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ROLE OF PLANT GROWTH REGULATORS IN CROP PRODUCTION

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Abstract

Plant growth regulators are organic compounds other than nutrients that in small amounts promote, inhibit, or otherwise modify a physiological process in plants. Plant hormones are signal molecules produced within the plant, and occur in extremely low concentrations. The growth regulators can either be natural or synthetic and are widely being used in the agricultural production and even for economic importance. Hormones regulate cellular processes in targeted cells locally and, moved to other locations, in other functional part of the plant. Hormones also determine the formation of flowers, stems, leaves, the shedding of leaves, and the development and ripening of fruits. Plant hormones shape the plant, affecting seed growth, time of flowering, the sex of flowers, senescence of leaves, and fruits.

Introduction

Plant hormones and growth regulators are chemicals that affect flowering, aging, root growth, distortion and killing of leaves, stems, and other parts; prevention or promotion of stem elongation, etc. Rastogi (2011) defined that the plant growth regulator or phytohormone as an organic substance produced naturally in plants controlling growth and other functions at a site remote from its place of production in minute quantities. They are naturally produced within plants, though very similar chemicals are produced by fungi and bacteria that can also affect plant growth (Srivastava 2002). Plant hormones are not nutrients, but chemicals that in small amounts promote and influence the growth, development, and differentiation of cells and tissues (Opik *et al.* 2005). The biosynthesis of plant hormones within plant tissues is often diffuse and not always localized. Plants utilize simple chemicals as hormones, which move more easily through the plant's tissues. They are often produced and used on a local basis within the plant body. Plant cells produce hormones that affect even different regions of the cell producing the hormone. The concentration of hormones required for plant responses are very low (10^{-6} to 10^{-5} mol/L). Because of these low concentrations, it has been very difficult to study plant hormones, and only since the late 1970s have scientists been able to start piecing together their effects and relationships to plant physiology. Hormones are transported within the plant by utilizing four types of movements. For localized movement, cytoplasmic streaming within cells and slow diffusion of ions and molecules between cells are utilized. Vascular tissues are used to move hormones from one part of the plant to another; these include sieve tubes or phloem that move sugars from the leaves to the roots and flowers, and xylem that moves water and mineral solutes from the roots to the foliage. A plant growth regulator is also an organic compound, either natural or synthetic, that modifies or controls one or more specific physiological processes within a plant through translocation. And they can be either synthetic or natural.

Classification of growth regulators

They are classified in to five major classes:

(1) Auxins (2) Cytokinins (3) Gibberellins (4) Abscisic acid (5) Ethylene

(1) Auxins: Auxins are compounds that positively influence cell enlargement, bud formation and root initiation. Auxins promote stem elongation, inhibit growth of lateral buds (maintains apical dominance). They are produced in the stem, buds, and root tips. Example: Indole Acetic Acid (IA). Auxin is a plant hormone produced in the stem tip that promotes cell elongation. Auxin moves to the darker side of the plant, causing the cells there to grow larger than corresponding cells on the lighter side of the plant. This produces a curving of the plant stem tip toward the light, a plant movement known as phototropism.

Auxin also plays a role in maintaining apical dominance. Most plants have lateral (sometimes called axillary) buds located at nodes (where leaves attach to the stem). Buds are embryonic meristems maintained in a dormant state. Auxin maintains this dormancy. As long as sufficient auxin is produced by the apical meristem, the lateral buds remain dormant. If the apex of the shoot is removed, the auxin is no longer produced. This will cause the lateral buds to break their dormancy and begin to grow. In effect, the plant becomes bushier. When a gardener trims a hedge, they are applying apical dominance.

(2) Cytokinins: Cytokinins are plant growth substances (phytohormones) that promote cell division, or cytokinesis, in plant roots and shoots. They are involved primarily in cell growth and differentiation, but also affect apical dominance, axillary bud growth, and leaf senescence. They were called kinins in the past when the first cytokinins were isolated from yeast cells. They also help delay senescence of tissues, are responsible for mediating auxin transport throughout the plant, and affect internodal length and leaf growth. They have a highly synergistic effect in concert with auxins, and the ratios of these two groups of plant hormones affect most major growth periods during a plant's lifetime.

Cytokinins counter the apical dominance induced by auxins; they in conjunction with ethylene promote abscission of leaves, flower parts, and fruits. The correlation of auxins and cytokinins in the plants is a constant (A/C = const.). There are two types of cytokinins: adenine-type cytokinins represented by kinetin, zeatin, and 6-benzylaminopurine, and phenylurea-type cytokinins like diphenylurea and thidiazuron (Aina *et al.* 2012).

(3) Gibberellins: Gibberellins (GAs) are plant hormones that regulate growth and influence various developmental processes, including stem elongation, germination, dormancy, flowering, sex expression, enzyme induction, and leaf and fruit senescence. GA is used extensively on seedless grape varieties to increase the size and quality of the fruit. Pre-bloom spray of 20 ppm induces rachis of the fruit cluster to elongate. This creates looser clusters that are less susceptible to disease during the growing season. GA is used to increase the yield of barley malt and to decrease the time required for this process to occur.

Application of GA to germinating barley supplements the endogenous content of this hormone and accelerates the production and release of hydrolytic enzymes. They can easily degrade the stored carbohydrates. Foliar spray of GA_3 at 100 ppm during panicle initiation stage enhances the panicle exertion and increases seed weight and yield in hybrid rice. GA has also been used to control flower sex expression in cucumbers and squash. GA application tends to promote maleness in these plants.

