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Plant Growth Hormones: Concept, Types and Their Role in Field Crop Production

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Plant growth hormones, also known as phytohormones, are naturally occurring chemical messengers that play a critical role in regulating plant development and responses to environmental stimuli. These hormones, including auxins, gibberellins, cytokinins, abscisic acid, and ethylene, function at very low concentrations to influence processes such as cell division, elongation, flowering, fruiting, dormancy, and senescence. Hormones interact through complex signal transduction pathways and often work synergistically or antagonistically to regulate growth. Additionally, synthetic substances known as plant growth regulators (PGRs) mimic the actions of natural hormones to enhance or inhibit specific plant responses. Recent discoveries have also identified newer classes of growth regulators, including jasmonates, salicylates, brassinosteroids, peptide hormones, and small RNAs, expanding our understanding of plant growth control. This paper outlines the sources, biosynthesis, modes of action, and applications of major plant growth hormones and their synthetic analogues in improving plant productivity and adaptability.

Introduction

Plant growth substances called hormones are well-known to improve the source-sink connection and encourage the translocation of photo-assimilates, thereby helping ineffective flower formation, fruit, and seed development and ultimately increase the yield of crops. In the non-classical concept Plant, hormones are chemicals that regulate plant growth. Plant hormones are signal molecules produced at a specific location in the plant and in extremely low concentrations. They are naturally produced within plants, though very similar chemicals are produced by fungi and bacteria that can affect plant growth. Also, a large number of related chemical compounds synthesised in the laboratory that function as hormones are called plant growth regulators (PGRs). Plant hormones affect gene expression and transcription levels, cellular division and growth. It is generally known that there are five major classes of plant hormones, some of which are made up of different chemicals that can vary in structure from one plant to the other. Each class has positive and inhibitory functions, and they often work in a cycle with each other, with varying ratios of one or more interplaying to affect growth regulators. Hormones like cytokines and auxins are chemicals

that regulate plant growth. As such, they shape the plant and affect seed growth, time of flowering, sex of flowers and the senescence of leaves and fruits. Also, they affect the tissues that grow upward and downward, the formation of the leaf and the growth of the stem. Plant growth hormones has played a major role in affecting different parts of the plant, growth, and development. Indole butyric acid (IAA) and naphthalene acetic acid (NAA), which are auxins are compounds that positively influence root initiation and in conjunction with cytokinins, they control the growth of stems, roots, flowers and fruits. Cytokinins, which include 6-benzyl aminopurine (BAP) and zeatin, are a group of chemicals that influence cell division and shoot formation. Plants need hormones at very specific times during plant growth and at specific locations; they also need to disengage the effects hormones have when they are no longer needed. Plant growth hormones (PGH) can change growth and development in various ways under different growth conditions. GA3 is responsible for stimulating the production of mRNA molecules in the cells, which in turn improves the chances of fast growth. Non-structural carbohydrates (NSC) and crude protein (CP) contents in rice straw were significantly increased by spraying GA3, especially on the 15th d after anthesis, and the fermentation quality of rice straw silage was improved with the increase of NSC and CP contents, Single panicle weight was also significantly increased by spraying GA3 after anthesis. Priming with GA3 was very effective in improving the salinity-induced decrease in the number of grains per ear on the main stem in both wheat cultivars, which can alter the uptake and pattern of accumulation of different ions between shoots and roots in the adult plants of wheat under saline conditions.

Concepts of plant hormones

Julius von Sachs first suggested the presence of growth-regulating hormones in plants in 1980. He proposed that certain ‘organ-forming substances’ in plants are produced in the leaves and translocated downward in the plant body. Also in 1880, an evolutionist Charles Darwin studied unilateral light's effect on plant movements. While conducting his experiments on canary grass (*Phalaris canariensis*), he found that if the coleoptile tip is provided light from one side only (i.e., unilateral illumination), the tip would bend towards the light. In the absence of illumination, however, no curvature could be induced.

According to (Gaspar *et al.*, 2003), the term ‘hormone’ was first used in medicine about 100 years ago for a stimulatory factor, though it has come to mean a transported chemical message. The word comes from the Greek, where its meaning is ‘to stimulate’ or ‘to set in motion’. Thus, the origin of the word itself does not require the notion of transport per se, and the above definition of a plant hormone is much closer to the meaning of the Greek origin of the word than is the current meaning of hormone used in the context of animal physiology. Plant hormones are a unique set of compounds with unique metabolism and properties. Their only universal characteristics are that they are natural compounds in plants with an ability to affect physiological processes at concentrations far below those where either nutrients or vitamins would affect these processes.

