REVIEW ARTICLE

Effects of plant growth regulators on the production of vegetables

Mahendra Kumar Yadav[1*], Juri Das[2]

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Significant research on vegetable production has focused on the effects of plant growth regulators. Review demonstrates that using the right plant growth regulators can help increase vegetable production. They play a critical role in early planting, sex modification, yield and quality enhancement, resistance to pest illness, plant growth regulation, postponing senescence to prolong plant productive life and are essential steps in guaranteeing vegetable production. Nonetheless, Plant Growth Regulator (PGR) effectiveness is determined in part by several factors, including the specific type of regulator, the targeted vegetable crop and environmental conditions. Sustainable and responsible use of PGRs is crucial to minimize environmental impact and ensure economic viability. PGRs are essential resources for growing vegetables, enhancing yield, quality, stress resistance and post-harvest characteristics, contributing to sustainable and efficient agricultural practices.

Key Words: *Plant growth regulators; Earliness; Sex modification; Delaying senescence; Vegetable production*

INTRODUCTION

Plant Growth Regulators (PGRs) or plant growth regulators, are substances that influence the growth and development of plants. These regulators may be artificial or natural and are frequently employed in agriculture and horticulture to manipulate various physiological processes in plants. Other hand phytohormones, also known as plant growth regulators, are chemical compounds that higher plants naturally create. They act in minute quantities to regulate growth or other physiological processes at a location apart from the source of synthesis. Based on their distinct functions, plant growth regulators can be divided into three main classes: ethylene, gibberellins, abscisic acid, cytokinins, auxins and gibberellins. Despite the fact that the term "plant hormones", another term for plant growth regulators is phytohormones [1]. The Greek word hormone is derived from the verb hormao (Upu w), which implies to stimulate or urge. An organic material known as a plant hormone is produced in one area of the plant and transported to another, where it triggers a physiological reaction at very low concentrations. It was referred to as phytohormone to differentiate it from animal hormone. Similarly, growth hormones are defined as chemicals that are produced in specific cells and then transmitted to other cells where they have a very tiny but significant effect on the process of development. But the word "hormone" is rather common and commonly used.

Phytohormones or plant hormones, are naturally occurring substances that are produced by plants and aid in the regulation of plant growth. Additionally, they are extremely versatile chemical controllers of plant growth. When these substances are generated, they are known as Plant Growth Regulators (PGRs). Rademacher [2] reported these findings. Internal plant hormones as well as artificial substances that have physiological properties akin to those of plant growth hormones or that can alter plant development in other ways are categorized as plant growth regulators. They are split up into two categories: Growth inhibitors (ethylene and abscisic acid) and growth promoters (auxins, gibberellins and cytokinin).

LITERATURE REVIEW

Use of plant growth regulators in solanaceous vegetable

Tomato: PGRs are advantageous for tomato growth characteristics and productivity. Different concentrations of GA_3 (20, 40, 60 and 80 ppm) and Naphthaleneacetic Acid (NAA) (25, 50, 75 and 100 ppm) were sprayed on the tomato plants. The maximum plant heights of 85.3 cm and 82.3 cm were noted when 100 ppm of NAA and 80 ppm of Gibberellic Acid (GA_3) were used. Using these concentrations boosted yield (483.6 q/ha and 472.2 q/ha), according to Prasad et al., [3]. In contrast to NAA at 50 ppm and GA_3 at 50 ppm, the application of Chlormequat chloride (CCC) at 500 ppm enhanced plant height, fruit number, fruit diameter and per plant seed yield after transplanting tomato seedlings over a 45-day period. Luitel et al., [4], who conducted 2,4-D experiments and discovered an increase in tomato yield in protected environments. They discovered that the highest fruit set (55.0 percent) was found with 5 ppm 2,4-D spraying on flowers, with 10 ppm following closely after. Nevertheless, the most fruits that a plant may produce (14.8) was produced with 10 ppm 2,4-D spray. Additionally, they discovered that 5 ppm was the second best fruit yield/plant (587.9 g), after 10 ppm.

