Geetanjali Sharma. / *International Journal of Preclinical & Pharmaceutical Research.* 2015; 6(3): 155-159.

e-ISSN 2249-7552
Print ISSN 2229-7502

International Journal of
Preclinical & Pharmaceutical Research

Journal homepage: www.preclinicaljournal.com

REVIEW OF PLANT GROWTH REGULATORS - CONTROL GROWTH, DEVELOPMENT AND MOVEMENT

Geetanjali Sharma*

Post Graduate Government College Madhya Marg, Chandigarh, 160011, India.

ABSTRACT

Plant growth and development involves the integration of many environmental and endogenous signals that, together with the intrinsic genetic program, determine plant form. Fundamental to this process are several growth regulators collectively called the plant hormones or phytohormones. This group includes auxin, cytokinin, the gibberellins (GAs), abscisic acid (ABA), ethylene, the brassinosteroids (BRs), and jasmonic acid (JA), each of which acts at low concentrations to regulate many aspects of plant growth and development. Virtually every aspect of plant growth and development is under hormonal control to some degree. A single hormone can regulate an amazingly diverse array of cellular and developmental processes, while at the same time multiple hormones often influence a single process. Well-studied examples include the promotion of fruit ripening by ethylene, regulation of the cell cycle by auxin and cytokinin, induction of seed germination and stem elongation by GA, and the maintenance of seed dormancy by ABA. Historically, the effects of each hormone have been defined largely by the application of exogenous hormone. More recently, the isolation of hormone biosynthetic and response mutants has provided powerful new tools for painting a clearer picture of the roles of the various phytohormones in plant growth and development. Hydroponic systems will not compensate for poor growing conditions such as improper temperature, inadequate light, or pest problems.

Key Words: Gibberellins, Cytokinin, abscisic acid, Phytohormones, Growth regulators.

INTRODUCTION

Plant growth regulators or phytohormones are organic substances produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production and active in minute amounts. Thimmann (1948) proposed the term *Phyto hormone* as these hormones are synthesized in plants. *Plant growth regulators* include auxins, gibberellins, cytokinins, ethylene, growth retardants and growth inhibitors. Auxins are the hormones first discovered in plants and later gibberellins and cytokinins were also discovered.

Hormone

An endogenous compound, which is synthesized at one site and transported to another site where it exerts a physiological effect in very low concentration. But ethylene (gaseous nature), exert a physiological effect only at a near a site where it is synthesized.Classified definition of a hormone does not apply to ethylene [1].

Corresponding Author

Geetanjali Sharma
Email: kksmhl@gmail.com

Plant growth regulators

- Defined as organic compounds other than nutrients, that affects the physiological processes of growth and development in plants when applied in low concentrations.
- Defined as either natural or synthetic compounds that are applied directly to a target plant to alter its life processes or its structure to improve quality, increase yields, or facilitate harvesting [2].

Plant Hormone

When correctly used, is restricted to naturally occurring plant substances, there fall into five classes. Auxin, Gibberellins, Cytokinin, ABA and ethylene. Plant growth regulator includes synthetic compounds as well as naturally occurring hormones.

Plant Growth Hormone

The primary site of action of plant growth hormones at the molecular level remains unresolved.

Reasons

• Each hormone produces a great variety of physiological responses.
• Several of these responses to different hormones frequently are similar.
• The response of a plant or a plant part to plant growth regulators may vary with the variety of the plant.
• Even a single variety may respond differently depending on its age, environmental conditions and physiological state of development (especially its natural hormone content) and state of nutrition. There are always exceptions for a general rule suggesting the action of a specific growth regulator on plants.
• There are several proposed modes of action in each class of plant hormone, with substantial arguments for and against each mode [4].

Hormone groups

Auxin - Substances generally resembles IAA and has the ability to stimulate the elongation of coleoptiles.

Gibberellins - are diterpenoids, which have the ability to elongate the stem of green seedlings especially certain dwarf and rosette types. Cytokinin - Usually substituted Adenines, which resembles zeatin (Naturally occurring cytokinin in *Zea mays*) and have the ability to stimulate cytokinensis in cultures of tobacco cells. Ethylene - Gaseous regulator that stimulate is diametric growth in the apices of dicot seedlings. Inhibitors - are regulators of growth, which originally depress the Auxins Gibberellins, Cytokinin, ABA and ethylene. Plant growth regulator includes synthetic compounds as well as naturally occurring hormones.

