Review Article

Uses of Plant Growth Regulators and Biofertilizers in Fruit Crops: A Review

Abstract

Plant growth regulators are extremely important natural hormones which control the growth and the physiological factors within the plant. They are naturally occurring as well as synthetic. PGRs like Auxins, ethylene, cytokinins and gibberellins are the growth inhibitors and growth retardants. The foliar application of plant growth regulators helped in increasing the quality of the fruit crops. Auxin is required for fruit retention in sweet cherry, litchi, grapevine, snake fruit and tomato. Most commonly used auxins are IBA, NAA, IAA, 2,4D etc. IBA at the concentration of 4000 ppm is the best plant growth regulator for rooting in cuttings. Gibberellins (GA) are diterpene plant hormones that influence various aspects of growth and development through complex biosynthetic processes. Application of GA with combination of Zinc and pruning showed better performance in fruit weight, ascorbic acid, and reduction in pre-harvest fruit drop. Repeated applications of brassinosteroid have a long-lasting effect on strawberry cv. Winter Dawn physiological growth. Triacontanol (TRIA), natural plant growth hormone in fruit crops. It regulates a variety of physiological processes in plants. Salicylic acid (SA) is a plant hormone best recognized for modulating host responses in response to pathogen infection.SA treatments boosted crop productivity and fruit quality criteria such as firmness, aril color, and individual sugar and organic acid concentrations at harvest. It is revealed by many studies that the application of biofertilizer play an essential role for increasing the sustainability of the soil and also enhance the organic matter content, aeration, fertility, availability of micro and macronutrients with in the soil which are the essential things for the better survival of the plant and results into the good quality and higher yield from the plant. The present review encompasses the use and the effect of different PGR's and biofertilizer on the fruit crops.

Keywords: *Fruit crops, Plant growth regulators, Biofertilizers*

Introduction

Plant Growth Regulators are the naturally occurring hormones in the higher plants for controlling growth and physiological factors. They synthesized in one site of the plant and utilized by the other part of the plant. PGR's is organic or natural as well as inorganic or synthetic. Phyto hormones are proposed by Thimmann as they are plant synthesized. There are mainly five PGRs named as Auxins, Cytokinins, ethylene, gibberellins and abscisic acid but the recent discovery of some PGRs like brassinosteroids, salicylic acid, triacontanol, melatonin, ALA (5-aminolevnlinic acid), oligosaccharins have been founded effective in fruit crops (Hajam *et al.*, 2018). Auxins are the first PGR which is discovered in higher plant by W. Went later on gibberellins and cytokinins was discovered. PGRs like Auxins, ethylene, cytokinins and gibberellins are the growth inhibitors and growth retardants (Suman *et al.*, 2017). PGR's is used for increase the fruit growth and for taken up a good yield and good quality crop. The foliar application of plant growth regulators helped in increasing the quality of the fruit crops because fruit is the high valued crop. Under field conditions, a variety of chemical and hormone-based PGRs have been utilized to improve stress tolerance and productivity of horticultural crops (Bons *et al.*, 2020). Likewise, growth regulator acetylene induces early flowering in pineapple. Application of NAA also increases the yield of the pineapple (Maibangsa *et al.*, 2000). Overall uses of PGRS depend on two factors; Growth promoter and growth retardant which ultimately results in increasing fruit value and quality. Hence, the use of plant growth regulators has achieved outstanding results in many fruit crops.

Application of fertilizers is considered as the important tool in the production of any crop which supplies a number of nutrients for increasing the soil fertility, crop production and ultimately results in the better yield of the produce. Fertilizer mainly NPK consider essential for the all type of the crop. Use of chemical fertilizers cause soil, water pollution as well as it is risky for the health of human being, it lead to raise the attention of many farmers toward organic or Biofertilizers (Pawar *et al.*, 2020). There are different types of biofertilizers like Nitrogen-fixing biofertilizer, Phosphorus solubalizing biofertilizer (PSB), Phosphorus mobilizing biofertilizer (PMB), VAM etc. Biofertilizers makes the nutrients available to the plant from the soil which ultimately encourage the synthesis of carbohydrates and proteins, cell division, resistance to the plant from root diseases and increase the production of the natural hormones like GA3, cytokinins, IAA which turns in the good vegetative growth of the plant and therefore results in the good production and the quality of the fruit crops. The application of various inoculants alone or in combination by various personnel has been seen to produce a positive reaction in horticultural crops. These bio-inoculants influence not just fruit yield but also fruit quality. PGPRs can also be employed as bio-pesticides to combat a wide range of plant diseases and insects. In horticultural crops and floriculture, vesicular–arbuscular mycorrhiza is the most prevalent inoculants (Pathak *et al*., 2017). NPK content in the soil increased due to inoculation of the VAM biofertilizer. Different fruit crops benefit from the usage of bio-logical fertilizers in terms of growth, yield, and quality. In comparison to chemical fertilizers, biofertilizers also maintain soil fertility and status. Biological fertilizers are more advantageous since they contain a variety of growth-promoting hormones. Bio-fertilizers are also used to control a variety of fruit plant diseases (Singh *et al.,* 2020). The followings are the different PGR's and their useful effects on the different fruit crops.

