EduTap

# SUMMARY SHEET

## *Agronomy and Field crops*

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# 1 Agronomy

## 1.1 Definition or meaning

- ✓ Agronomy is one of the branches of Agriculture, wherein the word **"Agronomy"** is derived from a **Greek word 'agros' meaning 'field' and 'nomos' meaning 'management'**.
- ✓ Agronomy is **branch of agricultural science,** which **deals with principles, and practices of soil, water, and crop management**.

**Norman Borlaug (1980)** has defined **"Agronomy as the science of manipulating the crop environment complex with dual aims of improving agricultural productivity and gaining a degree of understanding of the process involved."**

***Pietro de'Crescenzi** is **the father of Agronomy**.*

## 1.2 Branches of Agronomy

There are three branches of Agronomy viz.,

- ✓ Crop Science (Only field crops)
- ✓ Soil science
- ✓ Environmental Science (deals with applied aspects)

***The central theme of agronomy is "Soil-Crop-Environment relationship".***

** Kindly note, we will learn more about field crops (the 1st branch of Agronomy) in this chapter in detail and the rest two (Soil sciences and Applied aspects of environmental sciences in the coming chapters).*

## 1.3 Dimensions of Agronomy

There are 4 major dimensions of Agronomy. In simpler words, Agronomy has 4 major features.

1. Physical dimension – includes Soil, Water, nutrients, and Solar radiation
2. Biological dimension – includes Crops, Forests, Vegetation etc.,
3. Economic dimension – includes farm structure, ownership of land, markets, sales etc.,
4. Social dimension – includes Food, nutrition, health etc.,

***Agronomy is a main branch of Agriculture. It is synthesis of several disciplines like soil science, Agricultural chemistry, crop physiology, plant ecology, biochemistry, and economics.***

### 1.4 Scope of Agronomy

- ✓ **Identification of proper season for cultivation**
- ✓ **Proper methods of cultivation**
- ✓ **Availability and application of chemical fertilizers**
- ✓ **Availability of herbicides for control of weeds**
- ✓ **Water management practices**
- ✓ **Intensive cropping**

## 2 Introduction to Crops

### 2.1 Definition or Meaning of Crops

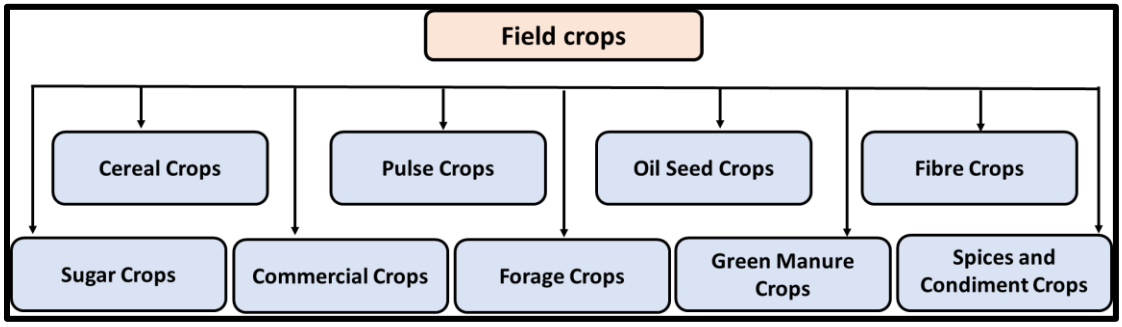
- ✓ **Crop** may be **defined as a cultivated plant that is grown commercially on a large scale**.
- ✓ **Example:** Field Rice - Rice grown primarily to meet the food requirement of humans.

## 3 Field Crops

### 3.1 Definition or Meaning of Field Crops

- ✓ **Field crop** may be **defined as a "CROP" (other than fruits or vegetables) that is grown for agricultural purposes** and on large scale.
- ✓ **Examples:** Cotton, Cereal, Pulses etc., are field crops

### 3.2 Classification of Field crops based on the use of plants and their products




#### 3.2.1 Cereal Crops

- ✓ **A cereal** is generally **defined as** a **cultivated grass grown for their edible starchy grains**.
- ✓ Cereals can again be divided into 2 types.

#### A. Major Cereal Crops:

- ✓ The **larger grains** that are **used as staple food** is considered as major cereals.
- ✓ **Examples:** Paddy/Rice (*Oryza sativa*), Wheat (*Triticum aestivum)* etc.,

### B. Millets:

- ✓ Millets can again be divided into 2 types.
  a. Major Millets
  b. Minor Millets

| | Major Millets | Minor Millets |
|---|---|---|
| **Meaning/Main Characteristics** | These are **found in abundance and grown in large quantities by farmers**. These are **easy to grow, and proper irrigation is essential** in growing these varieties. | These are yet another nutritious group of seed type plants which **are grown mostly for the use of fodder**. These are **highly nutritional in content and can be grown on residual moisture** (of previously grown crop). |
| **Examples** | Sorghum/Jowar/ Great millet (*Sorghum bicolor*), Bajra/Pearl millet (*Pennisetum typhoides*), Ragi/Finger millet (*Eleusine corcana*) | Foxtail millet (*Setaria italica*), Little millet (*Panicum milliare*), Kodo millet (*Paspalum scrobiculatum*), Proso millet (*Panicum millaceum*), Barnyard millet (*Echinochloa frumentaceae*) |

## 3.2.2 Pulse Crops

- ✓ Pulses are **grain legumes** used as food. The word legume is derived from the Latin word 'legere', with means 'to gather'.
- ✓ They help in maintaining the soil fertility as these crops have the **unique built-in ability of fixing atmospheric nitrogen in their root system**.
- ✓ Pulses can again be divided into 3 types.

| | Grams | Beans | Peas |
|---|---|---|---|
| **Meaning/Main Characteristics** | Generally, these are **grain legumes where grain is used for commercial purposes** and can be stored for long with proper care. | These are **generally used as vegetable but also the seeds can be stored and used for other commercial** purposes | These are a different class of legumes **belonging to specific genus with specific nutrirional value**. Actually the seeds are called Peas. |
| **Examples** | Red gram/Pigeon pea (*Cajanus cajan*), Bengal gram/ Chick pea (*Cicer arietinum*), Black gram/Urad (*Phaseolus mungo/Vigna mungo*), Green gram/Mung (*Phaseolus aureus/Vigna radiata*), Horse gram (*Macrotyloma uniflorum*). | Soybean (*Glysine max*), Field bean (*Dolichos lablab*), French bean (*Phaseolus vulgare*), Cluster bean (*Cyamopsis tetragonoloba*). | Pea (*Pisum sativum*), Cow pea (*Vigna unguiculata/V. sinensis*) |

## 3.2.3 Oil Seed Crops

- ✓ Oil seed crops are **grown for the purpose of oil**.
- ✓ These are again of 2 types

| | Edible Oil Seed Crops | Non-Edible Oil Seed Crops |
|---|---|---|
| **Meaning/ Main Characteristics** | As the name suggests, **these are edible oil** seed crops. | As the name suggests, these are **non-edible oil** seed crops, which are **used for some other purposes like oil for lamps, medicines** etc., |
| **Examples** | Ground nut/Pea nut (*Arachis hypogaea* ), Soybean (*Glysine max* ), Sunflower (*Helianthus annus* ), Safflower (*Carthamus tinctorius* ) | Karanja (*Pongamia pinnata* ), Mahua (*Madhuca indica* ), Castor seeds (*Ricinus communis* ) |

### 3.2.4 Fibre Crops

- ✓ These plants are **grown for extraction of fibres** which are mainly **used for clothing, rope making, carpet making and other purpose**s.
- ✓ These are again of 3 types based on the part of plant from which fibres are produced/extracted.

| | Fruit Fibres | Stem/Stalk/Bast Fibres | Leaf Fibres/ Hard Fibres |
|---|---|---|---|
| **Meaning/Main Characteristics** | As the name suggests, fibre is **extracted from the fruits of the plant** | As the name suggests, fibre is **extracted from the stem or stalks of the plant** | As the name suggests, fibre is **extracted from the leaves of the plant** |
| **Examples** | Cotton (*Gossypium hirsutum* ), Silk cotton (*Ceiba pentandra* ) | Jute (*Corchorus capsularis* ), Mesta (*Hibiscus cannabinus* ), Linseed /flax (*Linum usitatisamum* ) | Sisal (*Agave sisalana* ), Manila hemp (*Musa textiles* ) |

### 3.2.5 Sugar Crops

- ✓ Crops are grown to produce sugars and starch. **Example:** Sugarcane (*Sacharum officinarum*)

### 3.2.6 Commercial Crops

- ✓ In these crops, more than 75 per cent of the product is for trade but not for home consumption.

**Examples:** Sugarcane (*Saccharum officinarum*), Cotton (*Gossypium hirsutum*) etc.,

### 3.2.7 Forage Crops

- ✓ Forage crops refer to vegetative matter, fresh or preserved, utilized as feed for animals.
- ✓ It includes fodder, hay, silage, and pastures. **Examples:** Guinea (*Panicum maximum*), Setaria (*Setaria anceps*)

***Silage crops:*** *Such crops like corn, legumes, and grasses that have been harvested at early maturity, finely chopped, packed tightly to exclude air, and stored in tower silos, pits, or trenches for properly fermentation which is used as animal feed during lean period or off season.* ***Examples:*** *Maize, cowpea, Jowar, sorghum etc.*

### 3.2.8 Green Manure Crops

✓ Green manure crops are those crops which are used for incorporating their plant tissues into the soil for improving the soil productivity. **Examples:** Sunnhemp (*Crotalaria juncea*), etc.

### 3.2.9 Spices and Condiment Crops

✓ Products of the plants used to provide flavor and sometime color the fresh preserved food.

