FUNDAMENTALS OF HORTICULTURE

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Chapter -1

IMPORTANCE AND SCOPE OF HORTICULTURE

The word Horticulture is derived from the Latin word ***Hortus*** meaning **enclosure (garden)** and ***culture*** meaning **cultivation**. Thus, Horticulture means culture or cultivation of garden crops.

Enclosed places were used to grow fruit, vegetables, flowers and ornamental plants. Therefore, in the original sense, "Horticulture refers to cultivation of garden plants within protected enclosures"

Horticulture may be broadly defined as the science and art of growing fruits, vegetables, flowers and crops like spices condiments and other plantation crops.

Horticulture according to modern science is the cultivation, processing and utilization of a number of crops such as fruits, vegetables, ornamentals, plantation crops, spices, medicinal, aromatic plants and mushrooms

Branches of Horticulture:

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

The branches of horticulture can be broadly classified as under:

Main Branches:

1) **Pomology:** Pomology is a branch of horticulture which deals with the cultivation of fruit crops.

2) **Olericulture:** Olericulture is a branch of horticulture which deals with the cultivation of vegetable crops.
3) **Floriculture:** Floriculture is a branch of horticulture which deals with the cultivation of flower crops.

4) Plantation crops, Spices, Condiments.

a) **Plantation crops:** Tropical crops grown area on a large scale by a uniform system of cultivation under central management and centered around a factory are called plantation crops. Eg tea, coffee, coconut, palms etc.
b) **Spice crops:** Spices are dried vegetable substances which are used for seasoning food and imparting distinctive flavor and fragrance that gives zest or piquancy for enjoyment. eg. Black paper, cinnamon, nutmeg etc.

c) **Condiments:** Condiments are plant-products which add taste to the foodstuffs or food preparations. eg. Coriander, cumin etc.

5) Fruit and vegetables Preservation.
This branch deals with the principles and practices of preservation of fruits and vegetables in different forms for their use out of season or in areas where these crops are not grown.eg. jam, jelly, ketchup, pickles, etc.

Another sub branches of horticulture can be roughly classified as under:

1) Medicinal and Aromatic plants.

a) Medicinal plants: Medicinal plants are rich source of alkaloids and steroids having prophylactic or curative properties for treatments in several diseases and are used in pharmaceutical industries for preparing medicines for human beings and animals (veterinary medicines) eg. *Vinca, Isabgol* etc.

b) **Aromatic plants:** Aromatic plants are the plants which provide essential oils and are in great demand in cosmetic and perfumery industries. eg. Lemon grass, Patchouli etc.

2) **Ornamental gardening:** It is the branch of horticulture which deals with the study of growing of ornamental foliage and flowering trees, shrubs, climbers, seasonal flowers, cacti, orchids, indoor and outdoor garden plants.

3) **Landscape gardening:** It deals with planting of different types of ornamentals which create a picturesque effect by imitating nature in garden.

4) **Nursery management:** There is a scientific study for the production of plants in nurseries for their subsequent cultivation in fields

IMPORTANCE OF HORTICULTURE CROPS

The importance of horticulture crops can be enunciated by studying the following points;

1. Horticulture crops contributes to the national income :

The main contribution of horticulture crops is to increase the national income. It also increases foreign exchange earning achieved through the export of produce.

2. High production per unit area:

A horticulture crops give very high production per unit area as compared to cereals and pulses crops. In horticulture crops inter-crops are also taken during initial years of

cultivation. For example agronomic crops like Rice gives 4.3 t/ha yield, Jowar give 4-5 t/ ha yield. Whereas horticulture crops like Mango gives 18-19 t/ha, Banana gives 30-35 t/ha and Tomato gives 50-60 t/ha.

3. **Fruit and vegetables are "protective foods":**

Fruit and vegetables have good source of vitamins and minerals, proteins and other substances which are needed for human body. viz,. Minerals like calcium, iron, phosphorus, etc. and vitamin such as A, B complex, C are in adequate quantity.

4. **Source of income throughout the year:**

In vegetable crops, some of the vegetables are annual crops. Some vegetables give yield within month of planting/sowing, while crops like coconut give income throughout the year.

5. **Best utilization of undulating and barren land:**

The horticulture fruit crops such as Cashewnut, Aonla, Ber, Mango, Tamarind, Jamun, Karonda, can be grown on undulating, barren/wastelands where agronomic crops cannot be grown on such land.

6. Utilization of dry land areas for fruit crops like ber, custard Apple, drumstick, aonla, jamun etc., can be utilized under low water availability.

7. **No recurring expenditure:**

In the case of fruit crops, there is no recurring expenditure like layout of orchards every year encountered in the case of agronomic crops. There is no need to search planting material every year.

8. **Industrial use:**
The Horticulture crops are used in various industries such as Coconut in Coir and toys industries, aonala, turmeric, alovera, clove in Medicinal industries, turmeric, alovera in Cosmetic industry, flower like jasmine, rose in perfumery industry and kokum juice, ginger, turmeric, mango Pulp, aonala, candy in Preservation industry:

9. **Saving money:**
Horticulture crops are cultivated in kitchen garden. Thus, one can get a fresh supply of vegetables and save a considerable amount of money, besides being a source of creation and recreation.

10. Horticultural crops, especially the fruit crop reduce environment pollution and reduce soil erosion and help in increasing precipitation.

11. Fodder to cattle: During famine, leaves of some of the crops such as Tamarind, Aonala, Ber etc. are used as fodder.

12. Social Importance:

Horticultural crops have a great social importance which can be described in the following points.

a) Use in religious functions: eg. Coconut, Turmaric, Arecanut, Flowers of various kinds, Betalvine etc.
b) Symbol of love affection and friendship: Flowers are used for express affection and decorating halls and welcoming function.
c) Determination of standard of living: Standard of living of the country can be determined by the per capita consumption of fruits and vegetables. In case of Japan has high consumption of vegetables.
d) Aesthetic value: The flowers, fruits trees and other ornamentals have considerable aesthetic value.

Features of horticulture in general

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

13. Horticultural crops and Human Nutrition

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

Functions of fruits and vegetables in human body:

1. Fruits and vegetables provide palatability, taste, improve appetite and provide fibre thereby the constipation can be overcome.
2. They neutralize the acids produced during digestion of proteins and fatty acids.

3. They improve the general immunity of human body against diseases, deficiencies etc.
4. They are the important source of vitamins and minerals for used in several bio-chemical reactions occur in body.

Fruits:-

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

Vitamins/ Minerals
Role in human body Source

Vitamin-A

1. Essential for growth and reproduction.
2. Helps in resistance to infections, increases longevity and decreases senility.
3. Deficiency causes, night blindness, xeropthalmia, retardation in growth, roughness in skin, formation of stones in kidney. Eg. Mango, Papaya, Persimon, Dates, Jack fruit, Walnut, Oranges, Passion fruit, Loquât etc.

Vitamin – B2

1. Important for growth, health of skin and for respiration in poorly vascularised tissue such as the cornea.
2. Deficiency causes pellagra and alopecia, loss of appetite, loss of weight, sore throat, development of cataract, swollen nose and baldness. Eg. Bael, Papaya, Litchi, Pomegranate, Wood apple and Pineapple.

Vitamin – C

1. Deficiency causes scurvy, pain in joints, swelling of limbs, unhealthy gums, tooth decay, delay in wound healing and rheumatism. Eg. Barbados cherry, Aonla, Guava, Lime, Lemon, Sweet oranges, Ber, Pineapple and Pear.

Vitamin – B1

1 . Essential for the maintains of good appetite and normal digestion.
2. Necessary for growth, fertility, lactation and for normal functioning of nervous system.
3. Deficiency causes beri-beri, paralysis, loss the sensitivity of skin, enlargement of heart, loss of appetite and fall in body temperature. Eg. Walnut, Apricot, Apple, Banana, Grapefruit, Plum and Almond.

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

Calcium Causes Rickets, Osteomalacia. Sitaphal, Ramphal, Fig, Phalsa, Citrus, Sapota, Grapes, West Indian Cherry etc. Fruits are also a good source of energy eg. Avocado, Olive etc. They are also a good source of enzymes which are helpful in metabolic activities leading to proper digestion of food. Eg. Jamun and Papaya. All fruits have one or the other medicinal value. Regular consumption of fruits reduces obesity, maintain health and increase the longevity of life.

SCOPE OF HORTICULTURE CROPS

India, with its diverse soil and climate comprising several agro- ecological regions, provides an opportunity to grow a variety of horticultural crops. These crops form a significant part of total agriculture produce in the country comprised of fruits, vegetables, flowers, ornamentals, medicinal and aromatic crops, plantation crops, spices and condiments. Horticulture crops play a unique role in India's economy by improving the income of the rural people. Cultivation of these crops is an intensive labor which generated employment opportunities for the rural population. India's area under horticultural crops touched 2.1million hectares (21.03 lakh hectare). With regard to fruits, India is the second largest producer of fruits after China. A large variety of fruit crops are grown in India. Of these, mango, banana, citrus, papaya, guava, pineapple, sapota, jackfruit, litchi, grapes, apple, pear, peach, plum, walnut etc. are the important ones. India accounts for 10 per cent of the total world production of fruits. The leading fruit growing states are Maharashtra, Karnataka, Andhra Pradesh, Bihar and Uttar Pradesh. In regard to vegetables, many vegetables belonging to solanaceaeous, cucurbitaceous, leguminous, cruciferous, root crops and leafy vegetables are grown in Indian tropical, sub-tropical and temperate regions. Most of the important vegetables grown in India are onion, tomato, potato, brinjal, peas, beans, okra, chilli, cabbage, cauliflower, bottle gourd, cucumber, watermelon, carrot, radish etc. India ranks second in vegetable production next to China in case of area and production contributing 13.38 % to the total world production. India occupies first position in cauliflower, second in onion, third in cabbage in the world. In India, West Bengal, Orissa, Uttar Pradesh, Bihar, Maharashtra, Karnataka are the important states for horticultural crop production. Among these state West Bengal has first rank in Area and Production.

Flowers are indispensible part of the Indian festivals. In India, flower cultivation is being practiced since ages. It is an important/integral part of socio-cultural and religious life of Indian people. It has taken a shape of industry in recent years. India is known for growing traditional flowers such as jasmine, marigold, chrysanthemum, tuberose, crossandra, aster, etc. Commercial cultivation of cut flowers like, rose, orchids, gladiolus, carnation, anthurium, gerbera is also being done. The important flower growing states are Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, West Bengal, Sikkim, Jammu & Kashmir, Meghalaya, etc. The importance of plantation crops is immense in terms earning foreign exchange. This is one of the important sectors contributing about Rs.7,500 crores of export earnings. The major plantation crops include coconut, arecanut, oil palm, cashew, tea coffee, rubber cocoa, betel vine, vanilla etc. The leading states are Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra, Goa, Assam etc. Since from the ancient times, the world is fascinated about Indian spices. They constitute an important group of horticulture crops and are defined as vegetable products or mixture thereof, free from extraneous matter used for flavoring, seasoning and imparting aroma in foods. India is known as home of spices producing a wide variety of spices like black pepper, cardamom, ginger, turmeric, chilli, Coriander etc. Major spice producing states are Kerala, Andhra Pradesh, Gujarat, Rajasthan, Maharashtra, Karnataka, Orissa, Tamil Nadu etc. India has long and rich tradition of Ayurveda. In this regard, medicinal plants have proved to be life saver since from the inception of Ayurveda. India has diverse collection of medicinal and aromatic plants species distributed throughout the country. It has more than 9,500 species with medicinal properties.

Demand for these crops is increasing progressively in both domestic and export markets. Important medicinal plants are Isabgol, Senna, Opium poppy, Periwinkle, Coleus, Ashwagandha, etc. and aromatic plants are Japanese mint, Lemon grass, Citronella, Davana, Patchouli etc. In brief it can be stated that horticulture has great scope for the following reasons:-

1) Irrigation facility:

A number of irrigation projects have been completed and some are in progress. A numbers of percolation tanks are being constructed. New scheme of water conservation are launched and some are in progress. This development potential can be effectively used to increase area under irrigation which is useful to increase the area of horticulture crops, especially under the fruit crops.

2) Transport and marketing facility:

Horticultural crops being perishable in nature require quick transport facilities. Development in the transport facilities can help to increase the area under horticulture crops by carrying the produce quickly and safely to markets viz. Banana from Jalgaon to North India, Onion from Nasik to Ahmadabad, Grapes from Maharashtra to European country. The most important fact is market should be near or if it is distant, there should be a facility of precooling, cold storage etc. A number of cold storages are constructed by using the assistance of National Horticulture Board thereby increasing scope for cultivation of horticultural crops. Recently, Maharashtra state government has been sanctioned development of dry port in Jalna district which is used for storage as well as direct transportation of agriculture commodity from Jalna to Mumbai.

3) Development of new techniques for maximum production:

Many modern techniques have been developed for cultivating horticultural crops viz.,

a) Improved vegetative propagation techniques such as grafting, budding, layering, tissue culture etc. are developed.
b) Use of growth regulators
c) Use of protected cultivation
d) Efficient irrigation technique viz., micro irrigation like drip and sprinkler etc.
e) Use of special Horticulture practices such as ringing in guava, girdling in grapes, notching in fig, bahar treatments in fruits followed by farmers.
f) Use of new planting technique like high density planting.
g) Biotechnology is giving the protection cover to crops.

These potentials have increased the scope of horticulture crops.

4) Evaluation or Development of new variety:

Many of variety in fruit, vegetables and flower crops with the specific objective like higher yield, improved quality, disease and pest resistance etc. have been developed.

eg. Pusa jwala variety of chilli - it is resistant to leaf curl of chilli virus.
Sardar variety of Guava - It is spreading type variety.

5) Processing and value addition of horticulture crops :

Lack of processing industry 30-40% waste occurred because of improper post harvest handling and storage in fruits and vegetables. Therefore there is ample scope of processing industries which will prove to be a boost for production of fruits and vegetables.

6) New development scheme of state and central government:

A number of schemes promoting horticulture development are in operation. This is beneficial to small and marginal farmers and even to large farmers. Government gives subsidy, provide loans- short term, medium term and long term for cultivation of horticulture crops.

7) Availability of cheap manpower:

In India, a large population manpower which can be effectively used in the development of horticulture is easily available and helps them to provide employment and cheap labour reduces the production cost of horticulture crops.

8) Availability of diverse and congenial climate:

India has different types of climates which are suitable for horticulture crops. The Maharashtra state has diverse and congenial climate for cultivation of various types of fruits, vegetables and floriculture crops. eg. tropical, subtropical, temperate, arid crops are cultivated in Maharashtra.

9) Development of cooperative sector and export potential:

A number of co-operative bodies/ organizations working in retention to fruits, vegetables, and floriculture production and marketing federations have been established all over India. This take the responsibility of marketing the farmers produce on co-operative basis. The horticultural produce has a great export potential for earning foreign exchange.

Chapter No. 2

Classification of Horticultural crops

Horticultural crops having many species which are grown all over India. India endowed with rich vegetational wealth. Encompassing 356 domesticated species of the economic importance and 326 species of their wild forms or relatives. Indian subcontinent enjoys rich diversity of plant wealth besides; about 9,500 other species of ethanobotanical interest have also been recorded. Out of these more than 50 types of individuals types of species, plantation crops, etc. are under commercial cultivation in different part of the country under different sets of growing conditions. An attempt to deal with all these plants separately becomes tedious, cumbersome and infeasible and more so repetitive. To avoid these difficulties it is better to classify the plants in groups based on similarity in either of the traits are placed under one group. Such type of grouping of plants in different categories is referred to as classification.

To overall objectives of the classification is to systemize the presentation and make the remembrance of the plants easy and convenient.

Classification: Classification of plants means the grouping of different plants has some characteristics in common.

Classification of plants is a relatively dynamic process and undergoes change with change or increase in knowledge.

Purpose of classification:

a) For easy and quick cultural operations.
b) For breeding purpose and to evolve new varieties.
c) For facilitating propagation of crops.
d) For effective control of pest and diseases.
e) For cultivating crops suitable to different climatic conditions.

Horticultural plants are classified on following basis:

1) On the basis of duration of life/life span.
2) On the basis of climatic requirements.
3) On the basis of growth habit and physiological characters.
4) On the basis of plant parts used for consumption.
5) On the basis of whether leaves are shed during the year.
6) On the basis of longevity.
7) Botanical classification.

1) On the basis of duration of life/life span: The horticultural crops on the basis of duration of life are classified as;

a) **Annuals:** Plants which complete their life cycle in one season or one year are called as annuals. e.g. Tomato, Balsam, Marigold etc.
b) **Biennials:** Plants which complete their life cycle in two seasons or two years are known as biennials. e.g. Onion, Cabbage, Tuberose etc.
c) **Perennials:** Plants which require more than two years to complete their life cycle are called perennials. The perennials necessarily do not die after flowering.
    i. **Woody perennials:** These plants have hard and fibrous trunk and branches. e.g. *Bahuma* sp., Mango etc.
    ii. **Herbaceous perennials:** These plants have soft succulent stems. e.g. Banana, Chrysanthemum etc.

2) **On the basis of climatic requirements:**
Temperature:
a) **Temperate Horticultural crops:** In temperate regions, the temperature in winter season falls below freezing point. The crops shed their leaves and go into rest. These chilling temperatures help the plants to put forth new growth. Flowering and fruiting starts with the onset of spring. e.g.,
    - **Fruits:** Apple, Pear, Almond, Walnut etc.
    - **Spices:** Saffron, Kalajira, Asafoetida etc.
    - **Vegetables:** Cabbage, Cauliflower, European varieties of carrot and radish.

    These vegetables can be grown in sub-tropical regions, however they require temperate climate for seed production.

b) **Sub-tropical Horticultural crops:** In sub-tropical climate, the summer are hot and dry and winter are less mild. e.g.,
    - **Fruits:** Citrus, Guava, Pomegranate, Fig etc.
    - **Spices:** Turmeric, Ginger, Onion, Garlic etc.
    - **Vegetables:** Tomato, Brinjal, Chilli, Okra, Potato etc.

c) **Tropical Horticultural crops:** The climatic conditions in such areas are hot and humid in summer and mild in winter. e.g.,
    - **Fruits:** Mango, Banana, Pineapple, Sapota etc.
    - **Spices:** Black pepper, Turmeric, Ginger, Cloves etc.
    - **Plantation crops:** Coconut, Arecanut, Cocoa etc.
    - **Vegetables:** Tomato, Brinjal, Chilli, Onion etc.

3) **On the basis of growth habit and physiological characters:**
   a) **Trees:** Trees are the plants which have a distinct stem or trunk which may be woody or herbaceous.
      i) **Woody trees:** These plants have hard and fibrous trunks and branches. e.g. Apple, Citrus, Guava, Mango etc.
      ii) **Herbaceous trees:** These have soft succulent stems.
         - **Herbaceous trees (upright growth):** e.g. Banana, Pineapple.
         - **Herbaceous trees (postrate growth):** e.g. Strawberry.
   b) **Shrubs / bushes:** Shrubs or bushes produce a large number of branches and are smaller in size than trees. e.g.
      - **Fruits:** Phalsa, Coffee etc.
      - **Ornamental shrubs:** *Acalypha* etc.
   c) **Climbers:** These plants attach themselves to supports such as trellis, arches or lives plants. e.g.
      - **Fruits:** Grapes, Passion fruit etc.
      - **Spices:** Black pepper (live support) etc.
      - **Ornamental climbers:** Allamanda, Antigonan etc.

