

PLANT HORMONES

These are compounds, mostly organic while some are gases. They help to regulate some process in the growth and development of plants.

They generally apply to substances made in one part of the plant and translocated to some other parts where they are needed and induce physiological effects.

Plant hormones often called phytohormones are often synthesized in the meristematic and young tissues and often exert their effects after translocation to some relatively distant tissue from the one in which they originate.

The phytohormones include Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene etc.

AUXINS

The auxins are formed in the apical meristem of the stem and the root. Also formed in areas of active division such as buds, flowers or inflorescence or growing flower stock and then transported to other parts of the plant to produce a particular physiological effect.

Auxin movement is strictly longitudinal (polar) normally stem apex of the shoot downwards (this is called basipetal translocation). In few cases, upward transpiration current. At low concentration, they stimulate growth while at high concentration they retard growth.

Naturally occurring auxin (i.e IAA) is synthesized from the amino acid, tryptophan. However, certain other synthetic compounds (not formed in the plant) induce reactions in the plants similar to those caused by IAA. Such synthetic auxins include Indole Butyric Acid (IBA), α -Naphthalene Acetic Acid (NAA), 2,4-dichlorophenoxy Acetic Acid (2,4D), NaphthoAcetic Acid, Triiodobenzoic Acid.

CYTOKININS

These are hormones with basically the purine structure. Cytokinins (formerly called kinins) include Kinetin (6-furfuryl/ amino purine). In most cases, kinetin's are not known to be natural plant constituent and is probably not a true plant b

Hormones but have many effects on plant growth and development.

A naturally occurring cytokinin Zeatin, formerly isolated from Zea Mays grains is found in other plants. Some closely related compounds have been found to exhibit cytokinins activities such synthetic amino acids will include Benzyl Amino Purine (BAP). The natural cytokinins appear to remain principally in the apical root meristems, inflorescences and developing fruits.

Some certain cytokinins have been founded to be constituent of certain ERNA molecules in a number of different organisms. The manner of translocation of cytokinins is probably through the xylem to other parts of the plant.

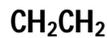
ABSCISIC ACID (ABA)

This hormone is widespread in higher plants and is found in many different organs (both old & young) of plants. ABA induces abscission (detached of plant parts that are dead) variety of plants and fruits of some

plant species. Some other hormones such as IAA and Ethylene interact with ABA in the control of abscission. ABA appears to be an internal factor inducing dormancy in buds of some woody plants. ABA also prevents or delays the germination of many kinds of seeds.

ABA retards the growth of a large variety of plants tissues, and organs including leaves, coleoptiles, stems, roots etc. it promotes senescence (process of ageing) through leaf abscission, degeneration of excised leaves and acceleration of decomposition of chlorophyll. This hormone also inhibits flower induction in some long day plants.

ETHYLENE



This gas is synthesized in and released from plant tissues. It exerts marked physiological effect at very low concentrations. When present in excess, it escapes from the plant tissues. This means, ethylene from one plant source may move to and influence the development and physiological reactions of other nearby plants. This hormone operates as a fruit – ripening hormone. E.g. treatments of fruits like bananas, oranges, mangoes etc when matured but not yet fully ripened, with ethylene hasten their ripening. This type of treatment is of commercial importance.

Endogenously generated ethylene plays a role in normal abscission process especially in interaction with IAA and ABA.

GIBBERELLINS

OR

GIBBERELIC ACID

Gibberellins or gibberellic acid are structurally distinctively and closely knit group of plants hormones. About 35-44 different gibberellins (designated GA₁, GA₂, GA₃ etc) all closely related chemically and found to be naturally occurring in higher plants or in the original fungus source. They are of wide occurrence in vascular plants most especially in very low concentrations. The best known of the gibberellins is gibberellic acid – A₃ (GA₃).

The main sites of synthesis of gibberellins in the higher plants are meristematic leaves, root tips and developing seeds. Translocation of gibberellins occur quite freely in both the xylem and the phloem. The gibberellins rival auxins in their physiological effects in the plants. Gibberellins can substitute at least in parts or real light induction of leaf expansion and also in the breaking of dormancy of some light sensitive seeds e.g. lettuce. Many long day plants have been induced to flower in short days after treatment with gibberellins.

PLANT NUTRITION

CLASSIFICATION OF PLANT MINERAL NUTRIENTS BASED ON THEIR BIOCHEMICAL FUNCTIONS

GROUP 1 – Nutrients part of carbon compounds

1. **NITROGEN (N):** This is a constituent of amino acids, amines, proteins, nucleic acids, nucleotides, co-enzymes, hexoamines.
2. **SULPHUR (S):** This is a component of cysteine and cystine, methionine, proteins, lipoic cell wall, co-enzymes A, thymine, pyrophosphate, biotin, Adenosine -5-phosphosulphate.

GROUP 2 – Nutrients that are important in energy storage or structural integrity.

