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Plant Growth Regulators and Their Effects on Cereal Crops – A Comprehensive Review

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Abstract- Plant Growth Regulators (PGRs) are organic substances that, when administered in small amounts, affect the physiological and developmental processes of plants. PGRs control germination, vegetative growth, reproductive development, grain filling, and resistance to abiotic stressors in cereal crops like wheat, rice, maize, barley, and sorghum. PGRs can improve growth characteristics, yield qualities, and grain production when used wisely, especially in stress-prone situations, according to a number of studies (Pandey et al., 2000; Govind et al., 2007; Sharma et al., 2008). Research data from various agro-ecological locations on the contribution of main classes of PGRs, such as auxins, gibberellins, cytokinins, abscisic acid, ethylene, and sulphydryl compounds like thiourea, to increasing cereal crop productivity are critically synthesized in this study. Source-sink interactions, physiological mechanisms, and stress mitigation effects are highlighted.

Keywords: Plant Growth Regulators, Cereals, Wheat, Rice, Maize, Yield, Stress Physiology

I. INTRODUCTION

Cereal crops play a major role in global agriculture and provide over half of the world's nutritional energy supply. The three most significant cereals that contribute to global food and nutritional security are wheat (Triticum aestivum L.), rice (Oryza sativa L.), and maize (Zea mays L.) (FAO, 2021). Abiotic stressors as drought, salinity, heat, and nutrient deficits often limit wheat output despite tremendous advancements in plant breeding and agronomic techniques (Ashraf & Foolad, *et al.,* 2007; Fahad *et al.,* 2015).

Plant growth regulators (PGRs) are organic compounds that control growth and development at low concentrations. They are also known as plant hormones or bioregulators (Davies, 2010). By altering physiological and biochemical processes such photosynthesis, enzyme activity, assimilate translocation, and antioxidant defense, exogenous PGR administration enhances crop performance. PGRs, especially sulphydryl compounds and classical phytohormones, have been shown in numerous studies to significantly improve cereal growth metrics, yield characteristics, and grain production (Pandey *et al.,* 2000; Govind *et al.,* 2007; Nilesh *et al.,* 2012).

II. CONCEPT AND CLASSIFICATION OF PLANT GROWTH REGULATORS

Plant growth regulators are categorized according to their physiological roles and mechanisms of action. Auxins, gibberellins, cytokinins, ethylene, abscisic acid, and other growth-modifying agents including brassinosteroids and thiourea are among the main types (Taiz et al., 2015).

Table 1. Classification of Plant Growth Regulators and their Major Functions

Class of PGR	Common Examples	Major Physiological Functions
Auxins	IAA, IBA, NAA	Cell elongation, root initiation, apical dominance
Gibberellins	GA_3, GA_4	Stem elongation, seed germination, flowering
Cytokinins	Kinetin, BA	Cell division, delay of senescence, grain filling
Ethylene	Ethephon	Senescence, ripening, stress responses
Abscisic Acid	ABA	Stress tolerance, stomatal regulation
Other bioregulators	Thiourea, Salicylic acid, Brassinosteroids	Stress mitigation, yield enhancement

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III. PHYSIOLOGICAL ROLE OF MAJOR PLANT GROWTH REGULATORS IN CEREALS

3.1 Auxins
Auxins are essential for controlling apical dominance, root growth, and cell elongation. Auxin seed treatment or foliar application enhances root architecture in cereal crops, leading to improved uptake of nutrients and water. In maize and wheat, auxin administration has been shown to improve root growth and tiller survival, increasing biomass accumulation and yield potential (Pandey et al., 2000; Srivastava et al., 2002).

3.2 Gibberellins
Plant height, spike length, and grain weight have all been demonstrated to increase when GA_3 is applied topically to wheat and rice (Sharma *et al.,* 2008; Hedden & Sponsel, 2015). However, overuse may make a person more susceptible to lodging, which highlights the importance of optimal dose management. Reproductive development, seed germination, and stem elongation are all impacted by gibberellins.

3.3 Cytokinins
Cytokinins sustain chlorophyll concentration and photosynthetic activity by controlling cell division and postponing leaf senescence. Increased test weight and grain yield in cereals are the outcome of applying cytokinins during reproductive stages, which enhances assimilate availability for grain filling (Khan *et al.,* 2012; Taiz *et al.,* 2015).

3.4 Ethylene
In cereal crops, ethylene functions as a hormone linked to stress. Increased ethylene production speeds plant senescence and lowers output under abiotic stress conditions. Ethylene inhibitors have been shown to increase grain yield stability and stress tolerance (Rademacher *et al.,* 2015).

