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Use of plant growth regulators on vegetative propagation of fruit crop

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Abstract
Fruits plays vital role in one's health as it's a highly nutritive commodity because of that fruits tree possess a high value. As the breeding aspect of production of fruits are already on a complete verged of efficiency. Plant growth regulators are organic compounds which are generally produce by plant itself which influence the fruit physical and chemicals parameters like colour, texture, taste, TSS etc. Synthetically build PGRs are also available in market which has shown an when applied in right quantities or concentrations has improved the factors like fruit quality, plant growth and has also affected the various physiological disorders, and have improved the market value of fruits. Growth inhibitors include gibberellins, cytokinins and auxins, whereas growth retardants include abscisic acid and ethylene. The study of plant growth regulators, as well as their usage and impact, are discussed in this paper.

Keywords: phytohormones, auxin, growth-promoters, fruits, applications

Introduction
In reaction to their surroundings, all plants spontaneously create hormones that regulate metabolism, growth, and development. Hormones are made in a variety of places and circulated throughout the plant system until they connect to receptors and cause reactions in specific cells. Auxin, cytokinin, gibberlin, abscisic acid, and ethylene are examples of phytohormones known as plant growth regulators (Small *et al.*, 2018) [1]. Auxins became the first hormones to be found in plants, followed by gibberellins and cytokinin's. In the past half century, much study has been conducted in the country on a variety of topics, including cultivars, propagation, irrigation, training, and pruning. It is a typical occurrence for low-quality fruits to be produced. As a result, foliar application of plant growth regulators to boost the quantity and quality of fruit crops would be profitable (Kumari *et al.*, 2018) [3].
Plant hormones are organic chemical substances that, when applied in modest concentrations, affect or regulate physiological processes in plants in a significant way. When applied to various plant parts, they are quickly absorbed and spread through the tissues. These compounds have a very specific impact. As a result of the usage of plant growth regulators, several excellent achievements in terms of growth, production, and quality have been achieved in various fruit crops (Ruchitha *et al.*, 2021) [4]. Vegetative propagation is the process of reproducing, regenerating, and multiplying plants. It is a practical method of obtaining particular features from a tree that would otherwise be lost through sexual propagation. While the majority of plants reproduce sexually, some reproduce vegetatively and others are triggered by hormonal therapies (Awotedu *et al.*, 2021) [2].
The usage and application of plant growth regulators in agriculture has a bright future, particularly in the case of horticultural crops. Understanding how the information supplied by these basic chemicals is incorporated during plant growth would be a huge task (Santner *et al.*, 2009) [5]. Aside from that, future research into optimising growth conditions and increasing the self-life of plant growth promoting rhizobacteria (PGPR) products that are not phytotoxic to crop plants, tolerate harsh environmental conditions, produce higher yields, and are cost effective will be beneficial to agricultural farmers (Verma *et al.*, 2017) [6].

Classification of Plant Growth Regulators
The main division of endogenous PGRs is divided into five classes. Auxins, gibberellins, and cytokinin's are examples. Ethylene with abscisic acid. Auxins and GAs have been categorised as cell elongation regulators, while Cytokinin's have been classified as cell division regulators. ABA has a general inhibitory effect, whereas ethylene is a volatile that has a hand in a variety of developmental processes. These kinds of descriptions are clearly simple, and they represent futile attempts to categorise PGRS based on their effects on plant tissues (Roberts, 2012) [7].
The synthetic auxins 2, 4-dichloro phenoxy acetic acid and naphthalene-1-acetic acid, which are commonly used in basic research and applications, do not function exactly like the natural IAA. Only a few of the auxins known, such as 4-chloroindole-3-acetic acid, phenylacetic acid and indole-3-acetic acid are successfully synthesized by plants and can be considered 'endogenous auxins' (Skůpa *et al.*, 2014) [8].