1. **PHOSPHORUS(P):** This is a component of nucleotides, co-enzymes, phospholipids etc. The phosphorus always have a key role in reactions that involve ATP.
2. **SILICON (Si):** This is deposited as amorphous silica in cell walls. It contributes to cell wall mechanical properties including rigidity and elasticity.
3. **BORON (B):** This complexes with mannitol, polymannuronic acid, mannan and other constituents of cell wall. Boron is involved in cell elongation and nucleic acid metabolism.

GROUP 3 – Nutrients that remain in ionic form.

1. **POTASSIUM (K):** This is requires as a cofactor of more than 40 enzymes. It is a principal cation in establishing cell turgor and maintaining cell electro-nerality.
2. **CALCIUM (Ca):** This is a constituent of middle lamella of cell walls. It is required as cofactors by some enzymes involves in the hydrolysis of ATP and phospholipids. It acts as a second messenger in metabolic regulation.
3. **MAGNESIUM (Mg):** This is required by many enzymes involves in phosphate transfer. Magnesium is a constituent of chlorophyll molecule.
4. **CHLORINE (Cl):** This is required for photosynthetic reactions involved in O₂ evolution.
5. **MANGANESE (Mn):** This is required in the activities of dehydrogenases, decarboxylases, kinases, oxidases and peroxydases involved with other cation activated enzymes and photosynthetic O₂ evolution.
6. **SODIUM (Na⁺):** Sodium is involved in the regeneration of phosphoenol pyruvate in C₄-plants and CAM-plants. They substitute for potassium in some functions.

GROUP 4 – Nutrients that are involves in Redox reactions.

1. **IRON (Fe):** Iron is a constituent of cytochromers, some iron proteins involved in photosynthesis. It is also involved in nitrogen fixation and respiration.
2. **ZINC (Zn):** Zinc is a constituent of alcohol dehydrogenase, glutamic dehydrogenase, carbonic anhydrase.
3. **COPPER (Cu):** Copper is component of ascorbic acid oxides, thyroximase, cytochrome oxidase, phenolase etc.
4. **NICKEL (Ni):** Nickel is constituent of urease (enzyme involved in reaction of uric acid). It can be found in nitrogen fixing bacteria. They are constituent of hydrogenase.

5. MOLYBDENUM (Mb): Constituent of nitrogenase, nitrate reductase, Xanthine dehydrogenase.

MYCORRHIZAL FUNGI
AND
NUTRIENT UPTAKE

Most of the mineral elements that go into the roots are mostly by direct acquisition from the soil atmosphere which is full of most of these elements in the soil solution. This process can be modified by association of mycorrhizal fungi with the root system.

Mycorrhizae (plural) are not usual. They are widespread under natural conditions. Much of the world's vegetation appears to have roots associated with mycorrhizal fungi. 83% of dicot, 79% of monocots and all gymnosperms regularly form mycorrhizal association.

However, plants from the family Cruciferae (Cabbage), chenopodiaceae (spinach), proteaceae as well as aquatic plants rarely have mycorrhizae.

Mycorrhizae are absent from roots in very dry, saline or flooded soils or where soil fertility is extreme (either high or low). Plants grown under hydroponics and young rapidly growing crop plants seldom have mycorrhizae.

The mycorrhizal fungi like others are composed of filamentous hyphae and the mass of hyphae (i.e. mycelium). There are two major classes of mycorrhizal fungi. These are:

- i Ectotrophic Mycorrhizal Fungi (EMF)
- ii Vesicular – Arbuscular Mycorrhizal Fungi (VAM) .

These are the two most important uptake in plants. Other minor classes of mycorrhizal fungi include:

- i Ericaceous mycorrhizal fungi,
- ii orchidaceous mycorrhizal fungi, which may have limited importance in terms of nutrient uptake by the root of plants.

ECTOTROPHIC MYCORRHIZA FUNGI

EMF typically show a thick sheath or mantle of fungi mycelium around the roots and some of the mycelium penetrate between the cutical cells.

The cutical cells themselves are not penetrated by the fungi hyphae but instead are surrounded by network of hyphae called the HARTIG NET. The amount of fungal mycelium is often so extensive that its total mass is comparable to that of the roots themselves. The fungi mycelium also extends where it forms individual hyphae or strands containing fruiting body.

The capacity of the root system to absorb nutrients is improved by the presence of external fungi hyphae that are much finer than plant roots and can reach beyond the areas of nutrient – depleted soil near the roots.

The ectotrophic mycorrhiza fungi infect exclusively tree species including the gymnosperms and woody angiosperms.

VESICULAR ARBUSCULAR MYCORRHIZA FUNGI

Unlike the EMF, the VAM fungi do not produce a compact mantle of fungi mycelium around the roots. Instead, the hyphae grow in a less dense arrangement both within the roots itself and extending outwards from the roots into the surrounding cells.

