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New Generation Plant Growth Regulators in Fruit Crops

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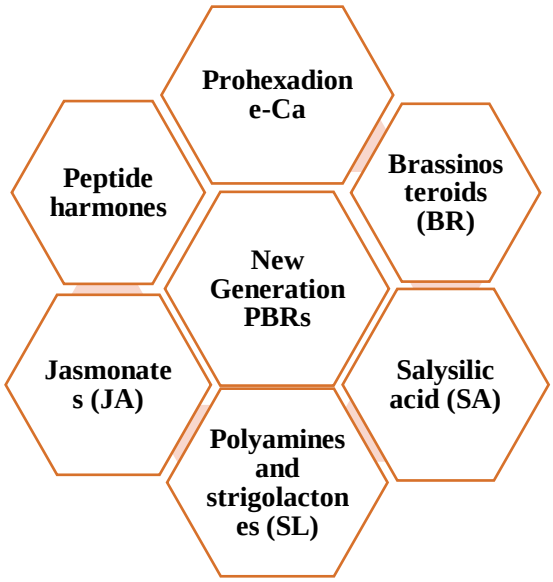
SUMMARY

New generation growth regulators are the organic substances obtained or synthesised as plant derivatives which play significant role in growth and development of plants. These includes brassinosteroids, jasmonates, salicylic acid, polyamines, strigolactones and prohexodione-Ca which can be used commercially in fruit crop cultivation. They have been known to play different functions in fruit crops such as, growth retardant, preventing leaf and fruit abscission, reducing preharvest fruit fall, inducing abiotic stress resistance, improving disease and pest resistance and many more. These bioregulators have created more options to fruit farmers while selecting suitable growth hormone for their crop.

INTRODUCTION

In order to meet the emerging consumer demand and challenges towards fruit production, there is the need to explore new interventions. One among that is use of new generation plant growth regulators in fruit crops. Plant growth regulators (PGR) or plant bio-regulators (PBR's) are defined as organic compounds, other than nutrients when used in small concentrations will affect the physiological processes in plants.

Fig 1. Different types of new generation plant growth regulators



There are five classical growth hormones (auxins, gibbrellins, cytokinins, ethylene and abscisic acid) having specific function in growth and development. Which were already commercially exploited in fruit crops. Use of new generation growth regulators in fruit crops are recent and emerging trend. These can be utilized at all stages of fruits cultivation starting from propagation to improving quality and also in inducing biotic and abiotic stress resistant. New generation PBR's includes brassinosteroids, jasmonate, salicylic acid, polyamines, karrikins and strigolactones and retardants such as 1-MCP and prohexodione-Ca. Recent studies through gene expression analysis proved that these new generation growth regulators are involved in endogenous modulation of certain major traits in plant system. Involvement of karrikins in papaya seed germination was reported. Similarly, brassinosteroids and analogues were involved in increasing the stem and cell elongation and also improving yield of fruit crops. Jasmonates and its derivatives such as methyl jasmonate (MeJA) are found to be involved in regulation of fruit ripening and inducing diseases resistance in grapes (Jia *et al*., 2015). Salicylic acid is involved in fruit fly resistance in mango and bacterial blight resistance in pomegranate due to systemic acquired resistance.

Strigolactones are carotenoid derivative involved in prevention of major biotic stress in citrus crop (Zheng *et al*., 2018). In banana major devastative disease is panama wilt especially the tropical race 4, resistance against this can be achieved by using MeJA (Sun *et al*., 2013) and MeJA are also efficient inducer of resistance against fusarium wilt. Likewise in apple semi dwarfing rootstock M26, genes responsible for dwarfing (*MdWRKY* genes) was identified, which are responsible reducing brassinosteroids endogenous level which directly leads to dwarfism (Zheng *et al*., 2018).

Brassinosteroids (BR): Brassinosteroids are class of plant polyhydroxy steroids which is present in almost every part of plants inc. *Brassicaceae.* Application of BR exhibited a decline in fruit abortion and fruit fall and increases pollen tube growth and fertilization. It prevents premature abscission of fruit and also regulates the activity of defence related enzymes which could develop strong defence mechanism against different pathogenic microorganisms. It also played significant role in another development, shoot elongation, flowering, petiole elongation and leaf expansion. Application of derivatives of brassinosteroids such as homobrassinolides enhances the photosynthesis and mobilization of metabolites to the flower which resulted in less flower drop and more fruit set, delay in fruit abscission. Preservation of loss of pectin material in middle lamella influenced sex expression and promotion of pollen tube growth which led to better fruit set and prevented flower drop. Application of both auxin and brassinosteroids was reported to induce dwarfism in autotetraploid apple.

