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Commercial use of plant growth regulators in horticultural crops: An overview

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Abstract

Plant growth regulators either synthetic or natural have been found great and wide application in increasing the crop production or when applied in small amount, they bring rapid changes in the phenotypes of the plant and also influences the plant growth, right from seed germination to senescence either by enhancing or by stimulating the natural growth regulatory system. In view of their wide spectrum effectiveness on every aspect of plant growth, even a modest increase of 10-15% could bring about an increment in the gross annual productivity by 10-15 million tonnes. The Plant growth regulators (PGRs) have various economic importance in agricultural field. In vegetable growing, growth regulator also become more popular for seed soaking, inflorescence spraying, producing hybrid seeds and making seeds resistant to pest and diseases. Thus, growth regulators improve seed germination power, resistant power against disease and unfavorable growth conditions, increase and produces yield earlier and therefore, the yield become more qualitative and quantitative. Hence, advances in PBR technology will likely to be achieved through a better understanding of the mechanisms responsible for developmental processes and a more comprehensive description of the specificity of substances in mediating key biochemical steps. So, their importance has been boon and advantageous for farmers and horticulturists due to whom they took advantage to earn by the practical implication of these hormones and growth regulators.

Keywords: Plant, growth, physiology

Introduction

It has long been believed that the growth of a plant is due to the nutrients absorbed by the soil and the nutrients in the plant. It is now known that plant growth is largely controlled by certain chemical substances known as growth controls. PGRs contribute to plant growth and morphogenesis. They should be used in the correct focus, category of use, details of specific species, seasons, etc. (Birader and Navalagatti, 2008) [6]. Gardening is a common term for a variety of crop combinations, for example, agriculture, pomology, floriculture and finishing, nursery, restorative, flavor and aromatic plants, mushrooms, among the various circles of developed plants. The theoretical history of the field of information provided, especially the use of crop growth controls in agriculture is important in better understanding the emergence, the way forward and its ideas. Since the 1930's, PGRs have been widely used in various agricultural activities. Indian agriculture is becoming more and more mechanized and science is increasing the opportunities to use inputs to improve food production and food security, the role of crop growth regulators becomes more important; Crop growth controls provide an immediate impact on crop development programs and do not consume much time. The powerful role of plant growth control in the various physiological and chemical processes of plants is well-known, not only making rapid changes in plant phenotype by accelerating germination or growth but also helping to increase productivity. In addition, the unusual use of plant growth controllers is known to bring about changes in tree conversion, growth and distribution of assimilates (source - sink balance) and the number and quality of the desired economic products of horticultural plants (Nickel, 1982, Nowale and Lawson, 1983) [74, 75].

Class of plant growth regulators

Auxins: IAA, NAA, IBA, 2-4D, 4-CPA

Gibberellins: GA₃

Cytokinins: Kinetin, Zeatin

Ethylene: Ethereal

Abscisic acid: Dormins, Phaseic Acid

Phenolic substances: Coumarin

Flowering hormones: Florigin, Anthesin, Vernalin

Natural substances: Vitamins, Phytochrome Transmittance

Newly identified PGRs: Brassinosteroids, Jasmonates,

Triacntanol, Salicylic acid, Polyamines, Ancymidol, Nitrobenzene, Seaweed products, xanthoxins, betasins, alar, mefluidide

Growth inhibitors: AMO-1618, Phosphon-D, Cycosel, B-999

Plant growth regulators and their associated functions

Class	Associated functions
Auxins	Apical dominance, root induction, control fruits drops, regulation of flowering, parthenocarp, phototropism, geotropism, herbicides, inhibit abscission, sex determination, xylem differentiation, nucleic acid activity.
Gibberellins	Stimulate cell division and elongation, stimulate germination of seeds Stimulates bolting/flowering in response to long days, prevention of genetic dwarfism, increase flower and fruit size, dormancy, induces maleness in dioecious flowers, extending self-life.
Cytokinins	Promotes cell division, cell enlargement and cell differentiation, stimulate bud initiation and root growth, translocation of nutrients, prolong storage life of flowers and vegetables, prevent chlorophyll degradation, morphogenesis, lateral bud development, delay of senescence.
Ethylene	Induce uniform ripening in vegetables, promotes abscission, senescence of leaf.
Abscisic acid	Act as plant stress hormone, dormancy induction of buds and seeds, induces seeds to synthesize storage proteins, dormancy, seed development and germination, stomata closing.