After entering the roots through either the epidermis or a root hair, the hyphae not only extend through the regions between cells but also penetrate the individual cells of the cortex. Within the cells of the cortex, the hyphae can form oval structures called VESICULES and branched structures called ARBUSCULES. The arbuscules appear to be the sites of nutrient transfer between the fungus and the host plant.

Outside the root, the external mycelium (VAM) can extend several centimeters away from the root and may contain spore-bearing structures. Unlike the EMF, VAM fungi make up only a small mass of the fungi material which is unlikely to exceed 10% of the root weight.

VAM fungi are found in association with the root of most species of herbaceous angiosperms. The association of VAM fungi of the roots of plants facilitate the uptake of the roots of plants facilitate the uptake of phosphorus and trace metals such as zinc and copper. By extending beyond the depletion zone for around the

roots, the external mycelium improves phosphorus absorption. Research has shown that the roots associated with mycorrhizal fungi can transport phosphorus at a rate more than four times higher than that of a root not associated with mycorrhizal fungi.

The external mycelium of EMF can also absorb phosphate and make it available to plants. In addition EMF proliferate in the organic litter of the soil and hydrolyse organic phosphorus for transfer to the root.

MOVEMENT OF NUTRIENT FROM MYCORRHIZAL FUNGI TO PLANT ROOT CELLS

Little is known about the mechanism by which mineral nutrients are absorbed by mycorrhizal fungi and transferred to plant root cells. With EMF, inorganic phosphate may simply diffuse from the hyphae into the net and be absorbed by the root apical cells. With VAM fungi, the situation may be more complex. Nutrient may diffuse cells, alternatively, because some root arbuscles are continually degenerating why new ones are forming. Such degeneration arbuscles may release their internal content to the host root cells. A key factor in the extent of mycorrhizal association with the plant root is the nutritional status of the host plant e.g. moderate deficiency of a nutrient such as phosphorus tends to promote infection. Mycorrhizal association in well fertilized soils may shift from symbiotic relationship to a parasitic one in that the fungus still obtains CHO from the host plant but the host plant no longer benefit from improved nutrient uptake efficiency. Under such conditions the host plant may treat mycorrhizal fungi as it does other pathogens.

PLANT GROWTH ANALYSIS

If we wish to measure the bio productivity of natural ecosystem or agricultural crops, the component of immediate interest is the total yield or net primary production. It is usually necessary to restrict our interest to above ground parts and in agricultural crops only in economic yield e.g the grains of cereals.

BASIC PRINCIPLES OF MEASUREMENT

Two types of measurement are needed for growth analysis. These are:

1. **PLANT WEIGHT:** This is usually the oven dried weight (g or kg) or it can be the organic matter or energy content.
2. **SIE OF ASSIMILATORY SYSTEM:** This is usually the leaf area (cm², mm², m²) but can also be the leaf protein or chlorophyll content.

This primary data of growth analysis can be made on individual plants derived from both canopies through the destructive nature of techniques required the use of homogenous sets of plants or plots of land. In this simple form, plant growth analysis requires little more than a balance, photosensitive paper, graph sheet and a calculator for quite detailed studies of quantitative aspect of dry matter.

The quantitative description of growth is based on several terms. The terminology used here follows that of Hunt (1978) which refers to the components of growth in terms of single letters of single letters for ease of mathematical notation.

COMPONENTS OF CLASSICAL GROWTH ANALYSIS

1. RELATIVE GROWTH RATE (RGR OR R) The relative growth rate of plant or crop is defined at any instant in time (t) as the increase of material per unit of material present. It is the only component of growth analysis which does not require the knowledge of the size of assimilatory systems. (leaves x systems).

$$R = \frac{\text{Log } W_2 - \text{Log } W_1}{T_2 - T_1}$$

$$T_2 - T_1$$

OR

$$R = \frac{\text{Log}_2 \text{TDW}_2 - \text{Log}_2 \text{TDW}_1}{T_2 - T_1}$$

$$T_2 - T_1$$

W_2 = second measured weight

W_1 = first measured weight

TDW_2 = second measured total dry weight

TDW_1 = first measured total dry weight

T_1 = initial time (days, months, etc)

T_2 = final time (days etc)

The unit of RGR or R is:

(Weight Weight⁻¹) time⁻¹ e.g. gg⁻¹ time⁻¹ RGR or R represents the efficiency of the plants raw material. The RGR or R serves as a fundamental measure of dry matter production and can be used to compare performance of species or the effects of treatments under strictly defined conditions.

However R, tells little about causal factors which determines the performance. These factors are included in other components of growth analysis such as the net assimilators rate (NAR) or (E) and leaf area ratio (LAR) or (F).