Auxins

Auxin application found to upgrade histological features such as callus formation and tissue and segregation of vascular tissue. There are several commercial uses of auxins in fruit crops like promotion of flowers, prevention of fruit drops and leaf drop, fruit thinning, plant propagation by different method and even in tissue culture also). Most commonly used auxins are IBA, NAA, IAA, 2,4D etc. Auxin is required for fruit retention in sweetcherry (Blanusa *et al.*, 2005), litchi (Kuang *et al.*, 2012), grapevine (Kuhn *et al.*, 2016), snakefruit (Rai *et al.*, 2016) and tomato (Serrani*et al.*, 2008). According to Aboelez *et al.,* (2021) Alphonso mango tree with NAA (200ppm) decreased the floral malformation and improves fruit quality, increase the yield of the plant. In pomegranate trees, NAA at 25 ppm increased blooming and fruit set (Ghosh *et al.*, 2009). The growth regulator NAA was reported to reduce pre-harvest drop rates, but the effects of this growth regulator differed depending on the variety and climate circumstances. (Especially daily temperatures) and the intended outcomes were not achieved always noticed (Greene *et al.*, 1987). NAA 200 ppm and 150 ppm pre-harvest application as an effective approach for improving the physico-chemical characteristics of guava fruits (Singh *et al.*, 2017). Even more effect of NAA on fruits is listed in the table 1below. According to Ghosh *et al.*, (2017) The best treatments were determined to be IBA @ 200 ppm followed by NAA @ 200 ppm and may be considered for commercial vegetative propagation of Stem cuttings of Phalsa. IAA and ABA play opposing roles in the ripening of unripe fruits. IAA has the ability to influence ripening-related gene expression by modulating its own biosynthesis as well as the biosynthesis and signaling pathways of ethylene and ABA. Although ABA has a stimulant effect on ripening-related parameters such as color development, sugar accumulation, titratable acid reduction, and fruit softening. Pre-harvest fruit drop control in 'Hamlin' orange was shown to be greatest when 2,4-D @ 10 ppm was applied (Medeiros *et al.*, 2000).

Gibberellins (GA)

Gibberellins (GA) are diterpene plant hormones that influence various aspects of growth and development through complex biosynthetic processes. The phytohormone, Gibberellin (GA) has a regulatory role in seed germination, stem elongation, leaf expansion, pollan maturation, development of flowers, fruits and seeds. GA3 has a wide range of applications in fruit crops for controlling various growth and developmental processes, and it has a low phytotoxic effect. Although plants produce some endogenous GA are naturally occur, but exogenous applications of gibberellins at various stages of growth alter several plant phenomena such as seed germination, stem elongation, flowering regulation, and fruit set (Chauhan *et al.,* 2020). Spraying gibberellic acid on self-pollinating apple plants boosted fruit weight and decreased the amount of asymmetrical fruit, restoring the exterior fruit quality. The use of exogenous GA enhanced the wax layer thickness and reduced the rate of fruit water loss, resulting in a significant increase in fruit storage capacity (Liu *et al.*, 2022). Application of GA with combination of Zinc and pruning showed better performance in fruit weight, ascorbic acid, and reduction in pre-harvest fruit drop (Kumar *et al.*, 2017). In apples, seed stratification combined with GA seed treatment yields superior outcomes and minimizes chilling requirements (Pipinis *et al.*, 2015). According to studies, using GA before blooming can also help citrus avoid floral induction (Garmendia *et al.*, 2019). In their study, Mahmood *et al.*, (2016) found that foliar application of 200 ppm GA resulted in better fruit set of parthenocarpic fruits in guava, as well as increased fruit growth, more ascorbic acid, and better TSS than β-NOA, which failed to produce any parthenocarpic fruit in guava. Even more effect of GA3 on fruits is listed in the table 1 below.