Hormone groups

Auxin - Substances generally resembles IAA and has the ability to stimulate the elongation of coleoptiles.
Gibberellins - are diterpenoids, which have the ability to elongate the stem of green seedlings especially certain dwarf and rosette types.
Cytokinin - Usually substituted Adenines, which resembles zeatin (Naturally occurring cytokinin in *Zea mays*) and have the ability to stimulate cytokinensis in cultures of tobacco cells.
Ethylene - Gaseous regulator that stimulate is diametric growth in the apices of dicot seedlings.
Inhibitors - are regulators of growth, which originally depress the Auxins are a group of phytohormones produced in the shoot and root apices and they migrate from the apex to the zone of elongation. Auxins promote the growth along the longitudinal axis of the plant and hence the name (auxeing : to grow). The term, auxin was introduced by Kogl and Haagen- Smit (1931). Went (1928) isolated auxin from the Avena coleoptile tips by a method called *Avena coleoptile or curvature test* and concluded that no growth can occur without auxin. Auxins are widely distributed through out the plant however, abundant in the growing tips such as coleoptile tip, buds, root tips and leaves. Indole Acetic Acid (IAA) is the only naturally occurring auxin in plants.

Physiological effects of auxin

Cell division and elongation

The primary physiological effects of auxin are cell division and cell elongation in the shoots. It is important in the secondary growth of stem and differentiation of xylem and phloem tissues [6, 7].

Apical dominance

In many plants, if the terminal bud is intact and growing, the growth of lateral buds just below it remains suppressed. Removal of the apical bud results in the rapid growth of lateral buds. This phenomenon in which the apical bud dominates over the lateral buds and does not allow the lateral buds to grow is known as *apical dominance*.

Skoog and Thimmann (1948) pointed out that the apical dominance might be under the control of auxin produced at the terminal bud and which is transported downward through the stem to the lateral buds and hinders the growth. They removed the apical bud and replaced it with *agar* block. This resulted in rapid growth of lateral buds. But when they replaced the apical bud with agar block containing auxin [8, 9], the lateral buds remained suppressed and did not grow.

Root initiation

In contrast to stem, the higher concentration of auxin inhibits the elongation of roots but the number of lateral roots is considerably increased i.e., higher concentration of auxin induces more lateral branch roots. Application of IAA in lanolin paste (lanolin is a soft fat prepared from wool and is good solvent for auxin) to the cut end of a young stem results in an early and extensive rooting. This fact is of great practical importance and has been widely utilized to promote root formation in economically useful plants which are propagated by cuttings.

Prevention of abscission

Natural auxins prevent the formation of abscission layer which may otherwise result in the fall of leaves, flowers and fruits.

Parthenocarpy

Auxin can induce the formation of parthenocarpic fruits (fruit formation without pollination and fertilization). In parthenocarpic fruits, the concentration of auxin in the ovaries is higher than in the ovaries of plants which produce fruits only after fertilization. In the later cases, the concentration of the auxin in ovaries increases after pollination and fertilization.

Respiration

Auxin stimulates respiration and there is a correlation between auxin induced growth and respiration. Auxin may increase the rate of respiration indirectly through increased supply of ADP by rapidly utilizing ATP in the expanding cells.

Callus formation

Besides cell elongation, auxin may also be active in cell division. In many tissue cultures, where the callus growth is quite normal, the continued growth of such callus takes place only after the addition of auxin.

Eradication of weeds

Some synthetic auxins especially 2, 4- D and 2, 4, 5-T are useful in eradication of weeds at higher concentrations.

Flowering and sex expression

Auxins generally inhibit flowering but in pine apple and lettuce it promotes uniform flowering.

Distribution of auxin in plants

In plants, auxin (IAA) is synthesized in growing tips or meristematic regions from where; it is transported to other plant parts. Hence, the highest concentration of IAA is found in growing shoot tips, young leaves and developing auxiliary shoots. In monocot seedling, the highest concentration of auxin is found in coleoptile tip which decreases progressively towards its base.

