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|---|---|
| **Course Code** | **HRT121** |
| **Course Title** | **Fundamentals of Horticulture** |
| **Credit Hours** | **3 (2+1)** |
| **Full Marks** | **75** |
| **Theory (Marks)** | **50** |
| **Practical (Marks)** | **25** |

**Objective(s) of the Course**

The students will be acquainted with the basic concept, principles and practices related to horticultural crop production.

| **Course Breakdown (Theory)** | | |
|---|---|---|
| **SN** | **Course Outline** | **Lectures** |
| 1 | Meaning of horticulture, its branches and its relation with other disciplines | 1 |
| 2 | Importance, scope and present status of horticulture in Nepal along with major constraints in its development | 1 |
| 3 | Classification of horticultural crops | 1 |
| 4 | Horticultural zoning of Nepal and its economic significance | 1 |
| **5** | **Environmental factors affecting horticultural crop production** | |
| 5.1 | Effect of temperature, light, humidity, rainfall, wind and their stress on production | 1 |
| 5.2 | Measures to overcome environmental stress | 1 |
| 6 | General introduction to types of horticultural enterprises (Orcharding, nursery raising, ornamental gardening, landscape, vegetable farming, seed production and postharvest handling & preservation) | 1 |
| 7 | **Orchard establishment and management:** | |
| 7.1 | Site selection and layout of orchard | 1 |
| 7.2 | Planting, soil and water management practices, wind break and shelter belts | 1 |
| 7.3 | Fertility and weed management | 1 |
| 8 | **Basics of plant propagation** | |
| 8.1 | Introduction of plant propagation, sexual method | 1 |
| 8.2 | Asexual method | 1 |
| 8.3 | Cutting and layering | 1 |
| 8.4 | Budding and grafting | 1 |
| 8.5 | Apomixis, specialized vegetative parts, micro and mist propagation | 1 |
| 9 | **Growth and development:** | |
| 9.1 | Concept of growth and development, dormancy ( seed and bud) | 1 |
| 9.2 | Germination, juvenility and maturity | 1 |
| 9.3 | Flowering, fruit set, fruit growth and development | 1 |
| 9.4 | Fruit maturity and ripening, unfruitfulness, fruit drop | 1 |
| 9.5 | Tuber, rhizome and bulb development; Senescence | 1 |
| 10 | **Plant growth regulators** | |
| 10.1 | Types of plant growth substances (auxin, gibberellins, cytokinins, ethylene and inhibitors) and their major functions | 1 |
| 10.2 | Commercial uses of PGRs in Horticulture | 1 |

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| 11 | **Training and pruning:** | |
| 11.1 | Basic principles and objectives of training and pruning | 1 |
| 11.2 | Various system/methods of training and pruning | 1 |
| 12 | Basic principles of off season and protected horticulture and their prospects ub Nepal | 1 |
| 13 | Importance and prospects of organic horticultural crop production in Nepal | 1 |
| 14 | Concept of high density planting, multi-tier cropping, multiple cropping and agro forestry | 1 |
| 15 | Importance and prospects of indigenous horticultural plants in Nepal | 1 |
| 16 | Principles of urban and periurban horticulture; vermiculture, hydroponics and aeroponics and river bed farming. | 1 |
| | **Total** | **30** |

| **Course Breakdown (Practical)** | | |
|---|---|---|
| **SN** | **Course Outline** | **Lectures** |
| 1 | Mapping of Nepal in terms of agro-climatic zones and potential regions for growing major horticultural crops | 1 |
| 2 | Identification of fruit, vegetable, plantation, medicinal, spices and ornamental plants | 1 |
| 3 | Identification of horticultural tools and equipments; manures and fertilizers; hormones and micronutrients | 1 |
| 4 | Orchard layout for different system of fruit planting | 1 |
| 5 | Preparation of pit for planting fruit saplings | 1 |
| 6 | Preparation of nursery bed for sowing of vegetable seed | 1 |
| 7 | Propagation practice in horticultural plants:<br>7.1. Cutting<br>7.2. Layering<br>7.3. Grafting<br>7.4. Budding | 4 |
| 8 | Training practice in horticultural plants | 1 |
| 9 | Pruning practice in different horticultural plants | 1 |
| 10 | Preparation and application of Bordeaux formulation | 1 |
| 11 | Preparation of hot bed for germination of vegetable seed in winter | 1 |
| 12 | Preparation of different concentrations of PGR for horticultural uses | 1 |
| 13 | **Total** | **15** |

## Lecture No: 1

## Meaning of horticulture, its branches and its relation with other disciplines

### Meaning of Horticulture:

The term "Horticulture" is derived from two Latin words i.e. "Hortus" meaning garden or enclosure and "Cultra" meaning cultivation. So, horticulture literally means garden culture or culture of garden crops.

Horticulture is the science and art involved in the cultivation, propagation, processing and marketing of ornamental plants, flowers, turf, vegetables, fruits, and nuts. It is unique among plant sciences because it not only involves science and technology, but it also incorporates art and principles of design.

### Branches of horticulture:

1. **Pomology:**
   It is derived from two words i.e. **"Pomum"** meaning fruit and **"Logos"** meaning discourse or study. So, pomology is study or cultivation of fruit crops. E.g. Mango, Guava, Grape, Banana etc.
   **Fruit:** It is a developed and matured ovary with or without accessory parts and which is generally eaten as raw.
2. **Olericulture:**
   It is derived from two words i.e**."Oleris"** meaning **Potherb** and **"Cultra"** meaning cultivation. So, Olericulture literally means potherb cultivation. In the present days it is broadly used to indicate the cultivation of vegetables.Eg. Brinjal, Okra, Tomato, Pumpkin etc.
   **Vegetable:** It is any part of the herbaceous plant that is generally used after cooking as a principal part of the meal.(Any of the regular occasions in a day when a reasonably large amount of food is eaten)

3. **Floriculture:**
   It is derived from two words i.e. **"Florus"** meaning flower and **"Cultra"** meaning cultivation. So floriculture means study of flower crops.

4. **Ornamental horticulture:**
   This branch deals with plants, trees or both that is commercially important for landscaping and avenue plantation. Turf or lawn grasses are also came under this branch. Sometimes it is also called as landscape management.

5. **Plantation and spices crops:**
   This branch deals with high value crops in horticulture. Tea, coffee, cardamom, ginger etc. come under this group.

6. **Postharvest preservation:**
   It deals with the practice and methods used in prolonging shelf life of flowers, fruits, vegetables, spices and plantation crops.

Apart from above branches, there are other sub-branches too. Some of the important fields are off-season production, high density planting system, multi-storied farming, protective cultivation, plant biotechnology etc.

**Relation of horticulture with other disciplines**

Horticultural science is not developed independently. The advances made in other sciences have greatly helped in appreciating the contribution of horticulture in meeting the daily dietary requirements in the world. Therefore, horticulture has an intimate relationship with many sciences; some of these are outlined briefly.

1. **Soil Science:**
   Soils are medium for plant growth and provide adequate air, minerals and water. In poor and infertile soils, horticultural crops cannot be successfully grown. The knowledge on soil meniral composition, soil texture, water holding capacity, nutrient movement and absorption capacity, soil pH and nutrient fixation are necessary before horticultural crops are planted.
2. **Agronomy:**
   Many cultural and management practices, such as plowing, weeding, fertilizer application, water management, etc. are done both in agronomy and horticultural. In addition, crops potatoes, beans, peas, etc. are dealt in both these sciences. Post-harvest technology of these crops in agronomy and horticulture are almost similar.
3. **Plant protection:**
   Numerous diseases and insect pests attack horticultural crops. If plant protection is not followed in time, a total failure of these crops could occur. For example, *Fusarium wilt* disease devastated the guava tree in chitwan, Nepal.
4. **Genetics and plant breeding:**
   The principles of genetics and plant breeding are used so commonly and frequently in horticulture that horticulturists have kneely studied these sciences. The selection, hybridization, and mutation have been useful tools in developing a variety/cultivar of desired quality.
5. **Botany:**
   Fruits, vegetables, and other horticultural crops are intimately associated with Botany. Studies related to morphology, physiology, systematic of these plants are based on botany and its application.
6. **Biochemistry and plant physiology:**
   The flower bud differentiation and fruit set are internally controlled biochemical and physiological processes. The changes in hormonal levels within the plant system lead a tissue to go in dormant condition or growth. Therefore, horticultural science is related to these sciences to understand different processes that undergo within a plant in natural environments.
7. **Statistics and computer sciences:**
   statistics has become an important tool in studying natural phenomena in fruits, vegetables and other crops. Many statistical methods and experimental designs are available and they can be used effectively and efficiently in evaluating the plant performance. In horticulture, we conduct a lot of experiments and generate hundreds and thousands of data. Computers help to processing these data and develop programs suitable for modelling plant system.
8. **Biotechnology:**

This is recently developed field of high tech in agricultural science, including horticulture. Manipulating genetic composition to suit specific requirements has developed many varieties and cultivars. Rapid multiplication of strains such virus free plants, disease and pest resistant crops have been possible by tissue culture merhods. Thus advances in horticultural crops are largely dependent on principles and methods used in biotechnology.

9. **Extension and Rural Sociology:**
   Horticultural science is also tried up with the principles and methodology followed in extension and rural sociology. The techniques developed, the varieties involved, the practices adopted in horticultural crop production must be tied without reach programs so that upon exclusion and expansion of these methods and new ideas could help meet local needs in rural societies.

## Lecture No: 2

## Importance, Scope, constraints and present status of horticulture

**Importance of Horticulture in Nepal:**

Horticultural crops have many fold increase in human life. They provide food, vegetables, nutrition, medicines, and industrial products and beautify the surroundings and finally conserve the environment. This branch of science has been associated to human beings from the start of human civilization. Some of the importance of horticulture could be outlined as below;

**Economic importance:**

Horticultural crops are considered as high value commodities which have the capacity to give more production than that of cereals. Also offseason and protective farming give more economic return than that of normal farming system. This enterprise also has the capacity to generate large number of employment hence capable of reducing poverty if planned and implemented properly.

Most of the vegetables are short duration crops and 3-4 crops can be harvested in a year from the same piece of land. Vegetable production is high yielder and good price compared to cereals.

As compared to the field crops per hectare yield of horticulture crops is very high. From an fruit area of land more yield is obtained e.g. paddy gives a maximum yield of only 30 q/ha, while Banana gives 300 to 500 q/ha, Pine apple 450 q/ha and Grapes 90 - 150 q/ha. In present shortage of food and scarcity of land by growing fruits more food can be produced.

