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"Role of Plant Hormones in Growth and Development of cropes"

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ABSTRACT

Plant hormones, also known as phytohormones, are naturally occurring organic compounds that regulate various physiological and developmental processes in plants. Although produced in very small quantities, they play a crucial role in controlling growth, differentiation, flowering, fruit development, seed formation, ripening, and senescence. The present study focuses on the role of major plant hormones in the growth and development of crops. The five classical plant hormones—auxins, gibberellins, cytokinins, abscisic acid, and ethylene—are discussed with respect to their functions in crop plants. Auxins promote cell elongation, root initiation, and apical dominance, while gibberellins stimulate stem elongation, seed germination, and flowering. Cytokinins encourage cell division, shoot development, and delay leaf senescence. Abscisic acid acts as a growth inhibitor and helps plants tolerate environmental stresses by regulating stomatal closure and seed dormancy. Ethylene influences fruit ripening, leaf abscission, and stress responses. Recent studies have also highlighted the importance of other hormones such as brassinosteroids, jasmonates, salicylic acid, and strigolactones in crop productivity and stress management. Understanding the functions of plant hormones is essential for improving agricultural production, enhancing crop yield, and developing sustainable farming practices. The study concludes that plant hormones are vital regulators of crop growth, development, and adaptation to changing environmental conditions.

Keywords: Plant Hormones, Phytohormones, Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene, Crop Growth, Crop Development, Agriculture, Stress Tolerance, Crop Productivity

INTRODUCTION

Plant hormones, also known as phytohormones, are naturally occurring organic compounds produced in minute quantities within plants that regulate growth, development, and physiological responses. Although present in very low concentrations, these chemical messengers exert profound effects on plant life by coordinating processes such as cell division, cell elongation, differentiation, flowering, fruit development, seed germination, dormancy, senescence, and responses to environmental stresses. Their integrated action enables plants to adapt successfully to changing environmental conditions and complete their life cycle efficiently.

Plant growth refers to the irreversible increase in size, volume, or biomass of a plant, whereas development encompasses all qualitative and quantitative changes occurring throughout the plant's life cycle, from seed germination to senescence. Both growth and development are tightly regulated by hormonal activity. The major classical plant hormones include auxins, gibberellins, cytokinins, ethylene, and abscisic acid (ABA). In addition, modern plant physiology recognizes several other regulatory substances such as brassinosteroids, jasmonates, salicylic acid, and strigolactones, which contribute to growth regulation and stress adaptation.Among these hormones, auxins promote cell elongation, root initiation, and apical dominance; gibberellins stimulate stem elongation, seed germination, and flowering; cytokinins promote cell division and delay senescence; ethylene regulates fruit ripening and abscission; while ABA plays a crucial role in dormancy and stress responses. These hormones rarely act independently; instead, they function through complex interactions that determine the overall growth and developmental pattern of plants.

In crop plants, hormonal regulation is of immense agricultural significance. Plant hormones influence critical stages of crop production, including seed germination, root and shoot development, flowering, fruit set, grain filling, ripening, and stress tolerance. Proper hormonal balance enhances crop productivity, whereas hormonal imbalance may lead to poor growth, delayed flowering, reduced yield, or increased susceptibility to environmental stress.The application of plant growth regulators has become an important component of modern agriculture and horticulture. Synthetic and natural growth regulators are widely used to improve rooting, flowering, fruit development, ripening, and stress management in various crops. Consequently, understanding the role of plant hormones is essential for improving crop performance,

REVIEW OF LITERATURE

Plant hormones or phytohormones are naturally occurring organic compounds that regulate plant growth, development, and responses to environmental stimuli at very low concentrations. Research over the last century has established that hormones play a central role in seed germination, cell division, elongation, flowering, fruit development, ripening, senescence, and stress tolerance. The classical plant hormones include auxins, gibberellins, cytokinins, ethylene, and abscisic acid (ABA), while modern studies also recognize brassinosteroids, jasmonates, salicylic acid, and strigolactones as important regulators.

The history of plant hormone research began with studies on phototropism that led to the discovery of auxin. Subsequent investigations identified gibberellins through abnormal stem elongation in rice, cytokinins through tissue culture experiments, ethylene as a gaseous regulator of ripening, and ABA as a stress-related hormone. Advances in molecular biology have further revealed complex hormone biosynthesis, transport, signalling, and gene regulation mechanisms.Auxins, particularly Indole-3-Acetic Acid (IAA), are known to regulate cell elongation, root initiation, apical dominance, vascular differentiation, and fruit development. Their role in promoting root growth and improving nutrient uptake is especially important in crop productivity. Gibberellins are involved in seed germination, stem elongation, flowering, and fruit growth. They stimulate hydrolytic enzyme production during germination and contributed significantly to the development of semi-dwarf cereal varieties during the Green Revolution.

