and auxin content, which is beneficial for flowering. Abscissic acid level will also increase which inhibits the vegetative growth and promote flowering. Thus pruning helps in obtaining regular fruiting and production of quality fruits.

Cropping:

- ✂ Grafted mango usually starts bearing from the 4th to 6th year after planting.
- ✂ The precocious varieties like dasehari start bearing even from the third or fourth year onwards.
- ✂ A grafted mango tree usually continue to bear till up to 50 years, but its most prolific years of bearing are generally from the 10 to 14 years.
- ✂ Seedling trees usually take about 8 years to come to bearing but their productive life is much longer.
- ✂ Fruit setting in mango depends on production of perfect flowers. Production of perfect flowers varies in between 1 to 80%
Jahangir: 1%, Baneshan: 3%, Alphonso: 10%, Neelum: 16% and Dsaheri: 80%

Harvesting:

- ☞ The mango fruit ripens in about 90 days after flowering.
- ☞ All fruits on a tree are generally harvested when a few fruits ripen naturally and fall from the trees.
- ☞ Another criterion for harvesting is a slight change of colour in certain fruits.
- ☞ Specific gravity is around 1.01.
- ☞ Development of sinus and shoulders are also good indicators of maturity.
- ☞ Fruits should be harvested individually along with pedicel and collected gently in baskets with the help of mango harvesters for minimizing damage

Storage:

Under room temperature mango fruits have short shelf life and at 8-10⁰c and 85-90% RH fruits can be stored upto 4 to 6 weeks.

Yield:

The yield of mango depends on no. of factors like age of the plant, soil fertility, climatic conditions, variety, type of plant material like graft or seedling, management of the orchard etc.

Varieties: 8 to 10 t/ha

Hybrids: 15-25 t/ha

Physiological disorders in mango

1. Alternate (Biennial) and Irregular bearing in Mango:

- ★ The tendency of bearing a crop in one year (On year) followed by no crop or lean crop in subsequent year/s (Of year) is referred as alternate bearing or irregular bearing.
- ★ Most of the promising varieties like Dashehari, Langda, Mulgoa, Kesar etc. are prone to this malady.
- ★ In ON year due to heavy crop load the tree is exhausted and not able to put up new vegetative growth to bear the crop in the following year resulting in to tendency of alternate bearing.

- ★ The other possible reason for this is due to the presence of many fruits in the ON year, the hormonal balance becomes favourable to gibberellins resulting in to vegetative growth than reproductive phase. so it exhibits alternatively.

Causes:

The various possible factors associated with the problem can be grouped as genetical (varietal), physiological (maturity of shoot and hormonal imbalance), environmental (occurrence of diseases or pests) and nutritional.

Remedies:

- ☞ Planting of regular bearing varieties like Amrapali, Ratna, Dashehari, Bangalora, mallika, Neelum etc.
- ☞ Application of Paclobutrazol (Cultar) @ 10ml a.i per 10 lit.of water/tree in the second fortnight of August.
- ☞ Pruning of the branches to reduce the inner areas of the plant.
- ☞ Meeting the nutrient requirements of the trees satisfactorily.

2. Mango malformation: It is a complex and serious malady in North India and not so common in South India. Some varieties like Chausa and Bombay green and are more susceptible than others in N. India. This malady has been distinguished into two groups i.e., vegetative malformation and Floral malformation.

a) Vegetative malformation: is more pronounced in young plants. Affected mango seedlings or young plants develop excessive vegetative branches which have limited growth, swollen and with very short internodes and develop abnormally compact rosette like shoots presenting a bunchy top appearance.

b) Floral malformation: The affected inflorescence becomes clustered and round. Most of the flowers lack essential organs and don't set fruit and its inflorescence continuously hang on the tree for months, being more green and sturdy.

Causes: Various causes like nutritional disorders, physiological, viral, fungal and acarological are reported. The available literature doesn't appear to support the above causes except the fungal; the only positive evidence for the cause of this is fungal origin. i.e., *Fusarium moniliformis*.

Control measures:

- Destruct the infected small plant or plant parts
- Spraying a fungicide like Captan @ 3grams or Bavistin @ 1gram / litre of water
- Remove the affected parts by pruning 30cms below and paste with Bordeaux paste.
- Early deblossoming combined with NAA 20ppm spray during October also reduces this considerably.
- Growing of resistant varieties like Bhadauran, Alib and Illaichi.

3. Spongy tissue:

A non-edible patch of flesh develops in the mesocarp of the fruit and becomes spongy, sour and yellowish is termed as spongy tissue. This can be detected only after cutting the ripe fruit. It is a physiological disorder in which the fruit pulp remains unripe because of un hydrolysed starch due to inactivation of

ripening enzyme because of high temperature, convective heat, and post harvest exposure to sunlight are the causes. Alphonso variety is very susceptible to this spongy tissue.

Remedial measures:

- ☞ **Sod culture** and **mulching** are useful in reducing spongy tissue.
- ☞ Growing mango hybrids **Ratna** and **Arka Puneet**, which are free from this problem.
- ☞ Harvesting fruits when they are **three fourths matured** rather than fully matured ones also reduces this malady.

4. Fruit Drop:

- ★ Fruit drop is serious problem in mango and cause great loss to the growers.
- ★ A tree producing several thousand panicles yields only a few hundred fruits. Most of the flowers falling down after full bloom or at later stage of development.
- ★ Only 0.1 to 0.25% perfect flowers or even less develop in to mature fruit.
- ★ Fruits drop at all stages of maturity.
- ★ Maximum fruit drop takes place in last week of April or first week of May depends upon favourable condition.
- ★ The fruit drop can be divided in to three distinct phases eg., pin head drop, post setting drop and May drop.
- ★ Several factors have been considered responsible for the formation of abscission layer. The causes can be divided in to two;

External causes:

- Unfavourable climatic conditions.
- High incidence of serious diseases like **powdery mildew** and **anthracnose** and pests like **hoppers** and **mealy bugs**.

Internal causes:

- Poor soil
- Lack of pollination
- Low stigmatic receptivity
- Defective perfect flowers
- Poor pollen transference
- Occurrence and extent of self incompatibility.
- Abortion of embryo
- Degeneration of ovules.
- Competition between developing fruit lets.
- Drought / lack of irrigation.

Measures to prevent fruit drop:

- ☞ Spraying of 2, 4-D @ 10 ppm or NAA @ 50 ppm at pea stage and at marble stage helps in preventing fruit drop.
- ☞ Providing pollenisers for self incompatible types.
- ☞ Maintaining sufficient soil moisture also prevents fruit drop and helps in increasing the size of the fruit.

- ☞ Provision of wind beaks all around the orchards, which prevents drop due to high velocity winds at the time of fruit development.

Pest and Diseases of mango

Pests of Mango

Stem borer

Nut weevil

Fruit fly

Leaf webber

Diseases of Mango

Powdery mildew

Anthraxnose

Sooty mould

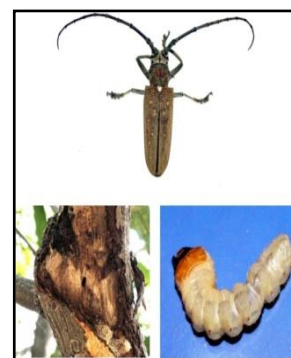
Mango malformation

Pests of Mango

1. Stem borer: *Batrocera rufomaculata*

Symptoms:

- Grub tunnels in the sapwood on the trunk or branches
- Grub bore into the sapwood and making irregular tunnels feeding the vascular tissues
- Interruption of nutrient and water transport on the tissue
- Drying of terminal shoot in early stage, frass comes out from several points and sometimes sap oozes out of the holes and wilting of branches or entire tree takes place



Management:

- Remove and destroy dead and severely affected branches of the tree
- Grow tolerant mango varieties viz, Neelam, Humayudin
- A swab of cotton wool soaked in chloroform or petrol (5ml) and kept in bore holes
- Methyl parathion 1ml/lit poured into the hole or tablet of aluminium phosphide inserted into the hole to kill the grub

2. Nut weevil: *Stenochaetus mangiferae*

Symptoms:

- Grub makes zigzag tunnels in pulp.
- It eats unripe tissue and bore into cotyledons
- Fruit dropping at marble stage, oviposition injuries on marble sized fruits.
- Tunnelled cotyledons in mature fruit by grubs.



Management:

- Collection and destruction of infested fruits.
- Ploughing orchard after fruit harvest to expose hibernating adults.
- Killing adults before fruit season by treating bark with spray of monocrotophos 1.6ml/lit or carbaryl 3g at fruit set and one month after fruit set.
- Hot water treatment of fruit for specified period at 60degree centigrade kills the weevil inside the stone but not fruit fly maggot within pulp.

3. Fruit fly: *Bactocera dorsalis*

Symptoms:

- Maggot bore into semi ripen fruit with decayed spots
- Dropping of fruits and Oozing of fluid

Management:

- Raking under the trees to expose the pupae
- hanging from the tree branches plastic containers with bait made of methyl eugenol 2ml+carbofuran 3G 3g+ water1lr



4. Leaf webber: *Orthaga exvinaceae*

Symptoms:

- Caterpillar webbing of terminal leaves and scrapes the chlorophyll content and leads to drying up of plants

Management:

- Spraying of Quinalphos 2ml/lit or carbaryl 3g/lit or monocrotophos 1.5ml/lit during July-august is effective



Diseases of Mango

1. Powdery mildew: *Oidium mangiferae*

Symptoms:

- Whitish or greyish powdery growth on inflorescence and tender leaves.
- Generally, the infection starts from in and spreads downward covering the floralaxis, tender leaves and stem.

Advanced stage

- Infected floral parts are severely damaged and drop off.
- Fruits are sometimes malformed, discoloured due to severe mildew attack.

Management:

- Two preventive sprays with wettable spray 0.3% before flowers open and fruit set.
- Spraying with karathane 0.1% before flowering and after fruitset (peanut stage).
- Resistant varieties are Neelum, Zardalu, Banglora and Janardhanpasand.



2. Anthraxnose: *Colletotrichum gleosporoides*

Symptoms:

- Produces leaf spots, blossom blights, wither tip, twigs blights and fruit rot
- Small blister like spots develop on the leaves and twigs
- Affected branches ultimately dry up
- Black spots appear on fruits and the fruit pulp becomes hard, crack and decay at ripening



Management:

- Avoid overcrowding in orchards
- Tree sanitation is important, diseased twigs are to be pruned and burnt along with fallen leaves and fruits
- Spray carbendazim/ thiophanate methyl (0.1%) chlorothalonil (0.2%) at 14 days intervals from fruit set until harvest

3. Sooty mould: *Capnodium mangiferae*

Symptoms:

- Fungi produce mycelium in superficially.
- Grow on sugary secretion of plant made by hoppers.
- Black encrustation is formed and it affect the photosynthetic activity.



Management:

- Controlling plant hoppers by spraying carbaryl 2g/lit and Spray dilute solution of starch 5%.
- Dried starch complex off in flakes is used to removing along with sooty mould growth.

4. Mango malformation: *Fusarium mangiferae*

It is a complex and serious problem in some variety of mango like chausa, jafrani

Symptoms:

- Two types of malformation namely vegetative malformation and floral malformation
- In vegetative malformation of small cluster of leaf with short internodes.
- In floral malformation individual flower greatly enlarged in large disc shaped



Management:

- Destruct the infected small plants or plant parts
- Spraying of fungicide like capton @ 3gm.
- Growing of resistant varieties like bhardhan.

BANANA

Botanical name: *Musa spp.*

Family: Musaceae

Origin: Tropical regions of South East Asia

Banana is one of the oldest fruits known to mankind. Its antiquity can be traced back to Garden of paradise where eve was said to have used its leaves to cover her modesty. It may be one of the reasons why banana is called **Apple of Paradise** and botanically named *Musa paradisiaca*.

Banana is the second largest produced fruit after mango in India accounting for 21.87 per cent of the total fruit production from 10.49 per cent of the area.

- Total cultivated area in India under banana was: 4.8 lac hectares
Production: 16.16 million tonnes
- Banana occupies 15% area under production among all the fruits in India.
- Tamil Nadu occupies first place among area under cultivation and production.
- The important banana growing districts in AP are Krishna, W.Godavari, Vishakapatnam, E.Godavari, Vigayanagaram, Srikakulam, Chittoor, Kadapa and Khammam districts.

Importance:

- The ripe fruits are delicious and are used for table purpose
- The end of the inflorescence technically known as pendant is cooked as a vegetable.
- Many products are made from banana such as banana chips, fig, soft drink, flour and jam.
- Starch is manufactured from pseudo stem
- The banana species *Musa textiles* is well known for their strong fibre.

Nutritional Value:

1. Banana is a good source of vitamin A and a fair source of Vitamin C and B₂.
2. Banana fruits are rich source of minerals like magnesium, sodium, potassium and phosphorous and fair source of calcium and iron.

Varieties:In banana there are three types. They are table varieties, culinary types and hill bananas. There are several varieties in banana but the commercially important varies are-

1. **Table varieties:** Poovan, dwarf Cavendish, Robusta, Grand nine, Rasthali, GrosMichel, Virupakshi, Nendran, Monthan, Karpura chekkara keli
2. **Culinary varieties:** Monthan. There are also other varieties like Yenugubontha and boodidhabontha belonging to this group.
3. **Hill Bananas:** Virupakshi (Syn: Sirumalai)

Description of varieties

1. Karpura Chakkarakeli

It is the leading commercial cultivar of southern and north-eastern states. It bears heavy bunches weighing 20–24kg. The fruits/bunch vary from 150–300. Though fruits are slightly acidic and crop duration is 16–17 months. However, it is resistant to Panama wilt.

2. Tella chakkarakeli

It is the leading commercial cultivar of east and west Godavari districts. It bears bunches weighing 6-8kgs. The fruits/bunch vary from 60-80, crop duration is 12 months. However, it is resistant to Panama wilt.

3. Dwarf Cavendish/ Basrai/ Vamanakeli

It is the leading commercial cultivar contributing to 58% of the total production owing to its high yield, ability to withstand strong winds. This selection produces bunches weighing 55–60kg and it will take 11 months duration for harvesting. It tolerant to Panama wilt

4. Robusta

It is a semi-tall sport of Dwarf Cavendish and is an important cultivar in Karnataka, Andhra Pradesh and parts of Maharashtra. The plants bear bunches weighing 25–30kg each with good-sized slightly curved fruits. Plants take approximately a year to complete their life-cycle. It is resistant to Panama wilt. It will take 11 –12 months for maturation.

5. Amrithpani

This is the choicest table banana for its tasty, crisp, good sour-sweet blended and pleasant flavoured fruits. Plant is medium-statured. Crop takes about 13–15 months to come to harvest with bunches weighing 15–18kg each. It has about 6–7 hands with bold, stout fruits, turning golden-yellow on ripening.

6. Grand Naine (AAA)

It is a tall mutant of Dwarf Cavendish It bears bunches weighing 25–30kg with uniform long fingers throughout the bunch. Crop takes about 12 months to come to harvest

7. Bontha

It is fairly tall and robust, growing to a height of 2.5–3.0m. Its bunches weighing 18–20kg each bear 60–70 fruits which are bold, stocky, knobbed and pale-green. A few allied members of Monthan are suited for making chips. It is susceptible to Panama wilt.

8. Yenugu Bontha

It is a mutant variety. It's bunches weighing 18–20kg each bear 60–70 fruits. Crop takes about 13–15 months to come to harvest and susceptible to Panama wilt.

Climate:

The banana is strictly a tropical crop. It grows luxuriantly in the warm, humid and rainy climate of tropical regions of the equator. It grows well in regions with a temperature range of 10-40°C and an average of 23°C. Low temperature

i.e. less than 10°C is unsuitable since, they lead to a condition called **choke** or **impeded inflorescence** and bunch development.

Banana grows well under high rainfall areas. On an average 100 mm rainfall per month appears to be satisfactory for growth of banana.

Soils:

Banana is voracious feeder and requires a well-drained soil with plentiful organic matter. Even though banana requires heavy irrigation, it cannot withstand water stagnation. Therefore, the soil should be well drained and deep (At least 1 to 1.5m depth).

Banana can grow well even under slightly alkaline soils. Such soils are found preferable for avoiding the wilt disease, which is known to be severe in acid soils. Suitable pH for banana is 6- 6.5.

Propagation:

Banana is propagated vegetatively through suckers and tissue culture.

Suckers:

There are two types of suckers. 1) Water sucker 2) Sword sucker.

- **Water sucker:** Have broad leaves and broad pseudostem and they don't produce a healthy banana clump and hence not suitable for planting.
- **Sword sucker:** It has a strong large base, gradually tapering to a slender point with one or two narrow sword like leaves at the tip. The sword sucker is most vigorous, grows fast and comes in to bearing early. Hence, sword suckers are preferred for planting.

Selection of sucker:

Select only 3-4 months old suckers from healthy vigorously growing and good yielding plants. The sword suckers should have 4-5" diameter at the base and 2-3 kg weight.

Preparation of the sucker:

The selected suckers should be separated from its mother plant along with a portion of a rhizome. Later, the stem of the suckers should be beheaded at 20-30 cm height in a slanting manner. This helps in producing new leaves quickly. The slanting cut also prevents the stagnation of water in the sucker. The old roots should be removed and then dipped in 0.1% cereson @ 1 g.per litre of water for 5 minutes before planting.

Land preparation:

The land should be deeply ploughed, harrowed and leveled and pits of 45cm³ should be dug at the required spacing. The pits should be exposed for weathering for about a week to control the presence of any grubs, ants, weevils etc. The soil from the pits should be mixed with the following thoroughly.

- 5-10 kg of FYM
- 0.5 kg of castor or neem cake
- 2 kg of wood ash or 50 grams of muriate of potash

- 200 grams of super phosphate.

The pits are then filled with the above-manured soil thoroughly. While filling the pits with the manured soil apply to the pit 50 grams of lindane dust to control weevil which affects the rhizome or sucker in the soil. The sword suckers are later planted straight in the pit along with a portion of rhizome at a depth of 10-15cm.

Planting:

The period of planting should be such that the active growth phase of the plant may continue un-hampered during the flower bud initiation stage or stage at which embryonic bunch is formed inside the pseudostem. This generally occurs between 4 and 5 months after planting. This stage determines the no. of hands / fingers in future bunch after planting. June-July (On set of monsoon) is the planting season.

Cultural operations in Banana:

1. Desuckering:

- During the growth of the mother plant, the suckers arise from its rhizomes from time to time. If all these suckers are allowed to grow, the mother plant loses its vigour and normal development resulting in lower bunch weight and total yield.
- Removal of all suckers up to flowering of mother plant and maintaining only one follower afterwards is the best desuckering practice.
- Desuckering or pruning is the removal of unwanted suckers. It is done by either cutting off the sucker or the heart may be destroyed without detaching the sucker from the parent plant.
- Some times 3-5 drops of kerosene is poured into the cavity left after digging the sucker. In South India, crow bar with a chisel like end is used for damaging the sucker.

2. Trashing:

It is the removal of undesirable material from the banana field like dried, diseased and decayed leaves, pseudo stem after harvest, male bud, last end of inflorescence and withered floral parts.

3. Mattocking:

After harvest of the bunch, the plant stem should be cut in stages at least after 30-45 days to facilitate mobilization of the nutrients from the mother to the developing ratoon plant. The pseudo stem should be cut leaving a stump of about 0.6m height.

4. Wrapping of bunches:

It is covering of bunches with polythene or gunny cloth that protects the fruits from intense heat, hot wind etc. and improves the colour of the fruits.

5. Removal of male buds (Denavelling):

Removal of male buds helps fruit development and increases bunch weight. Male buds are removed from the last 1-2 small hands with a clean cut keeping a single finger in the last hand.

6. Bunch Spray:

Spray of monocrotophos (0.2%) after emergence of all hands takes care of the thrips. Thrips attack discolors the fruit skin and makes it unattractive.

7. Bunch Covering:

Covering bunch using dried leaves of the plant is economical and prevents the bunch from direct exposure to sunlight. Bunch cover enhances quality of fruit. But in rainy season this practice should be avoided.

8. Dehandling of false hands of bunch:

In a bunch there are some incomplete hands which are not fit for quality produce. These hands should be removed soon after bloom. This helps in improving the weight of other hands. Sometimes the hand just above the false hand is also removed.

9. Propping:

Due to heavy weight of bunch the plant goes out of balance and the bearing plant may lodge and production and quality are adversely affected. Therefore they should be propped with the help of two bamboos forming a triangle by placing them against the stems on the leaning side.

10. Tipping :

It is the removal of male bud. The large heart shaped flower bud, contains infertile male flowers in reddish scale leaves. It should be cut soon after the bunch is formed, It is a practice recommended for improving the appearance of the bunch as well as to ward off ‘fingertip’ disease.

11. Removal of floral remnants:

The removal of dried and persistent floral remnants present at the apex of the fruit or finger helps in preventing the spread of fungal diseases. These floral remnants provide shelter to some of the fungal spores.

12. Earthing up:

It should be done during the rainy season to provide drainage and to avoid water logging at the base. It is to be done once in 2 or 3 months to prevent soil erosion from the basins and to avoid direct contact of water with pseudo stem.

13. Weeding:

In the first four months after planting, it is necessary to remove weeds. The stirring of the soil by the spade after every 6 or 7 irrigations is necessary to maintain its tilth and absorptive power. Weeds can also be checked by the use of herbicides. Diuron @ 4 kg per hectare and simazine @ 6kgper hectare control grasses and broad-leaved weeds when applied after planting and repeated 30 days after planting.

Glyphosate @ 1 kg a.i. per hectare at the time of planting followed by 0.5 kg a.i.per hectare at 30 and 60 days after planting of suckers is recommended. Banana is sensitive to 2, 4-D and hence the phenoxy compounds are not used.

14. Nutrient sprays:

Spraying of a mixture containing 2% urea and potassium Di-hydrogen phosphate immediately after the emergence of inflorescence stalk helps in increasing the size of the bunch and fruit content.

Cropping:

- Banana fruits develop partheno carpically.
- Banana comes to flowering in about 9 months after planting.
- The dwarf bananas are ready for harvest with in 11-14 months after planting, while tall cultivars take about 14-16 months to harvest.
- The fruits become ready in 3-4 months after flowering. Dwarf Cavendish variety takes about 11 months, Robusta 12 months and poovan about 13 months from planting to harvesting.
- Banana is categorized as climacteric fruit. Fruits don't ripe early and uniformly on the plant.
- The maturity standards of banana fruit, although vary with the variety and the purpose of marketing, can be judged by physical characters as well as by chemical analysis.
- The physical characters like colour, shape, size and the ratio between consumable to non-consumable portions are taken in to consideration.
- The total period required from planting to first harvesting is also taken into consideration for harvesting of the bunch. In India the main banana season is from September to April.

The indications of maturity for harvesting are:

- ❖ The fruits are harvested when top leaves start drying.
- ❖ Change in colour of the fruit from deep green to light green.
- ❖ Tendency of floral ends of the fruits to shed with slightest touch of the hand.
- ❖ Fruits should be plump and their angles should have rounded off i.e.; after the attainment of $\frac{3}{4}$ th full stage before the bunch is harvested.
- ❖ For export purpose, three fourths of the full maturity stage (recognized by the sharp angularities of the fingers) is considered to harvest. At this stage, the dwarf Cavendish shows a pulp-skin ratio of 35:1 or 40:1.
- ❖ The entire bunch is harvested with one-foot long stalk. After 15 minutes of harvest, when the latex flow ceases, the bunch should be packed properly and should not be allowed to come in contact with soil

Yield:

Yield of banana varies with variety, agro climatic situation and management practices adopted for production. Under Indian condition, varying yield between 15-40 tonnes per hectare has been reported. Tall cultivars usually yield 15-20 tonnes /ha. Dwarf varieties are 30-40 tonnes per hectare.

GRAPE

Botanical Name: *Vitisvinifera*

Family: Vitaceae

Origin: Armenia near Caspian Sea

It is probably and obviously the largest produced fruit of the world.

- Total cultivated area in AP and Telangana under grape was: 8000 acres
Production: 96000 tonnes
- The important grape growing districts in AP are Anantapur, Chittoor and Kurnool and in Telangana are Ranga Reddy, Hyderabad, Mahaboob Nagar.

Importance:

- In India, all most all our produce is consumed as table fruit, while in European countries 99% of their produce is used for preparation of wines.
- Grapes are also used for preparation of other products like raisins, fresh juice and Jams etc.
- The grape fruits are rich in sugar and particularly in hexose and are easily digestible.
- It is fairly a good source of minerals like Calcium, Phosphorous and Iron and vitamins B1 and B2.

Climate:

Grape is a semi-arid subtropical crop. It requires warm and dry summer and cool winter.

Parts of India having more than 100cm of rainfall are not suitable. A rain free period of 90 days from the time of pruning is most desirable. It thrives well in regions with a temperature range of 4.5°C and 45°C.

Soils:

Light soils are ideal but they can grow on any well drained soil which is the most important requisite for grape vine. Water table should be deeper than 2 meters. Soils at least 1meter depth with no hard pan up to 2 meters is suitable whether they are rich or poor. Ideal pH for cultivation of grape is 6.5 to 7.5.

Varieties:

1. **Thompson seedless:** Seed less variety. It has good quality and contains TSS (Total soluble sugars) 22%.
2. **Anas-e-shahi:** heavy yielder and contains TSS (Total soluble sugars) 10-17%.
Late maturity variety

The other important commercially grown varieties: Bangalore blue, Gulabi, Dilkush, PatchaDraksha. and Perlette

Seed less varieties: Thompson seedless. Puas seedless, Beauty seedless, Taj a ganesh and Kismis cherry

Propagation:

Grape can be propagated both by sexual and asexual methods. Sexual propagation is encountered with a no. of hazards like poor germination and long period for germination etc.

Asexual or vegetative propagation on the other hand has high percentage of success and it ensures genetical purity. Vegetative propagation in grape is practiced through cuttings, grafting, layering and budding depending on the varieties used and the growing conditions.