**Examples:** Ginger (*Zingiber officinale*), Garlic (*Allium sativum*) etc.

## 3.3 Classification of Field crops based on Ontogeny (Life cycle)

Based on the lifecycle of the Field crops, there are 3 types of field crops. They are

| | Annual crops | Biennial crops | Perennial crops |
|---|---|---|---|
| **Meaning/ Definition** | Crop plants that complete life cycle within a season or year. | Plants that have life span of two consecutive seasons or years. | They live for three or more years. |
| **Important Characteristics** | They produce seed and die within the season. | First years/ season, these plants have purely vegetative growth usually confined to rosette of leaves. The tap root is often fleshy and serves as a food storage organ.<br>During the second year / season, they produce flower stocks from the crown and after producing seeds the plants die. | They may be seed bearing or non-seed bearing. |
| **Examples** | Paddy/Rice (*Oryza sativa*), Wheat (*Triticum aestivum*), Maize (*Zea mays*), Mustard (*Brassica Spp*.) etc. | Sugar beet (*Beta vulgaris*) etc., | Napier fodder grass (*Pennisetum purpureum*), Coconut (*Cocos nucifera*) etc., |

## 3.4 Classification of Field crops based on Seasons

✓ **This classification is not a universal one**. It only **indicates the period** when **a particular crop is raised.** There are three major field crops based on seasons which is generally used by botanists.

| | Kharif Crops | Rabi crops | Summer/Zaid crops |
|---|---|---|---|
| **Main characteristics** | **Sowing season:** June-July **Harvesting season:** September-October. | **Sowing season:** October-November **Harvesting season:** March-April. | **Sowing season:** February-March **Harvesting season:** May-June |
| **Other requirements** | They **require a warm wet weather** during their major period of growth and **shorter day length** for flowering. | They **require cold dry weather** for their major growth period and **longer day length** for flowering. | They **require warm dry weather** for growth and **longer day length** for flowering. |
| **Examples** | Rice, maize, castor, groundnut. | Wheat, mustard, barley, oats, potato, bengal gram, berseem, cabbage and cauliflower Chickpea | Watermelon, musk melon, cucumber Seasonal vegetables, etc |

## 3.5 Classification of Field crops based on Mode of pollination

- ✓ Pollination is the **act of transferring pollen grains from the male part (anther) of a flower to the female part (stigma)**.
  - Unisexual flowers have only one kind of sex organ, either stamen or pistil.
  - The flower possessing both male and female reproductive parts are a bisexual flower.
- ✓ If it's a bisexual flower and self pollinated, pollination can happen naturally by pollen getting transferred to the pistil. But in unisexual flowers, it cannot happen on its own, it needs an agent to carry the pollen from the Stamen to reach ovary of the Pistil to fertilize into an embryo and then transform into a seed.

- ✓ ***Water pollination is called as Hydrophily.***
- ✓ ***Wind pollination is called as Anemophily.***
- ✓ ***Pollination by animals is called as Zoophily***
- ✓ ***Pollination by insets is called entomophily.***

- ✓ There are 3 types of crops based on pollination:
  1. Naturally or Normal Self- pollinated Crops
  2. Naturally or Normally Cross-pollinated Crops
  3. Often Cross Pollinated Cross

**I. Natural or Normally self-pollinated crops**

- ✓ These crops show a high degree of self-pollination (>95%) and cross-pollination is less than five percent. E.g., Barley, Ragi, Wheat, Beans, Grams, Groundnut, Sesamum, and Tobacco.

**II. Naturally or normally cross-pollinated crops**

✓ In these crops, cross-pollination occurs predominantly(>95%) with very little (i.e., 5 %) self-pollination. Example:

a. Field Crops: Alfalfa, Castor, Beans, hemp, Maize, Rye, Castor, Mustard, Sugarcane, and Sunflower.

b. Horticulture Crops. E.g., almonds, Apples, bananas, Cherries, Chestnut, Citrus, Datepalm, Grapes, Fig, Papaya, Mango, etc.)

c. Vegetables. E.g., All Cruciferous plants.

**III. Often cross-pollinated crop:**

✓ These crops are normally self-pollinated. However, cross-pollination in these crops usually exceeds five percent due to various agencies. E.g., Sorghum, Cotton, Safflower, etc.

## 3.6 Classification of Field crops based on Depth of the root system

**The root system of field crops differs in structure, function and extent**. Therefore, field crops can be classified according to the depth of their roots into 3 types

| | Hallow root crops | Intermediate crops | Deep root crops |
|---|---|---|---|
| **Meaning** | The **root system** of these crops extends in the soil to a **depth of one meter**. | The **depth** of the **root system** of these crops **ranges from 1-1.5 meters**. | The **root system** of these plants extends in the soil to a **depth more than 1.5 meters**. |
| **Examples** | Wheat, barley and rye. | Faba bean and sugar beat. | Alfalafa. |

## 3.7 Classification of Field crops based on the root system

There are 2 types of Field crops based on the Root system. They are

| | Tap root system | Adventitious/Fiber rooted |
|---|---|---|
| **Meaning** | The **main root goes deep into the soil**. | The crops whose roots are **fibrous shallow & spreading**. |
| **Examples** | Red gram, Grape. | Cereal crops, wheat, rice etc. |

## 3.8 Classification of Field crops based on $CO_2$ fixation

✓ **Carbon fixation or carbon assimilation** is the **conversion process of inorganic carbon (carbon dioxide) to organic compounds (Carbohydrates)** by living organisms, one of such processes is commonly **called as Photosynthesis** in plants.

Photosynthesis can be represented in the form of equation which is as follows

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

***Photosynthetically active radiation, often abbreviated PAR, designates the spectral range (wave band) of solar radiation from 400 to 700 nanometers that photosynthetic organisms are able to use in the process of photosynthesis***

### 3.8.1 Mechanism of photosynthesis

✓ Photosynthesis is a **complicated oxidation-reduction process** where **water is oxidized and CO2 is reduced** to carbohydrates. The **mechanism of photosynthesis consists of two parts**

| Light reaction | Dark reaction |
|---|---|
| **ATP and NADPH2 are produced** | **CO2 is reduced with the help of ATP and NADPH2** to **produce glucose** |
| It is also called as Hill's reaction as Hill proved that chloroplast produce O2 from water in the presence of light | The concept of dark reaction in photosynthesis was initially explained by Blackman. It is thus also known by the name Blackman's reaction. |
| It is also called as Arnon's cycle because Arnon showed that the H+ ions released by the break down of water are used to reduce the coenzyme NADP to NADPH | 2 types of cyclic reactions occur. They are **Calvin cycle or C3 cycle and Hatch slack cycle or C4 cycle** |

| C3 Cycle | C4 Cycle |
|---|---|
| 1. C3 cycle operates in all plants. | 1. C4 cycle operates only in C4 plants. |
| 2. The primary CO2 acceptor is Ribulose bi phosphate (RUBP a 5 Carbon compound). | 2. The primary CO2 acceptor is Phosphoenol pyruvic acid (PEP, a 3 Carbon compound). |
| 3. The first stable product is a 3-Carbon compound, phosphoglyceric acid (PGA). | 3. The first stable product is a 4-Carbon compound, oxalo acetic acid (OAA). |
| 4. The carboxylase enzyme is Rubisco. | 4. The carboxylase enzyme is PEP carboxylase and Rubisco. |
| 5. Single CO2 fixation. | 5. Two CO2 fixation. |
| 6. CO2 fixation is slow and less efficient. | 6. CO2 fixation is fast and more efficient. |

***Ribulose-1,5-bisphosphate carboxylase/oxygenase, commonly known by the abbreviations RuBisCO, RuBPCase, or RuBPco, is an enzyme involved in the first major step of carbon fixation, a process by which atmospheric carbon dioxide is converted by plants and other photosynthetic organisms to energy-rich molecules such as glucose.***

We are more concerned about C3 Cycle or Calvin cycle and C4 Cycle or Hatch slack cycle because based on this, the plants in plant kingdom are divided into 3 types (**three different processes that plants use to fix carbon** during the **process of photosynthesis**).

| **Feature/ Characteristics** | **C3 Plants** | **C4 Plants** | **CAM Plants** |
|---|---|---|---|
| **Distribution in the Plant Kingdom (% of Plant species)** | 85% | 3% | 8% (mostly succulent plants but not all of them)<br>**Succulent Plants** usually to retain water in arid climates or soil conditions and store water in various structures, such as leaves and stems. |
| **Type of Photosynthesis** | C3 photosynthesis | C4 photosynthesis | CAM photosynthesis |
| **CO2 Fixation Pathway** | via C3 cycle only | via C3 and C4 cycles, spatially (C4 in the mesophyll cell then C3 in the bundle sheath cell) | via C3 and C4 cycles, both spatially (in different parts of same cell) and temporally (C4 at night, C3 at day time) |
| **Stomatal movement** | Stomata open at daytime, close at night | Stomata open at daytime, close at night | Inverted stomatal cycle (open at night, close in the day) |
| **In which type of climate are they found the most?** | Temperate (Cool, wet environments) | Tropical or semi-tropical, high light intensity, high temperature, drought conditions<br>(Hot, sunny environments) | Desert or arid (xeric) habitats<br>(Very hot, dry environments) |
| **Examples (Important)** | Rice, Wheat, Soyabeans, | Sugarcane, maize, sorghum, millet | Cacti, orchids, pineapple |

| | | | |
|---|---|---|---|
| | Barley, Rye, Oats, | | |

**At the end of mechanism of Photosynthesis, food is ready for the plants in the form of Glucose.**

## 3.9 Classification of Field crops based on Climate

Based on the climate, field crops can be classified into 3 types. They are

| | Temperate zone crops | Tropical zone crops | Sub-tropical zone crop |
|---|---|---|---|
| **Meaning** | Crops plants are **winter hardy and tolerate very low temperature.** Can tolerate Chilling temperature. | Crops grow where **frost does not occur during the growing season**. | C**rops can tolerate some sub-freezing temperature, i.e. below 0°C** (below freezing point of water). |
| **Location** | Grow in **latitude between 30° North and 50° south**. | Grow in **latitude between 20° North and 20° south**. | Grow in **latitude between 25° North and 40° south**. |
| **Temperature range** | Chilling temperatures extend from freezing point to, depending on the model, 7 °C(45 °F) or even 16 °C (60 °F) | Normal growth is affected by temperature below 10°C. Plants are killed at freezing temperature. | Fruits plants are killed by temperature below -7°C. |
| **Examples of Crops** | Wheat, Oat and rye | Rice, Sugarcane, mango, pineapple etc. | citrus, date, fig and pomegranate etc. |

## 3.10 Classification of Field crops based on nutrient uptake

There are 2 types of crops based on nutrient uptake. They are

| | Restorative crops | Exhaustive crops |
|---|---|---|
| **Meaning** | Crops which **return nutrient and organic matter to the soil**. | Crops which **feed heavily on the soil and deplete soil nutrients**. |
| **Examples** | Berseem, alfalfa, soybean, all legume crops etc | Sorghum, tobacco, sunflower etc |

## 3.11 Classification of Field crops based on Special purpose

**Arable crops:** Crops which are cultivated on **ploughed land**. They are **annual crops** and include cereals, root crops, tobacco etc.,

**Aromatic crops:** The crop/plant contain **odoriferous and volatile substances**, which occur as essential oils, gum exudates, balsam, and oleoresin in one or more part of plant, wood, bark, foliage, flower etc.,

**Alley Crops:** Alley crops or hedge-row intercrops is grown under an agroforestry practice in which perennial, preferably **leguminous trees or shrubs are grown simultaneously with arable crop**. **Examples:** Sweet potato, black gram are grown in the passages formed by the rows of eucalyptus etc.,

**Augment crops:** Such crops are grown to **supplement the yield of main crops**. **Examples:** Japanese mustard with berseem.