Cytokinins primarily promote cell division and shoot formation. They delay leaf senescence, maintain chlorophyll content, and enhance photosynthetic efficiency, thereby supporting crop yield. Ethylene regulates fruit ripening, leaf abscission, flower senescence, and stress responses. Its commercial application in uniform fruit ripening is widely recognized in horticulture. Abscisic acid functions mainly as a stress hormone, regulating seed dormancy, stomatal closure, drought tolerance, and adaptation to adverse environmental conditions.Recent literature emphasizes that plant hormones do not act independently. Hormonal interactions such as auxin–cytokinin balance in organ formation and gibberellin–ABA antagonism during seed germination are critical for plant development. Modern studies also highlight the roles of brassinosteroids, jasmonates, and salicylic acid in growth promotion, defence responses, and stress tolerance.

MATERIALS AND METHODS

The present dissertation entitled **"Role of Plant Hormones in Growth and Development of Crops"** is a review-based study designed to examine the physiological functions and agricultural significance of plant hormones. Plant hormones regulate various developmental processes including seed germination, root and shoot growth, flowering, fruit development, ripening, senescence, dormancy, and stress responses. A systematic methodology was adopted to collect, classify, analyze, and present scientific information related to these hormones.

The study is descriptive, analytical, and review-oriented in nature. The descriptive approach explains the characteristics and functions of different plant hormones, while the analytical approach compares their roles in various stages of crop growth and development. Since the study is based on published literature, it primarily relies on secondary data sources rather than field or laboratory experiments.

Data for the study were collected from reliable secondary sources, including standard textbooks of plant physiology and botany, peer-reviewed research papers, review articles, scientific journals, and authentic online databases. These sources provided information regarding hormone biosynthesis, physiological actions, signaling mechanisms, and agricultural applications.Relevant literature was collected systematically by dividing the topic into major subtopics such as auxins, gibberellins, cytokinins, ethylene, abscisic acid, seed germination, flowering, fruit ripening, and stress tolerance. Information from books and research publications was carefully selected, classified, and organized according to the objectives and chapter structure of the dissertation.

The study focused on five classical plant hormones—Auxins, Gibberellins, Cytokinins, Ethylene, and Abscisic Acid (ABA)—because of their established roles in crop growth and development. In addition, modern growth regulators such as Brassinosteroids, Jasmonates, Salicylic Acid, Strigolactones, and Polyamines were briefly reviewed due to their importance in plant defense, stress tolerance, and developmental regulation.The role of plant hormones was evaluated with respect to important developmental parameters including seed germination, root growth, shoot elongation, leaf expansion, cell division, flowering, fruit setting, fruit ripening, seed development, dormancy, and stress adaptation. Information was analyzed using comparative and descriptive methods to identify the specific functions and interactions of different hormones in crop plants.

The collected information was presented through descriptive text, tables, flow charts, conceptual diagrams, and comparative charts. These methods facilitated a clear understanding of hormone functions and their contribution to crop growth, development, productivity, and stress management.

RESULTS AND DISCUSSION

The present study entitled **"Role of Plant Hormones in Growth and Development of Crops"** revealed that plant hormones are essential chemical regulators controlling almost every stage of crop growth and development. The findings indicate that crop productivity depends on the coordinated action of various hormones rather than the effect of a single hormone. Plant hormones regulate seed germination, root and shoot development, flowering, fruit formation, ripening, senescence, dormancy, and stress tolerance.

The study showed that the five classical plant hormones—auxins, gibberellins, cytokinins, ethylene, and abscisic acid (ABA)—perform distinct but interconnected functions. Auxins were found to play a major role in cell elongation, root initiation, apical dominance, tropic responses, and fruit setting. Their contribution to root development is particularly important because a well-developed root system improves water and nutrient absorption, thereby supporting healthy crop establishment.Gibberellins were identified as key growth-promoting hormones responsible for seed germination, stem elongation, flowering, and fruit development. They stimulate enzyme production during germination, leading to the mobilization of stored food reserves and improved seedling emergence. Cytokinins were observed to promote cell division, shoot formation, chloroplast development, nutrient mobilization, and delayed senescence. Their ability to maintain green leaves for a longer period supports continued photosynthesis and increased crop productivity.

