www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(6): 112-119
© 2022 TPI
www.thepharmajournal.com
Received: 24-04-2022
Accepted: 28-05-2022

Shweta Soni
Department of Vegetable Science, BUAT, Banda, Uttar Pradesh, India

Govind Vishwakarma
Department of Fruit Science, RLBCAU, Jhansi, Uttar Pradesh, India

SC Singh
Department of Fruit Science, BUAT, Banda, Uttar Pradesh, India

Sunil Kumar
Department of Vegetable Science, BUAT, Banda, Uttar Pradesh, India

RK Singh
Department of Vegetable Science, BUAT, Banda, Uttar Pradesh, India

Priya Awasthi
Department of Post Harvest Technology, BUAT, Banda, Uttar Pradesh, India

Vaishali Gangwar
Department of Plant Physiology, BUAT, Banda, Uttar Pradesh, India

Corresponding Author
Shweta Soni
Department of Vegetable Science, BUAT, Banda, Uttar Pradesh, India

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

Shweta Soni, Govind Vishwakarma, SC Singh, Sunil Kumar, RK Singh, Priya Awasthi and Vaishali Gangwar

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 (PBRs) 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: GA_3
Cytokinins: Kinetin, Zeatin
Ethylene: Ethereal

Abscisic acid: Dormins, Phaseic Acid
Phenolic substances: Coumarin
Flowering hormones: Florigin, Anthesin, Vernalin
Natural substances: Vitamins, Phytochrome Tranmatic
Newly identified PGRs: Brassinosteroids, Jasmonates, Triacontanol, 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, parthenocarpy, 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 source 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 *et al.* (2008) [72]
Sweet orange	NAA	Maximum reduction of fruit drop, fruit retention, number of fruits per plant and fruit yield per plant	Sweety *et al.* (2018) [104]
Sapota	GA_3 and NAA	Maximum fruit weight, fruit length, fruit diameter, volume of fruit, TSS, reducing and none reducing sugar, yield per tree, yield per hectare and extended shelf life	Sahu *et al.* (2018) [88]
	Ethylene	Minimized the ripening time and increase physico-chemical properties	Vidhya *et al.* (2017) [107]
Mango	GA_3	Retarded the total loss in weight, chlorophyll and ascorbic acid content, reduced amylase and peroxidase activity during ripening.	Sahu *et al.* (2018) [89]
	ABA	Higher total sugars and sucrose, regulating mang of ruitripening	Zaharah *et al.* (2012) [109]
	Ethylene	Initiating mango ripening	Nguyen and McConchie (2002) [73]
	paclobutrazol	Suppressing vegetative growth, increase flowering, fruit yield and quality	Yeshitela *et al.* (2004)
Banana	Ethephon (1-MCP)	Delayed ripening process	Xiaoyang *et al.* (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 *et al.* (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 *et al.* (2013) [12]
Pineapple	ABA	Reduced the intensity of internal browning, moisture loss and malic acid content in the crown leaves	Nanayakkara *et al.* (2005) [69]
Citrus	ABA, Ethylene	Induced callus formation	Goren *et al.* (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 *et al.* (2012) [33]
	GA_3	Increasing vegetative growth and yield	Singh *et al.* (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 *et al.* (2019) [44]
Capsicum	NAA	Increased plant height, early flowering, number of branches, plant spread, number of flowers per plant, shelf life and TSS	Singh *et al.* (2017) [98]
Okra	ABA	Enhancing health promoting component	Prajapati *et al.* (2019) [79]
	IAA	Maximum plant height and intermodal length	Dhage *et al.* (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 *et al.* (2018) [50]
	Brassinosteroid	Toincrease in plant growth and biomass, leaf area, chlorophyll content, photosynthesis rate, photochemical efficiency of PS II	Wajid Khan *et al.* (2017) [108]
Watermelon	TIBA	Better growth, early flowering, minimum sex ratio, highest fruit yield and superior quality	Chaudhary *et al.* (2016) [10]
Tomato	2,4-D and IAA	Development of seedless parthenocarpic fruit with increased size, increase growth and yield attributes	Gelmesa *et al.* (2013) [21]; Khaled *et al.* (2015) [41]
	GA_3	For yield attribute	Sharma *et al.* (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 *et al.* (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 *et al.* (2010) [10]
Brinjal	NAA	Long-styled flower percent, number of fruits/plant, and the highest fruit yield	Moniruzzaman *et al.* (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 *et al.* (2012) [109]
Bottle gourd	GA_3	Maximum fruit length, fruits weight and fruits girth	Kumari *et al.* (2019) [52]
Cucumber	GA_3	maximum fruit set percentage, fruit retention and TSS	Kadi *et al.* (2018) [34]
	Ethylene	Induce femaleness	Rudich *et al.* (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 *et al.* (2017) [96]
	CPPU	Increase number of fruits per vine, fruit weight and yield per vine	Sindhuja *et al.* (2017) [96]
Lettuce	ABA	Minimize the effects of drought stress	Al Muhairi *et al.* (2016) [1]
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	Khudus *et al.* (2017) [45]
	SA	Increased CO_2 assimilation and photosynthetic rate and increased mineral uptake	Bayat *et al.* (2012) [3]
Clerodendrum splendens	IBA	Increase in sprout length and root length	Jamal *et al.* (2015) [31]
Orchid	NAA	Enhanced the plant growth and development	Khandaker, M. M. *et al.* (2016) [43]
Rose	IBA	Increase survival percentage, maximum number of roots and the longest roots	Susaj *et al.* (2012) [103]
Marigold	NAA	Maximum weight and diameter of fully opened flower	Meshram *et al.* (2015) [61]
	GA_3	Increase vegetative growth and flowering	Mishra (2017) [62]
	CCC	Increased flower yield and number of flowers/plant	Kumar *et al.* (2011) [46]
	Triacontanol	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 *et al.* (2016) [90]