**Nutritional importance:**

Fruits and vegetables are rich in proteins, vitamins, minerals and fats. Consumption of fruits and vegetables regularly is good for human health. “One apple a day keep doctor away” just signifies the nutritional importance of horticultural commodities. Cereal grains cannot supply enough protein, vitamins and minerals. Vegetables are considered as cheaper source of vitamins and minerals. Almost all vegetables contain vitamins and minerals. They are also rich in carbohydrate. Human body needs 6 different vitamins A,B,C,D,E and K. vitamin A,B and C are available in high amounts in vegetables.

| | |
|---|---|
| CHO- Leafy veg. 8.7 gm | Protein- Fruit veg. 2 g |
| Fruit veg. 5.3 | Root veg. 1.35 |
| Root veg. 6.0 | Leafy veg. 2.2 |

**Cultural and religious importance:**

Fruits, vegetables and flowers have very long association with human values as well as their cultural and social ceremonies. In eastern terai, the marriage ceremony is not completed without taking a round of mango tree. Marrying a Newari girl to the bel fruit is culturally mandatory in Newar society. In some other societies, arecanuts are sent to invite people to important ceremonies. The chestnut(okhara), sweet orange, sour orange, , mandarins, walnut(daateokhar), banana are used to worship goddessLaxshmi during Tihar. Many kinds of fresh and dry fruits have been a ceremonial need for "BhaiTika". Similarly, different kinds of vegetables, flowers, and ornamental plants possesses many cultural and religious significance in our society.

**Medicinal importance:**

"Two cloves of garlic a day keeps doctor away" is a famous saying about the medicinal importance of the horticultural commodities. In *Ayurveda,* many horticultural plants have been listed with medicinal propertieswith their use value. Some of the examples are: avocado fruit suggested for diabetic patient, amala fruit is considered as diuretic and antibiotic. About 40 % of total drugs has been derived from plant materials. Among vegetables these crops occupy a significant place. Eg. The use of white cabbage can prevent ulcer. A dose of 360 gm powder made from white cabbage just prevent ulcer.

**Industrial importance:**

Many horticultural crops have tremendous industrial importance. Potato is widely used for potato chips, apples sold in canned from in America. Pickling of mango , garlic, ginger etc. are also common in Nepal. Similarly, there are a large number of horticultural commodities which are being used as raw materials for many big industries. In developed countries vegetables, fruit and flower nurseries are considered as industrial enterprises. These enterprises are capable of generating a large number of employments too.

**Aesthetic importance:**

To beautifying surrounding environment, flowers, ornamental plants, and fruit trees are commonly used. They are planted along the roadsides, near building, and in parks and other recreational areas. Ornamental trees such as goldmohar, ashoka, silver oak, etc. are considered good avenue trees.Bougainvillea are trained to climb up the buildings and beautifying office and residential buildings.

**Scope of horticulture in Nepal**

The term "importance" means values and usability, while scope indicates one or more conditions suitable for production. Some aspects that are partient to the scope horticultural crop production are mentioned as under.

**Climates:**

A variety of climates permit us to grow different horticultural crops.Based on the climate, 4 different zones in Nepal. These are tropical zone (75-750m high), sub-tropical zone (750-1500m high), warm temperate (1500-2000m high) and cool temperate (2000-

3000m high) These climates provide opportunities for growing plants that have different climatic requirements. Climatic variability is born to Nepal and this can be exploited to produce different kinds of vegetable seeds.

**Topography:**

Nepal is a mountainous country where lands are undulated and have a north or south facing slopes to different degrees. The slope that faces northeast can have crops growing successfully than in those facing south or southeast. For example, the slope facing north or northest of Tanahu district, near Sundarbazar area has successful citrus cultivation. The area facing south at the same elevation is devoid of citrus tree. The topography also determines the nature of soil types. Good and fertile soils very from loose shallow to deep and heavy clays. Successful cultivation of horticultural crops require specific conditions in terms of soil, climate, topography etc. for this, opportunities are available in Nepal.

**Demand and supply:**

The consumption of fruit and vegetable is good for human health. These produce, either in fresh in processed form, have high demands. The net per capita consumption of fruit and vegetable has increase as people demand for more and better food in hygienic conditions. According to the demands for preferential horticultural crops, supplies are less than limited. Therefore, there is a large scope for production of these crops.

**Proper use of land:**

The lands include both cultivated and forest areas. Nepal is basically a hilly country where more than 60 % of land is hilly and mountains. The hilly and forest regions in Nepal may have greater impact of horticultural tree species. There are several reasons for this viz.

1. These species provide fruits and timber.
2. They provide fodder and fuel wood,
3. They reduce soil erosion,
4. They provide job and opportunities to people,
5. They help to improve economic conditions of rural poor.

The land near buildings, roads etc. are mostly unused and can be covered easily with horticultural fruit trees of different kinks. Cereals and vegetable crops are intercropped in orchards for higher land use efficiency.

**Irrigation facilities:**

As for production of cereals and other agronomic crops, horticultural crops also require a regular supply of water. In most places, these cropsare raised as rainfed crops the well-established horticultural tree species can tolerate some effect of summer drought (although the plant performance is poor and yield is drastically reduced), but the vegetables and annual flowers cannot withstand water stress in summers. To meet the water requirements of different crops,a number of irrigation projects have been undertaken. Minor irrigation projects, Kankai and Koshi projects, horticultural provocation will further be enhanced.

**Marketing facilities:**

Compared toagronomic crop most horticultural commodities is perishable. These must be disposed quickly to get good price. In Nepal, cold storage facilities are almost non-existent and proper channel in price fixing and marketing system are yet to be developed.

Infrastructures are being developed to facilitate transportation and communication that will aid in handling, transport and marketing of fruits, vegetables and flowers. Since highways and new roads are under construction in different parts of the country, the produce of one locality can be mobilized and made available to other locality upon completion of these roads.

**Distribution of plant materials:**

The seed, seedlings and saplings are means of horticultural plant multiplication. The government farms and research stations semi-government agencies and may other projects aided by foreign governments are keenly interested in the distribution of planting materials. In fact, they have distributed good fruit varieties and pure seeds and seedlings free of cost or at subsidized rates. These distributions create interest in people who favour production of high value crops mainly fruits and vegetables. These institutions also provide some technical information and as a result, opportunities in horticultural profession will increase, be increased.

**Present status of horticulture in Nepal:**

**Vegetables: (area 41%, prodn. 63 %)**

During the last 10 years, area of vegetable crops has increased by about 41%, whereas the production has increased by about 63%. Now area and production of vegetable is 2, 86, 864 ha and 39, 58, 230 mt. respectively.

**Fruits: (area 64%, prodn. 85%)**

During the last 10 years, area of fruits has increased by about 64%, whereas the production has increased by about 85% . Now area and production of fruits is 1, 30, 449 ha and 10, 58, 519 mt respectively.

**Spices: (area 64%, prodn. 78 %)**

During last decades, area of spice crops has increased by about 64% whereas the production has increased by about 78%. Now area and production of spices is 58, 960 ha and 4, 04, 402 mt respectively.

**Flowers: (area 34 %, prodn. 47 %)**

During the last five years, area of flower has increased by about 34% whereas the production has increased by about 47% from. Now area and production of Flowers is 147 ha and 1, 34, 138 mt respectively.

**Major constraints of horticultural development in Nepal:**

Topographical variations, unbalanced and unplanned regional development effects, very low infrastructure development regarding the horticulture and very less allocation of national budget in this sector are some of the pronounced constraints of horticultural development in Nepal. The master plan for horticultural development (1990) has outlined following factors as major constraints for horticulture development in Nepal.

1. **Infrastructure constraints:**

   Several infrastructures constraints are involved in the retardation of horticultural development of the country. These involves, less transportation facilities in the remote areas, inadequate and unreliable supply of production inputs, lack of credit facility, less

developed marketing networks and infrastructures and virtually no storage and processing facilities.

**2. Physical and environmental constraints:**

The main environmental and physical constraints related to horticultural development are, a difficult terrain in hills and mountains where best suitable climate for major horticultural commodities exist, adverse climatic factors like monsoon rains, dry spring and summer, hailstorms, uneven distribution of rains, spring frost etc.

**3. Husbandry and agronomic constraints:**

Low fertility status of the soil, less availability of superior planting materials, no management efforts or alternatives to manage the insects and pests and less knowledge on management of horticultural commodities are some of the major husbandry and agronomic constraints.

**4. Technical backup/support constraints:**

Very low priority in fruits and vegetable research, low national resources allocation, less priority in human resources development, weak extension system, no reliable statistics on horticulture are some of the major technical support constraints faced by horticulture development.

**5. Socio economic constraints:**

Cereals and livestock are major agricultural components in our traditional subsistence farming system. However, some indigenous vegetables and fruits were there but not in a large production level. These have been neglected crops as compared to cereals and livestock in past. These factors contributed in to the less knowledge on the existing horticultural crops which brought in to the low consumption of these commodities. The fragmented and small land holding also forced farmers towards growing cereals for their food security than the cultivation of fruits and vegetables.

## Lecture No: 3
## Classification of horticultural crops

The horticultural system of plant classification is based mainly on the ultimate use of the plant. The plants are conveniently separated into those that are edible, usually fruits and vegetables, source of drugs, spices or beverages and of ornamental value. The horticultural plant classification makes it easy to understand the nature, culture, uses and growth habit of the plants. The Major groups accommodating almost all the horticultural plants are as discussed below.

1. **Edible plants**: these plants include fruit and vegetables.

**A. vegetables**

These are edible succulent plants or parts of a plant, which are usually cooked and eaten with staple food. The common classification system of vegetables is the classification based on the plant part used. This classification is similar to the cultural classification.

**a. Plant grown for aerial portion (**the aerial portion of a plant body, consisting of stems, leaves. and flowers-We cannot say that a particular plant part is always aerial because it varies from plant to plant. Green leaves are always aerial because light is necessary for formation of chlorophyll.)

i) **Cole crops**:(There are the crop which belongs to the genus Brassica of the cruciferaceae family.)crops belonging to the family Cruciferae. Examples: cabbage, cauliflower, broccoli, brussels's sprout, knolkhol (Gathgovi), etc.

ii) **Legumes or pulses**: crops belonging to the family leguminosae. Examples: pea, bean, soybean, etc.

iii) **Greens or potherbs**: crops grown mainly for their leaves. Examples: mustard, spinach, cress, etc.

iv) **Solanaceous fruit crops:** crops belonging to the family solanaceae whose economically useful parts are the fruits. Examples: egg- plant, tomato, bell pepperetc.

v) **Cucurbits or vine crops:** crops belonging to the family cucurbitaceae. Examples: cucumber, squash, melons and gourds.