Role of PGRs

Plant growth factors play an important role in the various physiological processes associated with the growth and development of horticultural plants. It is clear that changes in the level of endogenous hormones due to biotic and abiotic stress alter plant growth and any kind of deception including increased use of growth factors will help improve yields or at least crop nutrition. PGR (or chemical messengers) is produced in various areas such as leaves, foliage, root shoots, etc. They are also distributed throughout the plant system until they interact with the receptors and produce responses in targeted cells (Mitchell, 1942 and Rademacher, 2015) [63, 80] such compounds primarily increase or decrease plant growth in length. Because a large number of other processes such as flowering, fruit formation, ripening, fruit reduction, fat reduction, or quality factors can also be affected by "biological control", this term will be used for better growth and metabolic processes (Rademacher, 2015) [80]. Hormones

influence cell division, cell proliferation, cell formation and function, and have the ability to control how a plant responds to environmental stress (Ferguson and Grafton-Cardwell, 2014) [17]. Altering the action of hormones within the plant (Harms and Oplinger, 1988; Hopkins and Huner, 2004) [26, 28]. PGRs include plant growth characteristics based on factors such as crop type, incentive type, amount of incentive used, application time, growth phase, and location of application renewal (Mitchell, 1942) [63]. Growth controls can improve physical efficiency including photosynthetic ability and can increase the functional separation of the source from the sink and immersion in field plants (Solaiman *et al.*, 2001) [99]. The use of oil for growth and chemical controls in the flowering phase can improve body function and can play a significant role in increasing plant production (Dashora and Jain, 1994) [13]. A large group of PGRs are combined, reducing the shooting length. Such substances are often referred to as "growth retardants" (Rademacher, 2015) [80].

Commercial use of PGRs in horticultural crops

Crops	PGRs	Impact	Reference Citation
Fruits			
Mandarin	2,4-D and NAA	Decreased pre harvest fruit drop percentage, leading to increase in total number of fruits per plant, fruit weight, juice percentage, total soluble solids, acidity, vitamin-C, reducing sugars and non-reducing sugars %	Nawaz <i>et al.</i> (2008) [72]
Sweet orange	NAA	Maximum reduction of fruit drop, fruit retention, number of fruits per plant and fruit yield per plant	Sweety <i>et al.</i> (2018) [104]
Sapota	GA ₃ and NAA	Maximum fruit weight, fruit length, fruit diameter, volume of fruit, TSS, reducing and non-reducing sugar, yield per tree, yield per hectare and extended shelf life	Sahu <i>et al.</i> (2018) [88]
	Ethylene	Minimized the ripening time and increase physico-chemical properties	Vidhya <i>et al.</i> (2017) [107]
Mango	GA ₃	Retarded the total loss in weight, chlorophyll and ascorbic acid content, reduced amylase and peroxidase activity during ripening.	Sahu <i>et al.</i> (2018) [89]
	ABA	Higher total sugars and sucrose, regulating mang of ruitripening	Zaharah <i>et al.</i> (2012) [109]
	Ethylene	Initiating mango ripening	Nguyen and McConchie (2002) [73]
	paclobutrazol	Suppressing vegetative growth, increase flowering, fruit yield and quality	Yeshitela <i>et al.</i> (2004)
Banana	Ethephon (1-MCP)	Delayed ripening process	Xiaoyang <i>et al.</i> (2015)
Guava	GA ₃	Maximum growth, yield, quality attribute and highest germination	Lal and Das (2017) [53]
	BA	effective in shooting response, number of shoot/explants, shoot length reducing, physiological loss in weight (PLW), decay, reduction in diameter and juice content	Nagar <i>et al.</i> (2002) [68]
	Ethylene	Increase in the rate of skin yellowing and softening of immature-green fruit	Reyes and Paull (1995) [84]