Brinjal: During the blooming stage, the application of 2,4-D at a concentration of 2.0 ppm results in parthenocarpy, enhances fruit-set, speeds up fruit maturity and significantly boosts overall yield. When NAA at 40 ppm was combined with BARI Begun-5, the result was a high percentage of long-style flowering and an abundance of fruits and plants [5]. When compared to GA_3@100 ppm, 200 ppm and minimum reported in the control, Dhakar et al., [6] find that GA_3@150 ppm produced the largest plant height, per-plant number of leaves, leaf length, per-plant number of branches and stem diameter. The application of NAA at a concentration of 40 ppm produced the highest reported results for a range of growth and production metrics in brinjal plants, according to Singh et al., [7]. Plant height, the quantity of branches and leaves, average fruit weight, fruit girth, fruit length, fruit yield per plant, fruit yield per hectare and the number of fruits per plant are some of these measures. Included are days to 50% flowering as well. These findings imply that the best development and production in brinjal plants can be achieved by applying 40 ppm of NAA. The experimental treatment consisting of administering 80 ppm of NAA provided the highest fruit output and demonstrated superior plant height, fruit length, quantity of fruits per plant and time taken for initial flowering.

Chilli and capsicum: The highest seed output per plant, seed yield per fruit, average fresh weight of fruits per plant and average dry weight of fruits per plant were all achieved by spraying NAA@40 ppm as opposed to control [8]. The highest plant height, the number of branches, the days until the first flowering, the number of flowers per plant, the weight of the fruit, the number of fruits per plant, the number of seeds per fruit, the yield per plant and the yield of fruit per plot following the application of 60 ppm of NAA were all recorded for capsicum, according to Singh et al. [9].

According to Raj et al., [10], NAA at 75 ppm produced the highest yield (182.31 g) per plant and 6.37 t/hectare. However, plants that have been treated with GA_3 at concentrations of 20 and 60 ppm, respectively, generated the biggest plant height and the largest dry weight of 20 fruits. The plants treated with 2,4-D@7.5 ppm expanded in a north-south direction, with

[1]*Department of Agriculture, RNB Global University, Bikaner, Rajasthan, India;* [2]*Department of Agriculture, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India*

Correspondence: *Mahendra Kumar Yadav, Department of Agriculture, RNB Global University, Bikaner, Rajasthan, India, E-mail: mahendra.yadav@rnbglobal.edu.in*

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the highest number of seeds per fruit ever observed. The biggest fruit set percentage (44.11 percent) was found for NAA 40 ppm among the numerous growth regulators and their concentrations. Tapdiya et al., [11] observed 30 ppm or 43.47 percent. Raj et al., [10] investigated growth regulator's impact on chili yield and growth. After transplanting, the growth regulators were applied as a foliar spray 30 and 60 days later. At 75 ppm (38.26 days), NAA showed the earliest flowering, followed by GA_3 at 60 ppm (38.72 days).

Use of plant growth regulators in cole crops

Cauliflower: The maximum plant height, number of leaves per plant, leaf length, leaf breadth at harvest, curd diameter and marketable production per hectare were measured using Indole-3-Acetic Acid (IAA) 10 ppm+GA_3 70 ppm in comparison to control. According to Rahman et al., [12], it was also found that the plants planted on November 15th had the largest curd diameter, the longest leaves, the most leaves per plant, the highest plant height and the maximum commercial production on an acre.

According to Sitapara et al., [13]. In terms of plant stand in the field and vegetative growth, research has shown that treating cauliflower seedlings with NAA 10 ppm as a starting solution works well. The time from transplanting to harvesting was decreased by applying GA_4+GA_7 at a dose of 80 mg/liter of water. Applying 2,4-D together with Benzyladenine (BA) delays the yellowing of curds. In cauliflower, spraying 2, 4-D (100-500 ppm) one to seven days prior to harvest minimizes weight loss and leaf abscission. According to reports, applying BA (5-20 ppm) postharvest can extend the shelf life of curds [14]. Applying a starting solution with 10 ppm of NAA to cauliflower seedlings produced successful plant stands and vegetative growth in the field. Curd yield rose when NAA@120 ppm was sprayed foliarly [15].

