Field crops production and management

Handout

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2022/23

Chapter 1: Definition and Importance of Field Crops

Crop: A plant or a collection of plants produced artificially or naturally for the benefit/device of man. Crops are domesticated or derived from wild progenitors through selection and breeding, have characteristics of particular agronomic value as against survival characteristics in the wild progenitors.

The value of crop plant is dependent on its ability to produce a large amount of useful material than its wild progenitors. These crops vary in their nutritional requirements, soil and weather needs; susceptibility to pests and diseases, etc. Similarly, the parts of the crop that meet man's need equally vary. ***The need of human from crops may be grain, leaves, stem, fruits or the tuber (root)***.

Field crops: crops (other than fruits or vegetables) that are grown for agricultural purposes; cultivated plant those are grown commercially on a large scale. Field crops are sometimes called agronomic crops. The use of the phrase **'field crops'** is used as opposed to the phrase **'horticultural crops'**. The word horticulture is derived from two Greek words ***'horti'*** (meaning around home stand) and ***'culture'*** (meaning growing). Usually horticultural crops are cultivated around homes as compared to 'field crops' that are grown away from homes, i.e. in fields.

The term field crops can be include: Cereal and legume crops are used as a source of food, feed (for livestock), fuel, medicine, alcohol, Oil crops are mainly grown for the production of oil from their seeds.

Crop production- a systematic and planned activities to produce cereals, pulses, oil crops, root and tuber crops, fiber crops, beverage crops, for profit or subsistence. Crop production is basically conversion of environmental inputs like ***solar energy, carbon dioxide, water and soil nutrients*** into economic products in the form of human or animal food or industrial materials.

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophylls}]{\text{Solar energy}} C_6H_{12}O_{6\ (\text{glucose})} + 6O_2 + 6H_2O$$

It includes agronomy, soil science, entomology, pathology, microbiology, etc. The aim is to have better food production and how to control the diseases.

Crop productivity- refers to the utilizable part of the plant which is not the same in every crop is usually less than total biological production. Part of the biomass that is converted in to economic product is called crop yield or economic yield. The total dry matter produced by a crop is biological yield and a fraction of biological yield which is useful for man is economic yield.

***Importance of Field Crops*-** Crops are used:

- **Food for human and feed for livestock:** Human and other animals require energy, amino acids vitamins, and minerals. The most important crops that feed the world include Cereals (wheat rice, maize, sorghum, barely), Roots and Tuber crops (potato), Oil crops (linseed, sesame, sunflower, Soya bean)**,** Fruit crops and Vegetable crops.
- **Wood and wood products from crops:** Construction, Furniture**,** Fuel and Paper.
- **Textiles from fiber producing plants:** Plant fibers are used for clothing and textiles, examples Cotton, Sisal, flax
- **Drugs and Medicines:** Examples Tobacco, Coffee
- **Fossil fuels**
- **Prevent erosion**
- **Perfumes and spices:** Perfume-rose, Spice- pepper, ginger, for improving taste of food.
- **Aesthetic purpose:** For great pleasure, relaxation
- **Source of oxygen:** Oxygen is released as a byproduct of photosynthesis by green plants.

1.1.World population expansion & food supply

Throughout the human history, people have been divided in to the **"haves"** and the **"have-nots"**. Today, entire nations fall into one or the other of these categories with respect to food for an ever-increasing population. A "have not" nation is one that does not produce enough plant products to supply a reasonable diet for its people. Animal products also play a critical role in human nutrition, but animals are dependent on plants.

A country's ability to feed itself very much depends on three factors: availability of arable land, accessible water and population pressures including government bodies. The more people there are, especially in poor countries with limited amounts of land and water, the fewer resources there are to meet basic needs. If basic needs cannot be met, development stalls and economies begin to unravel. In some poor countries, attempts to increase food production and consumption

are undermined by rapid population growth; migration from rural to urban areas; unequal land distribution; shrinking landholdings; deepening rural poverty; and widespread land degradation. Lower birth rates, along with better management of land and water resources, are necessary to avert chronic food shortages.

The demographic picture: Not long ago, in 1984, it seemed as if the rate of population growth was slowing everywhere except in Africa and parts of southern Asia. Today, the situation looks less promising since progress made toward reducing birth rates has been slower than expected. According to United Nations population projections, the world's population has crossed 8 billion. While the death rate has decreased, the life expectancy on earth has increased.

According to estimates, the average life expectancy of people in 2019 is 72.8 years, which will increase to 77.2 years in 2050 (United Nations Population Division, 2019; UNFPA, 2019). The United Nations has announced that the world's population will reach 10 billion in 2037. In 2020 world population growth will slow by one percent, the first time since 1950. Currently, the world's average birth rate is 2.3 percent.

Over the next ten years, the population of the industrialized world will grow by less, while the number of people living in developing countries will expand to over. By and large, the biggest increases will occur in the poorest countries - those societies least equipped to meet the needs of the new arrivals and invest in their future. Widening disparities in income, climate change, poverty and war continue to the challenge the world's population, the United Nations says.

Meeting food needs: Worldwide, enough food is produced to feed everyone, yet this food and the technologies to produce it do not always reach those in need. As a result of food deficits, nearly 1000 million people do not get enough food to eat and over 400 million are chronically malnourished. Every year 11 million children under the age of five die from hunger or hunger-related diseases (Lean, Hinrichsen and Markham, 1990).

1.2.Status of field crops production in Ethiopia

Ethiopia's major staple crops include a variety of cereals, pulses, and oilseeds. Cereals are the most important field crops and the chief element in the diet of most Ethiopians. In 2019/20 Ethiopian cropping season the area coverage and production are 10,478,218.03 hectares (81.46%) and 296,726,476.94 Quintals (88.52 %) respectively (CSA, 2019/20). The principal cereals are tef, wheat, barley, maize, sorghum, and millet.

Pulses are the second most important element in the national diet and a principal protein source. They are boiled, roasted, or included in a stew-like dish known as “wot”, which is sometimes a main dish and sometimes a supplementary food. Pulses, grown widely at all altitudes from sea level to about 3,000 meters, are more prevalent in the northern and central highlands. According to CSA data in 2019/20 cropping season the area coverage and production are 1,563,768.72 hectares (12.16%) and 30,051,986.62 Quintals (8.97 %) respectively. Pulses were a particularly important export item before the revolution.

Oil crops are the third most important element in the national diet and refer to crops which are also classified within grain crops category, nonetheless. Oilseeds are grown to flavour the food consumed at home and earn some cash for peasant holders in the country. Various oil crops are produced in all the regions with differing quantity. According to 2019/20 cropping season CSA data the area coverage and production are 820,792.09 hectares (6.38%) and 8,421,360.34 Quintals (2.51 %) respectively. Pulses were a particularly important export item before the revolution.

Ethiopia's demand for grain continued to increase because of population pressures, while supply remained short, largely because of ***drought and government agricultural policies***, such as price controls, which adversely affected crop production. Food production had consistently declined. Consequently, Ethiopia became a net importer of grain worth about billions of birr annually.

1.3.Challenges and opportunity of crop production in Ethiopian

A. Opportunities

1) Plentiful **labor**
2) Varity of agro **ecological zone**: With altitudes ranging from 148 meters below sea level to 4,620 meters above it, the country has 18 major and 49 sub agro-ecological zones, each with its own agricultural and biological potential. Thus the country possesses one of the largest and most diverse **genetic resources** in the world.

3) Ethiopia has the soils and **climate** required for the production of a variety of food crops.
4) Ethiopia has also more than 80 million hectares of arable **land** out of which 16% is under cultivation.

5) Surplus **water** for irrigation. Over all irrigation development potential is estimated at 3.7 million hectares of land while only 5-6% of this area is currently utilized. Irrigable large scale farms such as in the Rift Valley have big potential for the expansion of cash crops such as sugar, oil seeds and horticulture.

B. Challenges

- **Subsistence production system:** It could be identified at least with the following five characteristics:
  - ✓ Small and often fragmented land (0.5 to 2.0 ha)
  - ✓ Primitive tools and implements
  - ✓ Production geared to personal needs rather than to market
  - ✓ Lack of alternatives or seasonal employment opportunities and
  - ✓ Almost total absence of reserves of either grain or cash

- **Disease and pests:** On the average, the pre and post -harvest losses due to diseases and pests is 30-40%.

- **Policy Factors:** It is one of the decisive elements that have a direct relationship with agricultural productivity. Some of the policy factors that greatly hamper agricultural productivity are:-
  - ✓ Weak agricultural research policy development.
  - ✓ Lack of capacity and educated man power to handle new technologies.
  - ✓ Absence of polices and instruments to intervene in the interest of national food security.
  - ✓ Weak and sporadic linkages between government agricultural policy institutions, agricultural research institutions with the subject people (farmers).
  - ✓ Lack of Education and skilled manpower in most rural Ethiopia.
  - ✓ No clear-cut policy was formulated to benefit the rural poor.
  - ✓ Farmers' indigenous knowledge, and the ability of farmers to be experimenters in their own right are not taken in to consideration as huge potential.

- **Lack of technologies:** We have not been able to design appropriate technologies (for land preparation, crop establishment, irrigation etc.) for a range of ecological settings to maximize production, minimize losses (pre and post-harvest) and increase value added (processing).

Appropriate technologies with distinctive advantage over existing ones for harnessing the different agro-ecological areas are generally lacking.

- **Social Infrastructure:** Social infrastructures such as hospitals, clinics, schools, water supply, etc. are lacking in rural areas. Rural people have to travel long distances in search of these facilities.

- **Food aid :** It should be borne in mind that, the majority of the farmers particularly farmers of north– central Ethiopia have assumed and some even accepted food–aid as the only, or in many cases the most efficient means of addressing food security since they are landless and are tied by the strong twin forces of religious and cultural practices.
  - Negative impact on producer's income thereby increasing the dependency on future food aid.
  - A major effect in further depressing Ethiopian grain prices especially in the years of high production (Mesfin, 1984).
  - Market uncertainty for domestic grain traders (Demeke and Freed, 2004).

- **Natural Climatic factors:** several natural climatic factors are responsible for low agricultural productivity in Ethiopia. Some of them are weather changes, soil erosion and lack of adequate rain fall (recurrent drought). **"*Elion*"** which is occurring around per 10 years round in Ethiopia is also kills millions of people (Example in 2007/08 it damages above 20,000 people) by drought.

1.4.Means for increasing crop production and productivity in Ethiopia

Even thou most Ethiopian farmers follow traditional crop production system, they have mechanisms to grow better crop and to maximize productivity. The following are major activities to do this:

1. **Soil conservation practice**
   - **Conservation tillage:** leaves at least 30% residue cover on the ground. This simple, low-cost practice can have a huge impact on the amount of soil eroded. Because of energy savings and obvious improvements in soil quality that can result from conservation tillage (especially from legume crop residue)

- **Contour farming and strip cropping** is the practice of planting along the slope instead of up-and-down slopes, and planting strips of grass between row crops.
- **Terraces** are structural practices that can reduce erosion by holding back the water and routing it along a channel at a lower velocity to where it can be safely discharged, usually into a grassed waterway.
- **Windbreaks** are the best way to protect soil from wind erosion. They can be in the form of rows of shrubs or trees.

2. **Provide good agronomic activity**
   - Amend tillage frequency and prepare good field with friable soil.
   - Use improved varieties (productive &high resistant)
   - Keep seeding time by considering onset of rainfall
   - Provide cultivation and weeding,
   - Application of different organic(animal dung & compost) and inorganic fertilizers
   - Effective pest control (cultural, physical or chemical)
   - Keep time of harvesting and prevent loss at storage
3. **Crop rotation**- good utilization of soil nutrients and prevent transmitted soil born insects.
4. **Irrigation**-farmers in area of irrigation can grow crop more than two times within a year. So, irrigation can be also considered as means of increasing crop production.
5. Apply better Agricultural policy which involves all stockholders starting from the preparation to implementation.
6. Introduce and use modern farming technologies

1.5.Food Self-Sufficiency and Food Security

Food security is defined as 'the access for all people at all times to enough food for a healthy, active life' (FAO, 1996). In contrast food self-sufficiency is defined as being able to meet consumption needs (particularly for stable food crops) from own production rather than by buying or importing. There is a long standing debate on whether food self-sufficiency is a useful strategy to achieve food security. Supporters of this proposition argue that relying on the market for to meet food needs is a risky strategy because of volatility in food prices and possible interruption in supplies. The opposing view is that it is costly for a household (or country) to focus on food self-sufficiency rather than producing according to its comparative advantage and purchasing some of its food requirements from the market.

