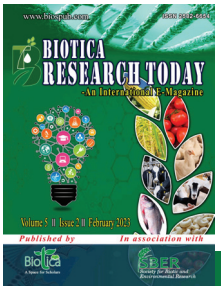
*Bio. Res. Today 2023, 5(2):153-155*



**Biotica Research Today**

e-ISSN: 2582-6654

*February, 2023*

**Article ID: RT1242** **Popular Article**

# Role of Phytohormones in Plants

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***Conflict of interests:*** The author has declared that no conflict of interest exists.

***How to cite this article?***

Jaryal and Thakur, 2023. Role of Phytohormones in Plants. *Biotica Research Today* 5(2), 153-155.



**Abstract**

Phytohormones are organic compounds, other than nutrients and vitamins, which are produced naturally in plants, synthesized in one part and usually translocated to other part where in very small quantity it affects the growth and other physiological function of the plant. These are classified into two types namely plant growth promoters (Auxins, Gibberellins and Cytokinins) and plant growth inhibitors (Ethylene and Abscisic acid). Certain compounds synthesized artificially also cause many physiological responses common to phytohormones. But the more recent ones such as brassinosteroids and jasmonates cannot be excluded from PGRs due to their significant role in important functions of plants. It is obvious that changes in the level of endogenous hormones due to biotic and abiotic stress alter the crop growth and any sort of manipulation including exogenous application of growth substances would help for yield improvement or at least sustenance of the crop.

**Keywords:** Brassinosteroids, Inhibitors, Phytohormones, Promoters

## Introduction

Plant hormones are a group of naturally occurring, organic substances which influence physiological processes at low concentrations. The processes influenced consist mainly of growth, differentiation and development, though other processes, such as stomatal movement, may also be affected. Plant hormones have also been referred to as 'phytohormones' though this term is seldom used. The term "hormone" comes originally from the Greek word and is used in animal physiology to denote a chemical messenger. Its original use in plant physiology was derived from the mammalian concept of a hormone. This involves a localized site of synthesis, transport in the bloodstream to a target tissue, and the control of a physiological response in the target tissue via the concentration of the hormone. Each plant hormone evokes many different responses. Also, the effects of different hormones overlap and may be stimulatory or inhibitory. Phytohormones have multiple functions and various combinations of them can act either synergistically (Auxins and Gibberellins) or antagonistically (Abscisic acid and Ethylene) to promote very specific responses. Some evidence suggests that flower initiation is controlled by hypothetical hormones called florigens, but these substances remain to be identified. Each hormone performs its specific functions; however, nearly all of the measurable responses of plants to heredity or environment are controlled by interactions between two or more hormones. Such interactions may occur at various levels, including

- The synthesis of hormones,
- Hormones receptors, and second messengers,
- Ultimate hormone action.

## Characteristics of Phytohormones

- The concentration of hormones required for the plant response is very low ($10^{-6}$ to $10^{-5}$ M), comparing with the requirement of mineral and vitamin for plants.
- The biosynthesis of plant hormones within plant is more diffuse and not always localized.
- Plant hormones are not nutrient, but chemicals that in small amounts promote and influence the growth, development and differentiation of cells and tissues.

## Main Functions of Plant Hormones

Plant hormones control all the growth and development activities like cell division, enlargement, flowering, seed formation, dormancy and abscission.

**Article History**

RECEIVED on 02nd Febuary 2023 RECEIVED in revised form 11th February 2023 ACCEPTED in final form 12th February 2023

Based on their action, plant hormones are categorized into two categories (Figure 1):

- Plant Growth Promoters
- Plant Growth Inhibitors

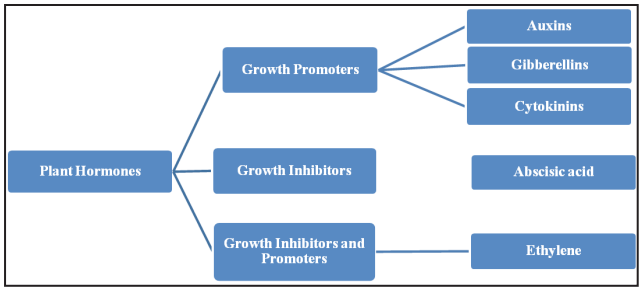


Figure 1: Classification of phytohormones

## Auxin

Auxin was the first class of growth regulator that was discovered. Auxin is a general name for a group of hormones that are involved with growth responses (*i.e.*, elongate cells, stimulate cell division in callus). The word Auxin has been derived from a Greek word *auxein*- "to grow/ increase".

