Advances in Bioresearch
Adv. Biores., Vol 14 (2) March 2023: 162-171
©2023 Society of Education, India
Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.14.2.162171

Advances in Bioresearch

REVIEW ARTICLE

Effect and Importance of plant growth regulators and molecular approaches on Fruit cuttings for development of fruit crops: A Review

Akshay Kumar, Vikram Singh*, Vishal Johar, Pankaj Kumar and Suprikesh Kumar Kadlag
Department of Horticulture, School of Agriculture,
Lovely Professional University, Phagwara, Punjab, India- 144411
* Corresponding author: vikram.26038@lpu.co.in

ABSTRACT
It is a prevailing wisdom that plants require water, sunlight, nutrient rich soil, oxygen and other contributors in order to grow and develop. However, apart from these external factors, there is a whole other realm of internal factors affecting plant's growth, appearance, yield and resilience. These internal factors are encompassed under one umbrella term – Plant growth regulators. These regulators are garnering a massive spotlight as these have a colossal potential in revolutionizing the horticulture in particular and agriculture in general. Following review dives deep into the types of plant growth regulators (also called hormones) and their practical uses, various experiments displaying effect of combinations of these regulators in certain plant cuttings, and how we can harness the ability of these regulators to signal, regulate, and control plant growth and development. This review also discusses how the amalgamation of genetics and biochemistry birthed various molecular approaches in order to affect fruit size.
Keywords: plant growth regulators, phytohormones, Fruit Crops

Received 25.12.2022 Revised 08.02.2023 Accepted 13.03.2023

How to cite this article:
A Kumar, V Singh, V Johar, P Kumar and S Kumar Kadlag. Significance of edible fruit coatings for improving the socio-economic status of fruit growers: A review. A Review. Adv. Biores. Vol 14 [1] March 2023; 162-171

INTRODUCTION

Thimann propounded the term "phytohormone" and these hormones are harmonized in plants. Plant growth regulators are the organic substances produced naturally in plants and play a substantial role in the growth and development of fruit crops as well as in agriculture crops too. They include auxin, gibberellins, cytokinin, and ethylene as growth promoter and abscisic acid as a growth retardant. The naturally occurring growth substances are commonly known as growth hormones while synthetic ones are called growth regulators. PGRs include hormones, but hormones do not include all PGRs. From the past history or recent data from ten to twenty years, we have concluded that we promote the growth and development of fruit crops by using plant growth regulators. Recent overviews on different PGR use in fruit production have been presented by [6]. Auxin is the first hormone discovered in plants, then gibberellins and cytokinin were discovered too, and later on, another was also discovered. By using plant growth regulators we modify or regulate the physiological growth of the plant. The doses are used in a very small concentration or small amount and they are quickly absorbed and rapidly move to the entire portion of the plant and give a better result [48]. Plant growth regulators in horticulture are playing a key role in boosting production with great advantages. The application of plant growth regulators in horticulture shows good results [17].

CLASSES OF PLANT GROWTH REGULATORS

Auxin

IAA (Indole Acetic Acid) is the naturally occurring Auxin in plants which promotes the growth of the plant. At low concentration it promotes the growth but at high concentration, it retards the growth. Auxin includes IAA, NAA, IBA, 2-4D, 4-CPA. The site of production is shoot and root tips, young expanding leaves, and seeds. In the past few years in many studies, we have found the role of auxin in signaling growth and development of plant. The Auxin response factors (ARFs) play a major role in the nuclear auxin pathway, though the ARF family contributes in multiple ways in response to plant development. We learned about ARF transcription factors which extrapolate many challenges in the near future [43].

Gibberellin

Gibberellins are organic compounds which promote several metabolic activities in plants. They play a considerable role in improving the seed germination, root and shoot elongation, flowering, growth of fruit crops, quality, and yield too. Gibberellin includes GA3. The Site of production is Embryos, roots, and young leaves. Many studies have indicated that GA is the mobile signal in plants and a number of developmental and adaptive growth processes require the mobility of GA to take place properly and a large number of proteins involve so far in GA transport which is essential for the growth and development [27].

