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Plant growth regulator's impact on tomato crop (*Solanum lycopersicum* L.) growth and yield: A review

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Abstract
Indian agriculture has become more scientific and mechanical through the use of inputs, such as plant growth regulators, which have a speedier effect on crop output and vegetative development in order to increase productivity and food safety. Because it is environmentally beneficial and takes less time to treat the plant, among other benefits. Vitamins and minerals are abundant in vegetable crops. Growth regulators must have a specific mechanism of action and be safe for the environment and toxicology when used in vegetable cultivation. Vegetable crops' physiological activity controls and, with the administration of a growth regulator, ultimately improves vegetable yield. The tomato fruit can be eaten raw, boiled, or processed into a variety of products, giving it a wide range of nutritional applications. Since it is a very important crop, increasing output in India is crucial, and the researchers benefit immensely from these adaptable resources. PGRs control vegetable activity, which ultimately improves vegetable yield.

Keywords: Tomato, curtail, growth regulators, growth and vegetable

Introduction

In many countries, tomato is also known as "Poor Man's Orange, Wolf Apple and Valayti Baingan" (Dhall and Singh, 2013) [11]. It is a day neutral plant of warm season but it can be grown in a variety of climatic conditions. It is susceptible to frost as well as high temperature as it adversely affects the growth and development. It can also be grown in the hills of India as an off-season vegetable crop. It is mainly a self-pollinated crop, but cross-pollination also takes place at a certain percentage. Tomato (*Solanum lycopersicum* L.) (2n = 2x = 24) is one of the most important crop which belongs to the family Solanaceae and the genus *Solanum*. Peru-Ecuador region is the origin of cultivated tomato which is in wild form (Rick and Holle, 1990) [35]. On the basis of its morphological and molecular studies, the tomato was renamed as *Solanum lycopersicum* from *Lycopersicon esculentum* (Peralta and Spooner, 2000) [29]. Throughout the country, the fresh tomatoes are in great demand around the year. For small and marginal farmers, it contributes to the nutrition of the consumer and fetches very good income after sending their produce (Singh *et al.*, 2010) [42]. Tomato flowers are borne in a small forked raceme cyme. They are pendent, perfect and hypogynous. In each compound inflorescence, there are four to eight flowers. The stigma leading to self-pollination due to the presence of light protective anther core. In tomato, pollen fertility is maximum on the day of anthesis which occurs at 7.00-8.00 and stigma is fully receptive at 16 hours before anthesis to the day of anthesis (Sidhu *et al.*, 1980) [41].

The ripe fruits are taken as raw and large quantities of tomatoes are used to prepare salads, soups, juice, preserve, pickles, ketchup, puree, paste and many other products (Chadha, 2001) [7]. Plant growth regulators improves the yield and quality to a great extent by genetic manipulations (Philosoph-Hadas *et al.*, 2005; Kucera *et al.*, 2005) [30, 20]. The appropriate elucidation of Gibberellic acid transport mechanism is essential for the survival of plant species and successful crop production (Gupta and Chakrabarty, 2013) [14]. Naphthalene Acetic Acid accelerates the maturity, produces better quality fruits, affects the physiological process and some other aspects such as to increase the number of branches, increased fresh weight, and yield (Revanappa, 1998) [34]. Ethrel, penetrates into the plant tissues, translocated and progressively decomposed to ethylene, which positively affects the growth process because of its systemic properties.

Role of Plant growth regulators on growth of tomato

A. Gibberellic acid

In 1926, the Japanese scientist Kurosava made the discovery of gibberellins. It is the second regulator of growth. It was isolated from "foolish seedling of rice," which is caused by the fungus "Gibberella fujikuroi." GA promotes seed germination as well as flower and fruit maturity. It is crucial for cell division and elongation, which in turn promote plant growth (Batlang *et al.*, 2006) [6]. In addition to increasing fruit setting percentage, fruit output, and shelf life, it has a significant impact in reducing pre-harvest fruit drop, a key issue.