Cabbage: Islam et al., [16] treated cabbage with varying amounts of GA_3. They ingested GA_3 at concentrations of 0, 90, 120 and 150 parts per million. According to their analysis, GA produced the lowest marketable yield-0 ppm while GA_3 produced the highest yield-120 ppm. The maximum plant height, GA_3 was used to measure the head diameter and the maximum number of loose leaves per plant at a concentration of 120 ppm. They so found that at 120 ppm, GA_3 was more effective. To boost vegetative output, seeds should be steeped in a 0.1% boric acid solution before being sown. To boost seed yields, 50 ppm boric acid should be sprinkled on seeds during the flowering stage. The cold tolerance of cabbage plants was boosted by spraying them with a solution containing Chlormequat Chloride (CCC) or Succinic Acid 2,2-Dimethylhydrazide (SADH) at doses of 2,500-5,000 ppm. Chaurasiy et al., [17] used foliar sprays containing 40, 80 and 120 ppm of NAA and 30 ppm, 60 ppm and 90 ppm of GA_3 on cabbage plants 30 and 45 days after transplanting. They discovered that NAA 80 ppm and GA_3 60 ppm provided the maximum plant height, leaf count per plant, spreading of the plant, stem diameter, plant weight, head weight and head yield when compared to all other treatments and the control.

Use of plant growth regulators in bulb crops

Onion and garlic: Patel et al., [18] found that roots were considerably less likely to deteriorate and lose physiological weight when submerged in 100 ppm of NAA. Anbukkarasi et al., [19] state that ethylene, fungicides and CCC all have a major effect on how long an onion may stay on the shelf at this time and how long it takes for it to sprout. In order to increase shelf life, pre- and post-harvest treatments for onions were examined by Priya et al., [20]. It is advised to apply GA_3@150 mg/l at the 7th leaf stage and NAA@150 mg/l during the 3rd leaf stage simultaneously to boost onion yield and growth [21]. When applied fifteen days before harvest, Malic Hydrazide (2500 ppm) efficiently prevents onion sprouting in storage. On the other hand, using 500 ppm of Ethephon (or) Alar topically to garlic at 20-25 Days After Sowing (DAS) improves clove size and yield.

Use of plant growth regulators in root crops

Radish: The growth and yield characteristics of radish, such as plant height, number of leaves, leaf length, root diameter, weight of root and yield, are significantly improved by the foliar application of GA_3@100 ppm. Singh et al., [22] discovered that the maximum plant height, leaf length, leaf breadth, number of leaves per plant and fresh leaf weight were all recorded when GA_3 (30, 35 and 45 ppm) was sprayed on radish plant leaves. The maximum leaf length, plant height and yield-related parameters of root length, fresh weight of roots and root yield kg/plot all increase with the application of GA_3 at a 15 ppm concentration. With the application of GA_3@30 ppm, the maximum plant height, maximum number of leaves, maximum root diameter, maximum root length, maximum fresh weight of root, maximum root yield and maximum ha^{-1} were obtained.

Carrot: Abbas [23] reported that applying GA_3 topically to carrot roots reduces both the fresh and dry weight of the roots. Carrot shoot to root ratio was found to be greater when GA_3 was applied topically. Applying IAA or NAA three times foliarly at 100 or 200 mg L^{-1} till 30 days after planting stecklings is a useful method for altering the umbel arrangement, which will improve seed quality and yield. Therefore, in order to produce a better yield of high-quality carrot seed, gardeners and seed firms may administer IAA or NAA at 200 mg L^{-1} [24].

Use of plant growth regulators in tuber crops

Potato: Comparing the plant to a control, a 250 ppm dose of ethrel given topically changed the plant's phenotypic and increased plant height, shoot diameter, tuber number per plant and total tuber production [25]. When potato tubers are submerged in a solution containing IAA at 250-1000 ppm, their dormancy is prolonged; however, when a 1% thiourea solution is used, the tuber's dormancy is broken. Application of GA_3 50 ppm was superior for the least number of days needed for germination and average tuber weight. In comparison to the control plants, all GA treatments-liquid and powder may enhance tuber weight and yield per plot. GA increases the leaf area index, which has an impact on growth, but it has no discernible effect on plant height. The 0.2 ml L^{-1} liquid's therapy. When it came to yielding the biggest tuber size, weight per plant and weight per plot, GA was the best [26].