Cytokinin

Cytokinin promotes cell division and is also known to delay senescence. Cytokinin was first found in corn and was referred to as "zeatin". Cytokinin contributes predominantly in plant growth and improves fruit size and fruit quality, and it is highly relevant in reducing long juvenile phase in those fruit trees which are linked with perennial fruit tree species. Cytokinin includes Kinetin, Zeatin. It is also known to be a vital plant growth regulator with respect to plant's resistance to stresses such as heat stress, cold stress, salt stress, and drought stress. Cytokinin response factors (CRFs) are involved during abiotic stresses and direct spraying of exogenous cytokinins is a quick and effective way for plants to survive in stress [73].

Ethylene

Ethylene is produced by many plant tissues in a very paltry amount and they are very powerful growth regulators that help in the development of fruit crops. They are found in matured fruit when fruits are under the ripening process. Ethylene is shown to break dormancy in plants and thus promote their growth. Ethylene includes Ethereal [19].

Abscisic acid

Abscisic acid is also known as growth retardant. When the loss of water occurs in the plant then an increase in the level of abscisic acid is found which consequently inhibits shoot growth and has very less effect on root growth. Abscisic acid includes, Dormins, Phaseic Acid. It plays a chief role in plant response to abiotic and biotic stress as well as in the regulation of seed development and germination [42].

Plant Growth Regulator Class, associated functions, and Practical uses

Class	Functions	Practical uses	References
Auxin	Shoot elongation	Thin tree fruit, increase rooting and flower formation	[10]
Gibberellins	Stimulate cell division and elongation	Increases stalk length, increases flower and fruit size	[8]
Cytokinin's	Stimulate cell division	Prolong storage life of flowers and vegetables and stimulate bud initiation and root growth	[1]
Ethylene Generators	Ripening	induce uniform ripening in fruit and vegetables	[20]
Growth inhibitors	Stops growth	Promote flower production by shortening internodes	[71]
Growth retardants	Slow growth	Applied in agriculture and horticultural crops to reduce unwanted longitudinal shoot growth without lowering plant productivity	[59]

EFFECT OF PLANT GROWTH REGULATORS IN FRUIT CROPS

Apple

The main aim of this experiment is to showcase the effect of plant growth regulators on Gala apples. They are using 300 mg L-1 ethephon, 400 mg L-1 pro-hydro jasmonate, and 400 mg L-1 abscisic acid. After applying these plant growth regulators, they enhance the red color of fruit and degradation of chlorophyll also occurs. However, this experiment was mainly conducted to enhance the color of Gala standard apples (Malus Domestica). Ethylene is the main growth regulator used to enhance fruit red color applied in the form of Ethrel; its application advances fruit maturity, allows early harvest, also increases red color in fruit skin even so ethephon application may reduce organoleptic quality and decrease the storage potential of fruit after harvest [12] [13]. However, Jasmonate and abscisic acid gives a positive effect on fruit ripening; their positive effect may be found in Fuji and Gala cultivars and results obtained from the application of prohydrojasmonate enhance the red color of the Mondial Gala cultivar [6]. The result obtained in Italy with Gala Brookfield cultivar also demonstrated the effect of abscisic acid in improving the red color of fruits [23]. This study also revealed that the fruit weight and soluble solids are not affected by the application of plant growth regulators. The prohydrojasmonate did not affect the fruit weight and soluble solids contents of Gala apple in United States in the experiment performed during two seasons in the years 2015 and 2016. Notably, 2016 season gave better results in which prohydrojasmonate and abscisic acid promoted red color of fruit without bracing the ripening process and without damaging the fruit quality [14].