Chapter 2: Crop Production as an Art, Science and Business

Crop production can be defined as an art, a science and the business of producing crops for economic purposes.

2.1. Crop Production as an Art

The knowledge of the way to perform the operations of the farm in a skillful manner. The skill is categorized as;

- **Physical skill**: It involves the ability and capacity to carry out the operation in an efficient way for e.g., handling of farm implements, sowing of seeds, fertilizer and pesticides application etc.

- **Mental skill**: The farmer is able to take a decision based on experience, such as (i) time and method of ploughing, (ii) selection of crop and cropping system to suit soil and climate, (iii) adopting improved farm practices etc.

2.2. Crop Production as Science

It utilizes all modern technologies developed on scientific principles such as crop improvement/breeding, crop production, crop protection, economics etc., to maximize the yield and profit.

For example, new crops and varieties developed by hybridization, transgenic crop varieties resistant to pests and diseases, hybrids in each crop, high fertilizer responsive varieties, water management, herbicides to control weeds, use of bio-control agents to combat pest and diseases etc.

2.3. Crop production as a Business

As long as agriculture is the way of life of the rural population, production is ultimately bound to consumption. But crop production as a business aims at maximum net return through the management of land, labour, water and capital, employing the knowledge of various sciences for production of food, feed, fiber and fuel. In recent years, crop production is commercialized to run as a business through mechanization.

Chapter 3: Origin of Cultivated Plants

The origin of crop plants is now basic to plant breeding in order to locate wild relatives, related species, and new genes (especially dominant genes, sources of disease resistance). Knowledge of the origins of crop plants is vitally important in order to avoid genetic erosion, the loss of germplasm due to the loss of ecotypes and landraces, loss of habitat (such as rainforests), and increased urbanization. Germplasm preservation is accomplished through gene banks (largely seed collections but now frozen stem sections) and preservation of natural habitats (especially in centers of origin).

In 18th century Russian explorer Vavilov recognized the genetic diversity of crops from region to region and from country to country. He also further concluded that the region or country where the ***greatest diversity of type*** occurred in each crop plant to be the ***center of origin*** of a crop. According to Vavilov, there are 8 centers of origin of cultivated plants. These are China, India, and Central Asia, Near East, Mediterranean Area, Ethiopia, South Mexico & Central America, and South America. Crops centers of origin would be two kinds: ***primary centers of origin and secondary centers of origin.***

- ☞ Primary center: where there are both wild relatives & genetic diversity
- ☞ Secondary center: Where there is genetic diversity or from where distribution is made to most other parts of the world.

Table 1: vavilov's eighgt centers of origin of cultivated plants

No.	***Center of origins***	***Basic crops***	***Total spp.***
1	China, Central & Western	Soybean, barley, millets, bulk wheat, sugarcane	136
2	India, including Burma & Assam	Rice, cotton, cow peas	11
3	Central Asia	Common wheat, cotton, sesame, hemp, pops, lentils	42
4	Near East, including Asia Minor & Iran	Some wheats, two-row barley, rye, common oats, alfalfa, vetch	83
5	Mediterranean Area	Durum, emmer, and spelt wheat, some oats, barley	84
6	Ethiopia	Common six-row barley, durum wheat, grain sorghum, millet, caster beans, chickpeas, lentils, coffee	38
7	South Mexico & Central America	Corn/maize, upland cotton, beans sweet potato	49
8	South America, esp. Peru, Bolivia, and parts of Ecuador	White potato, tobacco, peanuts, tomato, some cottons, lupins	45

Crops adaptation: Crops adapt best in their centers of origin or in areas/ countries whose environment are similar to that of their centers of origin**..**

Evolution is always in favorable of an organism fitting the environmental conditions where it is grown. Generally, there is direct relationship between crops feature and the environmental condition of their centers of origin as the result of evolution. For instance, tropical countries are characterized by warm temperature, short day and largely droughty, and hence crops originated in tropical regions are characterized with warm loving, short day and drought tolerant. Whereas those crops originated in temperate regions have opposite features to that of crops originated in tropical areas.

Table 2: Relationships between crops character and their centers of origin

No.	Feature	Tropical origin	Sub-tropical origin	Temperate origin
1	Drought tolerance	High	Medium	Low
2	Frost/cold tolerance	Low	Medium	High
3	Photoperiod response	Short day	Day neutral	Long day
4	Range of adaptation	Wide	Medium	Narrow
5	Morphology	Grassy/narrow leaved	Medium size leaved	Broad leaved

3.1. The Advantage of Conserving Crop Biodiversity

What is biodiversity?

Biodiversity is a contraction of "biological diversity" and refers to the number, variety and variability of living organisms. In its widest sense, therefore, it is synonymous with "Life on Earth". It embraces two different concepts: one is a ***measure of how many different living things there are*** and the other is the ***measure of how different they are***.

According to the Convention on Biological Diversity, "biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". The term "biodiversity", thus, refers to the variety of all life on earth, and explicitly recognizes how the interaction of the different

components of ecosystems results in the provision of essential ecosystem services on the one hand and social and recreational opportunities on the other, including being a source of inspiration and cultural identity.

The variety of concepts and definitions that abound indicates the difficulties facing any attempts to establish a practical, working definition of biological diversity. Perhaps one of the simplest and most widely accepted definitions used is the conservation of the maximum number of species. But even then, there are difficulties, as it is not clear what actually constitutes a species.

3.2. Causes for the Losses of Biodiversity

Important biological causes of the loss of biological diversity include the loss of habitats, the introduction of exotic species, over-harvesting of biodiversity resources, and homogenization of species in agriculture. The common factor of all these elements is that they are human-driven.

- **a)** *The loss of habitats*. Human disturbance of habitats on a worldwide scale or impact of human activity on world ecosystems (rivers are impounded, and natural grasslands are ploughed).
- **b)** *The introduction of exotic species*. Many are accidental, as with noxious weeds and insect pests. Others are deliberate.
- **c)** *Over-harvesting* by (illegal) hunting, and the systematic cutting of wood for heating purposes, or charcoal production, is other reasons for biodiversity loss.
- **d)** *Homogenization* in agriculture and forestry; in particular, industrial agriculture and forestry use a limited number of species.
- **e)** *Pollution and global environmental change* also threaten the world's biodiversity. Climate changes affect the distribution of species.
- **f)** *Demographic change-* population is most unevenly distributed and concentrated in cities along coastlines and inland waterways.

All these causes have one element in common: they are induced by human activity. This makes human activity the most important source of the current decline in biodiversity. Therefore, understanding the many aspects of human influences on biodiversity, and their underlying driving forces, is of crucial importance for setting priorities and counteracting the current negative trends.

Chapter 4: Classification of Crop Plants

Field crops have been classified on the basis of botany, agronomy, duration of life cycle, special purpose, season and zone of origin in which they are grown etc as indicated below.

4.1. Botanical classification

Botanical classification is based up on ***similarity of plant parts***. Most types of field crops may be belongs the following families.

i) **Gramineae/poaceae family:** They are Monocotyledons. The grass family includes about three-fourth of forages crops and all grain cereals crops. They possess long narrow leaves with parallel veins and fiber roots. They are annuals, biennials or perennials. The annual crops of this family are wheat, barley, maize, sorghum etc. while perennial crops is sugarcane, Napier grass etc.

ii) **Leguminaceae/fabaceae family**: they are Dicotyledon. Plants possess broad leaves and tap root system which bears nodules. Their seeds are borne in pods. The common annual legumes are horse bean, haricot bean, field peas, chickpea, cowpea, soybean etc. while perennial legume is alfalfa, Lucerne etc.

4.2 Agronomic classification

This type of classification of plants identifies a plant's ***agricultural use*** and ***their gross similarities.***

- **Cereal crops: -** These crops are grown for their edible grains rich in carbohydrate. They include Wheat, Barley, Tef, Maize, Sorghum, F. Millet.

- **Pulses/grain legumes:** - These crops are grown for their edible grains rich in quality protein. They include Faba bean, Field pea, Cow pea, Soybeans, Lentils.

- **Root & tuber crops: -** These are grown for their enlarged roots or tubers. Important root and tuber crops are Cassava, Sweet potato, Potato, Yam.

- **Fiber crops: -** They grow for their fiber and this includes Cotton, Sisal, Kenaf.

- **Oil crops: -** These crops are grown for their edible oil. They include Sesame, Sunflower, Safflower, Rape seeds, Linseed.

- **Sugar crops: -** Grown for their sugar content and includes: Sugar cane (60% sugar come from this crop in the world), Sugar beet (40% sugar from this crop).

- **Drug crops:** - These crops are smoked or chewed for their stimulant effect. They include Tobacco, Chat

- **Beverage crops: -** These crops are also sources of stimulants. They include Coffee, Tea, Cocoa

- **Vegetable crops: -** This group includes Tomatoes, Onions, Cabbages, Lettuce, Carrot, and Cucumber.

- **Fruit crops: -** This group includes perennial fruit bearing crops. They include Papaya, Mango, Avocado, and Banana.

- **Forage crops: -** Crops grown as feed for ruminants. They are fed to the animals either fresh or in dried form, such as hay and silaga (e.g. Alfalfa)

4.3. Special purpose classification

The name of the group is often derived from the ***purpose for which the crop is used***. Many of the crops previously mentioned are well suited for more than one purpose. Some of the special purpose groups are as follows.

i) Cover crops: - These crops are sown so as to make a growth to ***cover or protect the soil***. Example Alfalfa, Vetch, Cow pea, ...

ii) Green – manure crops: - Those crops, which are grown to be plowed under or to be disked into the soil to increase its productivity. As a rule

- Legumes are more desirable than non legumes
- Fast growing crops are preferred to slow growing
- High biomass producing crops are preferred to low biomass-producing crops. Example Cow pea, Vetch, Sesbania, ...

iii) Catch or emergency crops: - crops used as ***substitutes for staple crops*** that have failed on account of unfavorable conditions. They are quick growing crops. E.g. millet and chickpea

iv) **Soiling crops:** - Those crops are cut/harvested green and fed green to cattle directly from the field at their succulent stage. E.g. Alfalfa, Clover, Grasses, maize, ...

v) **Trap crops:** - Planted to attract pests.

vi) **Alley crops**: crops are grown in alleys formed by trees or shrubs to increase soil productivity and reduce soil erosion.

4.4. Classification based on duration of life cycle

Crop plant completes their life cycle after passing through progressive stages of development during certain period of time; accordingly crops are grouped in to three categories.

i) **Annual crops:** crops that complete their life cycle ***within a season or a year***. Most of field crops are annual in nature; they produce seeds within a season or year and die. Example- rice, wheat, barley, maize, Faba bean etc,

ii) **Biennial crops:** crop plants that complete their life cycle in ***two successive seasons or two consecutive live years***. During the first year they produce leaves and stored food and in the second year they produce fruits and seeds after which plant dies. Examples: cabbage, carrot, sugar beet etc.

iii) **Perennial crops:** the plants that live for ***three or more crops seasons*** are termed perennial crops. These plants may be seed bearing or no seed bearing. They may be propagated by seed or by vegetative propagation such as sugar cane, Napier grass, ginger and sweet potato or may produce fruits like citrus groups, mango, avocado etc.

4.5. Classification based on Zone of origin

Based on zones during which they are grown, crops can be classified in two groups:

i) **Tropical crops**: Crops grown only on slight heat and light charge. All phases of growth flow normally under high temperature regime. They are not resistant to low temperature. They are short day plants like maize, rice, cotton, and potato.

ii) **Temperate crops**: They are cold season's crops and cold resistant like wheat, barley, oat, field pea, and lentils.

Chapter 5: Major Physiology of Crop Plants

Crop physiology is the study of plant functions in crop communities. Plant functions in crop communities as affected by soil and environmental factors as well as by crop management practices in relation to crop yields are generally referred to as crop physiology. It deals with the plant functions in crop communities as against plant functions in individual cell organelles, cells, tissues and organs as is the case in plant physiology. Plant physiology is a discipline of botany where the structure of the cell, tissues and organs is associated with processes and functions.