		area, days to flower and number of flowers	
Gladiolus	GA_3	Increase plant growth and flowering attributes	Reshma *et al.* (2017) [83]
	ABA	As a hormonal trigger in ethylene insensitive senescence process	Kumar *et al.* (2014) [49]
	Ethrel	Increased corm splitting, delayed flowering and slightly shortened flower stems	Halevy *et al.* (1970) [25]
	SA	Improves vase life	Rahmani *et al.* (2015) [82]
	BA	Sprouting of multiple buds and increase production of corms	Sajjad *et al.* (2015) [91]
Tuberose	GA_3	Beneficial for sprouting	Ganesh *et al.* (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 *et al.* (2015) [48]
	SA	Increased growth, flower and seed yield	Kumar *et al.* (2015) [48]
Matthiola incana	Kinetin and NAA	Shoot length, greatest number of nodes and highest length of roots	Hesar *et al.* (2011) [27]; Kaviani *et al.*, 2013 [37]
Cactus	ABA	Increase in calli fresh weight and colour	Lema-Ruminska *et al.* (2013) [55]
Petunia	Ethylene	Induced adventitious root formation	Dimasi-Theriou *et al.* (1993) [15]
Gerbera	BA and GA_3	Increase vase life, fresh weight, solution uptake, membrane stability and TSS	Danaee *et al.* (2011)
Dahalia	MH	Highest number of flowers and diameter of bud	Malik *et al.*, (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.