Pre-harvest foliar application of growth promoters on Guava

The experiment was conducted at the Lovely Professional University's department of horticulture and Punjab Agricultural University's department of vegetable science. The experiment entailed pre-harvest foliar application of growth promoters like NAA (Naphthalene Acetic Acid) 100-200ppm, GA3 (Gibberellic acid) 20-75ppm, and Triacontanol) 5-15. After the application of these different growth regulators, it became apparent that out of all these different concentrations, the NAA 200 ppm gives better result and recorded maximum fruit size (53.14cm2) and fruit weight (138.53gm). This experiment was conducted on Guava (Psidium guajava) cv. Allahabad Safeda fruit was effective and enhanced the quality and increased the fruit yield. We observe from the conducted experiment that the pre-harvest application of NAA 200 PPM and 150 PPM is a very coherent technique to improve the physicochemical traits of the guava fruit crop and GA3 75 PPM and NAA 100 PPM are also beneficial in promoting guava fruits in the winter season. [31].

Guava

Role of plant growth regulators in guava (*Psidium guajava* L.) cultivation, Guava is an important fruit crop that is grown commercially in subtropical to the tropical region of the world. In India, productivity is low as compared to other countries. And for that many technologies have been developed and some of the most important were HDP, crop regulation, orcharding, use of improved varieties and hybrids, and use of growth regulators. Out of these technologies application of plant growth regulators plays a significant role in all stages of growth and development because they help to improve the final yield and quality of produce. It is proven that the use of PGRs is a powerful tool to enhance fruit production directly or indirectly according to our demand. PGRs increase the seed germination in the guava crop because germination of guava seed is in doubt due to hard seed coating over the endocarp. The application of GA3 improves germination as well reduces the germination period [28]. In guava propagation, PGRs play a very important role because guava is a hard root and therefore propagated through cuttings, hardwood, semi-hardwood, and softwood cutting because cutting treated with IBA at 1000ppm will improve the rooting percent by 37%, and cutting treated with NAA and dilute coconut water produced 100% healthy roots and shoots [2]. Spraying of GA3 at 15 to 30 ppm in January proved to be effective in increasing fruit retention and fruit yield in guava [36]. Sometimes flower killed in the rainy season results in auxin forcing the plant to produce more flower from reserved food materials and giving more fruit set and yield. Exogenous application of auxin increased the sink strength because the movement of metabolites takes place from a weaker sink to a stronger depends upon a hormonal level [3]. The role of PGRs in canopy management plays a very important tool to put up more plants per unit area by adopting different planting systems like Paclobutrazol and ethephon useful in high-density planting. Role of PGRs on crop regulation and fruit thinning, crop regulation plays a very important role in every crop as well as in guava to get more benefits. Growth regulators also enhance the shelf life of guava with the help of certain post-harvest treatments like Gibberellic acid, 2,4-D, Malic hydrazide, and Benzyl adenine applications the fruit will increase or extend the shelf life [30]. Growth regulators also improve the quality attributes and increase the TSS in many fruit crops like 2, 4-D increased the TSS in Allahabad safeda, NAA (40-80ppm) help in increasing TSS in guava and over all development of the fruit [55].

Use of auxin and gibberellins used at different concentrations to control Fruit drops and also improve the quality of fruit crops

Conducted an experiment in which they provided some information regarding the use of plant growth regulators for improving fruit production in subtropical crops by doing foliar of plant growth regulators application. We can improve the yield and quality of fruit crops [56]. The use of plant growth regulators became an important component as excessive fruit drop can easily be controlled by application of plant growth regulators - Auxin and gibberellins can be used to control fruit drop and to improve the quality of fruit [4]. Indicate that NAA 40 ppm is effective in increasing numbers of fruit per tree, fruit length, fruit diameter, fruit weight and fruit volume, TSS, total sugars, and non-reducing sugars against control in pomegranate cv. Bhagwa [50].and fruit-treated GA3 at 20ppm keeps higher fruit weight (128.6g) more firmness (3.54kg/cm2), and better juice recovery (57.75%). And in this research use of 50 ppm GA3 was found efficacious in incrementing the yield by around 37.13kg/plant, pulp weight by 173 g, juice content by 63.17 cc, TSS (12.50 0Brix), Ascorbic acid (135.30 mg /100gm), total sugar (10.13%) seed weight (6.67gm) and sugar-acid ratio (33.13) increases in cv. Allahabad safeda [35].

