Plant hormones

There are several types of hormones which stimulates or inhibits the growth of plants. The five types of hormones which controls plant hormones are auxin, gibberellin, cytokinin, ethylene and abscisic acid. Here is the description about these five hormones and their functions.

The plant growth is controlled by certain chemical substances called the plant hormones. These are also known as the growth factors, growth substances, plant growth regulators (PGR) or phytohormones. These can either promote or inhibit the growth of the plant.

On the basis of the function there are five types of plant hormones:

1. Auxin
2. Gibberellin
3. Cytokinin
4. Ethylene
5. Abscisic acid (ABA)

1. Auxin

This is the best known plant hormone and have many effects on the plant growth. Experiments on plant hormones were initially performed by Charles Darwin and his son Francis Darwin. They worked on the seedlings of the canary grass and were amazed to observe that the direction of the growth of the coleoptile (a sheath which protects the stem tip (plumule) of a germinating grass seed) was influenced only when its tip was exposed to light and not the base where the actual growth was taking place. They also observed that when the coleoptile was illuminated from one side, it bent towards the light but if the tips were chopped or covered with metal foil, bending response would not occur. After watching this, Darwin concluded that certain kind of 'influence' is generated at the tip which is then transmitted to the base where the growth takes place. However, he couldn't identify the influence.

After Darwin, Boysen-Jenson observed that if the tip of the coleoptile is decapitated, it neither grow nor bend towards light. The normal bending also occurred if the tip is cut off and replaced with an intervening block of gelatin. It was thus evident that the influence was due to chemical diffusing through the block of gelatin.

F.W. Went cut off tips of oat coleoptile and placed them on small agar blocks and let them for a few hours to allow all the chemical influence to diffuse into the agar. Like this, he

isolated auxin in agar block. Then he placed this agar block on the freshly decapitated coleoptiles and observed that the coleoptiles grew and bent away from the side on which the block was placed. He named this chemical influence as auxin which is derived from a greek word 'auxein' which means to increase or to grow. So, Went is credited as the inventor of auxin.

Functions of auxin:

1. Cell enlargement: Auxin causes cell enlargement by solubilisation of carbohydrates, loosening of cell wall micro-fibrils, synthesis of new wall material and increase in respiration.
2. Prevention of lodging: Lower inter-nodes of the stem of cereals are long and weak. AS a result the plant bends down or droops. Application of NAAM prevents lodging.
3. Apical dominance: In many plants, apical bud suppresses the growth of lateral buds. This condition is known as apical dominance. A plant with strong apical dominance has little or no branching like in sunflower.
4. It is responsible for the photo-tropism and geotropism.
5. It promotes root initiation in callus and stem cutting.
6. Delay of abscission of leaves by preventing formation of abscission layer. But promotes this in older leaves and fruits.
7. It induces parthenocarpy (production of fruit without fertilization).
8. Increases the number of female flowers.
9. Activity of cambium is promoted by auxin.
10. Healing of injury in plants.
11. Promotes xylem differentiation.

Uses of synthetic auxin:

1. IBA, IBA-alanine and NAA are used for rooting in stem cutting.
2. IAA and IBA induces parthenocarpy.
3. 2,4-D and 2,4,5,-T are used as weedicides.
4. NAA and 2,4-D are used for flowering.
5. Methyl ester of NAA are used for storage of potato.
6. Chlorophenoxypropionic acids is used to improve the quality of vegetable crops by inhibiting flower formation.
7. NAA is used to increase dwarf shoots and number of fruits in apple.

Some points related to auxin:

1. Auxin is synthesized on the root and shoot tips and are produced relatively in lesser amount in the roots.
2. Tryptophan, an amino acid, is the precursor of auxin.
3. Auxin produced at the shoot are transported to root through parenchyma (a vascular tissue in plants).
4. Low concentration of auxin results in the growth whereas high concentration will inhibit the growth of the same organ.
5. Auxin is active in free state and can be easily extracted.
6. Bound auxin is inactive and is meant for storage purpose like IAA- Inositol, IBA- Alanine.
7. Auxin are weak organic acids.
8. Some auxin occur naturally in plants and are called the natural auxin while many are synthetic:

a) Natural auxin: It was first isolated from human urine by Kogl and Haagensmit. It was named as auxin-a. But later Kogl obtained another auxin called auxin-b (auxentriolic acid) from corn germ oil and heteroauxin from human urine. Heteroauxin, also known as indole-3-acetic acid (IAA) is the best known natural auxin. Indole butyric acid is another natural auxin.

b) Synthetic auxin: e.g. naphthalene acetic acid (NAA), phenoxy acetic acid (PAA), 2, 4-dichlorophenoxy acetic acid (2, 4-D), 2,4,5- trichlorophenoxy acetic acid (2,4,5-T), naphthalene acetamide (NAAM).

9. Anti-auxin: Inhibits auxin activity e.g. TIBA (triidobenzoic acid) and PCIB (p-chlorophenoxy isobutyric acid).
10. Auxin is used for Avena test culture, split pea test and root growth inhibition test

2. Gibberellin

These largely effects the shoots of the plants and have little or no effect on the roots. It came under observation when some Japanese farmer noticed some abnormally tall and thin seedlings on the rice field which never bore seeds. This disease was called the foolish seedling disease or bakanae. E. Kurosawa found that Gibberella fujikuroi is the causative organism of this disease which is a fungus. Later on, Yabuta and Sumuki isolated Gibberellic acid which was responsible for the rapid growth from the fungus.

