**1. Concept of Crop Production:**

**1.1 Crop**

A crop is a community of plants grown under field conditions for its economic value. Crops produce food, fodder, fuel, fiber, drugs, condiments (crops that add color, flavor or taste) and other economic products.

The crop plants are derived from wild progenitors through selection and breeding, have characteristics of agronomic value as against survival characteristics in the in the wild progenitors. The value of a crop is dependent onto ability to produce larger amount of useful material. Crop plants or cultigen (specie or variety) needs those environmental conditions which allow a high possibility of a satisfactory and consistent yield of harvestable parts for which it is cultivated.

**1.2 Crop Production/Cultivation**

Crop production or cultivation is the process of growing crop on a piece of land.

Crop production involves land preparation(tillage), sowing, fertilizer application, irrigation, weed control, insect and disease management, harvesting, threshing and storage of crops. Crop production is actually the management of the both crop and the environment in which the crop is grown.

**1.2.1 General guidelines for crop production**

1. **Cultivar**

Select the best cultivar of the crop recommended for cultivation in your area.

1. **Field / Soil**

The soil should be prepared in advance.

1. **Manure**

Apply well rotten farm yard manure 1-2 months before sowing and mix it in soil.

1. **Seed Bed**

Prepare a deep and well pulverized seed bed for seed sowing.

1. **Inoculation**

If a leguminous crop is grown for the first time, the soil or seed must be inoculated by rhizobia (N-fixing bacteria).

1. **Commercial Fertilizer**

Synthetic fertilizers like urea, DAP, potassium sulphate, etc. should be applied with last ploughing i.e. before sowing. Half N should be applied at sowing N should be applied in 1-2 splits with irrigation. In rainfed (Barani) areas all fertilizer should be applied at sowing time. As leguminous crops require comparatively less nitrogen than other crops, therefore distinction has to be made when applying N fertilizer.

1. **Rotation**

In multiple cropping system, the crops must be rotated to achieve maximum yield without affecting soil fertility. This should be practiced in such a way that leguminous crops are followed by other crops.

1. **Seed**

Selection of good seed is of prime importance for raising crops and harvesting good yield. Select the best quality seed supplied by recognized agency or a reputed dealer.

1. **Method of Sowing**

Seeds of food grains and cash crops should be sown at definite depth and distance in rows by rabi or kharif drill. The seeds should be covered with soil after placing in rows. Fodder crops can be sown by broadcasting i.e. scattering of seed by hand and then covered with soil. This requires higher seed rate per unit area as compared to drill sowing.

1. **Irrigation**

Kharif crops usually have higher requirements of irrigational water than rabi crops. Preferably irrigate the field in the evening, particularly in summer months to reduce evaporation losses. Most field crops do not tolerate standing water for longer time, therefore do not allow water to remain standing in the field for longer period except for rice.

1. **Multi-harvest Crops**

Some fodder crops are multi-cut/multi-harvest. Apply fertilizer and irrigation after each cutting of fodder crops such as alfalfa (Lucerne), berseem(clover) and Shaftal (Persian clover). This will increase the succulence and yield of fodder.

1. **Thinning**

This may be necessary in order to have optimum plant population. This should be done within a month of germination. The weak and damaged plants should be removed first. Thinning is often done to reduce competition between plants, facilitate hoeing, harvesting and improve yield and quality of the produce. The number of plants per unit area depends on various factors such as plant character, duration of crop, time and method of sowing, soil fertility, purpose of cultivation, management practices and method of harvesting.

1. **Weeding**

Control weeds as early as possible. Weeding should be done when the field is in watter condition after irrigation. Hoeing and inter-culturing should be performed with light tools and implements. It should not be too frequent and deep. These operations should be completed before the reproductive stage of the crop. Kharif crops usually have higher weed infestation than rabi crops.