GA is also applied to citrus crops, through the actual use depends on the particular crop. For example GA_3 is sprayed onto oranges and tangerines to delay or prevent or prevent rind-aging, so that fruit can be harvested later without adverse effects on rind quality and appearance. For lemons and limes, GA_3 synchronizes ripening and enhances fruit size. GA is used extensively to increase the sucrose yield of sugarcane. Sugarcane, a normally fast growing C_4 member of the Poaceae is sensitive to cooler winter temperatures, which reduce internode elongation and subsequent sucrose yield. The adverse effects of cooler temperature can be counteracted by the application of GA_3.

(4) Abscisic acid: Abscisic acid (also called ABA) is one of the most important plant growth regulators. The name "abscisic acid" was given because it was found in high concentrations in newly abscissed or freshly fallen leaves. In plants under water stress, ABA plays a role in closing the stomata. Soon after plants are water-stressed and the roots are deficient in water, a signal moves up to the leaves, causing the formation of ABA precursors there, which then move to the roots. The roots then release ABA, which is translocated to the foliage through the vascular system (*Ren et al.* 2007) and modulates the potassium and sodium uptake within the guard cells, which then lose turgidity, closing the stomata (Yan *et al.* 2007).

ABA exists in all parts of the plant and its concentration within any tissue seems to mediate its effects and function as a hormone; its degradation, or more properly catabolism, within the plant affects metabolic reactions and cellular growth and production of other hormones (*Kermode 2005)*. Plants start life as a seed with high ABA levels. Just before the seed germinates, ABA levels decrease; during germination and early growth of the seedling, ABA levels decrease even more. As plants begin to produce shoots with fully functional leaves, ABA levels begin to increase, slowing down cellular growth in more "mature" areas of the plant. Stress from water or predation affects ABA production and catabolism rates, mediating another cascade of effects that trigger specific responses from targeted cells.

(5) Ethylene: Ethylene is most widely used plant hormone in agriculture because it regulates so many physiological processes. Auxins and ACC can trigger the natural biosynthesis of ethylene and in several cases are used in agricultural practice. Ethylene is very difficult to apply in the field as a gas. This limitation can be overcome if an ethylene compound is used. The most widely used such compound is ethephon or 2- chloro ethyl phosphonic acid (CEPA) (trade name ethrel).

Ethrel at 100-250 ppm sprayed at 2-3 leaf stage induce femaleness in cucumber and melons. Ethylene can be used for quick ripening of fruits for marketing. It helps in degreening of citrus and banana which increases its market acceptability. Storage facilities developed to inhibit the ethylene production and promote preservation of fruits have a controlled atmosphere of low O_2 concentration and low temperature that inhibits ethylene biosynthesis. A relatively concentration of CO_2 (3-5%) prevents ethylene action as a ripening promoter.

Other growth hormones

Other identified plant growth regulators include:

Brassinosteroids - are a class of polyhydroxysteroids, a group of plant growth regulators. Brassinosteroids have been recognized as a sixth class of plant hormones, which stimulate cell elongation and division, gravitropism, resistance to stress, and xylem differentiation. They inhibit root growth and leaf abscission. Brassinolide was the first identified brassinosteroid and was isolated from extracts of rapeseed (*Brassica napus*) pollen in 1979.

Salicylic acid - activates genes in some plants that produce chemicals that aid in the defense against pathogenic invaders.

Jasmonates - are produced from fatty acids and seem to promote the production of defense proteins that are used to fend off invading organisms. They are believed to also have a role in seed germination, and affect the storage of protein in seeds, and seem to affect root growth.

Plant peptide hormones - encompasses all small secreted peptides that are involved in cell-to-cell signaling. These small peptide hormones play crucial roles in plant growth and development, including defense mechanisms, the control of cell division and expansion, and pollen self-incompatibility.

Polyamines - are strongly basic molecules with low molecular weight that have been found in all organisms studied thus far. They are essential for plant growth and development and affect the process of mitosis and meiosis.

Nitric oxide (NO) - serves as signal in hormonal and defense responses (e.g. stomatal closure, root development, germination, nitrogen fixation, cell death, stress response). NO can be produced by a yet undefined NO synthase, a special type of nitrite reductase, nitrate reductase or non enzymatic processes and regulate plant cell organelle functions (e.g. ATP synthesis in chloroplasts and mitochondria) (Roszer 2012).

Strigolactones - implicated in the inhibition of shoot branching.

Karrikins - not plant hormones because they are not made by plants, but are a group of plant growth regulators found in the smoke of burning plant material that have the ability to stimulate the germination of seeds.

Benefits of using plant growth regulators:

- Promote and accelerate root formation on cutting
- Keep fruit on trees longer to allow further ripening achieved by the application of auxin
- Thin blossom clusters and increase berry size in grapes- achieved by the application of gibberellic acid
- Increase size and crispness of stalks of celery- achieved by the application of GA
- Control the size of plants

Conclusion: The plant growth regulators either synthetic or natural have been found great and wide applications in agriculture. These growth regulators which in minute quantity can have adverse effects to promote and modify a physiological process in plants. On the evidences of their adverse effects in small quantity these growth regulators have been found greater applications and economic importance for farmers. The growth regulators are used: to increase the fruit sizes, to induce early flowering and increase the number of flowering; to break the dormancy of some seeds, to quicken the maturity and improve the fruit quality; to increase the sugar content in sugarcane; to increase the yield and oil contents; to promote the flower initiation and control ripening some other fruits and many more.

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