**Vine** (A climbing or trailing woody-stemmed plant related to the grapevine).

vi) **Salad crops:** crops grown for salad purpose. Examples: lettuce, celery (Ajawain), etc.

vii) **Miscellaneous:** perennial vegetables like drumstick (Sajiwan), asparagus and vegetables like okra, sweet corn, etc. come under this group.

**b. crops grown for underground portion**

i) **Roots:** crops with swollen underground roots. Examples: carrot, radish, turnip (Salgum), sweet stems potato (Sakarkhanda.), etc.

ii) **Tubers:** crops grown for underground swollen stems. Examples: potato.

iii) **Bulbs and corms:** crops grown for underground bulbs and corms. The bulbs are made up of short stem with thick fleshy scaly leaves. Corms are compressed with reduced scaly leaves. Examples: onion, garlic, Colocasia, etc.

**Corms (**Resemble bulbs but composed entirely of stem tissue surrounded by a few paperly scale like leaves, food storage organs with adventitious roots at the base of corms)

**B. Fruits**

Fruits are the plants from which more or less succulent fruits or closely related structure is eaten as a desert or snack. Fruits plants are often perennial and usually woody.

**a. Temperate fruits**

i) **Tree fruits**: the fruits born on perennial tree.

**Pomes:** fleshy fruits in which the inner portion of the pericarp forms dry paper like core. Examples: apple, pear (Naspati), quince (Nepali apple), etc.

(Apple is a common, round fruit produced by the tree *malus domestica* , cultivated in temperate climates while quince is the pear-shaped fruit of a small tree of the Rosaceae family, *cydonia oblonga*)

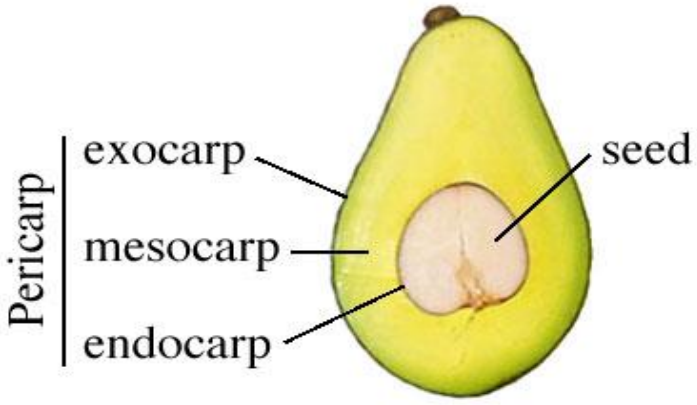
**Drupe/stones**: simple fleshy fruits having a stony endocarp. Examples: peach, plum (Arubakhada), apricot (Khurpani), mango, nectarine (Aru), etc.

(The main physical difference is that peaches have a fuzzy coating, whereas nectarines are smooth and do not have this coating. They are almost identical genetically, but there is a gene variant between the two.)

**Nuts:**(A nut is a fruit composed of an inedible hard shell)the fruits born on tree and are characterized by a hard shell that encloses the inner kernel (a softer, usually edible part of a nut, seed, or fruit stone contained within its shell.), which is the edible part of a fruit is called as nut. Examples: walnut

(Daateokhar), peanut (groundnut-Badam ),cashewnut (Kaju), macadamianut(Akharot)- (also known as the queen of nuts, are composed of approximately 76% fat ), hazelnut (Katus), almond (Madhesibadam),pistachionut (Pista nut), etc.

ii) **Small fruits:** fruits born on small or low growing plants, such as vines, shrubs, herbs, etc. Examples: grapes, strawberry (vuiaisalu), raspberry (Aisalu), etc.




**b. Tropical and sub- tropical fruits**

i) **Herbaceous perennials:** fruits born on perennial herbaceous plants of tropical and subtropical region. Examples: banana, pineapple, papaya, etc.

ii) **Tree fruits:** citrus fruits and all other tropical and sub-tropical tree fruits. Examples: orange, mango, litchi, guava, etc.

iii) **Nuts:** all the tropical and subtropical nuts. Examples: cashewnut, macademianut, etc.

**2. Non-edible plants:**

These plants are not eaten but grown for aesthetic uses.

**a. Flowers and foliage plants**

The plants grown for their blossom (Blossom is the flowers that appear on a tree before the fruit)crops or attractive are often classified according to their life span:

**Annuals :** petunia, zinnia, coleus, etc.

**Biennials :** hollyhock, sweet William, etc.

**Perennials:** roses, chrysanthemum (*Godavari)*, dahlia (Lahurephul), begonia (Magarkanche), etc.

**b. Nursery plants**

The nursery plants are usually primarily woody and perennials and most often raised for landscaping purposes. They are further classified according to their form of growth habit.

i) **Lawn or turf grass:** the herbaceous perennials are used for turfing purposes. Examples: Bermuda grass, blue grass, etc.

**Turf (**Upper stratum of soil bound by grass and a plant roots into a thick mat)

**Lawn** (A lawn is an area of land of closely mowed grasses that is primarily developed for aesthetic and recreational purposes)

ii) **Ground cover:** they are either herbaceous or woody plants used to cover the ground for landscaping purposes. Examples: sedum, periwinkle, etc.

iii) **Vines and lianas:** They are mostly of perennials. Examples: grapes, Rangoon creeper, pelican flower, etc.

iv) **Shrubs and tree:** almost all the shrubs and trees grown for landscaping fall under this category. Examples: shrubs, poinsettia (lalupate), crape myrtle (Asare), hibiscus (*jibrophul)*, etc.

**Shrubs** (Shrub is a woody plant with several stems/ branches arising at or near the ground level from the main stem, which is perennial in nature and smaller than a tree).

v) **Tees:** Rhododendron (Laligurans), gold mohar, pagoda tree, bottlebrush, etc.

**3. Miscellaneous plants:**

The plants having medicinal, spices and beverages properties fall under this category.

**a. Herbs, spices, condiments and drugs:** The plants, which provide special flavours, scents and colour of the food and the crops with curative (able to cure disease), laxative (a substance that makes it easier for the waste from someone's bowels to come out)and pesticide properties. Examples: vanilla, dill (Sauf), nutmeg, quinine, sparmint, black pepper, etc.

**Herbs (**Low growing plants eg-Mints, parsely)

**Spices (**an aromatic or pungent vegetable substance used to flavour food)

**Condiments (**a substance such as salt, mustard, or pickle that is used to add flavour to food)

**Drugs (**A medicine or other substance which has a physiological effect when introduced into the body).

**b. Beverage crops:** crops used for brewing drinks which are non- alcoholic.

Examples: coffee, tea, cocoa, etc.

**c. Oil yielding crops:** these crops are grown for oil content. Examples: sunflower, castor, etc.

**d. Plants yielding rubber,latex and gums:** the crops whose products of the sap and obtained by tapping from the bark. Examples: rubber, sweet gum, papaya, etc.

## Lecture No: 4

## Horticultural zoning of Nepal and its economic significance

**From the horticultural point of view Nepal can be divided into four zones:**

**1. Tropical zone**

- It has high and hot temperature throughout the year except some periods in winter.
- The annual average temperature exceeds $24^0$c
- There is no snowfall.
- The altitude range from 75 m msl to 750 msl.
- The whole terai and lower valleys in the hills fall in this zone.
- Tropical plants are those which do not tolerate severe cold but can tolerate warm temperatures. Those plants need strong sunshine, warms, humidity and a very mild winter. They cannot stand far against frost.
- Fruits that can be successfully grown are mango, Banana, Papaya, pineapple, litchi, Jackfruit, guava etc.

**2. Sub-tropical zone**

- This region is cooler than tropical area but it has distinct summer and mild frosty winter.
- The fruit crops grown under a climatic condition between temperate and the tropical are known as subtropical fruit crops.
- Summer is long and humid.
- Generally, altitude range is 750 m msl to 1500m msl. With an average annual temperature of 17-24 $^0$c.
- Lower Midhills and low-hills in this zone.
- They may be either deciduous or evergreen and are usually able to withstand a low temperature but not the frost.
- Sub - tropical plants like Orange, Litchi, Fig, Mango and cashewnunt are intermediate in character. They need warmth and humidity and can tolerate mild winters.
- Citrus fruit is predominant and other fruits grown are pomegranate, peach, plum, grape, citrus, jackfruit, etc.

**3. Mild temperate zone**

- In this zone the climate is moderate throughout the year and the winter is not very severe.
- Altitude ranges from 1500-2000 meters.
- During winter, the higher altitude may get snow.
- Mid-hills, base of the high hills and lower mahabharatlekh fall in this zone.
- The average annual temperature is 10-15$^0$c.
- Peach, plum, pear, Almond, Apricot, chestnut etc. can be grown successfully.

**4. Temperate zone**

- This zone has a pronounced winter with frost.
- Snow occurs every year.
- It is cold throughout the year with an average annual temperature being less than 10 $^0$c.
- The temperature in winter is below 0$^0$c.
- The altitude ranges from 2000 m msl to 3000 m msl.
- Mahabharatlekh and high hills fall in this zone.
- Apple, Pear, walnut and other stone fruits are grown here.

**Significance**

- The productivity of horticultural crops comparing with two giant neighboring countries i.e. China and India does not give matching results but in case of spices especially in large cardamom, Nepal's productivity is higher than these two countries. Large cardamom, ginger, tea and coffee have played significant role in trade balance while in case of fruits, flowers and some of the fresh vegetables Nepal faces still trade deficit.
- The unique agro-ecological zones favoured by altitudes, topography, and aspect within the country offer an immense opportunity for growing different types of fruits, vegetables, flowers, spices and other plantation crops.
- Actually, Nepal is the land of wonder with agro-climatic variability
- Altitudinal breaks have been defined that are significant to Agricultural and Forestry production. These breaks help identify and explain differences in crops, cropping patterns, planting dates, and need for supplemental irrigation.