2. NET ASSIMILATION RATE (NAR) OR UNIT LEAF RATE (ULR) : The unit leaf rate (E) of a plant or crop at any instant in time (t) is defined as the increase of plant material per unit of time. The NAR measures the net gain in dry weight of the plant per unit leaf area (kg/m²).

$$E = \frac{W_2 - W_1}{A_2 - A_1} \cdot \frac{\log_2 A_2 - \log_2 A_1}{T_2 - T_1}$$

$$E = \frac{W_2 - W_1}{T_2 - T_1} \cdot \frac{\log A_2 - \log A_1}{A_2 - A_1}$$

OR

$$E = \frac{TDW_2 - TDW_1}{T_2 - T_1} \cdot \frac{\log LA_2 - \log LA_1}{LA_2 - LA_1}$$

OR

$$E = \frac{TDW_2 - TDW_1}{LA_2 - LA_1} \cdot \frac{\log LA_2 - \log LA_1}{T_2 - T_1}$$

Where LA₁ = Initial leaf area

LA₂ = final leaf area

W₁ = Initial measured weight

W₂ = final measured weight

TDW₁ = Initial total dry weight

TDW₂ = Final total dry weight

3. LEAF AREA RATIO (LAR OR F) : The leaf area ratio of a plant or crop at any instant in time (t) is the ratio of assimilatory material per unit of plant material.

$$F = \frac{(LA_1)}{W_1} \cdot \frac{(LA_2)}{W_2}$$

The unit of F = Area (weight⁻¹) i.e cm² g⁻¹ or m² kg⁻¹

Where LA_1 = Initial leaf area

LA_2 = Final leaf area

W_1 = Initial weight

W_2 = Final weight

For the various components of classical growth analysis considered earlier on (i.e RGR, NAR and LAR) at time (t) (t_1 , t_2 etc), you need to measure

- i the net gain in dry weight (W). Hence measurement of initial dry weight (W_1) and final dry weight (W_2).
 - ii the leaf area, the initial (LA_1) and final (LA_2).
 - iii the time (t) at which all these are measured. Hence one can measure the RGR, NAR and LAR from three parameters: Weight (W), Area (A) and Time (t).
- A. The dry weight can be done in electric oven at 700C for 24hours, cooled and weight. The procedure should be repeated and the material should be weighted several times until a constant weight is achieved.
 - B. The LA can be measured by plucking the entire leaves of the plant in question and spreading over the PLANEMETER or the Lambda LEAF AREA METRE. But where this is not within reach, a rough estimate of the leaf area measurement can be achieved using the graph paper. The entire leaf area is traced on a graph paper and calculated by counting the cm² covered by the leaf area on the graph sheet. However, approximation of many incomplete squares often lead to error.

SEED DORMANCY AND GERMINATION

DORMANCY

Dormancy is a physiological quiescence often observed in viable seeds. It is a condition in which a seed with viable embryo fails to germinate under favourable environmental conditions such as good supply of oxygen, adequate moisture and temperature.

TYPES OF DORMANCY

1. Temporary Dormancy
2. Physiological Innate Dormancy

CAUSES OF PHYSIOLOGICAL INNATE DORMANCY

1. Seed hardness: add seed coats can serve as barrier to germination and development of embryo. Hardness of testa or seed covering is another cause.

SOLUTION

- a. Scarification
 - i. Chemical Scarification: Use of concentrated inorganic acids, conc. Sulphuric acid, ether and acetone absolute ethanol, inorganic salt ($KMNO_4$, Na_2SO_4 , $NaCl$ etc).
 - ii. Mechanical Scarification: This involves mixing seeds with pebbles, rubbing seeds with sand paper nipping holes or making punctures.
 - b. Heat Method
 - i. Dry Heat: This involves placing seeds above systems which give out heat. E.g. burning fire wood
 - ii. Wet Heat: This involves steaming to break dormancy.
 - c. Cold Treatment
2. Chemical inhibitors: presence of chemicals such as coumarine, phenols, abscissic acid etc can cause dormancy.

SOLUTION

- a. Leaching: Moderate leaching is required to break dormancy and effect germination of seeds. Over leaching can wash away growth promoters.
3. Dormancy due to immature embryo: For example *Cola nitida*, *C. millenii*.

SOLUTION

Storage

4. Need for Period of Ripening

SOLUTION

Storage

5. Photoblasticity: This is dormancy due to light sensitivity. e. g *ceiba pentandra*, *milicia excels*, *nicotiana tabaccum* etc.

SOLUTION

Exposure to day length illumination period of 16hrs or more.

GERMINATION

Is a process by which a dominant embryo wakes up grows out of the seed coat and establishes itself as a seedling when supplied with moisture.

Germination is a physiological process which involves a viable embryo spouting into a seedling with the emergence of a radicle (first) and a plumule (later) under favourable environmental conditions.

PROCESSES INVOLVED IN GERMINATION

1. Inbibition of water
2. Activation of Precursors of enzymes
3. Production of Amino Acids, Proteins, etc.
4. Mobilization of food materials

INTERNAL FACTORS AFFECTING SEED GERMINATION

1. Genetic pattern of seeds (genotype)
2. Ecological type of seed population (ecotype)
3. Seed maturity
4. Presence or absence of germination promoting and inhibiting substances
5. General chemical and structural composition of seeds.