5.1. Growth and Development

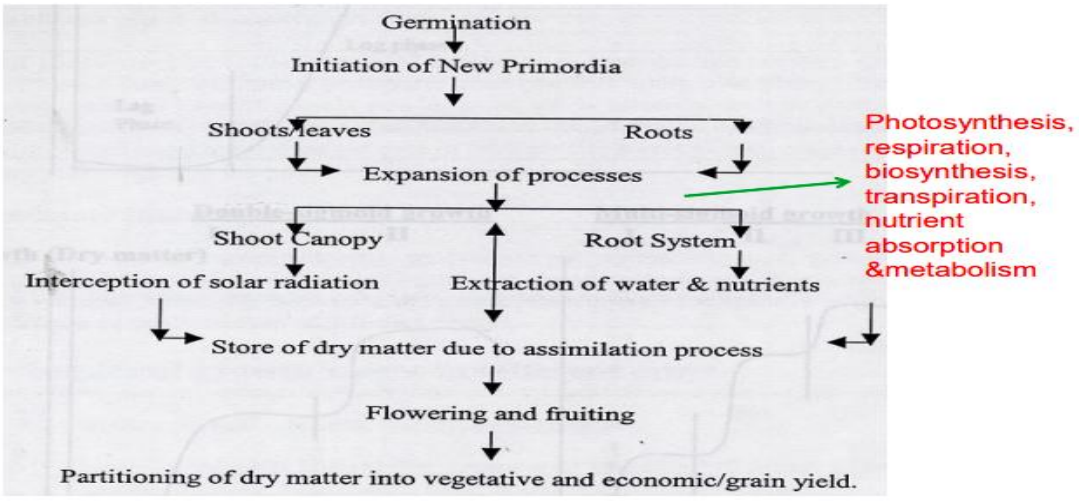
Germination- The term germination is applied to the resumption of the growth of the seed embryo after the period of dormancy.

- **Radicle** (embryonic root) is the part of a plant embryo that forms the root of the young plant.
- **Plumule**: rudimentary (undeveloped, not fully developed) shoot

Growth - Growth is defined as an irreversible increase in size of a plant or a plant part. Therefore growth describes a quantitative change in a plant or a plant part.

Development- Development is defined as a qualitative change occurring in a plant. e.g.:- Initiation of leaves roots and flowers.

Figure 1: Main processes in crops growth and development

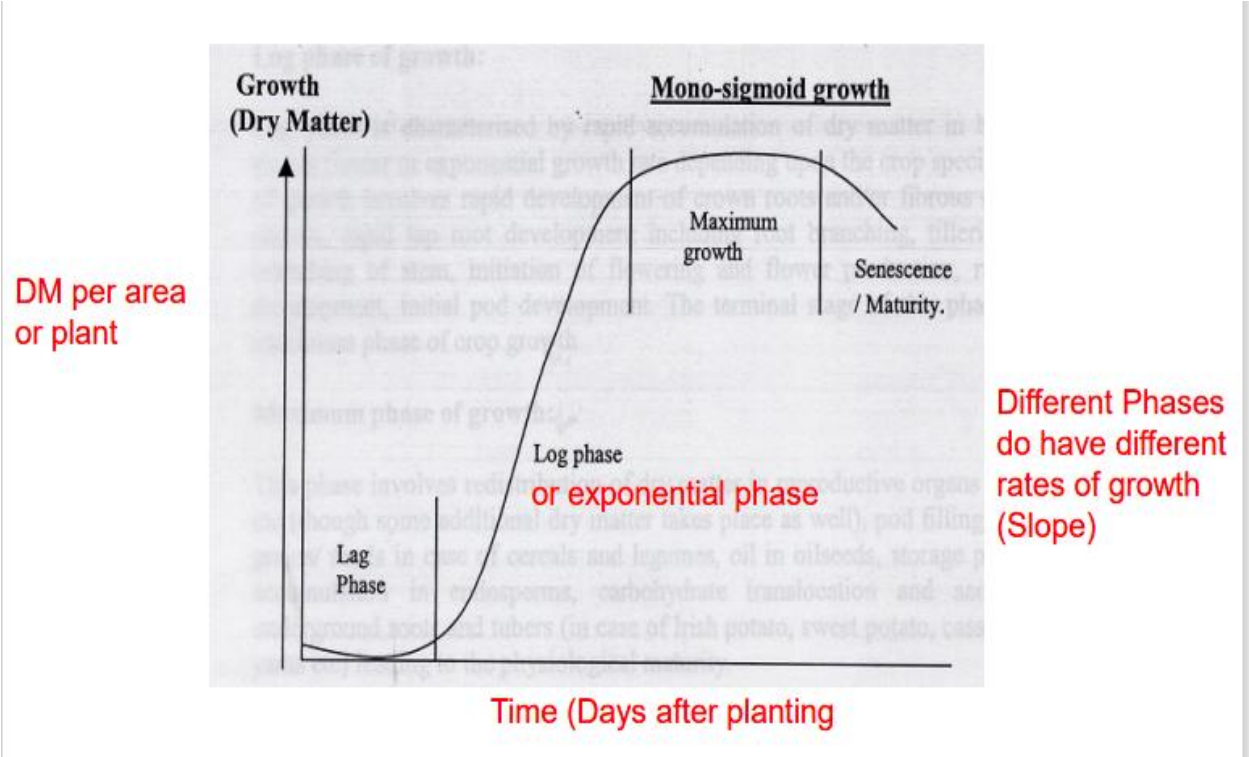


Growth Curve: -

- ☞ Used to describe growth

- A drawing showing organism's size or weight against time
- It shows cumulative size as a function of time
- A common one is S-shaped (sigmoid) growth curve
- This is exhibited by numerous annual plants and individual parts of both annual and perennial plants.

Figure 2: Growth pattern of annual crops with respect to time



- ***Note that lag, log, maximum and senescence phases are quite distinct in annual crops***

Lag phase of growth

- Is characterized with very low rate of dry matter accumulation
- It involves crop emergence, development of root and shoot primordia, crown nodes, crown roots, seminal roots, initial branching of tap roots in dicots, initial tillering in cereals and initial branching in dicots.

Log phase of growth

- Is characterized by rapid accumulation of dry matter in both roots and shoots
- It involves rapid development of crown roots and/or fibrous root system in cereals, rapid tap root development including root branching, tillering in cereals, branching of stem,

initiation of flowering and flower production, rapid leaf area development, initial pod development

- The terminal stage of this phase results into maximum phase of crop growth

Maximum phase of growth

- This phase involves redistribution of dry matter in reproductive organs (grains, pods), tubers, storage roots
- Pod filling, dry matter in grains/ seeds in case of cereals and legumes, oil in oilseeds, storage proteins, starch accumulation in endosperms, carbohydrate translocation and accumulation in underground roots and tubers (in case of Irish potato, sweet potato, cassava, cocoyam, yams etc) leading to the physiological maturity.

The senescence phase

- It is characterized by a decreasing in growth rate
- change in colour (loss of chlorophyll pigment)
- Loss of organs like leaf, fruit, seed

Examples of growth stages in different crops

1) **Smaller cereals**: - wheat, barley, oats, triticale- Germination/crop emergence, crown root initiation**, initial tillering, mid-tillering, jointing, flowering*, milk, dough and maturity stages.

2) **Cereals/Millets**; - maize, sorghum, pearl millets: Crop emergence, crown root development, knee high**, booting (sorghum and pearl millet), flowering** (tasseling and silking**), milk & dough (grain filling) and maturity stages.

3) **Legumes- pulses: -** Crop emergence, root development, nodulation**, stem branching, flowering**, pod-filling* and maturity stages.
   Note **,* sensitive stages to water-stress

Growth Analysis

- It systematic series of measurements and techniques employed to quantify plant growth
- In growth analysis two basic measurements are made, dry weight and leaf area

- The measurement is done at intervals ranging from days to weeks to quantify effects of environmental influences or to analyze genotypic differences between crop cultivars across areas of 0.1 to 10 m2
- large number of parameters are derived from these measurements

Objectives of growth analysis

- To compare the growth of different species
- To compare different varieties (Genotype) of the same species
- To compare growth of different plant parts
- To estimate effect of different environmental factors on crop growth. E.g.: effect of different temperatures on rice
- To evaluate effect of different levels of a given management practices. E.g: effect of different frequencies of irrigation on the growth of rice
- To determine the net result of different physiological process within a plant. Net result of photosynthesis, respiration

5.2. Structure and Functions of Crop Plants

Structure: A part of a body or organism, for example, an organ or tissue, identifiable by its shape and other properties.

Function: an organized systematic action of organelles, cells, tissue, organ, plant ¬ Anchorage, support, transport, synthesis

Process:

- a series of sequential events operating under natural conditions ¬ water and mineral absorption, transpiration, photosynthesis, respiration,
- In living organisms, structures and functions are intimately wedded

5.3. Yield Formation Process

The process of yield formation in crops takes place in three distinct phases:

1) Formation of vegetative infra-structures or organs for nutrient acquisition and photosynthesis,
2) formation of floral organs and yield container and
3) Production, translocation and accumulation of yield contents

Important crop yield and yield related parameters

Phenological and Vegetative growth Parameters

- ✓ **Days to heading (head emergence): -** The number of heading will be recorded as the number of days from the crop emergence to head emergence.
- ✓ **Days to maturity/90% Physiological maturity: -** it will be recorded at 90% physiological maturity of pearl millet when 90% of the plant reached their respective phenological stage of maturity a plot basis.
- ✓ **Days to 50% flowering**: The numbers of days from planting to 50% of the plant in the plot are in bloom.
- ✓ **Plant height (cm): -** The height of five pre-tagged pearl millet plants from the net area of each plot will be measured from ground level to the tip of the main stalk. Their average will be taken as plant height per plant**.**
- ✓ **Number of tillers or branches/plant:** number of branches/tillers on the plant from the base.
- ✓ **Number of pods/plant:** number of pods a plant before harvest.

Yield components and yield of pearl millet

- o **Head weight per plant (g):-** The heads of the five pre-tagged plants will be harvested and weight using sensitive balance and their average will be expressed as head weight per plant.
- o **Aboveground dry biomass: -** This will be recorded from the net plot area after sun drying **Grain yield per plant (g):-** Grain weight per plant will be recorded from five randomly taken plants from the net plot area.
- o **Grain yield (kg m^{-2}):-** determined from the net plot area and adjust to 12.5% grain moisture content.
- o **Number of seeds/pod**: count number of seeds in a pod from five randomly selected pods.
- o **Grain weight:** Harvesting the crop and after adjusting the moisture content, the clean grains will be weighed and recorded.
- o **100 seed weight (g):** The weight of 100 seeds will be determined by carefully counting the Seeds at random and weighed them using a sensitive balance.
- o **Harvest index:** it will be calculated by dividing seed yield by the total aboveground biomass yield.

Chapter 6: Factors Affecting Field Crops Production

Plant growth is complex process and influenced by Genetic (plant) factors, Environmental and Management factors as follows.

6.1. Crop (genetic) internal factor

Crops vary in their needs for water, nutrients, sunshine and day length, and agronomic management strategies. For example, water is very critical in the growth and production of sugar cane, bananas ... Whereas in the production of cotton, groundnut and beans (legumes in general), sunshine and day-length are the most critical. Therefore, in the selection of what to grow, you must bear in mind the variables which encourage the crops to perform optimally. Unless, you are prepared to create a micro-climate or environment for the crops of your choice, you should as a matter of importance check through the list of crops that perform optimally in the (selected) environment where you intend to grow the crops. For example, swamp rice (paddy rice) requires pre-nursery and nursery operations in the production of the rice seedlings; upland rice does not require pre-nursery and nursery operations. Most cereals require heavy sunshine, moderate water/rainfall and well drained soils.

Generally: a crop cultivar has an inherent yield potential. To make best use of climatic and soil factors the selection of crops should be made on their best qualities based on:

- Adaptability under the particular set of condition
- Yield potential (productivity)
- Resistant to a biotic and biotic factors
- Market quality and Harvesting quality
- Effects on soil health
- Viability and Purity
- Healthiness
- Size
- Freeness from mixture
- Animal feeding quality

6.2. Environmental (External) factors

The environment in which crops are grown can influence the rate of growth and development. **Environment** is defined as the aggregate of all the external conditions and influences affecting

the life and development of plants. Agronomic adjustments necessary for higher yield are aimed at creating optimal conditions for crop production to the extent possible.

Major factors of environment on plant can be broadly grouped into two: **climatic and edaphic (soil).**

6.2.1. Effect of Climate

It refers to the total complex of weather conditions, its average value and range of variation over appreciable areas of the earth's surface, usually conditions for many years (30 to 35 years) are taken into consideration. Climate largely determines the type of vegetation that grows naturally in any part of the world and the kind of agricultural production that is possible. The most important climate factors are: Moisture (water) supply, Light, Temperature, Humidity, Wind and Radiant Energy.