In dicot seedlings, the highest concentration is found in growing regions of shoot, young leaves and developing auxiliary shoots. Within the plants, auxin may present in two forms. i.e., *free auxins* and *bound auxins*. Free auxins are those which are easily extracted by various organic solvents such as diethyl ether. Bound auxins on the other hand, need more drastic methods such as hydrolysis, autolysis, enzymolysis etc. for extraction of auxin. Bound auxins occur in plants as complexes with carbohydrates such as glucose, arabionse or sugar alcohols or proteins or amino acids such as aspartate, glutamate or with inositol.

Biosynthesis of auxin (IAA) in plants

Thimann (1935) found that an amino acid, tryptophan is converted into Indole 3 acetic acid. Tryptophan is the primary precursor of IAA in plants. IAA can be formed from tryptophan by two different pathways [10].

- By deamination of tryptophan to form indole-3-pyruvic acid followed by decarboxylation to from indole-3-acetaldehyde. The enzymes involved are tryptophan deamintion and indole pyruvate decarboxylase respectively.
- By decarboxylation of tryptophan to form tryptamine followed by deamination to form indole-3-acetaldehyde and the enzymes involved are tryptophan decarboxylase and tryptamine oxidase respectively. Indole 3-acetaldehyde can readily be oxidized to indole 3-acetic acid (IAA) in the presence of indole 3-acetaldehyde dehydrogenase.

Transport of auxin in plant

The transport of auxin is predominantly polar. In stems, polar transport of auxin is basipetal i.e., it takes place from apex towards base. Polar transport of auxin is inhibited by 2, 3, 5 Triiodobenzoic acid (TIBA) [11] and Naphthyl thalamic acid (NPA). The substances are called as antiauxins.

Destruction / Inactivation of auxin in plants

Auxin is destructed by the enzyme IAA oxidase in the presence of O2 by oxidation.Rapid inactivation may also occur by irradiation with x-rays and gamma rays. UV light also reduces auxin levels in plants. Inactivation or decomposition of IAA by light has been called as photo oxidation.

Mechanism of Action

IAA increases the plasticity of cell walls so that the cells stretch easily in response to turgor pressure. It has been suggested that IAA acts upon DNA to influence the production of mRNA. The mRNA codes for specific enzymes responsible for expansion of cell walls. Recent evidences indicate that IAA increases oxidative phosphorylation [12] in respiration and enhanced oxygen uptake. The growth stimulation might be due to increased energy supply and it is also demonstrated that auxin induces production of ethylene in plants.

Gibberellins

Discovery

A Japanese scientist Kurosawa found that the rice seedlings infected by the fungus *Gibberella fujikuroi* grow taller and turned very thin and pale. An active substance was isolated from the infected seedlings and named as Gibberellin. Biosynthesis of gibberellins in plants. The primary precursor for the formation of gibberellins is acetate.

Ethylene

Ethylene is the only natural plant growth hormone exists in gaseous form.

Important physiological elects

1. The main role of ethylene is it hastens the ripening of fleshy fruits eg. Banana, apples, pears, tomatoes, citrus etc.
2. It stimulates senescence and abscission of leaves
3. It is effective in inducing flowering in pine apple

4. It causes inhibition of root growth
5. It stimulates the formation of adventitious roots
6. It stimulates fading of flowers
7. It stimulates epinasty of leaves.

Abscisic acid

Addicott (1963) isolated a substance strongly antagonistic to growth from young cotton fruits and named Abscissin II. Later on this name was changed to Abscisic acid. This substance also induces dormancy of buds therefore it also named as Dormin. Abscisic acid is a naturally occurring growth inhibitor.

Physiological effects

The two main physiological effects are
1. Geotropism in roots
2. Stomatal closing
3. Besides other effects

Geotropism in roots

Geotropic curvature of root is mainly due to translocation of ABA in basipetal direction towards the root tip.

Stomatal closing

ABA is synthesized and stored in mesophyll chloroplast. In respond to water stress, the permeability of chloroplast membrane is lost which resulted is diffusion of ABA out of chloroplast into the cytoplasm of the mesophyll cells. From mesophyll cells it diffuses into guard cells where it causes closing of stomata.

Other effects

i. Including bud dormancy and seed dormancy
ii. Includes tuberisation
iii. Induces senescence of leaves fruit ripening, abscission of leaves, flowers and fruits
iv. Increasing the resistance of temperate zone plants to frost injury.