Propagation through hardwood cuttings:

- It is the most popular method of propagation in grape.
- Cuttings made from well matured one season canes from productive vines which are of medium in thickness (0.7 to 0.8 cm), with an internodal length of 8-10cm and 25-30cm in length with at least 3-4 buds and dormant should be selected preferably from the October prunings.
- They are planted in well prepared flat beds, leaving two nodes above the soil surface.
- In North India these cuttings are planted in the nursery after allowing them to form callus by burying them in moist soil or sand for 4-5 weeks.
- The rooted cuttings will be ready for planting in the main field only after one year.
- In India grape is planted on its own roots.

Spacing: The spacing that is given between the vines will depend on soil, climate, and vigour of the variety, method of training, pruning and cultivation practices.

The spacing adopted for Anab e shahi 4.5x4.5mt and
Thompson seedless 3x3mt.

Planting:

The land is prepare thoroughly by deep ploughing and follow up by tillage and the land should be leveled. Pits of 1m³ are dug at required spacing and pits filled with Application of nitrogen to young plants hastens growth and before filling the pits 50 kg. of well-decomposed FYM, 2 kilograms of super phosphate. October is the ideal time for planting of unrooted cuttings directly in the field.

Training and Pruning:

Training: In the natural habitat, a grape vine is robust climber but it can be trained on any fashion. Although a no. of training systems are known only four namely

1. Head System:
2. Telephone system (Over head trellis / Telephone trellis system)
3. Pandal system (Arbour, Pergola, Mandwa, Over head or Bower system)
4. Kniffin System
5. V cardon

Among all the training methods pendal or bower system has more advantageous

Pendal System:

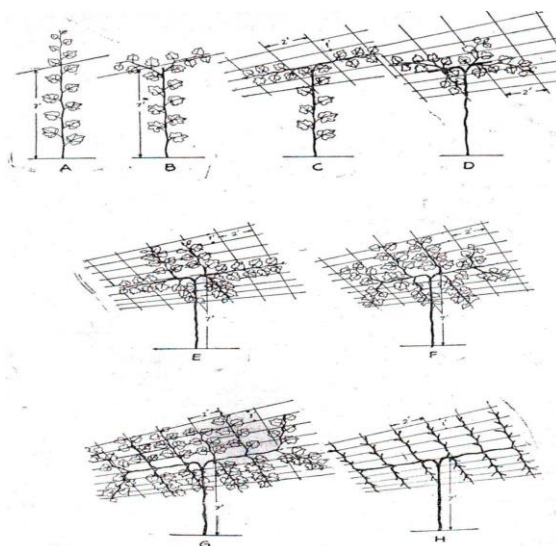
- This system is also called as Arbour, Pergola, Mandwa, Over head or Bower system.
- This is more popular system for Anab-e-shahi in A.P. This is best suited for vigorous varieties, which don't perform well on other systems.
- In this system the vines are spread over a criss cross net work of wires usually 7' (2.1m) above the ground supported by pillars(Concrete, stone or iron).
- Galvanized wires of 5,8 and 10-gauge thickness and turning buckles are used.
- Only the best growing shoot from the plant is allowed to grow upright along the stake provided up to the bower height.
- When the vine reaches the wires, it is pinched off 15cm below the pendal level to facilitate production of side shoots close to the wires.
- Two vigorous shoots in opposite direction are selected and allowed to grow in opposite directions on the wires overhead.
- These two shoots develop into primary arms. On each primary arm three laterals on either side at a distance of 60cm (2') (along the wires) are kept as secondary arms.
- Thus, there will be 12 secondary arms on each, which after maturity form fruiting canes.

Advantages:

- ❖ Greater spread of the vines.
- ❖ Better exposure of the foliage to the sun, resulting in better maturity of the canes.
- ❖ Superior quality of fruits, which are free from sunscald.
- ❖ The vines in general give uniform performance
- ❖ It gives good protection to the canes against hot desiccating winds with ease in bird scaring.

Disadvantages:

- ❖ It is the most expensive than all other systems
- ❖ Pruning, training and spraying operations become difficult
- ❖ The spraying material cannot reach effectively the leaves and shoots.



Pruning: Grape vines in these regions grow continuously without any dormancy (due to tropical climate). Hence by pruning in April (summer) the vines are forced to have a rest period, which helps in fruit bud differentiation.

1. Summer pruning:

It is done during March-April in the states of A.P. and Karnataka, but in July in Tamil Nadu. In this pruning the canes are cut back to one or two bud level for building up the fresh vegetative growth. Hence it is called back pruning or growth pruning.

2. Winter pruning:

This is done during the last week of November in A.P. and Maharastra, and in December in Tamilnadu. The mature canes (about 6 months old) are pruned. Entire foliage and immature shoots are removed. Levels of pruning differs with varieties. Anab-e-shahi and Bhokri are pruned to 5 bud level, Thompson seedless to 10 buds. This pruning is also called as forward pruning.

Pruning refers to the judicious removal of any plant part

- ❖ To establish and maintain desired vine shape
- ❖ To increase productivity
- ❖ To facilitate various cultural operations
- ❖ To distribute proper amount of bearing wood over the vein
- ❖ For consistent productivity

Manuring:

- Grape is a heavy feeder of fertilizers. The following manurial schedule is adopted in different years of growth.
- **At the time of planting:** Fill the pit with 50 kg of FYM, 3kg of super phosphate, 5 kg of castor cake or neem cake and two baskets of wood ash with top soil or silt.

Fertilizer management: gm/plt

Fertilizer	First year	Second year		Third year	
		Summer	winter	Summer	winter
Urea	100	500	500	750	750
Super phosphate	200	1500	1500	2000	2000
MOP	500	500	500	1000	1000
Castor Cake	5000	5000	5000	6000	6000

- Repeated sprays of magnesium sulphate and borax at 0.05% to 0.2% strength have helped to overcome most of the deficiency.

Irrigation:

- Vine yard irrigation is chiefly governed by the nature of soil, its drainage, the rainfall and its distribution and temperature in the locality.
- Grape vine requires judicious irrigation for optimum growth and yield. During initial year of planting, vine may be irrigated frequently.
- While stagnation of water around the conducive to excess and rapid vegetative growth at the cost of the fruiting of the vine.

- Grape requires 6-8 irrigations after April pruning till the south West monsoon begins. Vines are not irrigated from June-October. 8-10 irrigations may be given at 7-10 days interval after October pruning till March.
- Each adult vine needs 200 liters of water in winter and 300 liters of water in summer per irrigation.

Inter- culture:

- It is not feasible to grow any inter crop and frequent shallow tillage is desirable.
- The vineyard should be kept free from weeds by shallow digging of 8-10cm depth in 15-20 days interval with spade by manual labour and weeds hand picked.

Berry size and quality:

- Thinning of berries at pea stage increases the berry size by 20%, fruit quality with high sugar content in Anab-e-shahi and lowered the acidity in sub-acid varieties like Bhokri.
- Improvement in colour of berries and earlier maturity are the other advantages due to thinning. It also means to remove diseased, misshapen and shot berries.
- Stem girdling is also increases berry quality and size

Harvesting:

Grapes should be harvested when they are fully ripe as they don't ripen any further after harvest from the vine.

The criteria for maturity are:

- The bunches should be fully developed and every berry should attain a uniform size, shape and colour.
- The bunch is ready for harvest when the lower most berry of the bunch is soft and sweet.
- The berries should develop translucent look of colour peculiar to the variety. Anab-e-Shahi develop amber or light honey colour.
- The seeds of the ripened berries becomes dark brown Total soluble solids also give the indication of ripening. Anab-e-shahi is harvested when it records a brix of 15^o-16^o and Thompson seedless 21^o-22^o
- The bunches are harvested with secature or scissors. Then the immature and rotten berries are removed with the help of scissors.

Yield:

Anab-e-shahi: 10-15t/ha

Thompson seedless: 6-8t/ha.

Physiological disorders:

Pink Berry

- As the bunch approaches maturity some berries in the bunch develop pink colour at random.
- The pink colour changes to dull red colour rendering the bunch unattractive.

Management:

- Indiscriminate use of Ethereal for berry colouration can also cause this disorder.

CITRUS

Botanical name: *Citrus sps.*

Family: Rutaceae

Origin: : Tropical and Subtropical regions of south East Asia

- Citrus fruits are a group of fruits comprising of mandarins, sweet oranges, grape fruit, limes and lemons etc.,
- In India citrus is considered to be the third most important fruit crop.
- Citrus fruits are not only delicious and refreshing but also they provide vitamins, minerals and many other substances. Citrus fruits contain considerable amounts of Vitamin C. Fruits are also good source of Vitamin and P.
- The mild bitterness in juice is due to the presence of glucoside called Naringin which is said to have a medicinal value.
- AP leads first place in cultivation (2,07,500 acres) and production (12.45 lac tonnes)

Some of the Important Citrus Species:

1. Sweet orange : *Citrus sinensis*
2. Mandarin Orange : *Citrus reticulate*
3. Acid lime : *Citrus aurantifolia*
4. Lemon : *Citrus limon*

Important citrus cultivars grown in India:

1. **Sweet Orange:** More than half a dozen varieties are cultivated. Among them the important ones are-Sathgudi, Mosambi and Batavian. Washington Navel Orange and Pineapple.
2. **Mandarin Oranges:** The important commercially grown varieties are- Nagapur Mandarin, Coorg Mandarin, Khasi Orange, Kinnow Mandarin Kinnow Mandarin is a hybrid between King Mandarin (*C.nobilis*) and willow leaf Mandarin (*C.deliciosa*).
The other varieties are:Ponkan, Satsuma Mandarin, DancyTangarin, Darjeeling or Sikkim Orange and Cleopatra Mandarin.
3. **Limes and Lemons:** These are acid fruits. Generally employed for preparing drinks.

Limes: These include Acid lime, Key lime, Mexican Lime, Tahiti lime, Sweet lime, Coorg lime and Rangapur lime and sour lime. Among them the mostly cultivated one is acid lime. The important varieties of acid lime are -Vikram, Pramalini, Chakradhar, Balaji etc.

Lemons: Often confused with limes. These are grown in small scale in pockets. In this there are two types. They are seeded and seedless.

Seed Varieties: Lisbon, Villa Franca, Eureka, Nepali Round, Nepali Oblong and Rajhamundry.

Seedless Varieties: Malta, Lucknow and Italian.

Climate:

The sub-tropical climate is the best suited for citrus growth and development. Temperature below -4°C is harmful for the young plants. Soil temperature around 25°C seems to be optimum for root growth. Dry and arid conditions coupled with well defined summer having low rainfall (ranging from 75cm to 250 cm) are most favourable for the growth of the crop.

High humidity favours spread of many diseases. Frost is highly injurious. Hot wind during summer results in desiccation and drop of flowers and young fruits.

Soil:

Citrus can grow well in wide range of soils. Soil properties like soil reaction, soil fertility, drainage, free lime and salt concentrations, etc. are some important factors that determine the success of citrus plantation. Citrus fruits flourish well on light soils with a good drainage.

Deep soils with pH range of 5.5 to 7.5 are considered good. Light loam on heavier but well drained sub-soils appears to be ideal for citrus.

Propagation:

Seeds exhibit 45-90% polyembryony. The seedlings are free from decline and other virus diseases which are not transmitted through seed. Yet the yields are not good compared to budded plants.

Vegetative propagation methods like budding are practiced. Shield budding or T - budding is practiced all over the world. The varieties to be propagated should be well known for their good performance and free from diseases. The root stock should be compatible with the scions and well adapted to the soils of the regions where trees are intended to be grown.

Rootstocks:

The stock and scion must be compatible and should be capable of producing long lived, productive trees. The influence of the most important and widely used root stocks and their characteristics should be known to the grower for choosing the right kind of stock for the locality. The most commonly used stocks for sweet orange as well as mandarins in India are Jamberi (Rough Lemon) and Karna Khatta.

Planting:**Preparation of the field:**

The land is ploughed until a fine tilth is obtained. If it is a virgin land all the existing vegetation should be removed along with the roots. The land is leveled and pits are marked as per the system of planting to be adopted.

Lay out:

The square system of layout is commonly followed for planting the citrus crop. In order to facilitate orchard management practices economically and efficiently. Citrus trees should be planted in straight rows.

Digging of Pits:

4 weeks prior to planting. But where the soils are shallow or under laid with hard pan, pits of 1mx1mx1m may be dug to facilitate better root penetration. Before planting the pits are filled with 25kg of FYM, 1kg of bone meal, 3kg of wood ash and 50g of aldrin dust powder for control of termites.

Planting season:

Planting should be done at the beginning of the monsoon season (June/July) so that the humid weather helps the young plants to get established fast. In areas of high rainfall, (1000 mm and above) planting should be done at the end of the south - west monsoon season (October-December.)

Spacing: Spacing adopted for different citrus species are

Sweet Orange	:	6-8 m
Mandarin Orange	:	6-8 m
Acid lime	:	5-6 m
Lemon	:	6-8 m

Irrigation:

- ✚ Sweet orange trees are much more specific in their water requirement than any other fruit crops. Higher requirement of water is needed to produce satisfactory crop. Most of the santra plantations in India are rain fed conditions.
- ✚ Irrigation requirement of santra trees in the plains is similar to that of sweet orange, Irrigation should be given when the top of the soil goes dry of once in 7 -15days depending on the soil and weather.
- ✚ Irrigation water should not directly touch the tree trunk as it spreads diseases like gummosis and the soil should not be allowed to get excessively dry as it results in leaf fall.
- ✚ Irrigation should be given immediately after manuring.
- ✚ Water is very essential during blossoming and fruiting periods.
- ✚ Any shortage of water during maturity periods causes shrinking of the fruit and drying up of the pulp.

Manures and fertilizers:

In Andhra Pradesh, citrus growers apply large quantities of farmyard manure and organic cakes (Castor, Neem, Pongamiaetc) to improve soil structure and to create favourable conditions for healthy growth. Further, to meet the high demands for nutrients and to maintain plant productivity, organic manures are supplemented with chemical fertilizers. The fertilizer schedule recommended for Andhra Pradesh is

Age of Plant	Sathgudi			Acid Lime		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
1 Year	300	70	80	375	150	200
2 Year	600	140	160	750	300	400
3 Year	900	210	240	1125	450	600
4 th Year	1200	280	320	1500	600	800
5 th Year & above	1500	350	400	1500	600	800

- ✚ Fertilizers should be applied in a circular band at a radial distance of 120cm from the trunk of the plant is the most beneficial.
- ✚ Deep placement of fertilizers should be avoided. In fact, the maximum root activity in sweet orange plantation was found with in a depth of 25 cm while in acid lime they are more surface oriented, 80 -95% being located in the top 10 cm. As such, fertilizers are worked in shallow into the surface soil.
- ✚ A composite nutrient spray prepared and sprayed twice or thrice at 20-25 Days interval commencing from the appearance of new flush will correct deficiencies and increases the yield and quality of fruits. It is prepared as follows.

Zinc Sulphate	500 g
Copper Sulphate	280 g
Magnesium Sulphate	200 g
Ferrous Sulphate	200 g
Borax	100 g
Manganese Sulphate	200 g
Lime	900 g
Urea	1000 g
Water	100 lit.

Training and pruning:

In order to allow the growth of a strong trunk, all shoots in the first 40-50 cm from ground level developed in the early stage should be removed. The centre of the plant should remain open. Branches should be well distributed to all sides. Cross twigs and water suckers are to be removed early. The bearing trees require little or no pruning. All diseased, injured and drooping branches and dead wood are to be removed periodically for initiating citrus greening.

Interculture:

Before manuring, the basins are dug and the weeds are removed. The tree basins should be kept free of weeds. Superficial cultivation of citrus orchards is practiced to keep them free of weeds. Deep cultivation should be avoided.

Root stock sprouts water suckers and dead wood have to be periodically removed and cut ends are pasted with Bordeaux paste. Occasionally the water suckers are to be observed and they should be removed.

Intercrops:

Leguminous crops like soybean, gram, groundnut, cow peas, french bean, peas etc., may be grown in citrus orchards. Intercropping is advisable during the initial three-four years after planting.

Bahar Treatment:

- ✚ If left to nature the trees may bloom and fruit irregularly through - out the year. In order to overcome this problem and to force a full crop in any of the three seasons,

as required by the grower and the traders, Bahar treatment is practiced in citrus orchards.

- ✚ In Andhra Pradesh, the citrus trees generally bloom three times a year, i.e., in
 - January-February (Ambe bahar or Angam),
 - June (Mrig bahar or Edagam) and
 - October (Hastha bahar or Gairangam).
- ✚ Trees are treated for Ambe bahar in November or December. In this method from November onwards the amount of water is gradually reduced in successive irrigations and completely stopped in December.
- ✚ About the middle of December, the land is ploughed. When the trees start showing wilting symptoms (3-4 weeks), the soil around the tree to a distance of 120 cm is dug a depth of 10 cm and the recommended manure is added to the soil and the trees are irrigated.
- ✚ The first irrigation that follows is sparing while the subsequent ones are more plentiful. Flowers appear about a month after the first irrigation.
- ✚ In Maharashtra, the roots are also exposed for about 10 days as part of the bahar treatment. This method is occasionally practiced in a few places in Andhra Pradesh. Consequently; plants give new vegetative growth, profuse flowering and fruiting.
- ✚ However, this treatment is considered to be harmful in the long run and not encouraged as a routine practice.

Cropping:

- ✓ Budded sweet orange trees give a commercial crop in about 5 years. Mandarins may take one or two years more. Seedling trees take about 8 years to come to bearing. The life of budded tree is about 35 years and of seedling about 60 years.
- ✓ The fruit ripens in about 9 months after flowering. The harvesting season varies in different parts of the country. Sweet orange have three seasons of flowering and fruiting.

Harvesting:

Generally, citrus trees start bearing fruits 3 - 5 years from planting (although economic yields start from the fifth year and the trees may take 8 to 10 years to achieve full productivity) and can be harvested 5 - 6 months from flowering depending on the variety and the environment.

Season	Flowering season	Harvesting time
Ambebahar	January – February	September – October
Mrigbahar	June – July	March – April
Hasta bahar	September - October	May - June

Maturity Indices:

- Unlike some other fruits, citrus fruits do not ripen further once they have been removed from the tree, so it is important that they are picked at the right stage of maturity.

- Maturity is measured depending on different characteristics such as color, juice content, level of soluble solid (sugar) and solids to acid ratio.
- Normally, citrus fruits are harvested by hand.

Yield:

Sweet Orange: 600-800 fruits/tree

Mandarins: 1000-1500 fruits/tree

Acid Lime: 3000-6000 fruits/tree

Physiological disorders:

1. Fruit Drop:

Fruit drop in citrus occurs more or less in three distinct stages viz., post setting drop, pea size drop and pre-harvest drop. Among which the last one is most important and causes huge loss to the farmers. Based on the causal factors, the fruit drop can be classified broadly as i) Physiological drop ii) Entomological drop and iii) Pathological drop.

i) Physiological drop

The term is strongly associated to October fruit drop and describes the abscission of fruit lets as they approach 0.5-2.0 cm in diameter. This is mainly due to competition among fruits for carbohydrates, water, hormone and other metabolites.

ii) Entomological drop:

Citrus bud mite and orange bug are some important pests which causes heavy drop of flowers and fruits in oranges. Besides fruit fly (*Daucus dorsalis*) and fruit sucking moth (*Otherisfullonica*) are mainly causing fruit drop in the later crucial stage of fruit ripening. Its activity is first noticed during last week of October which continues till the final harvest.

iii) Pathological fruit drop:

Fruit drop also occurs due to pathogenic fungi viz. *Botryodiplodia theobromae*, *Colletotrichum gleosporoides* and *Alternaria citri* (stem end rot) which mainly occurs predominantly on the mature fruits near ripening.

Control of fruit drop

- ❖ Maintain balance nutrients in the plants to develop sufficient foliage to support the developing fruits.
- ❖ Prune the plants after harvesting to minimize pest and disease incidence.
- ❖ Irrigation should be applied at critical stages viz., flowering, fruit set and fruit development.
- ❖ Spray GA₃ 10 ppm + urea 1% at the time of flowering
- ❖ Spray 2, 4-D 15 ppm + Benomyl / carbendazim 1000 ppm + urea 1% one month after fruit set when the fruit size reaches pea size (8-10 mm).

2. **Granulation:**

The juice vesicles become hard, enlarged and turn opaque greyish in colour. The density of pulp is increased, juice contains increased minerals (Calcium, sodium, potassium) and decreased carbohydrate and organic acid. It results in lignification of juice cells that leads to formation of sclerenchyma

High humidity and fluctuation in temperature are the major factors. Young trees are more prone to granulation than older trees.

Management

- ☞ Avoid excess moisture
- ☞ Spray lime @ 20kg in 450 l of water.
- ☞ Spray zinc (0.5%) and copper (0.5%).

Lec: 9

POMEGRANATE

Botanical name: *Punica granatum*

Family: Punicaceae

Origin: Iran (Persia)

- Pomegranate was introduced into India from Persia or Afghanistan. It is a favourite table fruit in tropical and subtropical regions of the world.
- The fruit is liked for its cool and refreshing juice. The fruits are a good source of sugars (14-16%), minerals (0.7-1.0%) and a fair source of Iron (0.3-0.7 mg/100 g.)
- Maharashtra occupies first place in production and area under cultivation.
- In A.P it is grown in Ananthapur and some other districts nearby it can be cultivated in 5000 ha.

Climate:

The tree requires hot and dry climate during the period of fruit development and ripening. The optimum temperature for fruit development is 38°C. The tree cannot produce sweet fruits unless the temperature is high for a sufficient long period. Under subtropics it is deciduous in nature while in tropics it is evergreen. Under humid conditions, the sweetness of the fruit is adversely affected.

Soils:

It can be grown on varied types of soil. The deep loamy or alluvial soils are ideal for its cultivation. It can tolerate soils, which are slightly alkaline. It can thrive well on comparatively poor soils where other fruits fail to grow. It is rated as salt-hardy fruit plant.

Varieties:

The important commercially grown varieties are-Bhagwa, Bedhana, Jodpur, RedDholka, Ganesh, Alandhi, Musket Red, Jalore seedless, jyothei, Papershell

The edible part of pomegranate fruit is the juicy outgrowth of the seed called the aril.

Mridula: MPKV Rahuri, Maharashtra, developed this variety. Fruits are medium sized, rind smooth, and dark red in colour. Arils are blood red with very soft seed, juicy and sweet taste. It is significantly superior to other commercially grown pomegranates. The fruits weigh between 230-270g.

Ruby: This was released from IIHR-Bangalore. This is a complex hybrid between Ganesh, Kabul, Yercaud and Gul-e-sha Rose pink varieties. The fruit weighs between 225-275g. The rind colour is red, seeds are soft with dark red coloured arils. Average yield 16-18t/ha.

Ganesh: The rind colour is yellow seeds are soft with dark pink coloured arils. The fruits weigh between 200-250g.

Propagation:

Pomegranate plants raised from seed vary widely and are undesirable. Thus they must be raised vegetatively. Among the vegetative methods of propagation hard wood stem cuttings, air layering and root suckers are the important methods. Among these methods stem cuttings are universally used for raising plants on commercial basis.

Land preparation and planting:

Land is prepared thoroughly prior to pit digging It should be well levelled. Pits are dug 60-75 cm³ before the onset of monsoon. The pits are filled with 20-25 kg of FYM or Compost, 1 kg. of super phosphate and 25 grams of phorate granules with the good soil mixture.

Planting Season: The plants are planted usually in the beginning of the monsoon.

Planting system: Square or hexagonal system of planting.

Planting distance: The distance of planting in case of many improved varieties is 5.0 x 4.0m. However planting distance of 3.0 x 2.5 or 4 x 2 m has been reported to produce high and economic yield of good quality fruits.

Irrigation:

The newly set plants require regular irrigation so that the roots become well established and the plants can start growth. The plants may be individually watered daily or about a week after planting. In areas where planting is done during the monsoon, irrigation may be given whenever there is no rain for a prolonged period of time. After the plants are well established, in about 6 months, they can stand considerable amount of drought and irrigation may be given at intervals of 2 to 4 weeks depending upon the soil, climate, weather conditions and intercrops grown.

Manures and fertilizers: It is a hardy fruit plant, growing successfully in low fertile soils. Its productivity can be increased by application of manures and fertilizers. Both macro and micro nutrients affect its growth, development and productivity.

One year old plants should be manured with about 10 kg. of FYM and 150 to 200 grams of Ammonium sulphate. This amount is increased every year, so that a five year old plant gets 50 kg FYM and 1 Kg of Ammonium sulphate. The adult bearing trees are applied with 675g of Nitrogen, 250g each of Phosphorous and Potash.

Training: Pomegranate may be trained as multi-stemmed tree or single stemmed Tree

(i) **Single-stemmed tree:** The single stem is left by removing all the side shoots at the time of planting. The main stem is headed back at a height of about one metre results in the formation of branches. Four or five well distributed branches on all sides above 60 - 75 cm from the ground level are allowed to grow. In the third year

of planting one can maintain desired shape of the pomegranate. Single stemmed tree has tendency to produce less number of shoots.

The single stem system has its own disadvantages. The plants have a tendency to produce ground suckers, making the plant bushy. As such it is rather difficult to train the plant to a single stem. The crop is highly susceptible to stem borer and shoot hole borer. More over this system is hazardous. Thus single stem system of training is uneconomical for commercial cultivation. Therefore multi stem system of training is more prevalent in the country.

(ii) **Multi-stemmed tree:** In this method 3 - 4 stems are left at hill and remaining shoots are removed. In Maharashtra, the growers prefer multistem training by retaining all stems. But yield has not been found to be affected by number of stems per plant.

Pruning: Pomegranate plants don't require pruning except removal of ground suckers, water shoots and criss cross branches, dead and diseased twigs and giving a shape to the tree.

Flowering and crop regulation: Depending on climatic conditions of a particular location, pomegranate has different flowering and fruiting seasons in India.

Under tropical climate of S.India, with mild winter, the growth and flowering continues throughout the year. Similar pattern is also observed in sub-tropical, central and Western India. In the above areas there are three seasons of flowering.

Pomegranate produces flowers on previous season's growth as well as on one year to two years old spurs. Flowers are borne in clusters or in single depending upon the character of the variety. Flowers are borne on leaf axils and also some times terminally.