A. Moisture (water):

Water is absolutely essential of plant life. Plants use more water than any other substances they absorb.

Importance of water in plants:

The essential requirement of water for plant growth can be visualized from the fact that it may constitute 70 to 95 of total fresh weight when it is actively growing. It is used for Universal solvent for chemical reaction, dissolves essential nutrients through the plant, cell turgidity and for cell elongation so maintain shape and photosynthesis etc.

- The most sensitive metabolic/process to low water potential are: Cell growth, wall & protein synthesis, protochlorophyll formation, nitrate reductase level
- At low ψ (soil), the rate of expansion of both leaf and root decreases but rate of root elongation is affected to the LESSER extent signifying that shoot elongation is more sensitive than root elongation to low ψ (soil)
- Root elongation at low ψ (soil) occurs despite a decline in turgor of root cells most possibly due to the amount and activity of —expansions in root tips
- Low tissue water potentials (Ψ) vis-à-vis sensitivity of metabolic processes

Water stress ------ high root/shoot ratio

Table 3: Role of water with plants and impact of its shortage

Role of water with plants	Impact of water shortage
○ Primary component of photosynthesis and transpiration	○ Reduced growth and vigor
○ Turgor pressure(pressure to inflate cells and hold plant erect)	○ Wilting
➢ Solvent to move minerals from the soil up to the plant: NO_3^-, NH_4^+, $H_2PO_4^-$, K^+, Ca^{+2}, Mg^{+2}, SO_4^{-2}, $H_2BO_3^+$, Cl^-, Co^{+2}, Cu^{+2}, Fe^{+2}, Fe^{+3}, Mn^{+2}, MoO_4^{-2}, and Zn^{+2}	➢ Reduced growth and plant vigor ➢ Nutrient deficiencies
➢ Solvent to move products of photosynthesis throughout the plant, thus regulating transpiration and photosynthesis	➢ Reduced health of roots which leads(over time) to reduced health of plant
➢ Regulation of stomatal opening and closure, thus regulating transpiration and photosynthesis	➢ Reduced plant growth and vigor ➢ Reduced cooling effect = warmer micro climate temperatures
➢ Source of pressure to move roots through the soil	➢ Reduced root growth = reduced plant growth and vigor
➢ Medium for biochemical reactions	➢ Reduced plant growth and vigor

Plants can be classified according to the amount of water they require for normal growth:

1. Xerophytes: require little water. Example most desert plants
2. Mesophytes: require moderate amount of weather .Cereals, legumes
3. Hydrophytes: require large amount of water. Example , rice

The actual amount of Water required by plant varies depending on the following factors:

Transpiration ratio: the amount of water transpired in relation to the amount of dry matter produced. For examples, the crops barely in order to produce 1 unit or dry matter, plants require 800 units of water is transpired. The crop maize also in order to produce 1 units of dry matter, plant require 370 units of water is transpired. Even within the same crop this ratio varies.

Plant population: Within the limits of available moisture nutrients and other variables, as population density increases, yield increase and total water use also increase, at the same time it allows more efficient utilization of water because the soil is permitted with roots so the maximum amount of moisture that enters the soil is extracted from it and transpired by the crops.

Fertilizer application: When adequate moister is available, yield increase with application of appropriate fertilizer (especially N) and the water required to produce dry matter may decrease. It helps to enhance more efficient utilization of water. Additional nitrogen application helps

vigorous (more) root growth, exploitation of soil by root and to extra more water. When adequate moisture is not available, the benefit of fertilizer application is reduced by Excess application may damage the crop because fertilizes can burn root tissue , and Excess nitrogen result in abundant vegetative growth, water required to support such growth which drains the soil available moisture before the crop is matured, thereby reducing crop yield.

Stage of development: The crop passes through various growth stages. Seedlings generally have less efficient water utilization than mature plants because root systems don't fully exploit large volume of soil, and seedlings do not shade the soil surface which results significant amount of water are lost from the soil by evaporation.

Photosynthesis: Water use is high when the photosynthesis rate is high.

Relative humidity: It is the amount of water vapor in the air at particular temperature compared with the amount of water vapor that the air could hold at the temperature. When there is low RH in the atmosphere, the concentration difference is high and then transpiration is high.

Health of the plant: The overall health of the plant greatly affects its water use and water use efficiency. Plants that are infected by any of the pathogen have 3 greatly reduced water use efficiency, high transpiration and reduced yields.

Rain fall: Precipitation is the process by which condensed water vapor from the atmosphere falls to the earth's surface reaching in different forms inducing rain, snow and ice. Rainfall is the most important forms of precipitin in crop production. The minimum amount of rainfall on a single occasion that ensures at least some soil water storage is usually referred to as **effective rainfall**.

The effectiveness of rainfall in crop production depends on three of its characteristics- ***quantity, distribution and duration***. Light showers usually end up evaporated from the soil. Moderate RF over a longer period is more useful than a rain that delivers several inches of moisture in a short period.

Much of such RF will be lost to surface drainage and not available to crops. It might even by accompanied by soil erosion that will be detrimental to crop productivity.

The amount of water by itself is not a very high value unless it is distributed throughout the life of the crop. For example in maize production the critical time when moisture is needed is 10 days after tasselling and silking. For most crops this time occurs around flowering. Therefore, RF is of most value to crop productivity when it falls at these critical periods in the plant growth and development.

B. Light / Solar Radiation

This is the radiant energy from the sun, measured as a total amount (direct solar plus sky radiation). Radiant energy is significant factor in plant growth and development as the permeability of protoplasm, intake and loss of water, enzymatic activity, respiration, photosynthesis, flower initiation and ripening of fruits are all influenced by light directly or indirectly.

Solar radiation is very important in crop production as is a source of energy used by plants for photosynthesis, the effect of solar radiation on crop productivity depends on the angle at which it strikes the earth, the cloud cover, and the interception by plants. Three aspects of light: **intensity** (quantity), and **duration** (day length), **quality** (spectral distribution) are important.

The efficiency of light interception by a crop is dependent on many factors

- The ability of crop to produce full leaf cover early in the season like Maize, sugar cane,
- Plant population density. Crops grown in wide rows are less efficient in early parts of season than grown in narrow rows,
- Leaf arrangement. Rosette leaf arrangement (sugar beet) is less efficient than cereals leaf canopy,
- Leaf angle. Plants with more erect leaves are generally more efficient than those with leaf angle closer to the horizontal,
- Tillering. In cereals , tiller number, in general, increases with increasing irradiance,

Light Quality: the wave length of the radiation determines its quality. Plant pigments associated with photosynthesis have different absorption spectra. They absorb different wave length of light. Leaf chlorophyll absorbs radiation efficiently at 400-500 nanometers (blue) and 650-750 nm (red), these radiant energy wave length ranges that are most important to photosynthesis is considered to be only useful part photosynthesis active radiation (PAR). Within this range, it is known that

different pigments involved in photosynthesis have different wavelength where light absorption is maximum. However, in practice, light quality cannot be manipulated under field conditions.

Light Intensity: light intensity measures its quantity or brightness. Light intensity may be as high as 10,000 foot candle. Foot candle is a light produced by a standard candle.100-200 FC is minimum requirements to support the growth of most plants. 10,000Fc is maximum intensity of light that plants can use in photosynthesis under average field condition.

- Based on light intensity crops can be grouped:
  1. **Sun plants**: reach saturation at light intensities of 5000 or more FC.
     Examples: most crop plants
  2. **Shade plants**: reach saturation at about 500 FC.
     Example: coffee under forests.

Strategies for maximizing solar radiation interception and crop yield include:

- Early planting for earlier leaf area development,
- Crop stand that will allow development of an optimum Leaf Area Index at maximum leaf area development,
- Sowing at time that provide total ground cover during the period of maximum solar radiation levels,
- Uniform plant stand over the field to reduce early interplant competition and to increase solar radiation interception,
- Optimum fertilizer use to increase rate of growth and photosynthetic efficiency of leaf surface and,
- Extending the time of maximum radiation interception by active leaf surfaces

Light Duration: the duration of exposure to light periods (day-length and photoperiod) influence crop growth and development. The duration of light is measured by the hours of sunshine in 24 hours. The relative length of daily light and dark periods (photo-periodism) has a profound influence flowering, tuber formation and seed germination. Crop plants have been classified on the basis of their photoperiodic requirements for floral initiation into three groups.

1) **Long day plants (short night**):- are those which develop and produce flower normally when photoperiod is greater than a critical minimum (> 12 hrs. of light illumination). For example wheat, barley, sugar beet, oat.

2) **Short day plants (long night):-** are those which develop and produce flower normally when photoperiod is less than a critical maximum (< 12 hrs. of light illumination). For examples maize, rice, sugar cane, soya bean.
3) **Day neutral plants**: - the flowering development of such plants are not affected by photoperiod e.g. tomato, cucumber.

Most tropical crops are short day plants (requiring long –nights for flowering) and those of higher altitudes are generally long-day plants

C. Temperature

The measure of intensity of heat energy is called as 'Temperature". Growth and development are directly affected by temperature. Each crop has its own approximate temperature range, i.e. its minimum, optimum and maximum temperature limit at which growth is negligible or it ceases altogether and an optimum temperature falling between the two extremes. These maximum, minimum and optimum temperature ranges are known as **Cardinal temperature**. The cardinal temperature ranges for cool season crops are maximum 30-38 ^{0}C, minimum 0-5 ^{0}C and optimum 25-30 ^{0}C and also for warm season crops maximum 45-50 ^{0}, minimum 15-20 ^{0}C and optimum 30-38 ^{0}C.

Optimal temperatures for crop growth are dynamic as they differ with crops and varieties, duration of exposure, age of the crop and developmental stages. Most crops make their best development between 15 and 32^{o}C. All the biochemical processes increase with increasing temperature up to a certain level beyond which and below a minimum temperature these activities are reduced.

Temperature directly influences photosynthesis, respiration, cell wall permeability, nutrient and water absorption, transpiration, enzyme activity and protein coagulation. This influence reflects on crop growth. The effect of temperature on net photosynthesis is of vital concern in crop production. Plant growth is greatly affected by high temperature in several ways- inhabits starch synthesis, affect shoot growth, pollen malfunction resulting to reduced yield, causes desiccation and change in enzymatic structures and function, on the other hand low temperature affects crop growth, Pollen sterility, flower and pollen blasting (premature dropping of flow end fruit), and burning of leaves.

Effect of high temperature

Desiccation injury: High leaf temperature resulting either from intense insulation or high air temperature or both may result in excessive rate of transpiration. A relatively high rate of water loss, particularly at times when the rate of absorption of water is sluggish, often leads to death of some or all of the leaves or branches of a plant as a result of desiccation. In extreme cases, entire plants are killed in this way. High temperature may also cause pollen sterility (i.e. pollen tubes fails to grow), flowers and fruit 'blasting' (premature dropping of the flowers and fruit).

Effect of low temperature

Low temperature has both negative and positive effects on plants. The two major negative effects are chilling injury and frost.

Chilling injury: Crops native to tropical or subtropical regions are killed or seriously injured by relatively low temperatures above their freezing point. This type of low temperature injury is often called **chilling injury**. Developmental stages, such as early floral development and germination, are particularly sensitive to chilling. Living plant cells are usually killed when water freezes within them.

Frost: It is one of the very serious problem due to low temperature. It occurs in frost prone area early morning. Even though the temperature drops below 0^0C for a very short time, the cold temperature damages the young part of the plant immediately, these include leaves, flowers, twigs and seeds at soft dough stage.

To describe tolerances for minimum temperature, plants are categorized as **hardy, half-hardy**, and **tender**.

1. **Hardy** plants can withstand minimum temperature of -4 to -2 ^{0}C. ex. Peas, spinach, turnips, and cabbages.
2. **Half-hardy** crops can survive min. temp. of 1- to 0 ^{0}C. ex; carrots, beets and lettuce.
3. **Tender** crops cannot tolerate 0^0C. Ex; beans, corn, cucumbers, squashes, melons and tomatoes.

Based on their temperature response (adaptation) crops may be classified as:-

a. **Cool season crop** – damaged by hot weather. the optimum temperature for cool-season crops is 18-24 ^{0}C.For examples wheat barely , potato, oat
b. **Warm season crop**- killed by temperature below freezing. the optimum temperature for warm season crop is 25-35 ^{0}C. For examples sorghum, cotton, rice, maize.