Naeem *et al.* (2001) [25] observed that maximum days to flowering (42.67), plant height (77.78 cm) and number of branches (12.33) per plant were recorded in the plants sprayed with 60 mg per litre of gibberellic acid 10 days before transplantation in tomato. Khan *et al.* (2006) [18] studied that 4 levels of gibberellic acid concentration proved beneficial on the growth, leaf-NPK content, yield and quality parameters, especially in the case of Hyb-SC-3 in tomato. Serrani *et al.* (2007) [38] observed the role of gibberellins in tomato (*Solanum lycopersicum*) fruit development. Two different inhibitors of GA biosynthesis (LAB 198999 and paclobutrazol) decreased fruit growth and fruit set, an effect reversed by GA_3 application. Afroz *et al.* (2009) [1] reported that regeneration was significantly higher with different treatments used in combination with GA_3 from 68 to 73% in Avinash followed by Pusa Ruby (68.5 to 72.33%). Inclusion of GA_3 in the media also significantly reduced the days to regeneration in tomato. Gelmesa *et al.* (2010) [13] studied the effects of gibberellic acid and 2,4-Dichlorophenoxy Acetic Acid spray on fruit yield and quality of tomato (*Lycopersicon esculentum* Mill.). The experiment consisted of two tomato varieties-one processing (Roma VF) and one fresh market (Fetan). Results showed that significant increase in fruit length, fruit weight and fruit pericarp thickness over the control. Ouzounidou *et al.* (2010) [26] determined the comparative study on the effects of various plant growth regulators on growth, quality and physiology of *Capsicum annuum* L. Among PGRs, GA_3 @ 100μM was effective in promoting flowering and better for vegetative characteristics. Uddain *et al.* (2009) [52] revealed that four different plant growth regulators which were used as treatments, *viz*., Control, NAA, GA_3 and 2,4-D. Maximum plant height, number of leaves, number of branches, number of flowers cluster, average weight of individual fruit and yield were found in GA_3 in tomato. Kumar *et al.* (2014) [21] determined that highest plant height, number of leaves, number of fruits, fresh fruit weightmascorbic acid and total soluble solid (TSS) was estimated for GA_3 @ 50 ppm in tomato. Sattigeri *et al.* (2014) [37] observed that the application of GA_3 @ 20 ppm was effective in increase plant height (66.2 cm), leaves (143.3) and branches (20.1). The biochemical parameters tested, like chlorophyll content was significantly higher with GA_3 @ 20 ppm followed by vermicompost (2 and 1 t per ha) in tomato. Akand *et al.* (2015) [2] reported that the maximum plant height (132.05 cm), maximum dry matter content of leaves (14.43%) and maximum number of flowers per plant (104.7) significantly at the concentration of GA_3 @ 125 ppm in tomato. Chauhan *et al.* (2017) [9] reported that, application of GA_3 @ 50 ppm gave significantly highest growth characters *viz*., plant height (79.69 cm) and number of branches per plant (9.39) were recorded as field observations. While root length (6.80 cm), shoot length (8.76 cm), root fresh weight (0.81 g), shoot fresh weight (3.37 g), root dry weight (0.05 mg), shoot dry weight (0.20 mg), vigour index-I (789.25) and vigour index-II (22.66) also gave significant resulted in tomato. Tomar *et al.* (2017) [51] revealed that the maximum plant height was recorded as 99.03 and 85.47 cm with the application of GA_3 @ 30 ppm and NAA @ 30 ppm, respectively at the time of harvesting in tomato.

B. Naphthalene Acetic Acid

The existence of auxin was initially suggested by Charles Darwin in 1880. It was the first growth regulator of its kind to be found. Auxins are substances that have a favorable impact on bud formation, cell expansion, and root initiation. They also aid in the production of other growth hormones. Whereas NAA, IBA, 2-4D, and other hormones are synthetic, IAA is a naturally occurring hormone.