4) **On the basis of plant parts used for consumption:**
   a) **Fruits:**

Sr. No.	Name	Edible Part
1.	Apple (Pome)	Fleshy thalamus
2.	Banana (Berry)	Mesocarp and endocarp
3.	Cashew nut (nut)	Peduncle and cotyledons
4.	Coconut (Fibrous drupe)	Endosperm
5.	Custard apple (Etaerio of berries)	Fleshy pericarp of individual berries
6.	Fig (Syconus)	Fleshy receptacle
7.	Guava (Berry)	Thalamus and pericarp
8.	Grape (Berry)	Pericarp and placentae
9.	Mango (Drupe)	Mesocarp
10.	Orange (Hesperidium)	Juicy placental hair
11.	Papaya (Berry)	Mesocarp
12.	Pineapple (Sorosis)	Fleshy thalamus
13.	Pomegranate (Pome)	Aril

   b) **Plantation crops and spices:**

Sr. No.	Name	Edible Part
1.	Coconut (Fibrous drupe)	Endosperm
2.	Arecanut (one-seeded ovoid drupe)	Seed (Fresh and dried)
3.	Cocoa (5-ribbed drupe)	Beans (Seeds)
4.	Coffee (Fleshy Drupe)	Seed (Bean)
5.	Black pepper (One-seeded spherical dupe)	Dried wrinkled fruit
6.	Clove (Fleshy drupe)	Unopened flower bud
7.	Cinnamon (Fleshy berry)	Bark

8.	Chilli (berry)	Fruit and seeds
9.	Turmeric	Rhizome
10.	Ginger (Capsule)	Rhizome
11.	Onion	Leaves and Bulb
12.	Garlic	Cloves

c) Vegetables:

Sr. No.	**Name**	**Edible Part**
1.	Radish, Carrot, Turnip, Beetroot, Sweet potato	Roots
2.	Knolkhol, Potato	Stem
3.	Palak, Methi, Amaranthus	Leaf
4.	Cauliflower, Broccoli	Flower
5.	Tomato, Brinjal, Okra, Cucurbits	Fruit
6.	Beans and Pea	Pod
7.	Onion	Blub

5) On the basis of weather leaves are shed during the year:

a) Deciduous: the plants that are leafless or which shed their leaves during winter are referred to as deciduous. e.g. Apple, Fig, Grape etc.

b) Evergreen: The plants whose leaves persist the year round or grow continuously all the year round are known as evergreen.

The evergreens actually loose their leaves annually but not until a new set of leaves is developed. e.g. Arecanut, Coconut, Banana, Mango, Sapota etc.

6) On the basis of longevity:

The longevity of trees is very variable and plants can be classified on the basis as under;

Life span		**Plants**
a) 1000 years	:	Sweet chestnut.
b) 100-300 years	:	Walnut.
c) 50-100 years	:	Persimmon, Avocado.
d) 30-70 years	:	Apricot, Fig.
e) 20-40 years	:	Peach, Plum, Pomegranate.
f) 25-30 years	:	Currant, Gooseberry and Raspberry.
g) 4-5 years	:	Strawberry.

7) Botanical classification:

A) Botanical classification of vegetables:

a) Monocot:

i) Areaceae - Colocassia.

ii) Alliaceae - Onion, Garlic.
iii) Diascoreaceae - Yam.

b) Dicot:

i) Chenopodiaceae - Spinach.
ii) Cruciferae - Cole crops, Turnip, Radish.
iii) Leguminosae - Pea, Beans, Fenugreek.
iv) Euphorbiaceae - Tapioca.
v) Malvaceae - Okra.
vi) Umbelliferae - Carrot.
vii) Convolvulaceae - Sweet potato.
viii) Solanaceae - Tomato, Brinjal, Chilli, Potato.
ix) Cucurbitaceae - Gourds, Melons, Pumkin.
x) Compositae - Lettuce

B) Botanical classification of fruits:

a) Monocot:

i) Musaceae - Banana.
ii) Bromeliaceae - Pineapple.

b) Dicot:

i) Rhamnaceae - Ber.
ii) Sapotaceae - Chiku.
iii) Rutaceae - Nagpur Santra, Sweet Orange, Acid lime.
iv) Annonaceae - Custard apple, Bullock's heart.
v) Moraceae - Fig, Jackfruit.
vi) Vitaceae - Grape.
vii) Myrtaceae - Guava.
viii) Apocynaceae - Karonda.
ix) Anacardiaceae - Mango, Cashew nut.
x) Caricaceae - Papaya.
xi) Punicaceae - Pomegranate.

C) Botanical classification of plantations and spices:

a) Monocot:

i) Arecaceae (Palmae) - Coconut.
ii) Arecaceae (Palmae) - Arecanut.
iii) Alliaceae - Onion, Garlic.
iv) Zingiberaceae - Turmeric, Ginger.

b) Dicot:

i) Lauraceae - Cinnamon.
ii) Mytraceae - Clove.
iii) Piperaceae - Black pepper.

iv) Rubiaceae - Coffee.
v) Solanaceae - Chilli.
vi) Sterculiaceae - Cocoa.

8) Classification based on Rate of Respiration

(A) climacteric				(B) Non-climateric			
*Sharp rise in respiration after harvesting				*Steady respiration at the time of harvesting			
1	Mango	7	Fig	1	Citrus	7	Jamun
2	Banana	8	Peach	2	Grape	8	Cashew
3	Sapota	9	Pear	3	Pineapple	9	Cherry
4	Guava	10	Plum	4	Pomegranate	10	Strawberry
5	Papaya	11	Annona	5	Litchi		
6	Apple			6	Ber		

* Climateric fruits produce much larger amount of ethylene than non climacteric fruits.

*Highest ethylene production : (i) Apple- (25-2500L/L)
ii) Passion fruit (466-530 L/L)

9. Classification based on Photoperiodic responses

Long day plant	**Short day plant**	**Day neutral plant**
Passion fruit	Strawberry	Papaya, Guava
Banana, Apple	Pineapple, Coffee	Banana
Potato	Sweet Potato	Tomato
Onion	Indian spinach	Brinjal
Cabbage	Dolichos Bean	Chilli
Cauliflower	Cluster Bean	Okra
Raddish	Winged Bean	Cucurbits
Lettuce		Amaranths
Spinach		French Bean
Palak		Cowpea
Turnip		Sweet pepper
Carrot		
.Beet		

Chapter No.3

Soil and climatic requirement of Horticulture crops

The Climate and soil have important role played in growth of the plant. Fruit growers should have knowledge of the effect of various soil and climatic conditions on fruit growing. Horticulture crops cannot be grown in all type of soil and climate. Hence zone wise cultivation is made. Climate includes a number of parameters like temperature, rainfall, atmospheric humidity, wind, hail, light, whereas soil covers such factors as moisture supply, texture, chemical composition and soil temperature.

SOIL

Horticulture crops require soils as growing medium. It provides mechanical support, nutrients and water to the plant growth. The demand of Horticultural crops is mainly water, nutrients and growth hormones. The number of factors affects roots absorbing nutrients and moisture. To ensure development of an efficient root growth. The soils must contain adequate supply of air, water and low bulk density. Most of the Horticulture crops need well drained soil and cannot tolerate water logging. Therefore deep and well drained soils, free from hard sub soils, are needed for growth of the plant. While examining the soil, more attention is paid to its physical conditions rather than its chemical composition. Soil may defined as " superficial earth crust which function as store house of reservoir of water and nutrient at the same time providing the necessary physical support to the plant".

Properties of soil:

Soil are mainly classified as physical as well as chemical properties of mostly influenced mineral matter of the soil and by the soil particles like sand, silt and clay.

Sandy soils feel gritty when rubbed between your fingers. Silts feel smooth a little like flour most clays are sticky and mouldable.

Sand Particles

Course sand = 0.2 to 2 mm in diameter.

Fine sand = 0.02 to 0.2 mm in diameter

Silt = 0.002 to 0.02 mm in diameter.

Clay = < 0.002 mm in diameter.

On account of small size and relatively large surface area they exhibits colloids property and are capable of increasing the water as well as nutrient retention capacity of the soil. In a typical soil there should be proper proportion of these soil particles.

It is possible to alter the physical condition of the soil by adding organic matter. This improves the structure and texture of the soil.

Physical properties of soil:

Soil structure:

It should be uniform favorable for water penetration, soil aeration and drainage. It has different layers therefore soil profile pits have to be taken and examined the structure.

Soil aeration and drainage:

Soil aeration which is helpful for growth of aerobic organism. In the soil to promote metabolic activities of these organisms. Fruit and vegetables required well drained soil. Poor performance observed due to poor aeration and drainage. Therefore well drained soil is essential. Extreme wet and dry soil should be avoided.

Water Table:

Availability of water at a certain depth is called as water table. High percentage of water can rise into water logging which is affect on growth of the plants. Therefore water depth should not more than 2m throughout the year.

Soil depth and Organic matters:-

Heavy soil caused water logging and poor aeration. light soils are infertile due to lending of nutrients therefore the soils should 2 to 2.5 m deep for growing of fruits and vegetables. Successfully organic matters influenced on physical and chemical properties of soils. Whenever soil contain more amount of organic matter which will increase the production of fruits and vegetables.

Soil Texture :

In The case of Horticulture crops generally required medium textured soil. Fine and coarse textured soil should be avoided.

Soil Temperature:

Soil temperature affects the root activity and is influenced by aeration and drainage. In cold soils chemical and biological activities are slow and availability of nutrients like N, P, S and Ca is limited.

Nitrification would not start when the temperature is 4°C for successful growth of horticultural plants the soil temperature should be within the range of 26 to 36°C. Due to low temperature absorption and transport of water and nutrient is adversely affected.

Chemical Properties of soil:

Soil fertility:

Soil fertility depends on nutrients contain such as N.P,K, Ca, Mg and S are important elements required for growth development of plants. Micro-nutrients like Fe, Mn, Zn, Bo, Cu, Mo etc are also required.

Soil reaction:

Soil analysis is important to find out the chemical composition of soil. The safe PH range is from 6 to 8. Some soils are Problematic for plant growth like saline and alkaline soils. In Alkaline soils concentration of sodium salts above 0.1% is harmful. Boron is deficient in alkaline soils and is unavailable in acidic soils. Iron is available in acidic soils whereas calcium and magnesium are deficient. In alkaline soils K, Mn, Fe, and Boron are deficient.

Soil Salinity:

Information on salt tolerance is necessary to select salt tolerant varieties and to adopt proper soil management practices.

1) Salt tolerant Crops: Date palm, Phalsa, Sapota, Fig, Grape, Aonla, Wood apple, Ber, Chikory, Potato, Sweet potato, Watermelon etc.
2) Moderate salt tolerant crops: Pomegranate, Grape fruit, Lemon, apple, Pear, Plum, Beans, Cucumber, Brinjal, Garllic, Radish, Pea, Tomato, Turnip.
3) Salt Sensitive crops: Orange, Peach, avocado, strawberry, Asparagus, Beet, Cabbage, Cauliflower, Palak, Leek, Lettuce.

In general it may be stated that soils for fruit growing should be porous deep and aerated. They should not be water logged, marshy, saline, or acidic and three should be no hard pan at the bottom layers.

CLIMATE

Climate is defined as the whole of average atmosphere phenomenon for a certain region calculated for a period of thirty years.

Temperature:

Each and every Horticulture crops having its optimum temperature requirement which is suitable for their growth. It has range of temperature to which it is tolerant and below or above which the plant of that variety are liable to be injured to a more or less extent. Growth of banana

is influenced by temperature. It grows well with a mean monthly temperature of 26.5°C. When the temperature goes below mean temperature owing to reduced rate of leaf production and delayed the harvesting. Therefore it is important for growers not only to known the minimum temperature of the region were the fruit crops are to be grown but also the approximate minimum temperature that the particular plant or crop can withstand at different stage of growth.

Atmospheric Humidity:

The atmospheric humidity also influences growth and development of plants. Low humidity has drying effect and enhances water requirement whereas high humidity favors fungal diseases, tastelessness and low keeping quality. High humidity and low humidity are suitable for following crops; like high humidity favorable for Sapota , Banana, Mangosteen, Jackfruit and Breadfruit. Whereas low humidity suitable for Ber, Grape, Datepalm, Pomegranate, Citrus, Aonla and Guava. The atmospheric humidity affects the juiciness of the fruits which is observed in Ambia bahar fruits of Mandarin is juicer than mrig bahar fruit of Mandarin probably due to humidity during growing season of both bahar.

Rainfall:

Water requirement of the crops is dependent on soil type and evapo transpiration rate. For crop production it is not the total rainfall but its distribution is more important and in Indian subcontinent we have rains mainly confined to June to September , thereby fruit culture in India had to be supported by irrigation or one has to select crop where fruiting is confined to water availability periods and trees remains dormant during stress.

Excessive rains occurring in short periods are generally unfavorable to fruits as it leads to water logging and at blooming time may wash away pollens and thereby inhibit pollination. In low rainfall regions, cultivation of fruit crops is difficult if adequate and cheap irrigation facilities are not available.

Wind:

It is also one of the climatic factors influencing the plant growth. A situation which is exposed to wind causes evaporation of soil moisture and thereby necessities more frequent irrigation. Hot wind at the time of blossoming may cause failure of pollination due to drying of stigmatic fluid and reduced activities of the pollinating insects. In the case of deserts, valleys for avoidance of high speed wind windbreaks and shelter belts are suggested.

Wind direction and velocities have significant influence on crop growth both mechanically as well as physiologically. Mechanically effects on flower pollination, seed dispersal, tearing of leaves, lodging of plants, fruit drop, and uprooting of plants. Same like physiological effects like transpiration increase, plant desiccation, reduce plant height because of reduction in cell elongation.

Hail:

It is very rare in Maharashtra, in northern India the fruit crops are greatly affected by hail. They cause shedding of young fruits and flowers while maturing fruits become almost unmarketable.

Sunlight:

The sunlight is found to affect the quality of the horticulture crops like fruits exposed to light are found better in quality as compared to those receiving loss sunlight. This is because of more amounts of carbohydrates prepared in the leaves.

Eg. In Mandarin it has been observed that the fruits borne on the upper half of the tress and consequently receiving more light are richer in vitamin C content and also more sugars as compared to fruits on the lower half of the trees.

CLIMATIC ZONES OF HORTICULTURAL CROPS

Climate is one of the important complex factors which influence the fruit production. It includes several basic environmental factors such as temperature, rainfall, humidity and light. The Indian union fruit growing zones are based on the climatic factors. These zones are tropical, Sub-tropical, temperate and arid zone. However, there are certain exceptions to this for example, grape is a subtropical fruit, can be grown in temperate zone, Mango a tropical fruit, can be grown in subtropical zone.

1) Temperate zones:

Temperate fruits grow successfully in cold regions where temperature falls below freezing point during winter. During cold season, the trees shed their leaves and under go into rest period for breaking this rest period, a definite chilling period is required. This zones fruit includes apple, pear, walnut, pear, almond, plum, peaches, strawberry, cherry etc. Temperate zones states are Jammu and Kashmir, Himachal Pradesh, U.P., Arunachal Pradesh, Kulu valley parts in Punjab, and nilgiris hills of Tamil Nadu.

2) Tropical Zones:

This class requires hot and humid climate in summer and mild winter. It includes only evergreen fruits such as mango, Sapota, Papaya, Cashew, Pineapple, Banana etc. In tropical fruit zones state includes are west Bengal, Kerala, Karnataka, Tamil Nadu, Orissa, Andhra Pradesh and some parts of Maharashtra.

3) Sub Tropical Zones:

This class of fruit grows mostly in plains. Where climate is hot and comparatively dry and winter is less severe than temperate zone. This class includes fruits likes Citrus, Phalsa, fig

and pomegranate sub tropical states are plains of Punjab, U.P. some district of Bihar, M.P. and some parts of Maharashtra.

4) Arid Zones:

In arid zones rain is very low and its distribution in erratic leading to low plants stand and productivity. The water storage capacity of soil in these areas is very low, mainly. Poor textured and shallow soils. In this class fruits include Ber, custard apple, Aonla, Tamarind.

Agro climatic Zones of India:

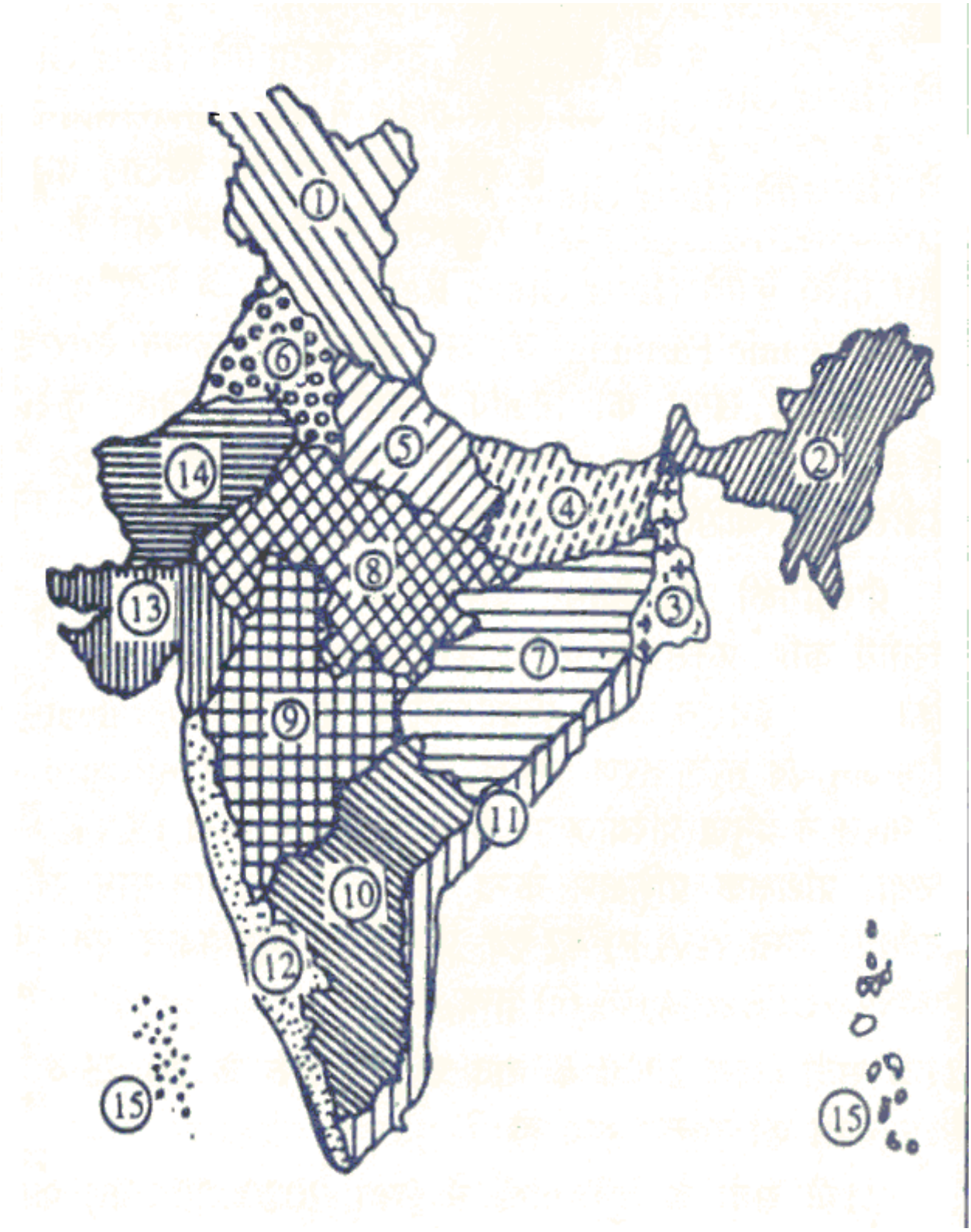
The planning commission during VII plan (1985-90) divided the country into 15 broad agro-climatic zones based on physiographic and climate. The emphasis was given to the development of resources and their optimum utilization in a suitable manner within the framework of resources constraints and potentials of each region.