Sweet potato: When growing sweet potatoes, it was discovered that using GA_3 at a concentration of 100 ppm recorded the maximum growth characteristics. According to Behera et al. [27], the spraying of GA_3@100 ppm demonstrated noticeably maximum vine length (125.50 cm) and petiole length (26.83 cm).

RESULTS AND DISCUSSION

Use of plant growth regulators in cucurbitaceous crops

Cucumber: In cucumber application of ethephon@300 ppm demonstrated the high fruit quality and overall output [28]. Applying ethylene (150-200 ppm), naphthalene (100 ppm), manganese (100 ppm), boron and molybdenum (3 ppm) to cucumbers twice, once at the two-leaf stage and once at the four-leaf stage, enhances the amount of female flowers, fruit-set and ultimately, fruit yield. On gynoecious cucumbers, growth regulators like GA (1,500-2000 ppm) and chemicals like silver nitrate (200-300 ppm) cause the male flowers to appear. Maleic Hydrazide (MH) and ethephon, both at 100 ppm, increase the number of principal branches and nodes. At 300-400 ppm, ethylene increases femaleness and slows down secondary development. At 200-300 ppm, ethylene smoothes the surface of fruit. Cucumbers are made more masculine with 400 parts per millions of Silver Nitrate ($AgNO_3$). When salicylic acid is applied exogenously, it raises the amount of chlorophyll and enhances fruit output. At 100 ppm, maleic hydrazide by itself improves fruit size at 200 ppm, slows apical development at 50-100 ppm and enhances femaleness. According to Sapkota et al., [29] the GA_3 300 ppm spray resulted in the most lateral branches, plant height, total number of fruits per plant, fruit set percentage and overall fruit yield.

Watermelon: The majority of growth traits were found to be superior, including the first female flower's appearance, main stem length, number of leaves per plant, number of primary branches per plant and inter nodal distance. GA_3 (20 ppm) was applied to watermelon during the second and fourth true leaf stages. Furthermore, the application of 2,3,5-Triiodobenzoic Acid (TIBA) (20 ppm) resulted in the earliest female flowering node, the greatest number of fruits, the average fruit weight, the yield of fruits per plot and the yield of fruits per hectare within the shortest duration of time [30]. Fruit length, fruit diameter, total soluble solid, total sugar, reducing sugar and non-reducing sugar were shown to be the attributes of TIBA 20 ppm that were highest. The weight and diameter, number of nodes at which the first male and female flowers appeared, the number of days it took for the first male and female flowers to appear, the first female flower to appear, the number of days it took for the fruit to form and other yield-attributing traits were measured following the application of GA_3@40 ppm. On the other hand, the highest fruit output per plant, fruit length and rind thickness were obtained with the application of TIBA@20 ppm, TIBA@25 ppm and 2,4-D@50 ppm, respectively [31].

Muskmelon: Spraying ethrel at the 2 and 4 leaf stages at 150 ppm produced better results than the other treatments when it came to the number of primary branches at the end of the harvest, the time it took for the first male and female flowers to open, the number of male and female flowers per vine and the sex ratio (male:female) as well as the length of time it took for the fruit to set to edible maturity. When compared to a water spray, the foliar sprays Salicylic Acid (SA) (0.5 mM) and GA_3 (50 ppm) improved the morphological and yield parameters. When muskmelon was under stress, exogenous administration of salicylic acid at 0.5 mM and gibberellic acid at 50 ppm was successful in reducing the negative effects of drought stress. The amount of male and female flowers in Pusa Sharbati was enhanced by the combination of ethrel 150 ppm and NAA 100 ppm [32]. The maximum number of fruits, lowest number of male flowers, highest number of female flowers, number of fruits per vine, fruit weight, fruit diameter and highest yield per plant were all seen in the treatment containing NAA 150 ppm+Ethrel 250 ppm.