Chaudhary *et al.* (2006) [6] determined that NAA @ 40 ppm gave the highest leaf area index (LAI). GA_3 at 10 ppm exhibited maximum amount of ascorbic acid content in chilli. Sharma (2006) [8] showed that an interaction effect of plant growth regulators on growth and yield significantly gave higher fruit yield (17.76 t per ha) in treatment NAA @ 40 ppm in brinjal. Bakrim *et al.* (2007) [5] observed that NAA treatment resulted in marked reduction in shoot length. GA_3 treatment promoted maximal shoot elongation. BAP affected negatively shoot length only at late stages, while 20E application stimulated shoot elongation at early stages and reduced it on the fifth day in tomato. Patel *et al.* (2012) [28] reported that plant height of tomato (86.40 cm) and brinjal (74.47 cm) was found to be maximum with NAA @ 50 ppm. Singh *et al.* (2012) [45] revealed that bio-regulators spray had significant influence on growth and yield. Spraying of NAA @ 50 ppm increased the plant height, number of secondary branches, leaf area, days taken for anthesis and number of flowers per plant. The maximum height (114.38 cm) was found in treatment NAA @ 50 ppm in capsicum. Kiranmayi *et al.* (2014) [19] studied the growth characters, the plants sprayed with NAA @ 20 ppm + 0.05% boron recorded maximum plant height (83.33 cm), maximum plant spread (137.33 cm), maximum number of primary branches (17.0) and minimum number of days to 50% flowering (63 days) compared to other treatments in chilli. Tamilselvi and Vijayaraghavan (2014) [49] recorded that NAA @ 40 ppm significantly increased the growth parameters of chilli *viz*., plant height (64.4 cm), number of primary branches per plant (7.56) and leaf area (503.2 cm^2 per plant) in chilli. Shankhwar *et al.* (2017) [39] revealed that the highest plant height (56.39 cm), number of leaves per plant (90.35) and number of branches (26.97) recorded maximum with NAA @ 40 ppm concentration in chilli. Singh *et al.* (2018) [46] revealed that application of NAA @ 100 ppm significantly facilitates the number of branches per plant in tomato.

C. Ethylene

This hormone is a gaseous plant hormone that is produced in all plant organs from methionine. Dhall and Singh (2013) [11] observed that the treatment ethylene gas @ 100 ppm registered the highest ripening percentage. The ripening and rotting percentage increased with increase in the concentration of ethephon @ 500-1500 ppm and with the duration of days for which the fruits were kept for ripening in tomato. Tiwari and Singh (2014) [50] found number of branches increased by Alar, NAA and Ethephon while 2,4-D, CIPA and Ethephon showed early maturity of fruits in tomato.