Plant growth hormones: mode of action

Hormones act as internal signals within the plant. In the same way as environmental signals, they must be perceived and then initiate a series of responses. Plant hormones (a hormone/receptor complex) interact directly with the DNA of plant cell to regulate gene expression. Plant hormones interact to affect cell physiology, transcriptional and translational changes. The steps between the initial perception and the final response are known as signal transduction – another set of chemical changes, this time occurring inside the cell, which alter the biochemistry and/or patterns of gene expression of that cell. These changes may then, in turn act as signals initiating yet further responses.

Types of plant growth hormones

Plant growth hormones are classified depending on the nature of production into two major classes; endogenous and exogenous hormones, hormone produced naturally inside the plant

tissue or cell and those produced chemically synthetic hormones respectively. The concentration of a plant growth hormone at a particular site will depend upon many different factors, including the rate of synthesis, degradation, and transport to and from the target cell. In addition, plant growth hormones are often chemically modified, which may inactivate them, although as this process is often reversible, it can also increase the effective concentration of a plant growth hormone in a cell. Finally, as the activity of plant hormones is thought to require binding to specific receptors, transport in and out of subcellular compartments also controls the concentration perceived by the cell. As all of these processes have the potential to be regulated by the environment, it can be seen that plant growth hormones act as a means of integrating environmental signals and distributing them around the plant. Classically, there are five major groups of plant growth hormones. These are the auxins, gibberellins, cytokinins, abscisins, and ethylene. However, many more compounds exist in plants that have all of the characteristics of the more established plant growth hormones, and their role in regulating plant development is becoming clearer. These compounds include the jasmonates, salicylates, brassinosteroids and peptide hormones. Recently, small RNA molecules have been identified that regulate gene expression in different parts of the plants; these, too, might be considered to fulfil many of the criteria of being a plant growth hormone. These have the following characteristics, which can be added to the definition above. In general, 1) Plant growth hormones are small, relatively simple organic compounds. 2) Specific receptors exist that bind these compounds. 3) Often, the presence of one plant growth hormone will affect the synthesis or action of other plant growth hormones.

Auxins: ($C_{18}H_{32}O_5$): The name Auxins is derived from the Greek word auxin, meaning to increase or to grow. Auxins are compounds produced in the meristem of apical buds, embryo, seed and young leaves that positively influence cell enlargement, bud formation and root initiation. They also promote the production of other hormones, and in conjunction with cytokines, they control the growth of stems, roots, flowers and fruits. IAA transport is cell-to-cell, mainly in the vascular cambium and the procambial strands, but probably also in epidermal cells. Transport to the root probably also involves the phloem. IAA, IBA and 2, 4-dichlorophenoxy acetic acid (2, 4-D), as well as picloram, are often added to nutrient media.

Auxin Biosynthesis: IAA is similar to the amino acid tryptophan which is generally accepted to be the precursor molecule from which IAA is derived by different pathways. Tryptophan is converted to indoleacetaldoxime through decarboxylation and then converted to indoleacetonitrile by a dehydration reaction.

Cytokinins: $C_{10}H_9N_5O$: Cytokines (CK) biosynthesis is through the biochemical modification of adenine. It occurs in root tips and developing seeds, and transport is via the xylem from roots to shoots. Cytokinins are often used to stimulate growth and development, zeatin, kinetin, BAP, 2, P and pyranil benzyl adenine (PBA) being common. They usually promote cell division, especially if added together with an auxin. In high concentration (1 to 10 mg/ml), they can induce adventitious shoot formation, but root formation is generally inhibited. They promote auxiliary shoot formation by decreasing apical dormancy.

Gibberellins: $C_{19}H_{22}O_6$: Gibberellins are synthesised from glyceraldehyde-3-phosphate, via isopentenyl diphosphate, in young tissues of the shoot and developing seed. Their biosynthesis starts in the chloroplast and subsequently involves a membrane and cytoplasmic step. GAs are probably transported in the phloem and xylem. However, the transport of the main bioactive polar GA1 seems restricted. Gibberellins induce the elongation of internodes and the growth of plants or buds in vitro. They also break the dormancy of isolated embryos or seeds. Gibberellins usually inhibit adventitious root formation as well as adventitious shoot formation.