Agro climatic zones of India :- (Planning commission 1989)

1	Western Himalayan Region	Ladakh, Kashmir, Punjab, Jammu etc. brown soils & silty loam, steep slopes.
2	Eastern Himalayan Region	Arunachal Pradesh, Sikkim and Darjeeling. Manipur etc. High rainfall and high forest covers heavy soil erosion, Floods.
3	Lower Gangatic plants Regions	West Bengal Soils mostly alluvial & are prone to floods.
4	Middle Gangatic plans Region	Bihar, Uttar Pradesh, High rainfall 39% irrigation, cropping intensity 142%
5	Upper Gangatic Plains Region	North region of U.P. (32 districts) irrigated by canal & tube wells good ground water
6	Trans Gangatic plains Region	Punjab Haryana Union territory of Delhi, Highest sown area irrigated high
7	Eastern Plateaus & Hills Region	Chota Nagpur, Garhjat hills, M.P, W. Banghelkhand plateau, Orissa, soils Shallow to medium sloppy, undulating Irrigation tank & tube wells.
8	Central Plateau & hills Region	M. Pradesh
9	Western Plateau & hills Region	Sahyadry, M.S. M.P. Rainfall 904 mm Sown area 65% forest 11% irrigation 12.4%

10	Southern Plateau & Hills Region	T. Nadu, Andhra Pradesh, Karnataka, Typically semi and zone, Dry land Farming 81% Cropping Intensity 11%
11	East coast plains & hills Region	Tamil Nadu, Andhra Pradesh Orissa, Soils, alluvial, coastal sand, Irrigation
12	West coast plains & Hills Region	Sourashtra, Maharashtra, Goa, Karnataka, T. Nadu, Variety of cropping Pattern, rainfall & soil types.
13	Gujarat plains & Hills Region	Gujarat (19 districts) Low rainfall arid zone. Irrigation 32% well and tube wells.
14	Western Dry Region	Rajasthan (9 districts) Hot. Sandy desert rainfall erratic, high evaporation. Scanty vegetation, femine draughts.
15	The Island Region	Eastern Andaman, Nikobar, Western Laksh dweep. Typical equatorial, rainfall 3000 mm (9 months) forest zone undulating.

AGRO CLIMATIC ZONES IN INDIA



Agro climatic Zones in Maharashtra

Maharashtra falls in the 9th Zones known as the western plateau and hills region. The aim is regionalization of the Indian agricultural economy and to bring integration of plans of the agro climatic regions with the state and national plans.

Maharashtra is the 3rd largest state of India located between 16 N to 22 N latitudes and 72 – 80 E longitudes.

On the basis of geographical features, the state is divided into 3 natural regions.

1) Konkan Comprising the Coastal area.

2) Sahyadri hill ranges known as Western Ghats.

3) The Deccan plateau.

Major portion of the state is semi arid with three distinct seasons of which rainy season comprises July to September. There are large variations in the quantity of rainfall within different parts of the State. Ghat and Coastal districts receive an annual rainfall of 2000 mm but most part of the state lies in rainshadow belt of the ghat with an average of 600 to 700 m. The rainfall variations from 500 to 5000 mm have been recorded with an average of 1000 m distributed over 60-70 days.

The state has been divided into 9 agro-climatic zones based on rainfall. Soil type and the vegetation as mentioned below:

1) South Konkan Coastal Zone

2) North Konkan Coastal Zone

3) Western Ghat Zone

4) Transition Zone -1

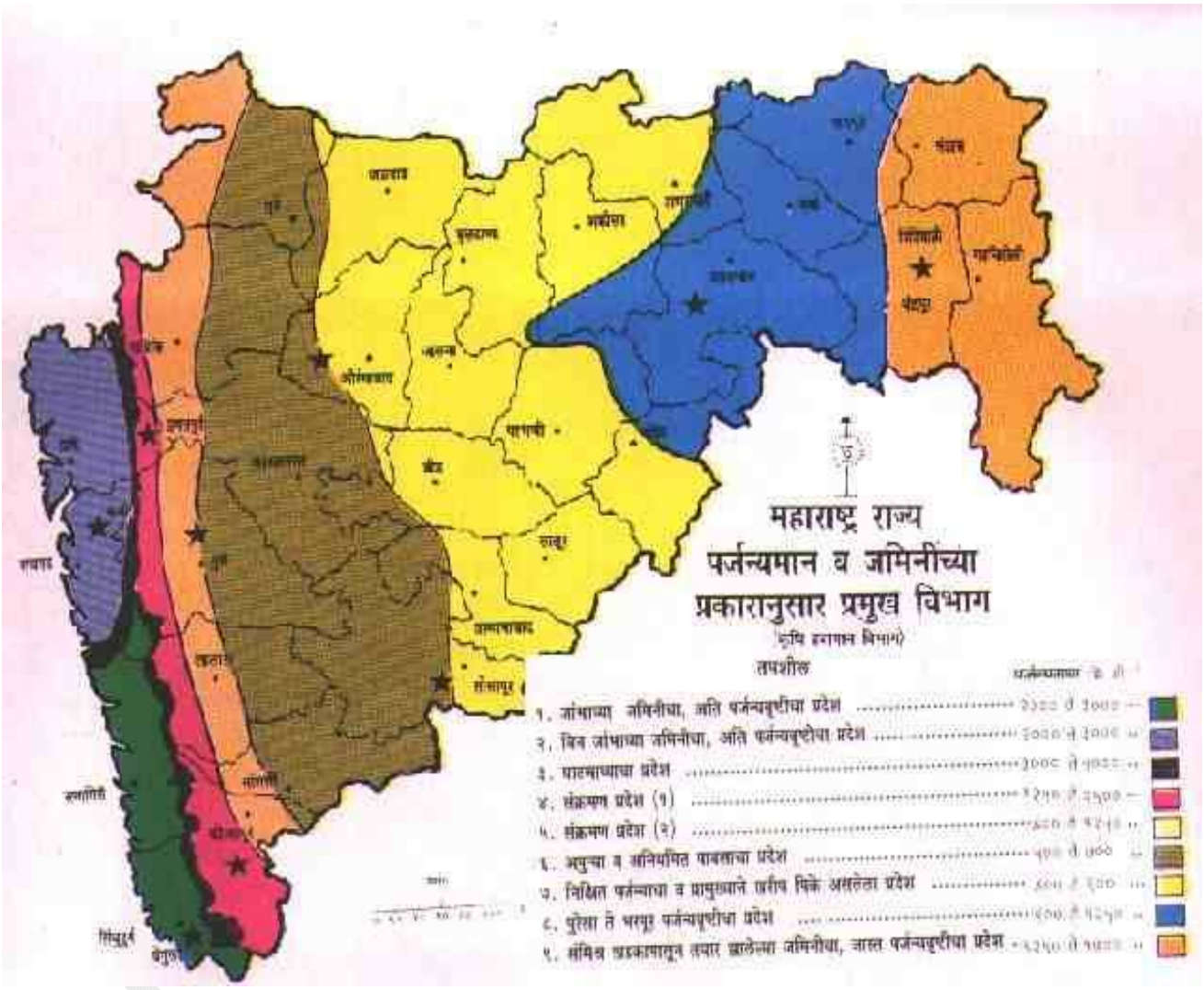
5) Transition Zone – 2

6) Scarcity Zone

7) Assured Rainfall Zone

8) Moderate Rainfall Zone

9) Eastern vidharbha zone


महाराष्ट्र राज्य
पर्जन्यमान व जमिनींच्या
प्रकारानुसार प्रमुख विभाग
(कृषि हवामान विभाग)
तपशील
१. जांभाच्या जमिनीचा, अति पर्जन्यवृष्टीचा प्रदेश
२. विना जांभाच्या जमिनीचा, अति पर्जन्यवृष्टीचा प्रदेश
३. घाटमाथ्याचा प्रदेश
४. संक्रमण प्रदेश (१)
५. संक्रमण प्रदेश (२)
६. अपुऱ्या व अनियमित पावसाचा प्रदेश
७. निश्चित पर्जन्याचा व हमखास खरीप पिके असलेला प्रदेश
८. पुरेसा ते भरपूर पर्जन्यवृष्टीचा प्रदेश
९. संमिश्र स्वरूपापासून तयार झालेल्या जमिनीचा, जास्त पर्जन्यवृष्टीचा प्रदेश

AGRO CLIMATIC ZONE IN MAHARASTRA

SOUTH KONKAN COASTAL ZONE

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/ Districts and tahsils included		Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern	
I	Very high rainfall zone with laterite soils	15.30 to 18.50 N Latitude 72 45 to 74 50 E Longitude	Comprises mainly of Ratnagiri and Sindhudurg Districts Total area of the zone is 13.20 lakh ha.area under cultivation 3.5 lakh ha.		Daily temperature above 20^0 C. Through out the year. May hottest above 33 ^{0}C. Rainfall due to S-W monsoon from June to Sept.	3105 mm in 101 days	Laterite. PH 5.5-6.5 acidic, poor in phosphorous rich in nitrogen and Potassium	Rice is the major crops i.e. 39% of cultivated area. Ragi 2nd imp crop 0.45 lakh ha. Vari is minor hill millet grown on the slopes, pulses like horse gram grown on residual moisture. Oilseeds-Niger/ Sesamum, area under Summer Ground nut, Jowar and Tur is likely to increase with irrigation. Horticultural crops-Mango, Coconut, Arecanut, Cashew nut Jackfruit, Banana and Pineapple Spices like clove Nutmeg and Black pepper	
			Districts.	**Tahsils**				**Highest**	Mango, Cashew nut, Coconut, Pineapple

			Sindhudurg	Devgad, Malvan, Vengurla, kankavli, Sawantwadi.				**Medium**	Arecanut, Jackfruit
			Ratnagiri	Mandangaon, Dapoli, Ratnagiri, Khed, Chiplun,Lanja, Rajapur				**Lowest**	Karonda
			Raigad	Mohad, Poladpur					

NORTH KOKAN COASTAL ZONE

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/Districts and tahsils included		Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern	
II	Very high rainfall zone with non lateritic soils	17 52 to 20 20 latitude 70 70 to 73 48 E longitude	Comprises Thane & Raigad districts. Total area 16.59 lakh ha Net sown area 4.69 lakh ha With forest zone about 3%. 32% of land is under forest.		Average daily temp 22 to 30^0C.Mini. temp17 to 27^0 C. Humidity 98%in rainy season & winter-60%	2607 mm in 87 days. Maximum rain received in July i.e.41%	Coarse &shallow. PH5.5to 6.5, acidic Rich in nitrogen, poor in phosphorus & potash.	Rice is major crop 40,600 lakh ha Vari 19,600 ha. Pulses-udid/ tur Vegetables-brinjal, tomato Oilseeds-sesamum, Niger Fruits-banana, Sapota	
			Dist.	**Tahsils**				**Highest**	Sapota, Litchi, Mango.

			Raigad	Panvel, Pen, Alibag, Roha, Murud, Shrivardhan, karjat, Mangaon, Mahad, Poladpur,				**Medium**	Banana, Papaya, Pineapple.
			Thane	Dahanu, Palghar, Vasai, Thane, Kalyan, Bhivandi, Mokhada, Sahapur, Murbad.				**Lowest**	Phalsa

WESTERN GHAT ZONE

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/ Districts and tahsils included	Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern
III	Western Ghat Zone /Ghat zone	Narrow strip extending from north to south along the crest of Sahyadri ranges	It includes hilly high lying terrains of Kolhapur, satara, Pune, Ahmednagar & Nasik districts & small area of sindhudurg district. Altitude varies from 1000- 1900mt.	Maximum temp. ranges from 29-39^0 C. Minimum temp ranges from 13-20 ^{0}C.	3000 to 6000 mm. Rainfall recorded in different places of the zone viz Igatpuri, Lonawala, Mahabaleshwar, & Radhanagari.	'Warkas' i.e. light laterite & reddish brown. Distinctly acidic, poor fertility low phosphorous & potash content.	25% area is under forest. Principal crops-rice/ragi/ kodra & other cereals. Rabi jowar, gram, groundnut, niger. Sugarcane major crop. Area under spices 353 ha. Fruits & vegetables 2933 ha. Well suited conditions for rainfed crops. Fruits-mango, cashew, jackfruit, jamun and karwanda.

			Dist.	**Tahsils**				**Highest**	Mulberry, Strawberry.
			Satara	Mahabaleshwar				**Medium**	Jamun, Mango, Karvanda.
			Kolhapur	Bavada, Radhanagari, Chandangad.				**Lowest**	Tamarind
			Nashik	Igatpuri					
			Pune	Khed, Maval, Mulsi, Valha, Bhor.					

TRANSITION ZONE -1

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/Districts and tahsils included		Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern	
IV	Sub Mountain Zone/ Transition Zone 1	Located on eastern slopes of Sahyadri ranges	Spreads over 19 tahsils of five districts viz, Nasik, pune, satara, sangli & Kolhapur. The area of the zone measures 10,289 Sq Km		Average maximum temperature is between 28-35^{0}C and minimum 14-19^0 C	700-2500 mm. Rains received mostly from S-W monsoon.	Soils are reddish brown to black tending to lateritic. PH 6-7.Well supplied in nitrogen but low in phosphorous & potash	Mainly dominated by kharif cereals, groundnut & sugarcane. Rabi crops are taken where there are deep soils & moisture holding capacity. Vegetables-potato, onion, chillies, tomato &brinjal. Fruits-mango, banana, guava cashew & grapes.	
			Dist.	**Tahsils**				**Highest**	Mango

			Satara	Javli, Phaltan				**Medium**	Cashew nut
			Kolhapur	Shahuwadi, Panhala, karvir, Kagal, Badrgad				**Lowest**	Aonla, Karonda
			Nasik	Nasik, Peth, Surgana					
			Pune	Khed, Maval, Mulshi, Velha, Bhor.					

TRANSTION ZONE-2

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/ Districts and tahsils included		Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern	
V	Western Maharashtra Plain Zone /Transition-2	It is a wider strip running parallel to Eastern side of Sub Mountain Zone.	This zone includes tahsils of Dhule, Ahmednagar, Sangli & central tahsils of Nasik, Pune, Satara & Kolhapur districts. Geographical area 17.91 lakh ha.Net area sown is 8.86 Lakh ha.		Water availability ranges from 120-150 days .Maximum temperature 40^0 C & minimum 5^0 C.	Well distributed rainfall 700 to 1200 mm.	Topography is plain. Soils grayish black .Moderately alkaline 7.4-8.4, lowest layer is 'Murum' strata. Fair in NPK content. Well drained & good for irrigation.	The zone is predominantly a kharif tract suitable for single rainfed crop. Principal crops grown -kharif & rabbi jowar, bajra, groundnut, wheat, sugarcane, udid, tur, gram & ragi.	
			Dist.	**Tahsils**				**Highest**	Mango,

									Pomegranate, Grape, Guava
			Nasik	Niphad, Kalwan, Dindhori, Sinner.				**Medium**	Fig, Banana, Papaya, Sapota
			Dhule	Akrani, Akkalkut, Taloda, Nandurbar, Navapur.				**Lowest**	Tamarind, Wood apple
			Ahamednagar	Akola, Sangmner					
			Pune	Junner, Ambegaon, Haveli					
			Satara	Vai, Satara, Karad, Koregaon					
			Kolhapur	Hatkangale					
			Sangli	Shirala, Valva					

SCARCITY ZONE

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/ Districts and tahsils included		Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern	
VI	Western Maharashtra Scarcity Zone/ Scarcity Zone	-	This zone covers geo graphical area of 73.23 lakh ha. The gross & net cultivated area is 58.42 ad 53.0 lakh ha respectively.		Suffers from very low rainfall with uncertainty & ill distribution. Occurrence of drought is noted once in three years. Dry spell varies from 2-10 weeks. Water availability 60-140 days. Which is affected due to 1) delayed onset of monsoon 2) early cessation of monsoon. Maximum temperature 41^0 C minimum - 14-15 ^{0}C	Less than 750mm in 45 days. Two peaks of rainfall. 1) June/ July2) September. Bimodal pattern of rainfall.	General topography is having slope between 1-2%. Infiltration rate is 6-7 mm/hr. The soils are vertisol. Soils have Montmorilonite clay. Poor in nitrogen, low to medium in phosphate & well supplied in potash.	Based on bimodal distribution of rainfall hence two cropping systems are noticed. During kharif shallow & poor moisture retentive soils are cultivated. Medium deep, moisture holding capacity soils are diverted to rabbi cropping. Kharif cropping 25-30%. Crops-bajra, jowar, groundnut, safflower, pulses etc. Productivity is rather low in both the seasons.	
			Dist.	**Tahsils**				**Highest**	Ber,

									Pomegranate, Grape
			Satara	Khandala, Phaltan, Khatav, Man, Koregaon				**Medium**	Sweet orange, Fig
			Sangli	Khanapur, Tasgaon, jat Miraj				**Lowest**	Tamarind, Wood apple
			Sholapur	North Sholapur, Karmala, Barshi, Sangola, Madha, Malsiras, Pandharpur, Mohol.					
			Kolhapur	Shirala					
			Pune	Shirur, haveli, Dond, Purandar, Baramati, Indapur					
			Ahmadnagar	Kopargaon, Sangmner, Shrirampur, Rahuri, Nevasa,					

				Shrigonda, karjat, jamkhed					
			Jalgaon	Amalner, Chalisgaon					
			Dhule	Sahada, Sindkheda, Sakri, Dhule					
			Nasik	Baglan, Malegaon, Chandvad, nandgaon, Nasik, Yeola					
			Aurangabad	Aurangabad, Paithan, Vaijapur, Gangapur, Kannad					
			Jalna	Ambad					

ASSURED RAINFALL ZONE

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/ Districts and tahsils included		Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern	
VII	Central Maha-rashtra Plateau Zone /Assured Rainfall Zone	-	Comprises parts of Aurangabad, Jalna, Beed & Osmanabad districts. Major parts of Parbhani & Nanded & complete Latur Buldhana & parts of Akola, Amravati, Yavatmal, Jalgaon, Dhule & Sholapur. Area accounts to 75 lakh ha. Gross cropped area is 67.8 lakh ha. Forest accounts to 9.90 % of geographical area.		Maximum temperature 41^0C Minimum temperature 21^0 C	700 to 900 mm 75 % rains received in all districts of the zone.	Soil color ranges from black to red. Type- 1) vertisols 2) entisols & 3) inceptisols PH 7-7.5	Jowar is a predominant crop occupying 33% of gross cropped area cotton-22.55%. Oil seeds 5.17%, pulses 7.63 %. Kharif jowar /bajra followed by gram, safflower. Area under paddy is increasing. Pulses- tur, mung, udid, gram & lentils. Oilseeds- groundnut, sesamum safflower & Niger. Sugarcane & summer crops are taken on availability of irrigation.	
			Dist.	**Tahsils**				**Highest**	Banana, Lemon, Grape, Mango
			Sholapur	South Sholapur, Akkalkot				**Medium**	Orange, Papaya, Guava, Pomegranate
			Jalgaon	Chopda, Yaval, Raver, Arodol, Jalgaon, Bhusaval, Aaldabad, Parola, Balgaon, Pachora, Jamner				**Lowest**	Aonla, Wood apple, Sweet orange
			Dhule	Shirpur					

			Aurangabad	Sillod, Aurangabad, Kannad, Khultabad					
			Jalna	Jalna, Partur, Bhokardan					
			Beed	Beed, Georai, Kej, Majalgaon, Ambejogai					
			Osmanagad	Kalamb, Osmanagad, Umarga					
			Latur	Latur, Ausa, Nilanga, Ahamadpur, Udgir					
			Parbhani	Parbhani, Jintur, Basmatpur, Gangakhed, Pathri					
			Nanded	Nanded, Bhokar, Kandhar, Mukhed, Biloli					
			Buldhana	Chikali, Malkapur, Khamgaon, Jalgaon					

			Akola	Akot, Akola, Murtijapur, Vasim, Balapur, Manglurpir					
			Amravati	Amravati, Chandur, Achalpur, Daryapur, Morshi, Melghat					
			Yeotmal	Pusad, Darva					

MODERATE RAINFALL ZONE

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/Districts and tahsils included		Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern	
VIII	Central Vidarbha Zone /Zone of Moderate Rainfall	There are five sub-zones of central vidarbha zone based on climate soil & cropping pattern	The zone includes entire Wardha, major parts of Nagpur Yavatmal 2 tahsils of Chandrapur & parts of Aurangabad, Jalna Parbhani & Nanded districts. Largest agro climatic zone encompassing 49.88 lakh ha geographical area & 35.73 lakh ha net cropped area.		Maximum temperature 33-38^0 C Minimum temperature 16-26 ^{0}C. Average daily humidity 72 % in rainy season, 53 % in winter & 35% in summer.	1130 mm.	Black soils derived from basalt rock. Medium to heavy in texture alkaline in reaction. Low lying areas are rich and fertile.	Cropping patterns Involves Cotton, Kharif Jowar, Tur, Wheat other Pluses & Oilseeds	
			Dist.	**Tahsils**				**Highest**	Orange, Mango

			Aurangabad	Aurangabad, Soygaon				**Medium**	Lemon, Papaya
			Jalna	Bhokardan, Jafrabad				**Lowest**	Aonla, Wood apple
			Parbhani	Hingoli, Kalamnuri					
			Nanded	Nanded, Bhokar, Hadgaon					
			Yeotmal	Kelapur, Vani, Yavatmal					
			Nagpur	Ramtek, Katol, Savner, Nagpur					
			Vardha	Vardha, Arvi, Hinganghat.					