OTHER HORMONES

NAME OF HORMONE	EFFECT	SOURCE IN PLANTS
Rhizocaline	For root formation	In leaf
Coumarin	For stem elongation	In roots
Pyhllocaline	For leaf growth	In cotyledon
Florigen	Induces flower formation	In leaf
Traumatic acid	For healing of wound through callus Formation i.e it induces cell division in cells around the wound.	In damaged cells around the wound
Coumarin	Inhibits germination of some seeds Retards growth of roots in some plant species	In plant tissues

COMPARISON OF SOME KNOWN EFFECTS OF PLANT HORMONES

Effect on	IAA	GA	Cytokinin	Ethylene or Chlorohydrin	Abscicic acid
Cell division	Promotes		Promotes		
Cell enlargement in stems	Promotes		Promotes		

Cell enlargement in roots	Indirectly inhibits		Inhibits		
Abscission of parts	Inhibits				Promotes
Bud dormancy		Breaks	Breaks	Breaks	Promotes
Seed dormancy		Breaks	Breaks	Breaks	
Seed germination	Promotes	Promotes			Inhibits
Sexuality in flowers	Promotes	Promotes			
Food store mobilization in seeds		Promotes			
Root initiation	Promotes		Promotes		
Parthenocarpy	Promotes	Promotes			
Onset of flowering		Promotes		Promotes	
Stem elongation or 'bolting'	Promotes	Promotes			
Apical dominance in buds	Promotes		Counteracts		
Leaf expansion		Promotes			
Bud formation			Promotes		
Root elongation			Inhibits	Inhibits	
Cambial activity	Promotes		Promotes		
Fasciation			Promotes		
Senescence or aging			Retards		
Movement of metabolites			Accelerates		
Movement of auxin				Inhibits	

These effects are to be seen in some plant only and may be restricted to certain parts of them.

PHOTOPERIODISM

The influence of day-length on reproduction and vegetative growth was studied by Garner and Allard (1920). According to them some plants require a day-length longer than 12 hours for flowering, while others require less than 12 hours for this purpose. The former are known as long day plants and the latter as short day plants and the plants which are day neutral flower at any day-length. The relation of the time of flowering to the daily length of the period of illumination is known as photoperiodism.

The development of plants as contributed by the relative length of the light and dark periods to which they are exposed, a phenomenon called photoperiodism, is one of the most notable of all reactions of the plants to their environment. The photoperiodism has helped in the control of flowering of a large number of agricultural and horticultural plants.

Artificial shortening of day-length by shading or lengthening by the day-length electric illumination has induced plants to flower either than the normal ones.

Flowering of various annual and biennial plants at different seasons of the year is mainly due to the seasonal day length. In agricultural research this is of particular benefit as by artificial control of day length (daily illumination) two crop varieties which normally flower at different seasons can be made to flower simultaneously so that cross pollination for the purpose of crop improvement can be effected.

Light Duration Effects on Vegetative Growth:

In all parts of the world except the tropics and sub-tropics, marked seasonal changes or variations occur in the lengths of the daily period. The shortest period of the year in latitude 40°N corresponding to the areas such as Madrid, Spain, China, Washington DC, is about 8-9 hours of day length while the longest day-length is about 15-16 hours. The same condition occurs in the southern cold zones. In tropical regions, the day-lengths approximate 12 hours all year round.

There has been found dissimilar in day-lengths of the day. Further experimentation on a variety of species soon resulted in the discovery that different kinds of plant react differently to given length of photoperiod the most effectively being on reproductive growth of plants. Flowering in some kinds of plants is favoured by short days, in other kinds by long days and in still some other kinds by a wide range of day-length.

Photoperiodic effects upon reproductive growth may indirectly induce effect upon vegetative growth. Many short day plants exposed to long days grow in height indefinitely, but if exposed to short days vegetative growth in height is soon checked as a result of the differentiation of a terminal inflorescence. Many long day plants on the other hand develop as leaf rosette or bunch when exposed to short days, elongation of flower-bearing stems occurring only under long day conditions.

Tuberization in a number of species is markedly influenced by the length of the photoperiod. In a number of varieties of potato for example, a few or no tubers form under 16-18 hours photoperiods, while there is a good yield when the plants are exposed to short (8-10hr) photoperiods. This is also true of formation of tuber in *Helianthus tuberosus* (Jerusalem artichoke). Furthermore, exposure of only one leaf of a plant of this species to a 9 hour photoperiod while the rest of the plant is under an 18hr photoperiod induces tuber formation just as if the entire plant were exposed to short photoperiod, but exposure of the terminal bud to a 9hr photoperiod while the rest of the plant is at an 18hr photoperiod has no such effect. The leaves are obviously the locus of a photoperiodic reaction, the effects of which are communicated in some manner or another to the underground organs of the plants and influences their development.