**Avenue crops:** Such crops are grown **along farm roads and fences**. **Examples:** Pigeon pea, Glyricidia sisal etc.

**Border/guard crops:** Such crops **protect another crop from trespassing of animals** or restrict the speed of wind and are mainly grown as border. **Examples:** safflower (thorny oilseed crop) is planted around the field of gram.

**Cash crops:** A crop, such as tobacco, grown for **direct sale** or a crop grown by a farmer primarily for sale to others rather than for his or her own use **Examples:** sugarcane, cotton, jute, tobacco etc.

**Catch/Contingent crops:** Such crops are cultivated to **catch the forthcoming season when main crop is failed**. **Examples:** linseed, toria, urd, moong, cowpea, etc.

**Contour crops:** Crops are grown on or along the contour line to **protect the land from soil erosion** **Examples:** marvel grass etc.

**Cover crops:** A close growing crop grown primarily to improve or protect the soil from erosion through their ground **covering foliage** and/ or rootmats between periods of regular crop production. **Examples:** Lobia, groundnut, urd, sweet potato, methi etc.

**Complementary Crops:** Both **main and intercrop is benefited to each other**. **Examples:** Jowar+ Lobia

**Competitive crops:** Such crops **compete to each other and are unsuitable for intercropping** **Examples:** Two cereals.

**Energy crop:** An energy crop is a plant grown as **low cost and low maintenance harvest** used to make bio- fuels, or directly exploited for its energy content. **Examples:** Sugarcane, Potato, maize, tapioca.

**Fouling Crop:** Such crops whose **culture practices allow the infestation of weeds intensively**. **Examples:** direct seeded upland rice.

**Ley crops:** Any **crop or combination of crop is grown for grazing or harvesting** for immediate or future **feeding to livestock**. **Examples:** Berseem+ Mustard.

**Medicinal crops:** The crop/plant contains alkaloids, glycosides, steroids or other groups of compounds of medicinal value, which is used commercially.

**Mulch crops:** Such crops are grown to **conserve the soil moisture through their ground covering foliage Example:** cowpea.

**Nurse crops:** A crop of trees (nurse trees), shrubs or other plants introduced to foster or nourishment of other crops by i.e. shading it, protecting it from frost, insulation or wind. **Examples:** Sunhemp in sugarcane, jowar in cowpea, Rai in pea.

**Paira/ Utera crops:** The seed of succeeding crops like Lentil, gram, pea, lathyrus, Berseem, linseed etc. is sown broadcast at 10 to 15 days before harvesting rice crop.

**Paired row crops:** Generally, the third row of crop is removed or growing of crop in pair row and the third row is escaped with an object to conserve the soil moisture in dryland areas.

**Smother crops:** Smother crops are specialized cover crops being ability to suppress weeds by providing dense foliage and quick growing ability. **Examples:** buckwheat, urd etc.

**Stimulate crops:** Stimulate crops **stimulate the human body**. **Examples:** tobacco, opium etc.

**Supplementary crops:** Such cops are neither complementary nor competitive. **Examples:** Maize+ cucurbits.

**Trap crops:** Trap crops are **grown to protect the main cash crop from a certain pest or several pests**. **Examples:** cotton red bug trapped by ladyfinger around cotton.

**Truck crops:** Growing **one or more vegetable crops on a large-scale form fresh shipment to distant markets**. **Examples:** potato, tomatoes, lettuce etc.,

## 4 Famous Names Given to Crops

| Famous Names | Crops |
|---|---|
| **King of Cereals** | Wheat |
| **Queen of Cereals** | Maize |
| **King of coarse Cereals** | Sorghum |
| **Camel Crop** | Sorghum |
| **King of Pulses** | Chickpea |
| **Queen of Pulses** | Pea |
| **King of oil-seeds** | Groundnut |
| **King of Weeds** | Congress Grass |
| **King of fodder Crops** | Berseem |
| **Queen of fodder Crops** | Lucerne |
| **Famine Reserves** | Millets |
| **White Gold of America** | Cotton |
| **Thorny oil-seed crop** | Safflower |
| **Vegetables Meat** | Cowpea |
| **Poor Man's Meat** | Soyabean |
| **Poor Man's substitute for Ghee** | Sesame |
| **Poor Man's Food** | Pearl Millet |
| **Wonder Crop** | Soyabean |
| **Yellow Jewel of America** | Soyabean |
| **Drosophila of Crop Plant** | Maize |
| **Backbone of America** | Maize |
| **Coarsest of Course Millet** | Kodo |
| **Small holder's irrigated crops** | Oil Palm |
| **Golden Fibre** | Jute |

## 5 Important Cell Organelles

| Organelles | Structure | Function |
|---|---|---|
| Nucleus | It is large and oval. | responsible for controlling the activity of the cell, as well as cell division |
| Endoplasmic reticulum | It is the network of tubes or membranes | provides a transport channel within the cell |
| Ribosomes | Small bodies either free or attached to the endoplasmic membrane | help in protein synthesis |
| Golgi bodies | Membranous sacs are stacked to form cisternae | help in cell secretion |
| Mitochondria | Double membranous organelle, rod shaped. | powerhouse of the cell; liberates energy in the form of ATP |
| Vacuoles | It is the membrane bound sacs in the cell. | store cell sap (mainly found in plant cells) |
| Plastids | It is double membrane bound organelle found in plants. | occur in plant cells; responsible for storing pigments |
| Centrioles | They are cylindrical structure made of tubulin protein. | present only in animal cells; help in spindle formation during cell division |
| Cell membrane | In plant it is found inside cell wall and in animal cell it is found as the outer layer. It is semi permeable membrane. | a semi permeable membrane that controls movement of molecules selectively across the membrane through active or passive process. |
| Cell wall | It is outer layer made of cellulose which is rigid and strong. | present only in plant cells; helps selective passage of molecules and also protects cell. |
| Nuclear membrane | Surrounds nucleus and is selectively permeable | Controls movement of molecules across the membrane |
| Lysosome | It is small, round, membrane bound organelle | Digests older cells and breaks food particle into smaller components. |

## 6 Crop Production

### 6.1 Definition or Meaning

- ✓ **Crop production** is the **branch of agriculture** that **deals with the production of crops for food and fiber.**
- ✓ Listed below are few important practices followed during crop production.
    1. Preparation of Soil.
    2. Sowing of Seeds.
    3. Irrigation.
    4. Application of manure, pesticides, and fertilizers to the crops.
    5. Protecting and Harvesting Crops.

6. Storage and preserving the produced Crops.

## 7 Preparation of Soil

This is the first and foremost agricultural practice followed in Crop Production for raising of crops.

There are three steps followed in the preparation of soil.

| Ploughing | Levelling | Manuring |
|---|---|---|
| Ploughing includes **loosening and digging of soil**. During ploughing, **the soil becomes loose and the nutrients in deep soil come to the top**. Also, **aeration of soil will increase thus air is available for breathing and roots are easily penetrated between soil**. | Leveling **helps in even distribution and soil is leveled after ploughing**. Leveling also **helps in water distribution without logging during irrigation**. | After ploughing and leveling, **manure is applied to further stages of farming**. |
| Other purposes of ploughing are the **integration of manure, uprooting of weeds, removal of infectious pathogens, insects** etc., | A plank of wood or iron is used for this. | Manuring is done **to replenish the soil with nutrients and thus helps in proper growth of the crop**. |
| **Ploughs of wood or iron are used for this purpose**. Bullocks or tractors are used to pull this plough. | | |
|  |  |  |
| Soil preparation gives agriculture field which is fertile containing ideal soil and makes it ready for farming. Manuring and removal of weeds at a regular interval and frequency help farmers to yield a better product. | | |

**Please note, Manuring would be dealt in detail in the coming chapters (Manures and Fertilizers)**

### 7.1 Ploughing

Before getting into ploughing, we shall see about the major difference between Tillage and Ploughing. Both are synonymously used and are very much similar except for a minor difference between the two is their intended purpose.

- ✓ Ploughing is the process of breaking, loosening the soil, and turning it over for uprooting weeds and aerating the soil. Here, the aim is to just turn the soil upside down.
- ✓ Whereas Tillage is defined as the mechanical manipulation of the soil for the purpose of crop production affecting significantly soil characteristics such as soil water conservation, soil temperature, infiltration, and evapotranspiration processes.

- By the definition, we understand that here, in tillage, we approach all the scientific methods to prepare the seed bed to get the best outcome.
- In tillage two or more steps are involved (depending on how many steps are required to make the seedbed favourable for the seeds to be sown)

✓ In a way, we can say that ploughing is a component of tillage which is just an act of disturbing the soil without any set purpose.

## 7.2 Tillage

✓ Tillage may be **defined as the mechanical manipulation of soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops**.

✓ The **word tillage is derived from 'Anglo-Saxon' words Tilian and Teolian**, meaning **'to plough and prepare soil for seed to sow, to cultivate and to raise crops'**. **Jethrotull** is considered as **father of tillage**.

✓ **Tilth** is the **physical condition of soil obtained out of tillage (or) it is the result of tillage**. The tilth may be a **coarse tilth, fine tilth or moderate tilth** (based on the type of soil in the field).

## 7.3 Objectives of tillage

The main objectives of tillage to name a few are

✓ To **control the weeds** effectively.

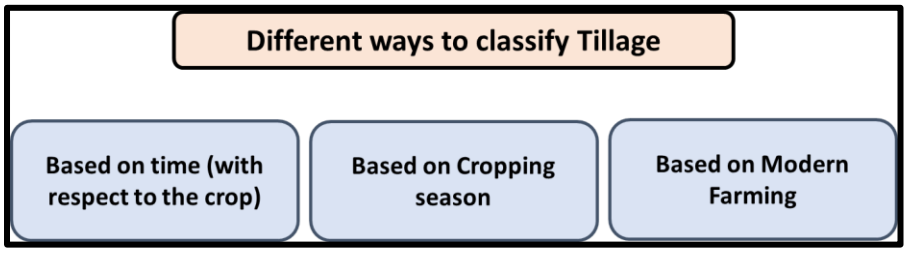
✓ To **aerate the soil**.