1. **Insect-Pests and Diseases**

 The field should be periodically checked for insect-pests and disease attack. The should be controlled by appropriate pesticide spray. As prevention is better than cure so it is wise to select disease resistant cultivars. Moreover, control by crop rotation is preferable.

1. **Harvesting and Storage**

Seed crops should be harvested at physiological maturity to avoid shattering of seed, particularly in grain legumes. Drying and yellowing of leaf or disappearance of the green color of the plant is generally an indicate of maturity in most field crops.

1. **Storage**

Storage at 10% moisture level is preferable. Storage bags and bins should be clean and dry. For log storage, the store or bin must be fumigated. Check insect/rodent attack periodically for proper and timely treatment.

**Field Capacity**

It is the moisture content in the soil after drainage of excess water from the soil.

OR

It is the soil condition when downward movement of water is ceased. It is usually achieved after 2-3 days of irrigation or rainfall. At this stage soil water contents are about 70%.

**Optimum Soil Water Content for Tillage**

It is the water content of soil at which you could compact it the most. It there is too little moisture, soil would resist compaction. Tillage should be done when soil has moisture content slightly less than field capacity.

**Available water**

Field Capacity is the upper limit of available water. The lower limit is the “permanent wilting point” when water is retained by the soil so strongly that it cannot be used by plants.

Field capacity = Saturation capacity – Gravitational water

Sandy and deep soils reach field capacity in a much shorter time than clayey soil and shallow soil. The water retained in a soil which represents the difference between field capacity and permanent wilting percentage is the available water.

**2. Classification of Crops:**

Crop classification is done to group similar plants as a class for better understanding.

1. Classification helps in identification of similar plants used for various purposes such as food, feed and fiber.
2. Crop classification is essential for orderly reference and avoiding confusion identification. E.g. There are more than 300 kinds of clover which are similar in appearance but differ from one another in specific way (berseem, shaftal). It is difficult to identify and refer them without proper naming and classification.
3. The common names in different countries are different according to local language. Even within the same country and the same language, the common names are different E.g. Wild oat is called Javi, Joudri in different parts of Punjab. Hence, long ago it was felt that every distinct plant species should have one name understood by all. This name is called botanical or technical name and it is written in Latin.

**2.1 Basis of Crop Classification**

Crop plants can be classified according to their structural features(botanical), agronomic use, biochemical pathways, life cycle(ontogeny) and climate requirements. Followings are different bases of crop classification:

1. **Botanical/Scientific Classification**

Botanical names of plants consist of genus and species and are universally accepted. **Carolus Linnaeus**, a Swedish botanist (1707-1778) was responsible for this binomial system of classification. The basic unit in this classification is the species.

**Species: -** can be classified as a group of plants that normally breed among themselves and have many characters in common.

* Closely related species are grouped into a genus.
* Closely related genera are grouped into a family.
* Closely related families are grouped into orders.
* Orders are grouped into classes and then classes into divisions or phyla.

For example, Wheat and Alfalfa can be classified botanically into following manner.

|  |  |  |
| --- | --- | --- |
|  | **Wheat(grass)** | **Alfalfa(legume)** |
| **Species** | aestivum | sativa  |
| **Genus**  | Triticum | Medicago  |
| **Family**  | Gramineae | Leguminasea |
| **Order**  | Graminales  | Rosales  |
| **Sub-class** | Monocotyledonae  | Dicotyledonae  |
| **Class**  | Angiospermae  | Angiospermae |
| **Division/Phylum** | Spermatophyta | Spermatophyta |
| **Kingdom**  | Plantae  | Plantae |

**Variety: -** A group of similar plants within a particular species that is distinguished by one or more than one character and given a name E.g. Shahkar have long ears, Inqlab-91, Faisalabad 2008.

**Cultivar: -** A cultivated variety is called a cultivar.

**Botanical Variety: -** when a group of plants occurring in nature is different from the general species it is classified as botanical variety.