Role of Plant growth regulators on Yield of tomato

A. Gibberellic acid

Naeem *et al.* (2001) [25] observed that the both time and concentrations had affected significantly the yield parameters of plants. Maximum fruit per plant (77.69), fruit weight (71.15 g) and yield (26840 kg per ha) were recorded in the plants sprayed with gibberellic acid @ 60 mg per lit at 10 days before transplantation, minimum fruit drop per plant also found in gibberellic acid @ 60 mg per lit in tomato. Sasaki *et al.* (2005) [36] studied that tomatoes treated with a mixture of 4-CPA and GAs showed increased fruit set and the numbers of normal fruits were more than the plants treated with 4-CPA alone during summer. Alexopoulos *et al.* (2006) [4] observed that application of GA_3 @ 30 days after transplanting significantly increased plant height and the number of branches. Late application of GA_3 induced a high percentage of sprouted tubers prior to harvest and significantly increased the physiological age of the tubers, as reflected by an increased rate of respiration, sprouting and weight loss after harvest. Although early application of GA_3 also increased tuber sprouting prior to harvest in potato. Prasad *et al.* (2013) [31] recorded that the maximum yield of 483.6 and 472.2 q per ha was obtained with the use of GA_3 @ 80 ppm and NAA @ 100 ppm, respectively in tomato. Ranjeet *et al.* (2014) [33] observed that the application of the plant bioregulators had a significant influence on plant growth, flowering, fruiting, yield and quality traits and GA_3 gave the highest yield than other plant growth regulators. So, GA_3 was superior among all treatments under investigation for the response of tomato production. Srividya *et al.* (2014) [48] found the evident from the data that among the various chemical treatments imposed, tomato fruits treated with GA_3 @ 0.3% recorded significantly highest shelf life of 43 days under ambient storage conditions. Verma *et al.* (2014) [53] observed that maximum number of flowers and number of fruits per plant were recorded in concentration at GA_3 @ 40 ppm in tomato. Akand *et al.* (2015) [2] revealed that highest yield (92.99 t per ha), maximum number of fruits per plant (56.42) and maximum fruit length (6.89 cm) was obtained from GA_3 @ 125 ppm concentration in tomato. Rahman *et al.* (2015A) [32] revealed that the application of GA_3 @ 50 ppm by root soaking had significantly increased the number of flowers, fruits and fruit yield per plant but similar results were achieved when only GA_3 @ 25 ppm was applied at the flowering stage in tomato. Kumar *et al.* (2016) [22] studied that GA_3 @ 100 ppm recorded significantly higher fruit yield per plant (1206 g), seed yield per plant (8.12 g), germination (90.92%) and vigour index (1424) over control (11.1069 g, 7.36 g, 87.60% and 1301, respectively) in tomato. Sreenivas *et al.* (2017) [47] observed that early fruit maturity (38.13 days), maximum yield (152.64 g per plant), maximum number of fruits per plant (84.67), maximum fruit weight (2.61 g) and maximum fruit set (30.15%) in 20 ppm seedling dip and 40 ppm foliar spray followed by 20 ppm seedling dip and 30 ppm foliar spray of GA_3 in chilli. Jakhar *et al.* (2018) [17] observed that all yield parameter was found to be significantly superior at concentration of GA_3 @ 50 ppm which increase the fruit length (6.10 cm), fruit diameter (5.93 cm), number of fruit per plant (30.80), fruit yield per plant (3.66 kg) and fruit yield per ha (1355.56 tonnes) in tomato. Singh *et al.* (2018) [46] revealed that number of fruits per plant and fruit weight was significantly improved due to increasing level of NAA @ 100 ppm application. Fruit weight and the number of fruits were significantly improved due to the GA_3 application and a maximum yield was also obtained due to application GA_3 @ 80 ppm in tomato. Baby *et al.* (2018) studied that the maximum fruit yield per plant (6.94 kg) and the maximum fruit diameter (5.52) was recorded in the treatment T_6 (GA_3 @ 75 ppm) in cherry tomato. Hossain *et al.* (2018) [16] studied that the maximum plant height (88.30cm) was found in GA_3 @ 20 ppm and the number of flower cluster per plant (10.12), bud per cluster (8.26), flower per cluster (5.99), number of fruits per plant (17.65) and fruit yield per plant (328.99 g) were found with the application of NAA @ 20 ppm + GA_3 @ 20 ppm in summer tomato.