EASTERN VIDARBHA ZONE

Sr. No.	Name of the Zone	Geographical location	Geographical spread of the zone/Districts and tahsils included	Climatic conditions	Average annual rainfall	Soil type	Crop and cropping pattern
IX	Eastern Vidharbha Zone/ High Rainfall Zone with Soils derived from parent material of different	-	Includes entire Bhandara & Gadchiroli and parts of Chandrapur and Nagpur districts. Geographical area is 32.7 lakh/Ha. And with almost 50% under forest. Gross crop area 10.8 lakhs/Ha.	Mean Maximum temperature varies from 32 to 37^0 C. Minimum temperature 15 to 24^0 C. Daily	950 to 1250 mm on western side. 1700 mm on extreme	Soils derive from parent rock granite, gneisses, and schists.	Paddy is predominant crop in Bhandara. Rabbi Pulses-Gram, Lathyrus. Paddy is followed by Rabbi Jowar Pulses and Oilseeds.

	crops. There are four subzone based on climate, soil sand crop pattern				humidity 73% for rainy season 62 winter & 35 summer	east side No of rainy days 59.	Brown to Red in colour. PH 6 to 7		
			Dist.	**Tahsils**				**Highest**	Mango
			Chandrapur	Varora, Rajura				**Medium**	Jamun
			Bhandara	Bhandara, Sakoli, Gondiya				**Lowest**	Tamarind
			Gadchiroli	Sirocha, Gadchiroli					
			Nagpur	Umred					
			Nanded	Kinvat					

Chapter 4
Plant Propagation method and propagating structure

Unlike agronomic plants, many horticultural plants are troublesome for seed propagation methods. Horticultural plants have annual to perennial life cycle and seed propagation is not economical. In such cases vegetative propagation is more effective. It is done by using various plant parts for propagation. Plant propagation is the process of creating new plants from a variety of sources: seeds, cuttings, bulbs, roots and other plant parts. Plant propagation also includes the artificial or natural dispersal of plants. Broadly sexual propagation and asexual propagation are two method of plant propagation.

3.1 Sexual Propagation:

Propagation of the plants by using seed as propagation material is called as sexual propagation. It has its own advantages over asexual method as follows.

It is simplest, easiest and the most economical process among various types of plant propagation. Some plants, trees, vegetables or fruits species can propagate only through sexual propagation, E.g., Papaya, Marigold, and Tomato, cucurbitaceous etc. This type of propagation leads to better crop species that are stronger, disease-resistant and have longer life span. They are hardy with deep root system, so they are vigorous in growth. Viral transmission can be prevented in this type of propagation. Sexual propagation is responsible for production of large number of crops and that too with different varieties. It is the only propagation process in which resultant offspring have genetic variation and exhibit diversity of characters from parent crops. This genetic variation is responsible for continuous evolution that keeps on producing better & better offspring. We can store the seed easily and easy to transport from one place to another place. Seed Propagation is necessary when vegetative propagation is unsuccessful or expensive e.g. We can see in the Papaya, Coconut and Arecanut. The Polyembryony: The phenomenon of production of more than one seedling from a single seed produces true to type, nucellar embryonic seedlings which could be used as rootstock for uniform performance, e.g. In mango different type of polyembryonic rootstock is there viz., Bappakai, olour, vallaikolumban, Chandrashekaran, Kurukkan, Mulgaon, Bellary, Goa, it is also common in Jamun, and Citrus fruit crops. Hybrids can be developed by sexual propagation. Rootstock is raised by seed. E.g. Rangpur lime, Jambheri etc.When seedlings are required large number seed propagation is easy means.

Disadvantage of Sexual Propagation:

Seedlings propagated through sexual propagation are unlikely to have same genetic characteristics as that of parent plants. Some plant species do not produce viable seeds and hence are unsuitable to propagate for the same. Plants that do not have seeds can't be propagated through this process. The Progenies are not true to type and so they may become inferior. In the commercial orchards, it is necessary to have uniform quality, growth and yielding capacities and such types of plants are not produced through seed. Seedlings have long juvenile period. The seed must be sown a fresh, i.e. immediately after extraction. eg. Orange plant raised as seedling will take 8-10 years for bearing while budded plants come to bearing within 3-4 years. Seedling tree are large size, and hence cost of harvesting, pruning, training and crop protection increases.

3.2 Asexual Propagation

Asexual propagation refers to the multiplication of any plant part from any vegetative parts like, root, stem, leaves etc. it has included several methods such as cuttings, layering, and grafting. It is also known as vegetative propagation or clonal propagation.

Advantages of vegetative propagation:

1) Progenies are true to type hence uniform growth, and fruit quality.

2) Certain rootstocks are resistant or tolerant to the adverse environmental factors such as frost and adverse soil factors like salinity or alkanity Ex: frost resistant rootstock is Trifoliate orange (*Ponicirus trifoliate)*, salinity resistant rootstock is Rangpur lime.

3) The ability of certain rootstock to resistant to pest and disease Ex: Apples when grafted on rootstocks Merton 778, 779 are resistant to wolly aphids.

4) Vegetatively propagated fruit frees comes bearing earlier.

5) Vegetativly propagated plants are generally dwarf in nature than seedlings. Dwarf tree facilities pruning, spraying and harvesting and more number of plants can be accommodated per unit area.

6) Novelty can be developed by grating or budding of many varieties on Single plant Ex. Rose, mango.

7) Plant produces seedless fruit.

8) Damaged part of tree trunk or rotting of rost can be repaired by bridge grafting or inarching to save Plant.

Disadvantages:

1) Plants are not vigorous and they are short lived

2) No new varieties are developed or evolved.

3) These methods are more expensive, laborious and time consuming.

3.2.1 Plant Propagation by cutting:

This is the method of Asexual (Vegetative) propagation in which vegetative part of plant like Stem, leaf and root are cut from parent plant and placed under favorable environmental conditions to form root and shoot to produce new independent plant. Rainy and spring season are the best time for planting the cuttings. It has main types which are given below.

A) Stem cutting:

It is the most important type of vegetative propagation. It can be divided into three types on the basis of nature of plant wood.

1) Hard wood cutting:

It is the simplest and cheapest method of multiplication. It is easily handled and transplanted. Firstly collect one year mature shoot. The size of the cutting should be between 10-30cm depending on the species and the stored food, to nourish the developing roots. A cutting possesses the two nodes with the basal cut just below one node and top slanting cut 2-3cm above the second nodes is preferred. This helps to maintain the polarity of the shoot. Cuttings are planted either in pots containing a mixture of soil and well rotten leaf manure soon after the detachment from the mother plant or treated with root promoting substances before plantation. The basal ends of the cuttings are treated with IBA 2000 ppm concentration (Indole butyric acid) or other promoting hormones and are stored in moist condition under relatively high temperature (65 to 75ºF) for 4-6 weeks to stimulate root initiation.
Ex: Grape, Fig, Pomegranate, Plum, Mulberry etc.

2) Semi Hard wood cutting:

Mostly used in evergreen plant. It is available into the month of June- July. The cutting should not attained the full maturity and are 5-6 month old. About 7-15 cm length of the cutting is selected, better retain 2-4 leaves on the top of cuttings and rooting is attempted under conditions of high humidity and freedom from chill with the aid of growth regulators. This cuttings of Crotons, Aralia, Acalypha etc. are raised.

3) Softwood cutting:

These are easy to root. Cutting of 7-12 cm length with the leaves intact are used for rooting. Ex. Carnation.

4) Herbaceous cutting:

These cuttings are soft, succulent and tender with 7-12 cm length. The leaves are removed before planting with or without the aid of auxins. Herbaceous cutting is used to propagate chrysanthemum and coleus.

Different growth regulators may be used to promote rooting. Good response in cuttings can be obtained by overnight dipping in 100-200 ppm IBA. 2000 to 5000 ppm of indole butyric acid (IBA), indole acetic acid (IAA) and naphthalene acetic acid (NAA) through quick dip methods are the most successful growth regulators. The basal ends of the cuttings are usually dipped in the hormonal powder or in the solution of auxins for few seconds. In some case, a fungicide should also be added to the growth regulator.

B) Leaf cutting:

The leaf blade alone or with the petiole intact is used as a starting point of a new plant. They need environmental condition same as softwood stem and herbaceous cuttings. Root promoting chemicals are helpful in the case of leaf cuttings.
Ex. Bryophyllum, Begonia etc.

C) Leaf bud cutting:

A cutting consisting of a segment of current season's growth with a leaf, axillary bud and a small section of stem used in the propagation of various plants. Ex: Blackberry, camellia.

D) Root cutting:

Roots should be 1cm in diameter and length 5-10cm are taken. In temperate fruit root cutting are prepared in December and kept in warm places in moss grass and transplanted during Feb-March and planted in sandy soil with good aeration. When the plant is in rapid growth stage root cutting should not be preferred.
Ex. Blackberry, Raspberry is commercially propagated by root cutting.

3.2.2 Plant Propagation by Layering:

Layering is the development of roots on a stem while it is still attached to the parent plant. After initiation of root plant will be detached to become new plant. The rooted plant is known as layering. Root formation during layering is stimulated by various stem treatments such as bending of shoot to a sharp 'V' shape Ex. Guava. Girdling by removing a ring of bark or by wrapping, and tightly stretching and tying the copper wire around stem. Ex. Grape. There are several methods of layering.

A) Simple layering or tongue layering :

In this method, a shoot of the plant that is used to be propagated, is bent down and buried in the soil at the depth of 8-10cm leaving the terminal bud. Root initiation takes place at buried portion. After initiation of root layer should be detached from the mother plant. Eg. Guava, Baramasi lemon, Raspberry, Gooseberry.

B) Compound or Serpentine layering:

The branch of plant buried alternately in the soil and exposed over their entire length. Stem cutting in number of places is covered for better results. The exposed part of the stem has buds to form new shoots, while the buried portion forms roots. After initiation of roots portions are detached from mother plant and planted at suitable place. Ex. Guava, muscadine grapes or ornamental vines.

C) Mound or stool layering

In this method a plant is cut beck at the ground level during the dormant seasons, and soil covered. Now shoots develop around the cat portion after allowing sufficient time for root initiation and growth the rooted shoots are separated and taken as individual layers. Ex. Guava, Apple.

D) Air Layering:

This method is also called as 'Chinese layerage', 'Pot layerage,' 'morcottage', 'gooty' etc.

In this procedure removal of a 3cm long ring bark below a bud portion from the basal portion of the selected shoot during the growing period of the plant. Scraping the exposed surface ensures complete removal of the cambium and phloem tissue and helps to retard healing. Application of root promoting hormone like IBA, NAA to the exposed wound accelerates rooting. After application of hormone it is covered with moist sphagnum moss then wrapped with polythene air tightly. Root initiation takes place in 2-3 month after which layer will be detached from mother plant and place in shade for future planting.

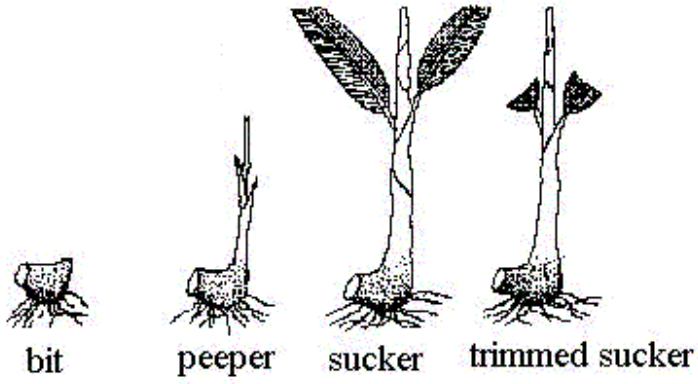
Ex. Pomegranate, Litchi, Guava, Jackfruit , Persimon, Kagzi lime, fig etc.

3.2.3 PLANT PROPAGATION BY SPECIALIZED STRUCTURES:

A) Suckers:

A sucker is a shoot which arises on a plant from below the ground. The most precise use of this term is to designate a shoot which arises from an adventitious bud on root. However, in practice, shoots which arise from the vicinity of the crown are also referred to as suckers even though originating from the stem tissue. Ex. Banana, Chrysanthemum, Black berry, etc.

51.10 Planting Material



B) Crowns:

The term crown is used to designate the part of plant stem on and below the ground, from which new shoots are produced. Ex. Pineapple.

C) Bulbs:

Bulbs are produced by monocotyledonous plants. A bulb is a specialized underground organ consisting a short, fleshy, usually vertical stem axis having at apex a growing point and enclosed by thick fleshy scales. Bulb scales morphologically are the continuous Sheathing leaf bases. The outer scales are generally fleshy and contain reserve food materials. The growth developed in the axils of these scales to produce miniature bulbs is known as bulbets. Arial bulbets are called bulbils. Bulbets or bulbils are separated and used for propagation Ex. Onion.

D) Corms:

A corm is the swollen base of a stem axis enclosed by the dry, scale like leaves with predominant leaf scales a corm is a solid stem structure with distinct nodes and internodes. The bulk of corms consist of storage tissue composed of parenchyma cells. In the mature corm, the dry leaf bases persist at each of these nodes and enclose the corm. His covering is known as tunic and gives a protection against injury and water loss. Ex. Gladiolus.

E) Stem tubers:

A stem tuber is the short terminal portion of an underground stem which has become thickened because of accumulation of reserve food materials. Ex. Potato propagation by tubers can be carried out either by planting the whole tuber or by cutting them into sections, each containing a bud or eye.

F) Tuberous roots [Root tubers]:

Certain herbaceous perennials produce thickened root's which contain large amount of stored food. The tuberous root differs from the tubers in that they lack nodes and internodes. Adventitious buds are present only at stem and these fleshy roots's are separated and used for propagation.

Ex. Sweet potato, Dahhia.

G) Rhizomes:

A rhizome is horizontal stem growing either underground or along the surface of ground. Typically it is the main axis of plant, producing root on its lower surface and extends leaves and flowering shoots above the ground. It may be thick and fleshy or slender and elongated but it is always made up of nodes and internodes Ex. Cana, Ginger. Propagation is through Rhizomes or dividing the rhizome into section each of which is capable of producing new shoot from nodes. Foods received from adventitious buds of lower surface.

H) Runners:

A runner is specialized stem which is developed from the axial of a leaf at the crown of a plant. It grows horizontally along the ground and forms a new plant at one of the nodes Ex. Strawberry. In propagating by runners the rooted daughter plants are dug when they have become well rooted and then transplanted to the desired location.

I) Stolens:

Stolen is a term used to describe various types of horizontally growing stem that produce adventitious roots on coming in contact with soil. Specifically these are prostrate stem as found in Bermuda grass [Cynodon dactylon].

3.2.4 Grafting and budding:

Grafting and budding is an act of joining two different plant parts together in such manner that they unite and continue their growth as simple plant.

A)Grafting

Definition

Grafting is the vegetative method of plant propagation and can be defined as "an art of scion with 3-4 month old is inserted in to the stem of rootstock in such a way that the union takes place and combination continue to grow."

Or

Stock is a lower portion of the graft union, whereas, scion is the upper portion of a place at which both unite is termed as graft union.

Why grafting and budding:

Plant propagation with cottage and layer age is very cheap, easy, and economical. However, Grafting and budding is necessary because.

1) When other methods are not successful.

2) Adoptability to pests' diseases tolerance to cold, unsuitable climate can be achieved by using suitable root stock.

3) Converting inferior plants to superior one Ex. Side grafting in mango, ber.

4) For modifying the growth of fruit plant.

Graft Incompatibility

The ability of two different plants when grafted together to produce a successful union and also to develop satisfactorily into one composite plant is termed as compatibility. The inability of two different plant to unite, when grafted together is often defined as incompatibility of graft.

Incompatibility may be classified into two types.

1) Translocated incompatibility

2) Localized incompatibility.

1) Translocated incompatibility:

In which the incompatible conditions cannot be overcome by the insertion of a mutually compatible inters tock. This type involves phloem degeneration and development of a brown line or necrotic area in the bark.

2) Localized in compatibility:

In which compatibility reaction apparently depends upon the actual contact between stock and scion. A symptom of this kind of incompatibility is that the graft is often mechanically weak with discontinuity in cambium and vascular tissue. A typical example of this kind of incompatibility is that when Bartlett pear is grafted directly on quince stocks, it is incompatible. When old home inter stock is introduce in between these combinations, the three parts combination becomes compatible and grow satisfactorily.

Symptoms of incompatibility:

Graft union malformation resulting from incompatibility usually expresses the following external symptoms. Viz.

1) Failure to form a successful graft or bud union with high percentage of success.

2) Yellowing of leaves in the later part of growing season followed by early defoliation accompanied by decline in vegetative growth, shoot dies back and general ill health of the tree.

3) Premature death of tree which may live only a year or two in the nursery.

4) Marked differences in the growth rate and vigour of scion and stock.

METHODS OF GRAFTING

Grafting is an art of connecting two pieces of living part together in such a manner that they unite, subsequently grow and develop into one complete plant.

Several grafting methods are classified as under.

1) Scion attached methods or approach grafts:

The scion unite with stock while both the component are on their own root system. After union takes place, the top of stock above the graft and base of scion plant is removed below the graft.