✓ To **provide adequate seed-soil contact to permit water flow to seed and seedling roots**.

✓ To **remove the hard pan and to increase the soil depth**.

## 7.4 Classification of Tillage

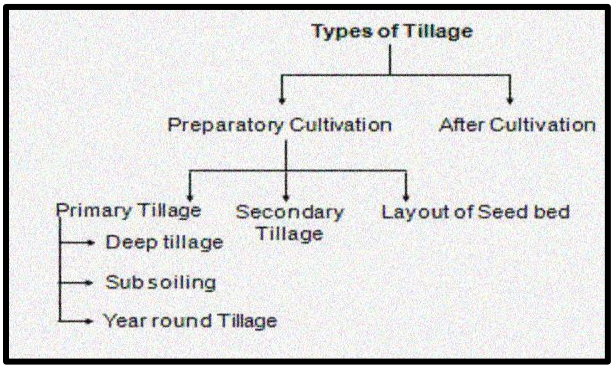
There are various types of tillage based on numerous aspects




## 7.5 Classification of Tillage based on time (with respect to the crop)

This can be further classified into 2 categories. They are

1. Preparatory cultivation
2. After cultivation




### 7.5.1 Preparatory Cultivation

- ✓ The **preparatory cultivation** or **tillage** is operations that are done before the **cultivation**. This **preparatory cultivation** is generally called as main field **preparation**.

### A. Primary Tillage

- ✓ The **tillage operation** that is **done after the harvest of crop** to **bring the land under cultivation is known as primary tillage or ploughing**.
- ✓ Ploughing is the **opening of compact soil** with the help of different ploughs.
- ✓ Country plough, Mould Board plough (MB Plough), Disc plough, tractor and power tiller drawn implements are used for primary tillage.
- ✓ The objectives of primary tillage are to reduce soil strength, to rearrange soil aggregates, to cover plant materials and burry weeds, and to kill insects and pests.

| |
|---|
| **Country Plough -** Indigenous plough is an implement which is **made of wood with an iron share point**.<br>It **cuts a V shaped furrow and opens the soil** but there is **no inversion**.<br>Ploughing operation is also **not perfect because some unploughed strip is always left between furrows**. |
| **MB Plough -** This type of plough **leaves no unploughed land as the furrow slices are cut clean and inverted to one side resulting in better pulverisation**. Mouldboard ploughs are **used where soil inversion is necessary**. **Victory plough is an animal drawn mouldboard plough with a short shaft.** |
| **Disc Plough -** A large, revolving, concave steel disc replaces the share and the mouldboard.<br>The disc turns the furrow slice to one side with a scooping action. The disc plough is **more suitable for land in which there is much fibrous growth of weeds as the disc cuts and incorporates the weeds**. The disc plough **works well in soils free from stones**. |

**Turn-wrest or Reversible or One-way Plough -** The plough bottom in this plough is hinged to the beam such that the mouldboard and the share can be reversed to the left or to the right side of the beam. This **adjustment saves the trouble of turning the plough in hilly tracts, but yet facilitates inversion of the furrow slice to one side only.**

**Power tiller** – It is a **machine used in agriculture for cultivation, tillage, sowing and weeding which contains a set of blades (tines) mounted with a wheeled housing and powered by gasoline engine or electric motor**

Primary Tillage can again be done in 3 ways based on the time of the year or type of soil or availability of water for irrigation.

### a. Deep Tillage:

- ✓ Deep ploughing **turns out large sized clods**, which are **baked by the hot sun when it is done in summer**. These **clods crumble due to alternate heating and cooling** and due to occasional summer showers. This process of **gradual disintegration of clods improves soil structure**.
- ✓ Summer deep ploughing kills pests due to exposure of pupae to hot sun.

### b. Subsoiling:

- ✓ Subsoiling **is breaking the hard pans without inversion and with less disturbance of topsoil**. A narrow cut is made in the topsoil while the subsoiler shatters hard pans.
- ✓ **Sub-soiling is essential and once in four to five years** where heavy machineries are used for field operations, seeding, harvesting, and transporting.

### c. Year-round Tillage

- ✓ **Tillage operations carried out throughout the year** are known as year-round tillage.
- ✓ In **dry farming regions**, field preparation is initiated with the help of summer showers and then repeated till sowing is done. Even after harvest of the crop, the field is repeatedly ploughed or harrowed to avoid weed growth in the off season.

## B. Secondary Tillage

- ✓ **Lighter or finer operations performed on the soil after primary tillage are known as secondary tillage, which can be done in 2 steps (Harrowing and Planking).** After ploughing, the fields are left with large clods with some weeds and stubbles partially uprooted.
- ✓ **Harrowing is done to a shallow depth to crush the clods and to uproot the remaining weeds and stubbles**. Disc harrows, cultivators, blade harrows etc., are used for this purpose.
- ✓ **Planking is done to crush the hard clods to smoothen the soil surface and to compact the soil lightly**.

**Harrow -** It is an implement **for breaking up and smoothing out the surface of the soil**. In this way **it is different from a plough, which cuts deeper into the soil**. A plough also lifts up the soil and tips it over, but a **harrow works mostly by cutting into the soil and breaking it up**.

| |
|---|
| **Cultivator** - Cultivator is an **implement used for finer operations like breaking clods and working the soil to a fine tilth in the preparation of seedbed**. Cultivator is **also known as tiller or tooth harrow**. |
| **Plank -** Plank is a very simple implement and consists of a heavy wooden beam of 2 m in length. When it is worked most of the clods are crushed due to its weight. It also **helps in micro levelling and slight compaction necessary after sowing**. |
| **Roller -** Rollers are used mainly, to crush the hard clods and to compact the soil in seed rows. |

### C. Layout of Seed bed

- ✓ After the seedbed preparation, **the field is laid out properly for irrigation and sowing or planting seedlings**.** These operations are **crop specific**.
- ✓ For most of the crops like **wheat, soybean, pearl millet, groundnut, castor** etc., **flat levelled seedbed is prepared**. After the secondary tillage, these crops are sown without any land treatments.
- ✓ **Growing crops during rainy season in deep black soils is a problem due to ill-drained conditions** and as tillage is not possible during the rainy season. **Broadbed and furrows (BBF) are, therefore, formed before the onset of monsoon and dry sowing is resorted to**.

** Please note, there are various methods of seed sowing. We shall discuss this in the coming sections.

## 7.5.2 After Cultivation

- ✓ The tillage operations that are **carried out in the standing crop are called After cultivation Tillage.**
- ✓ Collectively, the **cultivation practices taken up after sowing of crop is called inter-cultivation.** It otherwise called as **after operation or inter-culturing.**
- ✓ Broadly, there are **three Inter-cultivation practices.** They are, **Thinning and gap filling, Weeding, and hoeing, and Earthing up**.

### A. Thinning and Gap filling

- ✓ The objective of thinning and gap filling process is to **maintain optimum plant population**.
- ✓ **Thinning** is the **removal of excess plants leaving healthy seedlings.**
- ✓ **Gap filling** is done to **fill the gaps by sowing of seeds or transplanting of seedlings** in gap where early sown seed had not germinated. It is a **simultaneous process**.

### B. Weeding and Hoeing

- ✓ Weeding is the **process of eliminating competition of unwanted plants to the regular crop in respect to nutrition and moisture**. So that crops can be grown profitably. **Weeding and hoeing is simultaneous operation.** Hoeing is disturbing the topsoil by small hand tools which helps in aerating the soil.

### C. Earthing up

- ✓ It is the **process of putting the earth or soil** just **near the base for certain crops** like Sugar cane, Cassava, Papaya, Potato, etc. to give support to the plants.

* **Lodging** is the **displacement of stems or roots from their vertical and proper placement**. It can cause lower yields and diminish nutrient density.

### 7.5.3 Other important inter-cultivation practices

**Harrowing:** Stirring or scraping the surface soil in inter and intra row spacing of the crop using tools or implements. (This is also done as part of Secondary tillage operation, in general also.)

**Roguing:** Removal of plants of a variety admixed with other variety of same crop.

**Topping:** Removal of terminal buds. It is done to stimulate auxiliary growth (horizontal growth is promoted by arresting vertical growth). Practiced in cotton and tobacco.

**Propping:**

- ✓ The **operation of tying the leaves together** using the bottom dry and green leaves is known as propping.
- ✓ It is generally practiced in sugarcane and banana.

**De-trashing:** Removing of older leaves from the sugarcane crop.

**De-suckering:** Removal of auxiliary buds and branches which are considered non-essential for crop production and which removes plant nutrients considerably (they are called suckers.) Eg.Tobacco.

## 7.6 Classification of tillage based on Season/cultivation

This is further classified into

1. On season tillage
2. Off season Tillage

### 7.6.1 On Season Tillage

Tillage operations that are done for **raising crops in the same season** or at the **onset of the crop season** are known as on-season tillage. They can be **preparatory cultivation and after cultivation. (We have discussed these in the above section).**

### 7.6.2 Off season Tillage

Tillage operations done for **conditioning the soil suitably** for the **forthcoming main season crop** are called off-season tillage. Off season tillage may be, **post-harvest tillage, summer tillage, winter tillage and fallow tillage.**

**Post Harvest Tillage:** Done after harvesting the crop. The post-harvest tillage **enables the farmers to reduce the wind erosion and increase soil moisture**.

**Fallow Tillage:** Its of 2 types – Summer tillage and Winter tillage

**Summer Tillage:** Similar to the above and done in summer in rainfed areas where land is left fallow for summer due to lack of proper irrigation facilities and to avoid crusting (tightening of soil as a layer on top), tillage operations done.

**Winter tillage:** It gives better contact of the crop stubble with the soil, accelerating the decomposition of organic matter in the winter fallow season. It is carried out in rice growing areas.