References

1. Al Muhairi MA, Cheruth AJ, Kurup SS, Rabert GA, Al-Yafei MS. Abscisic acid-induced modifications in growth and pigment composition of lettuce (*Lactuca sativa* L.) under different irrigation regimes. Genetics and Plant Physiology. 2016; 6(1-2):72-84.
2. Baghizadeh A, Hajmohammadrezaei M. Effect of drought stress and its interaction with ascorbate and salicylic acid on okra (*Hibiscus esculents* L.) germination and seedling growth. Journal of Stress Physiology & Biochemistry. 2011;7(1):55-65.
3. Bayat H, Alirezaie M, Neamati H. Impact of exogenous salicylic acid on growth and ornamental characteristics of calendula (*Calendula officinalis* L.) under salinity stress. Journal of Stress Physiology & Biochemistry. 2012;8(1):258-267.
4. Bergstrand K-JI. Methods for growth regulation of greenhouse produced ornamental pot-and bedding plants-a current review. Folia Horticulture. 2017;29(1):63-74.
5. Berova M, Zlatev Z. Physiological response and yield of paclobutrazol treated tomato plants (*Lycopersicon esculentum* Mill.). Plant Growth Regulation. 2000;30:117–123.
6. Birader G, Navalagatti CM. Effect of plant growth regulators on physiology and quality in bitter gourd (*Momordica charantia*). M.Sc. thesis, University of Agricultural Sciences, Dharwad, 2008.
7. Bisht TS, Rawat L, Chakraborty B, Yadav V. A recent advance in use of plant growth regulators (PGRs) in Fruit Crops: A Review. International Journal of Current Microbiology and Applied Sciences. 2018;7(5):1307-1336.
8. Blanchard MG, Newton LA, Runkle ES. Exogenous applications of abscisic acid improved the postharvest drought tolerance of several annual bedding plants. Acta Horticulturae. 2007;755:127-132.
9. Bora RR, Sarma CM. Effect of gibberellic acid and cycocel on growth, yield and protein content of pea. Asian Journal of Plant Sciences. 2006;5(2):324-330.
10. Chaudhary DC, Patel NM, Rathva VD, Nurbhanej MH. Effect of growth substances on growth, flowering, yield and quality attributes of watermelon (*Citrullus lanatus* Thunb mans f.) cv. Durgapura Lal (RW-177-3). International Journal of Agriculture Sciences, 2016;8(40):1825-1828.
11. Choudhury S, Islam N, Sarkar MD, Ali MA. Growth and yield of summer tomato as influenced by plant growth regulators. International Journal of Sustainable Agriculture. 2013;5(1): 25-28.
12. Chouksey S, Singh A, Thakur RS, Deshmukh R. Influence of gamma irradiation and benzyl adenine on keeping quality of custard apple fruits during storage. Journal of Food Science and Technology. 2013;50(5):934-941.
13. Dashora LD, Jain PM. Effect of growth regulators and phosphorus levels on growth and yield of Soybean. Madras Agricultural Journal. 1994;81:235-237.
14. Dhage AA, Nagre PK, Bhangre KK, Pappu AK. Effect of plant growth regulators on growth and yield parameters of okra. The Asian Journal of Horticulture. 2011;6(1):170-172.