Plant growth regulators helps in improving the fruit set, quality and yield of fruit crops

[30]. Presented a study over the role of plant growth regulators in improving fruit set, quality, and yield of fruit crops. With the use of plant growth regulators we are getting some outstanding achievements in respect of growth, yield and quality [59]. Impact of NAA (40, 50, 60 ppm) and GA3 40, 50, 60, ppm) on fruit set and yield of pomegranate cv. Bhagwa. In this experiment, we observe that the NAA 40 ppm was very effective and thus increased the number of fruits per tree (62.44), increase fruit length (8.66cm), fruit diameter (8.71cm), fruit weight (262.23g), fruit volume (255.44ml), TSS (16.760 Brix, total sugar, (15.58%), reducing sugar (13.83%), non-reducing sugar (1.75% [4]. In this experiment, the effect of GA3 at 100 ppm, 6-benzylaminopurine (BAP) at 100 ppm, and Boric acid at 250 ppm and their application over Barhee date palm gives a good result like increase in fruit set, fruit retention bunch weight, fruit quality, and yield [5]. Effect of plant growth regulators on flowering, fruit set, and yield of custard apple and fruit were sprayed with different plant growth regulators viz., NAA (50, 75, 100 ppm), (GA3 50 75, 100 ppm), Ethrel (100, 200 and 300 ppm). These growth regulators were sprayed two times i.e., first, spray at the flowering stage and second at the fruit set stage and the result revealed that the NAA 100 ppm gives the maximum number of flowers per shoot (28.11) and the highest percentage of fruit set (70.13%), the lowest percentage of fruit drop (15.78%) the maximum number of fruit per plants (59.83) fruit weight (186.35g) and maximum fruit yield (11.18kg/plant) and maximum fruit yield (44.72qt/ha) recorded in the treatment of GA3 75 ppm, and from a whole experiment we concluded that foliar applications of GA3 75 ppm at full bloom stage gives higher yield and Ethrel increases the ethylene production in leaves which further helps in early ripening Ethrel 300 ppm takes minimum 111days was required for flowering to harvesting is recorded [41]. In this experiment, we study the effect of pruning and plant growth regulator like GA3, IAA, NAA, 2,4-D rejuvenation of physical-chemical qualities in sapota plant, and the plant is treated with these growth regulators (G1) at the control level, (G2) 20ppm, (GA3) 50 ppm NAA, G4 100ppm IAA, G5 20ppm 2,4-D as foliar spraying is applied and the result shows that the highest fruit weight (138.066g), pulp weight (120.076g), TSS (24.6860 B), ascorbic acid (14.63g/100g), and acidity (0.146%) were found in pruned branch tree, and out of growth regulators NAA 50 ppm give the highest ascorbic acid content (14.666mg/100g), and GA3 20 ppm bring out the highest fruit weight (134.494g), pulp weight (115.974g), TSS (24.9080B), lowest acidity (0.15%), seed weight (1.116g). Hence, we observe that a proper combined effect of pruning and growth regulators has a better effect on growth and yield [51].

Strawberry

The effect of bio fertilizers and growth regulators on the growth, flowering, fruit ion content yield, and fruit quality of strawberries, and through this experiment, we concluded that an appropriate combination of biofertilizers and growth regulators may improve the overall plant growth, fruit yield, and quality [57]. The three different biofertilizers viz. Azatobactor (10kg /ha), PSB (6kg/ha), and VAM (12 kg/ ha) and three plant growth regulators viz. GA3 (100 ppm), Triacontanol (5ppm), and NAA (50 ppm) are tested separately, and the combined application of biofertilizers and growth regulators (i.e., PSB@ 6kg/ha + GA3 @ 100ppm) helped in increasing the plant height, number of leaves and leaf area. The application of bio-fertilizers such as PSB helped to increase the biological nitrogen fixation and availability of phosphorus which is required for strong vegetative growth [33]. The physical characteristics of strawberry fruit are also affected by treating the plants with PSB (6kg/ha) + Triacontanol (5 ppm). The anion and cation content of strawberry fruit is positively affected by the application of biofertilizer and growth regulators. [49].The plant treated with PSB (6kg/ha) + Triacontanol (5ppm) gives the highest fruit yield with improvement in TSS content (11.40 B), Ascorbic acid (63.67 mg/100mg of fruit pulp), and the plant treated with PSB (6kg/ha) + Triacontanol (5 ppm) record higher yield and this may also increase the phosphate and potassium content in the fruit. And Triacontanol application may increase the number of roots which can help the plant to take more nutrients from the soil and increase production [52]. In the experiment, we have concluded that a significant combination of biofertilizers and plant growth regulators may help to improve the overall plant growth, flowering, fruit ion content, fruit yield, and quality, and the nitrate, ammonium, magnesium, calcium, and sulfate content of strawberry fruit was found maximum in the plants who are treated with Azotobacter (10kg/ha) + GA3 (100 ppm) [58].