- Differences in slope, aspect, air drainage, characteristics of soil surfaces and cloud cover can permit a crop to grow and produce significantly above and below the defined limits.
- Within, each zone finds predictable patterns of bedrock types, saprolite characteristics, soil depth and mineralogy. Consequently, zones reflect ranges of important soil properties. As examples tropical and sub- tropical soils are universally deep.
- The agricultural production pockets are delineated based on the present occurrence of cultivated land within that zone. Although, there is considerable variability within each pocket area, one can except that, on average, at least 60 % of the zones have soils with characteristics suitable for the production of agricultural crops.

## Lecture No: 5

## Environmental factors affecting horticultural crop production, Effect of temperature, light, humidity, rainfall, wind and their stress on production and Measures to overcome environmental stress

### Environmental factors affecting horticultural crop production

1. **Effect of temperature**

- Temperature is one of the most critical factors of the environment and has profound influences on all physiological activities of plants such as respiration, photosynthesis, transpiration etc. Temperature affects growth and development of vegetable crops during different phases such as seed germination, general survival, and development of economic parts, flowering, pollination and fruit set.
- The growth and development of some of the vegetable crops is affected at temperature less than $5^0$c, warm season crops cease growing at that temperature. Growth normally increases with increasing temperature for their growth and development, temperature below $18^0$c is cool season crops and temperature above $18^0$c is warm season crops. At $0^0$c plants killed by frost and $40^0$c , they are killed by heat.
- The favourable temperature range for the growth and development of any particular plant is known as the optimum temperature range or cardinal temperature. Within this range the two fundamental processes, photosynthesis and respiration are proceeding in such a way that the highest marketable yields are produced.

**Effect of temperature that causes:**

a. **Chilling injury**
b. **Freezing injury**
c. **Frost injury**
d. **High temperature injury**

**a. Chilling injury (above freezing)**

Tropical origin of plants are injured when the temperature drops to some points above freezing but low enough to cause damage tissues, cells or organs of the plant. This injury which causes due to low but above $0^0$ctemperature is called chilling injury. In tropical fruits such as banana chilling injury occurs in the temperature ranges of 0 to $6^0$c. It disrupts the entire metabolic and physiological processes in plants. Direct effect of chilling injury include: Necrosis, discolouration, tissue breakdown and browning,

reduce growth, failure to germinate in case of seeds etc. Most indirect effect may also occur as; reduced photosynthesis, reduce water absorption, delayed harvest etc.

**b. Freezing injury (below freezing)**

This occurs at temperature below freezing or close to freezing. This may cause permanent damage to the plants resulting in death. This injury is due to the formation of ice crystals, which causes mechanical injury to the cell. Such crystal formation in turn causes desiccation of the tissue or cells, which results in protein precipitation.

**There are different types of freezing injury**

i. **Black heart:** Pitch **(***Pith* is a tissue in the stems of vascular *plants*. *Pith* is composed of soft, spongy parenchyma cells, which store and transport nutrients throughout the *plant*).is killed and the heart wood (xylem) turns shiny brown.

ii. **Crotch injury:** killing of bark and cambium tissue in the crotch of the branches.

iii. **Collar or crown injury:** it is caused by severe damage of the frost at the ground level. In this case the bark of the young tree is killed and cracked open. The inner sap carrying tissue is ruptured through freezing. It may also extend up to roots.

iv. **Splitting of the bark:** it is caused by severe frost occurrence. It may extend to entire length of the trunk (the main woody stem of a tree as distinct from its branches and roots.) or branches under severe condition.

v. **Killing bark of shoot and young branches:** the tropical and sub- tropical fruit trees may be damaged by frost in early winter. The bark along the cambium layer become discoloured or killed very often. With this injury the flowers in mango may be killed and even fruits may be injured in papaya and citrus.

**C. Frost injury or winter kills**

- Frost injury and freeze injury are closely related, and the damage looks the same. In both cases, ice crystals form in water-filled plant tissues, dehydrating cells and disrupting membranes. The result is collapsed and/or darkened plant parts.
- It occurs as a result of thin layer of ice crystals deposited on soil and plant surface. Evergreen fruit trees and most herbaceous annual plants heavily suffer from frost. New twings, branches and shoots are severely affected. The most affected fruits shows dry patches and bears tasteless juice in citrus and guava. The young plants and top shoot may be killed immediately. Those tree which suffer from mineral deficiency or which are weak, diseased.

**Methods for protection from low temperature stress**

The following measures should be adopted for protecting the orchards from low temperature

i. **Planting windbreak:** always planting windbreak on the north-western sides of the orchard, which afford protection from the cold waves during the winter season. The ideal windbreak plants are mango, ber, mulberry etc.

ii. **Healthy tree:** Healthy tree can withstand frost damage much more effectively than weak and sticky plants. The fruit trees may be kept healthy by adopting proper cultural practices and plant protection measures.

iii. **Training of plants:** well trained, low headed tree withstand cold better than tall and improperly trained trees, so, it is very important to train young fruit tree properly.

iv. **Wrapping of trunk:** the exposed portions of the lower trunk of the young plants should be wrapped with old gunny cloth to avoid damage to bark by cold injury.
v. **Providing smoke screens:** the heaps of dry leaves, grass or trash should be kept ready in the orchard at several places. As and when a frost is threatened, these heaps should be ignited and allowed to burn slowly. The fire and smoke raises the atmospheric temperature of the orchard by a few degrees and thus the fruit trees are saved from the frost injury. In advanced countries oil lamps and specially designed heaters are installed at several places in the orchard and these are ignited when there is forecast of the occurrence of frost.
vi. **Planting frost tolerance kinds:** in the localities, where frost incidence is more common, plant only those kinds and varieties of fruits which can withstand frost damage. It is advisable to plant frost resistant deciduous fruits in such localities like pears, peaches, grape, plums etc. Langra and maldah varieties in mango and mandarin orange among citrus are comparatively frost tolerant.
vii. **Irrigation:** by irrigating the orchards during winter, it is possible to raise the temperature by $1^0$C to $2^0$C.this is one of the easiest and the most practical method to ward off frost. It is, therefore, desirable to irrigate the orhard during cold spell period.

**d.high temperature injury**

- This is accompanied by drought condition which leads to desiccation. Plants show "burning up" symptoms due to excessive water loss in transpiration. Warm, dry and windy weather speeds up the problem. High temperature may be lethal as a result of protein coagulation and enzyme denaturation. Symptoms of high temperature may include: Appearance of necrotic lesions, molting of leaves, fruits and death. The causes of these symptoms are:
- Because of elevated temperature, respiration rate increases and photosynthetic rate decreases, the tissue and deteriorate because of the bark of life supporting energy.
- Alternation in proteins or enzymes or membranes. With the disruption of membranes, there is a destruction of the compartmentation of cells, enzymes come into contact with substrates that they ordinarily would not and reactions occur that alter ion, water and organic solute movement.

High temperature during the growing and rest period causes injuries like sunburn and sunscald.

**i. Sunburn**

- The excessive heat during the growing season often results in the burning of leaves and fruits. During the day, branches, leaves, fruits and stem portions which are exposed to the sun becomes much hotter than the atmosphere are subjected to sunburn injuries. The transpiration losses are also much higher at the same time. The bark of the affected trunk and branches may crack or peel off in long stripes in extreme causes, such damage to the bark may result in the eventual death of trees or they may get crippled.

**ii. Sunscald**

- The hot intense sun rays fall on the exposed parts of the tree facing south west side, resulting into sunscald injuries. The hot sun also scorches the developing fruits. The

affected portion of the fruits first turn yellow, then brown on further scorching and later even turn black. Such fruits cease to grow from the affected side, whereas the growth on the other side continuous as usual. The fruits thus become malformed and misshapen. The peel of such fruits clings to the segment, which becomes woody and dry.

**Protection against hot weather**

The following measures should be adopted to save the tree fruit from sun injuries and adverse effect of hot weather.

i. **White washing:** This is the most practical methods for saving the trunks of fruit trees from sun injury. The lower bare trunk portion of the fruit trees from the sun injury. The lower bare trunk portion of the fruit tree should be white washed during April. White washing may have to be repeated in June-July if it gets faded or is washed out by rains. In the white wash material, little amount of copper sulphate should be added as it helps in warding off the fungal diseases. The effective white wash can be prepared as follows:
   - 1 kg of copper sulphate dissolved in 50 litres of water.
   - Similarly, 1 kg of lime dissolved in another 50 litres of water.
   - Then copper sulphate solution is slowly added to lime solution with constant stirring or alternatively, both the solution may be poured simultaneously to a third container and mix well.

ii. **Providing shelter:**quick growing temporarly shade plants can be planted around the basins to provide shade which helps in minimizing sunburn injury.

iii. **Wrapping of bare trunks:** wrapping of lower portion of the trunk of fruit tree with old gunny bags or some other farm waste material like rice straw is also very desirable practice, especially in case of young fruit plants of tender type.

iv. **Low headed trees:** the plants trained to low headed framework escape the ill effect of the hot sun better than the high headed trees. It is, therefore, desirable that the fruit trees should be trained to develop low heads, especially in hot and arid regions.

v. **Windbreaks:** by growing windbreaks in the western side of the orchards, damage by hot winds can be avoided the windbreaks should be planted before the planting of the fruit trees. Mango, jamun, mulberry etc. are suitable for windbreaks.

vi. **Frequent irrigation:** irrigation at regular intervals is quite effective against the hot weather and sun injury. The frequent ierrigation should be increased during the hot period (May-June) when desiccating winds.

**2. Light (Radiation)**

- Solar radiation actually regulates the distribution of temperature and this temperature regulates the crop production. Now we need to know that not all the radiation can be observed by the plant for the process of photosynthesis. So, there is only a particular radiation that can be used that is known as photosynthetic active radiation. PAR is a visible radiation only this radiation is useful for photosynthesis. The range of this radiation is 400-700 nm.
- The light intensity also known as radiation refers to the number of quanta or photons, impinging on a given area, or to the total amount of light which plants receive. All life on the earth is supported by the radiant energy from the sun, which plant convert into chemical energy by the process of photosynthesis.
- Light is one of the most important and variable component of the plant environment. The autotrophic plant is directly influenced by the intensity of light, which drives photosynthesis, and thereby, provides the chemical energy and carbon needed for the

plant growth and development. Thus, an alternation in light intensity, whether deficit or excess, will result in a disruption of plant metabolic processes. Plants respond to broader light wave length, 300 to 800 nm.