The relationship between temperature and crop management shows that the crop producers can do little or alter temperature, however, it is possible by adjust planting date(frost free period) and cultivar selection like early mature cultivars for areas with short growing seasons.

D. Humidity:

Humidity refers to the water vapor content of the atmosphere. The amount of water vapor in the atmosphere depends upon wind and temperature. Wind distributes the water vapor in the atmosphere, higher the temperature, more is the amount of water vapor that can be held by the atmosphere. The air is said to be **saturated** when it holds maximum amount of water vapor at a particular temperature. Therefore, a saturated atmosphere that causes fog, dew, or rain has a theoretical relative humidity of 100%. If the temperature rises, the atmosphere becomes unsaturated as it can accommodate some more water vapor.

The effect of humidity on crops is that the occurrence of high humidity over long periods combined with high temperature favors the rapid development and spread of fungal disease on crops and mold on stored produce. The lower the RH at a given temperature the more rapidly will the airs taken up water transpired by plant leaves or evaporated from a moist soil surface. Evapotranspiration increases with increase in temperature and decrease in R.H thus, relative humidity has considerable effect on water requirement of crops.

Relative humidity: is the ratio between the amount of water vapor in the air and water vapor required for saturation at a particular temperature and pressure. It can be expressed as percentage or ratio. **For example-** when the water vapor required for saturation of a parcel of air is 50g and the actual amount of water vapor present is 40 g. the relative humidity is

$$\textit{Relative humidity (RH)} = \frac{\textit{water vapor present in the air} * 100}{\textit{water vapor required for saturation}} \qquad RH = \frac{40x100}{50} = 80\%$$

When RH is 80 percent, it means that there is a deficit of 20 percent water vapor for saturation. Evaporation from the soil and temperature by plants continue to fill the deficit. It indicates that if RH is low or deficit is more, there is possibility of more evaporation and transpiration. Therefore, the parameter RH is widely used in agriculture compared to absolute and specific humidity.

Relative humidity (RH**) directly** influences the water relations of plant and **indirectly** affects leaf growth, photosynthesis, pollination, occurrence of diseases and family economic yield. The

dryness of the atmosphere as represented by saturation deficit (100-RH) reduces dry matter production through stomatal control and leaf water potential.

E. Wind:

Wind is movement of air in a horizontal direction. It originates either over the oceans or deserts. In general, wind increases transpiration, but it should be noted that wind affect transpiration in **two opposite ways**. By reducing the thickness of the layer of water vapor or diffusion shells on the leaf, it increases water loss. On the other hand, the cooling effect of wind tends to reduce the vapor pressure gradient and thus to lower the rate of transpiration.

Wind also alters the balance of hormones. Wind increases ethylene production in barley and rice; wind decreases gibberillic acid content of roots and shoots in rice. Nitrogen concentration in both barley and rice increases with increases in wind speed.

Hot dry winds cause reduction in plant height due to reduction in cell expansion, as the cells cannot attain full turgidity. When developing shoots are exposed to strong wind pressure from a fixed direction, the normal form and position of the shoots are permanently deformed.

The effect of wind on plant growth and development are both physiologically and mechanically.

a) **Mechanical damages**: The heavier sand particles carried by the wind causes soil erosion by scouring the soil surface. The strong wind in association with rain can cause lodging, stock breakage and grain shedding of grains.
b) **Physiological damages**: induces evapotranspiration that affecting the water balance. Hot dry winds may also affect photosynthesis and hence productivity, by stomata closure and reduced rate of gaseous exchange. Provision of windbreaks in exposed areas can minimize the adverse effects of high wind speed (Reddy 1999).

Growth of plants, in general, seems to be inhibited at wind speeds above 10kmph. However, there are individual variations. Tomato growth will not be optimum in a strong wind of 20m s^{-1}.

6.2.2. Edaphic/soil factor

Soil is a living body consists of weathered rocks, organic mater, water and living organisms. It is a natural medium for plant growth. Soil provides physical anchorage to plants and act as store house for water and nutrients needed. Following are the soil requirements for crop production.

- Suitability for using cultural implements in crop production,
- Resistance to erosion and management involved in profitable crop production,
- Adequate soil moisture storage to meet normal crop requirements under natural rainfall or irrigation,
- Optimum aeration in the root zone depth for efficient root system development,
- Availability of nutrients, sufficient for normal yields, and
- Freedom from adverse chemical soil conditions Such as concentration of harmful soluble constituent

Principal factors characterizing soil climate are soil air, soil temperature and soil moisture. Some of the soil factors that affecting plant growth:-

a. Soil Reaction/$_{P}$H/:- It defines the soil acidity or alkalinity based on the hydrogen ion concentration of the soil and is measured in $_{P}$H units. On the $_{P}$H scale, a value of 7.0 indicates a neutral reaction, all value below 7.0 indicate acidity while all values above 7.0 indicate alkalinity.

Each nutrient element has a pH range within which it is available to plants. Similarly, plants have pH adaptation, some being sensitive to acidity while others are sensitive to alkalinity.

- The optimum pH rang for most plants is ……6.5-7.0
- Most agricultural soils have a pH of between …….5.0-8.5
- Most plant nutrients are available with pH values …… 5.5-7.5

Therefore, the pH of the soil has significant influence on the availability of plant nutrients.
It also influences plant growth by affecting the activity of beneficial microorganisms. Most N-fixing bacteria are not very active in strong acid soils. Bacteria that decompose soil organic matter and thus release nitrogen and other nutrients for plant use also hindered by strong acidity.

b. Soil texture: - defined as the relative proportion of sand, silt and clay in the soil. The soil particles on diameter basis: sand ranges 2.00-0.05 mm, silt 0.05-0.002 mm and clay below 0.002 mm. An agricultural soils typically consists of a combination of all the three particles is called a loam.

Soil texture is very important in crop production. Fine textured sols (clay soils) generally have poor drainage and are prone to water logging. Poor- drained soils have low microbial activity but

clay soils have high water- holding capacity, high cation exchange capacity (CEC), and the ability of soil to attract and hold cations. Thus, clay soils have high nutritional status while sandy soils, which are coarse-textured, have low CEC.

Clay soils are further described as heavy soils because it becomes very hard when dry, and sticky and poorly aerated when wet and so difficult to till. They impede root development and thus are not suitable or root crop production. Clay soils have a small micro-pore that impedes drainage.

Sandy soils have more macro-pores (large pores). Sandy soils are light soils and are easier to till, They also drain better, and are warm, However, crop production on sandy soils requires frequent irrigation to make up for its poor water -holding capacity.

Soil texture is an important soil characteristic because it affects infiltration, retention of water, soil aeration, and adsorption of nutrients, microbial activities, tillage, the method and frequency of irrigation.

c. Soil structure: - It is the manner in which individual particles are arranged to form soil aggregate. Soil aggregates is a clump of many primary soil particles. Soil structures can be destroyed through soil compaction using heavy machinery, farm animals, vehicles, and raindrops. Poor soil aggregation is partly the cause of poor drainage and poor water holding capacity. Soil structure can be improved through, for example the addition of organic matter.

d. Soil fertility: - soil fertility is the ability of the soil to produce high yields consistently, provides environmental factors.

e. Soil constituents: - Even though the proportion will vary from one soil to another, a typical mineral soil consists of by volume Air (25%), Water (25%), Mineral (45%) and Organic matter (5%)

f. Soil depth: - insufficient soil depth for adequate root development is the most obvious physical property that can crop yield. There is a positive linear relationship between the effective rooting depth and yield of a crop.

g. Soil moisture: Essentially all of the water used by plants is supplied by the soil. Soil is made up of solid particles and pore spaces which the ideally pore spaces should occupy about 50 % of the soil volume.

Depending on the amount of water and its availability to plants soil moisture is declassified as

1. **Saturated soil** : the amount of soil moisture content at which plants can no longer obtain enough moisture to meet transpiration requirement, they wilt unless water is adds to the soil.
2. **Field capacity:** the amount of water remaining in the soil after being saturated and then freely drained.
3. **Permanent wilting point: -** the amount of water in the soil at which plants will wilt and not recover when placed in humid atmosphere.

6.3. Management factors

Management factor concerns about different agronomic activities healed on field. Field crop production and productivity can be affected by:

- Tillage and seed bed preparation
- planting material (seed) selection and methods of planting
- soil and water conservation
- fertilizer rate and application
- crop protection
- harvesting activities
- transportation and storage
- value addition and processing

6.4. Economic & social factors

Besides the innate characteristics of the crops and the environmental factors as climate and soil, other variables that influence permanent crops production are the economic factors. Economic factors include such variables as

- ✓ consumption preference and market forces demand
- ✓ level of development and living standard
- ✓ level/source of income
- ✓ labour availability
- ✓ supply of tools and materials
- ✓ marketing access and price

Chapter 7: Cropping System

It refers to the way and manner in which the farmer actually organizes growing of crops and how he/she arranges them in his/her fields. It includes the scheduling and cultivation of various crops with a farm enterprise in a given agricultural year.

In other words, cropping system usually refers to a combination of crops in time and space. Combinations in time occur when crops occupy different growing periods and combinations in space occur when crops are interplanted. When annual crops are considered, a cropping system usually means the combination of crops within a given year. In general, cropping system is the kind and sequence of crops grown on a given area of land over a period of time. It may be a regular rotation of different crops or it may be consists of only one crop, year after year on the same land.

It comprises all component required of the production of the set of crops of a farm and their relationship between them and the environment.

7.1. Shifting cultivation

Shifting cultivation was developed early in settled agriculture and persists with modification in many parts of the tropics. In this system, farmers cultivated a plot of land large enough to supply their family's need until soil fertility declined with continuous cropping. The farmers then moved on to another plot leaving the first plot to return to bush through regeneration of natural vegetation. The soil would recover its fertility during this fallow period. Shifting cultivation in the tropics is characterized with in variably a low level of input technology and management where in all operation are carried out manually using simple hand tools requiring high manual energy.

With increasing population and consequent reduction in availability of land, shifting cultivation has been replaced by sedentary occupation and reduced length of the fallow period. In most parts of the tropics, there are modified forms of shifting cultivation often involving land rotation.

7.2. Mono cropping /sole cropping /Mon culture

Mono cropping is the agricultural practice of growing a single crop year after year on the same land, in the absence of rotation through other crops.

Sole cropping: - growing one crop variety alone in pure stand at normal density.

Sole/Mono cropping has a number of disadvantages, including the following

- The practice carries within the risk : Natural hazard and Pest and disease attack ,build up Pest and disease, imbalance in nutrient removal from the soil

Advantages

- Encourages specialization in the techniques of production

7.3. Multiple cropping/Poly cropping:

The practice of growing two or more crops in succession on the same pieces of land **within a year**. It is intensification of cropping both in time and space dimensions i.e. more number of crops are sown within a given period of time on same pieces of land. It includes:-**mixed cropping** and **inter cropping**

1. **Mixed cropping:** Growing two or more crops simultaneously on the same piece of land. It has a number of technical and economic **advantages** which makes the system efficient.
   - Reduce total crop failure resulting from pest and disease attack
   - Giving the soil good structure and reduce erosion
   - Economically, the return per unit of lab our is higher as result of greater total yield
   - Reduce pest and disease attack.
   - Better use of the environment in terms of space, water and nutrients which enable to permits higher plant population than single crop and different crops obtain their nutrients at different soil depth

Disadvantages: Making mechanization difficult and Difficult in large scale farming

2. **Inter cropping:** - Farmers grow several crops simultaneously in the same season either by mixing their seeds or by growing them in separate rows. Both the crops may be sown or harvested at the same time or at different time. The intercrops are fast gowning and have short duration grown between two rows of slow gowning main crops.

There are basic spatial arrangements which are used in intercropping.

i) **Row intercropping** - growing two or more crops at the same time with at least one crop planted in rows.

ii) **Strip intercropping** - growing two or more crops together in strips wide enough to permit separate crop production using machines but close enough for the crops to interact.

iii) Relay intercropping - planting a second crop into a standing crop at a time when the standing crop is at its reproductive stage but before harvesting.

Table 6: Difference between inter cropping and mixed cropping

Inter cropping	**Mixed Cropping**
Objective is to utilize the space left between main crops	Objective is to get at least one crop under any hazard
More emphasis is given to the main crops and subsidizing crops are not grown at the cost of min cops	All crops are given equal emphasis ; there is no min or subsidiary crop
No competition between crops	In all combination there is competition
One crop is long duration and the other is short duration	Almost the same duration
Crops are sown without affecting the population of main crop when sown as sole crop • Sowing time may be same or different	sown without considering the population of either • It is same for all crops

- **Evaluation of inter-cropping systems:**

Land Equivalent Ratio (LER): it is the relative area of a sole crop or sole crops required to produce the yield or yields achieved in inter-copping.