**Divisions of Plant Kingdom**

1. **Thallophyta**

Simplest plants, no roots, stems or leaves E.g. Algae, Fungi and Bacteria

1. **Bryophyta**

Green plants without real roots and flowers. They grow in wet places and widely distributed worldwide e.g. Mosses, liverworts and hornworts. They have no economic use.

1. **Pteridophyta**

These are green plants having roots, leaves, stems and vascular tissue. They are unable to produce flowers and seeds. They reproduce by spores such as ferns and ornamental plants.

1. **Spermatophyta**

They are highly developed plants which produce flowers and seeds. They are divided into two subdivisions.

1. **Gymnosperms**

These are cone-bearing trees such as pine and cedar.

1. **Angiosperms**

These are highly specialized plants reproduce by seeds within an ovary. These are mostly the crop plants.

1. **Crop Classification on the basis of life cycle (Ontogeny)**

On the basis of life cycle crops are divided into three groups.

1. **Annual crops**

Crop plants that complete life cycle within a season or year. They produce seeds and die within the season E.g. wheat, maize, rice, barley, mustard etc.

1. **Biennial crops**

Plants that have life spam of two consecutive seasons or years. In the first year/season, these plants grow vegetatively and reserve food in their root or other parts. During the second year/season they produce flower and after producing seeds the plants die E.g. sugar beet, radish, carrot, onion, turnip etc. However, these plants are harvested during the vegetative stage to obtain commercial products.

1. **Perennial crops**

These crop plants live for three or more years. They may be seed bearing or non-seed bearing. These crop plants have regenerative power to re-sprout from the stubble after cutting E.g. sugarcane, alfalfa, cotton, Napier fodder grass, coconut etc.

1. **Agronomic Classification**

In this system crop plants are classified according to their use.

* **Cereal crops**

These are grasses grown for their edible seeds. Cereals are also known as grain crops. Cereal grains contain 60-70% starch and almost 95% of total starch used by human comes from cereals.

Cereals are also providing fat, soluble vitamin E. Cereal grain contain 20 to 30 % of the daily requirements of minerals such as selenium, calcium, zinc and copper. The major cereals are wheat, maize, rice, barley, oat, rye, triticale, sorghum, millet.

* **Forage crops**

Those crops which are grazed by animals or harvested for green chop, hay or silage. Technically forages have been defined as plant material with a dry matter fiber content over 25%.

These are grown specially to be grazed by livestock or conserved as hay or silage.

* **Hay: -** Grass or other plants such as clover or alfalfa, cut and dried for fodder.
* **Silage: -** Forage preserved in a succulent condition by partial anaerobic acid fermentation.
* **Fodder:** **-** When maize, sorghum, or other coarse grasses (including seeds and leaves) are harvested as whole plants and used for animal feed, they are termed as fodder.

Common examples of forage or fodder crops are alfalfa(lucerne), clovers (shaftal, berseem), sorghum, oats, barley etc.

* **Fiber crops**

These crops are grown for obtaining fiber. Different kinds of fiber are

* Seed fiber E.g. cotton
* Stem fiber E.g. jute, sun hemp, flax, kenaf, sisal

Fiber is used in textile, making ropes and bags.

* **Sugar crops**

These are grown for obtaining sugar E.g. sugarcane, sugar beet.

* **Oil seed crops**

These crops are grown for the purpose of extracting oil from their seeds. Major crops are rapeseed(canola), mustard, ground nut, sunflower, safflower, soybean, sesame, caster bean, linseed or flax.

* **Pluses or grain legumes**

These crops belong to the *Leguminoseae* (*Fabaceae*) family and are grown for edible seeds, E.g. chickpea, pea, pigeon pea, cowpea, mung bean, mash bean and lentil etc.

* **Root and tuber crops**

These are vegetable crops grown for underground parts like roots, bulbs, rhizomes and stem tubers E.g. carrot, radish, turnip, onion, garlic and potato.

