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Role of New Generation Plant Growth Regulators in Enhancing Productivity and Quality of Fruit Crops

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Abstract

Fruit crops play a vital role in nutritional security, farm income generation, and agricultural diversification, particularly in tropical and subtropical regions. However, fruit production is increasingly challenged by climate variability, irregular flowering, poor fruit set, excessive fruit drop, inferior fruit quality, and high postharvest losses. In this context, new generation plant growth regulators (PGRs) have emerged as powerful tools to regulate physiological and biochemical processes in fruit crops with greater precision and efficiency than conventional growth regulators. These PGRs include synthetic cytokinins such as CPPU, brassinosteroids, salicylic acid, polyamines, ethylene inhibitors, jasmonates, and nitric oxide donors, which influence flowering, fruit set, fruit retention, size enlargement, ripening behavior, stress tolerance, and shelf life. Unlike traditional PGRs, new generation regulators operate at lower concentrations and interact closely with endogenous hormonal signaling networks. This review critically examines the role of new generation PGRs in fruit crops, highlighting their mechanisms of action, effects on yield and quality attributes, stress mitigation, and postharvest performance. The review also discusses future prospects and challenges in integrating these regulators into sustainable and climate-resilient fruit production systems.

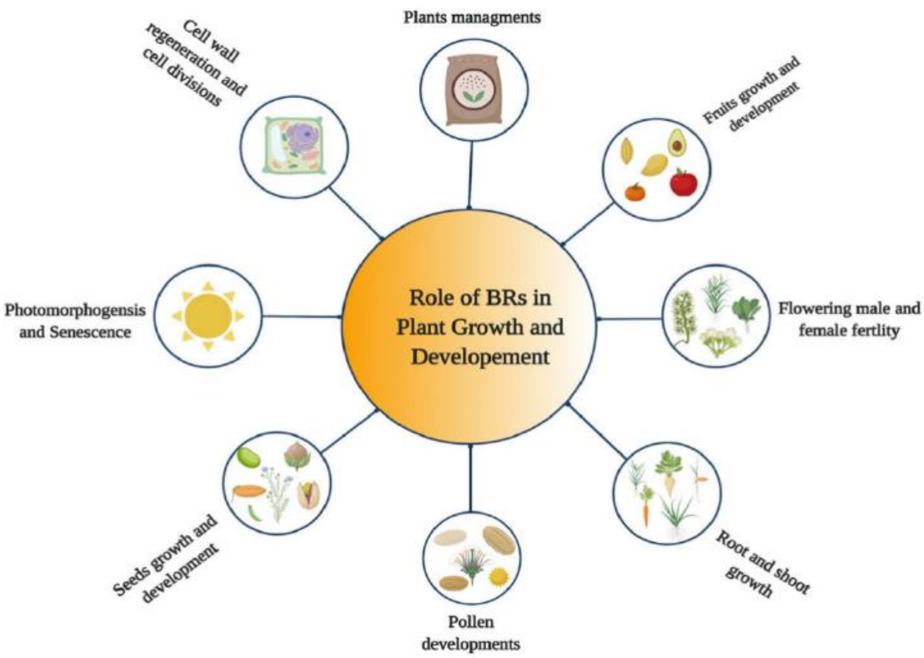
Keywords: New generation PGRs, fruit crops, CPPU, brassinosteroids, salicylic acid, fruit quality, stress tolerance

Introduction

Fruit cultivation is a high-value enterprise contributing significantly to agricultural income, employment, and nutritional security. Fruits are rich sources of vitamins, minerals, antioxidants, and dietary fiber, making them essential components of a balanced human diet. Despite advancements in varietal improvement and crop management, fruit productivity and quality remain constrained by physiological limitations and environmental stresses.

Plant growth regulators have long been used to manipulate plant growth and development. Conventional PGRs such as auxins, gibberellins, cytokinins, ethylene, and abscisic acid have been extensively applied in fruit crops to regulate flowering, fruit set, fruit drop, and ripening. However, inconsistent responses, narrow application windows, and environmental sensitivity have limited their effectiveness.

Recent advances in plant physiology and molecular biology have led to the identification of new generation PGRs, which act through refined hormonal signalling pathways and stress-responsive mechanisms. These regulators offer improved efficacy at low doses and greater specificity in targeting physiological processes. Their judicious use has shown promising results in improving yield stability, fruit quality, and postharvest longevity under changing climatic conditions.