1. Brassinosteroids (BRs)

In 1970, Mitchell and colleagues discovered a steroidal compound they named "brassins." In 1982, a growth substance similar to BL was discovered in the insect galls of chestnut (*Castanea crenata*) trees and named 'castasterone.' Both of these discoveries prompted subsequent research into similar chemicals in other plant species. All of these steroidal compounds with growth-promoting properties were together termed as "brassinosteroids" (BRs).

BRs are a group of naturally occurring polyhydroxy steroids (Rao *et al.,* 2002). Repeated applications of brassinosteroid showed that it has a long-lasting effect on strawberry cv. Winter Dawn physiological growth. With a greater TSS: acid ratio, decreasing sugar, and total phenol content, and more fruit of superior quality (Khatoon *et al.*, 2021). Babalık *et al.* (2019) reported that the application of BRs on the grape vine (*Vitis vinifera* cv. Alphonse) increase the yield, berry weight, cluster weight and the quality of the fruit. In strawberry plants, the effect of both BRs [24-epibrassinolide (EP24) and DI-31 (BB16)] on the activation of a defense response was also studied; both BRs have a protective effect against *Botrytis cinerea*, the cause of grey mould disease (Furio *et al.*, 2019). Application of BRs in the combination with CPPU and GA enhance the leaf number, leaf area and the dry weight of the seedless grape's variety Tas-A-Ganesh (Bhat *et al.*, 2011). The combination of BRs and NAA treatment improved pineapple fruit size, shape, and quality in the 'Pattawia' variety (Chumpookam *et al.*, 2017). Mostafa *et al.* (2018) was showed in their study that the sugar apple *Annona squamosa* L. treated with brassinosteroids in the combination with the hand pollination enhance fruit quality and fruit set. In terms of plant height, number of leaves, number of branches, leaf area, number of buds, day to first flowering, number of flowers per plant, day to first fruit set, number of fruits per plant, Polar and Radial diameter (cm), fruit weight (g), and fruit yield (q/ha), as well as quality parameters such as T.S.S, acidity, Ascorbic acid, and shelf life of Cape gooseberry, brassinosteroids was found to be the best treatment (Walling *et al.*, 2021).

2. Triacontanol (TRIA)

Triacontanol (TRIA), natural plant growth hormone in fruit crops which is found in the bee wax and the plant cuticle. In fruits crops, tricontanol (TRIA) has the ability to regulate and affect a variety of physiological processes in plants such as boost the growth, chlorophyll content, photosynthesis, transpiration, stomatal conductance, and nutrient uptake (Sharma *et al.*, 2018 and Ali *et al.*, 2021). TRIA promotes crop plant stress tolerance by modulating gene expression such as photosynthetic and related genes, stress mitigating genes, and antioxidant levels in response to acid mists, heavy metals, salt, water and temperature stress, transplant shock, and other stresses (Islam *et al.* 2020). Exogenous usage of triacontanol with salicylic acid has a considerable impact on strawberry growth, fruiting, and yields (Baba *et al.,* 2017). Moreover, to delay senescence, triacontanol inhibits active oxygen accumulation by increasing antioxidant enzyme activity, down-regulating enzyme genes related to fruit softening and coloring, and regulating ETH, ABA, and IAA biosynthesis, as well as promoting early strawberry fruit growth and development and improving stress resistance (Pang *et al.*, 2020). Triacontanol with the extract of *Ascophyllum nodosum* promotes fruit weight, fruit retention, and yield and fruit quality parameters in mango crop (Dash *et al.*, 2021). Samia *et al.*, (2020) showed that the cucumber plants treated with the small concentrations of triacontanol have the low effect of *Aphis gossypii.*