- The effect of the optimum range of light radiation favours the high rate of photosynthesis, normal rate of respiration and high amount of available carbohydrate for growth and development.
- Length of day (photoperiod) regulates both flower initiation and cessation of vegetative growth in some species. The optimum light intensity is not the same for all the crops. Based on duration of light response, the plants are classified into long day plants [(beans, cowpea, potato, radish, spinach, lettuce, Chinese cabbage etc.) (requiring shorter night 8-10 hours)], short day plants [(cowpea,bean,onion, sweet potato etc.) (requiring long nights 10-14hours)]and day neutral plants [((photo-insensitive).
- Most of perennial fruit cropsare light insensitive in their response to light duration. In case of cucurbit, day length and intensity of light combined with temperature and known to influence sex-expression. Light may promote seed germination in lettuce. Light also affects the quality of fruits and production of pigment. Direct light is required for the synthesis of red and blue anthocyanin pigment in some fruit species.

**Effect of light deficit (shade)**

**Adaptation to shade comes in two ways:**

i. Increase of leaf area in way that minimise the use of metabolities( for example, by increasing leaf area at the expense of photosynthate allocation to root growth) and

ii. A decrease in the amount transmitted and reflected light. Shade leaves are thinner but larger in surface area than sun leaves. Increased light absorption is brought about by increased number of chloroplasts per unit leaf area and by increased chlorophyll concentration of chloroplasts which is accompanied by a lower concentration of other pigments that interfere with light absorption process.

**3. Rainfall**

- Horticultural crops require an ensured supply of water than agronomic crops. The amount of rainfall in a given region determines the kind of horticultural crops to be grown successfully there. The distribution of rainfall throughout the year and the amount of rainfall are the two factors that are most important for horticultural crops.
- If the rainfall is distributed throughout year, most of the fruits need not be irrigated. Rainfall has influences on various phases of plant growth like germination, vegetative growth, flowering, fruit set, maturity and harvesting, fruit quality etc. For example a heavy rain just before flower bud initiation in mango may enhance more vegetative growth instead of reproductive growth. Too much more and too little water than the requirement of individual plant science cause effect on plant growth, flowering and fruiting.
- Heavy rainfall at blossoming is most limiting factor to fruit set as it washes away and destroyers the pollen as well as reduce receptivity of stigma. The amount of water available in plants is a function of precipitation. Precipitation could be defined as the condensation of water vapour in the air in the forms of water droplets and ice and their falling on the ground. Precipitation of following type:

**Rain:** the precipitation in the form of drops of water is called rainfall. Size of rain drop is more than 1.5 mm.
**Drizzling:** size of rain drop less than 0.5 mm.
**Snow:** when the temperature is less than $0^0$c, the precipitation takes place in the form of fine flakes and is called snowfall.
**Sleet:** partially melted snow (mixture of rain and snow) is called sleet.
**Hail:** precipitation in the form of solid is called hail.
**Fog:** it is a cloud and has its base very near to the ground.
**Clouds:** mass of mixture droplets of water or tiny ice crystals formed by the condensation of water vapour in free air at considerable elevation.
**Dew:** moisture deposited in the form of water droplets on cooler surface of solid objects such as stones, grass etc.
**Frost:** condensation takes place at a dew point that is at or below freezing point; frost will only form on a surface that is at or below freezing temperature.

**4. Humidity**

- Humidity could be defined as the ratio of the concentration of the existing water vapour in the air to the total amount the air could hold at the given temperature and pressure. Humidity plays the most important role in the occurrence of pests and diseases. Certain diseases like powdery mildew are associated with dry weather but humid condition is known to favour disease like downy mildew and fungal blights affecting foliage.
- Plants of tropical origin such as banana, pineapple, jackfruits etc. require high humidity. The primary of humidity is on the transpiration rate, which tends to reduce as humidity increases. Increased transpiration and too low relative humidity causes wilting and desiccation in plants. High relative humidity adversely affects the colour and keeping quality of fruits. High relative humidity promotes fungal and bacterial infection in plants.

**5. Wind**

- Winds can have very harmful effect on plant growth the more so when drying wind evaporates the plants, moisture to cause desiccation. Wind influences vegetation through physical impact. Wind bring fresh supplies of $CO_2$ ; thus helping in the process of photosynthesis. It helps in pollination and dispersal of seeds. Too low and too high wind velocity is harmful for fruit set. High wind velocities blow away the fruits and break the branches. High winds can interfere with pollination and cause premature dropping of flowers and fruits. Severe winds are especially harmful at the time of flowering and fruit set. High wind also accelerates moisture losses from the soil.
- During rapid growth of plants, $CO_2$is rapidly depleted on the root surface. A slight wind is essential for supply of $CO_2$ near the plant surface. In strong wind, the average velocity greater than 7.2 km/hours is limiting factors of vegetable production. Typhoons are very destructive to vegetable crops. All the vegetable crops are very susceptible to the strong winds. E.g. the seed production of onion is problematic in terai due to windy weather at the bolting stage of the crops in March-April.

## Lecture No: 6

# General introduction to types of horticultural enterprises (Orcharding, nursery raising, ornamental gardening, landscape, vegetable farming, seed production and postharvest handling & preservation)

## General introduction to types of horticultural enterprises

### A. Orcharding

- A piece of enclosed land planted with fruit trees is known as orchard.
- An orchard is an intentional planting of trees or shrubs that is maintained for food production. Orchards comprise fruit- or nut-producing trees which are generally grown for commercial production. Orchards are also sometimes a feature of large gardens, where they serve an aesthetic as well as a productive purpose.
- A fruit garden is generally synonymous with an orchard.

**The following points need to be considered before choosing a system of planting.**

- It should accommodate maximum number of plants per unit area.
- It should allow sufficient space for the development of each tree.
- It enables equal distribution of area under each tree.
- The intercultural operations such as ploughing, spraying hectare easily carried out.
- It makes supervision more easy and effective.
- Fruits ripening at the same time should be grouped together.
- Evergreen trees should be in the front and deciduous ones behind.
- A good fence is essential.
- Short growing trees should be allotted at the front and tall at the back for easy watching and to improve the appearance.

### B. Nursery raising

- As we say "Success of any production system depends on the kind of seed we are sowing", so is true with seedlings. Healthy seedlings grown in a well-managed nursery will decide the yield and consequently the profit.
- A nursery is a managed site, designed to produce seedlings grown under favourable conditions until they are ready for planting. All nurseries primarily aim to produce sufficient quantities of high quality seedlings to satisfy the needs of users.
- A vegetable nursery is a place or an establishment for raising or handling of young vegetable seedlings until they are ready for more permanent planting.

**Different types of nursery bed:**

1. **Raised nursery bed (For rainy season)**
   - This type of seed bed is useful during rainy season from June to September. But, if possible sky nursery bed is very good option during rainy season.
   - Raised up beds are made with 15 cm ridges in 1 meter in breadth and length as per need (Maximum 3-5 meters).
   - Well-decomposed compost should be added and mix properly in soil during bed preparation about 1-2 weeks before sowing seed.
   - Seeds are sown in line 2-3 cm deep with finger at spacing of 5-7 cm between two seeds, and slightly watered the bed by sprinkler or with the help of making hole on lead of bottles.

2. **Sky nursery bed (For rainy season)**

- Sky nursery beds are prepared in rainy season for producing seedlings of winter vegetables.
- During the months of June to September, rainfall is likely to continue for days if not weeks. In this period, raised nursery beds may not be sufficient in draining excess water, because rainwater will be frequently running on the ground.
- The nursery bed is prepared using wooden or bamboo stalks driven on ground and erecting about 60-70 cm above the ground with 1 m breadth and length as per the necessity, and placing 15-20 cm thick layer of soil on the planks or bamboo fibers.
- If it rains, the nursery bed should be roofed by plastic sheet; whereas, it can also be removed if it is not raining. There should not be roof for long time in sky bed. Application of compost and sowing methods are like in raised bed.

**3. Sunken nursery bed (For dry and hot season)**

- These types of seed beds are prepared during winter or dry season for holding moisture in soil.
- In contrast to the rainy season, rainfall is scarce and preparation of seedlings will require water during the months of February to May.
- During such season, nursery beds should be prepared to contain the moisture in the soil as much as possible.
- To prepare such nursery, the land should be dig out below the ground surface and keep the small raised boundary.
- The water would be preserved in effective way in comparison to raised bed; which help to grow up healthy seedlings. Application of compost and sowing methods are like in raised bed.

**Advantages of Nursery Management:**

- It is possible to provide favourable growth conditions i.e. germination as well as growth.
- Better care of younger plants as it is easy to look after nursery in small area against pathogenic infection, pests and weeds.
- Crop grown by nursery raising is quite early and fetch higher price in the market, so economically more profitable.
- There is saving of land and labour as main fields will be occupied by the crops after 1 month. More intensive crop rotations can be followed.
- More time is available for the preparation of main field because nursery is grown separately. As vegetable seeds are very expensive particularly hybrids, so we can economize the seed by sowing them in the nursery.

**C. Landscape gardening**

Landscaping is an aesthetic branch of Horticulture, which deals with planting of ornamental plants in such a way that it creates a picturesque effect. Landscape gardening can also be defined as the beautification of a tract of land having a house or other object of interest on it. It is done with a view to create a natural scene by the planting of lawns, trees, shrubs flowering annuals, climbers, creepers, etc. Further, landscape gardening is both an art and science of the establishment of a ground in such a way that it gives an effect of a natural landscape. It can also be defined as "improving of total living environment for the people".

**Principles:**

1. **Simplicity:**
   The plan must be simple. It should not contain too many themes or overcrowding of plants or other garden ornaments, as this creates confusion and hinders in getting the theme and also distract the viewers.

2. **Unity:**
   It is the most important feature of landscape planning. It increases aesthetic beauty of garden. It can be express by harmonious placement of garden features in proper way. It can be created by repetation of single component or by blending different components in harmony in such a way that every features express the total effect independently.

3. **Harmony:**
   It is an overall effect of various features, style and colour schemes of the total scene. Harmony is arranging different things in garden in such a way that it creates relation between all and make them all look one.

4. **Balance:**
   Balance is a design is an essential part for unity, harmony and proportion of design. All the component must be balanced. Therefore, correct position of plants and features create well balanced design. In a design, balance in a different planting materials like annuals, shrubs, tree should be maintained. Balance in size, shape, colour and form of building and different plants should be maintained. Too much green should be overcome by planting annuals, flowering shrubs and trees.

5. **Proportion:**
   In this, every feature should be in relarion with total space available for the garden. The space provided for lawn, paths, herbaceous borders, shrubbery, trees, building and other garden objects should be in a right proportion.