Biosynthesis of Gibberellins: Acetyl-CoA molecules are oxidised to produce mevalonic acid and CoA molecules. The primary precursor for the formation of gibberellin is acetate.

Abscisic Acid; $C_{15}H_{20}O_4$: ABA is synthesized from glyceraldehyde-3-phosphate via isopentenyl diphosphate and carotenoids in roots and mature leaves, particularly in response

to water stress. Seeds are also rich in ABA, which may be imported from the leaves or synthesized in situ. ABA transport is exported from roots in the xylem and leaves in the phloem. There is some evidence that ABA may circulate to the roots in the phloem and then return to the shoots in the xylem. In general, it acts as an inhibitory chemical compound that affects bud growth, seed and bud dormancy. It mediates changes within the apical meristem, causing bud dormancy and the alteration of the last set of leaves into protective bud covers. Since it was found in freshly abscised leaves, it was thought to play a role in the processes of natural leaf drop, but further research has disproven this.

Ethylene; C₂H₄: Ethylene is a gaseous, naturally occurring plant growth regulator. The gas ethylene (C₂H₄) is synthesized from methionine in many tissues in response to stress and is most commonly associated with controlling fruit ripening in climacteric fruits, and its use in plant tissue culture is not widespread. It is synthesized in tissues undergoing senescence or ripening. Transport being a gas, ethylene moves by diffusion from its site of synthesis. It does, though, present a particular problem for plant tissue culture. Some plant cell cultures produce ethylene, which, if it builds up sufficiently, can inhibit the growth and development of the culture. The type of culture vessel used and its means of closure affect the gaseous exchange between the culture vessel and the outside atmosphere, and thus, the levels of ethylene present in the culture.

Plant growth regulator (PGR)

TABLE 1. PLANT GROWTH REGULATORS THEIR RESTRICTED LOCATION AND FUNCTIONS

No	PGRs	Location	Action
1	Brassinolide (brassinosteroids)	Leaf and xylem tissue	Cell elongation; cell division;
2	Salicylic acid	Willow Bark	Activate defense gene, against pathogen invaders (is an active ingredient for aspirin)
3	Oligosaccharins(oligosaccharides)	Cell wall	Defense against pathogen
4	Systemine	Wound tissue	Defense activities as a signal molecule
5	Jasmonates	Seed	Seed germination; root growth and the storage of protein

These are generally substances synthesized artificially and have either a growth-suppressing or growth-enhancing effect. According to Davies, P. (2014) and H. O. Pik & S. Rolfe (2005), many more compounds found in plants that have all the characteristics of the more established plant growth hormones, and their role in regulating plant development are becoming clearer. These compounds include the jasmonates, salicylates, brassinosteroids and peptide hormones. Recently, small RNA molecules have been identified that regulate gene expression in different parts of the plants; these, too, might be considered to fulfil many of the criteria of being a plant growth hormone.

Role of Plant Growth Hormones in Field Crop Production

Plant growth hormones play important roles in plant growth and development. Plant growth regulators modify growth and development in various ways under different growth conditions. GA₃ is responsible for stimulating the production of mRNA molecules in the cells, which in turn improves the chances of fast growth. Nonstructural carbohydrates (NSC) and crude protein (CP) contents in rice straw were significantly increased by spraying GA₃, especially after anthesis, and the fermentation quality of rice straw silage was improved with the increase of NSC and CP contents. Single panicle weight was also significantly increased by spraying GA₃ after anthesis. Application of plant growth hormones in low concentration regulates growth, differentiation, and development, either by promotion or inhibition, and allows physiological processes to occur at their normal rate. Major plant growth regulators

(PGRs) significantly enhanced fibre yield in cotton, protein content in pea, chemical constituents in Croton, fruit size in Molina, seed germination rate in black gram and horse gram, floral buds in Jojoba and other growth parameters in different plants.