Peach

This study was conducted on the evaluation of different doses of indole-3butyric acid (IBA) on the rooting, survival, and vegetative growth performance of hardwood cuttings of Flordaguard peach (*Prunus persica* L.) Ten-year-old cutting was selected for the experiment and the basal portion of the cutting was dipped into different IBA doses IBA 1000ppm, 2000ppm, 3000ppm, 4000ppm, 5000ppm. After the treatment, the cuttings were planted at a distance of 15cm in rows. The cuttings treated with 3000ppm IBA solution took 7.05 days for sprouting and 6.0 days for rooting and the cutting treated with 3000ppm. IBA solutions gave the highest sprouting (94.45%) and survival percentage (90.55%), plant height (195.45cm), overall, the better development of a plant. And the application of 3000ppm IBA was the best in terms of rooting, survival, and vegetative of hardwood cutting of Florida guard peach. The beneficial effect of this work was that the rootstock plant of Florida guard peach, which is resistant to nematodes, became ready for budding/grafting in the field in one year instead of two years raised through seed, [29]. Also state that the different concentrations of IBA in Asian pear may improve the overall growth of the fruit [26]. The effect of the different levels of Indole-3-butyric acid on the growth and development of air layered lemon and this may have a very good effect on the growth and development of the lemon [37].

Pear

Impact of Plant growth regulators on the Endogenous Hormone Content of Calyx Development 'Korla 'Fragrant Pear [38]. Give a statement about the relationship between the endogenous hormone in the young fruit of 'KORLA' fragrant pear and the fall of calyx from the fruit. The hormone content is (Indoleacetic acid) IAA, Gibberellin acid (GA3), and Abscisic acid (ABA), of young 'Korla' pear treated with water, IAA and triiodobenzoic acid (TIBA) determined by high-performance liquid chromatography, and the result showed that the rate of calyx abscission in Korla pear fruit treated with TIBA was outstandingly higher than that fruit treated with water and IAA, and GA3 content was higher than the IAA and ABA contents during each period. The (IAA+GA3)/ABA in the calyx tube was significantly higher than that in the flesh and fruit stalk. After IAA treatment, the IAA, GA3, and ABA content of the first order calyx tube increased by 47.7%, 17%, and 31.6% respectively, and the fourth-order calyx tube increased by 65.3%, 39.9%, and 33.2% respectively. After TIBA treatment the first order calyx tube increased by 46.1%, 36.5%, and 50% respectively, the fourth-order tube IAA content is decreased by 25.5% and GA3 and ABA contents increased by 22.0% and 12.2% respectively. The IAA, GA3, and ABA contents of the flesh fruit stalk are not different from those in the calyx tube, and the result shows that spraying of IAA during flowering promoted calyx tenacity, whereas spraying of TIBA promoted calyx abscission. These all findings, research, and practical work improve the quality of 'KORLA' fragrant pear, and during the development of KORLA fragrant pear, the plant growth hormone shows a better result. For the research work, 30 'KORLA' fragrant pear trees were selected as sample plants, and 10 were sprayed with water. 10 were sprayed with 100mg/L of IAA, and 10 were sprayed with 100mg/L of TIBA [70].