6. **Scale:**
   In a garden, scale may be defined as a relative relationship between masses. Scaling of components, size, shape and form unites the different components of design. In genareal in a design, area can be divided in following manner which may vary with personal choice and type of unity.
   - Lawn (25-30%)
   - Paths (15-20%)
   - Trees (15 %)
   - Shrubbery (12-15%)
   - Herbaceous border (8-10%)
   - Buildings (25-30%)

7. **Acent/Focal point:**
   Acent is centre of attraction which is generally an architectural features focoused as a point of interest. The focal point attracts viewers to a point from where a single view can be seen abd form where the whole plan could be understood and all components look one which avoids monotonous view. Mostly objects like fountains, tree, status, etc are used as focal point. It may be anything, a flowering tree, shrubbery, floral clock, fountains, lakes, etc.

8. **Rhythm:**

Repetation of same object or objects at equidistance is called rhythm. It can be created through the shape, progression of size or continuous line movement. Rhythm creates movement of eye. It breaks the monotony and maintains maximum enjoyment.

**Elements of landscape design**

**1. Line:** In landscape, line can be drawn by repetation of same objects like planting Ashok tree, shrubs, etc. along the roads; hedges tree canopy, edges, etc. Line gives a scense of border to a particular object in landscape and avoids mixing two or more components.

**2. Colour:** Colours are divided into three groups.

- ✓ Primary colour: Bry (Blue, Red, Yellow)
- ✓ Secondary colour: Gov ( Green, Orange, Violet (purple)
- ✓ Tertiary colour : Mixture of Primary and secondary colours.
- ✓ Neutral colour: bs+gw (Black, silver, grey, white)
- ✓ Warm colours: Roy (Red, orange, Yellow) – used for creating focal point
- ✓ Cool colours:Gpb (Green, Purple, blue) – used for give feelings of coolness and relax eyes.

6. **Texture:** In landscape design, appearance of objects and their surface is referred as texture.
   - ✓ Coarse texture: Large leaf tree
   - ✓ Medium texture: medium leaf tree
   - ✓ Fine texture: Small leaf tree

Coarse texture is mostly used for focal point. Planting coarse and fine textured plants together attracts viewer's eye movement.

7. **Habit:** Habit of planting material (straight, globular, columnar, bushy) attracts viewers eye movement in different directions. Straight growing plants move viewers eye towards up where sky and tall plants jointly give scenery view, adding sky in landscape design. Globular plants move eyes in horizontal direction which related earth and other small components. Habit of plants play an important role in viewers eye movement and help the viewers by guiding what landscaper wants to show or the beauty of his design. Habit can be compared with silent direction signs, indicator or guide.

8. **Form:** in landscape design, form refers to shape of objects. Shape give to trees and hedges adds beauty, harmony, rhythm, unity and help to eatablish focal point.

9. **Light**: It has become an important element in landscape design. Light helps to create shade effect which can be utilized in improving beauty to landscape. Light are used in fountains, water bodies to give visual effects. Light adds colour in landscape if used smartly.

10. **Space/volume:** Design must be planned according to space available. The design should not be crowdy.it is possible to make a garden appear larger, longer, shorter by manipulating the apparent prespective and proportion. If space is less than design

should be planned in such a manner that less space also look more n volume than actual.

11. **Mobility:** In landscape design mobility refers to change in garden or landscape with time in space and volume. Use of annuals according to season changes colour in garden which give scense of change in garden.

12. **Style:** It may be formal, informal, free or wild style of gardening. In formal style, space, form, paths, line, etc. are geometrical. In this, land is selected accoding to design or converted according to design requirement.

## Lecture No: 7

## Orchard establishment and management: Site selection and layout of orchard, Planting, soil and water management practices, wind break and shelter belts, Fertility and weed management

### A. Site selection and layout of orchard

**Site selection:**

One has to take into consideration a number of factors before selecting a site for an orchard. In selecting a site for an orchard, choose a proven area for the fruit to be grown. Successful orcharding consists of not only yield, but economic production and efficient disposal. Among the desirability of piece of land or site for fruit growing are land values not from the quality of the produce but from the point of other characters connected with the industry.

Factors to be consideration for site selection:

**Climatic factors:** Fruits are classified as temperate, tropical and sub-tropical on the basis of their climatic requirements although this classification is not very rigid and some fruits may be grown in more than one climatic setup. Climatic factors such as temperature, rainfall, humidity, radiation etc. the biological activities like flowering and fruiting are greatly influenced by the environmental conditions. Temperature: The optimum temperature for the most fruit plants is 22-27 0C whereas the maximum temperature limit may be 40-52 0C at which most of the plants of temperate zone may not survive.

**Sunshine:** Sunshine is of great value to fruit crop because of its pollination, photosynthesis and on the development of colours. Intensity and quality of light influenced the formation of carbohydrates. Sunshine also influences the formation of flower bud.

Wind: The cultivar of plant to be grown is also determined by the velocity of wind. High wind velocity doesn't suit broad-leaved evergreen plants, which experience mechanical shedding of fruits. Flower, leaves etc. The increasing wind velocity retards the activity of pollinators. Bee activity is maximum when wind is still, gets little reduces when wind is 2-3 km/hr, gets greatly when wind velocity is 25 km/hr and their activity is altogether when the wind velocity is 40 km/hr.

**Rainfall:** Water controls both growth and development. Loss of water beyond a particular degree induces wilting of plants. Plants have some critical periods of water requirements and adequate supply of water during these stages definitely raises the yield. Water shortage at the critical period of water requirement i.e. early growth, bud differentiation, blossoming, fruit set and development lead to unprofitable effects. Rainfall is the ultimate source for the

moisture supply for the plants. The spread and intensity of rainfall plays an important role in selection of site for orchard establishment.

**Soil:** Deep well drained with good texture and structure, free from any hard pan or rock, any toxic element, free from salinity or alkalinity problems are well suited for orchard establishment. Soil pH level plays a crucial role in plant establishment. As far as possible flat land should be selected. There should be no hard pan up to a depth of 2m.

**Topography:**
Plain land is easy for any kind of cultural operation. Upland rolling or sloping fields which is not too steep for efficient orchard operation. River bottom or flat valley floors are usually undesirable in high hills a there is more cold air movement and frost injury. Fruit growing in too steep hill side is impractical as there is more soil erosion difficult in cultural operations like training, pruning, thinning, harvesting etc.

**Irrigation facility:** most of the horticultural crops are raised under irrigation. Soil that water facilities should be taken into consideration (quantity and quality). Water table should be below 2 m in depth.

**Nearness to the market:** saves the overhead charges in transport and gives close touch with market taste (in the case of commercial growers). In most cases a large percentage of the retail price of fruits is accounted for by transport charges.

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

**Availability of labour:** the site should be such that labours may be cheap, skilled and in plenty. As the fruit industry flourishes more skilled labour is needed.

## B. Layout and planting system of orchard

The plan showing the arrangement of plants in an orchard is known as the "orchard layout". There are several systems of planting; among them following are the important ones

1. **Square system:**
   It is most easy and popular method of planting fruit plant. In this system row to row and plant to plant distances are kept similar. The plants are planted exactly at right angle at each corner. Thus, every four plats make one square. Intercultural operations can be done in both directions as the distances between trees and rows are similar. Adequate space is there to go for inter cultivation of remunerative crops like vegetables. Trees are planted equidistant from each other, at the recommended spacing for mature trees. The distance from plant to plant and row to row remains the same. The four adjacent plants of two rows form a square.

**Advantages**

1. Irrigation channels and paths can be made straight.
2. Operations like ploughing, harrowing, cultivation, spraying and harvesting becomes easy.
3. Better supervision of the orchard is possible as one gets a view of the orchard from one end to the other.

**Disadvantages**

1. Comparatively less number of trees is accommodated in given area.

2. A lot of space in the centre of each square is wasted i.e., certain amount of space in the middle of four trees is wasted.

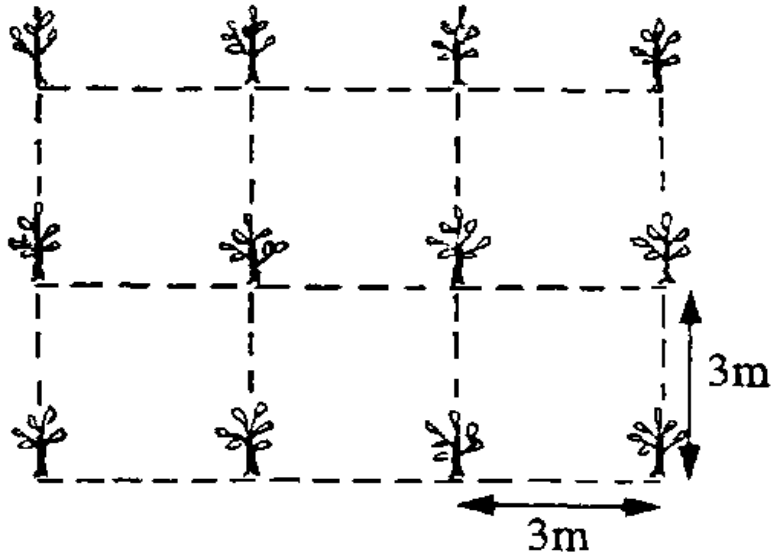



**Fig. 1 Square system of planting**

**Lay out procedures:**

1. Establish a base line/row.
2. Mark position of trees on this line using the wooden stakes leaving half of plant to plant distance (actual or adjusted) on both sides of the base lines.
3. Using right angle shaft, extend lines perpendicular to the base line from every position of the trees marked.
4. Stakes are fixed on these lines at plant to plant distance.

These are the basic procedures for laying out a square system. One can introduce a number of modifications in the procedure and in the tools to increase the efficiency.

**4. Rectangular system:**

In this system, the plot is divided into rectangles instead of squares and trees are planted at the four corners of the rectangle in straight rows running at right angles. Intercultural operations, spraying, harvesting can be done conveniently and more plants can be accommodated in the row keeping more space between the rows. Similar to square system, except that the distance between plants in the row and distance between rows is not the same but different. Row to row distance is more than that from plant to plant in the row

**Advantages**

1. Intercultural operations can be carried out easily.
2. Irrigation channel can be made length and breadth wise.
3. Light can penetrate into the orchard through the large inter spaces between rows.
4. Better supervision is possible. 5. Intercropping is possible.

**Disadvantages**

1. A large area of the orchard between rows is wasted if intercropping is not practiced.
2. Less number of trees are planted.