The varies types of scion attached method.

a) Inarching:

It is also known as simple approach grafting, simple inarching. In low rainfall area it should be done with the onset of rains while in region of heavy rainfall it should be done soon after the rainy season is over provided temperature does not fall below 15^0C. Heavy rainfall not a dry period adversely affects the union. Selection of parent tree for taking the scion is an important factor. It should be taken from healthy, vigorous, and high yielding plants. Scion should not be taken from old trees. The actual inarching operation. The stock is brought close to the scion. Then slice of bark about 6-8 cm long and about 8 mm in thickness at a height of about 20 cm above ground levels is removed with a sharp knife from stock. A similar cut is made in scion. Thus the combine layer of both stock and scion are exposed. The cut are brought together and tied firmly with the help of polythene stripe. Ex. In Mango and Guava propagation this is the most common method adapted by nursery man all over the country.

b) Tongue grafting:

It is modification of simple inarching and generally practiced with thicker rootstocks and scion. The rootstock first cut in inarching and second cut is made into a wood of stem about half way down the first cut sloping direction pointing tongue upwards. A similar cut is made in the scion shoot. Both cuts are made in such a manner that one feet into the other tightly. Ex. Apple, Pear and walnut.

2) Scion detached method:

Scion is completely severed from the parent plant during the process of union of stock and scion. The various methods used are as follow.

a) Veneer grafting:

This method is simple and used on soot stocks of one year having diameter of 1-1.5 cm for veneer grafting 3-6 month old scion shoot with lush green leaves is selected. Terminal and next to terminal shoot are most ideal. The shoots are defoliated 5-10 days prior to grafting leaving petiole attached. March- September is ideal method of veneer grafting. The rootstock is prepared for veneer grafting by making slanting cut 5 cm long, an oblique cut is made at the base of first cut so that piece of wood along with bark removed. The base of scion is fitted into rootstock in such manner that the cut surfaces, including cambium layer of scion and rootstock are facing each other. The rootstock and scion are tied together with polythene tape. When scion growth begins, the shoot of rootstock is removed above the graft union in one or two strokes. Ex. Mango is commercially propagated by veneer grafting.

b) Saddle grafting:

The rootstock is beheaded 25 cm above the ground level two upward slopping cut are made on the sides of the rootstock to form a 5-7 cm long wedge on its cut end on the stem of the scion shoot, a tongue is made. The wedge of the rootstock is then fitted into the groove of the scion.

c) Wedge grafting:

In this technique is employed using rootstock of more diameter than the scion. It is useful for top working. Rootstock with 5 - 7 cm or more girth should be selected and cleft grafted after decapitating the stock 45 cm above ground level. The beheaded rootstock is split to about 5 cm

deep through the center of stem with a knife when knife is removing; a hard wooden wedge is inserted to keep it open for subsequent insertion of the scion. Scion (15-20 cm) is used from a terminal shoot which is more than 3 months old and it is wedge securely (6-7 cm). The cleft of the scion is slipped into the split of the stock that has been force open write a wooded wedge. Ex. Walnut, Peanut.

d) Whip grafting:

It is essential that both the stock and scion are equal diameter, about one-year old rootstock is severed at the height of 23-26 cm from the ground level and a diagonal cut (3-4 cm) is made at the distal end of the rootstocks. A similar cut is made on the proximal and of the scion and cut surfaces of the both the rootstock and scion are bound together with polythene tape.

e) Stone grafting:

Germinating seeds of less than two weeks old are wedge grafted with mature scion. Moderate temperature and high relative humidity are major factors for success for splice grafting, germinating seeds less than 2 weeks old are used as rootstocks. A 2-3 cm long slanting cut is made in the epicotyls with matching cut of the proximal portion of the scion and united together. In wedge grafting the selected two weeks old seedlings are headed back by retaining 6-8 cm long stem with stone. The longitudinal transverse cut running 4-6 cm centrally down on the beheaded rootstock is made with help of soft grafting knife. A wedge shaped cut, slanting from both sides is made on lower side of scion stick. The Scion stick is inserted into saddle like cut on the rootstocks and pressed properly so that cambium tissue of the root stock and scion stick overlaps each other. Union is tied with the help of polythene strip, 2 cm width and 10 cm in length Ex. Mango.

3) Methods of grafting on established trees:

Methods which can be successfully adopted to convert the inferior established plants into the superior or desired one. These are.

1) Side grafting 2) Crown grafting 3) Top working

Top working is performed in three ways:

a) By inarching the new shoot's growing from the cut ends of branch of stock plant's.

b) By forket budding

c) By crown grafting

4) Method's of renovation:

This grafting method which is adopted to rejuvenable the old tree having religious feedings or the plants injured deeply due to mechanical operation, pests, disease at their roots etc.

There are two methods:

1) Bridge grafting 2) Buttress grafting.

B) BUDDING:

Budding is the vegetative method of plant propagation and can be defined as "an art of single mature bud inserted in to the stem of rootstock in such a way that the union takes place and combination continue to grow."

Different methods of budding:

1) Shield budding or T Budding:

In this method T or budding inverted – shaped incision is made on rootstock.

A transverse cut of 1 to 1.5 cm length is made first and then either below or above to this a vertical cut of 2.5 cm to 3 cm length is made and connected to transverse cut. Then the bark is lifted by using the ivory edge of the budding knife. The scion bud is removed in the form of a shield with or without a piece of wood. The bark is raised and then the bud is inserted into the 'T' cut surface of the root stock. This method of budding is practiced extensively in the propagation of sweet oranges, roses, plum and peaches.

2) Patch budding:

The patch of bark is removed from the stem of the rootstock. Then the patch of bud of exactly same size is removed from the bud stock taken from desired tree and fitted on the rootstock exposed area. Polythene film is tied to protect same. September and October are considered most suitable month for patch budding in mango. Patch budding is somewhat slower and more difficult to perform than 'T' budding. It is widely and successfully used on the plants with thick bark.

3) Flute budding:

This method makes use of the ring of tissues adjoining the bud relatively thick barked tree thicker than 1 cm. it is successfully used in Ber and cashew nut tree on the bark of rootstock

two horizontal cuts about 1 ½" to 2" apart are made to the extent of about ¾ of the diameter of the stem. Vertical cut connecting the horizontal cuts at both the ends are made and semi-circular bark is removed scion is prepared by repeating the same method the budstick and the bud accompanying with flute of bark is placed against the corresponding cut portion of the stock after this tying is attended in usual ways.

4) Ring budding:

The nature and method renders its usefulness only to small stock of not more than ¾"to 1" diameter. Budding operation is performed when the plant is in sap flowing conditions. A complete 1 ½" to 2" ring bark is removed around the stem of stock. A complete ring of bark of the same length with a prominent plumpy, healthy bud is removed from budstick when placed on stock; it extends all around the stock. After placing the ring in position tying is done in usual manner failure of the bud to unite, results in loss of terminal portion of stock above the ring portion.

5) Forket budding:

In Maharashtra state success has been achieved in mango by this method. The favorable season for operation is July to September.

The selection of th budsticks as well as the rootstock is the same as shield budding. At the height of about of 9" to 12" from the ground level horizontal cut is taken on the rootstock and then two vertical cuts from either end of the horizontal cut extending downwards are taken and a flap of bark is pooled cut exposing a rectangular portion of about 1" to 2" on the rootstock.

A rectangular piece of bark along with a matured plumpy bud of the same size [1" x 2"] is removed from the selected budstick. This piece of bark is then fitted on the exposed portion on rootstock and secured well. The panel of bark is then released to its original position and tied by sutali. The manuring, watering of the rootstock is carried out as and when required.

After about 15 days the bandage is removed. The panel of bark is pooled out again and the bud inside is observed. If the bud shown the scion of sprouting the panel of bark is removed by taking horizontal incision to the downward side of its on the root stock and bud again bandaged, keeping exposed the growing points in usual way. If bud does not show the sign of sprouting the panel of bark is released to its original position and bandage done usual ways after 15 days the same procedure is followed.

Within 3 to 5 weeks from the operation the bud sprout when the shoot coming from bud grows vigorously the terminal shoot of the rootstock is removed or cutoff in two to three steps as is done in the case of shield budding.

3.2.5 Micro Propagation:

Micro propagation [tissue culture or in vitro culture] in vitro Latin word means "in glass" refers to the multiplication of plants, in aseptic condition and in artificial growth medium, from very small plant parts like meristem tip, callus, embryos, an thesis etc. The German plant physiologist *Haberland* (1902) first described the biological principles of tissue and organ culture. At present tissue culture finds extensive application in agriculture and horticulture. Through some achievements have been made but the commercial utilization of the technique of tissue culture is still lacking behind.

Merits of micro- Propagation:

1) Tissue culture helps in rapid multiplication of true to type plants throughout the year.

2) A new plant can be regenerated from miniature plant parts, where as in conventional methods a shoot of considerable length is required.

3) Large number of plants can be produced in culture tubes in small space with uniform growth and productivity of growing them in large areas in nursery.

4) Plant raised by tissue culture is free from diseases.

5) Tissue culture coupled with somatic hybridization helps in evolving new cultivars in short times.

4) Micro-propagation facilitates long distance transport of propagation material and long term storage of clonal materials.

7) Tissue culture methods are particularly effective in plants that do not breed true from seeds, seeds are not viable or not available easily Ex. Banana and in plant propagation by conventional methods are expensive Ex. Orchids.

Demerits of Micro propagation:

1) It requires costly setting up and maintenance of laboratory is very high.

2) Tissue culture techniques require skill and manpower.

3) Slight infection may damage the entire plants.

4) Some genetic modification of the plant may develop with some variety and then maintenance of quality is difficult.

5) The seedling grown under artificial condition may not Survive when placed under environmental conditions directly, if hardening is not done.

*** Methods of micro propagation**

1) Meristem culture:

In meristem culture, the meristem and few leaf primordial are placed into suitable growing media. An elongated rooted platelets in produced after some weeks, which is transferred to soil when it has attached considerable height. A disease free plant produced is by this methods. The rapid multiplication of various herbaceous fruit plants is possible.

2) Callus culture:

A callus is mass of undifferentiated parenchymatous cells. When living plant tissue is placed in an articificial growing medium with other favorable conditions, callus is formed. The growth of callus varies with the endogenous levels of auxin and cytokinin manipulated in culture medium.

The callus growth and its organogenesis or embryogenel is can be classified cut three different stages.

Stage – I: Rapid production of callus after placing the explants in culture medium.

Stage – II: The callus is transferred to other medium containing growth regulator for induction of adventitious organs.

Stage – III: The new plantlet is their exposed gradually to the environment conditions.

3) Cell culture:

A cell suspension culture refers to cells or group of cells dispersed and growing in an aerated liquid culture medium. A piece of soft tissue culture medium is placed in liquid medium and shaken vigorously to obtain suspension of cells. The culture medium includes a complete range of ingredients like inorganic salts, sucrose and vitamins and balanced dose of hormones. Cytokinin induces adventitious buds in kiwi fruit in a suspension subculture for about a week.

4) Embryo culture:

Embryo culture, the embryo is excised and placed into a culture medium with proper nutrient in aseptic conditions. To obtain and quick and optimum growth of the embryo, the

culture medium is changed 2 to 3 times. When embryo has grown into a platelet it is transferred to soil. It is particularly important for the production of interspecific and intergeneric hybrids and to overcome the embryo abortion.

5) Protoplast culture:

Protoplast of plant cell can be isolated with the help of wall degrading enzymes and grown in a suitable culture medium in a controlled condition for regeneration of plantlet. Under suitable conditions the protoplast develops a cell wall followed by an increase in cell division and differentiation and grows into a new plant. The protoplasts first culture in liquid medium at 25 to 28^0C with light intensity of 100 to 500 lux and after undergoing substantial cell division, they are transferred into solid medium congenial or morphogenesis, many horticultural crops give response to protoplast culture.

CHAPTER-5

PRINCIPLES OF ORCHARD ESTABLISHMENT

Orchard is defined as planting of fruit trees. Orcharding is a long term investment. Due to being perennial in nature fruit plants once planted remain devoted to the land for many years. Any mistake made during the establishment of orchard it may very hard to rectify. So it deserves a very careful planning and organization. To avoid the mistakes there should be a proper selection of location, site, planting distance, soil climate, irrigation facilities, marketing facility, varieties and nursery plant material used may considerable reduce the loss during the production. While planning of an orchard, the following components need to be observed**.**

SELECTION OF SITE:

The fruit plants are of permanent in nature and mistakes committed in the outset are difficult to rectify at the later stage.

An orchard is a long term investment and deserves a very careful planning and organization. Any mistakes made initially in the selection of location, site, planting distance, soil, climate, irrigation facilities, varieties and nursery plant material used, considerably reduces the reduces the returns on investment.

The failure not only result in the loss of capital and wastage of long range efforts of the growers but also proves detrimental to the spread of gardening in the locality by making other prospective fruit grower apprehensive. It is therefore advisable to seek expert guidance of an experienced fruit grower before starting the enterprises.

Factors to be considered while selecting the site for fruits:

1) Climate and Soil:

Climate and soil are the chief natural factors on which the success or failure of the fruit growing is dependent. Climate include several factors like temperature, rain, atmospheric humidity, wind, hails, light, where as the soil factor including physical conditions of the soil and its fertility, nature of sub soil, its drainage conditions, temperature, texture and its composition.

2) Transport facilities:

Most of fruit, are perishable in nature and as such their quick transport to the market without much loss of time is important and for this reasons the site selected should be nearer to a marketing center and should be connected by a good road and railway. This will reduce the transport cost.

3) Irrigation facilities:

Adequate irrigation facilities should be available at hand and round the year. The supply of water should be plentiful and it should be available at the reasonable cost, otherwise the cost of production will be increased. The water should be free from objectionable imparities (salts).

4) Cheap manpower:

While selecting the site availability of cheap labour in the vicinity is taken into consideration so as to keep down the production cost.

5) Owners house:

For effective supervision of the orchard, it is essential that the owners should have his home in his own orchard. Therefore, availability of medical, educational and social amenities in the vicinity should also be considered while selecting the site.

6) The site should not be close to any diseased plantation.

7) The selected site should be free from cyclones, frost, hails, storm, strong and hot winds.

8) Market:

The varieties of crop selected should Command a good demand in the market. The market facilities must be available in selected site for ideal fruit orchard.

9) The site selected should be free from cyclones, frost, and hails, storms, strong and hot wind.

10) The varieties of crops selected should be command a good demand in market and they must do well the climate prevailing on the site.

Preliminary operations:

After selecting suitable site the first step should be to clean the land of all vegetation including shrubs, bushes, and standing local trees. After this, the land should be ploughed deep both ways and leveling may be taken up, if the land is undulating. Its leveling may involve shafting of major soil layers. In such cases the same may be divided into two or more sections, and then it should be leveled section-wise. To improve the physical and chemical conditions of the soil a green manuring crop before flowering should be grown and buried by ploughing.

Fencing:

To prevent the damages destruction of trees from stray cattle and also to protect the orchard from thieves, it is necessary to provide some kind of fencing on all sides of the garden. This should be done before planting the fruit trees. Fences may be prepared, using thorny bushes but they are not satisfactory since they require frequent repairs and replacements. Barbed wires

fencing is very good but its initial cost is very high. Some thorny plants such as *Prosophis juliflora, Caesalpinia sepiaria* [chillari], and *Carissa carandas* [karonda] etc. make a very good give fence.

Wind Breaks:

Close planting of tall growing tree's shrub on the windward side of an orchard should be done for protection from wind.

Fruit orchard causes heavy losses when exposed to strong wind. Heavy wind increases the losses of mistake both by transpiration and surface evaporation.

The high winds also causes the damage of fruit trees breaking of branches, destruction of blooms, dropping of immature fruits and erosion of surface soil. The growth and yield in protected orchards are definitely better than the exposed orchard. Hence establishment of a fall growing tree wind break is necessary to protect the orchard.

Selections of wind breaks:

While selecting wind break plant height is more important than thickness. Wind break will give full protection to a distance of 5 times height of free. The wind breaks should be erect and tall growing, quick growing, hardy & drought resistant. It should be strong and resistant to maximum wind.

Planting and spacing of wind breaks:

Planting of wind breaks should be done at least two years after planting of fruit trees. These wind breaks are planted in rows. These wind breaks are planted in rows, the first row of it should be planted 40 feet away from fruit plants, one to two rows of such trees are planted on the west and south side of orchard. They are planted at the spacing 12 x 12feet depending upon the species of windbreak used.

Species used as windbreaks:

Following trees are commonly used as wind breaks.

Casurina equsitfolia, *Eucalyptus sp.*

Averhoa Caramobola, Dalberzia sisso, Syzgium cumini, Sesbania egyptica etc.

Advantages of wind breaks:

1) It reduces the wind velocity.

2) It checks the evaporation losses of water from soil surface.

3) It increases fruit production by minimizing wind damage.

Disadvantage of wind breaks:

1) It is an ideal place for housing of insect pest & disease.

2) They are expensive since they keep 13-15% of land out of production.

Layout and Planting systems:

This refers to planting of fruit trees in an orderly manner to ansure number of trees / unit areaand facilitate various orchard operations successfully. Some kind of fruit trees need pollinators/ pollinisers for improving the fruit set which should also be kept in mind while preparing planting layout.

A number of planting system is being practiced. These are;

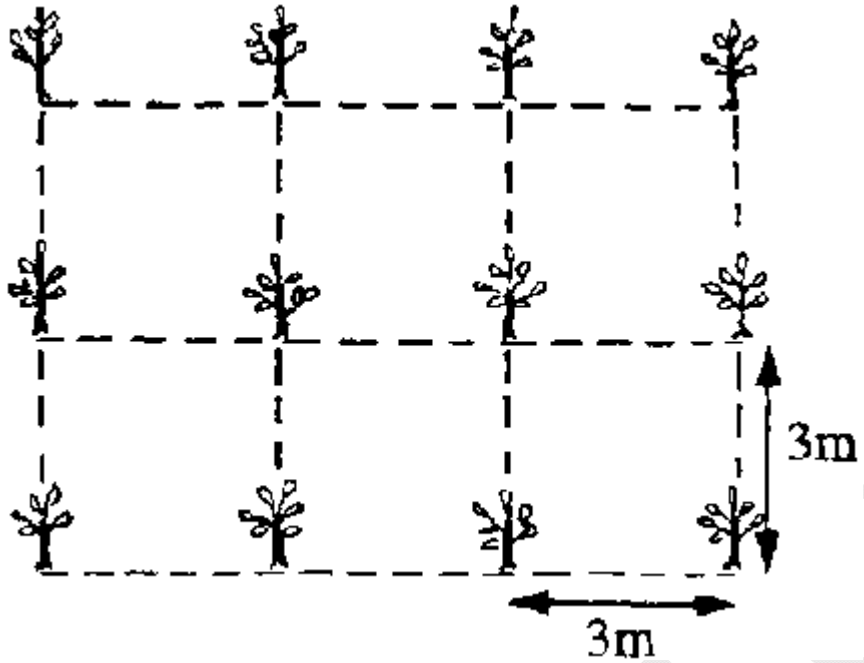
1) **Square system**
2) **Rectangular system**
3) **Hexagonal system**
4) **Triangular system**
5) **Diagonal/ quincunx system**
6) **Contour system**

Before selecting the method, following points should be kept in mind;

a) Maximum number of plants per hectare.
b) Optimum space utilization.
c) Optimum space for better development of plants.
d) Convenience in performing cultural operation.