The development of bulbs by certain species of plants is markedly influenced by the length of the photoperiod to which the plant is exposed. Bulb formation in most varieties of onions, for example, is favoured by relatively long photoperiods, the minimum effective photoperiod varying from about 12-16hrs according to the variety.

The length of the photoperiod has an important effect on the bud dormancy of many temperate zone woody plants. The short photoperiods of later summer and early fall are factors inducing dormancy in many such species. On the other hand, the long photoperiods of late winter and early spring are factors in breaking the bud dormancy of many such species.

Effect of duration of light on reproductive growth: Some plants flower under short day conditions while some do so under long day-length condition, while others are independent to both. Plants have been classified according to the effects of day-length on their reproductive development. The classifications are based on a 24hr cycle of light and darkness.

a. Short day plants

These are plants which flower when the day-length is below (less than) a certain critical day length. Day lengths in excess of this critical point will keep the short day plant vegetative. The so-called critical day-length differs with different species. Examples of short plants are *Nicotiana tabacum*, *Xanthium pensylvanicum* and *Glycine max* (soy beans), sweet potato, hemp (*Canabis sativa*).

b. Long day plants

These are plants, which flower after a critical day-length is exceeded. Examples include sugar beet (*Beta vulgaris*), Spinach (*Spinaceae oleracea*) and *Hyoscyamus niger*.

c. Day neutral

These are plants, which flower after a period of vegetative growth, regardless of photoperiod. That is, that range of plants flower readily over a wide range of day-lengths from relatively short photoperiods to continuous illumination. Examples include Tomato (*Lycopersicon esculentum*), *Mirabilis* (Four-O'clock), cotton (*goossypium*), certain varieties of tobacco, *pisum salivum* (garden pea).

d. Intermediate plants

These are plants, which bloom only under day-length within a certain range and fail to flower under either longer or shorter photoperiods e.g. some varieties of sugar cane.

The line of demarcations between the range of photoperiods favourable to flowering and the range of those which are not, is much sharper in some kinds of plants than in others.

PHOTOPERIODIC AND PHOTOINDUCTIVE CYCLE

The photoperiodic behavior is an important factor in determining the most favourable-season for raising many crop plants in mid-latitude regions. Any photoperiodic cycle which induces initiation of flowers in plants is called a photo-inductive cycle, while one which does not is called a non-photo-inductive cycle. For example, an 8hr photoperiod alternating with a 16hr dark period is possible photo-inductive cycle; for short day cocklebur plants having a critical photoperiod of 15.5hours; a 16-hour photoperiod alternating with 8hr dark period is one possible non-photo-inductive cycle for the plant.

The number of inductive cycles required by any kind of plants vary somewhat depending upon the age of the plant and environmental conditions, especially temperature, radiance and length of the photo-period.

General Mechanism of Photoperiodism:

a. Locus of Photoperiodism

Although the leaves are undoubtedly the principal loci of the photoperiodic reactions in some plants, other organs may fulfill this role at least in part. Some complementary loci may be the bud, or leaf-like cotyledon as in some plants, while in some herbaceous species the stem serve the role especially when in defoliated form.

b. Presence and Transmission of a Floral Hormone

The floral factor produced in photo-inductive leaves is apparently transported with ease in the plant. The floral factor or hormone has been termed florigen. This floral hormone is not species and has the same property in both day and long day plants. The distance over which florigen are transported in plants varies with the kind of plant and environmental conditions to which it is subjected. Translocation occurs in living cells and in petioles and stems through the phloem tissues.

c. The Role of Gibberellin

The levels of gibberellins have been implicated in the production of floral hormone. It is assumed that a high level of gibberellins-like hormone must be maintained in long day plants for the production of florigen. In short day plants, this situation is reversed, a low level of the gibberellins-like hormone being optimum for a flowering response.

d. Role of Light Quality

The pigments phytochromes- FR and phytochrome – R sensitive to the Red and Far Red radiation have also been implicated in flower formation. These same pigments have also been implicated in most of the phytomorphogenetical problems.

WEED BIOLOGY

Weeds are plants that interfere with human activity, or in some was intrude upon human welfare. This is a concept of weeds that has originated with humans and within the context of their food production needs. The Oxford English Dictionary (OED) defines a weed as: a herbaceous plant not valued for use or beauty, growing wild and rank, and it is a common knowledge that not all weeds are herbs. Therefore deleting the word 'herbaceous' from the (OED) definition improves it, but no means make the definition technically complete. In addition to human values there are ecological

considerations that should be noted when discussing weeds. While a patch of annual and perennial plants may compete with our crops, and so qualify to be called weeds, these same plants play an important part at crop harvest and during subsequent fallow periods in keeping the soil covered and protected from the erosion action of both rain and wind.

The good and bad sides of weeds were described by Salisbury (1964) as follows: weeds, as a class, have much in common with criminals; when not engaged in their nefarious activities both may have admirable qualities; a thief may be an affectionate husband and father outside business hours; an aggressive weed in one environment may be a charming wild flower in another.