B. Naphthalene Acetic Acid

Alam and Khan (2002) [3] reported that the spray of NAA at variable concentration significantly increased the fruit yield of tomato as compared to control. The nutrient contents were also increased in majority of cases. Patel *et al.* (2012) [28] observed that TSS (5.56 and 5.06 °Brix) and acidity (0.60 and 0.29%) were found maximum with foliar spray of NAA @ 100 ppm in tomato and brinjal, respectively. In tomato ascorbic acid was found maximum (22.46 mg per 100 g) with 2,4-D @ 8 ppm while in brinjal, it was maximum (16.46 mg per 100 g) with NAA @ 100 ppm. Desai *et al.* (2014) [10] observed that maximum acidity percent (1.41%) and ascorbic acid (109.33 mg per l00 g pulp) were found in NAA @ 75 ppm, maximum reducing sugars (1.68%), non-reducing sugars (1.98%), total sugars (3.67%) and TSS (4.33 ^{0}Brix) were found in GA_3 @ 75 ppm in tomato. Pargi *et al.* (2014) [27] concluded that naphthalene acetic acid had significant influence on growth, quality and yield, especially the treatment with the application of NAA @ 50 ppm and NAA @ 30 ppm in tomato. Moniruzzaman *et al.* (2014) [24] revealed that NAA @ 40 ppm produced highest percentage of long and medium styled-flower, leaf photosynthesis, number of fruits per plant and fruit yield (45.50 t per ha) in brinjal. Gare *et al.* (2017) [12] observed that foliar application of NAA @ 60 ppm gave significantly highest dry red chilli yield, the highest fruit setting and lowest flower drop. Singh *et al.* (2017) [44] revealed that NAA @ 60 ppm increased fruit weight (169.66 g), number of fruit per plant (9.87), number of seeds per fruit (110.78), fruit yield per plant (1.67 kg), fruit yield per plot (15.07 kg) and fruit yield per hectare (69.76 t per ha) in capsicum. Singh *et al.* (2019) [43] showed that the use of GA_3, NAA and 2,4-D at specific concentration (GA_3 @ 30 ppm, NAA @ 30 ppm and 2,4-D @ 5 ppm) in combination considerably increased the weight of fruit and significantly increased increases length of fruit (312 cm) in tomato.

C. Ethylene

Logendra *et al.* (2004) [23] observed that ethephon was significantly increased the fruit yield for the 1000 ppm treatement in tomato. Helyes *et al.* (2007) [15] conducted an experiment on effect of ethrel on ripening dynamic and lycopene content in case of two processing varieties. This experiment confirmed that all of the ethephon rates exceeding 3000 ppm caused enhanced fruit maturity, compared to untreated controls. There were no significant differences in fruit quality (°Brix, organic acid, sugar and lycopene content) observed resulting from ethephon effects in tomato.

Conclusion
Giberrelic acid, naphthalene acetic acid, and ethylene are used to greatly improve the output per hectare, as well as the number of fruits per plant, fruit settings, fruit weight etc . Because it encourages cell division and elongation, giberrelic acid frequently improves vegetative growth, or the height of the plant. Growth regulators such as giberrelic acid, naphthalene acetic acid, and ethylene raise plant height, fruit production per plant, and flower cluster count, all of which contribute to higher yield.

Author's Contribution
Conceptualization of research, Writing original draft. Review and editing (RK): Writing and reviewing (RK)
Designing of the experiments (); Contribution of experimental materials (); Execution of field/lab experiments and data collection (); Analysis of data and interpretation (); Preparation of the manuscript ().

Declaration
The authors affirm that none of the work presented in this review was influenced by any known conflicting financial interests or personal ties.

Data Availability
No data was used in the study. Rather the findings of the studies made in the related aspects of the review have been collected, collated and presented.