15. Dimasi-Theriou K, Economou AS, Fakiotakis SEM. Promotion of petunia (*Petunia hybrida* L.) regeneration *in vitro* by ethylene. Plant Cell, Tissue and Organ Culture. 1993;32:219-225.
16. Fahad S, Hussain S, Saud S, Khan F, Hassan S, Nasim W, *et al*. Exogenously applied plant growth regulators affect heat stressed rice pollens. Journal of Agronomy and Crop Science. 2016;202(2):139-150.
17. Ferguson L, Grafton-Cardwell EE. Citrus production manual. *Oakland, california:* University of California, Agriculture and Natural Resources, 2014, 3539.
18. Fishel FM. Institute of Food and Agricultural Sciences, University of Florida, Document No. PI-102 (http://edis.ifas.ufl.edu), 2006.
19. Ganesh S, Soorianathasundaram K, Kannan M. Studies on effect of plant growth regulators and micronutrients on growth, floral characters and yield of tuberose (*Polianthes tuberosa* L.) cv. ‘Prajwal’. The Asian Journal of Horticulture. 2013;8(2):696-700.
20. Garcia R, Pacheco G, Falcao E, Borges G, Mansur E. Influence of type of explant, plant growth regulators, salt composition of basal medium, and light on callogenesis and regeneration in *Passiflora suberosa* L. Plant Cell, Tissue and Organ Culture. 2011;106(1):47-54.
21. Gelmesa D, Abebie B, Desalegn L. Effects of gibberellic acid and 2,4 dichlorophenoxy acetic acid spray on vegetative growth, fruit anatomy and seed setting of tomato (*Lycopersicon esculentum* Mill.). Science, Technology and Arts Research Journal. 2013;2(3):25-34.
22. George EF, Hall MA, De Klerk G. Plant growth regulators I: introduction; auxins, their analogues and inhibitors. In: Springer, Netherlands (Ed.), Plant Propagation by Tissue Culture 3rd ed. The Netherlands, Dordrecht, 2008, 175-204.
23. Goren R, Altman A, Giladi I. Role of Ethylene in Abscisic Acid-induced Callus Formation in Citrus Bud Cultures. Plant Physiology. 1979;63:280-282.
24. Greenberg J, Kaplan I. Effects of Auxins Sprays on Yield, Fruit Size, Fruit Splitting and the Incidence of Creasing of ‘Nova’ Mandarin. Acta Hort, 2006, 249-254.
25. Halevy AH, Shilo R, Simchon S. Effect of 2-chloroethane phosphonic acid (Ethrel) on health, dormancy, and flower and corm yield of gladioliolus. Journal of Horticultural Sciences. 1970;45:427-434.
26. Harms CL, Oplinger ES. Plant growth regulators: their use in crop production. North Central Region Extension Publication 303, Specialized Soil Amendments, Products and Growth Stimulants. U.S. Department of Agriculture and Cooperative Extension Services. Illinois, IA, 1988.
27. Hesar AA, Kaviani B, Tarang A, Zanjani SB. Effect of different concentrations of kinetin on regeneration of ten weeks (*Matthiola incana*). Plant Omics Journal. 2011;4(5):236-238.
28. Hopkins WG, Hüner NP. Introduction to plant physiology, 3rd edition. John Wiley and Sons Inc, 2004, 560p.
29. Huang RH, Liu JH, Lu YM, Xia RX. Effect of salicylic acid on the antioxidant system in the pulp of ‘Cara cara’ navel orange (*Citrus sinensis* L. Osbeck) at different storage temperatures. Postharvest Biology and Technology. 2008;47:168-175.
30. Jakhar D, Thaneshwari Nain S, Jakhar N. Effect of plant growth regulator on growth, yield & quality of tomato (*Solanum lycopericum*) cultivar ‘Shivaji’ under Punjab condition. International Journal of Current Microbiology and Applied Sciences. 2018;7(6):2630-2636.
