Volume 2, Issue 3
March I 2024
Agri Roots
e- Magazine
www.agrirootsmagazine.in
ISSN: 2583-9071

Unlocking Agricultural Potential: Harnessing the Power of Growth Regulators

ARTICLE ID: 0082

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Plant growth regulators, once known as "Utteshu Vila" in older literature, have undergone a transformation in terminology, now commonly referred to as "phytohormones." Coined by Thiman in 1948, the term "phytohormones" emphasizes their vital role in stimulating plant growth and development. This article delves into the significance of plant growth regulators, tracing their evolution from traditional understanding to modern scientific insights.

Organic substances which are naturally synthesized in the plant, synthesized in one part and distributed to another part, where in very small quantities they affect the growth and other physiological functions of the plant, are called phytonutrients." However, the term growth regulator is used for chemical substances that act like stimulants, but are synthesized artificially. Different types of plant growth regulators. (1) Auxin (2). Gibberellin (3) Cytokinin (4). Ethylene (5). Abscisic Acid.

1. Auxins

Auxin's discovery traces back to Charles Darwin's observations in 1880, studying canary grass and noting phototropism in the plant's tip. Building on Darwin's work, Boysen-Jensen (1913) and Went (1926) conducted pivotal experiments, culminating in the identification of indole acetic acid (IAA) as the substance responsible for bending responses. IAA synthesis begins with tryptophan, making it a precursor chemical. Produced in regions of active growth, such as developing leaves, embryos, and fruits, auxin exhibits polar movement, primarily downward from the tip. Went's avena-ture test elucidated auxin's influence, as the coleoptile bent away from agar block pieces containing IAA. These discoveries underscore auxin's pivotal role in plant development, influencing growth processes and tropic responses, and paving the way for further understanding of plant hormonal regulation. Auxin's significance extends to agriculture, where it is utilized in plant propagation, root formation, and other growth modulation techniques.

The Role of Auxins

The role of auxin in plant physiology is multifaceted. One of its crucial functions is maintaining apical dominance, wherein it suppresses the growth of buds emerging from leaf axils, ensuring the dominance of the apical bud. Removal of the apical bud triggers growth in the axillary buds. Additionally, auxin plays a pivotal role in cell division and enlargement, particularly in the apical region, by increasing cytoplasm permeability and enhancing cell wall plasticity. This hormone also influences shoot and root growth, promoting shoot growth at higher concentrations and root growth at lower concentrations. Furthermore, auxin facilitates xylem differentiation, aiding in bud grafting in callus and ensuring proper vascular tissue connection for bud growth. It also enhances nucleic acid activity, stimulating RNA synthesis and specific enzyme production, thereby contributing to cell expansion. Ultimately, auxin's regulation of cellular growth, influenced by phytocatalyst levels, is fundamental to overall plant growth and development.. The different types of growth-related movements occurring in plants are as follows:

2. Gibberellins

In 1926, Japanese scientist Kurosawa discovered gibberellin, a substance extracted from the fungus *Gibberella fujikuroi*, which causes "foolish seedling disease" in rice plants. This disease made the plants tall, yellow, and seedless due to the fungus's secretions. Yabuta, Hayashi, and Kanbe were the first to isolate an active substance called gibberellin from this fungus. Later, Yabuta and Sumiki isolated gibberellin A and gibberellin V from fungi. Gibberellin was also found in higher plants, first isolated from *Phaseolus coccineus* by McMillan and Suter in 1958. Gibberellins are made in young leaves, roots, and shoots and move throughout the plant via phloem and xylem.

Role of Gibberellins

Gibberellin, a plant hormone, influences various aspects of plant growth and development. Firstly, it counteracts genetic dwarfism in plants by promoting increased height, particularly in species like pea, broad bean, and *Fasciosus multiflorus*, where mutations inhibit gibberellin synthesis, resulting in small nodes. Secondly, it facilitates the formation of flower stalks and flowering, especially in rosette plants and those requiring cold treatment for flowering. However, it doesn't induce flowering in short-photoperiod plants under inappropriate light conditions. Gibberellin affects the emergence of floral whorls by stimulating cell division and elongation in the sub-head region. Thirdly, gibberellin overcomes light inhibition of stem growth by increasing cell wall flexibility, thus promoting elongation, which is particularly evident in shade-grown plants. Fourthly, it serves as a reliable inducer of parthenocarpy, allowing fruit development without fertilization, unlike auxin. Lastly, gibberellin stimulates the germination process in endotrophic seeds by activating the enzyme amylase, which mobilizes starch stored in the endosperm to support embryo growth.