3. Salicylic acid (SA)

Salicylic acid (SA) is a plant hormone best recognized for modulating host responses in response to pathogen infection. Its importance in plant defense activation is widely known, but its production in plants is unknown (Lefevere *et al.,* 2020). Treatment of salicylic acid in combination with chitosan reduces pericarp browning and preserves litchi fruit quality for up to 6 days at 4°C (Kumari *et al.*, 2015). The foliar spray of salicylic acid enhanced the vegetative growth, earliness, flower cluster in strawberry (Mohamed *et al.*, 2017). Moreover, Pre-harvest SA treatments on pomegranate trees boosted crop productivity and fruit quality criteria such firmness, aril color, and individual sugar and organic acid concentrations at harvest and salicylic acid treatment of Manfalouty pomegranate trees stimulates all aspects of growth, including leaf pigments, initial fruit setting percent and fruit retention percent, gross and marketable yields, physical and chemical characteristics of the fruits, and initial fruit setting percent and fruit retention percent (Chakma *et al.*, 2021 and Aziz *et al.*, 2017). Post-harvest treatment of salicylic acid with the combination of aloe vera maintains the qualitative character of the orange cv. Thomson navel (Rasouli *et al.*, 2019). Jamun can be treated with salicylic acid and coated with chitosan after harvest to improve fruit quality during storage at room temperature for up to 6 days (Saurabh *et al.*, 2019). In ber (*Ziziphus mauritiana* L. cv.) Gola, Salicylic acid at 150 ppm is significantly superior to the in terms of growth characteristics such as tree spread, canopy volume, and shoots length (Gora *et al.*, 2021). Salicylic acid is an effective plant growth hormone to preserving the quality of papaya fruit after 28 days of cold storage by minimizing fruit degradation, maintaining freshness, TSS, acidity, and sugars. It also increased the activity of anti-oxidative enzymes in papaya fruit (Hanif et al.,2020).

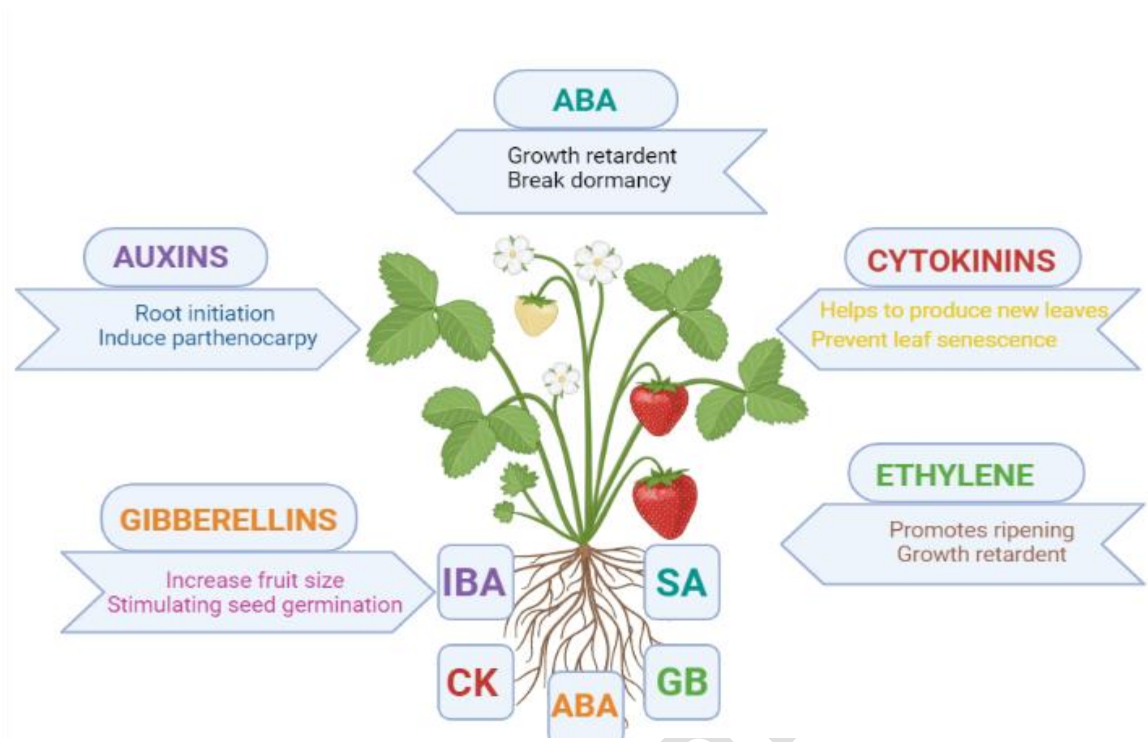

Figure 1: An overview of the role of PGR's in the plant growth and development

Several plant hormones like auxins, gibberellins (GA), cytokinins (CK), abscisic acid (ABA) play an important role in the development of the plant sowing in above figure 1. Auxins induce rooting as well as induce parthenocarpy in the fruit. On the other hand, GA helps in increasing the fruit size and stimulate the germination and ethylene promotes the ripening in the fruits and act as growth retardant. ABA is also a growth retardant phtyohormone which can also break the dormancy in the seeds.