31. Jamal A, Ayub G, Rahman A, Rashid A, Ali J, Shahab M. Effect of IBA (Indole Butyric Acid) levels on the growth and rooting of different cutting types of *Clerodendrum splendens*. Pure and Applied Biology. 2016;5(1):64-71.
32. Jyoti S, Patel NB, Patel JB. Effect of growth regulators and stages of spray on seed yield and seed quality parameters of ridge gourd [*Luffa acutangula* (Roxb) L.] Journal of Applied and Natural Science. 2016;8(3):1551-1555.
33. Kacha HL, Viradia RR, Leua HN, Jat G, Tank AK. Effect of NAA, GA_3 and ethrel on yield and quality of phalsa (*Grewia asiatica* L.) under South-Saurashtra condition. The Asian Journal of Horticulture. 2012;7(2):242-245.
34. Kadi AS, Asati KP, Barche S, Tulasigeri RG. Effect of different plant growth regulators on growth, yield and quality parameters in Cucumber (*Cucumis sativus* L.) under poly house condition. International Journal of Current Microbiology and Applied Sciences. 2018;7(4):3339-3352.
35. Kalyani M, Bharad SG, Parameshwar P. Effect of growth regulators on seed germination in guava. International Journal on Biological Sciences. 2014;5(II):81-91.
36. Kaur P, Mal D, Sheokand A, Shweta Singh L, Datta S. Role of Plant Growth Regulators in Vegetable Production: A Review. International Journal of Current Microbiology and Applied Sciences. 2018;7(6):2177-2183.
37. Kaviani B, Hesar AA, Tarang A, Zanjani SB, Hashemabadi D, Ansari MH. Effect of kinetin (Kn) and naphthalene acetic acid (NAA) on the micro-propagation of Matthiolaincana using shoot tips, and callus induction and root formation on the leaf explants. African Journal of Agricultural Research. 2013;8(30):4134-4139.
38. Kavyashree N, Naik BH, Thippesha D. Effect of plant growth regulators on yield and quality of sapota (*Achras zapota* L.) through crop regulation under hill zone of Karnataka. International Journal of Minor Fruits, Medicinal and Aromatic Plants. 2018;4(2):13-17.
39. Kazemi SS, Hashemabadi D, Torkashvand AM, Kaviani B. Effect of Cycocel and Daminozide on vegetative growth, flowering and the content of essence of Pot Marigold (*Calendula officinalis*). Journal of Ornamental Plants. 2014;4(2):107-114.
40. Khader SESA, Singh BP, Khan SA. Effect of GA_3 as a Post-Harvest Treatment of Mango Fruit on ripening, amylase and peroxidase activity and quality during storage. Scientia Horticulturae. 1988;36:261-266.
41. Khaled AM, Sikder S, Islam MR, Hasan MA, Bahadur MM. Growth yield and yield attributes of tomato (*Lycopersicon esculentum* Mill.) as influenced by Indole Acetic Acid. Journal of Environmental Sciences & Natural Resources. 2015;8(1):139-145.
42. Khalid S, Malik AU, Khan AS, Jamil A. Influence of exogenous applications of plant growth regulators on fruit quality of Young 'Kinnow' Mandarin (*Citrus nobilis* × *C. deliciosa*) trees. International Journal of Agriculture and Biology. 2012;14(2):229-234.
43. Khandaker MM, Rasdi MZ Md, Naeimah NN, Mat N. Effects of Naphthalene Acetic Acid (NAA) on the plant growth and sugars effects on the cut flowers mokara chark kuan orchid. Bioscience Journal. 2016;33(1):19-30.

