

PLANT GROWTH REGULATORS

Growth of the plant has for long been believed to be due to the minerals absorbed from the soil and the food materials synthesized by the plant. It is now however recognized that the growth of the plant is very much regulated by certain chemical substances known as growth regulators. These substances are formed in one tissue or organ of the plant and are then transported to other sites where they produce specific effects on growth and development.

Philips (1971) defined growth hormones as a substance which is synthesized and is transported to other cells where in extremely small quantities influences development processes.

The plants are known to produce 5 classes of hormones namely auxins, gibberellins, cytokinins, abscisic acid and ethylene. A plant tissue may contain more than one of these growth regulators at the same time. The leaf primordia and developing seeds contain both auxin and gibberellins and in some plants ABA also. Both auxins and gibberellins cause stem elongation by different mechanisms while ABA and ethylene inhibits stem growth. Thus, two or more growth regulators may be similar in their action. When the effect is more than the sum of their individual effects it is called synergistic and when the action of two growth regulators is opposite it is called antagonistic. The final growth and development of the plant is the sum of total interactions of different growth regulators that are present in the plant.

24.1 AUXINS:

The idea of the existence of auxins in plants was for the first time conceived by Charles Darwin in 1881. He showed that coleoptile of canary grass could bend towards light when it is unilaterally illuminated. However the coleoptile failed to bend when its tip was covered with an opaque cap. Most of the knowledge about auxins comes from the work on oat (*Avena sativa*) coleoptile. Went (1926) demonstrated that coleoptile tips contain a substance capable of elongation of decapitated coleoptiles. He placed several freshly cut coleoptile tips on an agar block which was kept on a piece of inert material like glass. After several hours he cut the agar block into small cubes. He placed the agar cubes eccentrically on decapitated coleoptile stumps for 2 hours in the dark. The effect of agar cube was similar to that of the tip as was shown by curvature of the coleoptiles(**Avena coliaptile curvature test**)

The first higher plant from which auxin could be extracted was maize kernels. It was identified as IAA. Indole Acetic Acid is the major auxin occurring in plants.

24.1.1 OCCURRENCE:

All the parts of the plant body produce auxin. However the major sites of auxin production are the **shoot tip, developing seeds** and **buds**. The amount of auxin present in different parts of the plant varies greatly. The amount is highest in the stem tip and coleoptile tip and decreased gradually down words.

Synthetic auxins:

There are a number of synthetic chemicals which are similar to IAA in their biological activity. However they do not occur in any plant. The important synthetic auxins are IBA (Indole Buteric Acid), NAA (Naphthalene Acetic Acid), 2, 4-D (2, 4 Dichloro Phenoxy Acetic Acid) and 2,4,5-T (2,4,5-Trichloro Phenoxy Acetic Acid).

24.1.2 BIOSYNTHESIS OF AUXINS:

Indole acetic acid (IAA) is synthesized from an amino acid Tryptophan in 3 different pathways. These 3 pathways have different intermediate compounds and the pathway is named after the intermediate compound produced as follows

(a) Indole Pyruvic Acid Pathway **(b)** Tryptamine Pathway and **(c)** Indole Acetol Doxime Pathway.

Indole Pyruvic Acid Pathway:

The first reaction involves transmission of Tryptophan to Indole Pyruvic Acid. The enzyme tryptophan amino transferase transfers amino groups (NH₂) from Tryptophan resulting in the formation of Indole Pyruvic Acid.

In second step Indole pyruvic acid is decarboxylated to form Indole acetaldehyde. The enzyme involved is Indole pyruvic decarboxylase. A molecule of CO₂ is removed. In the final step Indole acetaldehyde is oxidized to IAA by 2 enzymes namely Indole acetaldehyde dehydrogenase and Indole acetaldehyde oxidase.

Tryptamine Pathway:

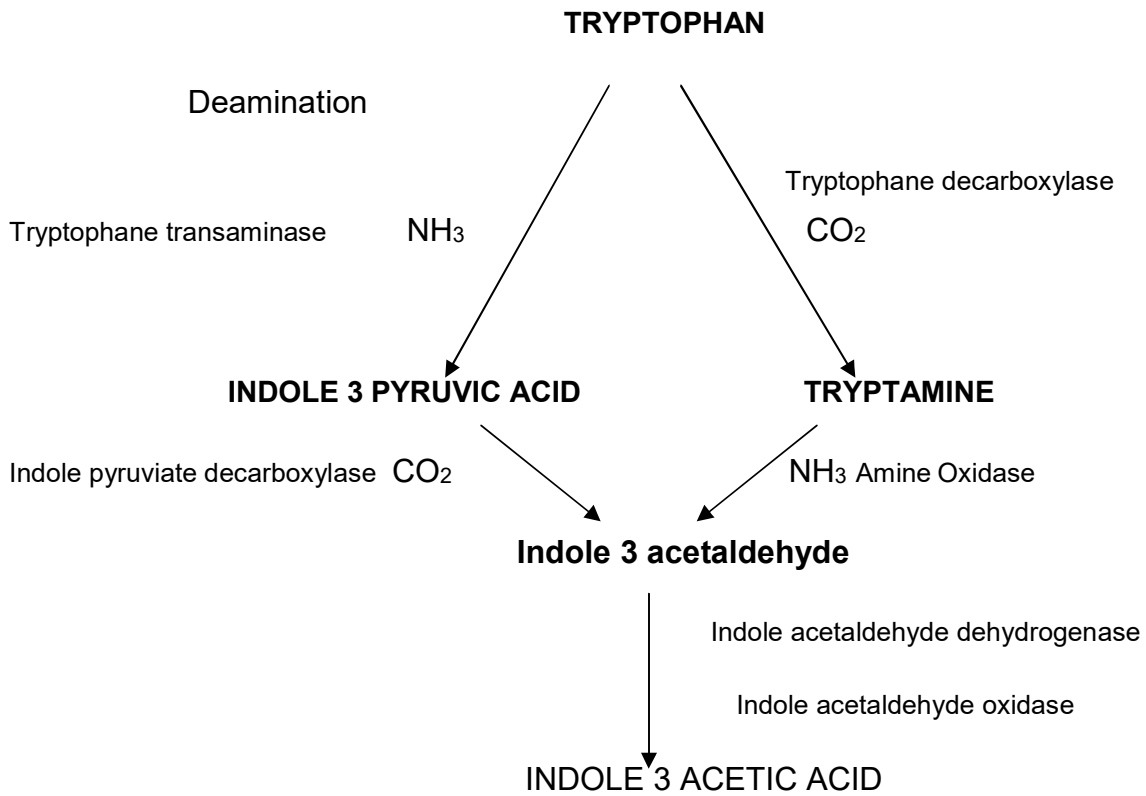
This pathway is of rare occurrence and was shown in tomato. Here tryptophan is first decarboxylated by the enzyme tryptophan decarboxylase forming tryptamine. Tryptamine then undergoes deamination forming indole acetaldehyde. The enzyme responsible for this reaction is amine oxidase. In the final step indole acetaldehyde is oxidized to IAA.

Indole Acetaldoxime Pathway:

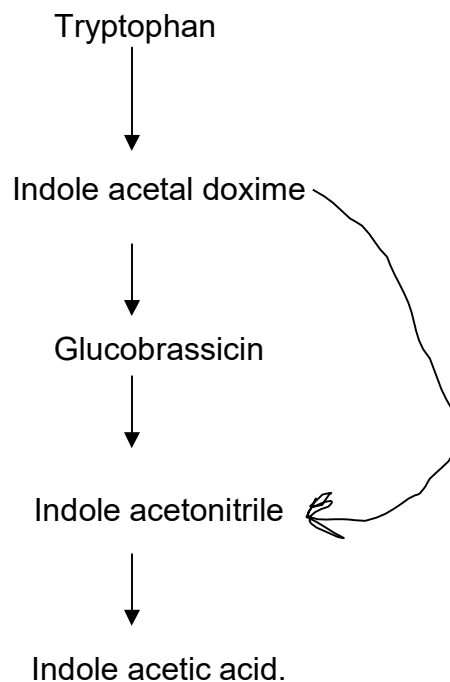
This pathway is characteristic of the members of the family Brassicaceae. In this pathway tryptophan is first converted to indole acetal doxime which in turn is

further converted to indole aceto nitrile directly or through an intermediary compound glucobrassicin. Indole aceto nitrile is converted to indole acetic acid. **Zinc** is essential for biosynthesis of auxin since it activates the enzyme **tryptophan synthetase**.

BIOSYNTHESIS OF AUXINS:



II. Indole Acetal Doxime Pathway:



TRANSPORT:

Auxin moves towards morphological basal end in stem cuttings. The movement of auxin is polar and basipetal. In roots it is polar but acropetal. In xylem it moves along the transpiration stream.

24.1.3 MODE OF ACTION:

It was observed that whenever auxin causes elongation of the coleoptile, the external medium in which the coleoptile was flooded, becomes acidic. The pH which was originally near neutral becomes decreased to 4.5. On this basis Hager, Menzel and Krans (1971) proposed **acid growth hypothesis of auxin action**. In this it was explained that the H⁺ ions decreases PH value and presumed to break the acid labile bonds or activate wall hydrolyzing enzymes and render the cell was soft. This will create suitable conditions for cell elongation.

Auxin and cell elongation:

The primary physiological effect of auxin is to promote the elongation of cells which may be due to increasing osmotic pressure and permeability of cytoplasm to water and decreasing cell wall pressure.