LER = Ia/Sa + Ib/Sb + Ic/Sc + . . . + InSn

Where Ia, Ib, Ic,… In are the individual crop yields in inter-cropping, and Sa, Sb, Sc . . . Sn are their yields as sole crops.

❖ A LER greater than 1 implies that for that particular crop combination, inter-cropping yielded more than growing the same number of stands of each crop as sole crop.

❖ A LER less than 1 implies that for that particular crop combination, inter-cropping was less beneficial than sole cropping.

❖ A LER equal to 1 implies that for that particular crop combination, yields harvested from inter-crops could have been obtained from the unit area planted to sole crop, and also the overall yield per unit area of inter-crop is not greater than that of the most productive sole crop.

Example: Calculate land equivalent ratio (LER): if one can get 75 kg maize and 25 kg faba bean as sole cropping; and 50 kg maize and 18 kg faba bean from inter cropping those crops.

Solution:

LER = I (maize)÷S (maize) + I (f.bean)÷S (f.bean)

=(50÷75) + (18÷25)

=0.66 + 0.72

LER =<u>1.38</u>

Recommendation/Interpretation:

1) Since the value of LER is exceed than 1; intercropping of Maize and Faba bean has better advantage than sol cropping of each crop.
2) LER of 1.38 indicates that 38% yield advantage is obtained when grown as intercrops compared to growing as sole crops.
3) In other words, the sole crops have to be grown in 1.38 ha to get the same yield level that is obtained from 1 ha of intercropping.

3. **Alley cropping:** It entails growing food crops between hedge row of planted shrubs and trees, preferably legumes, the hedges are pruned periodically during the crops growth to provide the biomass and prevent the shading to the crops, Hence alley cropping can be conveniently considered as a form of hedge row intercropping.
4. **Crop rotation:** It is the sequence of certain number of crops in definite order on the same pieces of land over a fixed period of time.

Several advantages are associated with crop rotation, among which are the following

- For balancing nutrient removal from the soil E.g crops like maize yam and cassava are exhaustion, Vegetables such as tomato, ground nut are relatively less demanding
- The different plant species is able to extract nutrients at different soil depth
    - Difference in the development of the root system
    - Rotate deep rooted crops with those having shallow root system.
- Reduce the incidence of disease by preventing pathogens form completing their life cycle
- Improvement in soil structure with reduction in erosion.
- Diversification of marketable row materials

5. **Fallow cropping:** Leaving the land free of crops for some times and cultivating for the other time.

Chapter 8: Agronomic Practices (Crop husbandry)

8.1. Tillage/land preparation

***Tillage*:** it is the manual or mechanized manipulation of the soil to provide a medium for proper crop establishment and growth. There are several purposes of tillage, the major ones are.

- ✓ **Land leveling.** Land is leveled for several purposes
- ✓ **Seed bed preparation.** For proper germination to occur, the seed must make good contact with the soil to be able imbibe moisture
- ✓ **Incorporating organic matter and soil amendments.** Stubble left after crop harvesting can be mixed to improve its physical characteristics. Fertilizer, organic and inorganic, and soil amendments such as lime, may be added to the soil during preparation prior to seeding
- ✓ **Weed control.** Weeds compete with crop plants for growth factors and may harbor diseases and insect pests. Weeds are controlled at various stages in crop production
- ✓ **Improve soil physical conditions.** Tillage can be used to break up the hard pan for root growth and development
- ✓ **Erosion control.** Tillage Provide a rough soil surface to impede the actions of the agents of soil erosion (conservation tillage)
- ✓ **Shaping the soil.** To create raised beds for planting or to create furrows for irrigation

The two basic groups of tillage according to the degree of soil stirring

1. **Conventional tillage**. The tillage system that leaves less than 15% of the soil covered with plant residue by clearing or remove the remain plant materials on the soil surface. There are two types of tillage operation.
   a. Primary tillage. The mechanical manipulation of the soil that produces a rough finish unsuitable for seeding; usually precedes secondary tillage.
   b. Secondary tillage. The mechanical manipulation of the soil that produces a finer tilth for preparing a seedbed; usually follows primary tillage.

The conventional tillage has advantages include the following

- ❖ Even though tillage may cause compaction, it is the most convent method of managing soil compaction when it occurs.
- ❖ It is easier to apply fertilizers and perform the agronomic operations when the land is clean.
- ❖ The lack of crop residue on the soil surface reduces the opportunity for overwintering / over summering of pests.

The conventional tillage has disadvantages include the following:

- ❖ Creates soil erosion
- ❖ Soil compaction. Creating a plow pan due to excessive and repeated use of primary tillage implements at the same depth places pressure on the soil.
- ❖ It is expensive
- ❖ Soil organic matter loss. Soil organic matter decreases over time.

2. **Conservation tillage**: entails practices in which some crop residue remains on the soil surface after the operation. The chief goals of this tillage practices are to reduce soil erosion and conserve moisture. There are different types of conservation tillage practices that vary in the degree of soil disturbance and the amount of crop residue on the soil surface like no tillage, mulch, strip, minimum tillage and ridge tillage. **Minimum tillage** can be defined as a method aimed at reducing tillage to the minimum necessary for ensuring a good seedbed, rapid germination, satisfactory crop stand and favorable growing conditions (Arnon 1972).

Conservation tillage has advantages that include the following

- o Reduces soil erosion from wind and water.
- o Reduces soil compaction.
- o Soil infiltration and moisture conservation is high because of a large amount of crop residue.
- o Reduce cost of tillage.
- o Soil temperature moderation.
- o Increase soil organic matter over prolonged periods of no tillage.

The disadvantages of minimum tillage include the following

- o Dependence on chemicals. Drastically reduced soil stirring means chemical are depended upon in no-till operations for weed control.
- o Higher risk of insect pests and pathogens in early crop establishment because of soil-borne pathogen sand soil surface insects.
- o The higher soil moisture increases the chance of leaching of water –soluble bases and then tends towards acidity over time.
- o Crop residue impedes the application of fertilizer.
- o High levels of herbicide use increase the opportunities for the development of herbicide resistance. And also new weed problem may emerge under conservation tillage.

8.2. Planting material (seed) and seed quality

Seed is the living link between parents and its progeny.

- Biologically, Seed is a ripe, fertilized ovule and a unit of reproduction of flowering plants.
- Agronomically, a seed material or propagule is the living organ of crop in rudimentary form used for propagation. It may be described as a plant embryo in dominant state surrounded by food supply and seed coat. A good crop stand and establishment depends on the quality of seed planted and the condition under which the seed was planted. It can be any part of the crop from which a new crop will grow.

Characteristics of Quality seed

Quality seed ensures uniform crop stand establishment with uniform vigour and population of seedling per unit area. Selection of good seed is, therefore, of prime importance for remunerative farming.

- The seed should be of adaptable crop variety or hybrid fitting into the cropping system
- Seeds have good yielding ability
- Seed should be pure (true to type) with high germination percentage,
- It Should be free from seed borne diseases , insects and insect eggs,
- Seeds should be Resistant to crop disease and pests.
- They should be materially well-developed, large, plump, bold, uniform in size, shape, colour with proper test weight,
- seed should be free from noxious, objectionable or satellite weed seeds, and

Method of planting: Seeds are sown either ***directly in the main field*** or in ***nursery bed***, where seedlings are raised and transplanted in the main field appropriate age of the seedlings.

Direct seeding: the crops are grown by sowing the seed directly in the main field. Direct seeding may be by broadcasting and row planting/ drilling.

1) **Broadcasting**: random seed distribution is called broadcasting; small sized seeds are difficult to plant individually. Most field corps seeded in this way. For examples wheat, oat, teff, rice etc.

Advantages

a. Rapid seeding
b. Suitable for small seeded crops that are difficult to plant separately.

Disadvantages

a. Uneven seed establishment
b. Require high seeding rate to make up for potential losses
c. Seeds may not germinate (not covered)

2) **Row planting**: it entails more accurate spacing between seeds in a row and between rows. It is a patterned (structured) distribution.

Advantages

a. Facilitate management practices/ cultivation, fertilization, pesticide application, harvesting)
b. Uniform of stand
c. To economize or optimize seeds and land resources.

Seed rate**:** Seed rate plays a vital role in ensuring the presence of required number of plants per unit area. The seeding rate should be estimated as closely as possible for optimal crop stand establishment. Over seeding causes intense competition among plants whereas under seeding results in under utilization of resources and reduce crop productivity. The seed rate of a crop depends up on spacing, seed size, seed weight, germination percentage and purity percentage.

Time of planting**:** Different crops are grown at different seasons depending up on their climatic requirement. Planting crops at proper time increases growth, development and yield of crops due to suitable environment available to the crop at its growth stages. Planting time is influenced by: Rain fall (moisture), temperature, occurrence of disease and pests, marketing, cropping system and available of labor. Early planting may jeopardize crop establishment if unexpected adverse weather (e.g. frost) occurs. Late planting, similarly, may produce low yields because of the loss of part of the growing seasons.

Depth of seeding**:** Depth of sowing is another factor affecting proper seed germination and good plant stand. Uneven and improper depth of seeding results in uneven plant stands on growth, development and yield of crops. It is, therefore, essential to sow the seeds of different crops at proper depth. The optimum depths of sowing of different crops depend up on:-

a. **Seed size**. Crops having bigger size sown at deeper depth while smaller seeds sown at shallower depth.
b. **Soil moisture content**. In relatively dry weather seeds sown deeply to contact with moist soil.

c. **Soil type.** Seed placement in heavy (clay) soils should be shallow and deep in light (sandy) soils. The optimum depth of sowing of most of the common cultivated crops generally ranges 3-5 cm.

8.3.Soil Fertility Management

Essential Elements for Plant Growth: A plant nutrient is a chemical element that is essential for plant growth and development/reproduction. Commonly, for an element to be an essential nutrient, it must fit certain criteria:

- A given plant must be unable to complete its life cycle in the absence of the mineral element.
- The function of the element must not be replaceable by another mineral element.
- The element must be directly involved in plant metabolism
- It should be required by most plants

Elements that might enhance growth or that have a function in some plants but not in all plants are referred to as ***beneficial elements.***

Sources of Nutrients: Seventeen elements are considered to have met the criteria for designation as plant nutrients. Carbon, hydrogen, and oxygen are derived from air or water. The other 14 are obtained from soil

***Macro nutrients*: Macronutrients** are needed by the plants in large amount, and large quantities have to be applied if the soil is deficient in one or more of them.

***Micronutrients*:** or trace elements are required in only minute amounts for correct plant growth and have to be added in very small quantities when they cannot be provided by the soil.

8.4. Fertilizer use and its Management

Fertilizer: is any material used as source of plant nutrient. Fertilizers are materials either **natural** or industrially **manufactured**, containing nutrients essential for the normal growth and development of plants.

Importance of Fertilizer Application:-soil is the cheapest and only ample source of nutrients which is not able to supply enough nutrients for crop production, if plant nutrients sources are not added from outside from time to time. Addition of fertilizer material from outside helps in maintaining the soil fertility and in turn better crop production is obtained.

***Organic Fertilizers*:** Organic fertilizers are good sources of nutrients for crop production. Balancing the quantity of nutrient application with organic sources to match crop need is more difficult than with commercial fertilizers. Nutrient content of most organic sources is highly variable and needs to be determined before application to soils to avoid over application of some nutrients.

***Chemical Fertilizers*:** Any natural or manufactured material, which contains at least 5 percent of one or more of the three primary nutrients (N P K), can be called fertilizer. Industrially manufactured fertilizers are called mineral fertilizers. Fertilizer may contain one or more of the essential nutrients. Those that contain only one of the major elements are described as single, simple or straight fertilizers. Those that contain two or more of the major elements are classified as mixed or compound fertilizers.

With the rapid increase in population and rise in standard of living there is increasing demand for food and feed grains. To meet up with the food demand it is necessary to intensify field crop production. Achieving and sustaining high crop yield of desired quality is only possible through the use of commercial fertilizers.