## 7.7 Classification of tillage based on Modern farming

It can be again classified into 2 types

1. Conventional tillage
2. Conservation tillage

### 7.7.1 Conventional tillage

- ✓ **Conventional tillage** involves **primary tillage to break open and turn the soil** followed by **secondary tillage to obtain seed bed for sowing or planting**.
- ✓ **There are more of disadvantages of conventional tillage than advantages**, viz., Continuous use of heavy ploughs creates hard pan in the subsoil, results in poor infiltration. It is more susceptible to run-off and erosion. It is capital intensive and increase soil degradation.
- ✓ To **avoid these ill effects**, modern concepts on tillage such as minimum tillage, zero tillage and stubble mulch tillage/farming is in rule. These collectively can be referred to as Conservation tillage.
- ✓ There is another term that is used which is known as **Reduced-Till (This generally is placed under the category of Conventional tillage, but it can be considered as a mid-way between Conservation and Conventional Tillage)**

### 7.7.2 Conservation Tillage

- ✓ **Conservation tillage** is an **agricultural management approach that aims to minimize the frequency or intensity of tillage operations** in an effort **to promote certain economic and environmental benefits**.

- ✓ It is a **tillage or tillage and planting combination that retains a 30% or greater cover of crop residue on the soil surface**.
- ✓ There are various concepts of convention tillage, viz., **Minimum Tillage, Zero Tillage or No-Tillage, Stubble Mulch Tillage, Rotary Tillage, Strip Tillage, Combined Tillage**

## A. Minimum Tillage

- ✓ It aims at **reducing tillage operations to the minimum necessity** for ensuring a good seed bed. The concept of minimum tillage was started in USA.
- ✓ Tillage can be **reduced in 2 ways:**
  - By omitting operations which do not give much benefit when compared to the cost.
  - By **combining agricultural operations like seeding and fertilizer application**.

The Minimum Tillage systems can be **grouped again into the following categories**

| Row zone tillage | Plough plant tillage | Wheel Track tillage |
|---|---|---|
| Primary tillage is done with mould board plough in the entire area of the field | After the primary tillage, a special planter is used for sowing. | Primary ploughing is done as usual. |
| Secondary tillage operations like discing and harrowing are reduced and done only in row zone (leaving the rest of the area). | One run over the field, the row zone is pulverized (loosening the soil, similar to grinding to powder), and seeds are sown by the planter. | Tractor is used for sowing; the wheels of the tractor pulverize the row zone in which planting is done. |

Please note, in all these systems, **primary tillage** is **as usual**. However, secondary tillage is replaced by direct sowing in which sown seed is covered in the row zone with the equipment used for sowing.

## B. Zero Tillage (No Tillage)

- ✓ In this process, new crop is planted in the residues of the previous crop without any prior soil tillage or seed bed preparation. No-till is defined as a system in which the soil is left undisturbed from harvest to planting except for nutrient injection.
- ✓ Zero tillage is **applicable for soils with a coarse textured surface horizon, good internal drainage, high biological activity of soil fauna**, favorable initial soil structure and an adequate quantity of crop residue as mulch.
- ✓ **Some important points regarding zero-tillage:**
  - In zero-tillage, the herbicides functions are extended. Before sowing, the vegetation present has to be destroyed for which broad spectrum, non-selective herbicides with relatively short residual effect (Paraquat, Glyphosate) are used.
  - During subsequent stages, selective and persistent herbicides are needed.
  - The herbicides applied should not cause injury to the succeeding crop.

- Higher dose of nitrogen has to be applied as mineralization of organic matter is slow in zero tillage.
- Large population of perennial weeds appear in zero tilled plots.

**Till Planting:** Till planting is **one method of practicing zero tillage.**

The **machinery accomplishes four tasks in one operation**: clean a narrow strip over the crop row, open the soil for seed insertion, place the seed and cover the seed properly. A wide sweep and trash bars clear a strip over the previous crop row and planter-shoe opens a narrow strip into which seeds are planted and covered.

### C. Stubble Mulch Tillage or Stubble Mulch farming

✓ Stubble-mulching refers to leaving the stubble or crop residue essentially in place on the land as a surface cover during a fallow period.

✓ It is generally followed in Dryland agriculture* (for soil and water conservation)

✓ **This can be again carried out via two methods**

a. Similar to zero tillage, a **wide sweep and trash bars** are used to **clear a strip** and a narrow planter shoe opens a narrow furrow into which seeds are placed.

b. A narrow **chisel of 5-10 cm width** is worked through the soil at a **depth of 15-30 cm leaving all plant residues on the surface**. The chisel shatters the tillage pans and surface crusts. Planting is done with special planters.

*Please note, Dryland agriculture is dealt separately in one of the coming chapters.

### D. Rotary Tillage

✓ Tillage operations employing rotary action of the special tool to cut, break and mix the soil (primary and secondary tillage operations done at one go) is called rotary tillage.

### E. Strip Tillage

✓ In the case of strip tillage system, only isolated bands of soil are tilled, which can be clearly seen in the picture below where strip tillage is being conducted.

### F. Combined Tillage

✓ Tillage operations **utilizing simultaneously two or more different types of tillage tools or implements** to simplify, control, or reduce the number of operations over a field is called combined tillage, which can be clearly seen in the picture below where combined tillage is being conducted.

## 7.8 Special Purpose Tillage

Tillage operations intended to serve special purposes are said to be special purpose tillage.

**In this topic, we shall discuss the following special purpose tillages**

### 7.8.1 Sub-soiling

Please note, this is already discussed as part of Primary tillage operation.

### 7.8.2 Clean Tillage

It refers to **working of the soil of the entire field** in such a way **no living plant is left undisturbed**. It is practiced to control weeds, soil borne pathogen and pests.

### 7.8.3 Blind Tillage

It refers to tillage **done after seeding or planting the crop (in a sterile soil) either at the pre-emergence stage of the crop plants or while they are in the early stages of growth so that crop plants (sugarcane, potato etc.) do not get damaged**, but, extra plants and broad-leaved weeds are uprooted.

### 7.8.4 Dry Tillage

- ✓ Dry tillage is practiced for **crops** that are **sown or planted in dry land condition** having sufficient moisture for germination of seeds and is suitable for crops like broadcasted rice, jute, wheat etc.,
- ✓ **Dry tillage is done in a soil having sufficient moisture (21-23%).** The soil becomes more porous, and soft due to dry tillage.

### 7.8.5 Wet Tillage or Puddling

- ✓ The tillage operation that is **done in a land with standing water** is called **wet tillage or puddling**.
- ✓ Puddling operation consists of **ploughing repeatedly in standing water** until the soil becomes soft and muddy.
- ✓ Initially, **5 to 10 cm of water** is applied depending on the water status of the soil to bring it to saturation and above and the first ploughing is carried out and then repeated for 3 times in an interval of 3-5 days between each ploughing.
- ✓ Puddling creates an impervious layer below the surface to reduce deep percolation losses of water and to provide soft seed bed for planting rice.
- ✓ Wet tillage is the **only means of land preparation for transplanting semi-aquatic crop plant such as rice*.**
- ✓ Planking after wet tillage makes the **soil level and compact**. Puddling hastens transplanting operation as well as establishment of seedlings.

## 7.9 Few important points regarding Ploughing

### 7.9.1 Depth of Ploughing

- ✓ The desirable depth of ploughing is 12 to 20 cm for field crops.

✓ Here below is the classification of ploughing (according to Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad 1985)

| Type | Depth (in cm) |
|---|---|
| Shallow | 5-6 |
| Medium | 15-20 |
| Deep | 25-30 |

### 7.9.2 Number of ploughing

✓ Number of ploughing depends on soil conditions, time available for cultivation between two crops and type of cropping systems.

✓ **Zero tillage is practiced in rice fallow pulses.**

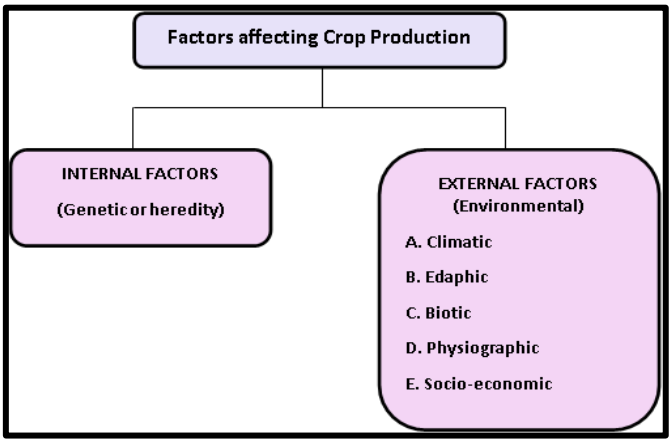
### 7.9.3 Time of ploughing

✓ The **optimum soil moisture content for tillage is 60% of field capacity** (we shall discuss this in the coming parts)

## 8 Factors affecting Crop Production

Now that we have gone through all the Stages or important practices followed in the Crop production of Field crops, we shall now see the various factors that affect Crop production.

These can be classified into 2 types. **This can be pictorially depicted as follows**




### 8.1 Internal Factors (Genetic or heredity)

The **increase in crop yields and other desirable characters are related to Genetic make up** of plants, which **make up for the Internal factors of Crop Production**.

✓ High yielding ability
✓ Early maturity
✓ Resistance to lodging

- ✓ Drought flood and salinity tolerance
- ✓ Tolerance to insect pests and diseases
- ✓ Chemical composition of grains (oil content, protein content)
- ✓ Quality of grains (fineness, coarseness)
- ✓ Quality of straw (sweetness, juiciness)

Example for salinity tolerance includes Pokkali variety of Paddy which is a traditional salt tolerant variety grown in saline waters of Kerala state.

## 8.2 External Factors (Environmental)

The following are the **external factors that affect the crop production**

### 8.2.1 Climatic Factors

- ✓ Nearly 50 % of yield is attributed to the influence of climatic factors.
- ✓ The following are the various atmospheric weather variables which influences the crop production.

1. Precipitation
2. Temperature
3. Atmospheric humidity
4. Solar radiation
5. Wind velocity
6. Atmospheric gases

We shall now study each atmospheric variable in detail. The images are self explanatory and important points are covered just below the image for each factor, in detail.

#### 8.2.1.1 Precipitation


- **Rainfall** one of the **most important factor influences the vegetation of a place**.
- **Total precipitation** in amount and distribution **greatly affects the choice of a cultivated species in a place**.
- In **heavy and evenly distributed rainfall areas**, crops like **rice in plains and tea, coffee and rubber in Western Ghats** are grown.
- **Low and uneven distribution of rainfall** is common in dryland farming where **drought resistance crops like pearl millet, sorghum and minor millets** are grown.
- In **desert areas, grasses and shrubs** are common.
- Though the rainfall has major influence on yield of crops, **yields are not always directly proportional to the amount of Precipitation** as excess above optimum reduces the yields.
- **Distribution of rainfall** is **more important than total rainfall** to have longer growing period especially in drylands.