The three distinct seasons of flowering in Pomegranate have been named as:

1. Ambe bahar (February-March)
2. Mrig bahar (June-July)
3. Hasta bahar (September-October)

Bahar treatment for crop regulation: A fully grown pomegranate has a tendency to bear flowers and fruits throughout the year. Owing to this, higher yield is not obtained during any period. Therefore, to obtain higher fruit yield during a particular period, pomegranate plants are given a resting period by which the natural tendency of trees is altered with artificial means. Manipulation of flowering in a desired direction is called bahar treatment. This treatment also helps in getting uniform and good quality fruits with a maximum production with fewer incidences of pests and diseases. Bahar treatment include root pruning, root exposure, use of chemicals, with holding water for about two months before flowering.

Normally only two bahar treatments are followed i.e., Ambe- baha rand Mrig -bahar. Hastha- bahar is seldom selected. For practicing Hasth-bahar,

the trees have to be forced to go in to dormancy by withholding water during August-September. This is rather uncertain because of the rains that occur during this period.

Ambe-bahar is practiced by withholding water after the end of monsoon. When the trees shed their leaves in October-November, subsequent land operation, manuring and irrigation induce the plants to flower during December-January and the fruits mature during July-August. This bahar is economical wherever irrigation facilities are available.

For Mrig-bahar, the growth of plants has to be suppressed during December-April by withholding water. The trees shed their leaves in March and remain dormant till May. Subsequent soil operation followed by application of manures and fertilizers and irrigation till the rainy season, induce flowering and fruiting where the fruits are harvested during October-November.

Harvesting:

Generally the fruits ripen in about 5 to 7 months from the time of flowering stage. Mature fruits should be immediately picked from the plants after maturity stage, as delay in harvesting leads to fruit cracking. Fruits are harvested in the morning and evening times. Fruits should not be twisted and harvested.

Fruits should be harvested with the help of clippers retaining 1 cm of the stock. All the fruits should be harvested in 2 to 3 pickings with in a span of 1 month. Immediately after harvesting the fruits are kept in plastic crates and taken to a cool place.

The maturity indices for harvesting fruits are:

- Fruits are ready for harvesting in about 150 to 170 days.
- External colour of fruit changes from green to yellow or red yellowish brown.
- Ridges on the fruit become flat.
- Fruits when tapped produce a metallic sound or cracking sound.
- Acidity of the fruit should be less than 1.85%.
- Basal beak shaped portion shrinks at the time of maturity.

Yield: 150 to 200 fruits/tree.

Storage:

Under room temperature fruits can be stored upto 2 to 3 weeks and at 0⁰c and 80% RH fruits can be stored upto 2 months.

Physiological disorders:

Fruit cracking: It is a serious problem and is more intense under dry conditions of the arid zone. The fully grown mature cracked fruits though sweet loose it's keeping quality and becomes unfit for marketing. They are liable to rot qualitatively. The cracked fruits show reduction in their fruit weight, grain weight and volume of juice.

- It is mainly associated with fluctuation of soil moisture, day and temperature, relative humidity and rind pliability.
- This disorder may also develop due to boron deficiency in young fruits and moisture imbalance in mature ones.
- Prolonged drought causes hardening of peel. If this is followed by heavy irrigation or rains the pulp grows and peel cracks.
- It is also a varietal character, since the rind thickness and texture are related to proneness to cracking.
- The percentage of cracked fruits is also related to season. Mrig-bahar (June-July) crop is more susceptible to fruit cracking because of variation in humidity.

Control :

- ✓ Adequate and regular irrigation and interculture throughout the bearing period.
- ✓ Cultivating tolerant/less prone types like Karkai, Guleshah, Bedana.
- ✓ Spraying Borax@ 0.1 to 0.2%
- ✓ Spraying of GA3 in the month of June at 250ppm
- ✓ Planting wind breaks around the garden.

PAPAYA

Botanical name: *Carica papaya* L.

Family: Caricaceae.

Origin: Tropical America

- Total cultivated area in AP under papaya was: 12500 ha
Production: 4 lac tonnes
- Leading papaya growing areas in AP: Anantapur, Kurnool, Kadapa, Prakasam
- It is one of the few fruit crops that flowers and fruits throughout the year giving early (9-10 months after planting) and high yields
- Besides its use as a fresh fruit, Papayas can be processed as Jam, Syrup, Preserves, Papaya candy, canned fruits, salad, and jelly.
- Papaya is also a commercial source of protease enzyme —Papain
- Papaya fruit is highly nutritive and is very rich in Vitamin A. It improves digestion and said to cure chronic constipation, piles and enlarged liver and spleen.

Climate:

- Papaya is essentially a tropical fruit crop and grows best in sunny places. It is very sensitive to frost but withstands extremes of temperature. Temperatures below 10°C will affect the growth and fruit set. It grows well in regions where summer temperature doesn't exceed 38°C but it can stand up to 48°C.

Soils:

- ❖ It can be grown on a variety of soils provided the soils are well drained.
- ❖ Heavy soils should be avoided as papayas cannot withstand water stagnation for more than 48 hours.
- ❖ A loamy soil with a pH of 6.5 to 7.2 is considered ideal. Medium black and alluvial soils are also suitable.

Varieties:

- **Diecious varieties:** Male and female flowers are produced in different plants Ex: Washington, CO-1, CO-2, CO-4, CO-6, Pusa Dwarf and PusaGaint
 - **Diecious varieties:** The plants produce male and bisexual flowers
Ex: Coorg Honeydew, Honeydew, Pusa delicious, Solo
1. **Honey dew:** Most popular variety all over india, with good fruit yield and quality having excellent taste and good flavour. The fruits have less number of seeds
 2. **Coorg Honeydew:** A selection from Honey Dew, it is a gynodioecious variety having excellent fruit quality under south Indian conditions.
 3. **Pusa Dwarf:** It is a dwarf-statured dioecious variety with good yield. Fruits are medium-sized with oval shape and are preferred by consumers.

4. **Red Lady:** Fruits are big -sized with spherical shape and high yielder. Suitable for long distinct markets and it has more shelf life
5. **CO-2:** It is medium-tall, dioecious variety, having good fruit quality with high papain content. It is predominantly cultivated for papain production.

Propagation:

It is mainly propagated by seeds. Since it is a highly cross-pollinated crop, the plants raised from seeds have a mixed inheritance, which makes the highly variable. So, genetically pure seeds should be collected from the sib mated or selfed fruits.

Raising of seedlings:

- Freshly extracted seeds germinate better and grow quicker. The fresh seeds are cleaned of the pulpy material adhering them, dried in shade.
- About 400 -500 grams of seed is required for raising crop in one hectare. Seedlings can be raised in nursery beds or in polythene bags. Among these, the seedlings raised in polythene bags are found good.
- Seeds are sown at a spacing of 5cm within the row and 15 cm between rows. Seeds germinate within 15-20 days.
- In about 2 months, seedlings grow to a height of 15 to 20 cm and are ready for transplanting. It is essential that large ball of moist soil containing the entire root system is lifted from bed and transplanted in the field without mutilating the roots in any manner.
- Hence, raising seedlings in polythene bags is more desirable for better establishment, after transplanting.

Planting:

- ❖ The land should be ploughed deep, harrowed and levelled.
- ❖ Pits of size 45cm X 45cm are dug and spaced about 2.5 m apart each way.
- ❖ The pits after weathering are filled with top soil mixed with 5 kg. of FYM, 100 grams of neem cake and 40 grams of super phosphate.
- ❖ Male and female plants 1:10 ratio should be maintained at the time of planting.
- ❖ The best time for planting in most parts of India is the beginning of the monsoon in the light rainfall tracts and close of the monsoon in the heavy rainfall tracts.

Manuring:

Papaya is a quick grower and heavy feeder. While planting, along with top soil 5 kg of FYM, 100 grams of neem cake and 40 grams of super phosphate should be mixed and pits are filled. After thinning of male and female plants first dose of 50 grams each of N, P and K per plant should be applied. The same dose should be applied at 2 months interval from second month of planting.

Irrigation:

For high and successful production regular irrigation is needed. Lack of moisture results in stunted growth and poor fruiting. During summer, irrigations are

to be given at 5-6 days interval and during winter 8-10 days interval. Ring system of irrigation is better.

Inter culture:

Land should be ploughed and harrowed cross wise at least twice in a year. Frequent weeding around the stems is necessary. When the entire area is covered by the foliage the weeding may not require.

Intercropping:

Vegetables can be profitably grown as intercrops for about 6 months from planting of papaya seedlings.

Flowering and fruiting:

Starts flowering 5-6 months after planting. Fruit setting commences a fortnight after flowering. Fruit takes 4 to 5 months to reach full maturity. Fruiting continues throughout its life.

Harvesting:

- ❖ Starts in about 9-10 months after planting. The maturity is well indicated by colour change and the consistency of latex. The latex of mature fruits becomes watery.
- ❖ Fruits for local consumption should be picked when the green colour is half way changed into yellow; for export it is necessary to pick sooner, after the blossom end has turned colour Individual fruits should be harvested by twisting by hand without damage.

Yield: Average yield is about 75-100 tones per hectare. Peak yield during 2nd year and decline by third year. Economic life of papaya is 2 to 3 years.

Papain:

- The cultivation of Papaya for producing papain will be a profitable proposition. Substantial quantities of papain can be extracted by adopting correct techniques.
- Papain is the proteolytic enzyme present in the milky latex obtained from green fruits of papaya. This enzyme is exclusively exported and there is great demand in the international market.
- Papain is used in breweries, especially for clarification of beer, medicines, cosmetics, tanning industry, tenderization of meat and fish, extraction of animal and plant protein from various animals and plants etc.

Papain extraction:

- The latex should be tapped from 75 to 90 days old immature papaya fruits early in the morning up to 10.00am.
- On the selected fruit, four longitudinal incisions should be given using a razor blade attached to bamboo splinter. The depth of the cut should not be more than 0.3cm.

- The tapping has to be repeated four times on the same fruit at an interval of 4 days. The latex should be collected in aluminium trays and shade dried. The dried latex is then packed in polythene bags.
- Before drying, potassium meta-bi-sulphate (KMS) 0.05% has to be added to the latex for better colour and keeping quality. The latex can also be dried in oven at a temperature range of 50-55 OC.
- Papain yield ranges from 1.23g to 7.45g per fruit and the cultivar. Washington variety recorded the highest mean yield of 7.45g per 100-150g of dried latex / tree / year.
- Varieties suitable for Papain: CO-2, CO-4, CO-5, Coorg honeydew, Pusa majesty and Pusa delicious.

Time for papain extraction: Cool and wet period—gives more papain. July to August is the best period.

SAPOTA

Botanic name: *Achras zapota*

Family: Sapotaceae

Origin: Tropical America

It is mainly cultivated for the milky latex produced from the bark and fruits, which yields a commercial product called “Gutta parcha” which is the base for the manufacture of chewing gum (Chicle).

Sapota, when fully ripe, is delicious and is eaten as dessert fruit. The pulp is sweet and melting. The sapota fruits are good source of sugar which ranges between 12 and 14 per cent.

Climate:

Sapota is a tropical fruit and it prefers a warm and moist weather and grows in both dry and humid areas. Coastal climate is best suited. In South India, it is grown on the hills up to a height of 1000m. The optimum temperature ranges between 11°C and 34°C.

Soils:

Sapota is a hardy tree and can be grown on a wide range of soils, but in sandy soils, the plants are uprooted by strong winds. Drainage is most important for sapota growing. Alluvial soils, sandy loams, red laterite soils are suitable.

Varieties:

- The important and widely adopted varieties are Cricket ball, kalipatti, Kirthibatti, Pala, Baramsi, Guthi, CO2, PKM-1 etc.
- **CO-3:** Trees are intermediate in stature. Fruits are dull brown, oblong sweet and yield annually about 157 kg fruits per tree
- **PKM-2:** A high yielder with a yield performance of 1500-200 fruits per tree per year weighing 80-100 kg. Fruits are bigger in size and oblong to oval shaped. The average fruit weight is 95g. TSS ranges from 25-27OB.
- **PKM-3:** Fruits are big sized with oval shape and have a cluster bearing habit. The fruit yield is 14 tones/ha.

Propagation:

Sapota is propagated both by seed and also by vegetative methods.

Seed propagation: In the earlier days, seedlings were used for planting, but they have some disadvantages such as slow growth, very long pre-bearing period of about 8-10 years.

Vegetative propagation: Among the vegetative methods, the most important are air layering, ground layering / pot layering, inarching and soft wood grafting. However; commercially followed method is inarching and now this method is replaced by softwood grafting.

Planting:

The land is ploughed twice and leveled properly to avoid water stagnation. Pits of 90cm size are dug at a spacing of 8X8 m or 9X9m. Planting is done preferably during early monsoon period. Each pit is filled with a mixture of 30 kg. FYM, 500 g. neem cake with top soil. Then the plant is planted in the center. Care should be taken to see that the graft joint is at least 15cm above the ground level.

Irrigation: Though sapota can tolerate drought conditions to some extent, yet it responds well to irrigation. Young plants are watered regularly during dry season and at long breaks in the monsoon, winter and summer at an interval of 6-12 days.

Manuring: The following doses of manures and fertilizers have been found beneficial for obtaining higher yield of sapota in Andhra Pradesh.

Age of the tree	FYM (Kg/Plant)	N (g/plt)	P (g/plt)	K(g/plt)
1-3 years	50	50	20	75
4-7 Years	50	100	40	150
7-10 Years	50	200	80	300
11 and above	50	400	160	450

Manures and fertilizers are applied twice in year. The first half is applied in the beginning of the monsoon (June-July) and the remaining half the dose at the end of the monsoon (September-October).

Intercropping:

Sapota has long pre-bearing age and till the trees cover the entire area with canopy, inter crops can be grown. Short duration fruits like banana, papaya, or vegetables can be profitably grown. Legume vegetables and pulses benefit in several ways.

Training and pruning:

In Sapota, a strong central stem is necessary. The Sapota, in general, has a well balanced distribution of branches and the crown assumes a uniform shape. After 3-4 years of planting, the lower most branches up to a height of 1 m may be removed. In sapota, new growth and flowering occur simultaneously and it has a mixed type of bearing habit.

Pruning in sapota is confined to open the tree to light, and removal of dead and diseased branches over shaded and crowded branches.

Flowering and fruiting:

Sapota starts bearing small crops from second or third year of planting but economical yields can be obtained from seventh year onwards. Flowers appear in leaf axils on new growth.

Harvesting: It matures in about 4-6 months after fruit set. The fruits to be harvested must be fully mature and maturity can be judged by several external symptoms as mentioned below.

- ❖ Fruits at full maturity develop a dull orange or potato brown colour.

- ❖ A mature fruit when scratched shows light yellow streak instead of a green streak, which is a sign of immature condition.
- ❖ Brown scaly material disappears from the fruit surface as the fruits approach full maturity.
- ❖ As the fruit matures, the milky latex content is reduced.

The matured fruits are harvested with stalk intact individually by giving a twist and collected without bruising. Continuous flowering and fruiting observed in sapota, though there are two distinct periods of harvest viz; September-November and January-March.

Yield:

4 to 5 years old trees: 250 fruits per plant.

6 to 7 years old trees: 800 fruits per plant.

8 to 20 years old trees: 1200-1500 fruits per plant

Lec. 12

GUAVA

Botanical Name: *Psidium guajava*. linn

Family: Myrtaceae

Origin: Tropical America (from Mexico to Peru)

- Guava is a subtropical crop. It is one of the most common and major fruits of India and is considered the fourth most important fruit in area and production after mango, banana, and citrus.
- In A.P it is commercially grown in North coastal districts and Anantapur in Rayalaseema.
- Guava is the rich source of Vitamin C, and a fair source of Vitamin A and B2 and minerals like calcium, phosphorus and iron. The vitamin C content of Guava is 2-5 times higher than oranges.

Climate:

Guava can be successfully cultivated both under tropical and subtropical conditions. It grows best with an annual rainfall below 100cm restricted between June-September. Places having more than 250cm rainfall are not suitable for guava. Optimum temperature requirement is 23-28°C.

Soil:

Guava adapts well to a wide range of soils. Well-drained, light sandy loam to clay soils is good. Since it is a hardy fruit crop, it can be grown on alkaline soils wastelands etc. It is sensitive to waterlogged conditions.

It tolerates a wide range of pH from 4.5 to 8.5. If the soils are having a pH of 7.5 and above there are more chances of getting guava wilt.

Varieties:

Allahabad safeda, Lucknow-49, ArkaMridula, Red fleshed and Allahabad Surkha etc.,

Hybrids:

1. **Saefd jam:** This is a hybrid variety released from Fruit research station, Sangareddy (A.P.). It is a cross between Allahabad Safeda and Kohir. Fruit size is bigger with less seed and vitamin C is more in comparison to their parents.
2. **KohirSafeda:** It is cross between Kohir and Allahabad safeda. Fruit is large in size, slightly acidic. Yield 300 fruits per tree.

Other varieties like Nasik, Dharwar, and Apple colour, Banarasi, Hafsi, Anakapalli, Harijha and chitdar etc. are also considered as good cultivars.

Propagation:

Guava can be propagated both by seed and vegetatively. Among the asexual methods viz., cuttings, air layering, stooling, grafting and budding are important.

Air layering or ground layering can be practiced for multiplication of guava plants commercially. It is very convenient, cheap and easy method. The layered plant being on its own roots grows more vigorously and establishes quickly even in difficult soil conditions.

Planting:

Digging of pits: Pits of 75-100 cm³ size are dug well in advance to the onset of monsoon. The pits are filled with a mixture of tank silt, FYM Or Compost and soil in equal proportions. To avoid termite problems dusts like lindane are also mixed in the soil mixture.

Planting season: Guava may be planted from June to December.

Spacing: generally adopted is 5-6 meters in square system of planting.

Flowering and fruiting:

- The guava bears flowers solitary or in cymes of two or three flowers, on the current seasons growth in the axils of leaves.
- Under natural conditions, guava tree produces flowers and a fruit twice in a year in North India, but in South and Western India it is thrice i.e. almost throughout the year, which results in no rest period and ultimately guava tree, bears small crops at different times of the year.

The pattern of flowering and fruiting periods in guava are:

1. **Ambe-bahar:**

When guava tree flowers during February-March or spring season, this flowering period is known as Ambe-bahar. The fruits ripe from July-September in rainy season. The fruits obtained during this season are insipid, watery and poor in quality i.e. taste and keeping quality.

2. **Mrig-bahar:**

When guava produces flowers in June-July or monsoon, this- flowering period is known as Mrig-bahar. The fruits ripe from November-January in the winter. The fruits obtained during winter are excellent in quality and therefore, the guava trees are made to produce the Mrig-bahar flowering only.

3. **Hasth-bahar:**

A guava tree produces flower in October is known as Hasth-bahar. The fruits ripe from February-April. The quality is good, but yield is very low. However, it fetches good price. This bahar in guava is not very common. It is mostly a chance crop. Hast-bahar is observed in western and southern India.

The practices followed for taking Mrig-bahar are:

1. **Restricting irrigation water:**

The trees should not be given irrigation from February to middle of May. Doing so, the tree sheds its leaves during hot season (April-May) and goes to rest. During this rest period, tree can conserve food material in its branches. In the month of June tree is well cultivated and manured followed by irrigation. After

about 20 -25 days the tree blaze in to profuse blossoms. The fruits mature during winter.

2. Exposing roots:

Carefully upper soil around the trunk about 45 - 60 cm radius is removed, so that the roots are exposed to the sun which results in reduction in supply of soil moisture from the soil to the top and therefore, the leaves begin to shed and the tree goes to rest. After about 3-4 weeks the exposed roots are again covered with the soil. Manuring and watering may be followed.

3. De-blossoming:

It can be done with the use of growth of regulators. Among many chemicals NAD (Naphthaleneacetamide) at 50 ppm is the most effective. Deblossming can also be done manually on small scale.

Irrigation:

- Guava is a hardy plant and generally it doesn't require much irrigation. But the yield and quality improve markedly by irrigation in summer.
- The young guavaplants need irrigation at weekly interval during summer months and 2-3 irrigations during winter months.

Manures and fertilizers:The fruit of guava are borne on current season's growth. Therefore, manures and fertilizers are required to encourage vegetative growth and fruiting.

Manures	One year after planting (Kg)	Bearing trees (Kg)
Compost	20	100
Ammonium sulphate	1.0	3.0
Super phosphate	1.0	2.0
Muriate of Potash	1.0	2.0

In case of zinc deficiency, spraying trees with 450g of zinc sulphate and 300g of slaked lime in 73 litres of water twice in a year, once in June-July and second in September-October corrects the deficiency.

Inter culture: The orchard should be kept clean by ploughing twice or three once in the beginning of monsoon to improve the infiltration of rain water into the soil and the second ploughing in the middle of the rainy season to control the weeds.

Inter cropping:

In the early stages of establishment of guava orchard till the commercial bearing, the interspaces can be utilized by growing suitable intercrops. Vegetable crops like bhendi, brinjal, beet root and fruit crop like papaya can be grown as intercrops. However, intercropping is not desirable in orchards with full grown plants.

Training and pruning:

- The main objective of training a guava plant is to provide a strong framework and scaffold branches suitable for bearing a heavy crop without damaging the branches.
- Training guava trees to open centre system is good.

- Care must be taken to prevent criss- crossing of the primary branches in the initial years of planting.
- In case of varieties having spreading habit, primary branches are allowed at least 75cm above ground level. It is better to shape the tree canopy to a limited height into a rectangular shape, allowing more spread in East-West direction.
- Dead, diseased and suckers coming up from the base and sides of framework should be pruned back annually.
- In guava, the flowers and fruits are borne on current season's growth in the axils of leaves arising from the old ones, hence, a light annual pruning is considered necessary to encourage new shoots after the harvest.
- Severe pruning reduces yield largely, light pruning is always desirable.

Pollarding or Dehorning:

When the trees are aged and don't give good yields, their branches may be pollarded or dehorned. In this method the branches are cut leaving 30 cm in length at their origin. The cut branches produce enormous shoots and flowers and ultimately give high yields.

Bending:

It is a common feature that in the guava trees branches growing upright and tall don't bear at all. In such cases, straight-growing branches may be bent and tied on the pegs driven on the ground. In bent branches dormant buds are activated and induced to bear flowers and fruits heavily.

Harvesting:

- Seedling guava trees require 4-5 years to bear, while vegetatively propagated plants start bearing from third year after planting.
- The fruits turn greenish yellow with the approach of maturity are considered ready for harvesting.
- Guava fruits mature for harvesting after 4-5 months of anthesis.
- Hand picking at regular intervals is suggested to avoid possible damage to fruits instead of shaking the tree.

Yield:

- The yield of guava varies due to different varieties, age of the plants, fruiting season and orchard management practices etc.
- Seedling tree of guava of 10 years old yields about 400-500 fruits.

APPLE

Botanical Name: *Malus pumila* / *Malus sylvestris*

Family: Rosaceae

Origin: South West Asia

- It is the most important temperate fruit. It is the premier table fruit of the world.
- Apple is also called as —**King of temperate fruit**
- It is a rich source of easily assimilable carbohydrate and it is also fairly rich in calcium, phosphorous and potassium. It also supplies vitamin B and C.
- In India it is predominantly grown in Jammu and Kashmir, Himachal Pradesh and hills of Uttar Pradesh, accounting for about 90% of the total production.
- Botanically apple fruit is a false fruit (**Pome**) with fleshy thalamus as edible portion.
- Most of the commercial apple varieties are diploids. Triploids are rare.

Climate:

Most of the apple varieties require 1000 to 1500 hours of chilling at below 7°C during winter to break the rest period. These conditions are available at an elevation of 1500 to 2700m above mean sea level in the Himalayan ranges.

Average temperature should be around 21 to 24°C during active growth period. Well distributed rainfall of 100 to 125cm through out the growing season is most favourable for its optimal growth and fruitfulness. Long drought spells during fruit development and excessive rains and foggy conditions at fruit maturity hamper fruit size and quality.

Soils:

Loamy soils rich in organic matter having a pH of 5.5 to 6.5 with gentle to moderate slope, proper drainage and good aeration are most suitable. The soil should be free from hard substrata and water logged conditions. The presence of lime in the soil is good for apple cultivation.

Varieties:

- In apple there are two types of varieties *i.e.*, **diploids and triploids**.
- The diploids usually have plenty of pollen and are self fruitful.
- The triploids on the contrary are self unfruitful and productive only when they are pollinated by diploid varieties.
- Golden delicious and red gold are recommended pollenizers in apple.
- **Diploids:** Red-delicious, Yellow delicious, Jonathan etc.
- **Triploids-** Baldwin, Beauty, Rome Beauty, Ambri, Sunheri, Ambroyal, Ambrich, Ambred Red.
- The cultivar Ambri is Indigenous and extensively grown in the Kashmir valley.

Propagation:

- Apple plants are commercially raised by vegetative means, since seedling plants are not true to type.

- Apple is generally propagated by budding or grafting on seedlings of crabapple, golden delicious etc. Shield budding is done with buds of current seasons growth in June. Among grafting methods tongue grafting is the ideal method. Grafting is done in spring.
- **Malling IX** root stock is popular which was introduced from East Malling research station, England. Several Malling root stocks developed in England are vegetatively propagated. They can be used to control the vigour of the plants and have resistance to wooly aphids, a pest on apple.
- **Crab apple** *Malus baccata* is most commonly used rootstock of apple in India.

Planting:

In flat and valley areas planting is done in square and hexagonal system of layout, in slopes contour / terrace planting is preferred. Pits of 1m³ size are made and kept open for a month and filled with a mixture of 40-50kg of FYM + 500g of Super phosphate + top soil.

The soil is allowed to settle for a month. Planting is done late in winter after the danger of frost is over. One year old plants are planted. The planting distance varies from 7 to 10m depending on the vigour of the rootstock.

Training and pruning:

The plants are trained according to growth habit and vigour of the root stocks. In India the apple trees are trained to **modified leader system** with 3-5 main branches and a clear trunk of 1.0 to 1.5m. After completion of training in 4-5 years with proper pruning the branches of the tree should make an extension growth of 25 to 50cm every year to maintain a balance between vegetative growth and fruit production. Some apple trees bear fruit on short crooked growth called spurs. These spurs bear for several years. Such spurs should be pruned to encourage vegetative growth and new spur development in only when they stopped bearing fruits. Pruning is done when the plants are dormant i.e. in the month of December-January.