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References
1. Afroz A, Chaudhry Z, Khan R, Rashid H, Khan SA. Effect of GA3 on regeneration response of three tomato cultivars (*Lycopersicon esculentum*). Pakistan Journal of Botany. 2009;41(1):143-151.
2. Akand H, Mazed HEMK, Pulok AI, Chowdhury SN, Moonmoon JF. Growth and yield of tomato (*Lycopersicon esculentum* Mill.) as influenced by different level of gibberellic acid application. International Journal of Applied Research. 2015;1(3):71-74.
3. Alam SM, Khan MA. Fruit yield of tomato as affected by NAA spray. Asian Journal of Plant Science. 2002;1:24.
4. Alexopoulos AA, Akoumianakis KA, Passam HC. Effect of plant growth regulators on the tuberisation and physiological age of potato (*Solanum tuberosum* L.) tubers grown from true potato seed. Canadian Journal of Plant Science. 2006:1217-1225.
5. Bakrim A, Lamhamdi M, Sayah F, Chibi F. Effects of plant hormones and 20-hydroxyecdysone on tomato (*Lycopersicon esculentum*) seed germination and seedlings growth. African Journal of Biotechnology. 2007;6(24):2792-2802.
6. Batlang V, Emongor VE, Pule-Meulenburg F. Effect of benzyladenine and gibberellic acid on yield and yield components of cucumber (*Cucumis sativus* L. cv. Tempo). Journal of Agronomy. 2006;5(3):418-423.
7. Chadha KL. Tomato; Handbook of Horticulture. ICAR publication; 2001. p. 8.
8. Chaudhary BR, Sharma MD, Shakya SM, Gautam DM. Effect of plant growth regulators on growth, yield and quality of chilli (*Capsicum annum* L.) at Rampur, Chitwan. Journal of Institute of Agriculture and Animal Sciences. 2006;27:65-68.
9. Chauhan SA, Patel NB, Mehta DR, Patel JB, Zala IM, Vaja AD. Effect of plant growth regulators on seed yield and its parameters in tomato (*Solanum lycopersicum* L.). International Journal of Agriculture Sciences. 2017;9(8):3906-3909.
10. Desai SS, Chovatia RS, Singh V. Effect of different plant growth regulators and micronutrients on fruit quality and plant micronutrient content of tomato. International Journal of Agricultural Sciences. 2014;10(1):130-133.
11. Dhall RK, Singh P. Effect of ethephon and ethylene gas on ripening and quality of tomato (*Solanum lycopersicum* L.) during cold storage. Journal of Nutrition and Food Science. 2013;3(6):1-7.
12. Gare BN, Raundal PU, Burli AV. Effect of plant growth regulators on growth, yield and yield attributing characters of rainfed chilli (*Capsicum annum* L.). Advanced Agricultural Research and Technology Journal. 2017;1(2):195-197.
13. Gelmesa D, Abebie B, Desalegn L. Effects of gibberellic acid and 2,4-dichlorophenoxy acetic acid spray on fruit yield and quality of tomato (*Lycopersicon esculentum* Mill.). Journal of Plant Breeding and Crop Science. 2010;2(10):316-324.
14. Gupta R, Chakrabarty SK. Gibberellic acid in plant. Plant Signaling & Behavior. 2013;8(9):e25504.
15. Helyes L, Lugasi A, Schober GY, Pek Z. Effect of ethrel on ripening dynamic and lycopene content in case of two processing varieties of tomato. Acta Horticulturae. 2007;758:275-280.
16. Hossain ME, Amin R, Sani MNH, Ahamed KU, Hosain MT, Nizam R. Impact of exogenous application of plant growth regulators on growth and yield contributing attributes of summer tomato. International Journal of Plant and Soil Science. 2018;24(5):1-14.
17. Jakhar D, Thaneshwari, Nain S, Jakhar N. Effect of plant growth regulator on growth, yield and quality of tomato (*Solanum lycopersicum*) cultivar 'Shivaji' under Punjab condition. International Journal of Current Microbiology and Applied Sciences. 2018;7(6):2630-2636.
18. Khan MMA, Gautam C, Mohammad F, Siddiqui MH, Naeem M, Khan MN. Effect of gibberellic acid spray on performance of tomato. Turkish Journal of Biology. 2006;30:11-16.
19. Kiranmayi P, Jyothi KU, Kumari KU, Vani VS, Suneetha DRS. Effect of NAA, 4-CPA and boron on growth and yield of green chilli (*Capsicum annum* L.) var. Lam 353 in summer. Agrotechnology. 2014;2(4):216.