**Precursor:** Tryptophan

**Site of production:** Auxin is made in actively growing tissue which includes shoot and root tips, young expanding leaves and seeds. Made in cytosol of cells.

**Transport:** Basipetal (or polar) transport. Auxin is transported in a basipetal (towards the base, base seeking) direction. In other words, auxin moves from the shoot tip towards the roots and from the root tip towards the shoots.

### *Types of Auxin*

1. Natural Auxin: IAA (Indole Acetic Acid)

2. Synthetic Auxin: NAA (Napthlene Acetic Acid), 2,4-D (2,4-Dichlorophenoxyacetic acid), 2,4,5-T (2,4,5-Trichlorophenoxyacetic acid), IPA (Indole Propionic Acid).

### *Functions*

**1. Apical dominance**: Auxin suppresses the growth of lateral bud. If the tip of plant is removed, the lateral branches begin to grow, in most of the plants apical bud suppresses the development of lateral buds. This is called apical dominance.

**2. Root initiation and development**: It is to be applied on cuttings to stimulate root growth and development.

**3. Leaf abscission inhibition**: Formation of a layer of tissue at base of organ which causes separation of particular organ from the source of attachment is termed as abscission. Auxin inhibits abscission as they prevent the formation of abscission layer. It delays fall of leaves.

**4. Acts as weedicides**: Many synthetic auxins are used as weedicides in order to kill the weeds. 2,4,5-T and 2,4-D are used to destroy the broad leaved weeds.

**5. Storage**: Exogenous application of auxins such as NAA at high concentration is used to prevent the sprouting of potato tubers. Hence, increases the storage life of the produce.

## Gibberellins

It was the second growth regulator. It was extracted from the fungus "*Gibberella fujikuroi*" which is the causal organism of "foolish seedling of rice". The infected plants were usually taller, seedless and pale in colour. He applied the fungal extracts to intact healthy plants and observed enhanced growth.

Now, gibberellins are designated as $GA_1$, $GA_2$ and so on. The common gibberellic acid is $GA_3$. At present 112 types of gibberellins are known. Gibberellins are plant hormones that promote growth, seed germination and leaf expansion. They occur at low concentrations in vegetative tissues but at higher concentrations in germinating seeds. Induce cell elongation and cell division.

**Precursor:** Terpenoids

**Site of production:** Embryos, roots and young leaves.

**Transport:** Made in the tissues in which it is used. Transport occurs through xylem, phloem, or cell-to-cell. Phloem seems to be most important transport route. Transport is not polar, as it is for auxin.

### *Functions*

**1. Stem elongation**: Gibberellins cause internodes to stretch in less light intensity. Stimulate stem growth through cell elongation and cell division.

**2. Seed germination and seedling growth**: GA activates germination of seeds which otherwise require cold (stratification) or light to induce germination.

**3. Regulates sex expression**: When used in higher concentration induces male flowers but when applied in low concentration it induces female flowers in cucurbits.

**4. Seed dormancy**: $GA_3$ is used to break the seed dormancy of freshly harvested seeds in many vegetable crops such as potato and lettuce.

**5. Flowering**: GA stimulates bolting in long day plants and can substitute for long days or cold treatments that are necessary for flowering.

## Cytokinin

Cytokinins are a group of plant growth hormones that promote cell division or cytokinesis especially controlling the transaction from G2 to mitosis in plant roots and shoots. They are primarily involved in cell growth and differentiation. Cytokinins occur in most plants including mosses, ferns, conifers, algae and diatoms.

**Precursor:** Purine Base

**Site of Production:** They are synthesized in root apex, endosperm of seeds, young fruits, where cell division takes place continuously.

**Transport:** via xylem (transpiration stream). Zeatin ribosides are the main transport form; converted to the free base or glucosides in the leaves. Some cytokinin also moves in the phloem.

### *Functions*

1. Cell division especially in carrot root tissue, pea callus.

2. Cell enlargement and differentiation Cytokinin may also induces cell enlargement in the leaves of *Phaseolus vulgaris*, pumpkin cotyledons.