Manures and fertilizers:

Application of manures and fertilizers start right from planting of an orchard. The first application should be made at the time of filling of pits. The fertilizer dose should depends upon soil fertility, type of soil, kind and age of trees, cultural practices, climate and crop load.

In an orchard of optimal fertility, N, P and K may be applied in the ratio 70:30:70 g/ year age of the tree. The dose should be stabilized (700:350:700gN: P: K per tree) after 10 years of age. These applications may be supplemented with FYM@10 kg per year age of the tree with the maximum of 100 kg. In off years the fertilizer dose of NPK may be reduced to 500g, 250g and 400g respectively. In bearing trees, FYM along with P and K should be applied during December-January. Nitrogen is applied during February-March, 2 to 3 weeks before bud break.

The Nitrogen can be applied in two split doses, first dose 2-3 weeks before bud break and the second one, one month after flowering. The fertilizers should be broadcasted in the tree basins 30cm away from the tree trunk up to the canopy drip line and mixed well in the soil.

Irrigation:

Most of apple orchards in India are situated in rain fed sloppy areas where irrigation facilities are inadequate except in flat valley areas. Apple requires uniform distribution of rainfall throughout the year or needs to be supplemented with irrigation during critical periods. The most critical period of water requirement in apple is from April to August, the peak requirement being after fruit set. During summer months, the irrigations can be given at 7-10 days interval and rest at 3-4 weeks interval.

Harvesting:

Since apple is a climacteric fruit, the maturity of fruits doesn't coincide with ripening. The fruits usually don't attain full ripe edible quality on the tree while harvesting. The fruits should be harvested at proper picking maturity to attain proper edible quality at ripening. There are several reliable maturity indices which can be adopted singly or in combination for proper fruit harvesting.

Harvest indices:

- TSS of the fruit pulp
- Ease in separation of fruit from the spur
- Change in ground surface colour from green to pale
- Change in seed colour to light brown
- Fruit firmness

Yield:

A full bearing tree yields from 40-100 kg fruit. The bearing generally commences after 5 years of planting and continues for about 50 years.

STRWBERRY

Botanical name: *Frajeria spp.*

Family: Rosaceae

Origin: Himalayan region

- ❖ Himalayan region is said to be the home of wild strawberry. Besides it also grows well in Dehradun, Nainital and mahabaleshwar.
- ❖ Strawberry is a small herb with shallow roots generally bear in june.

Varieties:

- Cambridge favourite: Mod season, compact grower, high yielder and heavy copper colour fruits.
- Cambridge late: Late cultivar, fruits was crimson in colour and pleasant flavour
- Cambridge prize winner: early bearer, fruits conical in shape and crimson in colour and suitable for sandy soils.
- Cambridge sentry: Mid season cultivar, glory crimson colour and good for jam making.
- Other varieties: Telisman, Red yountlet

Soils:

Highly fertile soil is prepared one year advance of planting. Strawberry grows in a variety of soils which is slightly acidic (pH 5.5-6.5). soils rich in organic matter is best for its growth. Do produce strawberries successfully light soil, good drainage, clean shallow cultivation and enough organic matter are essential.

Propagation:

Seed propagation is practiced commonly. Seeds are stratified at 0⁰c for 90 days so that they give better viability.

One year old runners are also used for propagation.

Planting:

In plains planting is done in Sep to October and higher altitudes it is done in march to april. If planted in august yields are heavy for four years. Late plantings should be avoided or plants need to be establish well before winters. If planted in spring no harvesting can be planned for first year.

Manures and fertilizers:

Application of NPK in the ratio 1:1:2 is beneficial. Sometimes side dressing with 50 kg nitrate is also recommended. A dose of bone meal may also be given after fruiting to increase fruit yield. In winter additional care is required and a top dressing of organic matter is recommended.

Cultural practices:

To obtain better quality fruits early planting, absolved freedom from weeds and pests, adequate irrigation and fertile soil in necessary. As strawberries roots

do not penetrate deep in soil ample moisture is needed for its growth. The soil is kept covered with straw which is removed after fruiting. To increase the yield removal of runners is also recommended. Strawberries is also grown as a rotation crop with vegetables.

Training:

There are three types of training systems recommended for strawberries

1. **Hill systems:** in this system the runners are removed so that all the nutrients are totally utilised by the mother plant. The only disadvantage of this system is that the cost of production is more and the yield is less, however the fruits obtained by this method are bigger.
2. **Spaced row system:** in this system the runners are not removed but the number and spacing of new plant is regulated. It gives higher yield and also increases the size of the plant.
3. **Matted row system:** in this system the runners are allowed to develop and a space of 90-124 cm given between the plants. The yield depends on the number of plants and spacing.

Harvesting:

The berries are highly perishable. The berries are picked by hand every 2-3 days interval after a period of about a month from the date of blossoming. To avoid loss they are harvested in the early or late hours of the day and then stored under proper refrigeration.

IMPORTANCE OF VEGETABLES IN HUMAN NUTRITION AND NATIONAL ECONOMY

Olericulture is one of the branches of Horticulture that deals with the vegetables. The word olericulture is derived from the Latin word. Oleris which means pot herb and the English word culture which means cultivation. Thus, olericulture means cultivation of pot herbs.

IMPORTANCE OF VEGETABLES IN NATIONAL ECONOMY

- India was the second largest producer after china among vegetable production
- Area under vegetable production in India 10.29 m.ha
 - Production: 175.01 m.T
 - Productivity: 17.01t/ha
- Top five states under vegetable production West Bengal, Uttar prdesh, Bihar, Orissa, Maharastra
- Highest productivity- Tamilnadu (28.92t/ha)
- India's share in world production: 14%
- India has a unique position in production among other countries as variety of vegetables.
- In the past, Indian vegetable exports were restricted to potatoes and fresh onions. But now the Government of India observes great opportunities for expanding exports of several more vegetables, including lettuce, fresh peppers, tomatoes, squash and gherkins.
- The utilisation of fruits and vegetables for processing in the organised and unorganised sector is estimated to be around 2 per cent of the total production, over the last few years, there has been a positive growth in ready-to-serve beverages, dehydrated and frozen vegetables, tomato products, pickles, spices paste and curried vegetables
- Exports as per APEDA of different vegetables based commodities is as fresh produce: Onion, okra, pea, cole crops, cucurbits, peas >2000crores
 - Vegetable seeds nearly 200crores
 - Processed vegetables >200crores
 - Dehydrated ginger, garlic, pea, onion, drumstick – 500croresAmong vegetables onion occupies first position in total export value of vegetables – 1500crores

Vegetable: The term vegetable is applied to the edible herbaceous plant or plant parts thereof, which are consumed generally in the unripe stage after cooking.

- Vegetables provide all the nutrient components like carbohydrates, protein, fat, vitamins, minerals and water along with roughages which are essential constituents of a balanced diet so as vegetables are called as Protective foods.

- ☛ According to the studies of Indian Council of Medical Research, New Delhi Recommended daily allowance (RDA) by the Indian Council of Medical Research in for an adult requirement was **300 g of vegetables. It includes 100 g roots and tubers, 125g of leaf vegetables and 75 g other vegetables.**

Vegetables are rich in

- 1. Carbohydrates:** Carbohydrates rich vegetables are: Potato, Sweet potato, cassava, elephant foot yam, taro, garlic, pea, onion *etc.*,
- 2. Proteins:** Proteins rich vegetables are peas, double bean, winged bean, Garlic, Brussels sprouts, cowpea, lima bean seeds, amaranthus leaves, drumstick leaves and menthi leaves.
- 3. Fat:** Fat rich vegetables are: Chilli, hyacinth bean, cluster bean, palak, fenugreek leaves, mustard leaves, radish tip, coriander leaves and *etc.*,

4. Vitamins

a) Vitamin A: (Beta carotene)

Symptoms: Night blindness, Dryness of skin, Xerophthalmia in infants and young children

Ex: Carrot, spinach, palak, mustard green, amaranth, coriander, sweet potato, pumpkin, tomato

b) Vitamin B1 (Thiamin):

Symptoms: Deficiency results beri-beri disease, muscular weakness

c) Vitamin B2 (Riboflavin):

Symptoms: Deficiency results dark red inflamed tongue

d) Niacin (Nicotinic acid):

Symptoms: Deficiency results nervous break down, stomach and intestinal disorder.

Pellagra showing inflammation and changing of skin in hand and feet.

e) Vitamin B6 (Pyridoxin):

Symptoms: Deficiency results in retarded growth and anaemia, skin disease.

f) Folic acid (Folicin):

Symptoms: Deficiency results in retarded growth and anaemia

Vitamin B rich vegetables are Leguminous vegetables, onion bulbs, green onion, sweet potato and cabbage contain a fair amount of vitamin-B group.

g) Vitamin E (Tocopherol):

Symptoms: Deficiency results in degeneration of kidney and necrosis of the skin and reduction in the capability of reproduction.

Ex: Green leafy vegetables are fairly good sources of this vitamin. Leaf vegetables like palak, fenugreek, drumstick *etc.*

h) Vitamin K: Daily requirement is 0.115mg

Symptoms: Deficiency results in delayed and faulty coagulation of blood in cut wounds, hindrance in normal secretion of bile from liver.

Ex: Green leafy vegetables

i) **Vitamin C (Ascorbic acid):** Daily requirement is 50mg

Symptoms: Deficiency results in Scurvy which characterised by weakness, bleeding of gums, defective bone growth

Ex: Turnip green, green chillies, Brussels sprouts, mustard green, Amaranth, coriander, drumstick leaves

5. Mineral contents:

Calcium: curry leaves, amaranth leaves, drumstick leaves, menthi, turnip, coriander and palak.

Iron: drum stick leaves and fruits, amaranth, menthi, mint, coriander, Spinach

Phosphorous: Garlic, pea, taro, lima bean, chilli, cauliflower and etc.,

Iodine: Tender fruits of okra contain iodine, essential for prevention of goiter disease.

6. Fibre: Ridge gourd, peas and beans and leafy vegetables

- Helps in prevents constipation
- Reduce risk of colon cancer
- Improve gastrointestinal health
- Improve glucose tolerance, reduce hyper tension and heart disease

7. Colour rich vegetables:

Red	Lycopene	Tomato, watermelon
	Betacyanins	Beet root
Orange	Beta carotene	Carrot, cantaloupe, pumpkin, sweet potato
Blue/Purple	Anthocyanins	Egg plant
Green	Chlorophyll	Green leafy vegetables

8. Flavonoids:

- Characteristic flavour of **Cole crops** is due to **Dimethyl trisulphide**
- Pungency and flavours of **Onion: Allyl propyl disulphide**
- Pungency and flavours of **Garlic: Diallyl disulphide**

9. Toxic substances: Trypsin inhibitors are widely distributed in legumes, especially in raw soybeans. They inhibit activity of trypsin in the gut and interfere with digestibility of dietary proteins and reduce their utilization by affecting hydrolysis of proteins to amino acids.

Colocasia- Oxalic acid (bitter taste)

10. Vegetables in disease prevention:

Bitter melon (cheratin) – treating diabetes

Ash gourd – for weak nervous systems

Onion – Bioflavonoids protect against cancer and heart disease

CLASSIFICATION OF VEGETABLES

Classification of vegetables based on botany, plant part used as vegetables, seasons of growing and methods of culture

I. **Botanical classification:**

- All vegetable belongs to Division Angiospermae. The Angiospermae has 2 classes mono and dicotyledone.
- They are further divided in to families, genus, species, subspecies and botanical varieties.

A. **Monocotyledonae:**

1. Amaryllidaceae – Onion, Garlic, Leak, Shallot, Chive.
2. Liliaceae – Asparagus
3. Araceae – Colocasia esculenta
4. Dioscoreaceae – Yam

B. **Dicotyledonous plants:**

1. Chenopodiaceae – Palak, Beetroot, Spinach
2. Asteraceae – Lettuce, chikori
3. Convolvulaceae – Sweet potato.
4. Brassicaceae – Cabbage, Cauliflower
5. Cruciferae – Brussels, Cole rabi or knol-khol, radish, mustard.
6. Cucurbitaceae – All cucurbitaceous vegetables
7. Euphorbiaceae: Tapioca (*Manihot esculenta*)
8. Fabaceae: Pea, French bean, Lima bean Asparagus bean, Cluster bean, Methi etc.,
9. Malvaceae: Okra (Bhendi)
10. Polygonaceae: Sorrel, Rhubarb
11. Solanaceae: Potato, Brinjal, Tomato, Chillies, Pepper.
12. Umbelliferae (Apiaceae) Carrot, parsley,
13. Rutaceae: Curry leaf, Drum stick

II. **Vegetables classification based on plant parts used:** According to parts used for consumption

1. Leafy vegetables: Amaranthus, Cabbage and Palak
2. Fruits : Tomato, Brinjal, Bhendi, Peas, Beans, Cucurbits
3. Flower parts: Cauliflower and Broccoli
4. Under ground parts:
5. Stem tubers: Potato and colocasia
6. Root tubers: Carrot, Sweet potato and Tapioca
7. Bulbs: Onion and garlic

The cultural requirements of crops in each group are not same i.e tomato, bhendi and cucurbits. Hence this method is also not of much value.

III. **Classification based on hardiness**

Classification based on ability to withstand frost and low temperature and it will be useful to know the season of cultivation of a crop

- a) **Hardy vegetables:** Tolerate frost and low temperatures and are basically winter or cool season or temperate vegetables. Ex: Asparagus, crucifers, garlic, leek, onion, parsley, peas, radish etc.

b) Semi hardy vegetables: Carrot, celery, beet root, globe artichoke, lettuce, palak, potato

c) Tender vegetables: Amaranthus, okra, brinjal, chilli, cucurbits, tomato, colocasia, yam, sweet potato

IV. Classification based on cultural requirement

This is the most convenient and widely used system of classification of vegetables. Vegetables having similar cultural requirements are grouped together and placed in one group. **For ex.,** crops belonging to group Cucurbits are seed propagated, direct sown, trailing and vigorous growing, cross pollinated and the cultural practice are almost same.

1. Solanaceous fruit vegetables
2. Cucurbits
3. Peas and beans
4. Cole crops
5. Bulb crops
6. Root crops
7. Potato
8. Tuber crops
9. Okra
10. Pot herbs / greens
11. Salad crops
12. Perennial vegetables

V. Classification based on season of cultivation

This is one of the most important classifications from the grower's point of view since majority of vegetables are season bound and specific to particular seasons.

Vegetables are classified into summer season crops, rainy season crops and winter season crops based on growth and production during particular seasons.

1. **Winter season crops** - Cruciferous vegetables, carrot, radish, beetroot, onion, garlic, peas.
2. **Mild winter** - Hyacinth bean, winged bean, tomato
3. **Summer season** - All gourds, amaranth
4. **Rainy season crops** - Bhendi, chilli, brinjal, cluster bean, cowpea etc.

TOMATO

Botanical name: *Solanum lycopersican*

Family: Solanaceae

Origin: Peruvian and Mexican region

- Tomato is one of the most popular and consumed vegetable grown all over the world.
- Total cultivated area in India under tomato was: 773.88 Thousand Ha
Production: 18731.97 Thousand MT
- Leading tomato growing areas: AP, UP, Karnataka, Maharastra, Haryana, Punjab and etc.,

Economic Importance and uses:

- Used for soup, salad, pickles, ketchup, puree, sauces etc.
- Major source of vitamin C and minerals.
- In India - 'poor mans orange' (Ascorbic acid 15 mg to 20 mg /100g edible portion).
- Rich in Citric acid and Mallic acid.
- Tomato contains - Na, K, Ca, Mg, P, K, Fe, Zn, Boron.

Varieties:

- **Pusa Ruby:** An early variety, plant habit is indeterminate; fruits are flattened, grooved, firm, medium-sized, uniform ripening, red and round; suitable both for rainy and spring seasons. Crop duration 130 to 135 days. Yield 12t/ha.
- **Pusa Early Dwarf:** Plant determinate; early ripening; fruits medium-sized, smooth, round oblate, red coloured; suitable for autumn season. Crop duration 120 to 130 days. Yield 12t/ha.
- **Marutham:** Fruits round, smooth, attractive suitable for summer season. Crop duration 135 to 140 days. Yield 12-14t/ha.
- **Arka Saurabh:** Semi indeterminate plant growth; fruit round, medium-large, deep red, nipple tipped; suitable for both fresh market and processing; Crop duration 130 days. Yield 7-8t/ha.
- **Arka Vikas:** Fruits medium large with uniform deep red colour, suitable for fresh market, tolerant to moisture stress. Crop duration 10-110 days. Yield 14-16/ha.
- **Other commercial varieties:**, Arka vital, Pusa 120, , S-12, Co 1, Pusa Lal Meeruti, Roma, Punjab Chuhara

Climate:

- Tomato is a warm season vegetable require a long season optimum temperature is 21 to 24⁰C. Mean temperature 16⁰C and above 27⁰C are not desirable.
- Temperature and light intensity effect the fruit set, pigmentation and nutritive value.
- Development of colouring pigment, lycopene will be hampered above 27⁰C.

Soil:

Tomato can be grown in a wide range of soils from sandy to heavy soils. A well drained, fairly fertile loam with fair moisture holding capacity is ideal for growing a good crop of tomato.

→ Tomato cannot withstand water logging. It is moderately tolerant to acid soil having pH 5.5 and ideal pH requirement is 6-7.

Cropping Systems:

- Cauliflower – Potato – Tomato, Rice – Tomato – Maize followed over all India
- Cauliflower – Potato – Okra, Sun flower – Cabbage – Tomato, Maize – Tomato – Water melon followed South Indian conditions
- Tomato is well fitted in different cropping systems which include cereals, grains, pulses and oil seeds.

Sowing time and seed rate:

Under mild climatic conditions, where there is no danger of frost, three crops can be raised in a year. In the hills, seeds are usually sown in March-April. In plains is grown during June to November.

Seed rate:

Open pollinated variety: 400-500 g / ha

Indeterminate F₁ hybrid: 125-175 g / ha.

- ☞ Seeds sown in an area of 4-5 cents (200-240 m²) will be sufficient to plant one hectare. Four to five weeks old seedlings are used for transplanting. Hardening of seedling is essential for their establishment in main field and is done by withholding irrigation for one week before transplanting.
- ☞ Seed treatment with fungicides like Captan or Cereson or Thiram @2g/kg
- ☞ The beds are fumigated with steam or formalin 40% after that covered with polythene sheet for 24 hours. It will minimize the attack of insect, pest and diseases.
- ☞ Protected Nursery/ Plug tray nursey: Protects the seed lings from insects and reduces vector borne viruses infestation and damage by other pest and diseases.
- ☞ Seed lings are watered daily or in alternate days.
- ☞ Stocky 25-35 days old, healthy seedlings of 10-15 cm height with 3-4 leaves are ideal for transplanting.

Transplanting:

Seedlings are transplanted on raised beds or on sides of ridges. Field is ploughed 4-5 times and raised beds of 80-90 cm width or ridges and furrows are prepared.

 Khariff : 60x45cm

 Rabi : 60x60cm

 Summer : 45x30cm

Manures and fertilizers

- ☛ Manure and fertilizer recommendation for tomato depends on the growth habit and productivity of variety and it varies from state to state.

- ☛ In most of states, in addition to 15-20 tonnes of FYM, 100-125 kg, N, 50-60 kg P₂O₅ and 50-60 kg K₂O are recommended for one hectare. Recommendation for F1 hybrid is 250:250:250 kg NPK/ha.
- ☛ Regarding the inorganic chemical fertilizer's half N, entire P and K should be applied as basal dose, half N is given in 2 to 3 splits. 30, 45, 60 days after sowing.
- ☛ Micro nutrients like B, Zn also need to be applied and lime is essential under acidic soil. Availability of Boron is considered to be essential for production of large size fruit with high vitamin content and prevent fruit cracking, while Zinc for higher ascorbic acid content and tolerances to diseases.
- ☛ Application of 25-30kg/ha of borax and 0.5% Zn is beneficial for yield and good quality of fruit.

Irrigation

- ❖ Furrow irrigation is the most common method in tomato and the crop require adequate moisture throughout growth period.
- ❖ Frequency of irrigation depends on the climatic and soil conditions. During summer, crop should be irrigated at 3-4 days interval.
- ❖ Water stress at flowering stage will adversely affect fruiting and productivity.
- ❖ A long spell of drought followed by heavy irrigation leads to cracking of fruits. Similarly, a dry spell after regular irrigation causes blossom end rot.
- ❖ Drip irrigation and sprinkler irrigation are becoming more common in areas of water shortage.

Inter-cultivation

Weeding, hoeing, earthing up and mulching are very important intercultural operations in tomato crop. In initial stages of crop growth 2-3 hoeing's are essential to keep the soil around the plants loose and free from weeds for better growth of the plant.

Field should be kept weed free by frequent weeding, hoeing and earthing up. Application of pendimethalin (1.0 kg a.i. / ha) as pre emergence spray along with one hand weeding at 45 DT is ideal for tomato.

Harvesting:

- ☛ In Indeterminate cultivars fruits can normally be harvested 70-100 days after planting. While determinate cultivar may begin fruit at 70 days depending on the environmental conditions.
- ☛ Generally, the tomatoes are harvested at mature green to turning stage for long distance marketing. Pink to light red for fresh local market.
- ☛ Harvesting maturity depends on the purpose whether for fresh market, processing, long distance transport etc.

Yield: Open pollinated variety: 20-25 t/ha

Hybrids: 50 t/ha

Seed production in Tomato:

Tomato is a self pollinated crop. Isolation distance recommended for tomato is 50-100mt.

Seed extraction:

Seeds of tomato can be extracted by three methods 1. fermentation; 2. acid treatment; 3. alkali treatment.

1. Fermentation:

Ripe fruits are crushed in non-metallic box. Entire mass is kept for fermentation. 4 to 5 days are required at 15 to 20⁰ C temperature complete fermentation. From formation and adhering of sweet in tomato flesh indicates completion of fermentation. Some chemicals present in the pulp suppress the seed germination before completion of fermentation.

Fermented mass and debris on top are removed. Seeds settle down at the bottom of the container. They are collected and washed thoroughly by clean water. Seeds are dried in the sun and stored in a cool dry place

2. Acid treatment:

HCl is used for a quick break down of gelatinous substance on the surface of the tomato seeds. About 250 ml of commercial H₂ SO₄ is thoroughly mixed with 10 litres of slurry and left for 30 min. The pulp is again stirred and washed and then allowed to dry in the sun. seed extracted by this method germinate well.

3. Alkali treatment:

Seed slurry is mixed with 10% washing soda in equal volumes and kept overnight in an equal volume and kept in an earthen pot. All the seeds will settle down at the bottom of the container. The clean liquid is washed off. Seeds are thoroughly washed with clear water and allowed to dry in the sun.

This is the safest method of seed extraction.

Physiological disorders

1. Blossom end rot:

- It is more common and destructive serious, ground discoloration starts.
- In blossom end of the fruit. Black spot develops to encompass ½ to 2/3rd portion of the fruit.
- Later the tissues shrink and skin becomes dark grey to black



Causes:

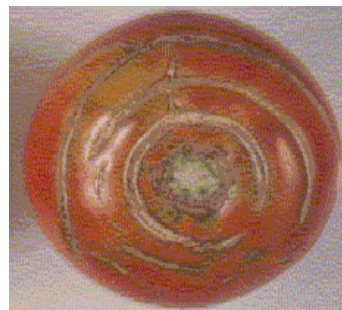
- Use of Ammonium sulphate, imbalance of Mg & K; deficiency of calcium
- Sudden change in the rate of transpiration especially in moisture stress conditions

Remedies:

- Cultural practices that concern soil moisture and maintain uniform moisture supply.
- Foliar spray of 0.5% CaCl₂ and apply Nitrogen in the form of Urea

2. Fruit cracking:

- They are Four types of cracking.
- Radial cracking: occurs mostly at ripe stage.
- Concentric cracking: it is common in mature green stage.
- Burst and circular fruit cracking appear very rarely



Causes:

- Fruit cracking occurs in middle of the May.
- Cracking also occurs in rainy season when rains fall in long dry spell.
- Boron deficiency in the soil also causes fruit cracking

Remedies:

- Picking of the fruit before the full ripe stage.
- Soil application of Borax @ 10 – 15 kg per ha or spray borax @0.25% at ripening stage

3. Puffiness

- Commonly known as hollowness or Tomato puffs or puffy tomatoes.
- As the fruit reaches about 2/3rd normal size outer wall continues to develop normally but remaining internal tissue growth is retarded.



Causes:

- Non fertilization of ovules
- Embryo abortion after normal fertilization
- High temperature and high soil moisture are predisposing factors.

Remedies:

- Maintenance of normal temperature.
- Spraying of Borax or Solubor 10-15 ppm at the peak flowering time

4. Cat facing:

A large scar is formed at the blossom end portion of the fruit. Such fruits have ridges and furrows and blotches at blossom end.



Causes:

- Low temperature.
- Faulty pollination
- Application of nitrogen during transition from vegetative to reproductive phase.

Remedies:

- Balanced fertilizer application
- Regulation of temperature.
- Recommended cultural practices should be adopted

5. Sunscald:

When fruits and leaves are exposed to the sun, there is appearance of yellow, white patches on green and ripen fruits.



Causes:

- High fruit pericarp temperature 40°C
- In bright sunlight, surface temperature may be more than 10°C higher than the air temperature.

Remedies:

- The best protection against sunscald is to utilize cultivars with enough foliage to cover the fruit and to provide enough water and pest protection to maintain the healthy foliage
- Crops planted at higher densities are less susceptible

6. Bronzing or internal browning

Also known as grey wall. Characterized by death of tissues within the fruits associated by vascular browning. Internal browning is associated with puffing and blossom end rot disorder.