Concept of New Generation Plant Growth Regulators

New generation PGRs differ from classical growth regulators in their mode of action, efficiency, and multifunctional roles. They often act as signaling molecules or modulators of endogenous hormones rather than directly inducing growth responses.

Characteristics of New Generation PGRs

- Effective at very low concentrations
- Influence multiple physiological pathways
- Improve stress tolerance and antioxidant defense
- Enhance sink–source relationship
- Environmentally safer with minimal residue concerns

Major Categories

- Synthetic cytokinins (e.g., CPPU)
- Brassinosteroids
- Salicylic acid and its analogues
- Polyamines
- Jasmonates
- Nitric oxide donors
- Ethylene inhibitors

Role of New Generation PGRs in Fruit Crops

Regulation of Flowering and Fruit Set

Irregular flowering and poor fruit set are major yield-limiting factors in many fruit crops. New generation PGRs enhance floral induction and improve ovary development by modulating hormonal balance.

Synthetic cytokinins such as CPPU stimulate intense cell division during early fruit development, thereby enhancing fruit set. Brassinosteroids promote pollen viability and stigma receptivity, resulting in improved fertilization. Salicylic acid influences flowering through its interaction with auxin and gibberellin signaling pathways.

Reduction of Fruit Drop and Improvement of Fruit Retention

Premature fruit drop is a common problem in fruit crops such as mango, citrus, and guava. New generation PGRs strengthen the pedicel–fruit junction by maintaining auxin transport and delaying abscission layer formation.

Salicylic acid and polyamines have been shown to reduce oxidative stress at the abscission zone, thereby lowering fruit drop. Nitric oxide donors enhance vascular connectivity and nutrient translocation to developing fruits.

Enhancement of Fruit Size and Yield

Fruit size is a key determinant of market value. CPPU and brassinosteroids increase fruit size by enhancing sink strength, stimulating cell division, and promoting cell enlargement. Improved carbohydrate partitioning towards developing fruits results in higher yield per plant.

In grapes, kiwi, apple, and guava, application of CPPU has consistently resulted in larger and heavier fruits without compromising quality when applied at optimal concentrations.

Influence on Fruit Quality Attributes

Biochemical Quality: New generation PGRs significantly influence biochemical constituents such as total soluble solids, titratable acidity, sugars, organic acids and vitamin C. Brassinosteroids and salicylic acid enhance sugar accumulation by regulating carbohydrate metabolism enzymes.

Color Development and Pigmentation: Fruit color is a major consumer preference trait. Jasmonates and brassinosteroids promote anthocyanin and carotenoid biosynthesis, resulting in improved peel and pulp coloration in fruits like apple, strawberry, and mango.

Antioxidant Capacity: Salicylic acid, polyamines and nitric oxide donors enhance the activity of antioxidant enzymes such as superoxide dismutase, catalase, and peroxidase. This improves cellular integrity and delays senescence.

Role in Stress Tolerance and Climate Resilience

Fruit crops are highly sensitive to abiotic stresses such as heat, drought, salinity, and cold. New generation PGRs activate stress-responsive genes and strengthen antioxidant defense systems. Salicylic acid and brassinosteroids reduce reactive oxygen species accumulation, maintain membrane stability, and protect photosynthetic machinery. Nitric oxide acts as a signaling molecule in stress adaptation, improving plant resilience under adverse environments.

Postharvest Role of New Generation PGRs

New generation PGRs are increasingly used in postharvest management to extend shelf life and reduce losses. Ethylene inhibitors and salicylic acid delay ripening, suppress cell wall degrading enzymes, and reduce decay incidence. These regulators help maintain firmness, minimize weight loss, and preserve nutritional quality during storage and transportation.

Future Prospects and Challenges

Despite their advantages, the large-scale adoption of new generation PGRs faces challenges such as:

- Standardization of doses and application timings
- Crop- and cultivar-specific responses
- Regulatory approvals and cost considerations
- Future research should focus on integrating PGRs with precision agriculture, nanotechnology-based delivery systems, and molecular breeding approaches to enhance their effectiveness and sustainability

Conclusion

New generation plant growth regulators represent a paradigm shift in fruit crop management. Their ability to fine-tune physiological processes, enhance yield and quality, mitigate stress effects, and improve postharvest performance makes them indispensable tools in modern horticulture. When applied judiciously, these regulators can significantly contribute to sustainable, climate-resilient, and profitable fruit production systems. Continued research and farmer-oriented extension efforts are essential to harness their full potential while ensuring environmental safety and economic viability.