20. Kucera B, Cohn MA, Leubner-Metzger G. Plant hormone interactions during seed dormancy release and germination. Seed Science Research. 2005;15:281-307.
21. Kumar A, Biswas TK, Singh N, Lal EP. Effect of gibberellic acid on growth, quality and yield of tomato (*Lycopersicon esculentum* Mill.). Journal of Agriculture and Veterinary Science. 2014;7(7):28-30.
22. Kumar S, Vyakarnahal BS, Deshpande VK, Kivadasannavar PK. Effect of growth regulators and fruit retention on fruit set, seed yield and quality of tomato parental lines. International Journal of Plant Sciences. 2016;11(2):322-330.
23. Logendra LS, Mun JG, Gianfagna TJ, Janes HW. Ethephon concentrations and advances harvest for limited cluster greenhouse tomato crop. Horticultural Science. 2004;39(7):1650-1651.
24. Moniruzzaman M, Khatoon R, Hossain MFB, Jamil MK, Islam MN. Effect of GA3 and NAA on physio-morphological characters, yield and yield components of brinjal (*Solanum melongena* L.). Bangladesh Journal of Agricultural Research. 2014;39(3):397-405.
25. Naeem N, lshtiaq M, Khan P, Mohammad N, Khan J, Jamiher B. Effect of gibberellic acid on growth and yield of tomato cv. Roma. Online Journal of Biological Sciences. 2001;1(6):448-450.
26. Ouzounidou G, Ilias I, Giannakoula A, Papadopoulou P. Comparative study on the effects of various plant growth regulators on growth, quality and physiology of *Capsicum annum* L. Pakistan Journal of Botany. 2010;42(2):805-814.
27. Pargi SC, Lal DEP, Singh N, Biswas TK. Effect of Naphthalene acetic acid on biochemical parameters, growth and yield of tomato (*Lycopersicon esculentum* Mill.). Journal of Agriculture and Veterinary Science. 2014;7(7):16-18.
28. Patel JS, Sitapara HH, Patel KA. Influence of plant growth regulators on growth, yield and quality of tomato and brinjal. International Journal of Forestry and Crop Improvement. 2012;3(2):116-118.
29. Peralta IE, Spooner DM. Classification of wild tomatoes: a review. Kurtziana. 2000;28(1):45-54.
30. Philosoph-Hadas S, Friedman H, Meir S. Gravitropic Bending and Plant Hormones. Vitamins and Hormones. 2005;72:31-78.
31. Prasad RN, Singh SK, Yadava RB, Chaurasia SNS. Effect of GA3 and NAA on growth and yield of tomato. Vegetable Science. 2013;40(2):195-197.
32. Rahman MS, Haque MA, Mostofa MG. Effect of GA3 on biochemical attributes and yield of summer tomato. Journal of Bioscience and Agriculture Research. 2015;3(2):73-78.
33. Ranjeet, Ram RB, Prakash J, Meena ML. Growth, flowering, fruiting, yield and quality of tomato (*Lycopersicon esculentum* Mill.) as influenced plant bioregulators. International Journal of Plant Sciences. 2014;9(1):67-71.
34. Revanappa NUG. Influence of NAA and cytokinin on growth and yield of chili. Karnataka Journal of Agricultural Sciences. 1998;11(4):1136-1139.
35. Rick CM, Holle M. Andean *Lycopersicon esculentum* var. *cerasiforme*: genetic variation and its evolutionary significance. Journal of Economic Botany. 1990;43(3):69-78.
36. Sasaki H, Yano T, Yamasaki A. Reduction of high temperature inhibition in tomato fruit set by plant growth regulators. Japan Agricultural Research Quarterly. 2005;39(2):135-138.
37. Sattigeri UT, Lal EP, Bangi SS, Tallur M, Bangi SS. Effect of nutrients and plant growth regulator on yield and biochemical parameter of tomato (*Lycopersicon esculentum* L.). Journal of Agriculture and Veterinary Science. 2014;7(6):01-04.