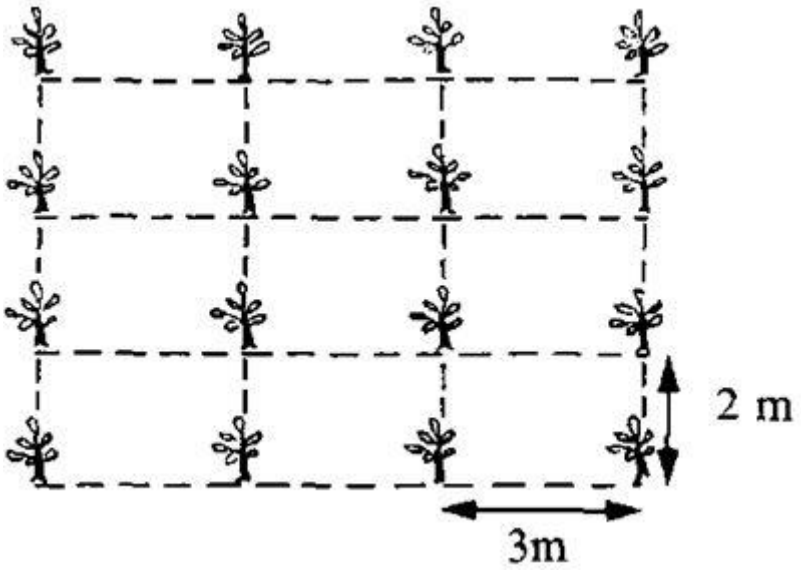



**Fig. 2 Rectangular system of planning**

**Procedure for lay out:**

**Step no's:** 1, 2 and 3 are as same as in square system.

**Step no.4:** Mark the planting positions on both the perpendicular lines following the spacing to be adopted between the rows.

**Step no.5:** It is same as in square system, but following the spacing to be adjusted between the rows.

**Step nos.** 6, and 7 are as same as in square system.

3. **Quincunx system/Diagonal pattern:**
   This system is also known as filler or diagonal system. This is a modification over Square system of layout. To make use of the empty space in the center of each square by planting another plant. The plants that are planted in the centre of each square along with tall growing plants at the corners of squares are termed as "filler" plants. Generally, filler trees will be of short duration and not be of the same kind as those planted on the corners of the square. When main plants of the orchard resume their proper shape, the filler plants are uprooted. Guava, Peaches, Papaya etc. are important filler plants. In this layout population becomes double than square system of mango+ papaya, mango+ fig.

**Advantages**

1. Additional income can be earned from the filler crop till the main crop comes into bearing.
2. Copared to square to square and rectangular systems, almost double the number of trees can be planted initially.
3. Maximum utilization of the land is possible. Approximately10% more plants than the square method

**Disadvantages**

1. Skill is required to layout the orchard.
2. Inter/filler crop can interfere with the growth of the main crop.
3. Intercultural operations become difficult.
4. Spacing of the main crop is reduced if the filler crop is allowed to continue after the growth of the main crop.

Quincunx.

**Procedure for lay out:**

**Step no-1:** Lay out the square system

**Step no.-2:** Draw diagonals of each square.

**Step no.3:** Mark the planting position of the filler tree by fixing a peg at the point of intersection of the two diagonals in each square.

Follow the procedure for the layout of a square system. In addition to this mark with Stakes at the centres of each square for the filler plants by drawing the diagonals.

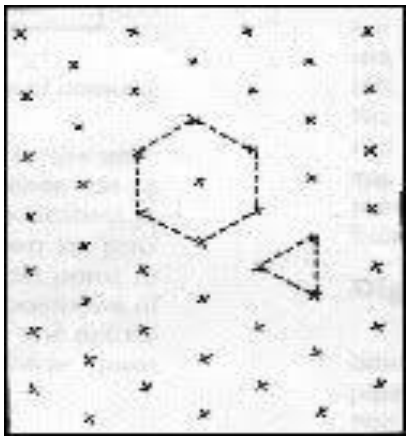
4. **Hexagonal / Triangular System**
   This system accommodates 15% more plants than square system. The plants are planted at the corner of equilateral triangle. Thus, six trees are planted making a hexagon. Seventh tree is planted in the centre. This is very intense method of planting and hence requires fertile land. In the suburb of cities where land is costly, this system is worth adoption. However, the laying out of system is hard and cumbersome.

**Advantages**

1. Compared to square system 15% more trees can be planted.
2. It is an ideal system for the fertile and well irrigated land.
3. Plant to plant distance can be maintained the same.
4. More income can be obtained.

**Disadvantages**

1. Intercultural operations become difficult.
2. Skill is required to layout the orchard.



**Layout procedures**

- Establish a base line on one side of the field as in the square system.
- Mark the position of trees on the base line at the desired distance and fix the Stakes.
- Make equilateral triangles on the base line maintaining the sides of the triangles equal to plant to plant distance.
- Mark all the triangles with stakes and join them into a line to form the second line of trees.
- Similarly, make equilateral triangles on the second line and cover the whole land.

**5. Contour system**

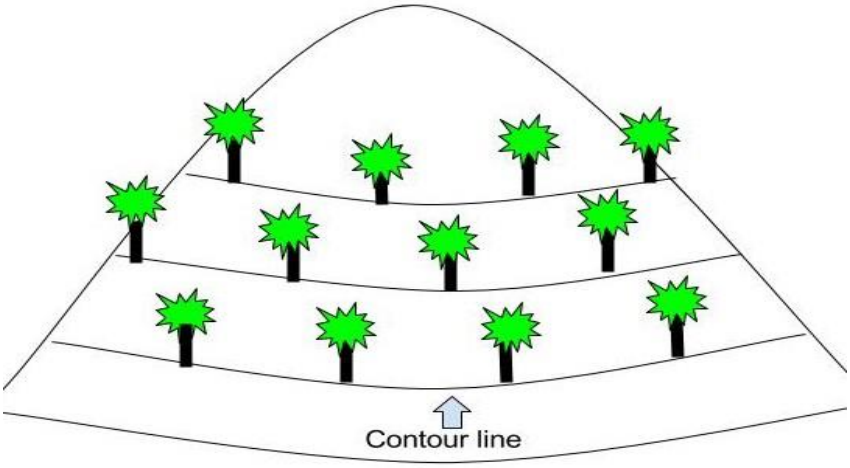
It is generally followed on the hills where the plants are planted along the contour across the slope. It particularly suits to land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult. The main purpose of this system is to minimize land erosion and to conserve soil moisture so as to make the slope fit for growing fruits and plantation crops. The contour line is so designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the, soil without causing erosion. Terrace system on the other hand refers to planting in flat strip of land formed across a sloping side of a hill, lying level along the contours. Terraced fields rise in steps one above the other and help to bring more area into productive use and also to prevent soil erosion. The width of the contour terrace varies according to the nature of the slope. If the slope becomes stiff, the width of terrace is narrower and vice-versa. The planting distance under the contour system may not be uniform. When the slope is <10% contour bunding is practiced and if the slope is >10% contour terracing is practiced. In this system the trees are planted along the contour line at right angles. Cultivation and irrigation can be practiced along the tree rows only.

**Advantages**

1. This system can be adopted in hilly regions, can control the soil erosion and helps simultaneously in the conservation of water.
2. Preservation of plant nutrients which are supplied as manures and fertilizers.

**Disadvantages**

1. Laying out of contour lines is difficult and time consuming.
2. Special skill is required to layout this system.
3. Special instruments are required for making contour lines.
4. The row to row distance will not be equal and adjustments may be required in the plant to plat distance.
5. Rows are broken in to bits and pieces.




**Layout procedures:**

- Contour system is a little more complicated than any other system of layout since planting has to be done on slopes.
- For the procedure mark contours at a distance equal to row to row distance on each contour lines.

The contours may be of full length or less than full length depending on variations in the degree of slope.

## Lecture No: 8

## Soil, weed, water and fertilizer management practices

**Soil management practices:**

Soil is one of the most important factors associated with the success or failure of fruit production. Most of the soil management practices in the orchard enhance nutrient and water supply needed for growth and production of fruit trees. This they do so by improving soil nutrient status, conserving soil moisture, altering of soil properties like soil pH and soil structure, maintaining soil organic matter contents and useful soil organism.

1. **Tillage:** Tillage means ploughing and hoeing of soil. The main objective is to loosen and pulverize the soil so that roots of fruit plants may penetrate in the soil easily. It facilitates circulation of air and absorption of water. Tillage removes the weed and helps in mixing manures and fertilizers.
2. **Clean cultivation:** clean cultivation means keeping the land of the orchard always free from grasses. It controls weed growth and improves moisture retention in the soil. Controls weeds and thus reduces competition for light, nutrients, and moisture. Such practices also help in good aeration and increase the nutrient availability. In this management system, the inter space between the trees is kept clean by removal of weeds.
3. **Sod culture:** In this system, grasses are allowed to grow in the interspaces between the trees without tillage or mulching. This practice is followed in the orchard located on sloppy land, particularly when the gradient of the slope is greater than 10 per cent. This system prevents soil erosion to the greatest extent; however it should not be followed in orchards of young or dwarf trees because such trees are shallow rooted and compete for nutrients and water with grasses. The roots of large trees on the other

hand penetrate the soil to a greater depth and are less likely to suffer from such competition. Tree basins are kept free of weeds by tillage or application of herbicides.

