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## Role of Plant Growth Regulators (PGRs) in Fruit Production in India

(\*Pradhum Banafar, Neha Dalvi and Atharav Lohakare)

School of Agricultural Sciences, G.H. Rasoni University, Saikheda (M.P.), India

\*Corresponding Author's email: [riyath29@gmail.com](mailto:riyath29@gmail.com)

Fruit production plays a pivotal role in India's agricultural landscape. With a variety of fruit crops cultivated in different climatic regions, India is one of the leading fruit producers globally. Fruits contribute significantly to the country's economy, nutrition, and export trade. Despite favorable growing conditions, many challenges such as low productivity, inconsistent fruit quality, poor flowering, and premature fruit drop persist in fruit farming. These challenges often limit the potential of fruit crops and result in suboptimal yields and quality. The application of Plant Growth Regulators (PGRs) has emerged as an effective strategy to overcome many of these hurdles.

Plant Growth Regulators (PGRs) are naturally occurring or synthetic compounds that influence plant growth and development. PGRs can stimulate or inhibit specific physiological processes such as cell division, elongation, flowering, fruiting, ripening, and senescence. In fruit production, PGRs have been used to improve fruit set, enhance fruit size, synchronize ripening, prevent premature fruit drop, and improve overall fruit quality. The adoption of PGRs in Indian fruit production is gaining momentum, particularly as farmers seek to maximize yields and meet market demands for higher-quality produce.

This review explores the role of PGRs in improving fruit production in India, focusing on their effects on different fruit crops and the challenges and benefits associated with their use. The review also highlights key research findings from across the country to provide a comprehensive understanding of how PGRs contribute to enhancing fruit yields, quality, and profitability.

### Types of Plant Growth Regulators Used in Fruit Production

There are several classes of PGRs, each with specific effects on plant growth and development. The primary PGRs used in fruit production in India are auxins, cytokinins, gibberellins, ethylene, and abscisic acid. Each class of PGRs plays a distinct role in influencing physiological processes that affect fruit production.

1. **Auxins:** Auxins are a group of PGRs that regulate cell elongation, root initiation, and flowering. In fruit production, auxins such as indole-3-acetic acid (IAA) and naphthalene acetic acid (NAA) are used to regulate fruit set, promote uniform fruit development, and reduce premature fruit drop. Auxins are known to stimulate the formation of fruit from unfertilized flowers, a process known as parthenocarpy. This is particularly useful in crops where pollination is inconsistent, such as mango, guava, and papaya. For instance, the application of NAA in mango orchards has shown to reduce fruit drop and improve fruit retention during the critical developmental phase.
2. **Cytokinins:** Cytokinins are PGRs that promote cell division and delay senescence. These regulators are often applied to improve fruit size and increase the number of branches and flowers in fruit trees. In citrus, for example, cytokinins like benzylaminopurine (BAP) have been used to promote bud break, enhance fruit set, and improve the size and uniformity of fruits. Cytokinins are also useful in managing fruit trees that have irregular

flowering patterns, such as guava and pomegranate. Their ability to delay fruit ripening also makes them valuable for extending the shelf life of harvested fruits.

- 3. Gibberellins:** Gibberellins are important for promoting cell elongation and improving fruit size. Gibberellic acid (GA3) is the most commonly used form in fruit production. Gibberellins are used to break dormancy in certain fruit crops, like grapes and apples, and to promote uniform growth and flowering. The application of gibberellins in grapevine cultivation has been shown to significantly increase berry size and reduce fruit drop, resulting in higher-quality fruit with improved marketability. Similarly, in pomegranate and citrus, gibberellins are applied to enhance fruit size and prevent premature fruit abscission.
- 4. Ethylene:** Ethylene is a gaseous plant hormone that plays a crucial role in regulating fruit ripening. It is widely used in post-harvest management to promote uniform ripening, enhance fruit color, and improve texture. In bananas and mangoes, ethylene is used to synchronize the ripening process, allowing for better market readiness. In addition to ripening, ethylene is also involved in fruit abscission, and its application in crops like apples and guava helps in controlling fruit drop. The controlled use of ethylene is beneficial in the export market, where fruits must meet strict quality standards.
- 5. Abscisic Acid (ABA):** Abscisic acid (ABA) is involved in the regulation of seed dormancy, stress responses, and fruit ripening. ABA is used in fruit production to improve fruit quality by enhancing sugar accumulation, increasing resistance to post-harvest diseases, and promoting uniform ripening. In grape and apple production, ABA is applied to enhance the sugar content of the fruit, leading to a higher brix level and better taste. Additionally, ABA application has been shown to help reduce the incidence of fruit cracking in certain crops, such as grapes and plums.