Table 7: Comparisons between organic and inorganic fertilizers

Features	**Organic Fertilizer**	**Inorganic Fertilizer**
Soil properties	Improving	Not improving
Nutrient content per wt	Very low	Very high
Rate of application per ha.	More quantity	Small quantity
Nutrient availability time	Slowly but for a long period	Immediately but for a short period
Application/management	Not easy	Very easy
Locally availability	Available	Not available
Nutrients	All essential nutrients	Very limited ones

***Fertilizer grade* –** The minimum guarantee of the plant nutrient content in terms of total nitrogen, available phosphorous pent-oxide and soluble potassium oxide. They may be divided in to low-grade and high-grade mixtures.

***Fertilizer ratio* –** the relative percentages of nitrogen, phosphorous pent-oxide and potassium oxide (e.g. 18 – 46 – 0)

Fertilizer application & factors affecting it

The objective of applying fertilizer is

- To promote greater plant growth or better crop quality,
- Maintain soil fertility
- Indirectly reduce soil erosion.

☞ ***Fertilizer rate indicates the amount of fertilizer to be added.***

Rate of fertilizer application depends upon the following:

1. **Crop types**: Different kinds of crops require different amount of nutrients. The leguminous crops require less N than cereals. Improved cultivars, particularly when they are high yielding, normally respond more to increased fertilizer does relative to unimproved local cultivars.
2. **Soil fertility level:** The ability of the soils to supply the necessary plant nutrients differs greatly from one place to another and at different times. More fertile soils require fewer nutrients to produce a good crop and frequent cultivation makes the soil to decline the fertility through times. Large application of fertilizes can be profitable on soils that have a high productive potential but which are low in fertility. Therefore, an increase in the amount of nutrient applied to the soil may or may not increase crop yield.
3. **Growth stage**: At earlier and midst age nutrient requirement is more than the later stages of crop growth.
4. **Moisture status:** If soil moisture status is good then response of fertilizer application is more fertilizer can be applied as compared to rain fed or dry land condition.
5. **Plant density:** If plant density is more then apply less fertilizer at early stage and more in later stage and vice versa in less plant density.
6. **Cropping system Adopted:** the combination of crop in the intercropping or in rotation also decides fertilizer level.

Principles of Methods of Fertilizer Application

(1) Evenly
(2) Near the plant root
(3) Cover it with soil after fertilizing
(4) According to different crop growth stage.

Every fertilizer materials should have guarantee law with regard to its content of N, P and K nutrient elements. The total nitrogen is usually expressed in its elemental form (N), phosphorous

in terms of available P or available phosphoric acid (P_2O_5) (citrate –soluble P_2O_5) and potassium as water-soluble K or water soluble potash (K_2O) and S as elemental S.

To know the amount of fertilizer to be added to the soil we should have information about the fertilizer analysis including form of nutrient tagged on the sac/container and soil nutrient requirement.

Table 8: Preliminary fertilizer blend formulas require basic NPS and the addition of micronutrients

No.	Formula	Amount in %
1	NPS	19 N – 38 P_2O_5 +7S
2	NPSB	18.1 N – 36.1 P2O5 + 6.7S + 0.71B
3	NPKSB	13.7 N – 27.4 P_2O_5 – 14.4 K_2O + 5.1S + 0.54B
4	NPSZnB	16.9 N – 33.8 P_2O_5 + 7.3S + 2.23Zn + 0.67B
5	NPKSZnB	13.0 N – 26.1 P_2O_5 – 13.7 K_2O + 5.6S+ 1.72Zn + 0.51B
6	NPSZn	17.7 N – 35.3 P_2O_5 + 6.5S + 2.5 Zn
7	NPSZn	15 N –31 P_2O_5 –8 K_2O + 7 S+ 2.2 Zn
8	NPSFeZn	17 N –35 P_2O_5 +8 S+ 0.3 Fe+ 2.2Zn
9	NPSFeZnB	17 N –33 P_2O_5 –0 K_2O + 7 S+ 2.2 Zn+ 0.3 Fe+0.5 B
10	NPSFeZn	15 N –30 P_2O_5–8 K_2O +7.0 S+ 0.3 Fe-chelate+ 2.2Zn
11	NPKSFeZn	17 N –20 P_2O_5 –8 K_2O + 11 S+ 2.2 Zn+ 0.3 Fe + 0.5 B
12	NPKS	15 N –29 P_2O_5–8 K_2O +10S

Methods of fertilizer application

In order to get maximum benefit from manures and fertilizers, they should not only be applied in proper time and in right manner but any other aspects should also be given careful consideration.

Different soils react differently with fertilizer application. Similarly, the N, P, K requirements of different crops are different and even for a single a crop the nutrient requirements are not the same at different stages of growth.

The aspects that require consideration in fertilizer application are listed below:

- Availability of nutrients in manures and fertilizers
- Nutrient requirements of crops at different stages of crop growth
- Time of application
- Methods of application, placement of fertilizers
- Foliar application

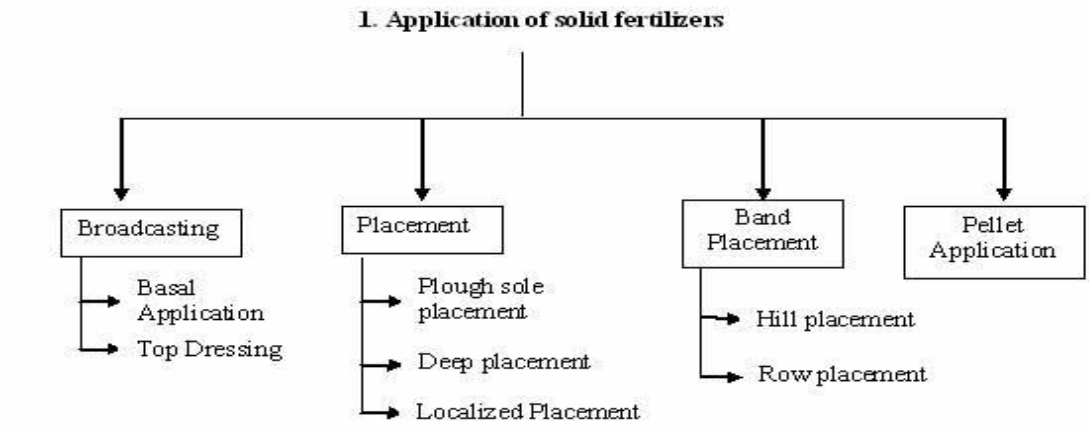
- Crop response to fertilizers application and interaction of N, P, and K.
- Residual effect of manures and fertilizers
- Crop response to different nutrient carrier
- Unit cost of nutrients and economics of manuring

Fertilizers are applied by different methods mainly for 3 purposes:

1. To make the nutrients easily available to crops,
2. To reduce fertilizer losses and
3. For ease of application.

The time and method of fertilizer application vary in relation to

a. The nature of fertilizer.
b. Soil type and
c. The differences in nutrient requirement and nature of field crops.



A) Broadcasting: It refers to spreading fertilizers uniformly all over the field. Suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphatic fertilizers such as rock phosphate are used. It may or may not be incorporated into soil. The ***lowest fertilizer efficiency*** obtained.

There are two types of broadcasting methods for fertiliser application depending on the time of application. They are:

i. **Broadcasting at planting –**The fertilizer is broadcasted just before planting, at the time of ploughing. Phosphoric and potassic fertilizer and half of nitrogenous fertilizer as per recommended dose for a particular crop is applied by broadcasting during planting.

ii. **Top dressing -**The method of application of fertilizer in the standing crops is known as top dressing. The objective of this method is to provide the nutrients, mainly nitrogen, in readily available form, for the growth of plants. Top dressing of phosphate and potassic fertilizers is ordinarily done on pastureland and in orchards or only on fruit trees growing in between agricultural crops. Top dressing with nitrogenous and potassic fertilizer should not be done when the leaves of plants are wet. This may burn or scorch the leaves if applied in the morning before 8 a.m. or just after rain.

The main disadvantages of application of fertilizers through broadcasting are:

1. Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.
2. The weed growth is stimulated all over the field.
3. Nutrients are fixed in the soil as they come in contact with a large mass of soil.

B) Placement: Put in or drilling or placing the fertilizer below the soil surface by means of any tool or implement at desired depth to supply plant nutrients to crop before sowing or in the standing crop is called placement. It is a method of placing fertilizer in the soil before sowing or after sowing the crops. Placement of phosphatic fertilizer below the seed, almost under all situations, has been found superior to broadcast application. Placement of fertilizers is normally recommended when the quantity of fertilizers to apply is small, development of the root system is poor, soils have a low level of fertility and to apply phosphatic and potassic fertilizer.

The most common methods of placement are as follows:

i. **Plough sole placement:** The fertilizer is placed in a continuous band on the bottom of the furrow during the process of ploughing. Each band is covered as the next furrow is turned. By this method, fertilizer is placed in moist soil where it can become more available to growing plants during dry seasons. It results in less fixation of P & K than that which occurs normally when fertilizers are broadcast over the entire soil surface.

ii. **Deep placement**: In this method, fertilizers like Ammonium Sulphate and Urea, is placed in the reduction zone as in paddy fields, where it remains in ammonia form (**denitrification**: conversion of nitrogen in unavailable form) and is available to the crop during the active vegetative period. This method ensures better distribution of fertilizer in the root zone soil and prevents loss of nutrients by run-off.

iii. **Localized placement**: It refers to the application of fertilizers into the soil close to the seed or plant in order to supply the nutrients in adequate amounts to the roots of growing plants. The common methods to place fertilizers close to the seed or plant are as follows:

a) Drilling: In this method, the fertilizer is applied at the time of sowing by means of a seed-cum-fertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this method has been found suitable for the application of phosphatic and potassic fertilizers in cereal crops, but sometimes germination of seeds and young plants may get damaged due to higher concentration of soluble salts.

b) Side dressing: It refers to the spread of fertilizer in between the rows and around the plants. The common methods of side-dressing are

⇒ Placement of nitrogenous fertilizers by hand in between the rows of crops like maize, sugarcane, cotton etc., to apply additional doses of nitrogen to the growing crops and

⇒ Placement of fertilizers around the trees like mango, apple, grapes, papaya etc.

3. Band placement: In this, fertilizer is placed in bands which may be continuous or discontinuous to the side of seedling, about 5 cms away from it and either at level with the seed, above the seed level or below the seed level. There are two types of band placement: It includes hill and row placement.

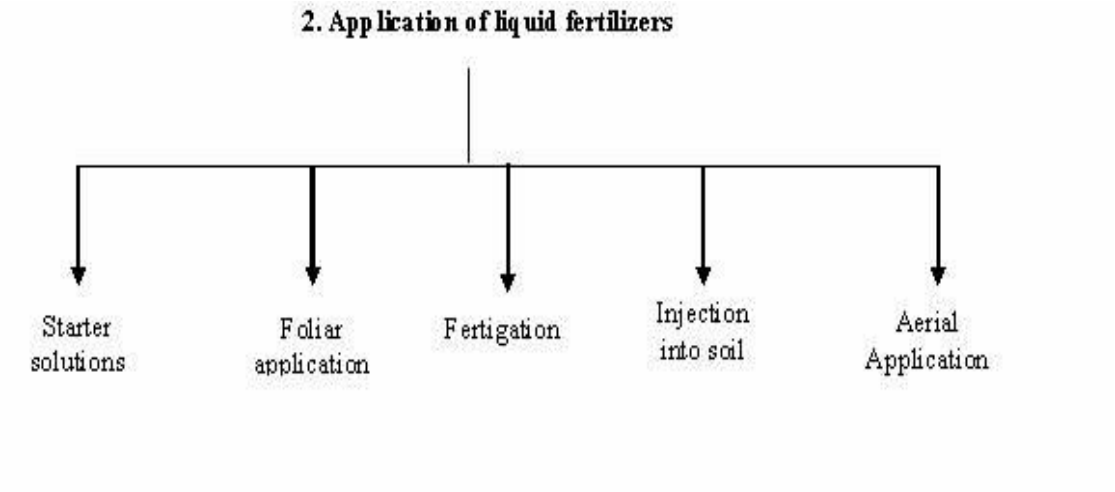
a) Hill placement: When the plants are spaced 3 ft. or more on both sides, fertilizers are placed close to the plant in bands on one or both sides of the plants. The length and depth of the band and its distance from plant varies with the crop and the amount of fertilizer as in cotton.

b) Row placement: When the seeds or plants are sown close together in a row, the fertilizer is put in continuous band on one or both sides of the one or both sides of the row by hand or a seed drill. It is practiced for sugarcane, potato, maize, tobacco, cereals and vegetable crops. Higher rates of fertilizers are possible with row placement than hill placement. For applying small amount of fertilizers, hill placement is usually most effective.

