International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating: 5.29
IJABR 2025; 9(6): 652-657
www.biochemjournal.com
Received: 10-03-2025
Accepted: 15-04-2025

Munaziha Bashir
M.Sc. Research Scholar, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Vijay Bahadur
Professor and Head, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Annjoe V Joseph
Assistant Professor, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Munaziha Bashir
M.Sc. Research Scholar, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Response of strawberry cv. winter dawn to plant growth regulators for growth, yield and quality under protected conditions

Munaziha Bashir, Vijay Bahadur and Annjoe V Joseph

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i6h.4595

Abstract
The present investigation "Response of Strawberry cv. Winter Dawn to Plant Growth Regulators for Growth, Yield, and Quality under Protected Conditions" was laid out in the naturally ventilated polyhouse at experimental field of the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj (UP), during 2024-2025. This experiment was laid out in randomized block design and the study consists of ten treatments (9+1) including control and these treatments are replicated thrice. The treatments were, T_0 (control), T_1 (Gibberllic acid @ 50 ppm), T_2 (Gibberellic acid @ 75 ppm), T_3 (Gibberellic acid @ 100 ppm), T_4 (Paclobutrazol @ 25 ppm), T_5 (Paclobutrazol @ 50 ppm), T_6 (Paclobutrazol @ 75 ppm), T_7 (Triacontanol @ 30 ppm), T_8 (Triacontanol @ 40 ppm), T_9 (Triacontanol @ 50 ppm). From our experimental findings it is concluded that the treatment T_1 (GA_3 @ 50 ppm) performed best in terms of vegetative parameters. The treatment T_2 (GA_3 @ 75 ppm) performed best in terms of number of runners and earliness in flowering. However, the treatment T_7 (Triacontanol @ 30 ppm) was found best for other yield parameters, and the treatment T_3 (GA_3 @ 100 ppm) was found to be best in terms of TSS. The treatment (Triacontanol @ 30 ppm) was best for acidity and total sugar content. Moreover, treatment T_6 (Paclobutrazol @ 75 ppm) was found to be best for vitamin C.

Keywords: Strawberry, plant growth regulators, flowering, fruiting, yield parameters

Introduction
Strawberry (*Fragaria x ananassa* Duch.) belongs to family Rosaceae. The origin of the cultivated Strawberry can be traced to the hybridization of two wild species, *Fragaria cheloensis Duch*. from South America and *Fragaria Virginiana* Duch. from North America during the 18th century. The chromosome number of Strawberry is 2n = 2x = 56. This is an octaploid species. It holds a prominent place among small fruits due to its short cropping period, high market demand, and economic profitability. Strawberry is a highly nutritious fruit, valued not only for its sensory appeal but for its rich nutrient profile. Strawberries are mainly composed of about 91% water making them an ideal choice for hydration and weight management. Strawberries are a good source of dietary fibre (2.0 g/100 g), which supports digestive health. In addition to this, strawberries are rich in bioactive compounds such as anthocyanins, ellagic acid, and other polyphenols which contributes to strong antioxidant and anti-inflammatory properties. The application of Plant Growth Regulators like GA3 can effectively promote vegetative growth by stimulating cell elongation and division, resulting in increased plant height, larger leaves and overall canopy development. Paclobutrazol acts as a growth retardant by inhibiting gibberellin biosynthesis, resulting in more compact plant, while it significantly alters plants metabolic and physiological processes. Triacontanol, a naturally occurring plant stimulant, enhances physiological efficiency by stimulating photosynthesis, enzymatic activity and nutrient uptake. It enhances overall plant vigor, increases fruit number by increasing biomass and improves both yield and quality attributes, including color, taste and sweetness. It is also known to increase chlorophyll content and improve stomatal conduction which affects photosynthetic efficiency and energy availability for fruit development.

Materials and Methods

Climatic Conditions and Geographical Location at the Experimental Site

The experimental site is located at a latitude of 25.57° North and longitude of 81.51° East, with an altitude of 98 meters above the mean sea level. The region is characterized by extremely hot summers and fairly cold winters. Temperatures can rise upto 46-48 °C and it may ocassionally drop to 4-5°. The relative humidity fluctuates between 20% and 94%, and the area receives an average rainfall of approximately 1013.4 mm.