Weeds are important components of our agricultural systems, and are subject to the evolutionary influences that affect crops and animals. De Wet and Harlan (1975) have identified three classes of plant; the wild plants that grow naturally outside of human disturbed habitats; the weeds that thrive in habitats that are continuously disturbed by humans; and the domesticates (crops) that are artificially propagated and often require cultivation and care by humans in order to grow and take optimum use of environmental resources. In general the definition of the weed depends on one's perception of the plant in time.

CHARACTERISTICS OF WEEDS:

Weediness has been described as the state or condition of a field in which there is an abundance of weeds. Weediness therefore implies both presence and number of weeds. There are specific characteristics that qualify a plant as a weed. Some of these characteristics are met by some plants, while others, such as those of weediness are acquired by virtue of a group of plants growing in a given location.

All terrestrial weeds tend to interfere with crop growth and some weeds (aquatic weeds) interfere not only with crop growth but also with use of waterways. Some workers have outlined the characteristics of weeds as those that are collectively shared by non crop plants which make them weeds. There are some features that set a weed apart from a crop.

INDIVIDUAL CHARACTERISTICS OF WEEDS:

- a. **Harmful to humans, animals and crops:** Weeds with this characteristics may contain poisonous alkaloids e.g. leaves of stinging nettle (*Ficaria verna*), and pods of *Mucuna pruriens*, high level of nitrates (e.g. *Amaranthus* spp) or parasitic on crops (e.g. *Striga* spp, *Cassytha* spp and *Buchnera* spp).
- b. **Wild and rank growth:** Weeds that possess these features are usually of large size. They tend to grow rapidly, and cover extensive areas. Examples of these weeds are *Rottboellia cochinchinensis* and *Andropogon* spp.
- c. **High reproductive capacity:** Many annual weeds have the ability to produce large quantity of seeds.
- d. **Persistence and resistance to control:** Weeds that possess these characteristics have diverse forms and propagate from seed and tubers or rhizome. Examples are purple and yellow nutsedge (*Cyperus*

rotundus and *C. asculents* respectively) which combine a well-developed tuber system with moderate production of viable seeds.

COLLECTIVE CHARACTERISTICS OF WEED GROUP:

- a. **May grow in an undesirable location:** The ability to grow in an undesirable location is a major attribute of most weeds. Consequently weeds are found not only in cultivated fields, but also in tennis courts and other recreational sites. Also they are known to grow through cracks in concrete and asphalt pavements.
- b. **May have large population:** Weeds that possess this characteristics tends to grow tensely around economic plants. Such weeds are adapted to overcrowding. Many annual weeds consist of large populations; examples are *Euphorbia heterophylla*, *Ageratum conyzoides* and *Aspilia Africana*. Weeds such as these are able to compete better with crops because of the numerical superiority that the weeds have over the crops with which they are associated.
- c. **Human often find them useless, unwanted, undesirable:** Many weeds that show these attribute have morphological feature such as thorns, prickles, etc. that make them objectionable. Examples of these weeds are *Amaranthus spinosus*, *Acanthus montanus* and *Ficus exasperate*.
- d. **Aggressive:** Many weeds that are aggressive have rapid seedling growth and wide tolerance to edaphic and environmental factors. Many are deep rooted, others have intraspecific variations while others exhibit great plasticity of growth. For example *Euphorbia heteroplylla* is very competitive in food legumes such as cowpea and soya beans because of its rapid growth and ability to form canopy over those crops.

ECONOMIC IMPORTANCE OF WEEDS:

It is estimated that some 1800 weeds species cause serious economic losses in crop production, and about 300 of these weed species are responsible for the serious economic losses in cultivated crops throughout the world. While reliable data on yield losses caused by weeds are not readily available in the tropics.

Losses caused by weeds in agriculture represents costs to the farming community, and these can be divided into direct and indirect costs.

DIRECT LOSSES CAUSED BY WEEDS:

- Weed reduce crop yield by interfering with crop growth. This interference includes competition with crops for nutrients, light and water. it also include the introduction of chemical into the soil that will adversely affect the growth of crop plants (allelopathy).

- Weeds reduce the quality of harvested agricultural products. The presence of weeds seeds such as those *Rottboellia chinensis* in maize or rice. *Solanum nigrum* in cowpea or soya beans will reduce quality of each of these crops.

Heavy weeds infestation interfere with speedy drying of crops and generally slow down harvest operations, thus increasing cost of harvesting.

Some weeds can be poisonous if eaten by grazing animals. *Amaranthus* spp. Is an example of a weed which can adversely affect livestock because of the high nitrate content of the shoots.

Presence of weeds can also increase the cost of irrigation through indirect costs in keeping the canals weed free.

The cost of weed control far exceed that of any other crop pest.