Growth retardants

There is no. of synthesis compounds which prevent the gibberellins from exhibiting their usual responses in plants such as cell enlargement or stem elongation. So they are called as anti gibberellins or growth retardants [13-19]. They are
1. Cycocel (2- chloroethyl trimethyl ammonium chloride (CCC)
2. Phosphon D – (2, 4 – dichlorobenzyl – tributyl phosphonium chloride)
3. AMO – 1618
4. Morphactins
5. Maleic hydrazide

CONCLUSION

In conclusion, plant growth regulators are a group of chemicals for controlling and enhancing the natural plant growth processes to better meet the requirements of food supply in general. Mechanisms are in place under the Codex system to oversee residues of pesticides (including plant growth regulators) in food for setting standards and public health protection.

REFERENCES

1. Chang C. Ethylene signaling: The MAPK module has finally landed. *Trends Plant Sci*, 8, 2003, 365–368.
2. Deshaies RJ. SCF and Cullin/Ring H2-based ubiquitin ligases. *Annu Rev Cell Dev Biol*, 15, 1999, 435–467.
3. Dharmasiri N, Estelle M. Auxin signaling and regulated protein degradation. *Trends Plant Sci*, 9, 2004, 302–308.
4. Goda H, Sawa S, Asami T, Fujioka S, Shimada Y, *et al.* Comprehensive comparison of auxin-regulated and brassinosteroid-regulated genes in Arabidopsis. *Plant Physiol*, 134, 2004, 1555–1573.
5. Gomi K, Matsuoka M. Gibberellin signalling pathway. *Curr Opin Plant Biol*, 6, 2003, 489–493.
6. Gray WM, Kepinski S, Rouse D, Leyser O, Estelle M. Auxin regulates SCFTIR1-dependent degradation of AUX/IAA proteins. *Nature*, 414, 2001, 271–276.
7. Guo H, Ecker JR. Plant responses to ethylene gas are mediated by SCF(EBF1/EBF2)-dependent proteolysis of EIN3 transcription factor. *Cell*, 115, 2000, 667–677.
8. Guo H, Ecker JR. The ethylene signaling pathway: New insights. *Curr Opin Plant Biol*, 7, 2004, 40–49.
9. Himmelbach A, Yang Y, Grill E. Relay and control of abscisic acid signaling. *Curr Opin Plant Biol*, 6, 2003, 470–479.
10. Kakimoto T. Perception and signal transduction of cytokinins. *Annu Rev Plant Biol*, 54, 2003, 605–627.
11. Lorenzo O, Piqueras R, Sanchez-Serrano JJ, Solano R. Ethylene Response Factor1 integrates signals from ethylene and jasmonate pathways in plant defense. *Plant Cell*, 15, 2003, 165–178.
12. Nemhauser JL, Mockler TC, Chory J. Interdependency of brassinosteroid and auxin signaling in Arabidopsis. *PLoS Biol*, 2, 2004, 258.
13. Peng J, Richards DE, Hartley NM, Murphy GP, Devos KM, *et al*. Green revolution genes encode mutant gibberellin response modulators. *Nature*, 400, 1999, 256–261.
14. Potuschak T, Lechner E, Parmentier Y, Yanagisawa S, Grava S, *et al*. EIN3-dependent regulation of plant ethylene hormone signaling by two arabidopsis F box proteins: EBF1 and EBF2. *Cell*, 115, 2003, 679–689.
15. Sasaki A, Ashikari M, Ueguchi-Tanaka M, Itoh H, Nishimura A, *et al.* Green revolution: A mutant gibberellin-synthesis gene in rice. *Nature*, 416, 2002, 701–702.

16. Smalle J, Vierstra RD. The ubiquitin 26s proteasome proteolytic pathway. *Annu Rev Plant Physiol Plant Mol Biol*, 55, 2004, 555–590.
17. Tiwari SB, Hagen G, Guilfoyle TJ. Aux/ IAA proteins contain a potent transcriptional repression domain. *Plant Cell*, 16, 2004, 533–543.
18. Turner JG, Ellis C, Devoto A. The jasmonate signal pathway. *Plant Cell*, 14, 2002, S153–S164.
19. Wang ZY, He JX. Brassinosteroid signal transduction—Choices of signals and receptors. *Trends Plant Sci*, 9, 2004, 91–96.