Experimental Details

Studies on response of strawberry to plant growth regulators for growth, yield and quality under Protected Conditions was conducted on cv. Winter Dawn during 2024-2025 in the naturally ventilated polyhouse of Horticulture Research Field of the Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj, (Uttar Pradesh). The experiment was laid out in RBD with ten treatments (9+1) control and these are mentioned as T_0: Control, T_1: Gibberellic acid @ 50 ppm, T_2: Gibberellic acid @ 75 ppm, T_3: Gibberellic acid @ 100 ppm, T_4: Paclobutrazol @ 25 ppm, T_5: Paclobutrazol @ 50 ppm, T_6: Paclobutrazol @ 75 ppm, T_7: Triacontanol @ 30 ppm, T_8: Triacontanol @ 40 ppm, T_9: Triacontanol @ 50 ppm. The runners were transplanted on
30th Nov. 2024 in the naturally ventilated polyhouse. The last harvesting was performed on 17th March 2025.

Results and Discussions

Response of Strawberry cv. Winter Dawn to Plant Growth Regulators on Plant height, Number of leaves and Number of runners under Protected Conditions

Plant Height (cm)

The maximum plant height 26.81 cm was recorded with the treatment T_1 (Gibberellic acid @ 50 ppm) and it was followed by T_2 (Gibberellic acid @ 75 ppm) with 26.66 cm. The minimum plant height was recorded under the treatment T_8 (Triacontanol @ 40 ppm). This increase in height of the plant with the application of GA_3 @ 50 ppm during the research period has got the support of Swamy (2013) in Strawberry, Sakamoto *et al*., (2004) [15] in rice, Weaver and McCune (1959) [16] in grapes, Amin *et al*., (2008) [17] in papaya. The increased plant height in strawberry may be due to modifying gene expression related to cell wall loosening and expansion enabling cells to elongate more rapidly (Sponsel and Hedden, 2004) [18].

Number of leaves per plant

Maximum number of leaves (27.17) per plant was recorded in treatment T_1 (Gibberellic acid @ 50 ppm), followed by T_8 (Triacontanol @ 40 ppm) with (26.05), while as the minimum number of leaves (20.80) was observed with treatment T_3 (Gibberellic acid @ 100 ppm). The increase in number of leaves may be due to enhanced chlorophyll content and accelerated meristematic activity. These observations are in close agreement with the findings of (Kumar *et al*., 2012) [19], in tomato, (Panse *et al*., 2013) [20] in brinjal, 9 Meena *et al*., 2015) [21] in okra.

Number of runners per plant

At last harvest the maximum number of runners (2.67) was recorded in treatment T_2 (Gibberellic acid @ 75 ppm), the minimum number of runners recorded was (0.87) in treatment T_4 (Paclobutrazol @ 25 ppm). However, no runners were produced in treatments T_5 (Paclobutrazol @ 50 ppm), T_6 (Paclobutrazol @ 75 ppm), T_7 (Triacontanol @ 30 ppm), T_8 (Triacontanol @ 40 ppm), T_9 (Triacontanol @ 50 ppm). Highest number of runners are produced due to the promotion of cell elongation and enhanced activity of the apical meristem. This hormonal stimulation promotes the outgrowth of lateral buds into runners instead of flowering shoots. The results were further supported by (Rajesh *et al*., 2012) [22].

Response of Strawberry cv. Winter Dawn to Plant Growth Regulators on First flower appearance (days), Number of flowers per plant, Duration of Harvesting (days), Polar Diameter (mm), Radial Diameter (mm), Number of Fruits Per Plant, Fruit Weight (g), Yield Per Plant (g) under protected conditions.

First Flower Appearance

Minimum days taken to first flower appearance (48.00) was noted with treatment T_2 (Gibberellic acid @ 75 ppm), maximum number of days to flower appearance (63.67) was found with treatment T_6 (Paclobutrazol @ 75 ppm). These findings have got the support from (Paroussi *et al*., 2022) [23], and (Kumar *et al*., 2014) [24]. Minimum number of days required to produce first flower is due to that GA_3 increases the activity of hydrolytic enzymes, like amylases, enhancing sugar mobilization to growing points, thus supplying energy for floral initiataion.