Jasmonic Acid (JA): Jasmonic acid is plant immune hormone derived from linolenic acid which can convert into variety of derivatives including Methyl jasmonate (MeJA). Initially MeJA was discovered as a secondary metabolite in essential oils of jasmine. Jasmonic acids play important role in regulation of plant physiological process, in plant growth and development. Jasmonic acid is commonly found highest in flowers, reproductive tissues, young leaves and lowest in roots and mature leaves. It is involved in regulation of senescence, leaf development, reduce leaf abscission, response to wounding of plants and defence responses. Preharvest spraying of ‘Kent’, 'Shelly' and’ Maya’ mangoes with 0.4 % prohydrojasmon (PDJ) induced red skin color with increased anthocyanins accumulation especially in the fruit located at outer side of tree canopy (Sudheeran *et al.,* 2019). Due to fruits exposed to sunlight phenyl propanoid pathway was activated by two-fold by pre-harvest application of PDJ.

Salicylic Acid (SA): Derived from Ortho-hydroxybenzoic acid is a secondary metabolite and the compound of saliciline obtained from white willow (*Salix alba*). SA discovered as an elicitor of tobacco plants inducing the resistance against *Tobacco mosaic virus* (TMV) in 1979. Application in plants involved in responses to pathogen attack and development of systemic acquired resistance in plants. Treatment of salicylic acid (1.0 mM) to mature litchi fruits (cv. Purbi) in combination with chitosan (2%) is highly effective in reducing pericarp browning, weight loss, decay loss and maintaining higher anthocyanins, phenolics, flavonoids, ascorbic acid and antioxidant capacity. Because the antisenescence property of SA helps in delaying the destruction of ascorbic acid in fruit during storage (Kumari *et al.,* 2015)

Polyamines: Polyamines are the biological compounds. These are ubiquitous in living organisms having lower molecular weight which contain aliphatic nitrogen groups. They act as cations (polycationic compound) at cellular pH values. Under Salt stress condition, NaCl leading to increased availability of precursors such as ornithine / arginine for polyamine biosynthesis pathway by and/or induction in the activities of respective enzymes. Putrescine, spermine and spermidine contents showed consistent increase under salt stress conditions. Polyamines also act as protector for plants against salinity by improving K^+/Na^+ homeostasis through restricting Na^+ influx into roots and thus preventing loss K^+ from cell.

Peptide hormones: Active peptide hormone is produced by the process of proteolytic cleavage of large molecular weight precursors. Plant peptide hormone is water soluble and classified into three types: non-secreted peptides, post-translationally modified small peptides, and cysteine-rich peptides (CRPs). Small peptide signals of plants include systemin, PSK (phytosulfokine), HypSys (hydroxyproline-rich glycopeptide systemin), Pep1, CLE (CLAVATA3/embryo surrounding region related)/TDIF (tracheary element differentiation inhibitory factor), PSY (plant peptide containing sulphated tyrosine), CEP (C-terminally encoded peptide), RGF/CLEL/GLV (root

meristem growth factor/CLE-like/GOLVEN), PIP (PAMP-induced peptide), IDA (inflorescence deficient in abscission) and CIF (casparian strip integrity factor) subclasses. Peptide hormones are now widely accepted as signalling messengers for plant growth and development process like defence responses, self-incompatibility, callus growth, root growth and organ abscission.

Prohexadione – Ca: Prohexadione-calcium (calcium 3-hydroxy-5-oxo-4-propionyl-cyclohex-3-enecarboxylate or ProCa) is primarily used as a plant bioregulator to influence vegetative growth and fruit formation in fruit crops especially pome fruits. Primarily, it is used to inhibit excessive vegetative growth in fruit trees and other crop plants. The chemical resembles 2-oxoglutaric acid structurally. As a result, dioxygenases involved in gibberellin production that require this molecule as a co-substrate (e.g. GA20 3ß-hydroxylase) are inhibited. As a result, treated plants produce fewer growth-active gibberellins and remain compact. ProCa also helps in reducing ethylene formation, reduce abortion of fruitlets, increases fruit set and prevents incidence of bacterial and fungal diseases and on insect pests in fruit crops

1-Methylcyclopropene: 1-MCP is a gaseous hormone used as synthetic plant growth regulator which commercially used to hinder the activity of ethylene in fruit crops. Preharvest spray of 1-MCP is known to have many beneficial functions in fruit crops such as delaying fruit harvest date, increasing fruit weight and firmness, decreasing fruit drop at harvest, inhibiting fruit internal ethylene production and reduction of fruit storage disorders

CONCLUSION

New generation bio-regulators can be an effective alternative for enhancing yield and quality of fruit crops as they are organic in nature, safe to use and are also effective in building biotic and abiotic stress resistance in fruit crops. They have huge scope and potential for commercialization but their application is limited to only to few major fruit crops. New generation plant growth regulators are an effective alternative for future fruit production combating major production challenges. By utilizing modern biotechnological interventions, these new generation growth regulators can be endogenously modified and utilized in breeding a new variety for commercial exploitation

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