3. Cytokinins

This is the generic name for substances that stimulate cell division in plants. And growth affects regulatory functions. Cytokinin is also called phytocyanin. Haverlandt (1913) Presented evidence that cell division is facilitated by substances obtained from phloem. Skoog,(1955) demonstrated that when the pith tissues of tobacco were separated from the vascular tissues So its growth took place without cell division. When the vascular tissues were brought back into contact, the marrow tissues Cell division occurred again. This test led to the discovery of cytokinin. Miser and Skoog (1955) described herring sperm-D Isolated a substance from non-serial nucleic acid and named it kinetin. In 1964, Skoog Zivatin was isolated from and after that other cytokinins were isolated.

Role of Cytokinin

Cytokinin and auxin play crucial roles in various aspects of plant growth and development. Firstly, they interact to regulate cell division and differentiation. When both substances are adequately supplied in tissue culture, they promote cell division and the formation of undifferentiated masses known as callus cells. Alterations in the ratio of cytokinin to auxin can lead to the differentiation of callus cells into plant tissues such as stems and leaves. Secondly, cytokinin influences cell and organ enlargement, as observed in experiments with cut cotyledons of various plants. This enlargement occurs through the absorption of water, facilitated by cytokinin-induced conversion of fats into reducing sugars, which are further metabolized into osmotically active sugars. Thirdly, cytokinins affect seed germination, with studies showing enhanced germination rates in lettuce seeds treated with kinetin or other cytokinins compared to seeds grown in darkness or under infrared light, which inhibits germination. Additionally, cytokinin regulates root initiation and growth, with low concentrations promoting root budding and elongation, while high concentrations inhibit root growth in certain plant species like lupine. Lastly, cytokinins play a role in bud development and shoot growth, influencing branching patterns and apical dominance. Application of cytokinin to the apical bud can promote lateral bud growth and branching, altering the plant's overall architecture.

4. Ethylene

This is the only gas nature’s catalyst. Gain (1934) proved that ethylene is a natural product of ripening fruits. Evidence of ethylene production has been found in leaves, flowers, seeds and roots.

Role of Ethylene

- **Fruit Ripening:** Fruit ripening involves an active process known as climacteric, marked by increased respiration followed by a decline. It includes hydrolysis of stored substances, pigment changes, altered respiratory rates, fruit softening, flavor development, and other biochemical reactions. Tissue permeability changes, enzyme production like malate synthase, and metabolic shifts contribute to ripening.
- **Seedling Emergence and Growth:** Seedling growth varies in dicotyledonous seeds, with above-ground germination leading to straight stem growth,

while hypogeal germination keeps cotyledons underground. Ethylene regulates growth, promoting straight growth under light. Absence of light causes etiolation, inhibiting arc expansion.

- **Leaf Abscission:** Leaf abscission involves the formation of a parenchyma layer at the petiole base triggered by cell-transforming enzymes, protein synthesis, and increased respiration. Ethylene synthesis induces senescence and enhances separation.

5. Abscisic Acid

In 1961, Liu and Kanous discovered a substance in cotton fruits that induced the separation of debladed petioles, naming it abscisin. However, its structure wasn't fixed. During further research, Ohkuma and colleagues isolated a similar substance from new cotton fruits, termed Abscisin-2nd. By 1965, they proposed its chemical structure. Concurrently, Carnaghavan and colleagues found a substance named dourmin in sycamore leaves, later identified as identical to abscisin. To prevent confusion, the substance was standardized as abscisic acid.

Role of Abscisic Acid

Abscisic acid (ABA) serves various roles in plant physiology. Initially believed to accelerate abscission, it was later found to mildly affect the separation process. ABA's involvement in dormancy, observed in potato tubers and dormant buds, is debated. It inhibits germination enzyme production, preventing vivipary. ABA, along with gibberellins and cytokinins, regulates seed germination by inhibiting specific germination factors. It induces stomatal closure by reducing potassium absorption and cell swelling, releasing malic acid. ABA accumulates in water-deficient plants, closing stomata to aid survival during water stress.

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