Number of Flowers per Plant

The maximum number of flowers (31.27) was seen in treatment T_2 (Gibberellic acid @ 75 ppm), then followed by treatment T_3 (Gibberellic acid @ 100 ppm) as (27.92). The minimum number of flowers per plant was recorded in treatment T_0 (Control) with 16.35. The maximum number of flower production may be due to the effect of plant growth regulators that encourages rapid growth of plant tissues by promoting cell elongation, shoot growth and floral initiation. By stimulating stem elongation and leaf expansion, GA_3 improves overall plant vigor, which supports a higher capacity for flower production. These results were also in obtained by (Thakur *et al*., 2017) [25].

Duration of Harvesting

The maximum duration of harvesting (29.00) was recorded in treatment T_7 (Triacontanol @ 30 ppm), followed by (28.33) in treatment T_9 (Triacontanol @ 50 ppm).The minimum duration of harvesting was seen in treatment T_5 (Paclobutrazol @ 50 ppm) with (23.67). These results have got the support from (Pang *et al*., 2020) [26]. The results showed that foliar application of triacontanol significantly extended the harvesting period by enhancing photosynthetic activity, improving nutrient assimilation, and promoting hormonal balance, especially of auxins and cytokinins (Kumar *et al*., 2013) [27].

Polar Diameter (mm)

The maximum polar diameter of (47.15 mm) was recorded in treatment T_7 (Triacontanol @ 30 ppm), followed by (42.14 mm) in in treatment T_9 (Triacontanol @ 50 ppm. The minimum polar diameter was seen in treatment T_3 (Gibberellic acid @ 100 ppm) with 32.75 mm.

Radial Diameter (mm)

The maximum radial diameter (29.10 mm) was recorded in treatment T_7 (Triacontanol @ 30 ppm), closely followed by (23.23 mm) in treatment T_9 (Triacontanol @ 50 ppm). However, the minimum radial diameter was found in treatment T_3 (Gibberellic acid @ 100 ppm) with (11.15mm). The increased dimensions in strawberry are due to enhanced physiological and biochemical processes essential for fruit development, by boosting photosynthesis and chlorophyll content. Triacontanol also improves nutrient uptake and translocation, supplies essential elements that supports the fruit enlargement. These results have found the support from Choudhary, Ashima (2023) [28] and similar to those of Khunte *et al*., (2014) [29].

Number of Fruits per Plant

The maximum number of fruits per plant (25.08) was found in treatment T_7 (Triacontanol @ 30 ppm), which is followed by (22.67) in treatment T_8 (Triacontanol @ 40 ppm). Whereas, the minimum number of fruits per plant (13.75) was recorded in treatment T_1 (Gibberellic acid @ 50 ppm). These results are consistent with those of Rani *et al*., (2005) in strawberry, Singh *et al*., (2016) [31]. (Sharma and Singh, 2009) [3], reported that the increased number of fruits are due to enhanced photosynthetic efficiency, which results in more production of carbohydrates and energy needed for flower initiation and fruit development.

Fruit Weight (g): The maximum fruit weight of (28.40 g) was recorded in treatment T_7 (Triacontanol @ 30 ppm), followed by (25.53 g) in treatment T_8 (Triacontanol @ 40 ppm). However, the minimum fruit weight (14.02 g) was found in treatment T_0 (control). The increased fruit weight in strawberry is due to the increased levels of natural growth hormones, promoting rapid cell division and enlargement in fruit tissues, increasing fruit size and weight. These results are in close context with Mehta *et al*., (2012) [32]. Triacontanol could promote fruit development by up-regulating factors related to fruit ripening related growth and development in strawberry Pang *et al*., (2020) [26].

Fruit Yield per Plant (g)

The maximum fruit yield per plant (314.90 g) was found to be in treatment T_7 (Triacontanol @ 30 ppm), which was followed by (296.43 g) in treatment T_8 (Triacontanol @ 40 ppm). The minimum fruit yield was seen in treatment T_0 (control) with (146.05 g). The increase in fruit yield per plant is due to enhanced photosynthetic efficiency by increasing chlorophyll content, which boosts carbohydrate production and translocation to the Verma *et al*., (2020) [33].