### 8.2.1.2 Temperature

**2. Temperature**

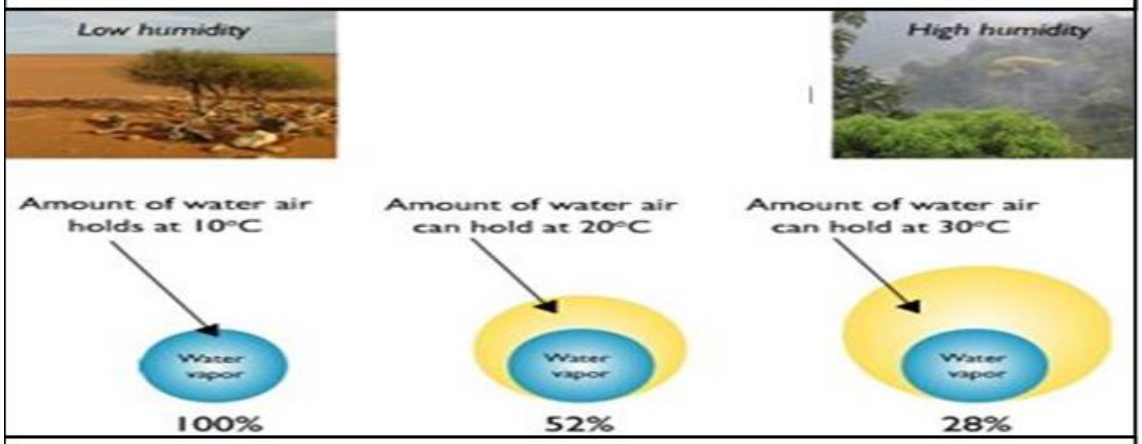
**Temperature requirement of some important crops**

| Crops | Minimum temperature °C | Optimum temperature °C | Maximum temperature °C |
|---|---|---|---|
| Rice | 10 | 32 | 36-38 |
| wheat | 4.5 | 20 | 30-32 |
| Maize | 8-10 | 20 | 40-43 |
| Sorghum | 12-13 | 25 | 40 |
| Tobacco | 12-14 | 29 | 35 |

- **The range of temperature** for **maximum growth** of most of the agricultural plants is **between 15 and 40ºC.**
- **The temperature of a place** is largely **determined by its distance from the equator (latitude) and altitude,** which influences distribution of crop plants and vegetation.
- Germination, growth and development of crops are highly influenced by temperature.
- The minimum, maximum (above which crop growth ceases) and **optimum temperature of individual's plant** is called as **cardinal temperature.**

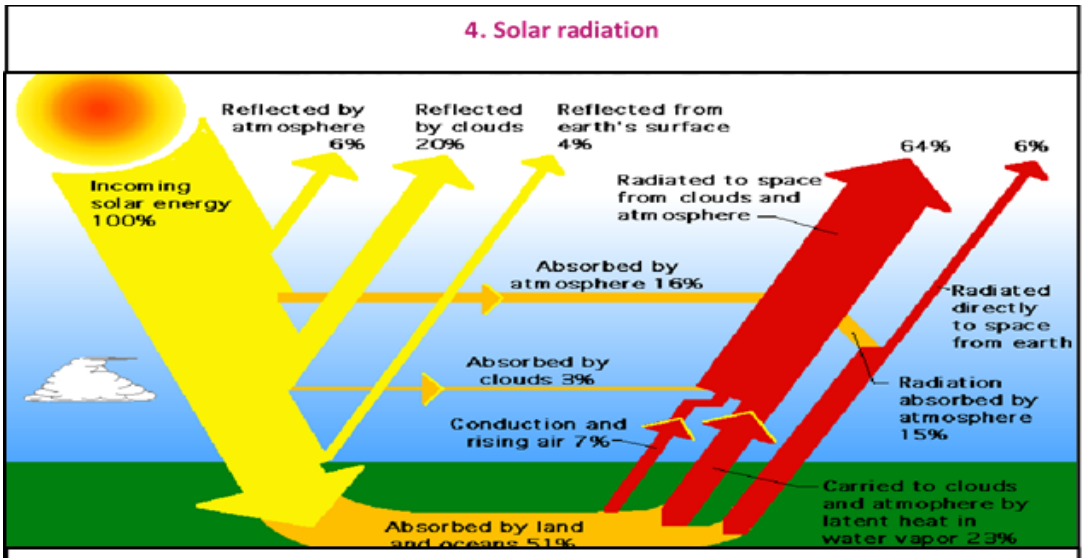
### 8.2.1.3 Atmospheric Humidity

**3. Atmospheric Humidity (Relative Humidity - RH)**




- **Water** is present in the **atmosphere** in the **form of invisible water vapour,** normally known as **humidity.**
- **Relative humidity** is **ratio between the amount of moisture present in the air to the saturation capacity of the air at a particular temperature.**
- If **relative humidity is 100%** it means that **the entire space is filled with water** and there is **no soil evaporation and plant transpiration.**
- Relative humidity influences the water requirement of crops
- **Relative humidity of 40-60% is suitable for most of the crop plants.**
- **Very few crops** can **perform well** when **RH is 80% and above.**
- When **relative humidity is high** there is chance for the **outbreak of pest and disease.**

### 8.2.1.4 Solar radiation

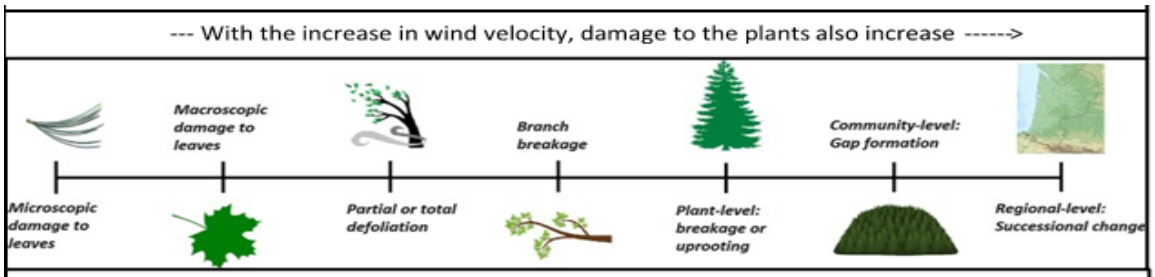



- **Solar radiation** controls **distribution of temperature** and there by **distribution of crops in a region.**
- Visible radiation is very important in photosynthetic mechanism of plants.
- **Photosynthetically Active Radiation (PAR -0.4 – 0.7µ OR 400 – 700nm)** is essential for production of carbohydrates and ultimately biomass.
- **Photoperiodism** is a **response of plant to day length**
  - **Short day – Day length is <12 hours** (Rice, Sunflower and cotton)
  - **Long day – Day length is > 12 hours** (Barley, oat, carrot and cabbage)
  - **Day neutral – There is no or less influence on day length** (Tomato and maize).

- ***Phototropism*** *is the* ***response of plants to light direction. Example:*** *Sunflower*
- ***Photosensitivity*** *is the* ***amount to which a plant reacts*** *upon* ***receiving photons****, especially visible light.*

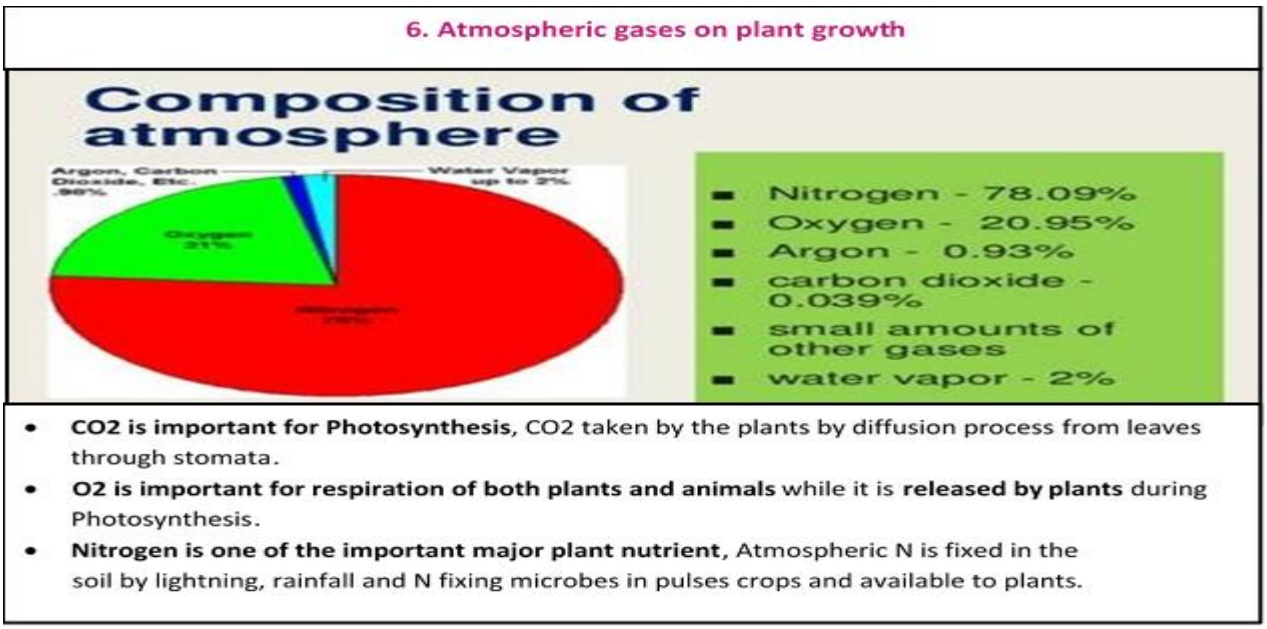
***Season bound varieties depends on quantity of light received.***

### 8.2.1.5 Wind velocity




- The moving wind not only supplies moisture and heat, also supplies fresh $CO_2$ for the photosynthesis.
- **Wind movement for 4 – 6 km/hour is suitable for more crops.**
- When wind speed is enormous then there is mechanical damage of the crops (i.e.) it
- removes leaves and twigs and damages crops like banana, sugarcane.
- Wind dispersal of pollen and seeds is natural and necessary for certain crops.