Remedies:

- Cultural practice which conserve soil moisture and maintain uniform moisture supply to the plants
- Two foliar sprays of 0.5% CaCl₂ at the time of fruit development.
- variety EL 235673 is found resistant

Pests of Tomato

1. **Fruit Borer: *Helicoverpa armigera***

Symptoms:

- ❖ Young larvae feed on tender foliage
- ❖ Mature larvae bore circular holes
- ❖ Thrust only a part of its body into fruit and eat the inner content



Management:

- ✓ Collect and destroy the infected fruits and grown up larvae
- ✓ Grow marigold crop as trapcrop
- ✓ Setup pheromone trap with Helilure at 12/ha
- ✓ Collection and destruction of damaged fruits and grown up caterpillars.
- ✓ Provide poison bait with carbaryl 50 WP 1.25 kg, rice bran 12.5 kg, jaggery 1.25 kg and water 7.5 lit/ha

2. Leaf eating caterpillar: *Spodoptera litura*

Symptoms:

- ❖ Young larva scrap leaves on ventral surface
- ❖ Grownups defoliate crops



Management:

- ✓ Plough the soil to expose and kill the pupae
- ✓ Grow castor along border and irrigation channel as trap crop
- ✓ Poison bait: Rice bran 5 Kg + Molasses or Brown sugar 500g + Carbaryl 50 WP 500g+ 3lit of water/ha. Mix the ingredients well and are kept around the field in the evening hours.
- ✓ Spray chlorpyrifos 20 EC 2 lit/ha or dichlorovos 76 WSC 1 lit/ha

3. Thrips: *Thrips tabaci*

Symptoms:

- ❖ Silvery streaks on leaf surface
- ❖ Pre-mature dropping of flowers



Management:

- ✓ Mechanically uproot the diseased plants and destroy them
- ✓ Use yellow sticky traps @ 15/ha
- ✓ Release larvae of *Chrysoperla cornea* @10,000/ha
- ✓ Spray methyl demeton 25 EC @1lit/ha or dimethoate 30 EC @1lit/ha

Diseases of Tomato

1. Damping off: *Pythium* sps.

Symptoms:

- ❖ Failure of seedling emergence from the soil either due to seed rots or killing of young seedlings before their emergence from the soil.
- ❖ Resulting in patchy appearance of seedlings stands in the nursery in early stages



Management:

- ✓ Change the nursery site every year & Used raised seed bed
- ✓ Either solarize the soil of the bed with transparent polyethylene (25 µm) sheet for 40-45 days during summer months or treat the soil with Formalin (5%) at least 20 days before sowing.
- ✓ Treat the seed with captan (0.3%) Thiram (3 g/kg of seed) is the only preventive measure to control the pre-emergence damping off.
- ✓ After seedling emergence from the soil, drench the bed with the mixture of mancozeb (0.25%) and carbendazim (0.1%) and repeat at 7-10 days Interval.

2. Early Blight: *Alternaria solani*

Symptoms:

- ❖ This is a common disease of tomato occurring on the foliage at any stage of the growth.
- ❖ The fungus attacks the foliage causing characteristic leaf spots and blight



- ❖ Spots enlarge, and by the time they are one-fourth inch in diameter or larger, concentric rings in a bull's eye pattern can be seen in the centre of the diseased area.

Management:

- ☛ Removal and destruction of crop debris and practice crop rotation.
- ☛ Spray the crop with Mancozeb 0.2 % for effective disease control.

3. Bacterial wilt: *Burkholderia solanacearum*

Symptoms:

- ❖ Characteristic symptoms of bacterial wilt are the rapid and complete wilting of normal grown up plants



- ❖ Infected plant parts when cut and immersed in clear water, a white streak of bacterial ooze are seen coming out from cut ends.
- ❖ The spreads through wounds, soil and implements.

Management:

- ☛ Crop rotations, viz., cowpea-maize-cabbage, okra-cowpea-maize, maize-cowpea-maize and finger millet-egg plant are reported effective in reducing bacterial wilt of tomato.

4. Mosaic: *Tomato mosaic virus (TMV)*

- ❖ The disease is characterized by light and dark green mottling on the leaves often accompanied by wilting of young leaves in sunny days when plants first become infected.



- ❖ The leaflets of affected leaves are usually distorted, puckered and smaller than normal. Sometimes the leaflets become indented resulting in "fern leaf" symptoms.
- ❖ The affected plant appears stunted, pale green and spindly

Management:

- ☛ Seeds from disease free healthy plants should be selected for sowing. Soaking of the seeds in a solution of Trisodium Phosphate (90 g/litre of water) a day before sowing helps to reduce the disease incidence.
- ☛ Crop rotation with crops other than tobacco, potato, chilli, capsicum, brinjal, etc.

BRINJAL

Botanical name: *Solanum melongena*

Family: Solanaceae

Origin: Indo Burma region

Common name: Egg plant

Brinjal is one of the most common tropical vegetables grown in India.

- Total cultivated area in India under brinjal was: 5.02Lac ha
Production: 83.47 lac tonnes
- Leading tomato growing areas: WB, Odisha, Gujarat, MP, Bihar etc.,

Economic Importance and uses:

- ❖ It is rich in minerals is Ca, Mg, P, K and Fe. It is also a good source of Vitamin A and C. Bitterness in Brinjal is due to presence of glycoalkaloids.

Varieties: Brinjal varieties are grouped on the basis of colour and shape of fruit.

1. **Long fruit varieties:** ex. Pusa Purple Long, Pusa Purple Cluster Long
2. **Long green varieties:** Arka Kusumakar, Arka Shirish, Krishna Nagar Green Long.
3. **Round purple:** ex: Pusa Purple Round, Arka Navaneet, Pant Rituraj, , Shyamala.
4. **Round green:** BanarasiGaint, Round Striped.
5. **Roundish white:** Ex: Manjeri, Visali, Swetha
6. **Oval or Oblong fruited varieties:** Junagad Oblong, Bhagyamati, H4., Pusa Anmol
7. **Cluster fruited varieties:** Ex: Pusa Purple Cluster, Arka Kusumakar, Bhagyamathi (APAU variety).
8. **Spiny varieties:** H-4, Manjeri.

Climate:

Brinjal is the warm season crop. It is susceptible to severe frost. It requires a long warm season, before fruit maturity. Optimum temperature is 22 to 33⁰ C.

Soil:

Brinjal is a hardy crop and is cultivated under a wide range of soils. Since a long duration crop with high yield, well-drained and fertile soil is preferred for the crop. Crops grown in sandy soils yield early and those grown in clayey soils yield more. Ideal pH for cultivation of crop is 5.5-6.6.

Season:

In hills, brinjal is sown during March and transplanted during April. In, plains there are three seasons for growing brinjal.

Seed rate: seed rate varies from 375 to 500 g per hectare.

Nursery raising:

- Seeds are sown in nursery bed and transplanted to main field after four weeks during summer and after 7 to 8 weeks during winter, when it is 8 - 10 cm tall.

- Since brinjal seedlings grow fast, sufficient care must be taken to sow seeds as thin or loose as possible. Hardened seedlings withstand transplanting shock better and establish well in main field.
- Seeds sown in an area of 4-5 cents (200-240 m²) will be sufficient to plant one hectare. Four to five weeks old seedlings are used for transplanting. Hardening of seedling is essential for their establishment in main field and is done by withholding irrigation for one week before transplanting.
- Seed treatment with fungicides like Captan or Cereson or Thiram @2g/kg
- The beds are fumigated with steam or formalin 40% after that covered with polythene sheet for 24 hours. It will minimize the attack of insect, pest and diseases.
- Protected Nursery/ Plug tray nursery: Protects the seed lings from insects and reduces vector borne viruses infestation and damage by other pest and diseases.
- Seed lings are watered daily or in alternate days.

Main field preparation and transplanting

Proper drainage is essential for growth of brinjal. Soil should be prepared to a fine tilth by 4 to 6 ploughings. FYM should be incorporated in soil at the time of final ploughing. Seedlings are transplanted in levelled land in plots of convenient size for irrigation. It may be grown on raised beds/ ridges during rainy season.

Planting distance of transplanting depends on soil fertility, climatic conditions and varieties. Long fruited varieties are transplanted at a spacing of 60 x 60 cm. Round fruited varieties at 75 x 75 cm.

Manures and fertilizers

Brinjal is a long duration crop with high yield potential. Flower and fruit production will be adversely affected when crop is grown under low fertility conditions. Depending on availability, 25 tonnes of FYM/ha may be incorporated in soil at the time of final ploughing.

NPK @ 100, 80, 60 kg per ha is generally applied, ½ of nitrogen full quantities of P and K is applied at the time of transplanting while the remaining quantity of nitrogen may be applied either twice or thrice depending upon soil conditions at 30 days, 45 days after transplanting.

Irrigation:

Brinjal is a shallow rooted crop it needs frequent irrigation. The crop is irrigated at 3 to 4 day interval during summer season 12 to 15 days during winter season. However during rainy spells irrigation is not needed. Brinjal is generally irrigated by furrow system of irrigation.

Inter-cultivation

Weeding, hoeing, earthing up and mulching are very important inter-cultural operations in tomato crop. In initial stages of crop growth 2-3 hoeing's are essential to keep the soil around the plants loose and free from weeds for better growth of the plant.

Field should be kept weed free by frequent weeding, hoeing and earthing up. Oxyfluorfen (0.25 kg a.i. / ha) Goal (0.25 kg a.i./ha) and Basalin (1.0 kg a.i. / ha) were also ideal as pre emergence application. Mulching with straw or plastic is also effective for weed control and for regulating soil temperature.

Harvesting:

Brinjal fruits are harvested at immature stage after attaining full size, but before loosing its glossy appearance. Dullness of fruit indicates over maturity. Usually fruits are harvested along with its stalk with a slight twist by hand. In some varieties, a sharp knife is also used for harvesting fruits along with fleshy calyx and a portion of fruit stalk.

Yield:

- Early short duration varieties: 20-30 t/ha
- Long duration varieties: 35-40 t/ha

Storage:

Under ordinary conditions the fruits can be stored for 1 to 2 days in summer, 3 to 4 days in winter at temperature of 7.2°C at 85 – 90% RH.

Seed production in Brinjal

Though brinjal is considered a self pollinated crop, varying amount of cross pollination takes place because of heterostyly. Cross pollination is observed upto 20%. Isolation distance recommended for brinjal is 200 m for foundation seed and 100 m for certified seed.

There are two basic methods used for the extraction of brinjal seed, a wet and dry extraction process. There is a general tendency to favour the wet extraction especially in large scale seed production. The dry process is favoured where relatively small amounts of seed are produced.

CHILLI

Botanical name : *Capsicum fruitiscens* – Bell pepper

Capsicum annum - Chilli

Family : Solanaceae

Origin : Peru

- ❖ Chilli is also called as hot pepper and Capsicum is also called Bell pepper.
- ❖ Andhra Pradesh had been leading both in area and production, contributing an average of 25% of the total area and over 40-50% of total production.
- ❖ Andhra Pradesh, Karnataka, Maharashtra, Orissa, Tamil Nadu, MP, WB and Rajasthan account for more than 80% of the total production.
- ❖ Total cultivated area in AP under chilli was: 4.41 Lac ha
Production: 5.14 Lac MT
- ❖ Leading tomato growing areas: WB, Odisha, Gujarat, MP, Bihar etc.,

Importance and Nutritive value:

- ☛ Green chillies are rich in proteins 2.9 g per 100 g. Ca, Mg, P, K, Cu and S. vitamins like Thiamine, Riboflavin and Vitamin C.
- ☛ Chillies are the major ingredients in curry powder.
- ☛ Pungency of chillies is due to capsaicin. The pigment (colour) in chillies is due to capsanthin also contains many other oleoresins which permits better distribution of colour and flavour in food.
- ☛ Indian chillies are mainly exported to Srilanka, USA, Canada, UK and Saudi Arabia etc.

Varieties

- **Andhra Jyothi** or G5: released from Lam Guntur. Fruits are short and called as Gundu types.
- **Bhagya laxmi** (G4): selection from thohian chillies grown largely for green chillies.
- **Sindhuri**: Tall growing and less pungent variety suit for green chillies
- **Baskar/ CA -235**: released from Lam, Guntur, anther mutant, Resistant to Thrips and Mites
- **Hissarsakthi**: multiple resistant variety developed at hissar.
- **Arka lohit**: highly pungent variety and Tolerant to Powdery mildew
- **MDU-1**, Ankur-1: Mutant varieties
- **Pujab Lal, Arka Abir**: Suitable for colour extraction

Climate:

Chilli is grown in both tropical and sub-tropical areas. It requires a well distributed annual rainfall of about 800 – 1200 mm. The crops continue to develop at high temperature but root development is retarded at a temperature of 30⁰ C. Fruit development is adversely retarded at 38⁰ C.

Soil:

Chilli can be grown on a wide variety of soils provided. They are well drained, well aerated and rich in organic manure. Ideal pH 6 to 7.

Season of sowing

Chilli seeds are sown in nursery beds during May-July. In south states chillies can be in May-June and September to October.

Seed rate

Varieties: 1.0 kg / ha.

Hybrids: 200 - 250 g / ha.

Nursery area: 100 sq.m / ha.

Seed treatment and Nursery raising

- Treat the seeds with Trisodium Artho Phosphate @ 150g/1kg seed for preventing viral diseases, imidacloprid @ 8g/1 kg seed for sucking pests and Captan/ Mancozeb @3g/kg seed for diseases.
- Drench the nursery with Copper oxychloride @ 2.5 g/l of water at 15 days interval against damping off disease.
- Prepare the nursery area of 3 cents with slanting slope of 2 % for the seedling production to cover 1 ha.
- Cover the nursery area with 50 % shade net and cover the sides using 40 / 50 mesh insect proof nylon net.

Field preparation

Thoroughly prepare the field with the addition of FYM @ 25 t/ ha and form ridges and furrows at a spacing of 60 cm. Apply 2 kg/ha of Azospirillum and 2 kg / ha of Phosphobacteria by mixing with 20 kg of FYM. Irrigate the furrows and transplant 40-45 days old seedlings, with the ball of earth on the ridges.

Transplanting:

Seedlings ready for transplanting 35 to 45 days. Short thick stem seedlings are preferred for better establishment. In older seedling topping has to be done one week prior to transplant. Early seedlings are transplanted singly different spacing 30 x 30 cm 45 x 30 cm, 45 x 45 and even 30 x 20 were tried in chillies.

Varieties: 60 x 45 cm Hybrids: 75 x 60 cm

Water Management

Chilli cannot with stand heavy moisture, hence, irrigation should be given only when necessary. Frequent and heavy irrigations induce lanky vegetative growth and cause flower shedding. The number of irrigations and interval between irrigations depend upon soil and climatic conditions.

Weed management

The critical stages for weed management are upto 90 days after sowing in direct sown crop and 60 days for transplanted crop. For effective weed management in nursery as well as in transplanted crop, application of pre-emergence weedicide *i.e.*, pendimethalin @ 3.0 ml/l within 2-3 days after sowing was found effective.

Manures and Fertilizers

Recommended a basal dose of 25 tonnes of Farm Yard Manure per hectare in June-July. A dose of 300N:60P:120K per hectare gave higher yields under irrigated conditions. Application of N in 3-4 split doses is more beneficial.

Inter Cultivation

Chilli requires frequent intercultivation. In the direct sown crop blade harrow is worked starting from 30th day of sowing. Four inter cultivations are needed at 10 days intervals alternated with blade harrow and tyned harrow. Final inter cultivation is given by the country plough.

Harvesting: Flowering begins 40 to 60 days after transplanting depending upon variety climate, nutritional status of plant. Roots starts ripening about 3 months after transplanting and picking may go on for 2 to 3 months.

Yield:

- Varieties: 2 - 3 t/ha of dry pods or 10 - 15 t/ha of green chillies.
- Hybrids: 25 t / ha of green chillies.

Dry Chilli:

- Varieties have thin pericarp, less seed and strong spike is suitable for drying
- Dry chilli contains 6% stalks, 40% pericarp and 54% seed.
- Well dried -12 % moisture, Big size, Bright red colour without whit chillies, Uniform size Length - 1.5-2 inches.

OKRA

Botanical name: *Abelmoschus esculentus*

Family : Malvaceae

Origin : South Africa

Okra is predominantly a crop of tropics and subtropics. It occupies fifth position, next to tomato, in area under vegetables in the country with a production of 33.24 lakh metric tonnes from an area of 3.47 lakh hectares.

❖ Total cultivated area in AP under chilli was: 21.5 thousand ha

Production 1.73 Lac thousand tonnes

Importance and nutritive value:

- The crop is cultivated for its young tender fruits, used in curry and soups after cooking. It is a good source of vitamins A and B, protein and minerals.
- It is also an excellent source of iodine and is useful for the treatment of goiter
- Dry fruit skin and fibres are used in manufacture of paper, card board and fibres. Root and stem are used for clearing cane juice for preparation of jaggery.

Varieties:

- **Arka Anamika:** Its plants are 100cm, upright, Fruits are dark green with 5 prominent ridges and comparatively less smooth surface. It takes 50 days (6th node) to first flowering and 55 days to first picking of tender marketable fruits. It is excellent yielder in south but with a lower performance in northern India. It is resistant to yellow-vein mosaic, the yield being 125q/ha.
- **Parbani Kranthi:** First flush becomes ready 55 days after sowing. The fruits are smooth, dark green, tender, slender, 5-ridged with long beak. Average green fruit yield varies from 85–90q/ha during spring-summer to 115q/ha in rainy season
- **Pusa Makhmali:** Fruits are light green, tapered, attractive and 12–15cm long, the yield potential being 80–100q/ha.
- **Pusa Sawani:** It needs 45–50 days from sowing to first picking. First fruit is borne on 6–8 node. Upper leaves are deeply lobed. Its yield is 120–125q/ha
- **Perkins long green:** Recommended for hilly areas
 - IIHR, Bangalore: Arka Abhay, Arka Anamika, Sel 4, Sel 10
 - IARI, New Delhi: Pusa Makhmali, Pusa Sawani
 - Punjab Agricultural University, Ludhiana: Punjab Padmini

Climate:

Okra prefers warm climate. It is sensitive to frost and requires frost free growing period. Optimum temperature 24 to 27°C. Seed does not germinate when the temperature is below 20°C. Plant growth is greater in rainy season, compared to summer season. Temperature higher than 42°C may cause flower drop.

Soil:

Okra prefers loose, well drained and rich soil. Roots are sensitive to high water stagnation. The ideal pH for growth of plants is 6-8.

Time of sowing:

In areas where winter is mild, bhendi is grown throughout the year. In north India summer crop is sown in February to March. In South India generally sown in November as main crop. However rainy season crop is sown in June-July throughout India.

Seeds and sowing:

- 20 to 25 kg per ha is required for summer crop and 12 to 15 kg per ha is required for rainy season crop.
- During summer seed is soaked in water at 12 to 24 hours the field is laid out in to ridges and furrows in flat bed.
- Sowing can be done by broad cast, line sowing and dibbling method. Sowing of okra is done in pits in west Bengal.
- Spacing adopted in summer season crop is 30 x 30 cm whereas rainy season crop is sown in rows at a spacing of 60 x 30 cm.

Land preparation and sowing

Field is ploughed thoroughly for 2-3 times for making soil to a fine tilth. Ridges and furrows or raised beds are prepared and dibbling on sides of ridges or on raised beds sow the seeds. Soak seeds for 6-12 hours before sowing to enhance germination during summer.

Manuring:

Well decomposed FYM @ 20 to 30 kg per has applied thoroughly in soil about 20 days before sowing. Besides this 100 kg N, 60 kg each of P and K are recommended $\frac{1}{2}$ nitrogen, full quantity of P and K are applied at 30 to 45 days of sowing at top dressing.

Irrigation:

First irrigation is given after seeds are germinated subsequently field is irrigated at an interval of 4 to 5 days in summer in case of rainy season there is no much emphasis on extra irrigation. Drip irrigation as given higher yield compared to furrow irrigation.

Inter culture:

First weeding is done 15 to 20 days after sowing. A total of 3 to 4 weedings is taken. Herbicide like basalin (fluchloralin) @ 2.5 lit per ha at pre plant incorporation.

Germination commences in 13 to 15 days of sowing and it can be over in another week. The crop is thinned at 30 days after sowing to maintain plant to plant distance of 30 cm.

Harvesting and yield:

- Harvest the fruits when they attain maximum size but still tender. Fruits of 6-8 cm long are preferred for export purposes.
- This is usually attained by 5-6 days after opening of flower.
- Harvesting is done in alternate days with a knife or by bending pedicel with a jerk.
- For harvesting, cotton cloth hand gloves should be used to protect fingers from stinging effect. It is advisable to harvest in morning hours since fruit hairs will be soft.
- Sprinkling water on pods during night will keep them cool and fresh for market.

Yield:

It varies from 60 to 75 quintols per ha in summer and 120 to 125 quintols per hectare in rainy season. Okra can be stored just for 2 to 3 days under room temperature conditions.

Seed production in Bhendi

Being an often cross-pollinated crop, provide an isolation distance of 400 m from other varieties. Field inspection and rouging should be conducted at pre-flowering, flowering and fruiting phases. Harvesting of initial two fruits will be helpful in promoting growth of plants.

PEAS AND BEANS

GARDEN PEA

Botanical name : *Pisum sativum*

Family : Fabaceae

Origin : Ethiopia

- ❖ Peas are highly nutritive and contain high content of digestible protein, Carbohydrate, Vitamin-C, phosphorus and minerals.
- ❖ Tender seeds are also used in soups. Like any legume crop, pea is an integral component of sustainable agriculture due to its soil enriching and conditioning properties.

Total cultivated area in AP under pea was: 385 ha

Production 100.45 tonnes

Varieties:

Basal on maturity period

1. **Early types** – green pods will be ready for harvest by 65 days after sowing.
Ex: Arkel, Asauji, Jawahar Matar-4, Early badger
2. **Mid season types** – pods will be ready for harvest by 85-90 days after sowing.
Ex: Bonneville, Jawahar Matar-1, Jawahar Matar-2, Pant uphar
3. **Late season types** – pods will be ready for harvest by 110 days after sowing
Ex: NP-29

Climate:

Optimum monthly mean temperature for growth of plants is 10-18.3°C. As temperature increases the maturity is hastened and yield is reduced.

Soil:

Crop prefers well drained, loose and friable loamy soil for early crop and clayey soil for high yield. Ideal pH is 6.0-7.5 and it grows under alkaline soil. If soil is acidic, liming is recommended

Season:

Pea is sown from beginning of October to middle of November. Yield is drastically reduced when crop is sown after 4th December. Crop sown in September will be susceptible to wilt disease.

Sowing and seed rate:

Soil is prepared to a fine tilth by disc ploughing followed by one or two harrowing. Seeds are sown in flat or raised beds by broadcasting or by dibbling at 2.5-5.0 cm depth.

- ❖ Early varieties are sown at a closer spacing of 30 x 5-10 cm and the seed rates is 100-120 kg/ha.
- ❖ Mid season and late varieties are sown at wider spacing of 45 x 10 cm.
- ❖ Late varieties are sown on either edge of raised beds which are 120-150 cm wide with furrows in between.
- ❖ Seeds treated with carbendazim 3g./kg seed before sowing.

Manures and fertilizers:

Well decomposed FYM is applied at a dosage of 8 to 10 t/ha at least 15 days before sowing. NPK should be applied in the ratio of 30: 50: 25 kg per ha. Foliar application of 0.1% ammonium molybdate is given to increase the number of root nodules, yield, TSS and number of grains per pod.

Irrigation:

Crop requires 2 or 3 irrigations. First irrigation is given 40 DAS, second irrigation at bloom stage 60 DAS. Method of irrigation – furrow method

Inter culture:

Manual or mechanical weed control has to be taken care of chemical weed control i.e. gaining dominance because it is cheaper and less time consuming. Various herbicides recommended are lasso (alachlor) at the rate of 0.75 kg a.i./ha, basalin at the rate 2 kg a.i./ha.

Harvesting

Since tender peas with high sugar content fetch premium price in market, care should be taken to harvest pods at correct maturity. Toughness of seeds is determined using Tendrometer, especially for processing purposes

Yield:

Early varieties 30 to 40 Q/ha

Late and Mid season varieties 60 to 70 Q/ha

Shelling percentage from 35 to 50 depending on variety, agro-climatic conditions, management practices, grain yield about 15 to 20 Q per ha.

DOLICHOS BEAN

Botanical name : *Dolichos lablab*

Family : Fabaceae

Origin : Ethiopea

- ❖ Dolichos bean is a good source of protein, mineral and vitamins.
- ❖ Methionine is the limiting amino acid in Dolichos bean.
- ❖ Dolichos bean is primarily grown the green pods which are cooked as vegetable.

Varieties:

Pole types: Pusa early prolific, Pusa Sem 2, Pusa Sem 3

RND- 1: High yielder, 210-240 days crop duration, yield 15-18t/ha

Bushy types:

Arka jay: released for IIHR, Bangalore, photo-insensitive variety. Fruits are long and curved, 75 to 80 days crop duration, plants are bushy.

Climate:

Indian bean can grow both in tropical and sub-tropical climatic conditions. It is susceptible to frost, extreme hot, cool season is relatively favourable.

Soil:

Crop prefers well drained, loose and friable loamy soil for early crop and clayey soil for high yield. Ideal pH is 6.0-7.5

Seed rate: 20 to 30 kg per ha.

Spacing: 100 x 75 or 75 x 75 cm is given for a pure crop

Season of sowing: Indian bean is sown in month of July, August. It can be sown early also, in areas where rain comes early.

Manures and fertilizers:

10 to 15 t of well decomposed FYM 13 kg N, 15 kg P, 40 kg K are applied organic manure is applied during land preparation along with half N, whole quantity of P and K. remaining half Nitrogen is top dressed at 30 to 35 DAS.

Irrigation:

Occasionally light irrigation was given. Dolichos bean can tolerate dry conditions during flowering. Optimum moisture should be maintained to reduce flower drop varietal character is also one up of the reason for flower drop.

Harvesting

Harvest the pods when they attain maximum size but still tender. This is usually attained by 2-3 weeks after opening of flower.

Yield: 50 to 90 quintals of green pods per hectare.

Seed yield: 0.6 to 0.8t/ha

Seed production in dolichos bean

Being an highly self-pollinated crop, provide an isolation distance of 50 m from other varieties.