Role of PGH on Grain yield and yield component

Seed priming with GA3 was very effective in improving the salinity-induced decrease in the number of grains per ear on the main stem in both wheat cultivars, which can alter the uptake and pattern of accumulation of different ions between shoots and roots in the adult plants of wheat under saline conditions. Paclobutrazol (PBZ) is a member of the triazole plant-growth inhibitor group. Like many plant growth regulators, triazoles have plant growth regulatory effects. Triazoles also increase tolerance of various plant species to biotic and abiotic stresses, including fungal pathogens, drought, air pollutants, and low and high-temperature stress, by reducing oxidative damage via elevation of antioxidants or reducing the activity of oxidative enzymes. PBZ is normally applied as a foliar spray. As one kind of cytokinin, 6-BA can reduce the ethylene sensitivity of cut flowers.

Zhang *et al.* (2007) reported that spraying external 6-BA on the leaves at the late growth period of the late-season rice could increase seed setting rate and grain yield by delaying leaf senescence. Pan *et al.* (2013) reported that foliar application of a plant growth regulator at the heading stage can increase grain yields. Peizataifeng and Huayou 86 in both early and late seasons in 2007 in the early season, grain yield of Peizataifeng under PBZ and 6-BA treatments was remarkably higher than that of CK, respectively.

Role of PGH on Grain Qualities

One of the most essential traits in assessing planting benefits is grain quality. There were significant effects on grain qualities by spraying an exogenous plant growth regulator. Du *et al.* (2010) studied that the plumpness of the inferior grain in rice was enhanced by 9.7% and 5.5% by spraying exogenous 6-BA and GA3 at 5 days before flowering, respectively. Application of 6-BA decreased the white rice rate and white area of grain and write degree compared to the CK, respectively. Furthermore, exogenous hormones had greater effects on the grain qualities of inferior spikelets than superior spikelets. Dong *et al.* (2009) reported that the effects of exogenous hormones on rice quality varied with exogenous hormone varieties and different grain positions by spraying GA3 (57.7 $\mu\text{mol/L}$) at an earlier filling stage in rice.

Significant differences in head rice rate, chalkiness rate and amylose content in the two cultivars between the treatments. The PBZ treatment significantly increased head rice rate and amylose content in the cultivar Peizataifeng in the early season. In the late rice season, significant differences in amylose content were observed among these treatments. No noticeable differences in brown rice rate and milled rice rate in the two cultivars were observed among the treatments in both early season and late season.

Head rice rate under PBZ treatment was significantly higher than that of the CK in the early season; however, there were increases to some extent in head rice rate and amylose content in the late season, but not significant as compared to the CK. Although PBZ treatment showed an increase in the chalkiness of grain as compared to the CK, the difference was not significant. PBZ treatment could improve grain milling quality traits and nutrition traits because of a higher head rice rate and amylose content.

Commercial application of plant growth hormones

There are many areas in agriculture, horticulture, pomiculture, moriculture, etc., where phytohormones can be used in successful cultivation to obtain greater yield. Quantity and quality of agricultural products are very important factors in agricultural economics; the high percentage of germination of sown seeds in the field has a bearing on the output. Pretreatment of seeds with IAA, NAA, GA, etc. is very effective not only in increasing the percentage of germination but also in the total yield of the crop plants. Suitable concentration and combination have to be determined for every crop plant.

The overall growth of plants, the number of tillers and branches that produce from every plant in the field, contribute to the total yield. Use of GA or IAA greatly enhances the

growth of plants and the total area of leaf surfaces. Some morphactins can also be used to produce more tillers. In the case of sugar cane, the use of GA has been found to increase the length of the internodes and also the sugar content.

Tissue Culture: Since the days of Haberlandt, attempts to grow plant cells, tissues and organs in an artificial but defined nutrient medium have met with great success. Various methods have been established to raise plantlets starting from single cells, pith, leaf, roots, etc. By modulating the nutrients and hormonal concentration, it is possible to regenerate the entire plant body from any living cell from any part of the plant body, which suggests that all cells are totipotent. Hormonal concentrations play a significant role in culturing explants into undifferentiated callus and callus to differentiate into roots, shoots or the entire plant from eh callus.

Stimulation of fruit set: One of the first recorded effects of auxins was the stimulation of fruit set in unpollinated ovaries of solanaceous plants. It is known that pollen was a rich source of auxin and that in some species, pollination alone was all that was required for fruit set to occur. In tomato, chemical stimulation of fruit set is all that is needed for fruit growth to take place as well.