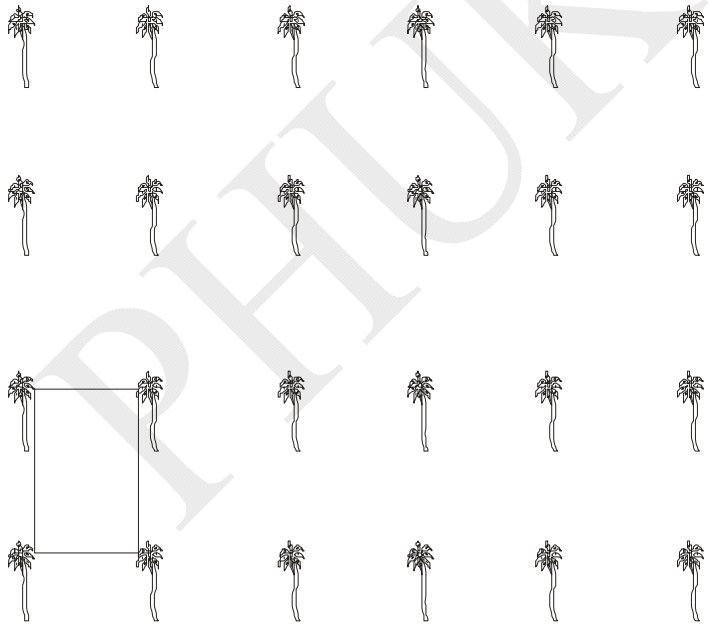
1) Square system

In this case a tree is planted on each corner of a square whatever may me planting distance such as row to row and plant to plant distance is same. This plan is commonly followed as it is easy to layout. Intercropping and cultivation are possible in two directions. It is commonly followed in Mango, sapota, banana and citrus etc.



2) Rectangular system:

Trees are planted in straight rows running at right angles on one side of the field. Distance from plant to plant and row to row is not same and four trees joined at the base give a rectangle.

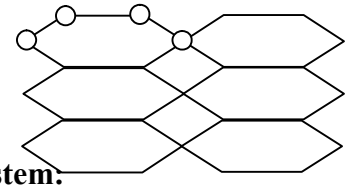


3) Hexagonal system:

In this method trees are planted at each corner of equilateral triangle. This way six tree from hexagon with the seventh tree in the center. That's why it is also called as septule. This plan

can be usually employed where land is expensive, and is very fertility with good available water supply. The trees are equally spaced from each other but it is difficult to layout. In this layout 15% more plants are accommodated than the square system. In this system inter cultivation difficult.

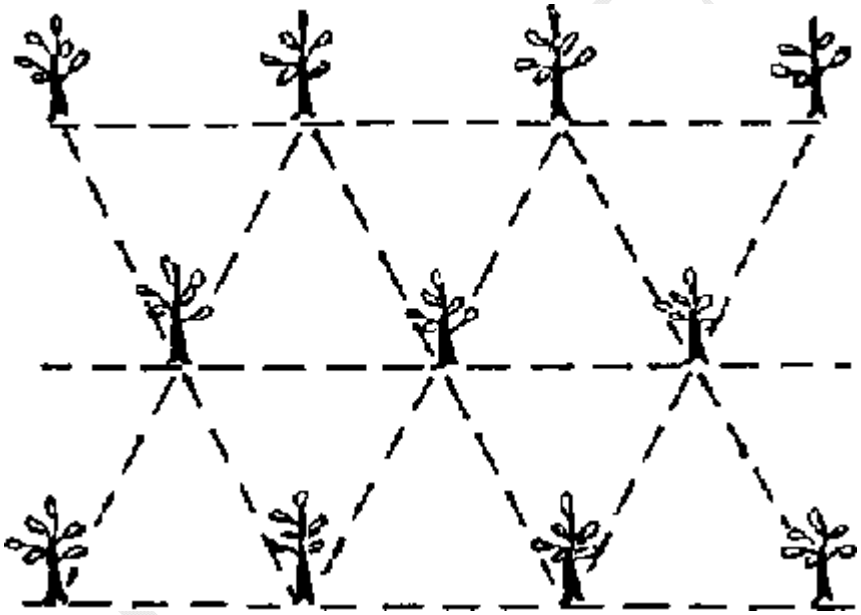
FIGURE



4) Triangular system:

In this system tree are planted as in the square system but the plant's in the 2^{nd} ,4^{th} , 6^{th} and such other alternate rows are planted mid way between the 1^{st},3^{rd}, 5^{th} and other alternate rows. It has no special advantages over the square system except providing more open space for the tree and for inters crops. It is difficult for layout & cultivation.

FIGURE



5) Diagonal or quincunx system:

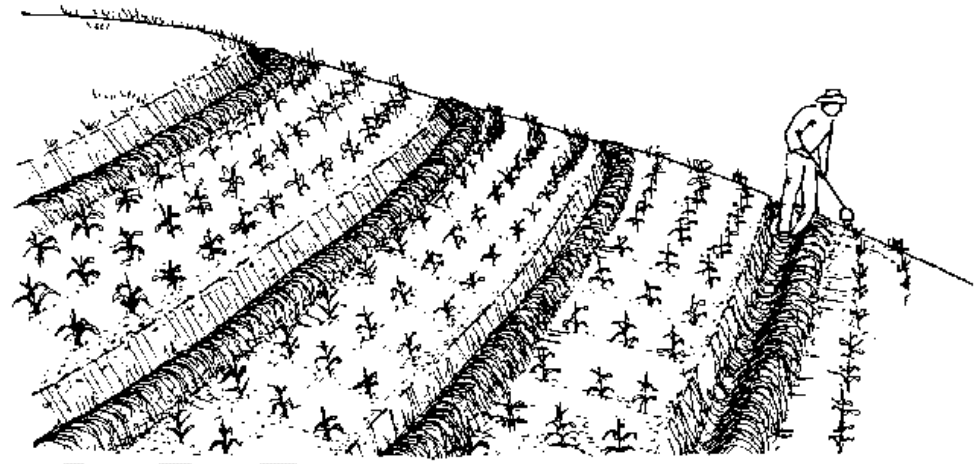
It is same as the square system with addition of a tree in the center of each square, that is at the points of diagonal cut. The central tree is filler tree which kept only for a short period. Ex: Mango + papaya, Mango + Fig.

FIGURE

6) Contour system:

Commonly followed on hills were land slopes are high. Trees are planted along the contour lines at right angles to the slope to reduce loss of top soil due to soil erosion. Planting marking done from the bottom to the top and distant between plants not same.

FIGURE



Intensive planting system for orcharding

7) HIGH DENSITY PLANTING:

High density planting means to increase the plant population per unit area for increasing the production of fruit crops.

It is intensive method of cultivation of horticulture crops. Mere increasing the plant population; however it is not sufficient in high density planting. High density plantation technique involves increasing the plant density in such a fashion that the growth of individual plant does not

interfere in the growth of the adjoining plants. Increase plant population may adversely affect the growth and production due to overcrowding and in terminating of branches and shade effect.

This can be avoided by,

1) controlling the size of the plant
2) Adjusting the planting distance and method of planting

Smaller size of the plant tops can be developed by selecting dwarf structure varieties in certain fruit crops which are genetically dwarf structure than the other commercial varieties such as mango variety Amprapali which can be planted at dwarf spacing 2.5 X 2.5M^2, Basarai in Banana at 1.2 X 1.2 m. Papaya variety Pusa Nanha at 1.8 X 1.8 m respectively, suitable for HDP. There by increasing the plant population. Plants can be made dwarf by using rootstock which have dwarfening effect on scion.

eg. Vallicolumban – mango

Trifoliate orange- citrus.

Malling IX- Apple.

In other case, controlling the plant size we can adapt the different type of training and pruning practices in fruit crops.

Advantages of HDP:

1) Best utilization of land and resources.
2) Increase in yield per unit area.
3) Quality production of fruit crops.
4) Easy intercultural operation, plants protection and harvesting.
5) To obtain export quality of the harvest.
6) Reduces labour cost.
7) More efficient use of fertilizer, water, fungicides, weedicide and pesticides.

Disadvantages:

1) Less life span of the fruit trees.
2) Cost of inter cultivation practices such as spraying, training, pruning etc is higher than normal planting system.
3) Closely planted trees bear inferior quality and small size fruits with low yield.
4) Intercultivation operation is difficult to carry.

8) Meadow orcharding:

This system has its origin in Israel. It consists of planting trees at ultra- low spacing. In this system, planting is followed at a distance of 45X75cm2 within a row and 210-270 cm2 between rows. The system accommodates ultra high density of plants varying from 30,000- 1, 00000 trees on a hectare basis. The plant is cut regularly at the height close to the ground. This system relies heavily on the use of growth regulators.

CULTIVATION OF NUMBER OF PLANTS IN DIFFERENT SYSTEMS OF PLANTING

Square and Rectangular system:

$$\text{No. of plants} = \frac{\text{Area in meter}}{\text{Planting distance}}$$

Eg. Suppose area is 10,000 sq. m. (1 ha) and planting distance is 10X 10 metre then

$$\text{Number of plants} = \frac{10{,}000}{10\text{X}10}$$

$$= 100 \text{ plants.}$$

Planning of an orchard:

Careful plan of orchard is necessary for:

a) Most economic and efficient management.

b) Attractiveness.

c) Economic layout and location of roads, drains, irrigation channels, path, hedge & wind break.

While preparing plan of big orchard following points should be born in mind.

1) Optimum spacing to give maximum number of trees per ha.

2) Building should be at centre or at high level for proper supervision.

3) Don't mix large tree with small trees.

4) Plant the fruit plant according to their soil requirement.

5) Irrigated tree should be near the source of water.

6) Evergreen tree should be at the front and deciduous should be behind.

7) Big trees should be at the backs & small growing should be in front.

8) Fruits, attacked by birds & animals should be close to the watchman shed.

9) Pollinators should be provided to self incompatible fruit tree Ex: Ber, Mango.

10) Crops requiring equal spacing should be grouped in one block.

Chapter 6
METHODS OF TRAINING AND PRUNING OF FRUIT CROPS

Horticulture crops have the highest production account in India. It is grown for their produce such as fruits, vegetables, flowers, medicinal components, spices oleoresins, aromatic essential oils etc. To maintain quantity and quality of horticultural crops, the field practices like training and pruning are much more important in order to harvest more. Such practices are also helpful for intercultural operations. Training is an operation performed on a plant was by orderly plants frame- work or structure is developed. In other words, training is an orientation of plant in space through techniques such as tying, fastening, staking, supporting over a trellis or pergola in a certain fashion or pruning of some parts. The important objectives of training are to admit adequate sunlight and air to the centre of the tree and to expose maximum leaf area to the sun, to limit growth and spread of the tree so that various cultural operations such as spraying and harvesting are performed at the minimum cost. It also helps to build the frame-work and arrangement of scaffold branches and protection of tree from sun-burn, sun-scald injuries and high-wind velocity. Another important operation is pruning. Pruning is an important horticultural practice. The knowledge of which is essential to the grower. It refers to the removal of plant part with an object to get better yield and quality of fruit. In horticulture crops prune has to remove disease and pest-affected branches which is not an economically valuable. The pruning is practiced in order to maintain the growth and vigour of the trees and to maintain a balance between the vegetative vigour and fruitfulness. It also helps to regulate the size and quality of fruit, to regulate the succession of crop, to spread tree for convenience of economy in orchard management and to induce vegetative growth of plant.

How to train the plants:

The formation of main framework of the tree is the most important part of training. Usually, two to four main branches are encouraged at almost the same height. This should be allowed to rise from different directions at some distance from one another as to form a balanced head. These branches are called scaffold branches. The framework is greatly strengthened if branches are spaced at 15 cm. apart vertically on the main trunk. If two or more branches of equal size are allowed to arise from one place, they form a bad crotch which is afterword's prone to split from their common joint. Most deciduous and evergreen trees trained to a single stem except pomegranate, custardapple, fig etc are better trained to two of three stems.

The Systems of training:

The system of training depends on the nature of plant, climate, purpose of growing, planting method, mechanization, etc. and consequently, intelligent choice is necessary.

Training of herbaceous annuals and biennials:

These plants are usually grown without any attempt to alter their growth pattern because, even if useful, it is not practical to alter their growth, as they are available in large number in the field. However, for some of ornamental value and creeping nature the following types of training such as-

(i) Staking or supporting of vine like plants. Such as cucurbitaceous, tomato vegetables crops.
(ii) Training on pergola or trellis of vine type fruit plants or even indeterminate type tomatoes.
(iii) Nipping of apices for encouraging lateral growth to give bushy appearance or fulsome

appearance in pot plants such as aster, marigold and chrysanthemum.
(iv) De-shooting or removal of lateral buds for making single stem for large flowers as in chrysanthemum and dahlia.
(v) Staking with bamboo sticks and tying together various shoots in potted chrysanthemum and tomato.

Training of woody perennials:

The woody perennials widely spaced and remaining a place for a long duration are trained to develop strong frame-work for sustainable production of quality produce and for ornamental beauty in different shapes (topiary). In these plants the following types of training are followed:-

1) The Central leader:

In this system, a tree is trained to form a trunk extending from the surface of soil to the top of the tree. In different kinds of trees, the central axis or main branches grow naturally grows vertically upwards and smaller side branch grow from it in various directions. If the central leader branch is allowed to grow indefinitely, it will grow more rapidly and vigorously than the side branches resulting close center and tall tree. Such trees bear the fruits more vigorously near the top. The lower branches in which remain more or less shaded are ultimately less vigorous and less fruitful.

2) The Open center system:

In the open center system of training, the trained stem is allowed to grow only up to a certain height by heading it within a year of planting of the tree and in during a all the subsequent vegetative and growth of lateral branches. Thus it results in a low head in which the bulk of the crop is borne closer to the ground than in the case of central leader tree. Open center system allows full of sunshine to reach each branch. Such trained trees, are more fruitful and greatly facilitate operations like spraying, thinning and harvesting.

3) The Modified leader:

Intermediate between the two is the modified leader system. It is developed by first training the tree to the leader type allowing the central stem to grow unhampered for the first or five years. Then central stem is headed back and lateral branches are allowed to grow as in the open centre system. This results in a fairly strong and moderately spreading tree.

Other methods of training:

1) The Caldwell System of Training:

The branches of the plant are bent and pegged to the ground. This induces a tree to come to bearing early and yielding better. No pruning is involved in this method ex: erect growing varieties of guava.

2) The Fan System:

This method of training is suitable for wall side planting in home garden. A fan-shaped frame is developed by allowing the branches to grow in only on plant's parallel to wall. Eg. Ornamental plants.

3) The Cordon System:

In this method, the vines are trained with a long straight trunk which is bent and fastened horizontally to a wire trellis. Ex. grape.

4) The Kniffin System:

The wine is trained on two to three horizontal wire trellis.

5) The Overhead Trellis or Telephone System:

The wires will be fixed horizontally on some posts just like telephone wires. The plant will be trained on to the wires with a suitable framework Ex: Grape.

6) The Pendal or Bower of Arbour System:

A pendal is erected with the help of pillars and wires. The plants are trained on the pendal with suitable frame work. ex: grape.

7) The Single stake or Umbrella System:

The main trunk will be supported by a stake. The trunk is beheaded at a height of 5-6 feet. The branch arising on the trunk will be hanging freely Ex. grape.

The Principle of pruning:

To admit more sunlight, remove unproductive branches which are producing few or no fruits and also keep plant in its proper vigor, vitality and to obtain optimum yields of good quality fruits.

The Methods of pruning:

Several methods are used to prune horticulture crops for getting or maintaining the high production and quality. In some of the tree species, pruning as a regular feature in bearing trees is done to strike balance between vegetative growth and production so that farmers get sustained production uniformly with optimum quality of produce.

1) The Thinning out: (deshooting)

This refers to the removal of the branches entirely from its base leaving no stub or it means complete removal of lateral branches or main trunk.

2) The Heading back:

This methods encourages spreading of growth, bushiness and compact plant by cutting back of the terminal portion of a branch to a bud. It is also called as pinching or this refers to pruning or cutting of main stem or all or a few branches leaving a basal portion. By removing of the terminal portion of the twig, the formation and translocation of the growth inhibiting substances ceases and lateral buds develop. This method is often followed for hedges and ornamental shrub.

3) The Disbudding or rubbing off:

Here the young buds are nipped without giving them the chance to sprout. The buds may be vegetative or reproductive. This is practiced regularly in flowering plants to make terminal buds to give bigger flower.

4) The Pinching and Topping:

This refers to the removal of the tip of the shoots alone with a view to stimulate lateral growth. This is practiced regularly in coffee to remove apical dominance and to all the side branches to grow vigorously.

Difference between training and pruning.

Training	**Pruning**
1) Training is mainly concerned with giving frame & shape to the plant	1) Pruning affects the function of plants as it influences cropping of plant highly.
2) Training determines the general character and even details of plant outline, it's branching of frame-work.	2) Pruning determines the canopy of plant to produce fruit.
3) By training, we can keep the plant or vine in a manageable shape and can dispose branches in desirable directions and positions.	3) By pruning, we can actually drive the flow of sap towards fruiting area on plant and force the plant or vine bear better quality fruit.

Chapter 7

Pollination, Pollinators and Pollinizers

It is the process of transfer of pollen grains from anthers of a flower to the stigma of the same or different flower is known as pollination. The pollen grains may be transferred to the stigma of a flower present on the same plant or different plant of the same species. Pollen grains are not motile. As they do not move themselves to the respective stigma of the same or different flower. It has twoich types which is given below.

1. Self pollination
2. Cross pollination

Self-pollenization (autogamy):

pollen moves to the female part of the same flower, or to another flower on the same individual plant. Or In self pollination transfer of pollen grains from the anthers to the stigma same flower or another flower present on the same plant. Eg. Grape (vitis), Papaya, Sapota, Apricot, Citrus, Tomato Lettuce Globe,Artichoke, Broad bean, Peas, Cowpea, Winged bean, Fenugreek.

This is sometimes referred to as self-pollination, but this is not synonymous with autogamy. Clarity requires that the term "selfpollination" be restricted to those plants that accomplish pollination without an external pollinator (example: the stamens actually grow into contact with the pistil to transfer the pollen). Most peach varieties are autogamous, but not truly self-pollinated, as it is generally an insect pollinator that moves the pollen from anther to stigma. Plants adapted to self-fertilize have similar stamen and carpel length.

Cleistogamy:.

It is self-pollination that occurs before the flower opens. The pollen is released from the anther within the flower or the• pollen on the anther grows a tube down the style to the ovules. It is a type of sexual breeding, in contrast to asexual systems such as apomixis. Some cleistogamous flowers never open, in contrast to chasmogamous flowers that open and are then pollinated. Cleistogamous flowers by necessity are self-compatible or self-fertile plants. Many plants are self-incompatible, and these two conditions are end points on a continuum.

Hybridization is effective pollination between flowers of different species of the same genus, or even between flowers of different genera (as in the case of several orchids). Peaches are considered self-fertile because a commercial crop can be produced without cross-pollination, though cross-pollination usually gives a better crop. Apples are considered self-incompatible, because a commercial crop must be cross-pollinated. Remember that most fruits are grafted clones, genetically identical. An orchard block of apples of one variety is in effect all one plant. Growers now consider this a mistake. One means of correcting this mistake is to graft a limb of an appropriate pollenizer (generally a variety of crabapple) every six trees or so.

Cross-pollination (syngamy):

Pollen is delivered to a flower of a different plant. Plants adapted to outcross or cross-pollinise have taller stamens than carpel to better spread pollen to other flowers.eg. Papaya, Date palm, Grape (muscadine), onion etc.