4. Pellet application: It refers to the placement of nitrogenous fertilizer in the form of pellets 2.5 to 5 cm deep between the rows of the paddy crop. The fertilizer is mixed with the soil in the ratio of 1:10 and made small pellets of convenient size to deposit in the mud of paddy fields.

Advantages of placement of fertilizers

- When the fertilizer is placed, there is minimum contact between the soil and the fertilizer, and thus fixation of nutrients is greatly reduced
- The weeds all over the field cannot make use of the fertilizers.
- Residual response of fertilizers is usually higher
- Utilization of fertilizers by the plants is higher
- Loss of nitrogen by leaching is reduced
- Being immobile, phosphates are better utilized when placed.



Following are the common methods of applying liquid fertilizers

a) Starter solutions: It refers to the application Solutions of fertilizers, generally consisting of N, P_2O_5, K_2O in the ratio of 1: 2: 1 and 1: 1: 2 are applied to young vegetable plants at the time of transplanting. Starter solution helps in rapid establishment and quick growth of seedlings.

The disadvantages of starter solutions are
(i) Extra labor is required, and
(ii) The fixation of phosphate is higher.

b) Foliar application: It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them. The concentration of the spray solution has to be controlled; otherwise serious damage may result due to scorching of the leaves. Important when root of plants damaged or low root uptake. Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese.

c) Application through irrigation water (Fertigation): It refers to the application of water soluble fertilizers through irrigation water. The nutrients are thus carried into the soil in solution. Generally nitrogenous fertilizers are applied through irrigation water. This save the application cost and allows the utilization of relatively inexpensive waters.

***d) Injection into soil*/Point injectors**: A narrow cylindrical tube (injector) penetrate the soil and allow liquid fertilizers to be inserted at depth yet avoid greatest root damages. For application of P and K fertilizers down into soil when roots grow. A pointed stick or lode is used to poke a hole in soil and fertilizer is poured into hole and covered immediately to prevent loss of ammonia. It is used for fruit tree, vines, shrub and tomato.

e) Aerial application: In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands or in sugarcane fields etc.

Time of fertilizer application: Fertilizer should be applied when plants need it, when it will be most effective, and when plants can readily take it up. Late summer and early fall fertilization may stimulate new growth that is not winter hardy, and summer drought may interfere with nutrient uptake, but spring, fall, and winter applications are acceptable. A split application may be beneficial, applying half the yearly rate in early spring and the rest in the fall as or after plants go dormant. If water is unavailable, do not fertilize at all - plants will be unable to absorb the nutrients. (During a dry season, application of fertilizer through an irrigation system - can be beneficial.)

After flowering, most of the crops especially cereals, contain lesser percentage of N due to greater accumulation of carbohydrates. It has been established that there is inverse relationship between nitrogen and carbohydrate in plants. The time of N application, therefore, depends on the end product of the crop. Fore examples, legumes require N until root nodules are formed which fix nitrogen. Nitrogenous fertilizers are soluble and highly mobile in the soil .They are, therefore, easily lost by leaching and volatilization. Phosphate and potassic fertilizers are loess mobile in soils as they are fixed/ absorbed on clay complex.

8.5 .Crop protections

Agricultural pests are one of the most limiting factors of crop production in Ethiopia. A **pest** is any organism which harms man or his property or is likely to do so. It estimated that insect pests, disease and weed reduce half of the food produced in the world at the time of growing, transporting and storing of crops. Insect pest and diseases account about 35 % yield reduction.

Weeds

Weeds are defined as any plants growing where man does not want them. Weeds encompass all types of undesirable plants, such as trees, bushes, broad- leaved plants, grasses sedges, aquatic plants, and parasitic flowering plants.

The following types of weed damage have been found:

- Compete the crop for essential plant nutrients, moisture and light
- Create harvest problem
- Reduced quantity and quality of plant and animals products
- Serve as alternative host for diseases causing agents and insects
- Losses from increased cost of production
- Reduced land value and limited crop choice
- Reduction of yield

Only in some ways may weeds be beneficial:

- ✓ Weeds reduce soil and nutrient losses from erosion and leaching when the land is bare
- ✓ Weeds provide feed and cover for wild life and
- ✓ Weeds add organic matter in to the soil.

Weed control methods

1) **Preventive methods**: land preparation, seed cleaning, field sanitation, proper quarantine, and regulation of contaminated crop seeds.
2) **Crop competition**: to be competitive or smoother crop, the crop must be vigorous and fast growing.
3) **Physical**: hand-weeding, tillage, mowing, burning, hoeing, flooding, and mulching
4) **Biological methods: -** Natural enemy (fungus or insects ,vertebrates)
   - Resistance species (allelopathy)
5) **Chemical methods**: using herbicides. , herbicides may be classified based on:

Nature of damage

a. Non selective herbicides: kill all plants when applied at adequate rates e.g. 2, 4-D

b. Selective herbicides: kill or stunt weeds in a germinations or growing crop without harming the crop e.g. Gram axon.

Time of application

a. Pre emergence- systemic herbicides e.g. soil- acting herbicides

b. Post emergence – selective herbicides e.g. sprays of 2, 4-D in cereals.

☞ *Important weed species of cultivated land in Ethiopia are Amaranthus, Cuscuta, cyperus species, Digitaria, Avena, Orobanche, Striga hermonthica etc.*

Insect pests

Insecta (insects) are arthropods that have small size, three body regions (head, thorax and abdomen) , three pairs of legs , a pair of antenne and they feed by mandibles.

Most insects are beneficial, others are considered as the most common crop pests.

1. **Beneficial insects:** Pollinators (e.g. Bees, wasps), Parasitoids (e.g.Tricograma on stalk borer), and Predators (e.g. Lady Bird beetle on aphids)
2. **Harmful insects:** Field pests (e.g. army worm), Storage pests-(weevils, flour moths), and Vectors (leaf hopper, aphids).

☞ *The major economic insect pests in Ethiopia are African boll worm, cereal stem borer, Red teff worm, sorghum chafer, wello bush cricket, Aphids, Army worm, weevils, flour moths etc.*

Plant disease

Disease is harmful deviation from the normal function of physiological process of an organism. Crop diseases cause yield reduction.

Plant disease may be classified into two categories on the basis of causal agent:

1. Abiotic (noninfectious) disease: caused by environmental factor and thus not infectious. E.g. abnormal levels of growth requirement (high, low or extreme).
2. Biotic (Infectious) disease: - caused by pathogen and can be transmitted. The organisms are fungus, bacteria, nematodes and viruses, parasitic higher plants.

The interaction between the causal organism (Pathogen), host and certain factors within the environment and these factors form what is called the **Disease triangle**. Disease will occur only

when the pathogen interacts with a susceptible host under favorable conditions. The presence of a pathogen alone is not sufficient to cause disease.

- ☞ *The most serious crop diseases in Ethiopia e.g. Rust, Smut, Leaf blight, Root rot, powdery mildew, Damping off. etc.*

Control measure

Exclusion of pathogen (quarantine), Eradication of pathogen, Use of resistance variety, and protecting susceptible host uses these various methods either separately or in combination (Integration).

Integrated Pest Management (IPM)*:* it is a pest management strategy that is socio- economic context of farming systems, the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible manner as possible, and maintains the pest population level below those causing economic injury (Dent, 1991). The economic injury level is the lowest population density that will cause economic damage. The ultimate objective of IPM is to reduce dependence on chemical control as the main input for crop protection.

8.6.Harvesting, storage & Marketing

Harvesting: For successful and efficient harvesting of a crop, it is desirable to know:

- ♦ When to harvest
- ♦ How to harvest
- ♦ How to minimize loss during harvest

When to harvest (maturity of the crop)

- ✓ For food crops, maturity refers to the stage of development at which a crop is most desirable to the consumer
- ✓ Generally, the market and botanical maturity are identical in cereal crops but vegetable crops they are not.

Maturity symptoms for some crops

- o Wheat: - yellowing of spikelet
- o Barley: - loss of green color from glumes/peduncle
- o Maize: - black layer in the placental regions of the grain
- o Sorghum: - yellow colored ears with hard grains
- o Finger millet: - brown colored ears with hard grains

- Tef: - yellowish of the vegetative part
- Pluses: - brown colored pods with hard seeds inside pods
- Groundnut: - pods turn dark from light color; dark colored patches inside the shell; kernels red or pink; on pressing the kernels, oil is observed on fingers

Storage: After harvest, products will go directly to:

- Consumption
- Markets
- Commercial storage

Reasons for storage include:

- ✓ To balance periods of plenty against periods of scarcity
- ✓ To make the products available the whole year round
- ✓ To use for coming seeding
- ✓ To improve quality
- ✓ Delay marketing of a crop until prizes rise

Shelf life of a crop during storage depends:

- ❖ initial quality of the crop
- ❖ storage stability
- ❖ external conditions

Marketing of Agricultural Crops

- Marketing: - getting the products to the consumer
- Agricultural marketing – is a process by which the producers and buyers of agricultural goods are brought together

❖ Buyer of agricultural crops can be divided in to three main categories:

- ☞ Those who purchase agricultural crops for direct consumption
- ☞ Those who demand agricultural crops for use as intermediate crops
- ☞ Those who buy agricultural crops for sending them abroad

- *Marketing of agricultural crops is more complicated than marketing of other non agricultural goods for the following reasons:*
  - ❖ Production characteristics (small scale, scattered, seasonal)
  - ❖ Product characteristics (more bulky and less value; perishable; varying, uncertain quality and quantity; elastic supply)
  - ❖ Consumption characteristics (continuous, regular and in small quantity, inelastic demand)

Chapter 9: Crop Improvement

It is the art and the science of improving the heredity of plants for the benefits of humankind. Hence, plant breeding is a science based on principles and practices of genetics and cytogenetics. It focuses on improving the genetic makeup of the plants to develop improved varieties. In other words, it is manipulation of plant genetics to produce more desirable products.

9.1. Objectives of Crop Improvement

Plant breeding programs have to set clear breeding objectives based on plant species and the growing environment for efficient use of resources. Generally, breeders aim to improve the characteristics of plants to make them more desirable agronomically and economically

The most common breeding objectives are:

1. **Yield**: Yield improvement is the ultimate goal of all plant breeding programs. Breeders often look for an increased quantity of useable or marketable products.

2. **Quality**: Quality is a component that adds value of the crop. Quality may mean the physical characters such as grain size, color, taste/ flavor, odor and texture or chemical compositions that attributes to these and other nutritional and utilization values.

3. **Pest resistance**: Almost all plants are exposed to various biological pests (weeds, insects and diseases) during their life cycles. Resistant varieties offer the cheapest method of pest control. Such resistant varieties not only increase production, but also stabilize it.

4. **Environmental stress tolerance**: The common environmental stresses include drought, water logging, frost, acidity, salinity, etc. These problems are generally very difficult to deal with by breeding because their complex nature requires a wide array of genetic response mechanisms. Despite the difficulties, plant breeders accepted improved response to stresses as achievable plant breeding goals.

5. **Improved adaptation:** All plants have adaptive mechanisms allowing them to exist in a complementary manner with environment. The major environmental factors that determine the adaptation of plants include temperature, moisture, photoperiod, and wind and soil conditions. These conditions limit the viability and productivity of many crops.

Two approaches can be taken in the improvement of plant adaptation. The first approach is modifying the environment, while the second approach is to alter physiological mechanisms associated with adaptation.

Adaptation tests of different varieties across multi-locations in Ethiopia could be the best example for the latter case. Through such practices, well-adapted cultivars will be identified whether they are widely or narrowly adapted certain localities. The other good example of improved adaptation is the acclimatization of maize to the highland areas of Ethiopia in recent years.

6. **Suitability to mechanization:** With the increasing production costs, producers are continually seeking ways to produce high quality crops more efficiently. Genetic variability has been demonstrated for a number of cost-saving traits. Mechanical harvesting equipment has been developed or is being considered for several crops. Traits that can be altered by breeding include constant head size, medium height, uniform ripening, resistance to mechanical injury and ease of harvesting.
7. **Change in maturity Duration / Earliness**: Earliness is the most desirable character which has several advantages. It requires less crop management period, less insecticidal sprays, permits new crop rotations and often extends the crop area. Development of wheat varieties suitable for late planting has permitted rice-wheat rotation. Thus breeding for early maturing crop varieties or varieties suitable for different dates of planting may be an important objective.

9.2. Methods of Crop Improvement

- Selection of superior plants- doing it quickly and doing it accurately
- Sexual recombination/hyberdization- of selected plants to generate new genotypes