Fig cuttings

The main purpose of this experiment is to illustrate the effect of natural plant growth regulators - mature coconut water, young coconut water, shallow extract - with the use of an appropriate concentration of PGR on fig cutting, in natural plant growth regulators the use of mature coconut water 20%, and 30%, young coconut water 20% and 30%, red shallot extract 60% and 70% and each treatment was repeated with three times, And also the use of manure, topsoil, husk charcoal and complementary fertilizer with a ratio of 1:1:1:1, The cuttings were soaked in PGR for 15 minutes, plant growth was nurtured with fertilization, watering, pest control, fertilized by using NPK 15:15:15 with the amount of 2g/plants and watering was done in two days. Coconut water was used to stimulate shoot growth in cuttings since coconut water is an abundant source of cytokinin. In case of ripened fruits, the content of cytokinin is reduced. The young coconut water has milk-like endosperm which is rich in auxin and cytokinin. And the result showed that the concentration of 20% and 30% young coconut water, matured coconut concentrations of 20% and 30%, and shallot concentrations of 60% and 70% increase the growth of fig plant cuttings. The effect of coconut water is decreased but mature coconut water increases the percentage of cutting up to 91.67%. So this result indicates that the mature coconut water still contains the percentage of cytokinin even if the amount has been reduced. Hence all these natural PGR can be used in this experiment increase the root and shoot growth in fig cuttings [16].

Plant hormone stress in fruit crops

Study about how plant hormone-mediated regulation of stress responses in fruit crops. Fruit crops are highly susceptible to different environmental stresses namely biotic and abiotic stresses. There are different causative agents found for different stresses like biotic stresses caused by fungi, bacteria, nematodes, viruses, weeds, and insects. And for abiotic stresses causative agent is climatic, physiographic, and different environmental factors which affect the plant development and productivity [63]. These stresses may engender morphological, physiological, biochemical, and molecular changes in plants [18]. Abiotic and biotic stresses typically interact in the ecosystem and mainly in horticulture crops. Abiotic stresses are important because they are considered cash crops and provide essential dietary elements, and quality of fruit production under abiotic stress conditions [47]. The phytohormone regulates normal physiological activities which manage the abiotic stress by forming signaling specific gene expression and they play a key role in promoting growth and development [68]. They include gibberellic acid (GA), auxin, cytokinin (CK), abscisic acid (ABA), ethylene (ET), salicylic acid (SA), jasmonates (JAs) involved in different stress regulation activities directly or indirectly, they act as a chemical messenger and these biomolecules allow plants to maintain normal growth under stress conditions [69]. To overcome the impact of environmental stresses, it is essential to use modern molecular approaches like association mapping, QTL mapping, marker-assisted selection, and whole-genome sequencing used to enhance the knowledge of tolerance of new cultivars. And to rectify the hormone stress in fruit crops the study of phytohormones is very essential because they have stress regulation mechanisms directly or indirectly without any negative effect on plants. Plant hormones are bimolecular compounds required in small quantities to regulate normal physiological activities [22]. There are various genes involved in the auxin-related pathway which shows the variation in expression during stress conditions [62]. GAs is growth-regulating hormones required in various developmental processes including germination, stem elongation, leaf expansion, and flowering. GA signaling in metabolism is critical for environmental factors and stress-tolerant in an adaptable physical environment, with the source and sinks relationship. It modifies the physiological metabolism in plants [67]. The (MEP) Methylerythritol phosphate pathway synthesizes the gibberellic acids in plastids from trans-geranylgeranyl diphosphate [9]. MEP pathway is present in higher plants and localized in the chloroplast and cytoplasm respectively. And GAs is modified by the degradation of DELLA protein which regulates the gene expression by acting as transcriptional activators, and they also interact with other phytohormones at the molecular level during stress conditions [15]. Abscisic acid plays important role in mediating stress responses when environmental conditions are unfavorable for plant growth and it results in stress responses at a cellular level [45]. And ethylene has the same activities as ABA for senescence but has a different site of action and regulates biotic and abiotic stresses. Ethylene also participates in growth and development and stress responses tools in plants. Salicylic acid enhances tolerance in plants against many external stresses including osmotic stress, salt stress, chilling, and heavy metal stress [22]. Jasmonates (JA) involve in various developmental processes and stress mitigating activities - under stress conditions they play important role in the physiological and molecular responses under abiotic stress conditions [71]. Jasmonic acid regulates water loss under drought conditions; it regulates the opening and closing of stomata Brassinosteroids (BRs) play a cardinal role in cell division and elongation, reproductive development, and leaf senescence. They also regulate secondary metabolites [53].