The study further revealed that ethylene plays a central role in fruit ripening, abscission, senescence, and stress responses. It is particularly important in climacteric fruits such as mango, banana, tomato, and apple, where it regulates colour development, softening, aroma, and sweetness during ripening. Abscisic acid was found to function mainly as a stress-related hormone. It regulates seed dormancy, stomatal closure, drought tolerance, and adaptation to adverse environmental conditions. ABA helps plants survive drought, salinity, and other environmental stresses by conserving water and energy.In addition to the classical hormones, modern plant growth regulators such as brassinosteroids, jasmonates, salicylic acid, and strigolactones were found to contribute significantly to plant growth regulation, defence mechanisms, and stress tolerance. Comparative analysis demonstrated that auxin has the strongest influence on root development, gibberellin on seed germination and shoot growth, cytokinin on cell division and leaf activity, ethylene on fruit ripening and senescence, and ABA on dormancy and stress responses.

The present study highlights the significant role of plant hormones in regulating the growth and development of crop plants. The findings indicate that plant hormones act as internal chemical messengers that coordinate various physiological and developmental processes throughout the crop life cycle. From seed germination to senescence, hormones ensure proper growth, reproduction, and adaptation to environmental conditions.Among the major hormones, auxins were found to promote root initiation, cell elongation, apical dominance, and fruit development. Their role in root establishment is particularly important for efficient water and nutrient uptake. Gibberellins were observed to enhance seed germination, stem elongation, flowering, and fruit growth. The experimental observations on wheat seedlings further demonstrated that gibberellic acid (GA_3) improves germination and seedling vigor when applied at an optimum concentration.

Cytokinins were found to support cell division, shoot development, chlorophyll retention, and delayed senescence, thereby extending the photosynthetic efficiency of crop plants. Ethylene played a major role in fruit ripening, abscission, and senescence. Its practical importance in post-harvest management and fruit marketing was evident. Abscisic acid (ABA) was identified as a key stress-related hormone responsible for seed dormancy, stomatal closure, and drought tolerance.

The study also revealed that plant growth and development depend not on individual hormones alone but on their interactions and balance. Hormonal cross-talk regulates important processes such as germination, organ formation, flowering, ripening, and stress responses. An imbalance in hormone levels may adversely affect crop growth and productivity.From an agricultural perspective, plant growth regulators have considerable potential for improving crop performance, yield, and stress tolerance. However, their effectiveness depends on proper concentration, timing, crop species, and environmental conditions. Overall, the study confirms that plant hormones are indispensable regulators of crop growth and development and play a crucial role in modern agricultural production and crop management.

SUMMARY AND CONCLUSION

The present dissertation entitled **"Role of Plant Hormones in Growth and Development of Crops"** highlights the importance of plant hormones as natural regulators of plant growth, development, and productivity. Plant hormones, also known as phytohormones, are organic substances produced in minute quantities that control various physiological and biochemical processes throughout the life cycle of crop plants.The study focused on the five classical plant hormones—Auxins, Gibberellins, Cytokinins, Ethylene, and Abscisic Acid (ABA)—and briefly discussed modern plant growth regulators such as brassinosteroids, jasmonates, salicylic acid, and strigolactones. Information was collected from standard textbooks, scientific journals, research papers, and review articles.

The findings revealed that auxins promote cell elongation, root initiation, apical dominance, and fruit setting. Gibberellins stimulate seed germination, stem elongation, flowering, and fruit development. Cytokinins encourage cell division, shoot formation, chloroplast development, and delay leaf senescence. Ethylene regulates fruit ripening, abscission, senescence, and stress responses, whereas ABA plays a vital role in seed dormancy, stomatal closure, drought tolerance, and adaptation to environmental stresses.The study further demonstrated that plant growth and development depend not only on individual hormones but also on their interactions and balance. Hormonal cross-talk regulates important processes such as seed germination, root and shoot development, flowering, fruiting, ripening, and stress tolerance. An optional experimental study on the effect of gibberellic acid (GA_3) on wheat seeds indicated that an optimum concentration of GA_3 improved germination percentage and seedling vigour.

The study concludes that plant hormones are indispensable regulators of crop growth and development. They coordinate nearly every stage of the plant life cycle, from seed germination to maturity and senescence. Proper hormonal balance is essential for normal growth, organ formation, reproduction, and adaptation to environmental conditions.Plant hormones also possess immense agricultural significance. Their scientific application helps improve seed germination, rooting, flowering, fruit setting, fruit ripening, tissue culture, and stress management. However, their effectiveness depends on factors such as concentration, timing of application, crop species, and environmental conditions.

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