34. Plant growth regulators

Plant hormones (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, temperature, chemical or physical stress. Hence, levels of hormones will change over the lifespan of a plant and are dependent upon season and environment.

The term “plant growth factor” is usually employed for plant hormones or substances of similar effect that are administered to plants. Growth factors are widely used in industrialized agriculture to improve productivity. The application of growth factors allows synchronization of plant development to occur. For instance, ripening tomatoes can be controlled by setting desired atmospheric ethylene levels. Using this method, fruits that are separated from their parent plant will still respond to growth factors; allowing commercial plants to be ripened in storage during and after transportation. This way the process of harvesting can be run much more efficiently. Other applications include rooting of seedlings or the suppression of rooting with the simultaneous promotion of cell division as required by plant cell cultures. Just like with animal hormones, plant growth factors come in a wide variety, producing different and often antagonistic effects. In short, the right combination of hormones is vital to achieve the desired behavioral characteristics of cells and the productive development of plants as a whole.

Traditionally five major classes of plant hormones are listed: auxins, cytokinins, gibberellins, abscisic acid and ethylene. However as research progresses, more active molecules are being found and new families of regulators are emerging; one example being polyamines such as putrescine or spermidine.
Note that this classification is based partially on the chemical structure and partially on the commonalities of plant physiological effects that certain substances exhibit. Members of one class may not relate from a structural point of view to another. Auxins for instance include not only many indole 3-carboxylic acid derivatives but numerous phenylacetic acids as well. Most cytokinins (such as zeatins) are derivatives from adenine but still differ widely in their chemical structure. Hence, the mechanism driving action may be different in each case and likewise each specific activity will differ also.

This is demonstrated by the range of optimal concentrations required for different factors which spans many decimals (0.001 – 100 mg/L).

Auxins

Auxin is the active ingredient in most rooting mixtures. These products help the vegetative propagation of plants. On a cellular level auxins influence cell elongation, cell division and the formation of adventitious roots. Some auxins are active at extremely low concentrations. Typical auxin concentration range from 0.01 to 10 mg/L.

Cytokinins

Cytokinins promote cell division, stimulate shoot proliferation, activate gene expression and metabolic activity in general. At the same time, cytokinins inhibit root formation. This makes cytokinins useful in culturing plant cell tissue where strong growth without root formation is desirable. Natural cytokinin hormone levels are high during maximum growth periods of mature plants. In addition, cytokinins slow the aging process in plants. Concentrations of cytokinin used for horticulture vary between 0.1 to 10 mg/L

Gibberellins

Gibberellins are derivatives of gibberellic acid. They are natural plant hormones and promote flowering, stem elongation and break dormancy of seeds. There are about 100 different gibberellins, but gibberellic acid (GA3) is the most commonly used form. Gibberellins are fundamental to plant development especially with respect to the growth of stems. Low levels of gibberellins will prevent plants from reaching their natural height. Gibberellin synthesis inhibitors are extensively used in grain production to keep stems artificially short: shorter and thicker stems provide better support and resist weather conditions better too.

Gibberellins are particularly effective at breaking seed dormancy and at speeding up germination. Seeds that are difficult to germinate are frequently treated with gibberillic acid solutions

Abscisic Acid

Abscisic acid (ABA) is a plant growth inhibitor and an antagonist of gibberellins: it induces dormancy, prevents seeds from germinating and causes abscission of leaves, fruits, and flowers. High concentrations of abscisic acid can be induced by environmental

stress such as drought. Elevated levels of abscisic acid will eventually induce dormancy, when all non-essential processes are shut down and only the essential metabolism is maintained in guard cells

Ethylene

Ethylene is unique in that it is found only in gaseous form. It induces ripening, causes leaves to abscess and promotes senescence. Plants often increase ethylene production in response to stress and before death. Ethylene concentrations fluctuate with the seasons while playing a role in inducing foliage and ripening of fruit.

Polyamines

Polyamines are unique as they are effective (and are applied) in relatively high concentrations. Typical concentrations range from 5 to 500 mg/L. Polyamines influence flowering and promote plant regeneration

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