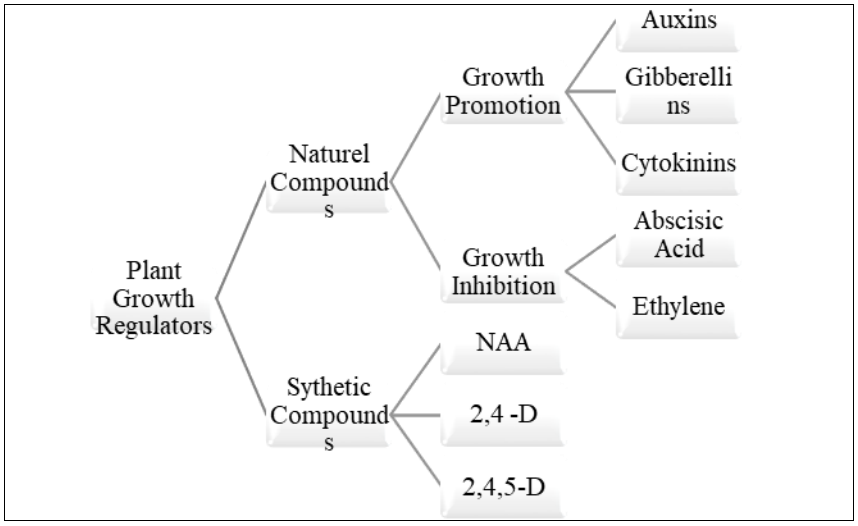

Fig 1: Classification of Plant Growth Regulators

Auxin

According to (Kogl and Haagen- Smit 1931), the name auxin was created to describe plant hormones that are particularly concerned with cell expansion or cell elongation. Auxins were phytohormones that were created in the shoot and root apices and moved from the apex to the elongation zone. 1- Naphthaleneacetic acid is a plant hormone that is produced from auxin that commonly used to propagate plants vegetatively from stems and cuttings. The effect of NAA on plant growth is very dependent on the time and concentration at which it is administered. NAA has been demonstrated to significantly stimulate the synthesis of cellulose fibres in plants. Fruit drop is managed in the majority of fruit plants by spraying NAA in various concentrations on different fruit crops. It's used after the blossoms have been fertilised (Kumari *et al.,* 2018) [3]. Auxins have significant effects on the sprouting of fruit trees by affecting the differentiation of xylem and phloem and the lignification process, which is considered a very important factor in the formation of a strong unit area during grafting and sprouting (Kako *et al.,* 2012).

PGRs have an effect on pomegranate cuttings. Maximum rooting, root number, and root length were seen in semi-hard and hardwood cuttings when IBA 500 ppm + Borax 1 percent was used. Cuttings handled with IBA 300 ppm+ Borax 2%, IBA 5000 ppm, and IBA 500 ppm+ Borax 1%, had the best field survival. In comparison to semi-hardwood cuttings, hardwood cuttings respond better to hormone therapy (Sharma *et al.,* 2009). Guava Softwood cuttings treated with IBA at 1000 ppm produced the most roots and had the longest shoot. Processing of semi-hardwood and softwood cuttings with 1000 ppm NAA showed early blooming and maximal root length, accordingly (Ruchitha *et al.,* 2021) [4]. The effect of growth regulators on the rooting of Dragon Fruit stem cuttings was investigated. The data and best results were discovered in IBA 7000 ppm: Average of cuttings rooted, The longest root's length, The average no of roots per cutting, and also the average length of each cutting's roots (Ayesha and Thippesha, 2018) [11]. In Satsuma mandarin, foliar sprays of 0, 10, 30, and 60 ppm 2,4-D reduced pre-harvest drop, drastically decreased proportion of small, very small fruit size, and increasingly large and marketable fruit size when compared to control (Amiri *et al.,* 2012) [12]. Its use of NAA at 250 ppm in the guava cv. Allahabad Safeda resulted in the maximum yield and fruit quality during the monsoon season and the largest deblos soming of the crop during the winter season (Dubey *et al.,* 2002) [3].

Gibberellin

The gibberellins were discovered by coincidence in a unique way. In the 20th century, Japanese farmers Kurosawa observed that some rice plants were larger in size, smaller in size, and paler than normal plants, had longer and narrower leaves that outgrew their uninjured neighbours, and were sometimes fruitless (Bisht *et al.,* 2018) [14]. Gibberellins regulate fruit development in a variety of ways and at various stages of development. Fruit production is a time-consuming and meticulous procedure. Hormones may influence the activity of developing fruits, that are particularly metabolically active and serve as large nutritional losses (Kumari *et al.,* 2018) [3]. They found foliar spraying of GA3 at 25ppm, boosted yield and fruit size in 'Hass' avocado (Garner *et al.* 2011). The application of GA3 to red jambu air madu fruits increased fruit length and width, according to (Moneruzzaman *et al.,* 2011) [16]. The spraying of GA3 (50, 100, and 150 ppm) accelerated the emergence of fresh shoots, increased length of shoot, and increased the highest number of leaves per branch in sapota (Bhujbal *et al.,* 2012). The treatment of GA3 at 80 ppm to strawberry increased acidity, runners' development, ascorbic acid, and vegetative growth, according to (Kumar *et al.,* 2012) [18].