Pollinating agencies

The pollen grains are motile, therefore, cross pollination involves some agencies to carry the pollen grains from the anther to the stigma. Such agencies which carry the pollen grains are called as pollinating agents.

The pollinating agents are of two type's viz., Abiotic and Biotic

Abiotic pollinating agents

It refers to situations where pollination is mediated without the involvement of other organisms; these abiotic factors that achieve pollination include wind and gravity. Only 10% of flowering plants are pollinated without animal assistance. The most common form, **anemophily, is pollination by wind**. This form of pollination is predominant in grasses, most conifers, maize jowar and many deciduous trees. In anemophily the air currents pick up the pollen grains from the anthers, while the stigma picks up the pollen grains from the air currents. **Hydrophily is pollination by water** and occurs in aquatic plants which release their pollen directly into the surrounding water. About 80% of all plant pollination is biotic. Of the 20% of abiotically pollinated species, 98% is by wind and 2% by water.

Biotic pollinating agents

It is the more common process of pollination which requires biotic pollinators: organisms that carry or move the pollen grains from the anther to the receptive part of the carpel or pistil. This is '"biotic pollination"'. The various flower traits (and combinations thereof) that differentially attract one type of pollinator or another are known as pollination syndromes. There are roughly 200,000 varieties of animal pollinators in the wild, most of which are insects. **'"Entomophily"', pollination by insects,** often occurs on plants that have developed colored petals and a strong scent to attract insects such as, bees, wasps and occasionally ants (Hymenoptera), beetles (Coleoptera), moths and butterflies (Lepidoptera), and flies (Diptera). In **'"Zoophily"', pollination occurs in flower by animals. "Malacophily" flowers are pollinated by snails. "Ornithophily" flowers are pollinated by birds** particularly, hummingbirds, sunbirds. In "**Chiropteriphily" flowers are pollinated by bats.** Plants adapted to using bats or moths as pollinators typically have white petals and a strong scent; while plants that use birds as pollinators tend to develop red petals and rarely develop a scent (few birds have a sense of smell).

Mechanics

Pollination also requires consideration of pollenizers. The terms **"pollinator" and "pollenizer"** are often confused: **a pollinator** is the agent that moves the pollen, whether it be bees, flies, bats, moths, or birds; **a pollenizer** is the plant that serves as the pollen source for other plants. Some plants are self-fertile or self-compatible and can pollinate themselves (e.g., they act as their own pollenizer). Other plants have chemical or physical barriers to self-pollination and need to be cross-pollinated: with these self-infertile plants, not only pollinators must be considered but pollenizers as well. In pollination management, an efficient pollenizer is a plant that provides compatible, viable and plentiful pollen and blooms at the same time as the plant that is to be pollinated.

Pollinizers :-

Pollinizer is defined as the source of pollen or to be the sire or media of the next plant that provides abundant, compatible and viable pollen at the same flowering time as the pollinated plant.

Eg. Most crab apple varieties are good pollinizers for any apple trees that bloom at the same time and are often used in apple orchards for pollination purpose. Some apple cultivars produce very little sterile or incompatible pollens with other apple varieties, these are poor pollinizers.

Pollinizers can also be the male plant in diocious species where entire plants are of a single sex, such as kiwi fruit, papaya etc.

According to the term of pollination cultivar X should be planted as a pollinizer for cultivar Y. A plant can only be pollinizer when it is self fertile and it physically pollinates itself without the help of an external pollinator.

Use and distribution of pollinizers

To ensure the adequate pollination or cross pollination. The exact arrangement of pollinizer or varieties or male plant to be used. Every third tree in every third row should be a pollinizer, so that the latter is the central tree of block of 8 of the main variety. In many instances, growers prefer to plant the pollinizer tree in complete rows across the plantation to facilitate the pruning, manuring, and harvesting of different varieties. Sometime 1 in 9 arrangement also used for adequate cross pollination.

Chapter No. 8
Kitchen garden, Garden type, parts and Lawn making

Fruits and vegetables play an important role in the balanced diet of human beings by providing not only the energy rich food but also promise vital protective nutrients. In order to make available the requisite quantity and kind of fresh fruit and vegetables every day to a family, it is better to have a nutrition garden to grow them in the house premises. Fruits and vegetables obtained from market lack freshness and deteriorate in the food value besides their exorbitant price. Therefore, the best quality of the fresh produce can be had from one's own nutrition garden as the time interval between the harvest and the consumption becomes the least. Working in a garden becomes a pleasure, an inspiration, a means of recreation and a possible family enterprise in which all members have due share to spend the leisure hours. The whole family can be engaged in it, where no great technical skill is required. The land available within the compound of the residential building can be utilized for laying out a nutrition garden, which would help in taking proper care, harvesting, irrigation and other operations. Big trees should be planted towards the northern side of the garden as they will not only shade the vegetables but the
roots may compete for moisture and nutrition if planted in between. A model nutrition garden generally consists of growing vegetables and fruits either separately or in combination. Thus the plan of growing vegetables and fruits has to be integrated in a most beneficial manner. The size of the garden may depend on the area available in the compound, the time available for its care and daily requirement of fresh fruits and vegetables of a family. To meet the demand of vegetables for an average family of 5 to 6 members, an area of 200 square meters will be sufficient. To produce 300g of vegetables per day, all the year round, about 50 square meters of area is required. Depending on the space available and the family size the planning may be done either for a big or a medium or a small size garden.

Guidelines/Principles in planning nutrition garden:

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

12. The plot should be provided according to convenience using minimum space.
13. Creeping vegetables like gourds and others may be trailed on the fence or erected pendals.
14. The area in between the perennial plants may be utilized for short duration shallow rooted annual vegetables or spices like garlic, coriander, etc.
15. If the land is limited preference can be given for growing those vegetables which are costly, highly perishable and not easily available in the market and which can produce maximum edible vegetables per unit area. The irrigation channel from the water source and path should be so planned and prepared that it covers the whole area of the garden for easy operation.

Garden and Garden Types

Garden can be defined as a place where various plants are grown accommodating many other aspects like paths, waterfalls, springs, pools and others, creating a pleasant and enjoyable site. There are different types of gardens. These ideas are called as forms of gardens or styles of gardens. The origin of different garden styles in nature. Following are the different types;

1. Landscape gardening: Garden is developed with due consideration to its original and natural landmarks. The goal in landscape gardening is to improve the landscape with an idea of developing a view or a design.

2. Formal garden: A formal garden is laid out in a symmetrical or a geometrical pattern. In this type of garden, the design is stiff and everything is done in a straight and narrow way. Symmetry on the sides or opposite to each is also one peculiarity of this style. e.g. If there is a plant on the left hand side straight land, a similar plant is planted on the opposite side. Flower beds, borders and shrubbery are arranged in geometrically designed beds. Trimmed formal hedges, Cypress, Ashoka tree and topiary are typical features of formal garden. e.g. Mughal, Persian, Italian and French gardens.

3. Informal garden: In an informal garden, the whole design looks informal. The plants and various features are arranged in a natural way. No hard and fast rules are observed in the form and design. The work, however, has to proceed according to a set and well through out plan otherwise the creation will not be artistic. While formulating the plan, various alternatives are considered. Anything anywhere, is not informal design. Informal style is rather complicated as compared to formal one, but there is more scope to imitate nature. e.g. English and Japanese gardens.

4. Wild garden: This is new style. The idea was put forth by William Robinson in the last decade of the 19th century. The concept of wild garden is not only against all formalists but it also breaks the rules of landscape style. Certain features are maintained in a natural way i.e.

i. Some grasses are allowed to grow as they grow in nature. No pruning or cutting is followed.
ii. Some bulbous plants are allowed to grow and spread in their own way.

iii. The creepers and climbers are allowed to grow and cover the tree as they grow in the forests and jungles.

Garden Style

Definition: The peculiarities in garden layout, features, trees, shrubs give a homogeneous effect to the garden and when practiced consistently in a particular area is called as the garden style of the area. The major garden styles based, on the above are;

A. Formal gardens: e.g. Mughal, Persian, Italian and French gardens.
B. Informal gardens: e.g. English and Japanese gardens.

A. Formal gardens:

1. **Mughal gardens:** The gardens laid out during the rule of Mughal Emperors in India are known as Mughal gardens. The Mughal gardens are similsr to the styles of gardens of Central Asia and Persia. Babar (1494-1531) was the first Mughal rulers to introduce this style in India. All other Mughal rulers and some of the Mughal *Begums* starting from Akbar and followed by Jahangir, Nur Jehan, Shah Jehan, and Aurangzeb all laid their hand in developing one or the other Mughal gardens in India. The main features of Mughal gardens, which are borrowed from the Persian style, are;

a) Site and Design: Mughal were very particular in choosing the site for their gardens and always preferred a site on a hill slope with a perennial rivulet or along the bank of a river. Mughal gardens were generally rectangular or square shaped with different architectural features.
b) Wall and Gates: The Mughals created the garden not only for pleasure and recreation but also as fort and residence surrounded by high walls with an imposing wooden gate at the entrance studded with bold iron nails and pointed irons spikes. The main purpose of walls is to protect from the enemies and shelter against hot winds.
c) Terrace: The Mughals came from the hilly terrains therefore they made terrace in gardens and they, selected location of garden near the hilly slopes. There fascination is so intense that even in the plains they created artificial terraces.
d) Running water: The style of having running water by constructing the water canal and tanks barrowed from the Percians. The canal paved with blue color to create illusion of depth. In plains of India summer is hot and dry; water is utilized for cooling effect.
e) Baradari: It is made from stones and masonry with a *pucca* roof and a raised platform for sitting. It is an arbour like structure. There were provided usually twelve or occasionally more doors on all sides for the Emperors to watch t e performance of dancing girls.
f) Tomb or Mosque: The garden usually made around a tomb such as Taj mahal, Akbars Tomb at sikandara. It is often said that the Mughal gardens were build around monument.
g) Trees and flowers: In the mughal garden trees were selected based on the symbol. Like life, youth, death etc. Fruit trees were considered symbols same as other trees. Flowers beds were of geometric pattern and constructed along the water canals or near to main building. The favorite flowers were rose, carnation, jasmine, tuberose, etc.

2. **Persian garden:**

This garden based on the idea of heaven and garden style is one of the oldest garden styles.

Two natural elements were used viz., water, the source of life and trees whose height is chosen for heaven. The Persian garden theme depend on the Mesopotamian mythology that there were four rivers of life that divided the land into smaller gardens. It is strictly formal and symmetrical garden type. It is made by cutting the terraces on the hilly slopes. It has two types one is Royal Hunting garden where huge acreage of forest land was set for royalty for hunting and horse riding and the second was the paradise garden.

3. Italian garden:

The garden style came into existence at the time of Renaissance. Masonry features which were strikingly different from those used in Mughal and Persian garden styles. The Italian garden elites looked upon their gardens as an extension of their lavish palaces, as a glamorous outdoor hall for entertainment and for showing off their wealth as well as status. The most prominent feature of the Italian gardens was the massive, flight of stairs, generally of marble, complete with balustrade to connect the different levels in the garden.

B. Informal garden

1. **English garden:** In 14th century monks and priests conceived the idea of gardening out of necessity mainly to supply vegetables to the imamates of the monasteries and for growing herbs for medicines. The spirit of gardening slowly came up with people who realized the goodness of residing in pleasant surroundings. The concept behind the gardens was that the gardens should look like the countryside without any artificial barriers such as fences, hedges etc. In 16th century gardens features like flower beds, topiary, terrace gardens were introduced in English gardens. Then gardens were laid out more emphasis on architectural features in 18th century. The main features were the curved paths, informal groups of trees, the main features were curved path, informal groups of trees, rivulets or streams, artificial waterfalls and clipped hedges. Now English gardens saw the advent of flowering annuals which subdued the importance of architectural features.

   The main features of English gardens in India are lawn, herbaceous borders and rockery.

2. Japanese garden:

The Japanese gardens are made based on the idea of heaven. It is continued with the same style of gardening which came since centuries which has still popular which can be attributed to the special relations of the Japanese garden to nature. Immutability is another important character of Japanese garden. Except seasonal variations in deciduous trees, the garden hardily undergoes any change during different season. A Japanese garden tries to capture natural scenery or to imitate a landscape. The tree most important elements in Japanese garden are water, stones and plants. Low sculptured bushes and trained dwarfed trees are very attractive features of Japanese garden.

It is classified into different types such as Hill garden, Flat garden, Tea garden, Passage garden, and sand garden.

Lawn

Lawn is an important feature of a landscape and a garden without a lawn is not considered as complete garden.

It can be defined as a piece of land which is thickly covered with uniformly green and soft grass. It is also known as the green carpet for a landscape as well as heart of garden. It has some importance such as it improves the appearance of the house and enhances its beauty. Lawn increases the value of real estate by increasing the convenience and usefulness. It will provide a perfect setting for a flower bed, a border, a shrubbery or a specimen tree or a shrub. It is also source of charm and pride and reduces the tension of the mind after days hard work as well as it is provide great satisfaction to the owner and becomes the centre of the gardens for major activities.

Lawn development needs some criteria which are given below;

A. Selection of site:

While selecting the field should be receive full sunshine throughout the year. Land should have moderate slope to ensure drainage. In a home garden, the lawn should be attached to the residential building and easily accessible from the front veranda or portico. Lawn site should not have big trees as the dried leaves fall over the grass and make the lawn dirty. Lawn should be devoid of perennial weeds like lavala (*Cyprus rotundus*) as it would hamper the growth of lawn.

B. Soil and soil preparation:

Soil should be well fertile loam containing sufficient humus. It should retain enough moisture and should also have adequate drainage. Soil should be little acidic with PH 5.5 to 6.0. Soil should be reclaimed If more acidic add lime and alkaline add gypsum.

C. Selection of grass:

In India, Doob grass (*cynodon dactylon*) is commonly for making lawn. *Zoysia japonica* commonly known as blue –green-grass or Korean grass can also be used. This two grasses are used in sunny places and for shady places, *Oxalis trifoliate*, wood meadow grass (*Poa nemorallis*) or carpet grass can be used.

D. Planting of lawn:

Lawn should be planted early rainy days by using the different method of lawn planting;

1. Showing of seeds:

   25- 30 kg seed required for an hectare. Before sowing of seed soil should be tilled fine followed by light rolling. Mix the sand or ash for even distribution of seeds. Seeds are sown uniformly and evenly on a windless day. Then watering is done with watering can fitted with fine rose.

2. Dibbling of roots:

It is common and cheapest method. In this method pieces of rooted grass taken from area free from weeds are dibbed at a distance of 10-15 cm both ways. After planting of root water apply liberally. Then it will ready within four months.

3. Turfing:
   This is quickest method of lawn planting in which pieces of uniform thickness of turf along with soil are made from place where grass is compact and free from weeds. These pieces of turf spread on the ground evenly, and beaten with a stick covered with fine soil. Then liberal watering is done. Grass starts growing within a short period.
4. Instant lawn: This type of lawn it is used for show not for use. Sometimes it becomes necessary to prepare green cover within few days sown the wheat or paddy seeds thickly on the ground with screen soil 2-3 cm deep. After germination, when the growth is 3-4 cm high it is moved lightly.
5. Turf plastering
6. Bricking: Bricks like structure were removed and plant on the ground and watered lightly.
7. Planting on polythene: The polythene where used in lawn planting it should be 800 gauge thicknesses. Cut it into suitable pieces of desired dimensioned. The mixture of soil is spread over the polythene and grass grown over it. It can be rolled and taken to the desired places and rolled out where temporary effect is to be created.

Maintenance of lawn:

After the establishment of the lawn weeding is an important practice which is done at regular intervals or whenever weed comes out. The weed frequency is more in rainy season therefore weeding should be regularly. Then watering/ irrigation according to season and should be frequent and preferable through sprinklers. Over watering and drainage should be avoided. Liming is done when soil is acidic in nature. Rolling helps to keep the surface leveled but it should be avoided when soil is wet. Light pruning is done is also known as moving, it is done in certain intervals when the length of the grass is reach 5-6 cm by using the mover during any season. Sweeping the lawn thoroughly after each moving is essential operation to clean out grasses and other debris. Continuous rolling and moving results in the formation of hardy and woody lower part of the lawn therefore scraping is done with the help khurapi in the month of April- may and is followed by raking to break the crust. For every square meter, 2 kg screened cow dung manure and 100 g powdered neem cake should be raked in followed by irrigation. Periodically manure is necessary to maintain the bright green color of grass. Nitrogen in the form of 2% urea solution is sprayed for this purpose. When the lawn is made on clay or loam it is likely to get soggy and thus unfit for use soon after a shower. To avoid this difficulty, a layer of coarse sand is sprinkled over the grass.

Diseases and their management

Fairy ring and Pale or yellow lawn is serious diseases occur in lawns. For controlling the Fairy rig disease drench Bordeaux mixture (4:4:50) or spray copper fungicides like Blitox.

Pale or yellow lawn is caused due to several factors such as waterlogged conditions, poor drainage, deficiency of nitrogen, and hardening of soil by creating oxygen deficiency. This can be corrected by providing poor drainage, frequent application of nitrogenous fertilizers and loosening of soil with the help of *khurpi* or rake or hand cultivator.

Chapter No. 9

IMPORTANCE OF SPICES, PLANTATION, MEDICINAL, AROMATIC CROPS

Medicinal Plants:

As per the survey made by environment, forest department and central government India has wealth of 9500 medicinal plants with the value of worth US $ 7500 Crores. Medicinal plants produce raw material for pharmaceutical industries for preparation of medicines. They contain alkaloids, Glycosides, Steroids etc. having both prophylactic and curative properties for treatment in several diseases. Medicinal plants are treasure of the country scattered all over, in open fields and forests. The Indian systems of medicine i.e. Ayurveda, Unani, Sidha and Homeopathy invariably use the medicine prepared from thousands of medicinal plants grown in varied agro climatic region of India.

This system of medicine is still providing life saving medicine to the majority of many people. It is reported that still today, this is the only therapy having curative role against some diseases. India is an important exporter of Indian medicines to USA, Germany, France, Switzerland, UK, and Japan. This is attracted attention of many people from developed world. Allopathy offers chemical based remedies but have some side effects also. However, the herbs and medicinal plants support the body's own defense system. Central government has established national Medicinal Plants Board for developing the medicinal plants. The board has launched different schemes to promote this sector.

Plantations crops

Tropical crops grown on a large scale by a uniform system of cultivation under central management and centered around a factory are called as plantation crops.

As compared to field crops, the plantation crops rich source of minerals, proteins,vitamins and other substances. They are high value crops and provide employment throughout the year. There is no need to prepare land every year. They have high calorific value and have great industrial use. Barren land or undulating land can be utilized. Plantation crops are maintained the ecological / environmental balance as well as reducing the air and sound pollution.

Spice Crops:

Spice crops play an important role in food industries which will provide flavors and aroma. Some of the spices improve the texture and give pleasing colour and palatable odour. They have importance in culinary preparations and used as colouring agents. 90-95% of the total production is consumed domestically and rests are export. They have tremendous export potential and medicinal values.

Aromatic crops:

Aromatic crops provide essential oils and used in cosmetic and perfumery industries. They are immensely popular in our society in various celebrations and festivals. They can also used in preparation pharmaceutical, confectionery, perfumery, ice cream, disinfectants. Essential oil is an integral part of our culture which is extracted from aromatic crops. They are growing in different agro climatic conditions in India.