Functions of Gibberellins:

1. In bolting: In rosette forming plants, inter-node growth is poor but large leaves appear to rise arise in tufts. The inter-nodes suddenly elongate and the stem becomes normal just before flowering. This is called bolting.
2. Parthenocarpy: Gibberellins have been found to be effective in inducing pathenocarpy in tomatoes, apple etc.
3. Breaking of dormancy: These can effectively break the dormacy of potato tuber, winter buds and seeds of many trees.
4. Increase in fruit size: These increases the number and fruit size of grapes.
5. Production of male flowers: These induces production of male flowers on genetically female plants.
6. Inter-nodal elongation: It helps in the elongation of the stem but not in roots.
7. It helps in the germination of the seed.
8. It is used to delay the ripening in plants like citrus.

Some points related to gibberellins:

1. Anti-gibberellins: Phosphon-D, amo-1618, CCC(chloro choline chloride) and maleic hydrazide (MH).
2. Gibberellins are used in induction of alpha-amylase in barley endosperm test, dwarf maize test and dwarf pea test.
3. Its precursor is acetyl CoA.
4. These are found in most of the groups of plants like algae, fungi, mosses, ferns etc.
5. These are produced at the apices of young leaves, embryo, buds etc and are transported through xylem.
6. Chemically these are terpenes (lipids) and are weak acids.
7. These have gibbane ring skeleton.
8. More than 100 types of gibberellins have been identified but GA3 form is most common.

3.Cytokinin

Callus formation from inter-nodal segments of tobacco can proliferate only if auxin is supplied with extract of vascular tissue, yeast extract, coconut milk or DNA. This was observed by Skoog. Later, Miller showed that yeast extract contains some growth regulators. This growth regulator was isolated from the herring sperm DNA and yeast cells and was called as kinetin (6-furfurylaminopurine). Letham named it as cytokinin.

Functions of cytokinin:

1. Cell division: These are found in a higher amount where rapid division is going on.
2. Morphogenesis: Cytokinins promotes cell division and in the presence of auxin, it promote cell division even in the meristematic tissues. In tissue culture, mitotic division are accelerated when both auxin and cytokinin are present. The ratio of high cytokinin and low auxin promote shoot buds in tissue culture.
3. Apical dominance: Cytokinin and auxin acts antagonistically in the control of apical dominance.
4. Delay in senescence: It delay the senescence of plant organs by controlling protein synthesis and mobilization of resources. This phenomenon is called the Richmond Lang effect. They helps to produce chloroplast in leaves. These are also called anti-ageing hormones.
5. Flowering: It helps in inducing flowering in certain species of plants like Lemna and Wolffia.
6. It promotes phloem transport.
7. It also promotes accumulation of salts in the cells.
8. It promotes production of female flowers.
9. It increases the resistance to low and high temperature and diseases.

Some points related to cytokinin

1. It is found at the tissues where rapid growth is taking place like growing fruits, root tips and shoot buds.
2. Chemically they are purines derived from tRNA.
3. The first naturally occurring cytokinin was identified from the young maize (Zea mays) and hence it was named as zeatin.
4. Cytokinin is also present in the coconut water (liquid endosperm).
5. It is used in tissue culture, chlorophyll preservation test and cell division test.

4. Ethylene

It is the only gaseous growth hormone. It is produced by almost all the organs but maximum production occurs in ripening fruits and senescent leaves. High concentration of auxin leads to the formation of ethylene.

Functions of ethylene:

1. It helps in ripening of fruits.
2. Inhibition of stem elongation and stimulation of transverse growth by causing increase in the girth of the plant and promotes horizontal growth.
3. It promotes apogeotropism in roots.
4. It increases the speed of senescence.
5. It also induces abscission of leaves.
6. It helps in breaking the dormancy of storage organs and initiates germination in peanut seeds.
7. Root initiation: Low concentration of ethylene induces rooting and growth of lateral roots and root hairs.
8. Flowering: It is used to initiate flowering and synchronizing fruit set in pineapples.
9. It helps in production of female flowers in a plant which is genetically male.

Some points related to ethylene:

1. Ethylene is used for sprouting of storage organs like rhizome and tubers.
2. It is used in the triple response test.
3. It can be placed in the group of both stimulator and inhibitor but largely is growth inhibitor.
4. It is the only hormone which is gas at normal temperature and pressure.
5. Since it is a gas, it can move in air too. Hence, any fruit kept with ripened fruit gets ripened too.
6. Its precursor is methionine.

5. Abscisic Acid

It was discovered by Addicott and Wareing separately. They named it abscisin II and dormin respectively. In 1967 it was decided to call it as abscisic acid (ABA). It is major inhibitor of growth in plants and is antagonistic to all the three growth promoters, especially GA. These are mainly produced in mature leaves but it is also called synthesized in stems, fruits and seeds and then transported to other parts through vascular tissues.

Function of abscisic acid

1. It hastens the formation of abscission layer and senescence.
2. Transpiration: It helps in closing of stomata by causing potassium ions to leave the guard cells during periods of water shortage or drought and hence is also known as stress hormone.
3. It promotes bud dormancy in seeds during winters.
4. Seed dormancy: It induces seeds dormancy hence is named dormin. Thus it helps the seed to withstand desiccation and other unfavorable factors.
5. It inhibits cambial activity.
6. Flowering: in induces flowering in some short day plants like strawberry.
7. It plays an important role in seed development, maturation and dormancy.
8. It induces synthesis of carotenoids in green oranges making them yellow.

Some points related to ABA

1. Its precursor is violaxanthin (a xanthophyll in chloroplast).
2. It is used in cotton or bean explant test.
3. It is chemically a dextro-rotatory cis-sesquiterpene.
4. In liverworts and algae, a compound called lunularic acid has similar activities as ABA.