### Role of PGRs in Specific Fruit Crops in India

The diverse range of fruit crops grown in India benefits from the use of PGRs, with each crop requiring specific applications of PGRs to address unique challenges.

- 1. Mango (*Mangifera indica*):** Mango is India's most important tropical fruit, but it often suffers from poor flowering, irregular fruit set, and high fruit drop. PGRs like NAA, GA3, and ethephon are commonly used to improve these aspects. For instance, GA3 is used to improve fruit size, while NAA helps in fruit retention and reducing fruit drop. The use of ethephon can induce uniform ripening, ensuring that mangoes are harvested at the right stage for the market. Additionally, PGRs like NAA are used to regulate the flowering cycle, which can help in synchronizing the harvest season and improving yield consistency.
- 2. Grapes (*Vitis vinifera*):** Grapes are another major fruit crop in India. PGRs, especially gibberellins, are extensively used to increase berry size, promote uniform bunch formation, and prevent fruit drop. The application of GA3 is particularly effective in improving berry size and enhancing the quality of table grapes. Moreover, cytokinins are used to improve fruit setting and prevent early fruit senescence. By using a combination of PGRs, grape growers in India can achieve better yields and improve fruit quality, thus enhancing profitability.
- 3. Citrus (*Citrus spp.*):** Citrus fruits, including oranges, lemons, and limes, face several production challenges, such as poor fruit size and irregular flowering. Cytokinins and gibberellins are applied to stimulate uniform fruit development and improve fruit size. The application of NAA can also help in preventing fruit drop, ensuring that the fruits reach maturity. In citrus, PGRs also play a role in improving fruit quality, particularly in terms of flavor and texture, which is crucial for both domestic consumption and export.
- 4. Guava (*Psidium guajava*):** Guava is an important fruit in India, but it is susceptible to poor fruit set and quality issues. The use of PGRs such as NAA and GA3 has been shown to improve fruit retention and enhance fruit size. PGRs can also help in controlling the ripening process and improving the flavor of the fruit. Guava growers benefit from PGRs that regulate the flowering process, allowing for more consistent and timely fruit

production. Additionally, the application of gibberellins can help in improving the size and quality of guava fruits.

5. **Papaya (*Carica papaya*):** Papaya is a highly productive tropical fruit that is grown extensively in India. However, it faces issues such as inconsistent flowering, poor fruit size, and early fruit drop. The use of gibberellins and auxins in papaya cultivation has been shown to improve fruit size, enhance fruit setting, and regulate flowering. The application of PGRs such as GA3 can help in inducing early flowering and accelerating fruit development, leading to higher yields. Additionally, the controlled use of PGRs can improve the marketability of papayas by enhancing fruit color and texture.
6. **Pomegranate (*Punica granatum*):** Pomegranate is a significant crop in India, particularly in the arid and semi-arid regions. PGRs like GA3 and NAA are used to enhance fruit size, improve fruit set, and reduce premature fruit drop. Gibberellins help in increasing the size and weight of pomegranate arils, while NAA aids in fruit retention. PGRs also help in controlling the ripening process and improving the color and texture of pomegranate fruits, making them more attractive for both domestic and export markets.

### Challenges and Limitations of PGR Use in India

While PGRs offer numerous benefits, their use in India is not without challenges. One of the key issues is the lack of awareness and training among farmers regarding the correct application of PGRs. Many farmers still rely on traditional practices and may misuse or overuse PGRs, leading to negative consequences such as abnormal fruit growth or reduced fruit quality.

Additionally, the cost of PGRs can be a barrier, especially for small-scale farmers who may not have the financial resources to purchase these chemicals regularly. The availability of high-quality PGR products is also inconsistent, with some regions facing issues with counterfeit or substandard products.

Furthermore, environmental concerns regarding the use of synthetic PGRs, especially when overused, have raised questions about the sustainability of their application. Research into organic and eco-friendly alternatives is needed to ensure that PGR use in Indian agriculture does not result in long-term environmental harm.

### Conclusion

Plant Growth Regulators (PGRs) have revolutionized fruit production in India by providing effective solutions to many of the challenges faced by fruit growers. From improving fruit set and size to enhancing fruit quality and yield, PGRs play a critical role in modern fruit farming. However, careful and precise application is crucial for maximizing their benefits while minimizing potential drawbacks. The future of PGR use in India will depend on ongoing research, farmer education, and the development of sustainable practices to ensure that PGRs continue to contribute positively to the growth of the fruit industry.

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