FRENCH BEAN

Botanical name : *Phaseolus vulgaris*

Family : Fabaceae

Origin : Ethiopea

French bean is an important cool season legume vegetable grown for its tender pods, shelled green beans and dry beans (Rajmah beans). Dry beans are rich in protein.

Varities:

Arka komal: Pods straight, flat, and green with large brown seeds. Good transport and keeping quality. Yield 19 t/ha and 3 t/ha seed in 65-70 days.

Bountiful: High yielder, 4 4.8t/ha

Contender: Plants bushy with pink flowers. Pods green, round long and stringless. Tolerant to mosaic and powdery mildew. Yield 20 t/ha.

Pusaparvathi: Developed through irradiation followed by selection from wax podded variety EC 1906. Plants bushy with pink flowers. Pod green, round long. Resistant to mosaic and powdery mildew. Yield 22-25 t/ha

Climate:

French bean is a cool season crop. It gave good yield under mild warm season. It is sensitive to frost. Optimum temperature 15-21⁰c

Soil:

Crop prefers well drained, loose and friable loamy soil for early crop and clayey soil for high yield. Ideal pH is 6.0-7.5

Seed rate:

Bush type of cultivars - 95 kg/ha

Pole type of cultivars - 25 to 30 kg/ha

Spacing:

Bush type- 60 x 15 cm

Pole type- 1 m x 60 – 75 cm x 30 cm Seeds are sown 5 cm deep.

Sowing:

French bean is sown twice in a year. First sowing is done in July to September and second time in January to February.

Manures and fertilizers:

It has poor nodule formation capability, well decomposed FYM up to a dosage of 20 to 30 t/ ha is given, besides that 60 kg N, 40 kg P and K are applied. Nitrogen is applied in two splits. Half nitrogen first split is given at the time of sowing whole quantity of P and K. Second split is given at flowering stage.

Irrigation:

Irrigation is required in the early phases of crop growth during blooming and pod development period. Plants are susceptible to water stress. Irrigation at regular intervals are necessary. Lack of adequate soil moisture results in reduced percentage of pod setting, reduced length of pods, reduced number of seeds per pod and high fibre content in pods.

Inter cultivation:

Shallow cultivation is to be done at early stages of crop growth. Deep cultivation will disturb plant growth because of root pruning. Cultivation in early stages helps to keep down the weeds.

Dwarf varieties do not need support. Climbing varieties need to be supported with bamboo sticks. Single stick is fixed near each plant.

Harvesting:

- Pods are ready for harvest, 2 to 3 weeks after first blossom. Pods are harvested when they are young, tender and delicate.

- Mature pods contain developing seeds. These are separately picked and shelled.

Yield:

Bushy varieties is 4 to 5 t/ha,

Pole varieties 7 to 10 t / ha

Yield of dry seeds varies from 1.2 to 1.8 t / ha.

Seed production in French bean

Being an highly self-pollinated crop, provide an isolation distance of 50 m from other varieties.

CLUSTER BEAN

Botanical name : *Cyamopsis tetragonolobus*

Family : Fabaceae

Origin : Ethiopea

- Pods of cluster bean are rich in food value they are rich in protein, minerals, vitamin A, vitamin C.
- Tender pods are used as vegetables in south India. They are dehydrated and stored to use.
- It is also nutritious fodder. Mucilaginous seed flow is valued as Guar gum (galactomannan).
- This gum is used in textiles, paper, cosmetics and oil industries. It is useful adsorbent for explosives.

Varieties:

- ❖ **PusaMausami:** it is good for rainy season, photo sensitive variety.
- ❖ **Pusasadabaha:** it is selection from local cultivar from Rajasthan, non branching type.
- ❖ **Pusa Nav Baha:** it consists of good characters of both Pusa Mausami and Pusa Sadabaha.

Climate:

This hardy and drought tolerant crop comes up well during summer and rainy. It cannot tolerate shade and prefers long day condition for vegetative growth and short day condition for flowering.

Soil:

Crop prefers well drained, loose and friable loamy soil for early crop and clayey soil for high yield. Ideal pH is 7.5-8.0

Seed rate: seed rate varies due to cultivar in general 30 to 40 kg per ha

Seed sowing:

Seeds are either broadcasted or dibbled behind country plough at a distance of 25-30 cm. Seeds are also dibbled at specified spacing of 45-60 cm x 15 cm.

Season: Main rainy season crop is sown during June-July and extended up to September October. Summer crop is raised by sowing during February-March.

Manures and fertilizers:

Requirement of manures and fertilizers of cluster bean is less because it is sensitive crop. Well decomposed. FYM is applied up to 20 t/ha. Nitrogen 20 kg / ha; 70 kg/ha P and K are to be given. Nitrogen may be applied in two splits.

Intercultural operations:

The field is kept free of weeds during initial stages. Though a hardy crop.

Irrigation:

Irrigation at flowering and fruiting stages is the most critical. For getting high yield in vegetable types, irrigation may be done at 7-10 days interval. Stacking is also necessary to avoid lodging in tall varieties.

Harvesting and yield:

- Harvesting starts 40 days after sowing and pods are harvested at tender stage.
- A vegetable yield of 5-8 tonnes and seed yield of 0.6 to 1.0 t/ha are expected within crop duration of 120 days.

COWPEA

Botanical name : *Vigna unguiculata*

Family : Fabaceae

Origin : Ethiopia

- ❖ Tender pods are used as vegetable and dry beans as pulse.
- ❖ Due to its nutritive value and soil improving properties, it is also used as a fodder, green manure and cover crop.
- ❖ Being a legume crop, cowpea fits well in inter-cropping system.

Varieties:

- ❖ **Arka Garima:** Plants vigorous, bushy, with purple flowers. Pods round and thick, fleshy and string less. Tolerant to heat and drought. Yield 18 t/ha in 90 days.
- ❖ **Pusa Komal:** Plants bushy, flowers in 45 days. Pods light green, 25-30 cm long. Resistant to bacterial blight. Yield 10 t/ha
- ❖ **Vyjayanthi:** Fruit weight 16.17 g; No. of seeds / pod 20-22; Productivity 12.6 t/ha.

Climate:

Cowpea is a warm season crop and comes up well between 21-35°C. Grain types and dual purpose types are tolerant to hardy conditions including high temperature, drought and poor soil.

The climbing yard long bean prefers mild climate than grain types. Performance of varieties varies with day length, rainfall and temperature.

Soil:

Cowpea can be grown in any soil, fertile loose soil rich in humus is required for a prolonged harvest.

Season: In areas where winter is mild, cowpea can be grown throughout the year.

Land preparation and sowing:

Land is prepared to a fine tilth by 2-3 ploughing and harrowing. Field is divided into plots of convenient size and seeds of bushy varieties are dibbled at a spacing of 30 x 15 cm with 1-2 seeds per hole.

- ❖ Bushy vegetable types: Seed rate: 20-25 kg/ha, Spacing: 30x15cm
- ❖ Semi-trailing vegetable types: Seed rate: 20-25 kg/ha, Spacing: 45x30cm
- ❖ Trailing vegetable types: Seed rate:4-5 kg/ha, Spacing: 2x2m

Manures and fertilizers:

Recommended a fertilizer dose of 20:30:10 kg NPK / ha along with 20 t. of farmyard manure for cowpea.

Irrigation:

Cowpea, in general, is sensitive to water logging and requires less moisture compared to other vegetables. Grain types require only 2-3 protective irrigations at flowering and pod development stages. Water requirement of vegetable types with protracted and long fruiting phase is more than that of grain types.

Inter culture:

Shallow cultivation and earthing up is necessary during early stages of crop to check weed growth. Fluchloralin (2 litres /ha) will effectively check weed growth for 20-25 days. Once crop is covered, weeds will naturally be under control.

Harvesting and yield:

Tender fruits are harvested after attaining full size but before they become fibrous. Yard long bean is usually harvested in alternate days and harvesting period extends up to 45 days under good management practice

Yield

- Bush varieties - 4-5 t/ha
- Semi-trailing varieties - 7-8 t/ha.
- Yard long bean varieties - 15-18 t/ha

Seed yield

- Bush varieties - 750-1250 kg/ha
- Semi - trailing varieties - 1000-1500 kg/ha.
- Yard long bean varieties - 450-600 kg/ha:

CUCURBITS

Crops belonging to family Cucurbitaceae are generally known as 'Cucurbits'. It consists of a wide range of vegetables either used for salad purpose (cucumber) or for cooking (all gourds), pickling (West Indian gherkin) or as dessert fruit (muskmelon, water melon) or candied or preserved and sweet (ash gourd). As a group, cucurbits occupy the largest area in India and in other tropical countries. The family Cucurbitaceae comprises about 117 genera and 825 species in warmer parts.

General features

Cucurbit vegetables have the following common features:

- **Long tap root system:** Tap root may grow up to 175-180 cm and laterals are confined to top 60 cm. Hence crops like bottle gourd, ash gourd and parwal are largely utilized in river bed cultivation.
- **Branched stem-**Stem is 3-8 branched and prostrate / climbing and spread up to 9-10 m.
- **Leaves** are simple, mostly 3-5 lobed, palmate and rarely pinnately lobed (*Citrullus* sp.).
- **Tendrils** on axils of leaves are simple in *Cucumis*, simple or bifid in others and absent in bush types.
- Cucurbits are highly cross pollinated and pollination is done by honey bees and bumble bees. Flowers are born in axils of leaves and are solitary or in racemose clusters. Individual flowers are unisexual, large and showy.
- Fruit is essentially an inferior berry and is called as "pepo."
- Cucurbits are mostly seed propagated. A few are vegetative propagated like parwal and coccinia.
- **Sex forms** – A wide range of sex forms like monoecious, andro monoecious, gynandro monoecious and dioecious forms are noticed in the family.
 - a) Hermaphrodite form - This is the most primitive form and bisexual flowers only are produced in a plant. This is noticed in Satputia variety of ridge gourd and in a few lines of cucumber and mush melon.
 - b) Monoecious form - This is the advanced form and plants produce both male and female flowers in a plant. Majority of the cucurbits exhibit monoecious condition.
 - c) Andromonoecious form – Muskmelon and some cultivars of water melon produce both male and bisexual flowers in a plant.
 - d) Gynomonocious - This is noticed in cucumber and the plants produce female and bisexual flowers.
 - e) Trimonoecious form- This is a condition wherein, the male, female and bisexual flowers are produced in a single plant

- f) Dioecious form – Male and female flowers are produced on separate plants in parwal, coccinia and kakrol.

Flowering:

Majority of cucurbits start flowering 30-45 days after sowing. An alternate sequence of male and female flowers follows upto fruit set. The first 4 and 6 flowering nodes bear male flowers and alter female flowers

Pollination:

Pollination takes place early in morning between 6-8 am in cucumber, pumpkin, muskmelon and watermelon. In snake gourd and pointed gourd, anthesis takes place during night and pollination early in the morning.

Sex modification

- Majority of cucurbits are monoecious and sex ratio (male: female) ranges from 25-30:1 to 15:1.
- Sex ratio is influenced by environmental factors.
- High N content in the soil, long days and high temperature favour maleness.
- Besides environmental factors, endogenous levels of auxins, gibberellins, ethylene and abscisic acid also determine sex ratio and sequence of flowering. A primordium can form either a female or a male flower and it can be manipulated by addition or deletion of auxins.
- Endogenous application of plant growth regulators can alter sex form, if applied at 2-4 leaf stage.
- High ethylene level induces female sex and is suggested to increase female flowers in cucumber, musk melon, summer squash and pumpkin.
- In cucumber, maleic hydrazide (50-100 ppm) GA 3 (5-10 ppm), Ethrel (150-200 ppm), TIBA (25-50 ppm), boron (3 ppm) also induce female flowers.

Some of the important cucurbit crops are

S.No	Common Name	Scientific Name	Origin
1	Cucumber	<i>Cucumis sativus</i>	India
2	Ridge gourd	<i>Luffa acutangula</i>	Spain
3	Bottle gourd	<i>Lagenaria siceraria</i>	Malabar region of India
4	Bitter gourd	<i>Momordica charantia</i>	Indo Burma Region
5	Pumpkin	<i>Cucurbita moschata</i>	
6	Snake gourd	<i>Trihcosanthesanguina</i>	China
7	Water melon	<i>Citrullus lanatus</i>	South Africa

Varieties

1. Cucumber:

- ❖ Introduction: Japanese long green, Poinsette, Straight eight, China long
- ❖ **Hybrids:** Himangi, Phule subhangi, Pusasanyog
- ❖ IARI released varieties: Japanese long green, KTCH – 8, Straight – 8

- ❖ **Poinsettia:** Originally developed in US multiplied by National Research Station, New Delhi. Resistant to angular leaf spot, downy mildew.

2. Ridge gourd

- ❖ **Arka swathi:** cross between medium fruits at IIHR – 54 and long fruit at IIHR 18. Average yield is 52 tonnes per ha.
- ❖ **Arka sumeeth:** it is a cross between early fruiting IIHR – 54 and long fruited IIHR. Suitable for cultivation round the year on Karnataka.
- ❖ **Pusanasadar:** selection from Neemuch variety. Released from IARI, Delhi 15 to 16 t/ha.
- ❖ **Satputia:** it is a cultivar from Bihar, bears hermaphroditic flowers, fruits produced in clusters.

3. Bottle gourd

- ❖ **Pusa Manjari:** hybrid between PusaSummer Prolific Round x Selection 11
- ❖ **Pusa Meghdoot:** hybrid between PusaSummer Prolific Long x Selection – 2
- ❖ **Pusa Summer Prolific Long:** it is suited for growing as a summer crop.
- ❖ IIHR, Bangalore: Arka Bahar
- ❖ IARI, New Delhi: Pusa Naveen, Pusa Summer Prolific Long (PSPL), Pusa Summer Prolific Round (PSPR), Pusa Sandesh, PusaMeghdoot, PusaManjari,

4. Bitter gourd

- ❖ **Arka Harith:** selection from Rajasthan. Collection released by IIHR, Bangalore. Yield is 130 Q/ ha in 120 days and suitable for both summer and rainy season.
- ❖ **Pusa Do Mausami:** it is a selection from IARI, New Delhi. Suitable for cultivation in both season (summer and rainy).
- ❖ **Pusa Vishesh:** it is dwarf vine variety suitable for picking and dehydration. It is released by IARI, New Delhi.

5. Pumpkin:

- ❖ CO 1, CO 2, Arka Suryamuki, Arka Chandan. PusaViswas and Ambili

6. Snake gourd

The cultivated varieties are two types

1. Light green – with white stripes
2. Dark green – with palegreen stripes

7. Water melon:

- ❖ **Arka jyothi:** F1 hybrid by crossing IIHR – 20 with crimson sweet. Fruit is dark green in colour with blue angular stirpes.
- ❖ **Arka manik:** F1 hybrid IIHR – 21 and crimson sweet. Fruits are green with dark green stripes.
- ❖ **Pusabedana:** released by IARI, New Delhi. It is a cross between tetra – 2 (4x) x Pusarasard (2x). fruits are dark green with faint stripes. It takes 120 days for first harvest.
- ❖ **Sugar baby:** introduction from US. Fruits are bluish black in colour. Fruits will ripe in 85 days and gives 150 Q per ha.

Soil requirements:

All the cucurbits prefer well drained sandy loam for early crop and clay for heavy yield. The crops cannot with stand water stagnation. The ideal soil pH is 5.5 to 6.7

Climatic requirements:

- Most of cucurbits are warm season crops and cannot with stand even light frost. It prefers dry climate with bright sunshine.
- Compared to other cucurbits cucumber comes up well in a slightly lower temperature of 18-24⁰c. above 30⁰c, female flower production is reduced considerably.
- Ridge gourd and sponge gourd requires long and warm climate. Humid warm climate is preferable. It grows best in rainy season. Optimum temperature is 24 to 37⁰C.
- Bottle gourd is highly sensitive to photo period, short days and humid climate favour femaleness, optimum temperature for cultivation is 20 to 30⁰C.
- Bitter gourd can be grown in both tropical and sub-tropical climate. Warm climate is considered best. Require minimum temperature 18⁰ C for seed germination and 30⁰ C for growth and development.
- Water melon is a warm season crop. It cannot tolerate high cold and frost. It requires a minimum of 18⁰ C temperature for seed germination and 24 to 27⁰ C for growth and development.
- Pumpkin can be grown in both tropical and sub-tropical climate. Warm climate is considered best.
- Snake gourd can be grown in tropical and sub tropical climates. High humidity is favourable for growth. Snake gourd may not be successfully grown above 1500 m altitude.

Land preparation:

- ❖ Land is ploughed 4-6 times to a fine tilth and well rotten manure @ 20-25t/ha is incorporated in the soil at the time of final ploughing. Since most of the cucurbits are direct sown and will not respond to transplanting.
- ❖ Seeds are sown in hills/mounds/pits/basins along the sides of furrows or either sides of raised beds depending on season, soil, rain fall and slope of the land.

Propagation:

Cucurbits are mostly seed propagated. A few are vegetative propagated like parwal and coccinia.

Seed treatment

- Before sowing the seeds that are treated with *Trichoderma viride* 4 g or *Pseudomonas fluorescens* 10 g or Carbendazim 2 g/kg of seeds before sowing

Particulars seed rate, Spacing and Planting season for direct sowing

S.No	Crop Name	Seed rate Kg/ha	Spacing	Season
1	Cucumber	3 to 5 kg	1.5-3m X 60-90cm	Oct-Nov
2	Ridge gourd	5-7 kg/ha	1.5-3mX 60-120cm	Summer: Feb-Mar Rainy season: Jun-July Rabi: Dec
3	Bottle gourd	3-6 kg/ha	1.8-3m X 0.6-1.5m	Kharif: Jun-July Rabi: Oct-Nov Summer: Feb-Mar
4	Bitter gourd	4-6 kg/ha	1.5-2mX 60-120cm	Oct-Nov Summer: Feb-Mar
5	Pumpkin	1.0 kg /ha	2 m x 2 m. Pit size 30 cm ³	June- July December- January
6	Snake gourd	3 to 6 kg/ha	1.5 to 2 m x 60 to 90 cm	April to July October to November
7	Muskmelon	4-6 kg/ha	2.5m X 1m	Oct-Nov

Thinning:

When seeds are sown in hills or pits, seedlings should be thinned to 2-3 plants per hill or pit. Similarly, in furrow system retain only 1-2 plants at a point. Thinning can be done 10-15 days after sowing or at the time of first top dressing. It can be applicable all most all cucurbits.

Manures and Fertilizers:

For all cucurbits well rotten farm yard manure @ 20-25 t/ha is applied at the time of final land preparation in addition to this recommended dose of NPK fertilizers should be applied.

The recommended doses NPK should follow like

S.No	Crop Name	Recommended dose
1	Cucumber	100 kg N, 50 kg of P ₂ O ₅ & 50K ₂ O Full dose of P & K and half dose of N should be applied as basal dose. Remaining N should be applied in two top dressings, one at the time of vining and at fruit set stage.
2	Ridge gourd	100 kg N, 60 kg of P ₂ O ₅ & 60K ₂ O Half nitrogen, entire P and K are applied at the time of sowing in raised beds or pits. Remaining nitrogen is applied 30 to 45 days after sowing.
3	Bottle gourd	100 kg N, 50 kg of P ₂ O ₅ & 50K ₂ O Full dose of P & K and half dose of N should be applied as basal dose. Remaining N should be applied in two top dressings, one at the time of vining and at fruit set stage.

4	Bitter gourd	70 kg N, 25 kg of P ₂ O ₅ & 25 K ₂ O Apply 1/3 rd N and full dose of P and half dose of K either just before sowing or 10-15 days after sowing as basal dose. ½ K can be applied 45 days after sowing. Remaining fertilizers can be applied in several split doses (5-6) at fortnightly intervals.
5	Pumpkin	Apply 10 kg of FYM (20 t/ha) and 100 g of NPK 6:12:12 mixture as basal and 10 g of N per pit after 30 days of planting. Apply Azospirillum and Phosphobacteria @ 2 kg/ha such and Pseudomonas 2.5 kg/ha along with FYM 50 kg and neem cake @ 100 kg before last ploughing.
6	Snake gourd	10 to 15 tonnes of well decomposed FM per ha is incorporated. 60 kg N, 50 kg P and 40 kg per ha is the blanket recommendation. Half nitrogen is top dressed at a stage when the plants start bearing.
7	Watermelon	90-100 kg N, 60 kg of P ₂ O ₅ & 60K ₂ O Full dose of P & K and half dose of N should be applied as basal dose. Remaining N should be applied in two top dressings, one at the time of vining and at fruit set stage.

Irrigation:

- Irrigation is done by running water through the furrows or drawing to pits/basins from main irrigation channel. Frequency of irrigation depends on season and soil factors. In dry weather, crop is to be irrigated at every 3rd to 5th day.
- Flowering and fruiting period are very critical and any stress during the period will adversely affect the yield.
- All the cucurbit crops cannot tolerate water stress and cannot with stand water stagnation even for a short period. In areas where water is a limiting factor, adopt drip irrigation.

Intercultural operations:

- All the cucurbit crops are shallow rooted crop and no deep inter cultivations are required. During the early stages of crop, basins should be kept clean by weeding. Weeding should be done twice or thrice till the vines from both sides meet. Once the plants cover the field there is no need to weed the interspaces. Large weeds may be pulled out by hand.
- Application of weedicides as Pre-sowing incorporation of fluchloralin @ 3 l/ha or butachlor @ 2.5 l/ha.

Training and pruning: Vines are trained on bamboo with the rope or wire for high production and quality. Cucumber can be trained in bower system. The height of Bower should be about 1.5 m and spacing is kept as 2 m x 1 m between row to row and plant to plant respectively.

Training as the following advantages:

- ❖ Expansion of fruit area results in increased number of fruits.
- ❖ Intercultural operations can be done easily
- ❖ Better pollination and fruit set.
- ❖ Fruit becomes attractive due to proper exposure to sun light.
- ❖ Low incidence of fruit fly or other insects and diseases.
- ❖ Spraying and resting operations can be done easily.
- ❖ 100 per cent clean harvesting can be easily done

Pruning of secondary shoots up to 10 nodes increase the fruit production. Field should be kept weed free throughout cropping season. First weeding may be given 15 to 20 days after sowing. Two more weedings are given at 25 to 30 day interval.

Harvesting

Crop Name	Maturity indices
Cucumber	<ul style="list-style-type: none">➤ Crop becomes ready for harvesting in about 60 to 70 days after sowing.➤ Fruit takes 7 to 10 days from setting to reach marketable size.➤ Cucumber is harvested when it is till tender and green.➤ Over mature fruit will fetches less price
Ridge gourd	<ul style="list-style-type: none">➤ Crops is ready for harvest in about 60 days after sowing.➤ Both crops are picked at immature and tender stage.➤ Fruits attain marketable maturity 5-7 days after anthesis➤ Over mature fruits will be fibrous and are unfit for consumption.
Bottle gourd	<ul style="list-style-type: none">➤ Crop will be ready for about 60 to 100 days after seed sowing. Bottle gourd takes about 15 days after fruit set to reach marketable stage.➤ Fruit is harvested when it is till tender and medium in size.➤ Tenderness and edible maturity are judged by pressing the skin little pubescence persisting on the skin.
Bitter gourd	<ul style="list-style-type: none">➤ Harvesting starts 55-60 days after sowing.➤ Picking is done when fruits are fully grown but still young and tender.➤ Seeds should not be hard at the time of harvest
Pumpkin	<ul style="list-style-type: none">➤ When the fruits turn from green to yellow and easy detachment of stalks from the stem, harvesting can be done.➤ Well matured fruits are harvested 85 - 90 days after sowing.
Snake gourd	<p>Young tender half grown fruits are ready for harvest in about 8 weeks</p> <ul style="list-style-type: none">➤ after planting. Fully ripe fruits are collected for seed purpose.
Water melon	<ul style="list-style-type: none">➤ Seed maturity and fruit maturity coincide in watermelon and it is mostly by 40-45 days after anthesis.➤ A dull sound when ripe the fruits are thumped, in contrast to metallic sound in mature fruit.➤ Withering of tendril at fruit axil and colour of ground spot where fruit rests on ground changes from

Yield:

S.No	Common Name	Yield
1	Cucumber	15-20 t/ha
2	Ridge gourd	7.5-15 t/ha
3	Bottle gourd	20-25 t/ha open pollinated varieties 40-45 t/ha hybrids
4	Bitter gourd	11-25 t/ha
5	Pumpkin	18-20 t/ha in Varieties 30-40t/ha in hybrid.
6	Snake gourd	13 to 20 tonnes per ha.
7	Watermelon	35-50 t/ha open pollinated varieties 75 t/ha hybrids

Seed production in cucurbits

Varietal seed production

Being an highly cross -pollinated crop, provide an isolation distance of 100 m from other varieties for foundation seed production and 500mt for certified seed production.

Hybrid seed production:

Isolation distance for foundation seed production: 1500mt

Isolation distance for certified seed production: 1000mt

ONION

Botanical name : Allium cepa

Family : Alliaceae

Origin : Central asia

Importance:

- ★ Onion is valued for its bulbs having characteristic odour, flavour and pungency, which is due to the presence of a volatile oil – allyl – propyl - disulphide and the red colour is due to the presence of another pigment “Quercetin”.
- ★ It is consumed either raw or cooked along with spices and vegetables. Primarily the bulbs used as vegetables. The flowering shoot known as Scape is also used as vegetable.
- ★ It is rich in minerals like phosphorus and calcium and carbohydrates. It also contains Protein and Vitamin C.

Climatic requirements:

Onion is best suited as a tropical crop. It does best where the season is mild without the extremes of heat or cold or excessive rainfall. A relatively high temperature as well as long photo period (*i.e.*, a temperature of 15.6 to 21.1^o C for about 10 hours a day and about 80% RH) is essential for bulb formation, where as temperature alone is more important than the length of days in seed stalk development.

Soil

It grows best in light soils which may be sandy loam or silt loam. It is sensitive to higher acidity and the optimum pH of the soil should range from 5.8 to 6.5.