GA, on the other hand, was shown among several other plant growth regulators, to become the most responsive for vegetative characteristics such as runner development. In strawberries, NAA at 100 ppm proved effective in reducing yield characteristics (Suvalaxmi *et al.,* 2016). Gibberellic acid causes increased division of cells, which boosts plant vegetative development. GA3 reduces strawberry blooming, and as a result, vegetative growth, as measured by the production of runners, improves (Rana *et al.,* 2020) [20]. While in strawberry cv Chandler, 2

foliar applications of 100 ppm GA3 at one month after sowing and fifteen days after blooming resulted in leaf quantity, crowns for each plant, plant height, and runner per plant with the maximum value (Narayan, 2014) [21]. In pomegranate cv. Ganesh, a spray with GA3 75ppm enhanced fruit size and yield (Reddy and Prasad, 2012) [22]. The result of a 10-ppm spraying of gibberellic acid at the fruit setting stage on fruit quality was studied quickly after harvest on young 'Kinnow' mandarins (Khalid *et al.,* 2012) [23].

Cytokinin's

The creation of cytokinin's could be followed back to Folke Skoog's laboratory at the University of Wisconsin during the 1940s. The term cytokinin's refers to every one natural compound chemical that have been shown to encourage cell division. Cytokinin is a term created by (Letham, 1963) [24]. Cytokinin's is a special class of plant growth regulators with a fascinating history. It took more than a century for their presence as chemicals effective of stimulating cell growth in cultivated plant tissues to be discovered (Kaminek, 2015) [25] Cytokinin's regulate a variety of physiological and biochemical processes, throughout a complex network of cross-talk routes, involving axillary shoot branches, the releasing of root meristematic cell pattering, apical dominance as well as the creation of lateral roots (Koprna *et al.,* 2016) [26]. Discoveries of Cytokinins associated activities or quantities increasing raspberry, kiwifruit, grapefruit, and strawberry are examples of fruit crops that have immature seed and developing fruits show that CKs play a significant role in flower and fruit growth (Böttcher *et al.,* 2015) [27]. The soluble carbohydrate component of the fruit osmotic pressure was considerably changed by dipping kiwifruits in 10 mg/L CPPU (Nardozza *et al.,* 2017) [28]. Throughout axillary bud growth and flowering in apples, evidence of the expression of various gene associated with Cytokinin's activities was found (Tan *et al.,* 2018) [29]. In bananas, the impact of 10 mg/L CPPU on inhibiting ripeness was also observed (Huang *et al.,* 2014) [30]. The effect of CPPU and MT (at 100 mg/L) in increasing the fruit size of sweet cherry 'Bing' by 15% was attributable to increased cell multiplication rather than fruit enlargement (Zhang *et al.,* 2011) [31]. BA (100 mg/L), for example, properly encouraged lateral branching in immature apple trees (Aremu *et al.,* 2020) [32]. In pear, 100 mg/L BA increased fruit vegetative growth significantly without affecting yield or fruit morphology (Canli and Pektas, 2015) [33].

Abscisic acid (ABA)

This hormone is widely distributed in higher plants and can be detected in a lot of organs and tissues. ABA affects the leaf of a wide range of plants to abscise, as well as the fruits of some plant species. At least some temperatures region woody plants' buds appear to be affected by ABA, which appears to be an internal component that causes dormancy (Bisht *et al.,* 2018) [41]. Exogenous administration of ABA was shown to affect the ripening process in several climacteric fruits like bananas and kiwi fruit by regulating endogenous ABA levels (Zaharah *et al.,* 2012) [53]. As a new and potentially helpful chemical thinner, ABA has arrived on the horizon. On both apples and pears, he has always been demonstrated to be an effective thinker (Greene, 2009) [35].

Ethylene

Ethylene is a natural hormone produced by plants that has a number of impacts on the health, development, and storage stability of a variety of fruits and vegetables. The bioactivity of ethylene is influenced by both internal and external sources, which can be purposely or indirectly exposed to biologically active quantities of ethylene in harvested fruits (Suman *et al.,* 2017) [36]. Ethephon treatment causes a larger percentage of flower bud development in pineapple (Onaha *et al.,* 2001) [37]. foliar spray of 0.5 gm PBZ + 0.4 gm ethephon / l increased blooming in litchi with inconsistent fruiting, according to study (Ramburn, 2001). Urea 2% + Ethrel 200 ppm was also proven to be really effective. In comparison to the control, these treatments dramatically increased fruit quality throughout the years of the trial in mango (Karuna *et al.,* 2007) [39]. Throughout berry maturation, ethylene is engaged in the diametric rise, or isodiametric growth, of grape berries, as well as the decrease in acidity and increase in anthocyanins (Chervin *et al.,* 2004) [40].