Custard apple	BA	Enhanced shelf-life	Chouksey <i>et al.</i> (2013) ^[12]
Pineapple	ABA	Reduced the intensity of internal browning, moisture loss and malic acid content in the crown leaves	Nanayakkara <i>et al.</i> (2005) ^[69]
Citrus	ABA, Ethylene	Induced callus formation	Goren <i>et al.</i> (1979) ^[23]
Phalsa	NAA	Increased number of flowers per shoot, number of fruits per shoot, 100 fruits weight, juice percentage, minimum seed percentage and the maximum yield per hectare	Kacha <i>et al.</i> (2012) ^[33]
	GA ₃	Increasing vegetative growth and yield	Singh <i>et al.</i> (2017) ^[97]
Vegetables			
Bitter gourd	NAA	Produced lower sex ratio gave, maximum number of fruits per plant and finally yield per hectare with the maximum BCR	Khatoon <i>et al.</i> (2019) ^[44]
Capsicum	NAA	Increased plant height, early flowering, number of branches, plant spread, number of flowers per plant, shelf life and TSS	Singh <i>et al.</i> (2017) ^[98]
Okra	ABA	Enhancing health promoting component	Prajapati <i>et al.</i> (2019) ^[79]
	IAA	Maximum plant height and intermodal length	Dhage <i>et al.</i> (2011) ^[14]
	SA and ABA	Significantly reduced the harsh effects of drought on okra germination and growth parameters, enhance the tolerant ability	Baghizadeh and Hajmohammadrezaei (2011) ^[2]
	CCC	Lowest days to first flowering, 50 per cent flowering, nodal position of first flower, highest total number of harvestings, number of fruits per plant, yield per plant and per hectare, weight of a single fruit, fruit breadth, Vitamin – ‘A’ and crude fiber per cent	Kumar <i>et al.</i> (2018) ^[50]
	Brassinosteroid	To increase in plant growth and biomass, leaf area, chlorophyll content, photosynthesis rate, photochemical efficiency of PS II	Wajid Khan <i>et al.</i> (2017) ^[108]
Watermelon	TIBA	Better growth, early flowering, minimum sex ratio, highest fruit yield and superior quality	Chaudhary <i>et al.</i> (2016) ^[10]
Tomato	2,4-D and IAA	Development of seedless parthenocarpic fruit with increased size, increase growth and yield attributes	Gelmesa <i>et al.</i> (2013) ^[21] ; Khaled <i>et al.</i> (2015) ^[41]
	GA ₃	For yield attribute	Sharma <i>et al.</i> (2018) ^[94]
	Ethylene	Promotion of fruit ripening, flowering and overall plant growth	Sunidhi and Gandhi, 2019 ^[101]
	Cytokinin	Breaking dormancy after seed imbibition, also allowing germination and growth of dormant embryos.	Nawaz <i>et al.</i> (2012) ^[71]
	PBZ	Improves the photosynthetic activity and water balance	Berova and Zlatev (2000) ^[5]
	Thiourea	Increased plant dry weight and the tomato yield after inoculation	Nasr A. (1993) ^[70]
Onion	NAA	Reduced physiological loss of weight, spoilage loss	Patel <i>et al.</i> (2010) ^[10]
Brinjal	NAA	Long-styled flower percent, number of fruits/plant, and the highest fruit yield	Moniruzzaman <i>et al.</i> (2014) ^[65]
Pea	GA ₃	Maximum number of pods per plant, seed yield, seed index and protein content in seeds	Bora and Sarma (2006) ^[9]
Pumpkin	GA ₃	Enhancing growth and yield	Sure <i>et al.</i> (2012) ^[109]
Bottle gourd	GA ₃	Maximum fruit length, fruits weight and fruits girth	Kumari <i>et al.</i> (2019) ^[52]
Cucumber	GA ₃	maximum fruit set percentage, fruit retention and TSS	Kadi <i>et al.</i> (2018) ^[34]
	Ethylene	Induce femaleness	Rudich <i>et al.</i> (1969) ^[87]
Muskmelon	Potassium nitrate	Quality attributes such as TSS, carotene, ascorbic acid, flesh thickness, fruit firmness, skin colour, moisture content and shelf life	Sindhuja <i>et al.</i> (2017) ^[96]
	CPPU	Increase number of fruits per vine, fruit weight and yield per vine	Sindhuja <i>et al.</i> (2017) ^[96]
Lettuce	ABA	Minimize the effects of drought stress	Al Muhairi <i>et al.</i> (2016) ^[11]
Cluster bean	SA and Thiourea	Higher yield parameters, yield and gum content	Meena and Meena (2017) ^[58]
Flowers			
Calendula	NAA	Greater amount of carbohydrate accumulation and increased metabolic activities	Khodus <i>et al.</i> (2017) ^[45]
	SA	Increased CO ₂ assimilation and photosynthetic rate and increased mineral uptake	Bayat <i>et al.</i> (2012) ^[3]
<i>Clerodendrum splendens</i>	IBA	Increase in sprout length and root length	Jamal <i>et al.</i> (2015) ^[31]
Orchid	NAA	Enhanced the plant growth and development	Khandaker, M. M. <i>et al.</i> (2016) ^[43]
Rose	IBA	Increase survival percentage, maximum number of roots and the longest roots	Susaj <i>et al.</i> (2012) ^[103]
Marigold	NAA	Maximum weight and diameter of fully opened flower	Meshram <i>et al.</i> (2015) ^[61]
	GA ₃	Increase vegetative growth and flowering	Mishra (2017) ^[62]
	CCC	Increased flower yield and number of flowers/plant	Kumar <i>et al.</i> (2011) ^[46]
	Triacantanol	Increase plant height, number of laterals, number of leaves and leaf area	Muruganandam (2014) ^[67]
Chrysanthemum	GA ₃	Increase plant height, number of branches, suckers, leaves plant ⁻¹ , leaf	Sajid <i>et al.</i> (2016) ^[90]