* **Tuber: -** potato, sweet potato
* **Root: -** Radish, carrot, turnip, beet
* **Bulb: -** Onion, garlic
* **Narcotic or drug crops**

These crops have some narcotic or drug value E.g. poppy, tobacco, tea, caster bean, mint. These are also called medicinal crops.

* **Vegetable or garden crops**

Vegetable crops which are grown for their edible leaves, shoots, flowers, fruit and seeds E.g. broccoli, cabbage, cauliflower, cabbage, spinach, pumpkin, tomato, eggplant etc.

* **Spices and condiments**

Crops or their products used for flavor, taste and add color to the fresh or preserved food E.g. ginger, garlic, fenugreek, turmeric, chillies, onion, coriander etc.

* **Condiments: -** are added to a dish to add or complement its flavor. E.g. mustard, soy bean.
* **Spices: -** are dried seeds, root, bark or other vegetative matter used to add flavor and color to a dish. E.g. pepper, fennel, cloves, turmeric, ginger.
1. **Classification on the basis of Season**

For the purpose of planting, water rates and Govt. revenue crops are divided into two major seasons.

1. **Kharif crops**

Those crops which are planted from March-July and harvested in autumn or winter are called kharif crops. E.g. Maize, rice, sorghum, millet, peanut, sesame, soy bean, sunflower etc.

1. **Rabi crops**

The crops which are planted in winter from Oct-Dec and harvested in summer from March-May. E.g. Wheat, barley, gram, lentil etc.

1. **Zaid Kharif crops**

These are planted in Aug-Sep and harvested in Dec-Jan E.g. Toria.

1. **Zaid Rabi crops**

These are crops which are planted in February and harvested in May-June E.g. Tobacco, Musk melon.

1. **Crop classification on the basis of growth habit**

In this system plants are classified according to their mode of vegetative and reproductive growth.

1. **Determination plants**

Those plants which initiate their reproductive stage after completing vegetative growth E.g. wheat, barley and rice.

1. **Indeterminate plants**

In these plants vegetative and reproductive stages continues simultaneously. Mature and immature fruits, flowers and flower buds are all present on one plant at the same time E.g. tomato, okra, eggplant, cucumber and water melon.

Soybean is the only crop which has determinate and indeterminate as well as semi-determinate growing type.

1. **Crop classification on the basis of mode of CO2**

This classification is based on the effective utilization of resources and the mode of CO2 fixation.

1. **C3 plants or inefficient plants**

During photosynthesis, some plants fix CO2 and form a three-carbon-molecule, 3-phosphoglyceric acid (3PGA). This pathway was first worked out by Calvin and his co-workers. Plants with this pathway of carbon assimilation are called C3 pathway plants. Such plants cannot utilize CO2 efficiently, therefore they are also called inefficient plants. Wheat, oar, rice, banana and cotton fall in this category.

1. **C4 plants or efficient plants**

Another pathway of CO2 fixation was found in some plants by Hatch and Slack (1966). In these plants the first product of photosynthesis is a four-carbon molecule. Plants which fix CO2 via the Hatch and Slack pathway are called C4 plants. These plants do not exhibit photo-respiration and make efficient use of CO2, light, temperature, and water. Therefore, they are called efficient plants. The best examples of efficient plants are sugarcane, sorghum and maize.

1. **Crassulation acid metabolism (CAM) plants**

CAM plants fix CO2 into four-carbon acids as do the C4 plants. Fixation CO2, however, occurs at night when the stomata are open. Typical CAM plants grow in deserts and have succulent fleshy leaves and stems with low transpiration and water requirements, e.g. pineapple and prickly pear.

1. **Crop classification on the basis of mode of pollination**

Pollination is the transfer of pollen from anther to a stigma. According to the mode in which pollen is transferred, plants fall into two groups.

1. **Self-pollinated plants**

Those plants in which the pollen from an anther is transferred to the stigma of the same plant in the same flower or in different flowers of the same plant.