Table 1

Fruit crop	Plant Growth Regulators	Concentration	Effect of PGR on fruits	References
Ber Cv. Umran	NAA	10 ppm	Increased fruit yield	(Bons *et al.,* 2020)
Orange Cv. Hamlin	2,4, -D	10 ppm	Pre-harvest fruit drop can be minimized.	(Kumari *et al.,* 2018)
Plum	GA_3	10 ppm	Increased vegetative growth and fruit weight, volume and yield	(Sharma and Singh, 2008)
Sapota	GA_3	150 ppm	Early sprouting, increased shoot length and no of leaves per shoot.	(Bhujbal *et al.,* 2012)
Strawberry	GA_3	80 ppm	Vegetative growth, runners, ascorbic acid, as well as acidity all improved.	(Kumar *et al.,* 2012)
Grape	CCC	3000ppm	Improve yield and vine.	(Suman *et al.,* 2017)
Guava	CCC	250 and 500 ppm	Enhance fruit set and improve weight	(Suman *et al.,* 2017)

			and quality of fruit.	
Guava Cv. sardar	NAA	80 ppm	Improve in TSS, total sugar.	(Kher *et al.*, 2005)
Sapota Cv. kalipatti	NAA	150 ppm	Maximum no of fruit, higher yield.	(Bons *et al.*, 2020)
Phalsa	NAA	200 ppm	Bush height or shoot length maximums.	(Kacha *et al.*, 2012)
Guava Cv. Allahabad safeda	GA_3	50 ppm	Improve yield, pulp weight, juice content, TSS, ascorbic acid, total sugar, seed weight and sugar acid ratio.	(Lal and Das, 2017)
Pomegranate Cv. Bhagwa	NAA	40 ppm	Increasing fruit per plant, fruit length, fruit diameter, fruit weight, fruit volume, TSS, total sugars and other chemical parameters.	(Anawal *et al.*, 2015)
Date palm	NAA	150 ppm	Increase yield and fruit quality.	(Harhash and Al-obeed, 2007)
Guava cv. Allahabad Safeda	Ethephon	1000 ppm	Tree height and canopy volume must be kept to a minimum.	(Singh and Bal, 2007)
Peach cv. July Elberta	Ethephon	250 mg./L	75% fruit thinning and improve fruit weight.	(Ali *et al.*, 2012)
Sweet Cherry cv. Windsor	Ethephon	500 ppm	Affect fruit quality and increasing weight and colours.	(Smith and whiting, 2010)
Pear	CPPU	10 to 20 ppm	Full bloom, increasing fruit size and better performs.	(Flaishman *et al.*, 2001)
Kiwifruit	CPPU	2.5 to 40 ppm	Increased treated fruit size and gave better fruit shape.	(Lawes *et al.*, 2001)
Apple cv. Royal Gala	CPPU	10mg/L and 50mg/L	Full bloom, improve fruit size and no effect on fruit drop, fruit shape, and seed number.	(Stern *et al.*, 2002)
Mango cv. Zihua	ABA	5 mg/L	Improve plant growth and promoted fruit softening.	(Zaharah et al., 2012)

Conclusion

Plant growth regulators are signification role in fruit crop and their production. PGRs enhance the fruit quality and stress tolerance in open and under protected condition. PGRs improve shelf life of fruit, flower, fruit as well as improve the vegetative growth in horticulture crop. Plant growth regulators reduced chemical and physiological side effect of fruit and plant. PGRs help to reduced economic cost, labour requirement and other nutrient requirements. It applied at various stage of plants and different concentrations. Its not like another agriculture chemicals which required in higher quantities a small amount or doze is enough for required outcomes. Auxins can control the fruit drop by spraying in different fruit plant. Gibberellins enhance the plant vegetative part in different developmental stages. Cytokinins improve root meristem, inflorescences and developing fruit. Abscisic acid slows down seed germination and plant growth. Ethylene used for advance fruit ripening and break dormancy. Future experiment needs plant growth regulators more exhaustive and attentiveness used for plant vegetative growth.

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