Auxin stimulates the production of hydrolyzing enzymes like B-1, 3-gluconase, pectin methyl esterase and cellulase which soften cell wall and increase the plasticity resulting in reduction of wall pressure and cell elongation. Under the influence of auxin, cellulose synthetase increases and new wall material is synthesized within the cell wall resulting in extension or growth of the cell.

24.1.4 PHYSIOLOGICAL ROLE OF AUXINS:

A. Cell division:

Auxin has been found to be responsible for initiating and promoting cell division in certain tissues eg. Cambium. When ever wound is caused in the plant a swelling called callus is developed because of the proliferation of the parenchyma cells stimulated by auxin and a chemical substance traumatic acid. This can be put to practical use in **grafting** where the callus plays an important role in strengthening the union between stock and sion. Hence, during grafting of grapes, it was found that immersion of stock and sion in 0.1 percent of IAA resulted in quick growth of callus and success of graft union.

B. Root initiation:

The stem cuttings of some plants readily form adventitious roots when put in the soil. Adventitious root formation will takes place at the basal end of stem cuttings. Cuttings of such plants which do not readily root, form abundant roots when treated with auxins. Synthetic auxins like IBA, NAA are particularly very effective. In general cuttings of herbaceous plants readily respond to auxins while those of woody perennials like eucalyptus, mango and others fail to respond to auxin application.

In air layering of guava auxins like IBA at 500 ppm is used for root initiation.

C. Apical dominance:

The presence of apical bud causes a complete or partial inhibition of lateral buds. This is due to the presence of higher concentration of auxin at the apical bud, which causes a preferential movement of nutrients towards it.

In plants like sunflower, the main stem continues to grow and the lateral buds in the axils of leaves do not emerge and grow into branches. However when the tip of the main stem is cutoff or when it terminates into an inflorescence, the lateral buds emerge into branches. In either case the influence of the shoot apex on the lateral bud is lost. This phenomenon of inhibition of laterals by the shoot apex is termed as apical dominance.

In plants like potato and tomato apical dominance is weak consequently the apical growing point of the main stem fails to suppress the emergence of lateral buds. Such plants are therefore extensively branched and bushy.

D. Inhibition of abscission layer:

Abscission is a process of dissolution of the middle lamella and primary walls of the cells at the base of the petiole, pedicle or peduncle. Abscission refers to detachment of plant organs. It is a balance between the inhibition of auxin and promotion of substances like ABA, Ethylene etc several auxins (2,4-D, IAA, NAA) inhibits the abscission of both leaves and fruits.

Ex: application of NAA at 20 to 30 ppm twice at 15 days interval reduces flower and fruit drop in chillies and cotton, 2,4-D prevents defoliation in cabbage and cauliflower that often occurs during harvest.

E. Flower initiation.

Application of auxin inhibits flowering in several photoperiodically sensitive plants such as xanthium, soybean and others. But the exception is pineapple (*Ananas comosus*) a day neutral plant. This plant can be made to bloom promptly with the application of NAA or 2,4-D. However in this plant the effect of auxin is not direct but is mediated through ethylene formation.

Application of auxin also alters the sex ratio of flowers. In monoecious cucurbits increase the number of female flowers but the decrease the number of male flowers. Similarly in dioecious plants like cannabis, the male plants start producing female flowers when auxin is applied. Here again the effect of auxin is not shown to be direct but is mediated through ethylene formation.

F. Production of parthenocarpic fruits:

It is a general observation that in the absence of pollination and fertilization the ovary of the flower does not develop into the fruit, but the flower abscises and falls. However application of auxin causes development of ovary into the fruit in several plants such as tomato, brinjal and others. Such fruits are seedless as these have developed without the normal process of fertilization these are known as parthenocarpic fruits. The presence of large number of seeds in a fruit lowers its commercial value in the canning industry.

G. Eradication of weeds:

Plant roots are extremely sensitive to auxins. Very high concentration of auxins over stimulates growth promoting activities of root cells resulting in distorted roots with blocked sieve tubes. The roots ultimately decay and the plant is killed. 2,4-D and 2,4,5-T are effective weedicides at higher concentration of 1 to 3 percent . **2,4-D** is selective weed killer. It is highly toxic to **broad leaved plants** or dicotyledons while relatively non toxic to narrow leaved plants or monocot.

H. Growth in thickness:

The stem of dicots and gymnosperms not increase in length but also in thickness. Increase in thickness of the stem and root is due to radial growth. The process is termed as secondary growth.

I. Vascular differentiation:

Not only the activation of cambial rings but also the differentiation of cambial derivatives into xylem and phloem is also under the control of hormones. Interaction of both auxin and GA is involved in this.

J. Prevention of lodging:

Naphthyl acetamide when applied on the base of oats and flax, they grow stiff, woody and erect. Thus lodging in these crop plants is prevented.