Varieties:

- ★ **Red onion varieties:** N-53, Pusa Red, Nasik Red, Hissar 2 and Punjab selection
- ★ **White onion varieties:** Pusa White Round, Pusa White Flat, Pujab 48 and Udaypur 102
- ★ **Yellow onion varieties:** Early Grano and Brown Spanish. These varieties have less pungency and used as salads
- ★ **Arka Kirtiman-** F1 hybrid of CMS 65 x Selection 13-1-1. Suitable for kharif and rabi seasons, bulbs medium size and dark red, yield 45-60 t/ha, good keeping quality, suitable for export to Gulf countries.
- ★ **Arka Lalima–** F1 hybrid of MS 48 x Selection 14-1-1, bulbs globe shaped an deep red each weighing 120-130 g, good shelf life of 5 months, tolerant to purple blotch, suitable for export to Gulf countries.

Propagation:

Methods of planting: The following three methods of planting are followed depending on soil, topography, climatic conditions and economic aspects:

1. Raising seedlings and transplanting
2. Planting bulbs directly in the field.
3. Broadcasting or drilling of seeds directly in the field.

Transplanting method :

- ★ This is the most common method practiced for irrigated crop as it results in high yield and large size bulbs. In plains, seeds are sown during October-November for a Rabi crop.
- ★ Seeds are first sown in well prepared nursery beds of 90-120 cm width, 7.5-10.0 cm height and convenient length.
- ★ Seed rate varies from 8 to 10 kg/ha. Seedlings of 15 cm height and 0.8 cm neck diameter are ideal for transplanting and this is achieved in 8 weeks.
- ★ For transplanting, the land is brought to a fine tilth by thorough ploughing, leveling and breaking clods. The field is then divided into small plots of convenient sizes for irrigation and seedlings are transplanted at 15 x 8-10 cm spacing.

Planting of bulbs:

This method is practiced in hill slope and in terrace cultivation since seedlings are easily washed off in rain. Medium sized bulbs obtained from a seedling planted June crop are used for planting in September – October after giving a month rest.

Bulbs are dibbled at 15 cm apart on the side of 45 cm wide ridges or in beds or in furrows depending on soil or climate. 10-12 quintals of bulbs are required to plant one hectare.

Broadcasting or drilling method

Direct sowing by broadcasting or drilling at 30 cm apart is practiced in some areas to save labour for transplanting. Here seed requirement is as high as 25 kg / ha. Care should be taken to remove weeds during initial stages to prevent smothering of seedlings by weeds.

Irrigation

It requires 14-18 irrigations from planting to harvest depending on the season. At bulb formation stage i.e 70 to 75 days after planting irrigation is essential. Drought at this stage results in cracking of the bulb and low yield

Weeding and inter-culture

During early stages of the crop, plants grow slowly and it is essential to remove weeds. Pre-plant incorporation of Basalin (2 kg a.i./ha) along with one hand weeding at 45 days after transplanting is recommended to control weeds.

Being a shallow rooted crop, deep inter-culture operation is likely to injure roots and reduce yield. Generally two hoeings are essential for making soil loose and to cover bulbs.

Manures and Fertilizers:

25 tonnes of FYM, 60 to 100 Kg N, 40 to 60 Kg P₂O₅ and 60 to 80 Kg of K₂O. FYM should be incorporated at the time of field preparation, P and K along with half of N should be applied in bands, 5 cm below the seedlings to the side before transplanting. The rest of N may be top dressed 2 months after planting.

Harvesting :

- ★ As a bulb crop is comes to harvest after 4 months of planting. Green bunch onions are harvested when they are lead pencil thickness with a small bulb, as a direct vegetable. Onion should be harvested at 50% neck fall stage.
- ★ Onions for storage should be fully developed, thick neck bulb which results due to premature harvesting – do not store well.
- ★ In India the bulbs are harvested by hand pulling in small area, if soil is light The leaves are cut leaving about 2-2.5 cm tops above the bulb after complete drying.
- ★ The bulb after harvesting are left in the field under shade for 4 days for curing which helps the bulbs in storing well

Yield:

Common big onions give 25-30 t/ ha yield,

Curing of onion bulbs

- Sprouting and rotting are common problems in storage since bulbs contain high moisture.
- The bulbs should be adequately cured for proper development of skin colour and to remove field heat before storage of bulbs.
- It is done till the neck is tight and outer scales are dried. This will prevent infection of diseases and minimize shrinkage loss.
- Bulbs are cured either in field or in open shade or by artificial means before storage.
- During kharif season, bulbs are cured for 2-3 weeks along with top. In rabi, bulbs are cured in field for 3-5 days; tops are cut leaving 2.0-2.5 cm above bulb and again cured for 7-10 days to remove field heat.

Storage:

- Onions are stored in special house constructed with thatched sides covered with bamboo stick for good air circulation the sides can be covered with the gunny cloth instead of bamboo stick in order to have better circulation.
- Onions are stored rakes 2 to 3 layers in well ventilated rooms and is desirable for proper storage.

Physiological disorders

Bolting in onions:

- Premature production of seed stalk is known as bolting when such seeds stalk are produces which produce will grow bulb purpose.
- It becomes a problem, the production of bolt takes at the cost reserved foods at stalks and then bulbs keep long storage.
- Some of the salient features of bolting are the bolts are little bit smaller in size normal inflorescence. Bolting occurred to the extent of 50 to 80% in the onions planted in the later part of kharif or early rabi season.
- Bolting may be due to one or two more factors like varietal difference, extremes of temperature, growth obstacles, poor seed quality, poor soil, amount of sun shine *etc.*,
- A species of 5% MH 40 in water reduced percentage of bolting to about 3% control when are applied 2 ½ months after transplanting

Seed production in onion

Onion is a cross-pollinated crop and isolation distance of 1000-1600 m and 500 m is recommended for production of foundation and certified seeds, respectively. Two methods of seed production are followed-seed to seed method and bulb to seed method.

1. Seed to seed method: In this method, the first season bulb crop is left to over-winter in the field so as to produce seed in the following season. Even though seed yield is more under seed to seed method, bulb to seed method is followed for production of quality seeds.

2. Bulb to seed method

- Bulbs are produced as for market and bulbs with desired quality are replanted for seed production.
- Bulbs are replanted in first fortnight of October. Normally medium sized bulbs of 2.5 to 3.0 cm diameter are planted on the side of ridges or on beds at 45 x 30-45 cm spacing. 1000 kg bulb is required to plant one hectare.
- Flower stalks will be produced during third month after planting of bulbs and seeds ripen within six weeks after formation of flower clusters.
- Heads are harvested when seeds turn black in colour, but before seeds are shed. Seeds are dried in well ventilated rooms under shade and are stored. Seed yield is 800 – 1000 kg / ha. Seed production of varieties which do not store well in storage is done by seed to seed method.
- Mostly the bulb to seed method is used because of the following advantages over the seed to seed method.
- It permits selections of "true-to-type" and healthy bulbs for seed production.
- Seed yields are comparatively very high. The seed to seed method, however, can be practiced for varieties having a poor keeping quality

GARLIC

Botanical name: *Allium sativum*

Family: Alliaceae

Origin: Central asia

Importance:

- Un injured bulbs of garlic contain an amino acid called as Allicin. It is odourless, colourless water soluble amino acid. The other principle ingredient responsible for typical odour of garlic is Diallyl disulphide. The typical flavor of garlic is due to the presence of Chemical Allicin plus Diallyl disulphide.
- It reduce the cholesterol level in the blood. Garlic used in the case of TB, rheumatism, sterility, cough, red eyes etc in the form of garlic juice.
- Garlic has higher nutritive value than other bulb crops. It is rich in proteins, phosphorous, potassium, calcium, magnesium and carbohydrates. Ascorbic acid content is very high in green garlic.

Climate:

The frost hardy but excess hot drought long not tolerate, prefers moderate temperature in summer and winter. The maturity of bulb should coincide in dry period. Bulbing takes place during longer days and at high temperature, exposure to low temperature subsequent to bulb formation, favours the process.

Soil:

Garlic can be grown on a variety of soils but it thrives better on fertile, well-drained loam soils. The pH of soil between 6 and 7 is suitable for good crop. Highly alkaline and saline soils are not suitable for garlic cultivation.

Varieties: Agrifound White, Agrifound Parvathi, Yamuna Safed 1, Yamuna Safed 2

Preparation of soil: The soil should be thoroughly prepared by repeated ploughing. Well decomposed FYM at the rate of 10 to 20 tonnes per hectare is to be applied.

Propagation: by clove or bulbils or aerial bulbils. Tissue culture techniques as used as explants are also in practice.

Season of planting: In Maharashtra, Karnataka and AP August to November

Spacing: The ideal spacing is 15 cm x 10 cm. the seed rate 500 to 600 kg of cloves per hectare. The sowing can be done by three methods

1. Dibbling
2. Furrow planting
3. Broad casting.

Cloves of 8-10 mm diameter since give increased yield of better quality, care should be taken to select bigger cloves from outer side of bulbs. About 500 kg cloves of 8-10 mm diameter are required to plant one hectare.

MANURES AND FERTILIZERS

Garlic responds very well to organic manures. For a normal soil 50 tonnes of farmyard manure, 100 kg N, 50 kg P and 50 kg K/ha through chemical fertilizer has been recommended. Micronutrients also increase its yield potential.

IRRIGATION

Before planting the field should be given light irrigation. Irrigation is repeated on every 3rd day during the initial stages the crop is irrigated more frequently per once in a week but afterwards the crop irrigated once in 15 days. The frequency is decrease the crop is reached maturity the harvesting time the irrigation is stopped.

INTERCULTURE

First weeding is done one month after planting and second one month after first weeding. Hoeing the crop just before the formation of bulbs helps in setting of bigger sized well filled bulbs.

Harvesting:

- The garlic crop is ready for harvesting when tops turn yellowish or brownish and show signs of drying up and bend over.
- Depending on season and soil, the bulbs begin to mature in 4-5 months after planting. At this stage, tops became dry and bend to ground.
- Early harvest results in poor quality of bulbs, which can't be stored for longer period.

Yield: 50-110 q/ ha are obtained

Curing of Garlic bulbs

- The bulbs are cured in field for about a week after harvesting.
- In order to avoid damage from sun, the bulbs are covered along with the tops of each other.
- After this the bulbs are cured for another 7-8 days in shade either with tops or after cutting tops by leaving 2.5 cm.
- Curing in shade may be on a floor having ventilation from bottom or a wire racks.
- Grading is done according to size, colour and shape.

Storage:

- Garlic is fairly cured in ordinary ventilated rooms. Tied leaves are hanged in well ventilated rooms. Packing is done singly in polythene bags or small sized bags packed together. Storage at 1.5°C and 75% RH decreases the storage loss with reference to ambient temperature.

Physiological Disorders:

- The rubberification and premature sprouting of bulbs are main physiological disorders in garlic.

- Rubberification and premature sprouting of bulbs are noticed mostly in fields which are located in low-lying areas of watershed where there is heavy deposition of nutrients along with silt during heavy rains.
- With the application of higher levels of nitrogen, there is an increased level of premature sprouting of bulbs which results in splitting and rubberification of bulbs.
- Delayed harvest during rainy season has increased premature sprouting and splitting of bulbs.
- It was observed that rubberification was totally controlled by application of micronutrients i.e. zinc sulphate, ammonium molybdate, neem cake insecticides and growth regulator like GA.

Potato

Botanical name : ***Solanum tuberosum***

Family : **Solanaceae**

Origin : South America

Importance:

It is one of the important crop of the world. In India, it is used only as a vegetable. Sometimes it is also mixed with other vegetables. It is also used for making of chips, halwa, gulab jamun, rasgulla, murabha, kheer, guzia and barfi etc. According it contains 74.7 per cent water, 22.9 per cent sugar, .6 per cent protein, 0.1 per cent fat, 0.6 per cent mineral matters, 0.01 per cent calcium, 0.03 per cent phosphorus and 0.0007 per cent iron.

The potato tuber may contain an alkaloid (Solanine), if it is exposed to light. It is poisonous compound but 70 per cent of it is removed when potatoes are peeled.

Varieties

Kufri Jyoti, Kufri Muthu, Kufri Swarna, KufriThangam, Kufri Malar, Kufri Soga and Kufri Giriraj are commonly cultivated.

Climate:

Potato is basically cool season crop. It is grown in winter in plains of India. Potato is a long day plant but cultivated as day plant. It requires favourable environmental conditions such as low temperature and short day conditions at the time of tuberization for rapid bulking rate.

About 20°C temperature is good for tuber formation and it reduces as the temperature increases. Tuberization is badly affected at about 30°C temperature.

Soil

The soil should be friable, porous and well drained. The optimum soil pH range is 4.8 to 5.4.

Season

Hills

Summer : March – April

Autumn : August – September

Irrigated : January – February

Plains

Planting is done during October – November in plains.

Seed rate

About 3000 – 3500 kg/ha of seeds is required.

Seed treatment

Use Carbon disulphide 30 g/100 kg of seeds for breaking the dormancy and inducing sprouting of tubers.

Preparation of field

Prepare the land to fine tilth. In hills provide an inward slope in the terraces. Provide drainage channel along the inner edge of the terrace. Form ridges and furrows with a spacing of 45 cm between ridges either by hand hoe or ridger.

Planting

Use disease free, well spouted tubers weighing 40 – 50 grams for planting. Plant the tubers at 20 cm apart.

Irrigation

Irrigate the crop 10 days after planting. Subsequent irrigation should be given once in a week.

Manures and Fertilizers:

Apply 15 t/ha of FYM and 2 kg each of *Azospirillum* and *Phospho bacterium* as basal and 120 kg N, 240 kg P and 120 kg K/ha in two splits; half as basal and the balance for top dressing on 30 days after sowing. Apply Magnesium sulphate at 60 kg/ha as basal dose.

Weed control:

The critical period of weed-competition is upto 60 days and it is essential to keep the field weed-free during that period. Take up the first hoeing on 45th day without disturbing stolons. Second hoeing and earthing can be taken up at 60th day.

Harvesting :

Harvested potatoes are heaped under shade for a couple of days, so that their skin becomes hard and soil adhering with them is also separated out.

Yield: 350-450 quintals/ha

Storage:

Potatoes can be stored in the cold storage at the temperatures of 4 to 7°C and relative humidity.

COLE CROPS

- Vegetables belonging to the family Brassicaceae are known as cole crops.
- *Ancestor: Brassica oleracea var. sylvestris*
- Cole crops include cabbage, cauliflower, knolkhol, Brussels sprouts, Chinese cabbage, Sprouting broccoli, Kale etc.
- Mediterranean region is the centre of origin of cole crops
- The word cole was originated from the word Caules means stem. They are originated single wild species wild cliff cabbage known as “Cole worts” *Brassica oleracea var sylvestris*.

Cabbage

Botanical name : *Brassica oleracea var capitata*

Family : Brassicaceae

Origin : Mediterranean region

Importance:

- Fourth position among vegetables in India as well as the world.
- Cabbage is used as boiled vegetable, salad, cooked in curies and processed also.
- Cabbage is also used often for drying, pickling and canning.
- The processed or fermented product Sauerkraut
- In ancestral time, it was used against gout, diarrhea and stomach troubles.
- Due to presence of indole 3 carbinol, it protects against bowel cancer.
- Cabbage juice is used as a remedy against poisonous mushrooms

Varieties: There are eight groups of cabbage as detailed below

1. Copen hagen market group: heads are round, large and compact. Ex: Golden acre.
2. Flat head or drum head group: heads are flat. Plant is medium to large. Ex. Pusa Drum Head – It is resistant to Black leg and dry rot diseases
3. Conical head group: heads are small pointed
4. Savoyee group: foliage very mulch glittered and wrinkled. Leaves are twine with little bloomy. This group include chief drum head savoy.
5. Red cabbage: it has deep purplish red coloured heads. Ex: red rock, red Danish. Protein content is lowest. Highest in kale.
6. Early varieties: Golden acre: IARI variety selection from Copen hagen market.
7. Pride of India: Selection from Copenhagen Market which is popular in west Bengal.
8. Late varieties: Pusa drum head: it was released by IARI. It is a selection from an introduction EC 774.

Climate:

- Cabbage is a biennial crop. Vegetative growth including head formation takes place in first season.

- For transforming into reproductive phase, it requires chilling temperature and hence seed production is possible in hills only.
- Cabbage tolerates low temperature better than cauliflower and minimum temperature for growth is 0°C.
- Optimum temperature for growth and heading is 15-20°C.

Soil:

- Cabbage can be grown in wide range of sandy to heavy soils. However, well drained soils give larger yields.
 - The optimum pH of soil for cabbage cultivation is between 6.0-6.5.
- Season of sowing: August – November is suitable season.
Seed rate: 200-500 g/ha seed is required

Nursery

- About 100 sq.m nursery area is required for raising plants for one hectare area.
- Apply FYM at 300 kg, and 10 kg of (9:9:9) along with 50 g of Sodium molybdate and 100 g of Borax.
- Sow the seeds at 10 cm between rows in raised seed beds after drenching it with Copper oxychloride (2.5 g/lit).
- Transplant 40 - 45 days old seedlings at a spacing of 45 cm. Avoid land infected with 'club root disease'.
- Generally, 4-6 weeks old seedlings are ready for transplanting but older seedlings up to 8 weeks age can also be transplanted.

Preparation of field

Bring the soil to a fine tilth. Pits should be taken up at a spacing of 40 cm either way in Hills. Ridges and furrows are formed at 45 cm apart in plains.

Spacing

The following distances are generally recommended on the basis of maturity of cultivars viz., for early varieties 45 x 45 cm or 60 x 30 cm, mid varieties 60 x 45 cm and late varieties 60 x 60 cm. The planting is done on the flat land, ridges or in furrows depending on climate and soil conditions.

Planting

30 – 40 days old seedlings are selected for planting. Hardening of seedlings is done by withholding irrigation 4 - 6 days prior to planting.

Irrigation

- Irrigation is given immediately after transplanting.
- Later it is irrigated at 10 to 15 days interval.
- At the time of maturity of head watering should be suspended otherwise can be bursting or splitting.
- Total 6 to 8 irrigations are required.

Manuring:

- *Azospirillum* and *phosphobacteria* 2 kg each are recommended along with FYM. At high temperature formation of head can be improved by spraying 2 % common salt.

- Starter solution is given to increase the production to an extent of 0.25 tonnes per ha.
- Starter solution consists urea, potassium sulphate, single super phosphate at 1:1:2. It is given twice first immediately after transplanting and second 15 days after first application.
- Foliar application of Molybdenum and cobalt increases cabbage head size. It is done 1 to 2 months after transplanting.

Inter cultural operations

- Include hoeing, earthing up, weeding and mulching. Shallow hoeing is to be done for better soil aeration and also put to the weeds.
- Earthing up helps to produce healthy heads it is done four to six weeks after transplanting.
- Removal of weeds is to be done reduce intensity of weed chemical trifluralin, basalin can be used for these purpose.
- Mulching with black polyethylene sheet control weed and conserve moisture is to be done.

Harvesting, Yield and Storage

- The harvesting of cabbage is done when the heads reach at marketable size. The early cultivars grown under comparatively warmer conditions develop loose head at the initial stage, but become harder at maturity.
- In some cultivars, the heads start cracking soon after the maturity. In such cases, the quality of head deteriorates fast, if harvesting is delayed.
- Hence, harvesting should be done at right stage for getting good quality head.
- The early cultivars take 60-80 days, medium 80-100 days and later 100-130 days for harvesting after transplanting.
- Delay in harvest may cause bursting and bolting

Yield

Late maturity varieties : 35 – 40 t/ha

Early maturity varieties : 30 – 35 t/ha

Physiological Disorders

1. TIP BURN

Symptoms:

- The tissue near the center of head is affected and affected tissue breaks down, loses moisture, becomes dry and eventually turn black or brown

Causes:

- Deficiency of calcium
- High levels of nitrogen.
- High temperature.
- Exposure to long hours of day light.
- High relative humidity.



Control:

- Foliar spraying with calcium.
- Maintaining the adequate and uniform moisture supply.
- Apply only required amount of nitrogen.
- Use of resistant or tolerant varieties like Titanic, Roundup, and Super boy are less susceptible.

2. BLACK SPECK

Symptoms:

- It is characterized by dark spots that occur on outer leaves or sometimes throughout the head.
- Symptoms may not appear at harvest but the initial damage occurs in the field with the typical symptoms developing during storage at low temperature.

Causes:

- Application of high rates of fertilizers.
- Fluctuations in temperatures

Control:

- High rates of potassium in soil have been shown to reduce the severity of disease.
- Application of required amounts of fertilizers only.
- Use of tolerant varieties



3. BOLTING:

Symptoms:

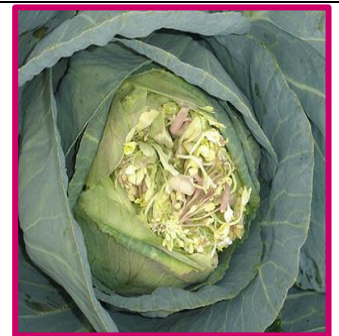
- Development of seed stock in the earlier stages.
- The heads may be partially formed or not formed completely.

Causes:

- Early sowing of seeds in the hot weather.
- Sudden and extreme changes in temperature during crop growth.
- Poor growth of seedlings due to inadequate moisture supply, poor viability of seeds, and attack of insect pests and diseases.

Control:

- Avoid sowing in warm climate.
- Supply adequate amount of nutrients.
- Grow bolting resistant varieties.
- Transplant healthy seedlings.



Seed production in Cabbage

Isolation distance of 1600 m and 1000 m is recommended for production of foundation and certified seeds, respectively.

In cabbage, during seed production, three methods have been followed to facilitate flowering and seed production.

1. Stump method
2. Stump with central core intact method
3. Head intact method

1. Stump method

- When the crop in the first season is fully matured, the heads are examined for true to type.
- The plants with off type heads are removed. Then the heads are cut just below the base by means of a sharp knife, keeping the stem with outer whorl of leaves intact.
- The deheaded portion of the plant is called 'stump'. The stumps are either left in-situ or replanted in the second season.
- After over wintering (dormancy breaking), the buds sprouts from the axis of all the leaves and leaf scars.

Advantages

- Gives extra income by way of sale of heads
- Seed yield is slightly high

Disadvantage

- ❖ Flower stalks are decumbent and requires very heavy staking



2. Stump with central core intact method

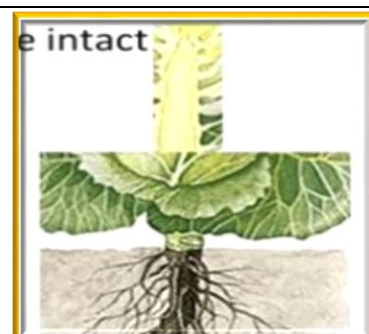
- When the crop is fully matured in first season, off type plants are removed and rejected.
- Then the heads are chopped on all sides with downward perpendicular cuts in such a way that the central core is not damaged.
- When the head start bursting after over wintering, two vertical cross cuts are given to the head, taking care that the central growing point is not injured.
- In the absence of such cuts, the heads burst out irregularly and sometimes the growing tip is broken.

Advantages

- Heavy staking is not required
- Seed yield is high


Disadvantage

- ❖ Chopped heads cannot be marketed



3. Head intact method

- In this method, when the crop is fully mature in first season, the heads are examined for true to type.
- The plants with off type heads are removed from the field and rejected.

→ The head is kept intact and only a cross cut is given to facilitate the emergence of stalk	
<p>Advantages</p> <ul style="list-style-type: none"> ➤ Heavy staking is not required ➤ Saves time and labour <p>Disadvantage</p> <ul style="list-style-type: none"> ❖ Seed yield was low compared others 	

CAULIFLOWER

Botanical name : *Brassica oleracea var capitata*

Family : Brassicaceae

Origin : Mediterranean region

- The edible part of cauliflower is known as curd, which consists of a shoot system with short internodes, branches apices and bracts.
- It has high quality of proteins and peculiar in stability of vitamin C after cooking. It is rich in minerals such as potassium, sodium, iron, phosphorus, calcium, magnesium etc.
- The inflorescence extract has been used in the treatment of scurvy, as a blood purifier and as an antacid.

Varieties:

Early Kunwari: It has bluish green leaves with waxy blooms. The curds are white and not so compact. It is the earliest cultivar released by Punjab Agricultural University.

Pusa Deepali: The plant has erect growing habit and a narrower frame. The curd is somewhat round, medium-sized and white to creamy white in colour.

Pusa Himjyoti: It has erect bluish green leaves with a waxy coating. The curd is pure white and retains its colour even after exposure. Recommended for the spring-summer sowings in the hills.

Pusa Shubhra: It is field resistant to black rot and curd blight.

Pusa snowball K-1: Field resistant to black rot. It has upright waxy light green leaves, self-blanching, snow-white curds.

Varieties released from IARI: PusaAghani, Pusa Deepali, Pusa Early Synthetic, PusaHimjyoti, Pusa Hybrid-2, PusaKatki, Pusa Sharad, Pusa Shubra, Pusa Snowball-1, Pusa Snowball-2, Pusa Snowball K-1, Pusa Synthetic,

Climate:

- The optimum temperature for growth of young plants is around 23°C, but in later stages 17-20°C are most favorable.

- The tropical cultivars show growth even at 35°C. In temperate regions, the growth of young seedlings may be ceased, when temperatures are slightly about 0°C
- The temperature higher or lower than the optimum required for curd formation of the cultivars may cause physiological disorder viz. riceyness, leafy curd and blindness.

Soil:

- Cauliflower can be grown in all types of soil with good fertility and good regime.
- In light soil, the plants are most sensitive to drought and therefore, adequate moisture supply is important.
- The optimum pH of soil for cabbage cultivation is between 6.0-6.5

Season of sowing: Sep. – Nov and Oct. – Nov.

Nursery:

- 100sq.m nursery area is sufficient to transplant in one hectare of the main field.
- Apply FYM at 300 kg and 10 kg of No. 5 mixture (9:9:9) along with 50 g of Sodium molybdate and 100 g of Borax.
- Sow the seeds at 10 cm between rows in raised seed beds after drenching it with copper oxychloride (2.5 g/lit).
- Transplant 30 to 40 days old seedlings at a spacing of 45 cm.