44. Khatoon R, Moniruzzaman M, Moniruzzaman M. Effect of foliar spray of GA_3 and NAA on sex expression and yield of bitter gourd Bangladesh Journal of Agricultural Research. 2019;44(2):281-290.
45. Khudus S, Prasad VM, Jogdand SM. Effect of Plant Growth Regulators on Growth and Flower Yield of Calendula (*Calendula officinalis* L.) cv. BonBon. Chemical Science Review and Letters. 2017;6(22):1290-1294.
46. Kumar A, Kumar J, Singh MB, Rajbeer JP, Ram N. Effect of plant growth regulators on growth, flowering and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. Asian Journal of Horticulture. 2011;6(2):418-422.
47. Kumar GD, Kumar A, Kumar V, Kumar M, Prakash S. Effect of bio-regulators on improvement in chemical traits, strorage life and organoleptic quality of Ratol Mango. International Journal of Current Microbiology and Applied Sciences. 2018;7(8):3802-3810.
48. Kumar KP, Padmalatha T, Pratap M, Reddy SN. Effect of plant Bio Regulatores on growth, flowering and seed yield in china aster (*Callistephus chinensis* L. Nees) cv. Kamini. Indian Journal of Agricultural Research. 2015;49(4):348-352.
49. Kumar M, Singh VP, Arora A, Singh N. The role of abscisic acid (ABA) in ethylene insensitive Gladiolus (*Gladiolus grandiflora* Hort.) flower senescence. Acta Physiol Plant. 2014;36:151-159.
50. Kumar P, Haldankar PM, Haldavaneka PC. Study on effect of plant growth regulators on flowering, yield and quality aspects of summer okra (*Abelmoschus esculentus* L. Moench) Var. Varsha Uphar. The Pharma Innovation Journal, 2018;7(6):180-184.
51. Kumar R, Bakshi M, Singh DB. Influence of plant growth regulators on grwoth, yield and quality of strawberrry (*Fragaria x Ananassa* Duch.) under U.P. Sub tropics. The Asian Journal of Horticulture. 2012;7(2):434-436.
52. Kumari K, Kamalkant Kumar R, Singh VK. Effect of plant growth regulators on growth and yield of Bottle Gourd (*Lagenaria siceraria* (Mol.) Standl.). International Journal of Current Microbiology and Applied Sciences. 2019;8(7):1881-1885.
53. Lal N, Das RP. Effect of Plant Growth Regulators on Yield and Quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda. International Journal of Current Microbiology and Applied Sciences. 2017;6(5):857-863.
54. Lalel HJD, Singh Z, Tan SC. The role of ethylene in mango fruit aroma volatiles biosynthesis. The Journal of Horticultural Science and Biotechnology. 2003;78(4):485-496.
55. Lema-Ruminska J, Goncerzewicz K, Gabriel M. Influence of abscisic acid and sucrose on somatic embryogenesis in Cactus *Copiapoa tenuissima* Ritt. *Forma mostruosa*. The Scientific World Journal. 2013, pp.1-7.
56. Malik SA, Rather ZA, Wani MA, Din A, Nazki IT. Effect of growth regulators on plant growth and flowering in dahlia (*Dahlia variabilis*) cv. Charmit. Journal of Experimental Agriculture International. 2017;15(3):1-7.
57. Medlicott AP, Sigrist JMM, Reynolds SB, Thompson A. K. Effects of ethylene and acetylene on mango fruit ripening. Annals of Applied Biology. 1987;111:439-444.
58. Meena H, Meena RS. Assessment of sowing environments and bio-regulators as adaptation choice for cluster bean productivity in response to current climatic scenario. Bangladesh Journal of Botany. 2017;46(1):241-244.
59. Meena OP. A review: Role of plant growth regulators in vegetable production. International Journal of Agricultural Science and Research. 2015;5(5):71-84.
60. Mehdi M, Ahmed N, Jabeen N, Afroza B. Effect of different concentration of ethrel on growth, fruiting behavior and yield of cucumber (*Cucumis sativus* L.) under greenhouse conditions. The Asian Journal of Horticulture. 2012;7(2):579-58.
61. Meshram P, Badge S, Gaidhani A. Influence of foliar application of gibberellic acid and NAA on growth, quality and flower yield in African marigold. Journal of Agroecology and Natural Resource Management. 2015;2(2):162-164.
62. Mishra P. Effect of plant growth regulators on growth and flowering characters of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. International Journal of Agricultural Science and Research. 2017;7(1):173-178.
63. Mitchell JW. Plant-growth regulators. Department of Agriculture., Misc. Pub, U. S., 1942, 495p.
64. Modise DM, Likuku AS, Thuma M, Phuti R. The influence of exogenously applied 2,4 dichloro phenoxy acetic acid on fruit drop and quality of navel oranges (*Citrus sinensis* L.). African Journal of Biotechnology. 2009;8(10):2131-2137.
65. Moniruzzaman M, Khatoon R, Hossain MFB, Jamil MK, Islam MN. Effect of GA_3 and NAA on physico-morphological characters, yield and yield components of brinjal (*Solanum melongena* L.). Bangladesh Journal of Agricultural Research. 2014;39(3):397-405.
66. Mostafa LY, Kotb HRM. Effect of Brassinosteroids and Gibberellic acid on parthenocarpic fruit formation and fruit quality of Sugar Apple *Annona squamosa* L. Middle East Journal of Agriculture Research. 2018;7(4):1341-1351.
67. Muruganandam C. Influence of organic inputs and growth regulators on growth of French marigold. International Journal of Development Research. 2014;4(8):1712-1714.
68. Nagar BL, Dashora LK, Yadava LP. Effect of ultra-violet radiation, cytokinin and vapor gard on postharvest shelf life of kagzi lime (*Citrus aurantifolia* Swingle). Journal of Applied Horticulture. 2002;4(1):21-24.
69. Nanayakkara KPGA, Herath HMW, Senanayake YDA. Effects of Pre-harvest Treatments of Potassium, Post-harvest Treatments of Calcium, Potassium, Abscisic Acid and Light on Reducing Internal Browning in Pineapple (*Ananas comosus* (L.) Merr. cv Mauritius) under Cold-storage. Acta Horticulture, 2005, pp. 321-327.
70. Nasr AA. The effect of cytokinin and thidiazuron on tomato inoculated with endomycorrhiza. Mycorrhiza. 1993;3:179-182.
71. Nawaz A, Amjad M, Khan SM, Afzal I, Ahmed T, Iqbal Q, *et al*. Tomato seed invigoration with cytokinins. Journal of Animal and Plant Science. 2012;22(4):121-128.
72. Nawaz MA, Ahmad W, Ahmad S, Khan MM. Role of growth regulators on preharvest fruit drop, yield and quality in kinnow mandarin. Pakistan Journal of Botany, 2008;40(5):1971-1981.