### 8.2.1.6 Atmospheric gases on plant growth

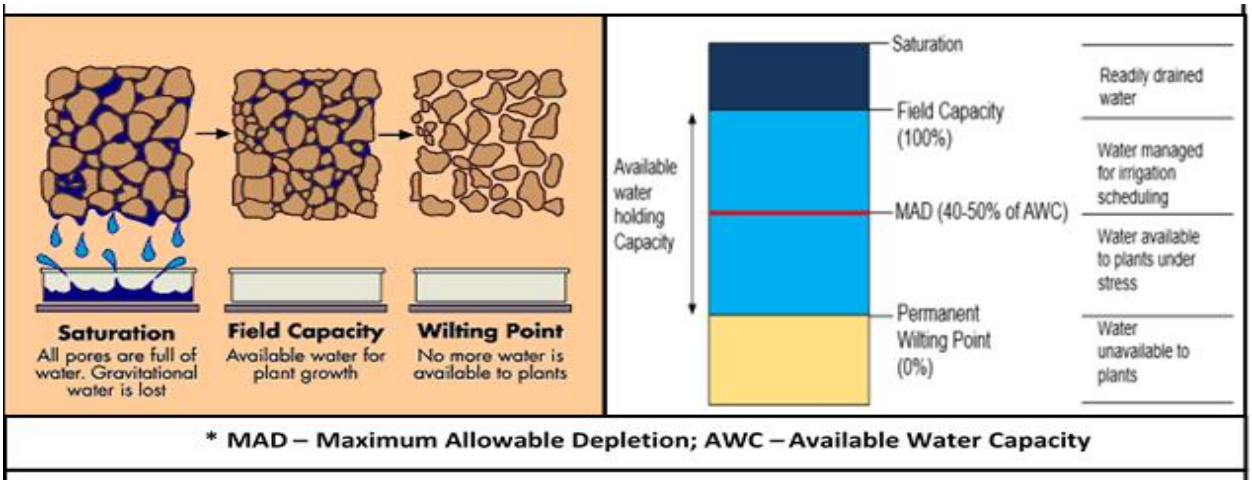



### 8.2.2 Edaphic Factors

✓ The word Edaphic means "influenced by the soil" and is derived from the Greek word "Edephos". Edaphology is concerned with the influence of soils on living things, particularly plants, which is one of the branches of Soil science. Plants grown in land completely depend on soil on which they grow. The soil factors that affect crop growth are

### 8.2.2.1 Soil Moisture

✓ Soil moisture (also called **rhizic water**), is the water present in the space between the soil particles. Soil moisture influences the physical, chemical, and biological characteristics of the soil.



- Soil water **helps in chemical and biological activities of soil** including mineralization.
- It influences the soil environment Eg. it moderates the soil temperature from extremes.
- **The moisture range between field capacity and permanent wilting point is available to plants** - **Available Water Capacity**
- Available moisture will be more in clay soil than sandy soil.

## Kinds of Soil Water

There are three main types of soil water - Gravitational water, Capillary water, and Hygroscopic water.

**Gravitational water:**

✓ **Free water** that moves through the soil below the root zone due to the force of gravity. **Gravitational water** is found in the macropores. It moves rapidly out of well-drained soil and is **not considered to be available to plants**.

**Capillary water:**

✓ The water that remains in the soil after gravitational water is drained out, that is subject to the laws of **capillary** movement, and that is in the form of a film around the soil grains. This **water is available for plant growth.**

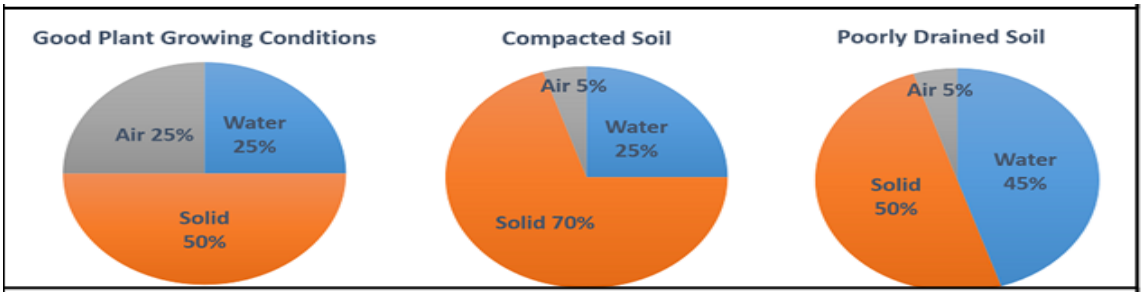
✓ **Capillary action** (sometimes capillarity, capillary motion, capillary effect, or wicking) is the **ability of a liquid to flow in narrow spaces** without the assistance of, or even in **opposition to, external forces like gravity**.

**Hygroscopic water**

✓ When water is held tightly as thin film around the soil particles by adsorption forces and no longer moves in capillary pores, is called hygroscopic water. This hygroscopic water is **unavailable to plants in amounts sufficient for them to survive.**

### 8.2.2.2 Soil air

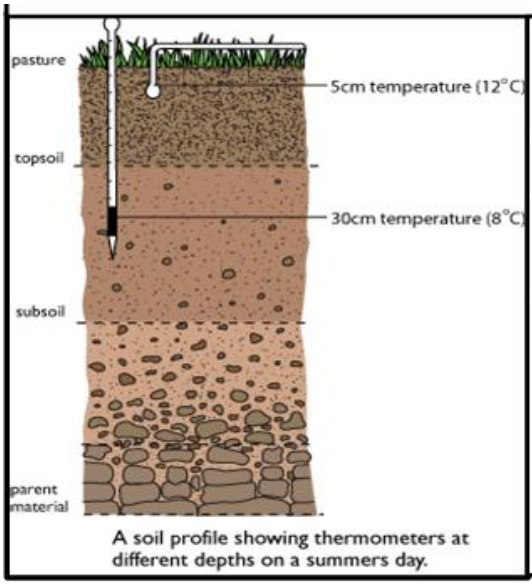
Soil air is the gaseous phase of the soil. Soil air plays an important role in plant growth and the activity of soil organisms.




- The **volume ratios of the three constituent phases** of soil, namely **solids, water and air** are continually changing as the **soil undergoes wetting or drying, swelling, or shrinking, tillage or compaction and aggregation or dispersion**.
- Specifically, **water and air compete for the same pore space**, and their **volume fractions are so related that an increase of one generally decreases the other.**
- **Field air capacity** is the fractional volume of air in a soil at field capacity. The air capacity depends on soil texture.
- In **sandy soils**, it is of the order of **25 percent or more**. In **loamy soils**, it is generally between **15 and 20 percent** and in **clay soils** which tend to **retain more water**, it is likely to **fall below 10 percent of the total soil volume.**
- **Germination is inhibited in the absence of oxygen**
- **O2 is required for respiration of roots and micro organisms.**
- Soil air is essential for nutrient availability of the soil by breaking down insoluble
- mineral to soluble salts and for proper decomposition of organic matter.
- **Potato, tobacco, cotton linseed, tea and legumes need higher O2 in soil air**
- Rice requires low level of O2 and can tolerate waterlogged (absence of O2) condition

### 8.2.2.3 Soil Temperature

- ✓ Not only the temperature in atmosphere, but temperature in soil also effects the seed germination and growth of a plant.
- ✓ Soil temperature is simply the measurement of the warmth in the soil. Ideal soil temperatures for planting most plants are 65 to 75 F. (18 to 24 C.). Nighttime and daytime soil temperatures are both important.

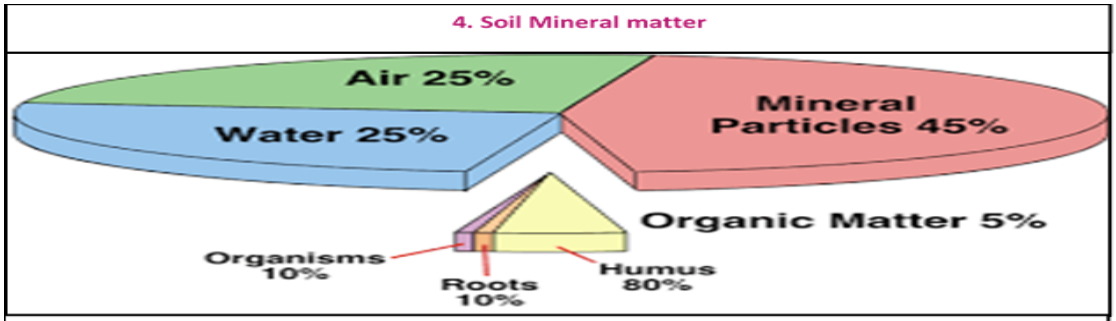



A soil profile showing thermometers at different depths on a summers day.

- It **influences** the **rate of absorption of water and solutes (nutrients)**
- It **affects the germination of seeds** and growth rate of underground portions of the crops like tapioca, sweet potato.
- Soil temperature controls the microbial activity and processes involved in the nutrient availability
- Cold soils are not conducive for rapid growth of most of agricultural crops

### 8.2.2.4 Soil Mineral Matter

✓ Its quite clear from the picture below that Soil, as such is composed of 4 main components, Viz., Soil air, soil water, Inorganic matter (Mineral matter), and Organic matter (though some humus, roots, organisms are also part of that, they are minimal, hence not considered).




- Mineral matter is the predominant component of mineral soils. It constitutes about **45% of total soil composition**.
- It is made up of a **number of particles which vary in size, shape and chemical composition**.
- Mineral matter is divided into **sand, silt and clay**, which are often considered as the **main mineral particles**. These are **collectively called soil separates** and they are often cemented or aggregated together to form peds and aggregates.
- It forms a greater part of the body of mineral soils therefore they contribute more to soil mass.
- **It determines, through its composition, the soil texture and therefore, the soil texture class of a soil.**
- It also gives support to erected structures and other constructions on the earth's surface.