3. Dormancy of certain light sensitive seeds (lettuce) can also be broken by kinetin treatment.

4. Delays leaf senescence.

5. Promote flowering in some plants.

6. Inhibit apical dominance and help in growth of lateral buds. Therefore, it is also known as anti-auxins.

## Ethylene

Ethylene is a colorless gaseous hormone, found in ripened fruits, flowers and leaves and nodes of stem. Synthesis of ethylene is inhibited by carbon dioxide and requires oxygen. Auxins increased ethylene level in plants and many of auxin actions are attributed through ethylene such as increased percentage of female flowers, apical bud dominance and leaf epinasty.

**Precursor:** Methionine

**Site of Production:** Cells undergoing senescence and ripening fruits

***Functions***

1. Induces uniform ripening in vegetables.

2. Promotes abscission and senescence of leaf, flowers *etc*.

3. Inhibition of stem elongation, swelling of radial stem, horizontal growth of stem *w.r.t.* gravity (triple response).

4. Induction of Femaleness: Cucumber, Squash, Melon.

5. It stimulates the formation of adventitious roots.

## Abscisic Acid

The plant growth regulator ABA is one of the wide spread and naturally occurring inhibitor found in plants. It was for the first time identified in *Acer pseudoplatanus* leaves and buds and gave the name **dormin** to it. In 1963, it was isolated from young cotton fruits and named it Abscisin II which was strong antagonistic. Later it was changed to Abscisic acid.

**Site of Production:** Plastids. Most tissues especially leave and seeds.

**Transport:** xylem and phloem (greater amounts).

***Functions***

1. Promotes stomatal closing: Water stress brings about an increase in ABA synthesis thereby regulates closure of stomata. ABA plasma membrane receptor. Mutants that lack the ability to produce ABA exhibit permanent wilting and are called wilty mutants because of their inability to close their stomata. Stomatal closing can also be caused by ABA synthesised in the roots and exported to the shoot.

2. Leaf abscision: ABA produces abscision layer at the base of leaf petiole where dead cells are formed.

3. It induces dormancy of buds and seeds.

4. It increases the resistance of temperate zone plants to frost injury.

## Brassinosteroids

Brassinosteroids are the sixth group of plant hormones with significant growth-promoting activity. Brassinosteroids were first isolated and characterized from the pollen of rape plant, *Brassica napus* L. (Table 1). Subsequently, they have so far been reported from 44 plants and are regarded probably ubiquitous in the plant kingdom. These are considered as hormones with pleiotropic effects, as they influence carried developmental processes like growth, germination of seeds, rhizogenesis, flowering and senescence. Brassinosteroids also confer resistance to plants against various abiotic stresses.

Table 1: The occurrence of brassinosteroids in vegetables

| Plant Part | Vegetables |
|---|---|
| Pollen | *Brassica napus, Vicia faba* |
| Seed | *Cole crops, Beta vulgaris, Raphanus sativus, Lablab purpureus, Phaseolus vulgaris, Pisum sativum, Vicia faba, Apium graveolens* |
| Shoot | *Pisum sativum, Solanum lycopersicum* |

**Jasmonic Acid:** It participates in leaf senescence, defense mechanism against fungi, inhibits premature germination of oil containing seeds (*Brassica* spp.) (Meena, 2015).

**Morphactins:** Morphactins are the group of substances which act on morphogenesis and modulate the expression of plants. Morphactin weakened apical dominance and increased the number of lateral branches in *Luffa acutangula* (Bisaria, 1977).

## Conclusion

Plant growth substances have key role in different physiological processes related to growth and development of plants. It is obvious that changes in the level of endogenous hormones due to biotic and abiotic stress alter the crop growth and any sort of manipulation including exogenous application of growth substances would help for yield improvement or at least sustenance of the crop. Hormones usually move within plant from a site of production to site of action. Phytohormones are physiological intercellular messengers that are needed to control the complete plant lifecycle, including germination, rooting, growth, flowering, fruit ripening, foliage and death. In addition, plant hormones are secreted in response to environmental factors such as abundance of nutrients, drought conditions, light and temperature, chemical or physical stress. Hence, levels of hormones will change over the lifespan of a plant and are dependent upon season and environment. Auxins like IBA, IAA and NAA were found as effective root promoting growth regulators.

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