Bitter gourd: When 75 ppm of GA_3 was applied to bitter gourd, the male-to-female ratio in the Cultivar (CV) decreased. Faisalabad long [33]. The bitter gourd had increased leaf area and leaf area index when 50 ppm of NAA was given [34]. Furthermore, it increased the male to female sex ratio and the minimum number of days until the first female flower appeared, all at the same concentration, by repressing the male blossoms and elevating the female ones. Mia et al., [35] while in cv. BARI Karol, a greater NAA concentration of 150 ppm likewise results in a drop in the sex ratio. In Khatoon et al., [36] using emmeril, some cucurbits are bred to produce more female blooms. The bitter gourd variety had a maximum number of female flowers, a minimum number of male flowers, an early pistillate flower appearance, a delayed male flower appearance and a narrow sex ratio [37].

Bottle gourd: According to Kumari et al., [38] study, bottle gourds treated with 200 parts per milligram of ethylene (ppm) in their foliage showed positive effects on fruit output (kg/vine), the number of fruits per vine and the number of days before the first harvest. Conversely, the maximum fruit length, weight and girth were obtained by the application of distilled water, while the maximum vine length and total number of nodes per vine were obtained through the foliage application of GA_3@150 ppm. The length of the main vine and the number of nodes per plant in cultivar increase when it is administered at a greater dosage of 100 ppm [39]. The cultivar ABG-1 exhibited the lowest sex ratio and the highest number of female flowers when treated with 600 ppm of ethrel.

Pumpkin: Spraying of ethrel (250 ppm) in pumpkin crops significantly enhanced the growth parameters and yield by recing the staminate flower and increasing the pistillate flowers [40].

Use of plant growth regulators in other vegetables

Okra: It was shown that foliar spraying the okra would maximize the output per plant of the variety Varsha Uphar at 30 days after planting with CCC at 600 ppm, ethrel at 300 ppm and PBZ at 150 ppm [41]. However, when GA_3@150 ppm was administered, minimum days for the first blossoming and the first harvesting were required. When NAA was sprayed at a concentration of 20 parts per million, the highest plant height was observed; when cycocel was sprayed at a concentration of 1000 parts per million, the number of branches and internode length were measured [42]. GA_3@50 ppm generated the best seed quality attributes, including average pod weight (g) and 100 seed weight (g), according to data from Ravat et al., [43].

CONCLUSION

In conclusion, it has been found that PGRs have positive impacts on vegetable production, with respect to yield and yield-contributing traits of several vegetable crops. PGRs help plants grow roots and become more resilient to environmental stresses like drought and temperature fluctuations. Plant growth is regulated by plant hormones, which are naturally occurring substances produced by plants. These hormones, also known as plant growth regulators, are versatile chemical controllers that can alter plant development. Significant research on vegetable production has highlighted the importance of plant growth regulators in enhancing yield, quality and resistance to pests. Sustainable use of PGRs is crucial for minimizing environmental impact and ensuring economic viability, contributing to efficient agricultural practices and enhancing yield and quality of vegetables.