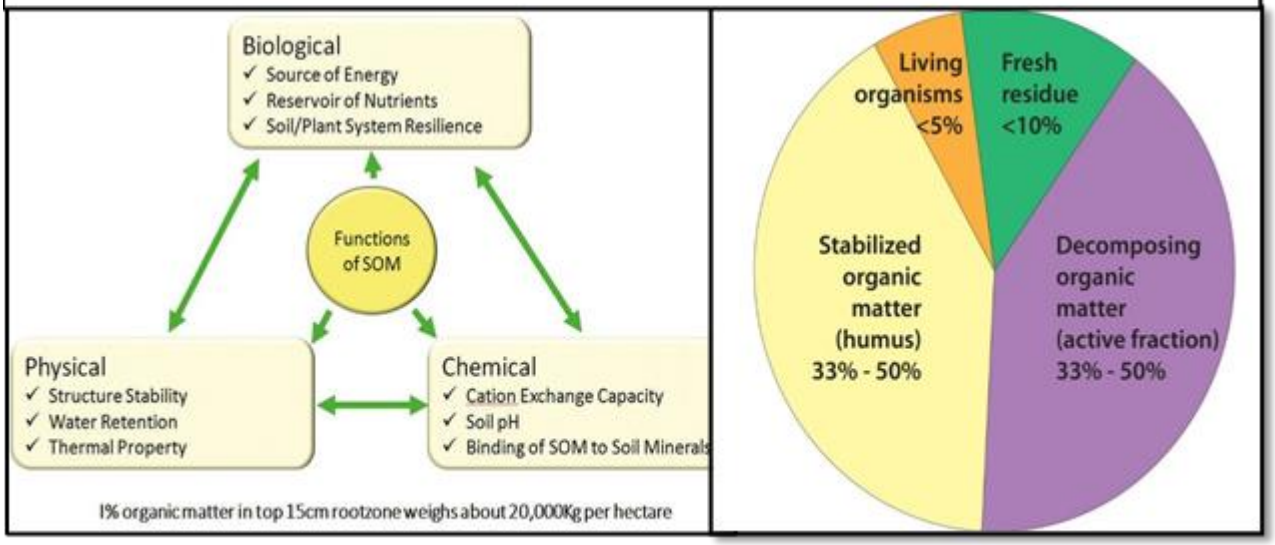
### 8.2.2.5 Soil Organic Matter

✓ Soil Organic matter is only 5% of the total soil components.

✓ The Soil Organic matter (SOM) can be further divided into living organisms which is <5% of the total SOM, Fresh residue at 10%, Stabilized Organic matter (Humus formed by the decomposition of leaves and other plant material by soil microorganisms) at 33-50% and Decomposing organic matter, which is again at 33-50%.

## 5. Soil Organic Matter (SOM)

- It **supplies all the major, minor and micro nutrients to crops** and **improves the texture** of the soil
- It **increases the water holding capacity of the soil** and a source of food for most microorganisms
- Organic acids released during decomposition of organic matter enables mineralisation process thus releasing unavailable plant nutrients.




### 8.2.2.6 Soil Organisms

## 6. Soil Organisms

- Soil organism is **any organism inhabiting the soil during part or all of its life**, which range in size from microscopic cells that digest decaying organic material to small mammals that live primarily on other soil organisms, **play an important role in maintaining fertility, structure, drainage, and aeration of soil**.
- Some soil organisms are pests.
- Soil organisms are commonly divided into five arbitrary groups according to size.

1. **Protists** - Smallest of all and include bacteria, actinomycetes, and algae.
2. **Microfauna** - less than 100 microns in length and generally feed upon other microorganisms and include single-celled protozoans, some smaller flatworms, nematodes.
3. **Mesofauna** - somewhat larger and are heterogeneous, including creatures that feed on microorganisms, decaying matter, and living plants. The category includes nematodes, mites, springtails.
4. **Macrofauna -** are also quite diverse. The group also includes slugs, snails, and millipedes, which feed on plants, and centipedes, beetles and their larvae etc.,
5. **Megafauna** - constitute the largest soil organisms and include the largest earthworms, perhaps the most important creatures that live in the topsoil.

- **Soil reaction is the pH (hydrogen ion concentration) of the soil**.
- Soils **generally range from an extremely acidic pH of 3 to a very alkaline pH of 10.**
- Soil pH affects crop growth and neutral soils with **pH 7.0 are best for growth of most of the crops**. Soils may be acidic (<7.0), neutral (=7.0), saline and alkaline (>7.0) Low/high PH pH also interferes with availability of other plant nutrients.
- Availability of phosphorus is high within a pH range of 6.0 to 7.5 due to higher solubility of phosphorus compounds. At low pH, phosphorus is precipitated.
- Metallic cations like Fe, Mn, Cu, Zn precipitate at high pH, hence their availability is less in alkaline soils.
- At lower pH, H+ ions replace K and thus leaching of K occurs. At high pH, potassium compounds availability is reduced. Boron is leached out at low pH.

**Optimum pH range for availability of different**

| Nutrient | Optimum pH range |
|---|---|
| N | 6 to 8 |
| P | 6.0 to 7.5 |
| K | 6 to 7.5 |
| S | 6 and above |
| Ca and Mg | 7 to 8.5 |
| Fe | 6 and below |
| Mn | 5 to 6.5 |
| Bo, Cu, Zn | 5 to 7 |
| Mo | 7 and above |

### 8.2.3 Biotic Factors

✓ These include the beneficial and harmful effects caused by other biological organism (plants (Flora) and animals (Fauna)) on the crop plants. They are both useful and harmful based on their presence. The table below clearly explains how biotic factors effect crop production.

| Plants (Flora) | Animals (Fauna) |
|---|---|
| • **Competitive and complimentary nature among field crops when grown together**<br>• Competition between plants occurs when there is demand for nutrients, moisture, and sunlight particularly when they are in short supply or when plants are closely spaced<br>• When different crops of cereals and legumes are grown together, mutual benefit results in higher yield (synergistic effect)<br>• Competition between weed and crop plants as parasites | • Soil fauna like **protozoa, nematode, snails, and insects** help **in organic matter decomposition**, while using organic matter for their living.<br>• Insects and nematodes cause damage to crop yield and considered as harmful organisms.<br>• **Honeybees and wasps help in cross pollination and increases yield and considered as beneficial organisms**<br>• Burrowing earthworm facilitates aeration and drainage of the soil as ingestion of organic and mineral matter by earthworm |

### 8.2.4 Physiographic Factors

✓ **Physiographic** factors are again of 4 types viz., Topography, Altitude, steepness of slope, and exposure to light and wind.

| Physiological Factor | Characteristics |
|---|---|
| **Topography** | The **nature of surface earth** (leveled or sloppy) is known as topography. Topographic factors affect the crop growth indirectly. |
| **Altitude** | **Increase in altitude** causes a decrease in temperature and increase in precipitation and wind velocity (hills and plains) |
| **Steepness of Slope** | It results in run off of rain water and loss of nutrient rich top soil. |
| **Exposure to Light and Wind** | A mountain slope exposed to low intensity of light and strong dry winds may results in poor crop yields (coastal areas and interior pockets). |

### 8.2.5 Socio economic Factors

✓ **Society inclination to farming** and members available for cultivation

✓ **Appropriate choice of crops by human beings** to satisfy the food and fodder requirement of farm household.

✓ **Breeding varieties by human invention** for increased yield or pest & disease resistance

✓ **The economic condition of the farmers** greatly decides the input/ resource mobilizing ability (marginal, small, medium, and large farmers).

# 9 Concepts related to Numericals

## 9.1 Field Performance of Machines

The **rate at which a machine can cover a field** while performing its intended function is one of the considerations in determining the cost of operation of the machine.

### 9.1.1 Theoretical field capacity

It is the **rate of field coverage that would be obtained if the machine were performing its function 100 % of the time at the rated forward speed and always covering 100 % of its rated width**,

$$\frac{\text{width (cm)} \times \text{speed (metre / sec)} \times 36}{10000}$$

**Theoretical field capacity (FCT)** = ha / h

It can be represented in another form of equation as well,

**Theoretical field capacity (FCT)** $= \frac{SW}{10} ha/h$

**Where,**

FCT = effective field capacity, hectare per hr.

S = speed of travel in km per hour.

W = theoretical width of cut of the machine in meter

### 9.1.2 Theoretical time per hectare

It is the **time that would be required at the theoretical field capacity**.

### 9.1.3 Effective operating time

It is the **time during which the machine is actually performing its intended function**. The **effective operating time per hectare is greater than the theoretical time per hectare if less than full rated width** is utilized.

### 9.1.4 Effective field capacity

It is the **actual coverage of the machine based on the total field time**. Effective field capacity is usually expressed as hectares per hour. It is calculated as follows

Effective field capacity (FCA) $= \frac{S \times W}{10} \times \frac{E}{100}$ ha/h

Where,

FCA = effective field capacity, hectare per hr.

S = speed of travel in km per hour.

W = theoretical width of cut of the machine in metre, and

E = field efficiency in per cent.

### 9.1.5 Field efficiency

It is the **ratio of effective field capacity to theoretical field capacity** expressed as **percent**.

**Field efficiency (E)** $= \frac{\text{Effectifive field capacity}}{\text{Theoretical field capacity}} \times 100$

### 9.1.6 Soil Inversion

**Soil inversion** = $\frac{\text{No.of weeds seen on the surface after ploughing in the same area}}{\text{No.of weedsseen on the surface before ploughing in an area}} \times 100$

### 9.1.7 Soil pulverization

It is the **quality of work performed by a plough expressed in terms of particle size distribution**. It is determined by sieve analysis.

## 9.2 Problems on field capacity and field efficiency of tillage implements

**Problem 1:**

A 5 x 20 cm double action disc harrow is operated by a tractor having a speed of 5 km/h. Calculate the actual field capacity , assuming the field efficiency of 80 percent.

**Solution:**

Size of the harrow (width) = 5 x 20 = 100 cm

Area of coverage = $\frac{S \times W}{10} \times \frac{E}{100}$

= (1 x 5 x 80) / 1000

= 0.4 ha/h

**Problem 2:**

A 3 x 30 cm plough is moving at a speed of 4 km/h. calculate how much time it take to plough 500 x 500 m field when the field efficiency is 70 %.

**Solution:**

Width of the plough = 3 x 30 = 90 cm = 0.9 m

Effective field capacity = (0.9 x 4 x 70)/ 1000

= 0.25 ha/h = 2500 m2/h

Time required = 500 x 500/ 2500

= 100 h

**Problem 3:**

A 4 bottom 40 cm mould board plough is operating at 5.5 km/h speed with 75 % field efficiency. Calculate what is the rate of doing work in hectares per hour.

**Solution:**

Width of the plough = 4 x 40 = 160 cm = 1.6 m

Area covered = 1.6 x 5.5 x 75/1000

= 0.66 ha/h

**Problem 4:**

An indigenous plough has a 20 cm wide furrow at the top and 10 cm depth.
Calculate the volume of soil handled per day 8 hours if the speed of working is 2.5 km/h.

**Solution:**

Furrow cross section = 10 x20/2
= 100 cm2
Distance traveled in 8 hours = 8 x 2.5 x 1000 = 20,000 m
Volume of soil handled = 20000 x 100/ 10000
= 200 m3