Only 1-3% cross-pollination occurs in these plants E.g. wheat, barley, rice, sorghum, soy bean, okra, most pulses, tobacco and tomato.

1. **Cross pollinated crops**

In these plants, the pollen grains from anther of one plant are transferred by insects, winds or other means of stigma of another plant. These plants have open flowers and cross pollination occurs up to 96%. E.g. maize, brassica, sunflower, grapes, mango and alfalfa.

* “in cotton and sorghum both self and cross pollination.”
1. **Crop classification on the basis of mode of propagation**

**Propagation**

The production of off springs from a single mother plant is called propagation.

There are two types pf crops on the basis of mode of propagation.

1. **Sexually propagated plants**

 These plants are propagated by seeds. E.g. sorghum, gram, maize and rice etc.

1. **Asexually propagated plants**

 Those plants which are propagated asexually by using specialized plant parts or utilizing artificial techniques such as cutting, grafting and layering. E.g. sugarcane, potato, garlic, ginger and fruits and ornamental plants.

These plants also called vegetatively propagated plants.

1. **Crop classification on the basis of climate zones**

Various crops adopted different climate zones.

1. **Temperate zone crops**

These crops can tolerate very low temperatures. Temperate zone climate can exist even in the tropics at high elevations E.g. in Kalam, Sawat, Chitral and Gilgit. Wheat, oat and rye are major temperate zone crops. Temperate zone fruit plants such as almond and apple resume growth after chilling requirement. “Chilling is the substantial amount of winter cold required by some plants before flowering”.

1. **Tropical crops**

These crops grow in areas where frost does not occur. Normal growth of these crops is affected by temperatures below 10oC and plants are liked at freezing temperature. E.g. sugarcane, mango, banana papaya and pineapple.

1. **Sub-tropical crops**

These crops can tolerate some sub-freezing temperatures but cannot grow well in temperate or tropical zones. Sub-tropical plants are liked temperatures below -7 oC. Sub-tropical plants are citrus, date, fig and pomegranate. The climate of Pakistan is semi-arid sub-tropical.

1. **Crop classification on the basis of photoperiod**

Plants grow vegetatively and then change from vegetative to reproductive stage by producing flowers and fruits. This change is brought about by changes in day length i.e. numbers of hours of light.

On the basis of response to day length crops are classified into three groups.

1. **Shor-day plants**

These plants change from vegetative to reproductive stage when the days become shorter. If they are kept in long-day environment, their vegetative growth will continue, E.g. soybean and rice.

1. **Long-day plants**

These plants change from vegetative to reproductive stage when days become longer. In shorter day environment these plants will continue to grow vegetatively, e.g. wheat, barley, oat and gram.

1. **Day-neutral plants**

Plants whose initiation of flowering is not affected by the length of day like potato and cucumber.

1. **Special purpose classification**

Sometimes certain crops are grown for specific purposes under various circumstances.

1. **Catch or emergency crops**

These crops are grown to substitute major crops that have failed due to unfavorable conditions. E.g. if the sowing of wheat is delayed due to cotton plant maturity farmer can plant berseem (a quick sowing crop). Similarly, if sugarcane crop is failed due to less water availability then farmers can plant sorghum (which needs less water)

1. **Cash crop**

A crop which is grown to generate income rather than substitute E.g. cotton, sugarcane and rice.

1. **Cover crop**

These crops are planted to provide a cover for soil and reduce erosion and nutrient losses by leaching E.g. clover and rye.

1. **Companion crop**

The growing of two crops together is called companion cropping E.g. berseem and barley, berseem and oat. Maize and lobia sometimes grown together.

1. **Green manure crops**

These crops are grown and when reach at maximum vegetative growth are incorporated in the soil. The purpose of G.M is to improve soil fertility E.g. berseem, guara and cowpea.

1. **Relay crops**

A relay crop is planted as a second crop when the first crop has reached to reproductive stage but before harvesting E.g. planting of wheat in standing cotton.