Herbicidal action: 2, 4-D and picloram (4-amino-3, 5, 6-trichloro picolinic acid) are two auxin-type herbicides that, at low concentration, bring about growth responses in plants similar to IAA. At higher concentrations, they are herbicidal. 2, 4-D is commonly used to control broadleaf weeds in grasses, and picloram is used for vegetation control on non-crop land because of its high activity and soil persistence. Both compounds cause epinastic bending in leaves, a cessation in growth in length, and increased radial expansion. After several days, tumors may form, followed by a softening and collapse of the tissue.

Increasing fruit size in grape: GA is used extensively on seedless grape varieties to increase the size and quality of the fruit. Pre-bloom sprays of 20ppm induce the rachis of the fruit cluster to elongate. This creates looser clusters that are less susceptible to disease during the growing season. GA also reduces pollen viability, as well as decreasing ovule fertility in grape. Application of GA at bloom, therefore, results in a decrease in fruit set, which reduces the number of berries per cluster, but increases the weight and length of the remaining fruit.

Increasing yield in sugarcane: Sugarcane growth is very sensitive to the reductions in average daily temperature normally experienced during the winter months in many canes producing regions of the world, especially Hawaii. GA application is used to overcome the reduced growth of the 3~5 internodes undergoing expansion during the cooler winter season. GA treatment has resulted in an increase in fresh weight of harvested cane of 10.9 ton/ha and has increased sucrose yield by 1.1 ton/ha or 2.8%.

Malting barley: - Gibberline is one of the major growth hormone used to increase the yield of malt barley and to decrease the time required for the malting process to undertake. Embryo growth and yield of malt extract are competitive processes, by increasing the rate of malting relative to embryo growth, a greater yield of malt extract occurs. Application of GA to germinating barley supplements the endogenous level of this hormone and accelerates the production and release of hydrolytic enzymes that degrade the storage proteins and carbohydrates of the endosperm into the sugars and amino acids that comprise the malt extract.

Conclusion

Plant growth hormones, produced in low concentrations within plants, play a vital role in regulating growth and development by influencing parameters such as shoot length, leaf area, chlorophyll content, photosynthesis, yield, and quality traits. Their effectiveness depends on proper absorption, with common application methods including foliar spray, drenching, and pre-plant soaking. Factors like application method, plant part absorption, and environmental conditions affect their efficacy. Optimizing these variables can enhance the effectiveness of plant growth regulators while minimizing phytotoxicity.

References

1. Agegnehu, Getachew; Taye, G. (2004). Effect of Plant Hormones on the Growth and Nutrient Uptake of Maize in acidic Soils of the Humid Tropics. *SINET: Ethiopian Journal of Science*, 27(1), 17–24.
2. Davies, P. (2014). A1. *The Plant Hormones: Their Nature*, (January 2010).
3. Dong MH, Liu XB, Lu CQ, Zhao BH, Yang JC (2009) Effects of exogenous ABA and on the main quality characteristics of grains at different positions of panicle in rice. *Sci Agric Sin* 35(5):899–906 (in Chinese with English abstract)
4. Gaspar, T., Kevers, C., Faivre-Rampant, O., Crèvecoeur, M., Penel, C., Greppin, H., & Dommes, J. (2003). Changing concepts in plant hormone action. *In Vitro Cellular & Developmental Biology-Plant*, 39(2), 85–106.
5. H. Ö pick & S. Rolfe 2005. *The Physiology of Flowering Plants*. Published in the United States of America by Cambridge University Press, New York
6. Pan, S., Rasul, F., Li, W., Tian, H., Mo, Z., Duan, M., & Tang, X. (2013). Roles of plant growth regulators on yield, grain qualities and antioxidant enzyme activities in super hybrid rice (*Oryza sativa* L.), 1–10.
7. Sing SP, Paleg LG (1984) Low temperature-induced GA3 sensitivity of wheat. I. Characterization of the low-temperature effect on isolated aleurone of Kite. *Plant Physiol* 76: 139-142
8. Zhang WX, Peng CR, Sun G, Zhang FQ, Hu SX (2007) Effect of different external phytohormones on leaves senescence in the late growth period of late-season rice. *Acta Agric Jiangxi* 19(2):11–13