Seed rate: 375 g /ha.

Spacing: 60 x 45 cm

Transplanting:

Normally, a hardened seedling is likely to give better results and since the early crops are raised in the monsoon, 5-6 week old seedlings stand better chance of establishment.

Starter solution of ammonium sulphate and superphosphate (1:2) in combination with 0.1 ppm of IBA was best and economical for early and total yield.

Manures and fertilizers:

- Hills: Apply 30 t/ha of FYM and 90 kg N, 90 kg P and 90 kg K as basal dose and 45:45:45 kg NPK / ha after 45 days.
- Plains: Apply 15 t FYM / ha and 50 kg N, 100 kg P and 50 kg K as basal and 50 kg N after 45 days. Apply 2 kg of Departmental vegetable micronutrient without mixing with the chemical fertilizers.

Irrigation

- Irrigation is given immediately after transplanting.
- Later it is irrigated at 10 to 15 days interval.

Inter cultivation:

Gap filling after 20 days of planting to maintain the population and uniform growth. Hoeing and weeding on 30th and 45th day. Avoid deep inter cultivation as it is a shallow rooted crop.

Blanching:

In cauliflower, for getting quality curd, blanching is an important operation to protect the curds from yellowing due to direct exposure to sun. The curds may also lose some of their flavour, because of this exposure. Drawing and tying the tips of leaves when curds are fully developed may do the blanching. By using a different coloured twine each day. It is easy at the time of harvest to select those tied earlier.

Harvesting indices and harvesting


- Curds are compact, attain proper size and retain original colour. Delayed harvesting results in non marketable curds, loose and discoloured curds.
- The large leaves are then trimmed away until only sufficient jacket leaves remain to protect the curd. When transporting loose, more jacket leaves should remain than when packing in crates.
- Cauliflower can be stored successfully at 0°C and 90-95 per cent RH for 2-4 weeks

Yield

Hills : 20 – 30 t/ha, Plains : 15 – 20 t/ha

Physiological Disorders:

1. Buttoning

<p>Symptoms:</p> <ul style="list-style-type: none">→ Very small curd or buttons are formed.→ Leaves also remain small, which are unable to cover the curd.	
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Causes:

- Poor supply of nitrogen.
- Transplanting of over aged seedlings.
- Transplanting of poor seedlings.
- Sowing of early varieties late and vice versa.

Control:

- Right selection of variety.
- Apply recommended dose of nitrogen.
- Transplant 4-5 weeks old, healthy and vigorous seedlings having 5-6 leaves.
- Maintain adequate supply of nutrients.

2. Riceyness

<p>Symptoms:</p> <ul style="list-style-type: none">→ Pedicels bearing the individual flower bud elongate.→ Premature initiation of floral buds is characterized by riceyness in cauliflower and is considered to be of poor quality for marketing.	
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Causes:

- Warm weather conditions. Disorder may result from any temperature higher or lower than the optimum required for a particular cultivar
- Use of poor quality seed.

Control:

- ☛ Grow the crop when temperature is favorable.
- ☛ Use high quality seed.
- ☛ Sowing of crop at favorable weather conditions.

3. Browning

Symptoms:

- It is also known as brown rot or red rot.
- At initial stage water soaked areas develop in the centre of curds.
- In advance stage the stem becomes hollow with the cavity surrounded by water soaked tissues.
- Later curd changes to rusty brown and becomes bitter in taste.



Causes:

- ☛ Deficiency of boron.

Control:

- ☛ Apply borax @ 10- 15 kg/ha at field preparation or spray 0.1% boric acid.
- ☛ Harvest the crop at proper maturity stage.
- ☛ It can be controlled by application of borax or sodium borate @ 20 kg/ha. In case of acute deficiency, spray of 0.25 to 0.50% solution of borax @ 1 to 2 kg/ha is advocated

4. Whiptail

Symptoms:

- It is characterized by the lack of leaf lamina and leaf consists only bare mid rib which looks like whiptail

Causes:

- Deficiency of molybdenum particularly in acidic soils having ph below 5.0



Control:

- ☛ Apply 0.5-1.0 kg sodium or ammonium molybdate/ha at field preparation.
- ☛ Spray the crop with 0.1-0.3% ammonium molybdate with teepol as sticker.
- ☛ Add lime in the soil to raise the pH to 6.5

ROOT CROPS

CARROT

Botanical name : *Daucus carota*

Family : Apiaceae

Origin : Central Asia

Importance:

Carrot is an ancient cool season root vegetable. Roots are used for making soups, stews, curries, pies, pickles and for salad purposes. Sweet preparation 'gajar halwa' prepared out of carrot is delicious and popular. Carrot roots are rich sources of α and β carotenes and contain sucrose 10 times that of glucose or fructose.

Carrot has many medicinal properties. It increases quantity of urine and helps in elimination of uric acid. Purple and black carrots are used for preparation of a beverage called 'kanji' which is a good appetizer.

Climate

Carrot is cool season crop. Some of the tropical types tolerate quite high temperature. Optimum temperature for better growth 18.3 to 20.9°C. Carotene content is reduced at temperature at below 15.6°C and above 21.1°C that is why carrots grown 15 to 20°C will develop good colour.

Soil:

It requires deep well drained sandy loam. This type of soil is particularly good for early crop. Heavy soils will check the development of roots and cause forked lateral roots. It is grown in rainy season under heavy soil condition or black soil condition even then it will produce abnormal or forked roots. Carrots does not grow well in highly acidic soil. Maximum yield can be obtained at pH of 6.5

Varieties

- European Varieties: Nantes, Chanteney
- Asiatic Varieties: Pusa kesar
- **Nantes:** It is a European type, gives skin stumpy orange group, perfect and cylindrical. The core is tender sweet self coloured. Gets ready in 120 days.
- **Chanteney:** European varieties it has attractive deep reddish orange. It has a tapering but distinct stump end and core sweet and indistinct gets ready in 120 days.
- **Pusa kesar IARI:** is a selection from a cross between local red with nantes half long. It has self coloured central core less. Varieties released by Punjab agricultural university.

- **Ooty-1:** Developed at Horticultural Research Station (TNAU), Udhagamandalam: roots are 25 cm long with deep orange colour; yield 45-50 t/ha in 100-110 days.

Seed rate:

5 to 6 kg per ha it can be up to 6 to 9 kg per ha

Sowing time is September (best). Optimum temperature for germination 7.2 to 23.9°C. it can be sown from June-July, August, September and in hills the month of January – February. The seeds are sown on ridges on flat land about 1.5 cm deep.

Method of sowing:

Seeds are directly sown in the field in ridges per furrow or flat bed. In rainy season, ridges and furrows are made. In Rabi season if the soil is loose, sowing is done on flat beds. If the soil is hard, sown on ridge and furrows.

Seeds are thin and light there are mixed with soil or broken rice at 1:1 or 1:0.1 or 10:1 ratio. Seeds are sown to a depth of 1 to 5 cm at a spacing of 30 cm between rows.

The seeds germinate within 5 to 10 days after sowing under good moisture conditions. Thinning has to be done at distance 5 to 10 cm. thinning is done at 8 to 10 days after germination, the resulted spacing is 30 x 5 to 10 cm.

Manuring:

Depending on soil fertility Farm Yard Manure at the rate of 30 tonnes per hectare is applied at the final ploughing and dosage of 40 to 60 kg nitrogen, 25 to 50 kg of phosphorous and 90 to 110 kg of potassium per hectare is recommended has basal dosage. Excess nitrogen reduces root quality damage the content of sugar, dry matter, carotene and vitamin C.

Earthing up:

Should be done at 60 to 70 days after sowing to help in development of roots the soil is earthed up covered the top of developing roots to prevent loss of colour of tops, the tops becomes green and toxic on exposure to sun light.

Mulching:

Field is mulched with soya bean stubbles or rye mulch comparatively to conventionally tilled plots.

Harvesting and yield: Early carrots are harvested when they are partly developed. For the purpose of distinct markets otherwise they are retained in the soil till they reach full maturity stage they should not be retained afterward. They have become puffy core becomes hard and is unfit for consumption.

There are two methods of harvesting.

1. Roots are dug out when they are sufficiently moist which khurpa or spade in black. Light irrigation has to be given before harvest, so that easy pulling of roots can be facilitated without damage by holding the leaves.
2. In case of Asiatic variety the roots are harvested when they attain marketable stage 2.5 to 5 cm in diameter, at the upper end after harvesting the roots they are

trimmed and washed before sending them to the market. They are packed with gunny bags.

Yield:

Tropical types give around 20 to 30 tonnes per ha

Temperate type may give 10 to 15 tonnes per ha

Physiological disorders

1. **Cavity spot** - This is primarily caused by calcium deficiency induced by excess potassium. Symptoms appear as a cavity in cortex.
2. **Carrot splitting** – Splitting or cracking of roots is a major problem in carrot cultivation. Though this is a genetic character, other factors are also influencing cracking. Excess nitrogen and its untimely application promote cracking.

RADISH

Botanical name : Raphanus sativus

Family :Cruciferae

Origin : Europe or Asia

Radish is a popular root crop throughout India. The edible portion is fleshy root it develops both primary root and hypocotyls.

Varieties:

Radish roots vary greatly in size and colour as well as the length of time for which they remain edible. The radish varieties are divided broadly. 1. European or temperate types 2. Asiatic and sub-tropical

Temperate types are smaller in size mild in taste and are mostly raised as salad crops. A pure white thin and tender variety becomes ready in about 30 days after sowing.

- **Pusa Himani**: a long white variety released by IARI it is suitable for sowing for mid December to late February in plains and during summer in the hills.

Tropical types:

- **Japanese White**: roots grow better when the temperature is low, they are pure white 30 – 45 cm long mildly pungent with blunt end.
- **Pusa Desi**: Roots are of same size as though of Japanese type they have green stem end they are more pungent they have tapering root are suitable sowing early August.
- **Pusa Chetki**: roots are pure white, wild pungent suitable for sowing from March – August. Roots becomes ready for harvest within 40 – 45 days.

Climate:

Radish is tolerant to heat. The develops its flavour, texture and size, the cool season the temperature between 10 to 15°C are required. They should be harvested while they are still young and small rather than allow to reach edible size the long and large varieties can withstand heat and rain much better. Bolting is

quick when the day length increases. Long days as well as high temperature produce premature seedling or formation of stalks without adequate roots.

Soil: Raddish is grown in all types of soil but light friable soils is considered best. Sandy loamy soil with high amount of humus is ideal. It can also be grown fairly on acid soils. The summer crop is preferably grown on cool moist soils such as silty loams.

Land preparation and sowing:

- In plains of North India, radish can be grown throughout the year. Since temperate radish tolerates frost, it is successfully grown between September and January in plains.
- Tropical types are sown from middle of September onwards. If sowing is done later than November, it bolts earlier. Land is ploughed to a fine tilth and ridges of 25 cm height and furrows are prepared at 30-45 cm distance. Seeds are sown continuously in ridges. Spacing depends on type of varieties.
- Indian tropical cultivars take longer time and grow larger. Distance between two rows is kept at 45 cm and seeds are sown continuously on ridges. Later they are thinned to keep a distance of 6-8 cm in a row. Accordingly, seed rate varies from 10.0 kg for large varieties to 12.0 kg for temperate European types.

Irrigation:

Radish requires plenty of water from sowing to harvest. For rapid germination and subsequent production of roots, soil should be moist and loose. So irrigate immediately after sowing. If irrigation is restricted, roots will be tougher and pungent, making it unfit for marketing.

Inter-culture

In radish, the epicotyls grow up and develops into root tubers. As it grows in size, there is a tendency to bulge out. These roots are to be covered by way of one earthing up, which will take care of weeds also.

Harvesting

Depending up on the cultivar, roots will be ready for harvest in 25-55 days after sowing. If harvesting is delayed, roots will become bitter and pithy. Harvesting is done manually. A light irrigation is given before pulling out roots. After harvesting, roots are washed, made into bundles and marketed along with a few leaves.

Yield: European varieties yield 5-7 t/ha while in Indian cultivars, it varies from 15-20 t/ha.

BEETROOT

Botanical name: *Beta vulgaris*

Family :Chenapodiaceae

Origin : Mediterranean area

- ❖ Beet root is a popular root crop grown for its fleshy roots which are used as cooked vegetable, salad and for pickling and canning.

- ❖ Young plants along with tender leaves are also used as pot herbs.
- ❖ Beet root is a rich source of protein, carbohydrates, calcium, phosphorus, and vitamin C

Varieties: A few of the improved varieties popular in India are: Detroit Dark Red, Crimson Globe, Early Wonder, Ooty-1, Crosby Egyptian

Climate:

Beet root is hardy to low temperature and prefers cool climate. Though it grows in warm weather, development of colour, texture, sugar content etc. of roots is the best under cool weather.

High temperature causes zoning i.e., appearance of alternate light and dark red concentric rings in the root. Extreme low temperature of 4.5-10.0°C for 15 days will result in bolting.

Soil:

Deep well drained loam or sandy loams is the best for beet root cultivation. Heavy clayey soils result in poor germination and stand of crop due to formation of a soil crust after rains or irrigation.

Roots may be misshaped and will not develop properly in heavy soils. Beet root is highly sensitive to soil acidity and the ideal pH is 6-7.

Land preparation and sowing

- ❖ Being a cool season crop, beet root is raised during winter in plains and as a spring, summer crop in hills by March-April.
- ❖ In plains, sowing is practiced during September-November.
- ❖ Land is ploughed to a fine tilth by thorough ploughing making it loose and friable. Clods are to be removed completely.
- ❖ Apply well decomposed farmyard manure at the time of final ploughing.
- ❖ Flat beds or ridges and furrows are prepared.
- ❖ Water-soaked 'seed balls' which contain 2-6 seeds are drilled 2.5 cm deep in rows at spacing of 45-60 x 8-10 cm.
- ❖ 5-6 kg of seeds is required for one hectare.
- ❖ Staggered sowing at 1-2 weeks interval ensures steady supply of roots during the season.

Manures and fertilizers:

On sandy soils, organic manure @ 25 t/ha is recommended. For an average soil, 60-70 kg N, 100-120 kg P and 60-70 kg K/ha is recommended. Entire farmyard manure, half of N and full P and K should be applied basal at the time of land preparation prior to sowing and remaining at 30-45 days after sowing.

Aftercare

Thinning is an essential operation when more than one seedling germinates from each seed. Moist soil is essential for seed germination and for further growth. Usually, 5-6 irrigations are usually given during summer and three irrigations during winter in North Indian plains.

Field is usually kept weed free by light hoeing at early stage of crop. Swollen roots are also to be covered with soil by earthing up.

Harvesting

- ❖ Medium sized tubers are of great demand and tubers are harvested after attaining a diameter of 3-5 cm.
- ❖ Harvesting is done 8-10 weeks after sowing by pulling the top with hand. Later tops are removed, graded and marketed.
- ❖ In European countries, where small sized bunches are in demand, tubers are tied in bundles of 4-6 with their tops.

Yield varies from 25 to 30t/ha and the tuber stores well at 0°C and 90% RH.

LEAFY VEGETABLES

AMARANTHUS

Botanical name : *Amaranthus blitum*

Family : Amaranthaceae

Origin: Central and South America

- Leaves and succulent stem are good sources of iron (38.5 mg/100g), calcium (350-400 mg/100g), vitamin A and vitamin C.
- The iron availability is only about 15.2 – 53.6% of total iron. High oxalate content (1-2%) and nitrate (1.88.8 g/ kg dry matter) levels are reported from leaves of various species.
- Short duration, quick response to manures and fertilizers, high yield, easiness in cultivation and availability of diverse types suited to specific agro-climatic situations make it a favourite crop of farmers to fit in any cropping systems.
- Both leaf and grain types play a vital role to combat malnutrition of poor people.

Varieties

Varieties released from IARI, New Delhi

- PusaChottiChaulai: Plants dwarf with succulent, small and green leaves; responds well to cutting.
- Pusa Badi Chaulai, Pusa Kirti, Pusa Kiran, Pusa Lal Chaulai

Varieties released from IHR, Bangalore Arka Suguana, Ark Arunima (multicult variety with broad dark purple leaves)

Climate and Soil:

Amaranthus is widely distributed in both tropical and sub-tropical regions. Leaf amaranth is a warm season crop adapted to hot humid climatic conditions. It is grown throughout the year in tropics and in autumn, spring and summer seasons in temperate regions.

Amaranth comes up well in well drained loamy soil rich in organic matter. The ideal pH is 5.5-7.5 but there are types which can come up in soils with pH as high as 10.0. Red amaranth requires bright sunlight for colour development.

Method of sowing:

The seed is sown broadcast after mixing with fine earth for uniform distribution. Seed rate:2-3 Kg /Ha

Manuring:

Small quantities of Ammonium sulphate or urea can be mixed with irrigation water and applied when the seedlings are about 4-inchhigh to push vegetative growth.

Amaranth is a heavy feeder and high yielding crop. 20-25 tonnes of FYM and 50:25:20 kg NPK / ha are recommended as basal dose. Under pulling out method, 20 kg N should be top dressed twice during subsequent pulling out of seedlings.

For clipping varieties, a still higher dose of 75:25:25 is advisable. Apply N after every clipping or cutting.

Irrigation

Grain amaranth is a drought tolerant crop, but leaf amaranth requires frequent irrigation to keep soil moist. Frequency of irrigation depends on soil.

Interculture

Amaranth is a short duration and shallow rooted crop. Provide light hoeing to prevent soil crust formation after irrigation and to keep soil loose. Field also should be kept weed-free, especially during initial stages.

Harvesting

Amaranth is harvested early in the morning by pulling out or by clipping. In the first method, grown up plants are pulled out at 30, 45 and 55 days after sowing, along with roots, washed and sent to market in small bundles. In multi-cut method, first clipping or cutting is done 25-35 days after sowing. .

Yield: 7500 Kg /Ha in a span of 2 months

PALAK

Botanical name: Beeta vulgaris Var. Bengalensis

Family:Chenopodiaceae

Origin: Indo – china

Spinach is grown in north India. Vegetable growers mostly cultivated spinach while spinach is limited to kitchen gardens.

Varieties:

1. **All green** released by IARI, New Delhi. Leaves are uniformly green given 6 to 7 cuttings at 20 days interval starting from one month after sowing 125Q per hectare.
2. **Pusa palak:** IARI released produce uniform green leaves it is late in bolting
3. **Pusa Jyothi:** evolved treating the seed of all all green 2% colchuri it produces large green tender succulent leaves. Leaves are brittle in nature they have flavour and colour it gives 6 to 8 cutting. Yield: 50 tonnes per hectare.
4. **Pusa Harit:** evolved by hybrid sugarbeen x local palak released by IARI. It was developed to mainly to suit hilly regions. Crop require chilling a character inherited from sugar beet. Leaves are thick green and big sized. It is a late bolting variety.
5. **Jobner green:** university of udaipur popular in Rajasthan. It is a mutant variety from the popular of local collection it produces large thick tender succulent leaves. The taste is equal to all green gives yield of 300 q per hectare.

Soil:

Prefer sandy loam good drainage. Neutral pH. Cultivar Jobner green can withstand pH of 10.5. crop is regarded as highly salt tolerant and grow saline soil. Spinach is regarded as still more tolerant to saline condition.

Climate:

Prefer autumn and winter mild climate in plain. Withstand frost and some extent and warm weather. If temperature is very high, it results in bolting.

Sowing time:

Sown 2 to 3 seasons and condition are favourable. Sown through out the year. In plains spring season and rainy season are the important times of sowing. In hilly areas it can be sown even the a month of April.

Seed rate:

25 to 30 kg per ha. Beds are made irrigation channel in between. Seeds are soaked in water to hasten up germination. In general the seeds are sown by broad casting. But time of sowing is preferable.

Spacing:

20 cm is kept in successive time. Germination commences within 10 DAS will complete in soon. One light irrigation after sowing is essential.

Manuring:

Nitrogen fertilizer is more important. Apply 35 to 40 to per ha of well decomposed FYM 25 to 50 kg of N, P, M are given as basal and 25 kg Nitrogen after every cutting.

Irrigation:

Number irrigations are essential in light or sand soil. Summer crops require frequent irrigations at 3 to 4 days interval. In winter, autumn irrigations are given at 10 to 15 days interval.

Harvesting:

Starts at 25 to 30 DAS. It may continue to 15 to 20 days interval. Cut only green succulent tender leaves, winter crops gives more cuttings than summer crop. Jobner green gives more cuttings compared to all.

Yield: varies with cultivar 120 to 300 quintals per ha.

DRUMSTICK

Botanical name: Moringa olerifra

Family: Moringaceae

Origin: South West India

Importance:

- ☛ It is also known as Moringa.
- ☛ It is also known as ben oil tree.
- ☛ Drumstick is grown for its nutrient rich tender, but full grown pods, leaves and flowers which are used for culinary preparations.
- ☛ Fruits are rich in vitamin C (120 mg/100g), carotene, phosphorus and minerals like magnesium, potassium, sulphur.
- ☛ Seed are also very important as they give oil which is known as ben oil or beh oil. This oil is used for illumination and soap making industry. The oil is highly prized it is used for lubricating wrist watches, computer peripherals and delicate goods.
- ☛ Flowers are used as tonic and diuretic. The roots of the plants are used for seasonal pickle and for flavouring ghee.

Varieties:

There are perennial and annual types in drumstick.

Perennial types are mostly suitable for kitchen garden

Ex: Jafna, Kodaikas, Moringii, Kuttumaringi, Palmedu, Moringi, Palamedumoringi.

Annual: they are commonly planted on commercial scale their fruit and seed. KN 1, PKM 1 and PKM 2

PKM 1:

- It is annual type belong to Moringa.
- Each tree 250 pods are pod length well 60 to 75 cm. each fruit weigh 150 grams and contain 70% edible pulp.
- Estimated yield per hectare 520 Quintals.

PKM 2:

- The plants are thick growing around 4 to 8 m height each tree has around 12 branches beans flowers in clusters 3 to 4 pods can be obtained in a cluster.
- First harvesting is taken at 170 to 180 DAP. Each pod weight 280 grams with 125 cm length and it girth of 8 cm.
- A yield will be around 980 quintals per hectare.

Climate and soil

- * Drumstick is predominantly a crop of dry and arid tracts.
- * However intensive cultivation with good irrigation and systematic cultural practices will give good yield especially for annual type.
- * The plant put forth luxuriant growth at 25-30°C. Higher temperature results in heavy flower shedding. Crop is also injured severely by frost.

- * Though the crop comes up well in all types of soil, performance is better in sandy loam rich in organic matter.
- * A pH range of 6.0 – 6.72 is most ideal.

Propagation

- + Propagated by seeds or limb cuttings.
- + Perennial types are commonly propagated by limb cuttings. Annual types are propagated by seed.
- + The yield in perennial is used during first two years. Perennial types are to be planted at wider spacing, annual closer spacing.
- + The limb cuttings 1 to 1.4 m length and which having 14 to 16 cm girth are collected from index plants and these limb cuttings are planted at distance of 2.0 x 2.5 m
- + Planting time: June to October.
- + In case of seed propagation or 625 g of seed is required for one hectare.
- + Average seed weight is 0.288 g and 10 g contain 35 seeds. Seeds @ 625 g/ ha can be either sown in pits or transplanted after raising seedlings in polythene bags.

Pit size and planting:

Around 45 to 60 cubic centimeters pit are dug up and pits are refilled the top soil is mixed with 5 to 10 kg FYM, 25 g of SSP and 50 g of folidol dust. The pits are irrigated before planting per sowing either seed and seed per pit area sown and regular watered 15 to 20 days.

Seeds germinate. Thinning is practiced seedling 15 to 20 cm height only vigorous plants are retained other or removed.

Nursery:

- ☛ In case of seed propagation instead of direct sowing a nursery can also be sensed with 15 x 75 cm polythene bags.
- ☛ Bags are filled with mixture of sand, soil, biofertilizers and seeds are sown per bag.
- ☛ They are allowed for one month, till the seedling attains 30 cm height. Seeds are transplanted to the main field.
- ☛ Nitrogen is done in the month of June transplanting in the month of July.
- ☛ Flowering is attained during the month of January to February and pods will come to harvest from March onwards. Around 75 to 100 additional plants are grown in polythene bags per the purpose of gap filling.

Manuring:

100 grams of Urea, 60 grams of each SSP and MOP are applied for each plant and then they are sufficiently irrigated. The plants are top dressed with 100 g of Urea 3 months after the first application besides this inorganic fertilizer well decomposed FYM @ 10 to 15 Kg may be added for each tree. The manures and fertilizers are applied in ring trenches dug at 60 to 90 cm among from the tree during the rainy season.

Aftercare:

Training and pruning practices are important when seedling attain 75 to 100 cm height, they are headed back this practice helps in production of side shoots, strong side shoot is allowed in all direction when the side shoots are 45 cm long, they are again headed back. This helps in development of better frame work and increase the yield.

Moringa plant can fell down during heavy wind. Wind movement height rise. The soil trunk mound up 30 to 45 cm height from ground level.

Irrigation:

The basins of trees should be cleaned of all weeds mid slight sowing of soil is very useful. Basin method of irrigation is followed in drumstick. Irrigation management is important in this crop. Since the plant need optimum moisture for good growth and development.

First irrigation is given to pits before sowing next irrigation after 3rd day of sowing light irrigation are given to maintain optimum moisture till the seeds are germinate. Irrigation 10 to 15day interval in the absence of rains is beneficial however they should not be any water stagnation otherwise they will be a heavy flower drop soil should never become too dry or too wet.

Harvesting:

- ❖ Annual type comes to first harvest in about 6 months after sowing or planting perennial.
- ❖ Perennial types which are seed propagated may come to first harvest during third year of planting.
- ❖ The pods should be harvested at optimum edible maturity around 60 days after pollination the pods will reach this stage. F
- ❖ lowering and fruit bearing takes place simultaneously and continues uninterrupted for the next 2 to 3 years 1 to 2 harvestings

Yield:

- ☛ Annual type 200 to 250 fruits per tree per year, during first and second year.
- ☛ Perennial type can yield up to 80 to 90 fruits during the first 2 years and afterwards the yield will increase up to 500 to 600 fruits per tree per year during the fifth year.