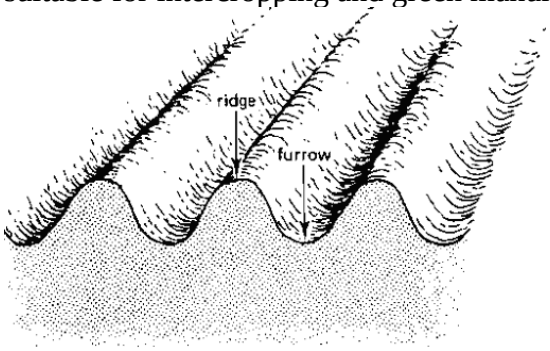
4. **Mulching:** mulching refers to the practices of soil moisture conservation by placing straw or cut grasses on the soil surface between the tree rows to check surface evaporation. Mulching also checks the germination of weeds. This useful effect is more pronounced during the drying periods of May-June. Some other advantages of mulching are: Keeps soil cool. Reduce surface run-off. Prevents soil erosion. Allows absorption of more rain water.
5. **Sod mulch:** In this method, grasses are allowed to grow in the entire area of the orchard. Tree basins are mulched with straw, instead of tilling. The grasses are mowed down regularly and are spread to maintain the mulch in basins. This method is best suited in orchards on steep slopes to prevent soil erosion.
6. **Cover crop:** These crops are raised mainly in the beginning or in advance of the rainy season, so that these may provide the necessary protection to the soil when damage by soil erosion is the greatest. Examples of some of the cover crops are cowpea, mung bean, soya bean. Cover crops help to improve the physical condition of the soil by adding the organic matter to the soil.
7. **Intercropping:** The practice of growing any economic crop in spaces of the fruit trees in the first few years or in the unoccupied spaces of the long duration crop in the early periods is referred as intercropping. The following important principles should be observed while growing intercrops. Intercrops should not occupy the area where the roots of the fruit trees are concentrated. Soil fertility should be maintained or improved when intercrops are grown. Whatever may be the intercrop grown, it should be kept well away from the main fruit trees and irrigated independently. The intercropping should be stopped when trees occupy the entire orchard space.
8. **Green manuring crops:** These crops are raised during the rainy season and are buried into the soil after a few months of growth for incorporation of the organic matter. The green manuring crops are generally incorporated into the soil just when they reach the blooming stage. Green manuring crops also helps to improve the physical condition of soil by adding the organic matter to the soil.

**Water management practices:**

Despite the fact that nearly 75% of the total area on the earth's surface is occupied by water. This can be traced to the fact that 97.3% of the water is in oceans and seas. Only 2.47% is the fresh water. Water is a vital factor and natural resource for the growth of any living organism, and is a limiting factor for plant growth. It is the most important in supporting all forms of life. Plants also require water for their better growth and production. Where there is shortage of water, particularly during critical stages like flowering and fruiting, there can be drastic reduction in yield. Hence, the necessity of irrigation is to make up this deficiency of water. Commonly employed irrigation systems are:

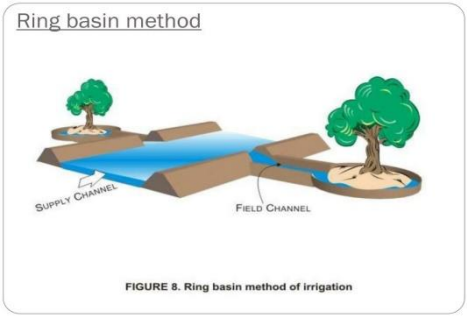
1. **Flood system:**
   In this system whole area is irrigated through one head i.e. without division of the unit area into small plots. In this system the root zone is fully saturated with the excessive use of irrigation water, fully saturating the root zone. This system is useful when intercrops or green manuring crops are grown in the orchard. Through, it is easy and cheap method some of the demirits are: wastage of water, weed growth and risk of bark disease like collar rot or foot rot.

2. **Furrow irrigation:** This system suitable for vegetable crops and in sloppy orchard land areas, particularly for old orchard. Make 20-30 cm deep furrows on either side of the tree at proper distance depending upon age and spread of the plant. Restrict the furrow length to 80-100 feet only to avoid wastage of irrigation water. In this system, the water moves slowly in furrows in the area between the rows. The trees are fed through the lateral movement of water. The consumption water is less in this system and there is no risk of bark diseases. Saturation of root zone is comparatively less. Not suitable for intercropping and green manuring.





3. **Basin system:** A small circular basin is provided around the tree trunk. These basins are linked directly with one another through straight channel. There is less wastage of water. This system is suitable for young fruit plants below 1-2 years of age. In this system, basins around the trunk are linked directly with one another through strait channel. Water wastage and weed growth are less in this system. However, water passing through the channel touches the tree trunk directly and hence risk of spreading of bark diseases is more. Helpful especially in loose textured soil where flooding or furrow method has limitation.

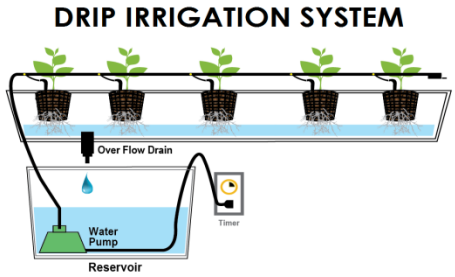



4. **Modefied basin system:** This is an improved system over the basin system. In this system, main channel runs in between the tree lines and the basins are linked

independently through small sub channels. Attention should be paid to block the sub channels after basin has received adequate water. The size of basin is increased with the increase in tree canopy size every year. This is a good system of irrigation for young orchard up to 6-8 years of age and also for arid regions, having water shortage. Incidence of bark diseases are less and intercropping is possible.

5. **Sprinkler system:** This system is used when water supply is not adequate. The water is pumped with pressure through the sprinklers attached to pipes and these sprinklers are adjusted in such a manner to overlap up to one fourth area covered by the other sprinkler. These are then moved to the next point after sufficient percolation has taken place. This is suitable in those areas where the land is undulated or sloppy and the water supply is not regular from the canal.

6. **Drip irrigation:** Also called trickle irrigation. The water is supplied with pressure after filtering it through the pipes with attached hoses designed to supply water in drops. Small holes are placed around the tree in a circular pattern and the percolating water moves down and sideways wetting the root zone. This is very costly method and most useful in areas with scanty rainfall for high density plantation. This system requires regular water supply. In this system, loss of water due to evaporation and erosion of soil are nil but percolation and seepage loss are appreciable. The advantage of application of liquid fertilizers to the root system is available. However, some of the demirits associated with this method are as: High initial cost. Damage to the pipe line during tillage. Infestation of diseases to the underground parts of the plants.




**Drainage:** drainage refers to the removal of excess gravitational water from the soil. When a field is water logged, the soil pore spaces are filled entirely with water. There will be no pores space for oxygen, which is necessary for root respiration, resulting in insufficient energy for absorbing and transporting water. In addition, it predisposes the plant to disease, especially root infecting diseases such as foot rot disease in citrus, papaya, etc. So, proper drainage is a must.

There are two methods of drainage to remove excess water from the field; they are

1. **Surface drainage:** Surface drainage is the removal of excess water from the surface of the land. This is normally accomplished by shallow ditches, also called open drains. The shallow ditches discharge into larger and deeper collector drains. In order to facilitate the flow of excess water toward the drains, the field is given an artificial slope by means of land grading.
2. **Sub-surface drainage:** this system is commonly used in areas where soil will not drain quickly on its own. This is accomplished by the construction of open ditches and tiles to intercept ground water and carry off it.

**Fertilizer management:**

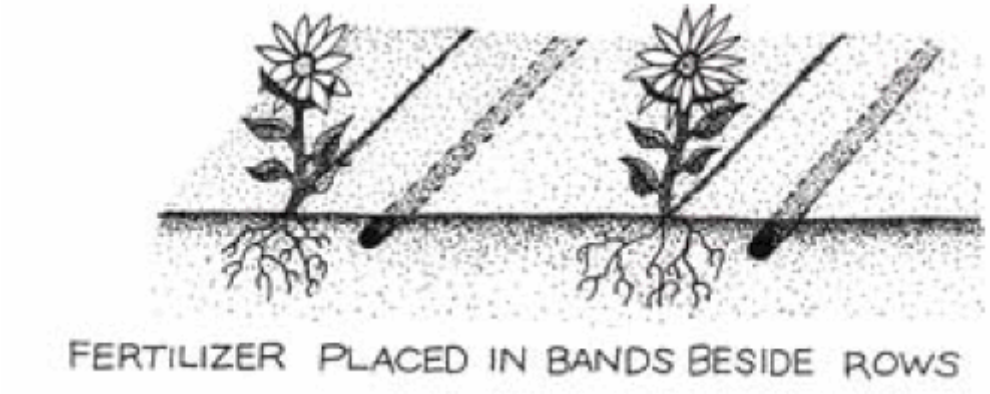
Application of fertilizers to the fruit trees is a very important management practices that influences the bearing of fruit trees. Application of proper dose manures and fertilizers in right time and right manner is the most important practice in orchard management. Fruit trees are exhaustive, so they remove large amount of nutrients from the soil which need to be replenished by external application. An orchard can be maintained in commercial bearing only by adding adequate manuring.

**Time of application:** From February to April the tree fruits have the highest requirements of nutrients for vegetation, flowering and fruit setting. The best time for applying nitrogenous fertilizers is about two weeks prior to the initial of growth and flowering. If the quantity is small, the application can be done in single dose. If it is large, split the quantity in two equal doses; one before the initiation of growth and second after fruit set. The phosphorous fertilizers should be applied along the nitrogenous fertilizers. The potassium fertilizers should be applied in spring or in some fruits trees about 4-5. weeks prior to the fruit maturity as it improves fruit quality. Organic manures should be applied about 3 months ahead of the spring flush so that by that time nutrients are converted into readily available forms. The time of application of micronutrients depends upon the kind of fruit tree and severity of deficiency, if the deficiency is mild; one spray in April may be enough but if the deficiency is acute 4-5 repeated sprays at monthly intervals may be needed to correct deficiency. Usually, the sprays are more effective than soil application.

**Method of application:** The method of application should be appropriate taking into consideration the age of trees, their root extensibility, type of orchard management, kind and method of fertilizers to be applied. The different methods are as follows:

1. **Broadcasting:**
   Spreading the fertilizer uniformly over the entire field. This is applicable in full bearing or closely planted orchard. Suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphate fertilizers such as rock phosphate are used. In this methods nutrients cannot be fully utilized by plant roots as they move laterally over long distances and the weed growth is stimulated all over the field.

2. **Band/stripe placement:** This placement can be made either in bands or in trenches around the tree or fertilizers are drilled or injected into the soil. This method is commonly used when fertilizers are applied in small quantities to young trees and when phosphorous and potassium fertilizers need to be incorporated into the root zone or in case of plants with poorly developed root system.




3. **Foliar application:** It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliar of growing plants. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them. The concentration of the sprayed solution has to be controlled; otherwise serious damage may result due to scorching of the leaves. Foliar application is effective for application of micronutrients like Zinc, sulphur, boron and manganese. Sometimes insecticides are also applied along with fertilizers. This method has been commercialized in a number of fruit crops like citrus, pineapple, guava, etc.


4. **Application through irrigation water (Fertigation):** It refers to the application of water soluble fertilizers through irrigation water. The nutrients are thus carried into the soil in solution. Generally nitrogenous fertilizers are applied through irrigation water. If possible fertigate a day or two after rain or after a normal irrigation, so that the soil is moist.