Chapter-10

Use of Growth Regulators in fruit Production

Plant hormones are organic substances that regulate plant growth, which are also known as Phytohormones. They are synonymous to plant growth substances. They are small molecules which get produced within the plant and occur in extremely low concentrations. They regulate cellular processes in targeted cells locally and when moved to other locations of the plant. Plant hormones shape the plant; affect the seed growth, time of flowering, sex of flowers, senescence of leaves, fruits formation, leaf formation, stem growth, fruit development, ripening, plant longevity, and even the plant death. Hormones are vital to plant growth, and without them, plants would be mostly mass of undifferentiated cells. So they are known as growth factors or growth hormones. Sometimes the term growth hormones are misused with growth regulators therefore we can define the growth hormone as "*It is an organic substance produced naturally within the plants which control the growth and other functions at a site remote from its place of production and active in minute amounts"*.

Whereas plant growth regulators "it is a naturally occurring as well as synthetic substances other than nutrient and vitamins which regulates the growth of plant when applied in small quantities. As above given definition it indicates, all the phytohormones are growth regulators but all growth regulators are not phytoharmones.

Growth regulators are either growth promotes or growth inhibitors. Growth promoters are *Auxins, Gibberllins, Cytokinins* and growth inhibitors are - *Absecisic acid and Ethylene.*

Auxins:

Dr. Kogl and his co-worker in 1933 isolated auxin – 'a' has isolated from human urine which is known auxenotrolic acid with the formula C18 H32 O5 and is identical with the growth promoting substance found in the coleoptile tip of grasses. Its presence has been shown in yeast and *Aspergillus niger* and many higher plants. Auxin 'b' is an auxenolonic acid (C18 H30 O4) which is extracted from corn germ oil. It has been reported from other vegetables oils, malt and *Rhizopus*. These auxins responsible for revolutionary changes in the field of horticulture. Auxins are used for flowering, thinning, and root promoting as well as weedcide etc. they have played important role in plant viz.,

1) Cell division and enlargement: IAA and GA which are used for cell elongation and division of plants.
2) Tissue Culture: Now day's tissue culture technique is very important for propagating new individual in horticulture crops. Growth hormones have been playing important role in plant parts like shoot, callus growth, root multiplication. Viz., IBA is used for shoot multiplication, as well as 2-4-D is used for callus growth and IAA and IBA used for root multiplication.

3) Promote root initiation:
   Root formation possible only if there are developing buds and leaves on them. Dormant buds fail to induce rooting. In ringing technique the cuttings immediately below the buds also prevents rooting. Explicitly the rootings in all such cases depends on the presence of hormones. The auxin has been found to increase the rate of formation and final number of initials. Auxin has played an important role in root formation. E.g. IBA is most commonly used for root initiation.
4) Delay Leaf/fruit abscission
   Formation of abscission layer often results in premature fall of leaves, flowers and fruits. The premature drop of fruits as apple, pear and citrus can be prevented to a great extent by spraying with dilute solution of 2, 4-D, IAA, NAA or some related auxin. The auxin 2, 4-D has been used successfully to prevent defoliation of cabbage and cauliflower often occurs during harvesting.
5) Apical dominance:
   Initiation of growth of lateral buds by the terminal bud of a plant shoot. In most of plants, apical dominance results from the release of auxin by apical meristem.
6) Prevention of lodging:
   Many crops plant belonging to Gramineae and leguminoceae have a tendency to lodge. It means plant fall down due to excessive elongation and softening of the basal internodes of the stem. Lodging cause's deterioration reduces quality of produce and its result is a great loss of farmers. Therefore application of alphanaphthyl acetamide on the base of such plants prevents lodging and causes them to grow stiff, hard and erect.
7) Effect of Dormancy:
   Some of the growth hormones are used to prevent the dormancy as well as breaking dormancy. In the case of storage of fruits and vegetables it has an importance. Thus, recently MH (Malic Hydrazide) retards or inhibits the sprouting in potato and onion at the time of storage. This saves much valuable food from waste. In other case this hormones have break the seed dormancy of bulbs, corms, tubers etc. Thus, dormant potato soaked in 2% solution of ammonium thiocyanate will sprout several weeks in advance. This chemical is not hormone, probably acts by realizing or activating the hormones already present.
8) Sex Expression:
   The spray of auxins increases the number of female flowers in cucurbits. E.g. NAA
9) Flower Initiation:
   Generally auxins are inhibits flowering but spray of NAA (Nepthalene acetic acid) cause flowering in pineapple.

10) Parthenocarpy:

Parthenocarpy means development of fruits without pollination and fertilization. If flower buds emasculated and auxins paste is applied to the stigma of the flower a seedless fruit develops.

11) Weed Control:

Weeds are unwanted plants growing in field crops. This weed causes competition for water, nutrient, minerals, light and space etc and do not allow proper growth of the plants. Hence, these unwanted plants should be removed by mechanically and by other methods. One of this method is by using auxins like 2, 4-D.

Gibberellins:

Gibberellins were discovered in Japan by kurosawa in 1928 in rice plants infected by a fungus *gibberella fujikuroi*, which cause the "bacane" disease which is also known as foolish seedling disease in plants. Since then number of gibberellins have been isolated from both fungus and plants. Yabuta and Sumiki in 1938 isolated and extracted the disease causing substance in crystalline from and named it as gibberellin. Chemically gibberllins is gibberellic acid. More than 100 types of gibberellins were discovered so far. These are named as GA1, GA2, and GA3 and so on. In plants, gibberellins are synthesized from acetate units of acetyl coenzyme-A. The sites of their synthesis occurs in actively growing organ of plants like, apical buds, tips of growing roots and young leaves. It also enlarges berry & bunch size of grape and remain green for longer period. They have played important role in plants viz.

1) Promote growth and Increase cell elongations :

Especially those plants which are genetically dwarf types, which are converted to a phenotypically tall plant. Gibberellins induce of cells in stem. They are used to increase the length of jute fibers to increase their economic value.

2) Promote seed germination and breaking of dormancy.

In seeds gibberellins treatment induces the synthesis of amylase enzyme. Amylase convert insoluble starch into soluble sugar, the latter is made available to embryo as food during seed germination. Therefore, gibberellins are used to promote seed germination in monocotyledons.

3) Induce maleness:

Gibberellins are usually found to cause maleness in plants.

4) Promote seedlessness. Ex. GA-3, GA-7

External applications of gibberellins induce development of seedless or parthenocarpic fruits. Practically, gibberellins have been found to be more effective effective than auxins in

causing parthenocarpic development of fruits in plants like tomatoes, apples and pears. It has improved fruits-set in tomatoes. Such as it induce parthenocarpy in pome and stone fruits.

5) Increase pollinations

6) Promote bolting and flowering :

7) Replace chilling requirement of plants and light requirement

Cytokinins:

While working on tissue culture in tobacco Skoog and Miller (1954) discovered substances which stimulate cell division. They have also isolated a compound from the autoclaved herring (a silver fish) sperm DNA and it was named as "Kinetin" which also causes effect. Later Letham (1963) proposed the term cytokinin for kinetin and analogous substances. Cytokinins are purine derivatives especially of adenine. They are naturally synthesized by the young plant organs like root tips and some part of the seeds, fruits, leaves, etc. were active cell division occurs. As compared to auxins and gibberellins, it is less mobile in plant body.

Actions:

1) Cell divisions: Cytokinin plays important role in cell division. This has been established in plants parts like roots, anthers and in callus tissue.

2) Cell enlargement: In several cases it has been observed that cytokinins induce cell enlargement which causes leaf enlargement

3) Breaking dormancy: Cytokinins can break dormancy of many seeds and also promote their germination.

4) Promote hermaphrodite flower in Grape.

5) Delay of senescence: Senescence is a degradation of an organ. In senescent leaves disintegration of chlorophyll takes place. Leaves turn yellow, proteins are degraded and ultimately leaves are shed from the plant.

6) Used in propagation by tissue culture method, Ex. Kinin, Kinetin, BA (Benzyl adenine)

Ethylene:

This is the only gaseous hormone which is produced naturally by plants and also called as fruit ripening hormone. It is colourless, unsaturated hydrocarbon gas, which is lipid- soluble and lighter than air. It is almost formed all parts of seeds plants but the shoots apex of seedling and

ripening fruits are the major site of ethylene formation. Application of auxin promotes ethylene production. Therefore it is called secondary hormones.

A Synthetic chemical known Ethrel (Ethephon-2)

Actions:

1) Apical dominance arrested

2) Stimulation of lateral growth

3) Induction of flowering

4) Helps in fruit ripening

5) Promote rooting

6) Helps chlorophyll Formation

7) Promote seed germination

8) Increase female flowers.

9) Break dormancy

Growth Retardants:

These chemicals inhibit the integration of gibberellins and slow-cell division and cell elongation Ex. 1) Cycocel [CCC] 2) Alar [B9] 3) Phosphoric D 4) Chloromquata [2, 4 dichlorobenzyl] (Cycocel) is used for arresting growth and inducing fruit fullness.

Actions:

1) Retards stem elongation

2) Prevents cell division

3) Accelerate flower initiation

4) Inhibits root development.

Growth Inhibitors:

Inhibitors like, Abscisic acid, Boric acid, cinnomic acid and maleic hydroxide are present in plant System they arrest metabolic activity and suppress the growth of plants. Ex. MH- Maleic hydrazide

TIBA – Tri – iodobenzoic acid

Actions:

1) Accelerate the loss of chlorophyll

2) Inhibits germination

3) Induces flowering

4) Increases yield of tubers

5) Induces male sterility

Use of Growth regulators in horticultural crops

1) Propagation:

They are applied in the form of paste and solutions. The concentrations of the chemicals vary with plant species and type of cuttings and method of application. IAA, IBA & NAA are used for rooting in stem cutting. Below are the methods which are used while application of these hormones.

a) Soak method:

10-100 ppm for 12-24 hrs called soak method.

b) Quick dip method:

1000 to 5000 ppm for 5 seconds. Some growth regulators are used in layering, grafting and budding for getting high success.

2) Seed germination:

GA Significantly accelerates seed germination of many plant species. Pre-Soaking the okra seeds in GA such increases germination.

3) Induction of Flowering:

Application of NAA at 10 to 50 PPM causes early flowering in pineapple as well as 2, 4-D 6 to 10 PPM induces flowering in pineapple.

4) Sex expression:

Plant growth regulators can change the sex of flowers. Application of NAA, IAA & GA at 50-100 PPM increases female flowers in cucurbitaceous crops like cucumber, pumpkin, Bottle gourd, etc.

5) Flower and fruit thinning:

Many fruit trees produces heavy flowering and fruiting by using NAA at 5 to 10 PPM and NAA at 5 to 7 PPM thinning of apples, Peaches, and Grape is done successfully.

6) Preharvest drop of fruit:

Flower and fruit drop is a problem in many fruit crops. Ex. Application of NAA 10 to 50 PPM in Mango, citrus, reduces fruit drop by preventing formation of abscission layer.

7) Fruit development:

Application of 50-100 PPM GA in grapes increases the berry size.

8) Early maturity:

Early harvest fetches higher prices in the market in the Pineapple application of 20 PPM NAA induces early flowering and early maturely at least by two months.

9) Early ripening and color development:

Fruit like mango, Papaya, Banana, custard apple ripens after harvest. They are climatic fruits dipping of fruit in 20-50 PPM in enthrall solution induces golden yellow color to fruit & induces early maturity.

10) Delayed maturity:

Delay ripening is required when fruit are sent to long distances markets. Dipping of fruit in 2, 4 -D, 2, 4, 5- T or MH-40 extends storage life of fruit.

11) Sprouting of bud:

Ethylene, GA, Thiourea, IBA and Cytokinin spray induces sprouting of buds.

12) Breaking of dormancy:

GA, ethylene, NAA are used in breaking dormancy in seeds & bulbs. Ex. - Application of 0.1% Thiourea breaks the dormancy of potato.

Preparation of hormone solution & tips of use:

To make 1 PPM solution add 1 mg Con. Hormone + 1 liter water, some hormones are dissolved in water, while others are soluble in alcohol or acetone. Use separate pump for spraying hormone. Pump should be free from residue of weedicide. Use glass or plastic when sills. Don't store the solution spray it immediately. Hormones are often used in the morning or evening times for better result. Use sticker in the solution. Use given concentration of hormones apart from this is causes harmful effect.

Important hormones their names dissolution medium

Sr.No.	Name of hormones	Short Name	Dissolution medium
1	Indole Acetic acid	IAA	Alcohol, acetone
2	Indole Butyric acid	IBA	Alcohol, acetone
3	Gibberalic Acid	GA_3	Alcohol, acetone
4	Chloromquat	Linosin	Water
5	Benzoadenite	BA	Isopropide, Alcohol
6	Maleic hydrazide	MH-40	Alcohol, acetone
7	Tri ido benzoic acid	TIBA	Alcohol, acetone
8	Ethrel	Ethrel	Water
9	4 CPA	CPA	Alcohol, acetone
10	Abscisic acid	ABA	Alcohol, acetone

Chapter – 11

Irrigation Methods in Fruit Crops

Water is a plant constituent it is also a solvent. As a solvent, it is a carrier of plant nutrients from soils. It keeps plant cells turgid and regulates their temperature. Water is needed for manufacture of carbohydrates particularly in the process of photosynthesis. It influences vegetative growth, fruit development and its quality. It regulates blossoming, fruit set, size and yield of fruits. Water supply to fruit trees is made by adopting following methods of irrigation.

I) Surface irrigations:

1) Uncontrolled or wild flooding system:

When the land is flat, level the entire area is flooded by letting in water. This system is commonly practiced in canal or tank fed area in wet land. This is a wasteful method as the water is supplied in excessive quantity. The entire area is allowed to saturate with water and interval between two irrigations is kept fairly long. It also causes stagnations in shallow and drained soils. There is more weed growth. It is followed to protect banana orchard when there is cold wave.

2) Controlled flooding:

The entire area in between the two rows of grape vines is irrigated by letting in water. The flooding may be controlled by making ridge and subsidiary channels after every six or eight vines, thus dividing the vine yard into many compartments.

3) Basin system:

Basin is a bed bunded around with a tree at the centre. The size of basin is determined by the spread of tree roots. This method is useful in fruit crops which require seasonal watering as in guava, pomegranate and fig etc and in case of younger fruit crops which require frequent irrigations. It is appropriate for light soils. The diameter of the basin varies from 1 to 2½ meter depending upon the canopy of the tree.

4) Bed system:

This is a flat rectangular or square bed of the size of 1½ m x 2 m, depending on the planting spacement with the embankment of about 30 cm height. It is generally practiced in heavy soil and in fruit crops like banana. The position of fruit crops like banana. The position of fruit tree is kept either at the centre or at the centre of the beds.

5) Ring system:

This is modification over basin system. In this system there is an additional round ridge of 1.25 m diameter around the trunk of a tree. The ring is meant to avoid excessive irrigation and watering to the trunk. The size of the bed is as per spacing of fruit trees. In this system the water is not allowed to touch the bark of the tree trunk thereby reducing the chances of collar rot, roots rot and gummosis.

6) Furrow system:

This system is suitable where the water can move horizontally as in case of loose alluvial and sandy soil ad where the plantation is under the land with a moderate slope. Ridges and furrows are opened with a ridge between the rows of the fruit trees about 75 to 90 cm wide and 10 -15 cm deep. The water is let in the furrows. The length of the furrows is about 15 to 50 meters depending upon the slope of land.

II) Subsurface or Drip method:

Drip is an irrigation method in which water is near to the tree one there is no wastage by runoff, Seepage or evaporation. This method is suitable in areas where water is scarce or saline, topography is undulating and spacing of plant is wide. It is a costly method. Slightly saline water can also be used by this method.

III) Sprinkler irrigation:

The method of applying water to surface of the soil in the form of spray is known as sprinkling. Three general types of sprinklers are used i.e. fixed nozzles attached to pipes, perforated pipes and rotating sprinklers. For irrigation of fruit trees rotating sprinklers are preferred. The sprinklers are placed under or by the side of the tree and water are forced out through rotating nozzles. The nozzles are normally spaced 16 cm apart. Each rotary nozzle covers a circle of about 16 meters. The initial cost is very high but there is considerable saving of water and labor. The method is suitable on undulating lands as there is no run off and thus helps to prevent erosion. However his method increases humidity in orchard and trees are subjected to more damage by insects, pests and diseases. Saline water cannot be used by this method as it causes injuries to leaves.

Chapter – 12

Method of Fertilizer Application in Fruit Crops, Including Fertigation Technology

C, H, O is obtained by plants through atmosphere and water is obtained through organic residue in soil and from atmosphere through thundering. Symbiotic bacteria and free living bacteria also fix atmospheric nitrogen. Rests 12 nutrients are received from soil mineral, and they should be supplemented through fertilization.

Following methods of application of manures and fertilizers are adopted.

I) Application by incorporation in soil:

1) Application in pit or trenches before planting:

In order to have proper drainage in the fruit orchard pits of size 90 cm x 90 cm are dug as per spacement of plants. In case of grapes trenches of 50 meters, length 90 cm deep and 90 cm width are prepared 3 meters apart at the direction from north to south. In these pits or trenches first 15 cm bottom layer is filled in with dry leaves of sugarcane and trash. On this, 5 cm layer of top soil is put. Then a dose of phosphatic fertilizer is applied as basal dose. This basal dose varies with the crop and variety to be planted. Then again 15cm layer of soil is added. The remaining portion of the pits or trenches is filled up with top soil and well decomposed FYM in proportion of 1:1 or 2:1.

2) Application to young nonbearing plants:

The nitrogen carrying manures and fertilizer FYM, groundnut or castor cake, ammonium sulphate, Urea etc are applied in split doses during the vegetative growth period i.e. during June – July, October – November and January – February. They are applied in the active root area and mixed with the soil. Phosphatic fertilizer should be applied once in a year in one dose and deeper in the soil in active root zone. As the plants grow in age, the quantity of manure and fertilizer should be also increased. The need of dose per tree varies with the variety and age.

3) Application to adult tree:

When the whole land is occupied by the roots, F.Y.M. and compost should be applied by broadcasting and mixed by harrowing thoroughly with the soil. Phosphatic fertilizers should be applied 10 -15cm deep in the soil.

II) Application of green manures:

This method in nonbearing orchard to add organic matter to the soil and also to improve soil texture. It also adds nitrogen to the soil. The common green manuring crops like Dhainca, Sanhemp, Guar etc are properly grown in between the rows of the plants and should be incorporated in the soil just prior to the flowering stage of the green manuring crop. Cut the

green matter place it in a ridge repeat this process to complete the area. Adequate soil moisture or subsequent rains are essential for proper decomposition of green matter in the soil.

III) Application through Foliar spray:

This is supplementary to ground application and cannot substute soil fertilization. This refers to spraying on leaves of growing plants with suitable nutritional solution. The solution is prepared in low concentration to administer any plant nutrient or combination of nutrients. Higher concentration causes scorching of leaves. This method makes the nutrient available immediately to the metabolic stream of the plant as they are quickly absorbed by the foliage. To control nitrogen deficiency 1-2% urea is sprayed. The micronutrient sprays may also be applied. The best time for foliar spray application is when the fruit trees are putting forth the spring flush of growth and when new leaves are ½ to 2/3 expanded. If the deficiencies of these micro-nutrients persist repeated application should be given till symptoms of these deficiencies disappear.

Fertigation

Application of fertilizers to the crops through irrigation water with the help of drip irrigation is called fertigation.

It is most economical, beneficial and saves the wastage of fertilizers and labor cost. It is mostly used in horticultural crops that are irrigated with the help of drip irrigation system and planted at wider spacing.