CROP	PGR's Concentration	Result	References
Guava (*Psidium guajava)*	IBA (3000 ppm)	Maximum number of roots per cuttings, highest percentage of roots, length of the roots, and also high fresh and dry weight of the roots in cuttings	Sujin *et al.*, 2020
	GA3 (200 ppm)	This resulted in a better response to the growth of the fruit, TSS, and the ascorbic acid content of the guava fruit.	Mahmood *et al.*, 2016
	NAA (200 ppm)	Showed maximum fruit set, fruit retention, and lowest fruit drop in guava.	Vani *et al.*, 2020
Grapes (*Vitis vinifera*)	IBA + GA3 (20 ppm +10 ppm)	This resulted in improved quality and cold storage capacity of superior seedless table grapes at a single spray at full bloom.	Guzman *et al.*, 2021
	CPPU (1 ppm)	Maximum berry size, the weight of the pea, the thickness of the peel, and the thickness of the pedicel can be observed.	Senthilkumar *et al.*, 2018
Papaya (*Carica papaya*)	IBA (100 ppm)	This resulted in 108% more female flowers, 3.33% male flowers, and 10% hermaphrodite flowers on the papaya plant.	Higida *et al.*, 2015
	GA3 (500 ppm)	This resulted in the highest germination of the seed, plant spread, and maximum leaves number per plant in papaya.	Mali *et al.*, 2015
Citrus (*Citrus spp*.)	IBA (500 ppm)	The highest survival percentage and high growth of the root and the shoot can be observed.	Singh *et al.*, 2015
	2,4-D (30 ppm)	This resulted in the reduction of the fruit drop in kinnow fruit.	Sihag *et al.*, 2019
Pomegranate (*Punica granatum*)	GA3 (50ppm)	This resulted in maximum firmness of the fruit, thickness of the peel and the weight of the arils, and high TSS content of the fruit.	Niazi *et al.*, 2020
	GA3 + 2,4-D (30ppm + 10ppm)	Maximum growth of the plant, yield, and quality of the fruit can be observed in pomegranate cv. Bhagwa.	Bharty *et.al.*,2021
Mango (*Mangifera indica*)	CPPU (1ppm)	Foliar application can result in an increase in yield, and maximum number of fruits per panicle in mango cv. Keshar.	Kulkarni *et al.*, 2017
	NAA (50ppm)	This resulted in an increase in the number of fruits, the weight of the fruit, fruit retention, and fruit quality of mango cv. Amrapali.	Ghosh *et al.*, 2016
	BRs (1ppm)	This resulted in an increase in the length of the fruit, fruit weight, fruit volume, and mesocarp pulp in mango fruit.	Patel *et al.*, 2021
Strawberry (*Fragaria× ananassa*)	GA_3(200ppm)	This resulted in the maximum height of the plant, plant spread, and length of the petioles.	Khunte *et al.*, 2020.

Custard apple (*Annona reticulata*)	GA_3 (50ppm)	The result showed that the higher germination and the highest seedling growth in custard apple	Jadhav *et al.*, 2015.
Litchi (*Litchi chinensis*)	Ethrel (100 ppm & 150ppm)	The result shows the high number in pure panicle emergence and high yield of the fruit in litchi.	Kumar *et al.*, 2018

Table 1: Effect of different Plant Growth Regulators at different concentration on fruit crops.

Biofertilizers in fruit crop

Bio fertilizers support a variety of microorganisms and have the ability to mobilize soil nutrients via bio-logical process. Bio-fertilizers are non-toxic to the environment and play an important role in crop production in fruit crop. There are many Biofertilizers which are uses in the fruit crops for better output. Some of these are mentioned here in different fruit crops and also listed in Table 2 below.