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REFERENCES

1. Pallabi N, Dhanalakshmi TN, Rudramuni T, et al. Glimpses about role hormones in plants. Innov Farm. 2016;1(2):59-61.
2. Rademacher W. Plant growth regulators: Backgrounds and uses in plant production. J Plant Growth Regul. 2015;34:845-872.
3. Prasad RN, Singh SK, Yadava RB, et al. Effect of GA_3 and NAA on growth and yield of tomato. Veg Sci. 2013;40(2):195-197.
4. Luitel BP, Lee TJ, Kang WH. Fruit set and yield enhancement in tomato (*Lycopersicon esculentum mill.*) using gibberellic acid and 2, 4-dichlorophenoxy acetic acid spray. J Bio Env Con. 2015;24(1):27-33.
5. Moniruzzaman M, Khatoon R, Hossain MF, et al. Effect of GA_3 and NAA on physio-morphological characters, yield and yield components of brinjal (*Solanum melongena* L.). Bangladesh J Agric Res. 2014;9(3):397-405.
6. Dhakar S, Singh Y. Studies on the effect of inorganic fertilizers and plant growth regulator on growth and yield of brinjal (*Solanum melongena* L.). Indian J Basic Appl Res. 2015;1(2):27-39.
7. Singh S, Saxena AK, Chand V. Influence of plant growth regulators (GA_3) and (NAA) on growth and yield attributes of brinjal (*Solanum melongena* L.). Int Res J Modern Eng Technol Sci. 2021;3(5):2582-5208.
8. Patel VP, Lal EP, John S, et al. Comparative study of the effect of plant growth regulators on growth, yield and physiological attributes of chilli, *Capsicum annuum* L cv Kashi Anmol. Int J Farm Sci. 2016;6(1):199-204.
9. Singh P, Singh D, Jaiswal DK, et al. Impact of naphthalene acetic acid and gibberellic acid on growth and yield of capsicum, *Capsicum annum* (L.) cv. Indra under shade net conditions. Int J Curr Micro App Sci. 2017;6(6):2457-2462.
10. Raj AC, Holebasappa K, Hore JK, et al. Effect of plant growth regulators on growth and yield of Chilli (*Capsicum annuum* L.). Research Crop. 2016;17(2):320-323.
11. Tapdiya GH, Gawande PP, Ulemale PH, et al. Effect of growth regulators on quantitative characters of chilli (*Capsicum annuum* L.). Int J Curr Microbiol Ap Sci. 2018;6:2151-2157.
12. Rahman MA, Imran M, Ikrum M, et al. Effects of planting date and growth hormone on growth and yield of cauliflower. J Environ Sci Nat Resour. 2016;9(2):143-150.
13. Sitapara HH, Vihol NJ, Patel MJ, et al. Effect of growth regulators and micro nutrient on growth and yield of cauliflower cv.'Snowball-16'. Asian J Horticult. 2011;6(2):348-351.
14. Meena OP. A review: Role of plant growth regulators in vegetable production. Int J Agri Sci Res. 2015;5(5):71-84.
15. Dixit A, Sahu TK, Bairwa PL. Effect of foliar application of plant growth regulators on yield, quality and economics of cauliflower (*Brassica oleracea var. botrytis* L.) cv. pant shubhra. J Pharmacog Phytochem. 2020;9(1):1197-1199.
16. Islam MM, Khan MS, Parven A. Growth and yield potential of late planting cabbage influenced by gibberellic acid. Int J Bus Soc Sci Res. 2017;6(1):62-67.
17. Chauasiy JM, Meena M, Singh H, et al. Effect of GA_3 and NAA on the growth and yield of cabbage (*Brassicaoleracea var. capitata* L.) cv. pride of india. Bioscan. 2014;9(3):1139-1141.
18. 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 J Hortic. 2010;5(2):263-265.
19. Anbukkarasi V, Paramaguru P, Pugalendhi L, et al. Studies on pre and post-harvest treatments for extending shelf life in onion-a review. Agric Rev. 2013;34(4):256-268.
20. Priya EP, Sinja VR, Alice RP, et al. Storage of onions-a review. Agric Rev. 2014;35(4):239-249.
21. Bista D, Sapkota D, Paudel H, et al. Effect of foliar application of growth regulators on growth and yield of onion (*Allium cepa*). Int J Hortic Sci Technol. 2022;9(2):247-254.

22. Singh MS, Singh RP, Yadav HS. Response of growth regulators and their methods of application on yield of radish (*Raphanus sativus* L.). 1989;4(2):84-88.

23. Abbas ED. Effect of GA_3 on growth and some physiological characterizes in carrot plant (*Daucus carota* L.). Ibn Al-Haitham J Pure Appl Sci. 2011;24(3):52-57.

24. Noor A, Ziaf K, Amjad M, et al. Synthetic auxins concentration and application time modulates seed yield and quality of carrot by altering the umbel order. Sci Hortic. 2020;262:109066.

25. Awati RA, Bhattacharya AB, Char BC. Effect of foliar application of plant growth regulators on growth and yield of potato seed tubers propagated from micro plantlets on soilless solid media in greenhouse. Adv Res J Crop Improv. 2016;7(2):234-239.