38. Serrani JC, Sanjua R, Rivero OR, Fos M, Martínez JLG. Gibberellin regulation of fruitset and growth in tomato. Plant Physiology. 2007;145:246-257.
39. Shankhwar B, Nigam AK, Vasure N, Vishvakarma D. Effect of different plant growth regulators on growth of chilli (*Capsicum annum* L.) cv. Pusa Jwala. Agriculture Update. 2017;12(5):1187-1189.
40. Sharma MD. Effect of plant growth regulators on growth and yield of brinjal at Khajura, Banke. Journal of Institute of Agriculture Animal Science. 2006;27:153-156.
41. Sidhu AS, Kalloo, Pandita M. Studies on some important aspects of floral biology in vegetables crops. Haryana Journal of Horticultural Science. 1980;9:207.
42. Singh B, Kaul S, Kumar D, Kumar V. Combining ability for yield and its contributing characters in tomato. Indian Journal of Horticulture. 2010;67(1):50-55.
43. Singh J, Dwivedi AK, Devi P. Effect of plant growth regulators on yield attributes and quality trait of tomato (*Lycopersicon esculentum* Mill.). International Journal of Chemical Studies. 2019;7(1):1798-1801.
44. Singh P, Singh D, Jaiswal DK, Singh DK, Singh V. Impact of naphthalene acetic acid and gibberellic acid on growth and yield of capsicum, *Capsicum annum* (L.) cv. Indra under shade net conditions. International Journal of Current Microbiology and Applied Sciences. 2017;6(6):2457-2462.
45. Singh RN, Pal SL, Rana DK, Rawat SS, Gusain MS. Effect of bio-regulators on growth and yield parameters of capsicum cultivars under controlled condition. Horticulture Flora Research Spectrum. 2012;1(1):50-54.
46. Singh SK, Kumar A, Beer K, Singh VP, Patel SK. Effect of Naphthalene acetic acid (NAA) and gibberellic acid (GA3) on growth and fruit quality of tomato (*Lycopersicon esculentum* Mill.). International Journal of Current Microbiology and Applied Sciences. 2018;7(3):306-311.
47. Sreenivas M, Sharangi AB, Raj AC. Evaluation of bio-efficacy and phyto-toxicity of gibberellic acid on chilli. Journal of Crop and Weed. 2017;13(3):174-177.
48. Srividya S, Syam SRP, Sudhavani V, Ramanjaneya RA. Effect of post-harvest chemicals on fruit physiology and shelf life of tomato under ambient conditions. International Journal of Agriculture and Food Science Technology. 2014;5(2):99-104.
49. Tamilselvi C, Vijayaraghavan H. Impact of plant growth regulators and formulations on growth of chilli (*Capsicum annum* L.). Plant Gene and Trait. 2014;5(8):1-3.
50. Tiwari AK, Singh DK. Use of plant growth regulators in tomato (*Solanum lycopersicum* L.) under Tarai conditions of Uttarkhand. Indian Journal of Hill Farming. 2014;27(2):38-40.

51. Tomar S, Singh SK, Dubey AK, Singh JP, Abhishek. Role of plant hormones on vegetative growth of tomato (*Lycopersicon esculentum* Mill.). International Journal of Current Microbiology and Applied Sciences. 2017;6(9):3319-3323.
52. Uddain J, Hossain KMA, Mostafa MG, Rahman MJ. Effect of different plant growth regulators on growth and yield of tomato. International Journal of Sustainable Agriculture. 2009;1(3):58-63.
53. Verma PPS, Meena ML, Meena SK. Influence of plant growth regulators on growth, flowering and quality of tomato (*Lycopersicon esculentum* Mill) cv. H-86. Indian Journal of Hill Farming. 2014;27(2):19-22.