Effect on guava

Maximum plant height, canopy spread, trunk girth, fruit weight, TSS, total sugars, and vitamin C were achieved with a combination of vermicompost (30 kg/plant) + Azospirillum @ 250 g/tree + PSB @ 250 g/tree in guava (Rani *et al.*, 2021).The application of liquid biofertilizer (RDF +NFB, PSB and KSB) in combination shows a good number of fruits per plant, fruit weight, fruit diameter, fruit volume and yield in guava (Nirujogi *et al.*, 2021). The maximum yield and maximum fruit weight of guava can be found by the application of Biovita (Biofertilizer) at higher concentration (25ml). The improved benefits of Biovita on guava yield and yield attributes may be due to increased vegetative development, such as number of leaves, shoot of main branch, and length of shoot, allowing the plants to harvest more sunlight and produce more photosynthates (Lall *et al*. 2016). Dheware *et al.*, (2020) concluded that the application of the biofertilizer along with organic manure can enhance the fruit growth and the quality parameters of the guava fruit. The study by Das *et al.*, (2017) revealed that the exclusive use of Biofertilizers can be accomplishing the quality parameter requirement and improve the growth performance of guava crop.

Effect on mango

In mango, the application of Azotobacter along with Phosphorus Solubilizing Bacteria (PSB) and Vermicompost at the concentration of 50g, 50g, 3kg respectively can increase the plant growth parameters particularly girth of the rootstock, height of the plant, girth of the scion, number of shoot/plant and number of nodes/shoot and also improve the soil health in the rhizosphere of the mango tree (Poonia *et al.*, 2018).The inoculation of three biofertilizers viz; Azospirillum, *Pseudomonas fluorescence* and Vesicular Arbuscular Mycorrhiza (VAM)in the potting mixture of grafted alphanso mango enhance the girth of the stem, height of the plant and number of leaves per plant. (Shankarappa *et al.*, 2018).Mango tree treated with the mycorrhizae in combination with chicken manure tea, *A. chroococcum*, *B. circulans*resulted in highest fruit set in first season and lowest fruit drop in both seasons (El-Hamid *et al*., 2019).

Effect on apple

The increase in the percentage of fruit set, fruit yield, weight of fresh leaf, total chlorophyll content of the leaf in ‘Anna’ apple tree with the application of extracts of Biofertilizer (Azolla, cynobacteria and their mixture) alone and in combination (Taha *et al.*, 2018). In the study of Thomas et al., (2022) founded that the application of Biostimulants in the combination with AM fungi and PGPR (@ 200gm/ nursery bed + 20g + 50ml per plant respectively) increases scion’s radical growth, success rate, total length of the root, shoot’s fresh weight and dry weight, total biomass of the apple plant in the nursery.

Effect on papaya

Dual inoculation with Azotobacter strains Azoto 3 and PSB, as well as 75 percent NP and 100 percent K doses, dramatically increased papaya plant growth and nitrogen uptake in the nursery. This approach could be used to improve papaya vegetative growth in the nursery, lowering production costs and increasing yield while reducing papaya disease by preserving healthy plant growth in the nursery (Mamta *et al.*, 2017). Potting mixture enrich with Biofertilizers and organic manure (*T. harzianum*, AM Fungi and castor cakes) increase the germination percentage, germination index and reduce the number of days to germinate in Papaya at nursery level (Devi *et al.*, 2019).The study of Hari *et al*., (2021) revealed that the weight, length, volume of the fruit, pulp percentage, and total yield of the papaya plant can be increased by the application of AM fungi and PGPR with 100 percent dose of nitrogen.

Effect on citrus

Organic and biofertilizers have an important role in raising citrus orchard productivity, improving fruit quality, and increasing nutrient availability in soils, as well as delivering economic benefits by lowering synthetic agrochemical inputs and preserving natural resources. To maintain citrus productivity, raise citrus tolerance to biotic and abiotic stresses, and retain soil health, organic and biofertilizers must be part of the integrated fertilizing system as a partial supplement to inorganic fertilizers (Abobatta *et al.*, 2020). According to Hazarika *et al.*, (2019), application of 75% N via FYM along with 25% via IF + Azospirillum + AMF + KSB gives high growth, high yield and quality in 'Assam lemon' citrus.

Effect on grapes

Nagy and Pinter (2015) showed that the foliar application of the algae suspension and amino acid mixture significantly increase the greenness of the leaves, mineral content in the leaves, berry size and weight of the bunches and ultimately increase the yield of the grape vine. The application of Biofertilizers increase the nutrient status in the leaves when it is applied at the higher depth of 0-20cm and 20-40cm) (Junior, *et al.*, 2018).Study by Hassan *et al.,* (2020) showed that for obtaining the best vegetative parameters, mineral content, higher yield with best fruit quality with the application of Rhizobacterien with poultry manure in trench method.