26. Prathama M, Rosliani R, Pangestuti R, et al. Study of growth and yield of potato plants (*Solanum tuberosum* L.) under several gibberellin application during the dry season. InBIO Web of Conferences. EDP Sciences. 2023;69:1016.

27. Behera S, Hanchinamani CN, Hadimani HP, et al. Effect of plant growth regulators on growth parameters of sweet potato (*Ipomoea batatas* (L.)). J Plant Develop Sci. 2018;10(5):271-275.

28. Mir AA, Sadat MA, Amin MR, et al. Plant growth regulators: One of the techniques of enhancing growth and yield of bangladeshi local cucumber variety (*Cucumis sativus*). Plant Sci Today. 2019;6(2):252-258.

29. Sapkota B, Dhital M, Shrestha B, et al. Effect of plant growth regulators on flowering and fruit yield of cucumber (*Cucumis sativus* cv. Malini) in Chitwan, Nepal. J Agri Forestry Uni. 2020;4:161-167.

30. Meshram LT, Sonkamble AM, Patil SR, et al. Effect of plant growth regulators on yield and quality of watermelon. Pharm Inno J. 2022;11(3):2424-2427.

31. Kumar PS, Rao MCS, et al. Effect of plant growth regulators on flowering and yield attributes of watermelon (*Citrullus lanatus* Thunb). Environ Ecol. 2023;41(1):58-62.

32. Devi YR, Madhanakumari P. Effect of plant growth regulators on flowering and yield of muskmelon (*Cucumis melo* L.). Plant Arch. 2015;15(2):899-901.

33. Ghani MA, Amjad M, Iqbal Q, et al. Efficacy of plant growth regulators on sex expression, earliness and yield components in bitter gourd. Pak J Life Soc Sci. 2013;11(3):218-224.

34. Kumar PR, Vasudevan SN, Patil MG. Effect of foliar sprays of NAA, triacontanol and boron on growth and seed quality in bitter gourd (*Momordica charantia* L.) cv. pusa visesh. J Hortic Sci. 2014:148-152.

35. Mia MAB, Islam MS, Shamsuddin JH. Altered sex expression by plant growth regulators: An overview in medicinal vegetable bitter gourd (*Momordica charantia* L.). J Med Plant Res. 2014;8(8):361-367.

36. Khatoon R, Moniruzzaman M, Moniruzzaman M. Effect of foliar spray of GA_3 and NAA on sex expression and yield of bitter gourd. Bangladesh J Agric Sci. 2019;44(2):281-290.

37. Aishwarya K, Reddy PS, Sadarunnisa S, et al. Influence of plant growth regulators and stage of application on sex expression of bitter gourd (*Momordica charantia* L.) cv. vk-1-priya. Plant Arch. 2019;19(2):3655-3659.

38. Kumari K, Kamalkant KR, Singh VK. Effect of plant growth regulators on growth and yield of bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). Int J Curr Microbiol Appl Sci. 2019;8(7):1881-1885.

39. Ansari AM, Chowdhary BM. Effects of boron and plant growth regulators on bottle gourd (*Lagenaria siceraria* (Molina) Standle.). J Pharmacogn Phytochem. 2018;7(1S):202-206.

40. Sakthinathan B, Swaminathan V, Balasubramanian P, et al. Effect of ethrel on sex expression on pumpkin (*Cucurbita moschata* L.). Int J Chem Stud. 2017;5(6):964-966.

41. Kumar P, Haldankar PM, Haldavanekar P. Study on effect of plant growth regulators on flowering, yield and quality aspects of summer okra (*Abelmoschus esculentus* L. Moench) var. varsha uphar. Varsha Uphar. 2018;7(6):180-184.

42. Kumawat A, Gupta NK, Jain NR, et al. Studies on the effect of plant growth regulators and micronutrients on okra (*Abelmoschus esculentus* L.) cv. parbhani kranti. Int J Curr Microbiol Appl Sci. 2019;8:3216-3223.

43. Ravat AK, Nirav Makani NM. Influence of plant growth regulators on growth, seed yield and seed quality in okra [*Abelmoschus esculentus* (L.) Moench] cv. GAO-5 under middle Gujarat condition. Int J Agri Sci. 2015;11(1):151-157.