INDIRECT LOSSES CAUSED BY WEEDS

Weeds cause many other types of losses in agriculture that cannot be readily related to weeds. These losses are indirect in nature and include the following:

- Weeds serve as alternative hosts for many plant diseases and animal pests (e.g insects, rodents, rodents, birds etc.) that attack crops. Examples of weeds that serve as alternative hosts of arthropods and nematodes are *Imperata cylindrical*, *Amaranthus spinosus*, *Eleusine indica* and *Cyperus esculentus*.
- The presence of weeds impose a limit on farm size, Farmers generally cultivate only the area that they know from experience they will be able to keep weed free. Inputs are costly, and too large an area creates a serious risk for the farmer.
- The presence of weeds can reduce the economic value of lakes by preventing or liming fishing activities.
- Weeds such as *Imperata cylindrical*, become fire hazards in the dry season throughout the savanna vegetation zone. Other grasses that poses such danger include *Andropogon* spp, *Pennisetum* spp and *Hyparrhenia* spp. Such bush fire expose the soil to erosin hazards, destroy wild life and impoverish the soil.

BENEFICIAL EFFECTS OF WEEDS:

Many plants species known as weeds have positive values both individually and collectively. Some of the beneficial effects of weeds are:

- Weeds provide a vegetative cover that protects the soil surface against erosive action of rain and wind.
- Weeds play an important part in nutrient recycling
- Weeds add organic matter to the soil both from roots and from the above ground parts.

WEED SEED PRODUCTION:

Weeds survive seasons of adverse weather through seed production. Most weeds, particularly annuals, maintain their genetically heritable traits through seed production. The long-lived species tend to produce fewer seeds than the short-lived species that face more environmental hazards. Other roles played by the seed in a weed's life cycle have been mentioned and these are:

- (a) Spread of weed species (dispersal)
- (b) Temporary source of food for the embryo, and
- (c) Protection during conditions that are unfavourable for germination (dormancy).

The seed therefore plays important roles in the survival and multiplication of weeds. Weed seeds are continuously added to agricultural land during each cropping cycle.

Mature weeds shed their seeds on agricultural lands and thus add to the population of weed seeds in or on the soil. Several factors affect the quantity of weed seeds, i.e. the seed rain. These factors include damage by animals and adverse weather conditions. Some of the weed seeds that fall on the soil surface may be moved into the soil profile through

- (a) Cracks and fissures in the soil,
- (b) Cultivation practices and
- (c) Harvesting of root and tuber crops.

Weed seeds that move into the soil profile may remain dormant for many years and may germinate when they are moved to or near the soil surface during land preparation. Some of the weed seeds that are on or in the topsoil may be killed by heat during preplanting bush burning, and by mulching. Germination weed seeds may also be killed by pre-emergence herbicides. Non-dormant weed seeds that escape these actions will germinate and the seedling weeds could be killed by adverse weather conditions, pre- or post-emergence herbicides, mechanical or hand weeding. Only those weed seedlings that escape these actions grow to maturity to produce mature seeds that add to the seed rain. It is this seed rain that replenishes the reservoir of viable seeds in the soil. Harper (1977) described this reservoir as the seed bank. It consists of seeds produced in a given area plus weed seeds that have migrated to the area as a result of the action of various agents of dissemination. Seeds in the seed bank always exceed those that germinate because of differences in the dormancy characteristics of all weed seeds in a seed bank.

CHEMICAL COMPOSITION:

Certain weed seeds can be economically valuable for their nutritive qualities. It has been found that seeds of some species had high contents of essential amino acid and the results suggested that these weed seeds could be excellent sources of protein and oil.-

SEED DISPERSAL:

Weed seeds are dispersed in space and in time. Seed dispersal in space involves the physical movement of seeds from one place to another while dispersal in time refers to the capacity of many seeds to

remain in a dormant state for a period of time. In the latter case the appearance of seedlings of a given weed species in a habitat is spread over an extended period.

REASONS FOR DISPERSAL IN TIME

- Aeration : Deep-buried weed seeds may go into induced dormancy because of inadequate oxygen supply in the soil. Improvement in aeration therefore favours better seed germination.
- Light: Some seeds either require light for germination or germinate better in light, while others are insensitive to light. In order for light-sensitive seeds to respond to light, they must first imbibe water. Seed of *rottboellia cochinchinensis* germinate better in light than in darkness.
- Soil nitrate level: High nitrate level in the soil favour germination of weed seeds. Soil nitrate is affected by fertilizer application and by cultivation practices. In laboratory studies, germination of many plant seeds has been improved with potassium nitrate and urea.

Germination Behavior of Weed

Many weed species seeds are subject to dormancy of different kinds, thus causing delayed germination of variable duration. This phenomenon appears more frequently in non-cultivated species. Seed germination is influenced by many internal factors including the genetic pattern of seeds (genotype), the ecological type of seed population (ecotype), seed maturity, presence or absence of germination promoting and inhibiting substances, and the general chemical and structural composition of seeds.