Effect on other fruit crops

The height of the plant, the number of leaves, the number of crowns, the number of runners, the number of flowers, and the number of fruits per plant all increased dramatically in Azotobacter-treated plants (Tripathi *et al.*, 2016). According to the studies of Verma *et al.*, (2019) Plant height, number of branches per plant, number of thorns, and stem diameter of dragon fruit plants all improve dramatically when organic bio-fertilizers are used. Application of Azotobacter in combination with PSB and vermicompost gives good yield, quality, number of fruits per plant, weight of the fruit in Cape gooseberry (*Physalis peruviana* L.) (Shreekant *et al.*, 2018).Kumar et al., (2020), investigated that by the use of biofertilizers and organic manure in strawberry there is a significantly increase in the leaves number, leaves length and width, plant spread, petioles length, plant height, fruit numbers, numbers of runners, fruit weight, berry weight, T.S.S. content, and also increase in the ascorbic acid content of the fruit.

Table 2: Effect of different Biofertilizers (alone and in combinations) on different fruit crops.

Crop	Biofertilizer	Result	References
Guava *(Psidium guajava*)	*Azospirillium brasilense*+ AMF	The result showed the best fruit retention, yield with maximum length of the fruit, diameter, weight of the fruit and weight of the pulp.	Das *et al.*, 2017
Grapes (*Vitis vinifera*)	Nitrobien and Rhizobacterien	At tributes of Flame Seedless grapevines, the best management system for attaining the best vegetative growth parameters, leaf mineral content, and providing the best yield with fruit quality.	Ahmed *et al.*, 2020
Papaya (*Carica papaya*)	Azospirillum + PSB	The result showed the maximum fruit yield per plant and per ha. In papaya.	Agrawal *et al.*, 2021
Pomegranate (*Punica granatum*)	vermicompost+PSB+ KMB+ *Trichoderma viride* + *Paecilomyces lilacinus*.	It showed that the biofertilizers enhance the vegetative growth and flowering behavior of the pomegranate plant.	Jat*et al.*, 2021
Mango (*Mangifera indica*)	Azotobacter chorococcum + Azospirillum brasilense + AM + Panchagavya	Maximum fruit weight, yield, and biochemical attributes such as TSS and total sugars, as well as a 10-day shelf life	Sau *et al.*, 2017
	Azospirillum + PSB + K-mobilizer	The result revealed that the soil microbial population, leaf and soil nutritional status, flowering shoots, yield, and fruit quality are all improved.	Kundu*etal.*, 2018
Strawbarry (*Fragaria* × *ananassa*)	Vermicompost + Azotobacter + PSB + AM	Result revealed the maximum height of heplant, plant spread, number of leaves per plant and maximum leaf area.	Singh et al., 2015
Litchi (*Litchi chinensis*)	AMF + *Trichoderma viride* + *Azotobacter chroococcum* + *Bacillus megatarium*	Increase in growth indices such as tree height, girth, spread, and chlorophyll content in leaves.	Kumar *et al.,* 2018

Conclusion

Plant growth regulators are essential regulators of several physiological processes in commercial fruit production. Biofertilizers are non-toxic to the environment and play an important role in crop production in fruit crop. PGR's and biofertilizers are very responsive to increase the production of crop by improving the quality and soil nutrient content, and to available the nutrient to the plant. The present review study on the PGR's and the Biofertilizers in fruit crops gives the information about the utilizations and effectiveness of different hormones and Biofertilizers in combination/ alone on the quality and yield of the fruit crops. PGR's like Auxins, GA, SA, BRs and etc. have many uses and less toxic to the plant which ultimately gives a successful production of the fruit crops. Biofertilizers like Azotobacter, Vesicular Arbuscular Mycorrhizae (VAM), Azospirillium, PSB, mycorrhiza, plays an essential role in production of any crop. They provide nutrient, make the nutrient available to the plant as well as keep the soil healthy, fully loaded with essential microorganism which gives a positive result in the production of the crop. Many studies in this review revealed the utilization of the PGR's and Biofertilizers in the fruit crops and their results towards the higher yield, good quality production and ultimately benefits to the farmers.

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