73. Nguyen H, Mc Conchie R. Effect of Ethylene and Ripening Temperatures on the Skin Colour and Flesh Characteristics of Ripe 'Kensington Pride' Mango Fruit. Acta Hort. 2002, 635-642.
74. Nickel LG. Plant growth regulators, Agricultural uses. Springer Verlag, Berlin Heidelberg, New York, 1982.
75. Nowale J, Lawson GW. Outlook in Agriculture. 1983;2:179-184.
76. Pal SL. Role of plant growth regulators in floriculture: An overview. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):789-796.
77. Patel MJ, Patel HC, Chavda JC. Influence of plant growth regulators and their application methods on yield and quality of onion (*Allium cepa* L.). Asian Journal of Horticulture. 2010;5(2):263-265.
78. Prajapati S, Jamkar T, Singh OP, Raypuriya N, Mandloi R, Jain PK. Plant growth regulators in vegetable production: An overview. Plant Archives. 2015;15(2):619-626.
79. Prajapati U, Asrey R, Arora A, Singh AK, Hasan M. Differential effects of abscisic acid and fluridone on postharvest quality parameters of detached capsicum (*Capsicum annum* L.) fruits. Journal of Scientific and Industrial Research. 2019;78:242-247.
80. Rademacher W. Plant growth regulators: backgrounds and uses in plant production. J Plant Growth Regul, 2015;34:845-872.
81. Rahimia S, Naderib R, Ghaemaghami SA, Kalatejari S, Farham B. Study on effects of different Plant Growth Regulators types in shoot regeneration and node formation of Sutsuki Azalea (*Rhododendron indicum*): A commercially important bonsai. Procedia Engineering. 2013;59:240-246.
82. Rahmania I, Ahmadia N, Ghanatib N, Sadeghia M. Effects of salicylic acid applied pre- or post-transport on post-harvest characteristics and antioxidant enzyme activity of gladiolus cut flower spikes. New Zealand Journal of Crop and Horticultural Science. 2015;43(4):294-305.
83. Reshma VS, Panchbhai DM, Kumar P, Adarsh MN. Effect of GA_3 Spray on Gladiolus (*Gladiolus spp*.) Varieties under Dry Conditions of Vidharba Region, Int. J Pure App. Biosci. 2017;5(3):123-129.
84. Reyes MU, Paul RE. Effect of storage temperature and ethylene treatment on Guava (*Psidium guajava* L.) fruit ripening. Postharvest Biology and Technology. 1995;6:357-365.
85. Robbertse PJ, Stassen PJC. Paclobutrazol suppressed vegetative growth and improved yield as well as fruit quality of 'Tommy Atkins' mango (*Mangifera indica*) in Ethiopia. New Zealand Journal of Crop and Horticultural Science. 2004;32:281-293.
86. Roychowdhury N. Effect ofplant spacing and growth regulators on growth and flower yield of gladiolus grown under polythene tunnel. Acta Horticulturae, 1989, 246.
87. Rudich J, Halevu AH, Kedatr N. Increase in femaleness of three cucurbits by treatment with ethrel, an ethylene releasing compound. Planta. 1969;86:69-76.
88. Sahu CK, Patel MK, Panda CM. Effect of pruning and plant growth regulator on plant growth and fruit yield of sapota (*Manilkara zapota* L.) cv. Cricket Ball. International Journal of Current Microbiology and Applied Sciences. 2018;7(9):1352-1357.
89. Sahu CK, Patel MK, Panda CM. Effect of pruning and plant growth regulator on physico-chemical quality of sapota (*Manilkara zapota* L.) cv. cricket ball. The Pharma Innovation Journal. 2018;7(8):335-338.
90. Sajid M, Amin N, Ahmad H, Khan K. Effect of gibberellic acid on enhancing flowering time in *Chrysanthemum morifolium*. Pakistan Journal of Botany. 2016;48(2):477-483.
91. Sajjad Y, Jaskani MJ, Qasim M, Mehmood A, Ahmad N, Akhtar G. Pre-plant soaking of corms in growth regulators influences the multiple sprouting, floral and corm associated traits in *Gladiolus grandiflorus* L. Journal of Agricultural Science. 2015;7(9).
92. Schaller GE. Ethylene and the regulation of plant development. BMC Biol. 2012;10:1-3.
93. Shafeek MR, Helmy YI, Ahmed AA, Ghoname AA. Effect of foliar application of growth regulators (GA_3 and Ethereal) on growth, sex expression and yield of summer squashplants (*Cucurbita peop* L.) under plastic house condition. International Journal of Chem Tech Research. 2016;9(6):70-76.
94. Sharma A, Khanal A, Dhital B. Effect of gibberellic acid on postharvest shelf-life and quality of tomato. Journal of Postharvest Technology. 2018;6(4):82-90.
95. Shehata AM, Fahmy AA. Effect of salicylic acid concentration and application times on vegetative growth, seed yield and guaran production of guar (*Cyamposis tetragonoloba* L.) plant. Middle East Journal of Applied Sciences. 2019;9(3):795-803.
96. Sindhuja T, Venkatesan K, Premalakshmi V, Jeyakumar P. Effect of cytokinins and potassium nitrate on quality attributes of Muskmelon (*Cucumis melo* L.). Trends in Biosciences. 2017;10(20):3812-3815.
97. Singh B, Yadav AL, Meena AK. A study on foliar feeding of GA_3 and NAA on vegetative growth and yield of phalsa (*Grewia subinaequalis* D.C.). International Journal of Current Microbiology and Applied Sciences, 2017, 6(6).
98. Singh P, Singh D, Bahadur V, Jaiswa DK. Study on naphthalene acetic acid and gibberellic acid on growth and quality of capsicum (*Capsicum annum* L.) cv. Indra under shade net conditions. International Journal of Current Microbiology and Applied Sciences. 2017;6(6):2582-2585.
99. Solaimanalai AC, Shivakumar S, Anbumani Suresh T, Arumugam K. Role of plant growth regulators in rice production.: A Review. Agric Rev. 2001;22:33-40.
100. Srivastav M, Kishor A, Dahuja A, Sharma RR. Effect of paclobutrazol and salinity onion leakage, proline content and activities of antioxidant enzymes in mango (*Mangifera indica* L.). Scientia Horticulturae. 2010;125:785-788.
101. Sunidhi, Gandhi N. Effect of different concentrations of ethephon on ripening and quality of tomato (*Lycopersicon esculentum*). Journal of Pharmacognosyan Phytochemistry. 2019;SP1:33-35.
102. Sure S, Arooie H, Azizi M. Influence of plant growth regulators (PGRs) and planting method on growth and yield in oil pumpkin (*Cucurbita pepo* var. *styriaca*). Not Sci Biol. 2012;4(2):101-107.
103. Susaj E, Susaj L, Kallço I. Effect of different NAA and IBA concentrations on rooting of vegetative cuttings of two rose. Research Journal of Agricultural Science, 2012, 44(3).
104. Sweety Rana GS, Reddy GC. Impact of growth