3.5 Abscisic Acid
Abscisic acid (ABA) controls osmotic adjustment and stomatal closure, which are important aspects of stress physiology. By preserving cellular water balance and safeguarding photosynthetic machinery, exogenous ABA treatment improves drought and salinity tolerance in wheat (Mishra & Dubey, 2006; Hasanuzzaman *et al.,* 2014).

3.6 Sulphydryl Compounds and Thiourea
The potential of sulphydryl chemicals, such thiourea, to improve grain production, antioxidant activity, and photosynthetic efficiency has drawn a lot of interest. In wheat and maize, thiourea treatment increases enzyme activity, postpones senescence, and fortifies source-sink translocation (Pandey *et al.,* 2000; *Govind et al.,* 2007; Nilesh *et al.,* 2012).

IV. EFFECT OF PGRS ON GROWTH PARAMETERS OF CEREAL CROPS

4.1 Germination and Early Seedling Growth
In cereals, seed priming and foliar PGR application greatly increase germination percentage, seedling vigor, and early establishment. During germination, thiourea and GA_3 increase enzyme activation, resulting in quick and consistent seedling emergence (Pandey *et al.,* 2000; Farooq *et al.,* 2009).

4.2 Plant Height and Biomass Accumulation
By encouraging cell elongation and leaf expansion, gibberellins and thiourea dramatically raise plant height and dry matter accumulation. Cereal photosynthetic capability and biomass production are improved by increased canopy development (Sharma *et al.,* 2008; Nilesh *et al.,* 2012).

4.3 Tillering and Leaf Area Index
Auxins and cytokinins have a favorable effect on tiller initiation and survival, which raises the leaf area index and effective tiller number. According to Pandey *et al.*, (2000) and Khan *et al.,* (2012), increased leaf area improves photosynthesis and light interception, which increases the potential yield.

V. INFLUENCE OF PGRs ON YIELD ATTRIBUTES AND YIELD

Table 2. Effect of PGRs on Yield Attributes of Major Cereal Crops (Summary from Literature)

Crop	PGR Applied	Major Yield Attributes Improved	Reported Yield Increase
Wheat	Thiourea	Tillers, grains/spike, 1000-grain weight	10–25%
Rice	Cytokinins, GA_3	Panicle length, grain number	8–20%

Maize	Auxins, Thiourea	Cob length, kernel weight	10–22%
Barley	Brassinosteroids	Grain filling, harvest index	7–18%

5.1 Grain Number and Grain Weight

Improved assimilate availability during reproductive phases leads to increased grain number and weight. Thiourea increases sink strength and glucose translocation to growing grains, resulting in improved grain filling (Govind *et al.,* 2007; Nilesh *et al.,* 2012).

5.2 Grain Yield

Several multi-location and multi-season studies have shown that foliar application of PGRs improves grain yield in cereals, especially under stress and late-sown circumstances (Freeha *et al.,* 2008; *Sharma et al.,* 2008; Govind *et al.,* 2007).

VI. ROLE OF PGRs IN ABIOTIC STRESS TOLERANCE

Plant Growth Regulators increase drought, salinity, and heat tolerance by strengthening antioxidant defense systems, lowering membrane lipid peroxidation, and preserving photosynthetic activity. Sulphydryl chemicals boost superoxide dismutase and catalase activity, reducing oxidative stress and delaying senescence in cereals (Liu *et al.,* 2002; Govind *et al.,* 2007; Hasanuzzaman *et al.,* 2014).

VII. MECHANISM OF ACTION: SOURCE–SINK RELATIONSHIP

PGRs affect carbon partitioning by increasing photosynthetic capacity (source) and grain filling efficiency (sink). Improved photosynthate transfer from leaves to developing grains leads to increased grain weight and yield (Wardlaw *et al.,* 1980; Carr & Wardlaw, 1965).

VIII. FUTURE RESEARCH NEEDS

Future research should concentrate on crop- and stage-specific PGR dose optimization, PGR integration with fertilizer and water management, molecular mechanisms underpinning PGR-mediated stress tolerance, and the long-term environmental and economic effects of PGR use.

IX. CONCLUSION

Plant Growth Regulators are essential for boosting cereal crop growth, yield, and stress tolerance. Among the many PGRs, thiourea, gibberellins, and cytokinins exhibit consistently favorable impacts across cereals and habitats. Their careful and integrated application can provide a considerable contribution to long-term crop productivity under changing climatic conditions.

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