		area, days to flower and number of flowers	
Gladiolus	GA ₃	Increase plant growth and flowering attributes	Reshma <i>et al.</i> (2017) ^[83]
	ABA	As a hormonal trigger in ethylene insensitive senescence process	Kumar <i>et al.</i> (2014) ^[49]
	Ethrel	Increased corm splitting, delayed flowering and slightly shortened flower stems	Halevy <i>et al.</i> (1970) ^[25]
	SA	Improves vase life	Rahmani <i>et al.</i> (2015) ^[82]
	BA	Sprouting of multiple buds and increase production of corms	Sajjad <i>et al.</i> (2015) ^[91]
Tuberose	GA ₃	Beneficial for sprouting	Ganesh <i>et al.</i> (2013) ^[19]
China aster	GA ₃	Increase number of primary branches, flower yield per hectare, seed yield per plant and seed yield per hectare	Kumar <i>et al.</i> (2015) ^[48]
	SA	Increased growth, flower and seed yield	Kumar <i>et al.</i> (2015) ^[48]
<i>Matthiola incana</i>	Kinetin and NAA	Shoot length, greatest number of nodes and highest length of roots	Hesar <i>et al.</i> (2011) ^[27] ; Kaviani <i>et al.</i> , 2013 ^[37]
Cactus	ABA	Increase in calli fresh weight and colour	Lema-Ruminska <i>et al.</i> (2013) ^[55]
Petunia	Ethylene	Induced adventitious root formation	Dimasi-Theriou <i>et al.</i> (1993) ^[15]
Gerbera	BA and GA ₃	Increase vase life, fresh weight, solution uptake, membrane stability and TSS	Danaee <i>et al.</i> (2011)
Dahlia	MH	Highest number of flowers and diameter of bud	Malik <i>et al.</i> , (2017) ^[56]

Conclusion

Either synthetic or natural crop growth controllers have been found to be more efficient and comprehensive in increasing crop production or when used in small amounts, bring about rapid changes in plant phenotypes and also contribute to plant growth, from seed purification to licensing or by enhancing or revitalizing the growth control system. By looking at their overall performance in all aspects of plant growth or just a small increase of 10-15% can bring about an increase of total annual production by 10-15 million tons. Plant growth regulators (PGRs) have various type of economic significance in the agricultural sector. In vegetable growth, growth control is also popular for seed immersion, inflorescence spraying, hybrid seed production and seed resistance to pests and diseases. Therefore, growth regulators improve seed germination capacity, disease resistance and poor growth conditions, increase and produce a crop early and, therefore, yields are better and more balanced. Therefore, advances in PGR technology are likely to be achieved by a better understanding of the mechanisms responsible for development processes and a broader definition of specificity in designing key chemical steps organic farmers because they have used their profits by finding out what these hormones and growth regulators mean.

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