regulators on fruit drop and yield parameters of sweet orange (*Citrus sinensis* Osbeck) cv. Jaffa. Journal of Pharmacognosy and Phytochemistry. 2018;7(4):3417-3419.

105. Taleb RAZ, Ahmad N, Shadaideh A. Influence of auxin concentrations on different ornamental plants rooting. International Journal of Botany. 2013;9(2):96-99.
106. Veisseire P, Linossier L, Coudret A. Effect of abscisic acid and cytokinins on the development of somatic embryos in *Hevea brasiliensis*. Plant Cell, tissue and Organ Culture. 1994;39:219-223.
107. Vidhya M, Pandiarajan T, Pandiselvam R, Amirtham D, Balakrishnan M, Haseena R, *et al*. Effect of ethylene concentration and exposure time on physico chemical quality and colour value of sapota fruit (*Manilkara zapota*). Asian Journal of Chemistry. 2017;29(5):970-974.
108. Wajid Khan M, Shahid MA, Balal RM. Determination of critical level of brassinosteroid (24-epibrassinoloid) for heat-tolerance in okra (*Abelmoschus esculentus* L.). *B.* Life and Environmental Sciences. 2017;54(3):207-217.
109. Zaharah SS, Singh Z, Symons GM, Reid JB. Mode of action of abscisic acid in triggering ethylene bio-synthesis and softening during ripening in mango fruit. Postharvest Biology and Technology. 2012;75:37-44.
110. Zamir R, Rab A, Sajid M, Ahmad I. Influence of zeatin, glutamin and auxins on root and shoot organogenesis of Guava (*Psidium guajava* L.) cv. safeda seedling explants. Pure Appl. Biol. 2017;6(1):197-206.
111. Zhu X, Shen L, Fu D, Si Z, Wu B, Chen W. Effects of the combination treatment of 1-MCP and ethylene on the ripening of harvested banana fruit. Postharvest Biology and Technology. 2015;107:23-32.