Molecular approaches in plant growth regulation of fruit crops

The use of molecular approaches has been successful for the development and growth of plants by the use of genetics. In particular, the combination of genetics with biochemistry and molecular biology allows the study of plant growth, development, and gene functions. Molecular approaches allow the generation of a plentiful amount of data at multiple levels of experimentation from gene sequence and expression to protein and specific traits. That will help in the understanding of growth regulation at the gene level in fruit crops. In this, we can discuss the pragmatic use of gene sequencing, transcription study, and protein synthesis that regulates the traits in different horticultural crops and their approaches. Different techniques like PCR, SDS-PAGE, transgenic technology, gene annotation tools, and DNA microarray method are used to study various gene functions in molecular approaches. The various positive results may find after doing molecular approaches in fruits crops [46].

Molecular regulation of fruit size in horticultural plants

The fruit size is a quintessential indicator of fruit yield and quality. There are several molecular mechanisms that are involved in the resolution of fruit size, including hormonal regulation (IAA, GA, CK, ABA, ETH, and BRs) CLV-WUS signaling pathway, MADS-box family, ubiquitin-proteasome pathway, (QTLs) quantitative trait loci, MicroRNA, and endoreduplication [74]. Fruit development is usually grouped into three different stages i.e., fruit set, fruit growth, fruit maturation, and fruit size are important to trade characteristics in flowering plant species, Plant hormone regulates the various plant growth and development process and also responds to environmental and endogenous signals in response to fruit development and fruit size [34].

Some examples of genes involved in the fruit size regulations of horticultural plants like auxin

Pathways	Species	Gene name	Function in fruit size	References
Auxin (IAA)	Apple	ARF106	ARF106 related to strong QTL (Quantitative trait loci) for fruit weight	[21]
Gibberellin acid (GA)	Pear	PbGA20ox2	PbGA20ox2 promotes fruit set and Parthenocarpic fruit development	[66]
Ethylene (ETH)	Melon	CmACS7	Associated with round fruit	[11]
Abscisic acid (ABA)	Strawberry	FveCYP707A4a	FveCYP707A4aRNAi fruits exhibit smaller size and lighter weight	[39]
MADS-box family	Apple Strawberry	MdMADS8/9 FaMADS9	Suppression of MdMADS8/9 leads to significantly reduced fruit flesh Suppression of FaMADS9 leads to significantly reduced fruit flesh	[25] [54]
Ubiquitin-proteasome pathway	Chinese jujube	ZjDA3	A negative regulator in regulating fruit size	[24]
MicroRNA	Apple Apple Orange	MiRNA172p Md-miRNA156 Pt-miR156a	Elevated miRNA172p expression leads to significantly reduced fruit size in apples while miRNA172 with reduced expression leads to large fruits Overexpression of apple Md-miRNA156 in Arabidopsis resulted in short siliques Overexpression of orange Pt-miR156a in Arabidopsis resulted in short siliques	[72] [60] [67]

CONCLUSION

In conclusion, plant growth regulators (PGRs) are becoming a salient feature of horticulture and agriculture all across the world, Recent experimentation and particular case studies of applying PGR to apple, guava, strawberry, peach, and fig have elucidated that these organic substances are highly efficacious in order to increase fruit quality, yield, pulp weight, seed weight along with decrease in fruit drop. Apropos combination of bio fertilizers and PGRs have been successful in mediating biotic and abiotic stresses resulting in greater plant resilience and tolerance. Furthermore, modern molecular approaches analyzed using techniques such as DNA microarray and others have promised changes such as increasing branching, suppressing shoot growth, increasing return bloom, removing excess fruit, or altering fruit maturity. However, best results are obtained when PGRs are used in germane quantities along with safety precautions and having important role in commercial fruit production.

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