Table 1: Response of Strawberry cv. Winter Dawn to Plant Growth Regulators for Plant height (cm), Number of leaves per plant, number of runners per plant under Protected Conditions

Treatment	Plant height (cm)	Number of leaves per plant	Number of runners per plant
	90 DAP	90 DAP	90 DAP
T_0	19.71	23.45	1.33
T_1	26.81	27.17	1.06
T_2	26.66	24.01	2.67
T_3	23.93	20.80	1.50
T_4	19.13	25.88	0.87
T_5	21.06	24.63	0.00
T_6	17.76	21.28	0.00
T_7	21.10	25.35	0.00
T_8	15.94	26.05	0.00
T_9	18.73	23.80	0.00
F test	S	S	S
SEm	1.58	0.43	0.45
CD (5%)	4.70	1.29	1.33
CV	12.98	3.10	104.70

Table 2: Response of Strawberry cv. Winter Dawn to Plant Growth Regulators for days taken to first flower, number of flowers per plant, duration of harvesting, polar diameter, radial diameter under protected conditions

Treatment	First flower Initiation (days)	Number of flowers per plant	Duration of harvesting	Polar diameter (mm)	Radial diameter (mm)
T_0	61.00	16.35	26.00	37.40	22.90
T_1	53.67	24.03	25.67	37.90	23.03
T_2	48.00	31.27	24.00	41.45	13.75
T_3	51.67	27.92	26.00	32.75	11.15
T_4	59.33	24.63	24.33	38.40	19.97
T_5	57.67	21.03	23.67	37.27	20.80
T_6	63.67	20.30	24.00	37.43	17.77
T_7	54.00	28.23	29.00	47.15	29.10
T_8	56.00	24.07	25.33	37.39	21.18
T_9	59.67	23.70	28.33	42.14	23.23
F test	S	S	S	S	S
SEm	0.99	0.89	0.75	0.77	0.31
CD (5%)	2.95	2.66	2.23	2.29	0.91
CV	3.04	6.49	5.08	3.42	2.61

Table 3: Response of Strawberry cv. Winter Dawn to Plant Growth Regulators for fruits per plant, average fruit weight (g), fruit yield per plant under protected conditions

Treatment	Number of fruits per plant	Average fruit weight	Fruit Yield Per Plant (200 m²)	B:C ratio
T_0	18.92	14.02	146.05	1.95
T_1	13.75	18.40	236.52	3.44
T_2	20.17	19.20	233.11	4.15
T_3	20.47	21.33	224.27	4.05
T_4	17.97	19.83	221.60	3.57
T_5	15.17	23.43	225.07	3.50
T_6	16.33	22.98	211.41	3.41
T_7	25.08	28.40	314.90	6.63
T_8	22.67	25.53	296.43	5.12
T_9	22.12	23.80	272.93	4.44
F test	S	S	S	
SEm	1.22	0.32	0.74	
CD (5%)	3.63	0.95	2.20	
CV	10.87	2.54	0.54	

Response of Strawberry cv. Winter Dawn to Plant Growth Regulators for determination of TSS (° Brix), Acidity, Total sugar, Ascorbic acid, pH under protected conditions

TSS (° Brix)

The TSS was found maximum in treatment T3 (Gibberellic acid @ 100 ppm) with 9.27 °Brix, followed by 8.03 in treatment T_7 (Triacontanol @ 40 ppm). Whereas, the minimum TSS 3.10 was recorded in treatment T_5 (paclobutrazol @ 50 ppm). The observed rise in TSS may be attributed to the breakdown of cell walls as suggested by (Anitha *et al*., 2005) [34], along with a reduction in respiration and an increase in dry matter due to water loss. The reduction in TSS levels could be due to sugar dilution caused by water spraying during the first ripening phase. This has got the support from (Khatoon *et al*., 2021) [35].

Titrable Acidity (%)

The maximum acidity (%) was found highest in treatment T_7 (Triacontanol @ 30 ppm) with 1.70%, closely followed by 1.30%, in treatment T_4 (Paclobutrazol @ 25 ppm). The minimum acidity (%) 0.50% was found to be in the fruits with treatment T_1 (Gibberellic acid @ 50 ppm). The reduction in titrable acidity is likely due to reduced respiration and slower accumulation of organic acids, this result has got the support from (Sharma *et al*., 2018) [36], and in contrast to increasing acidity may be attributed to enhanced metabolic activity and organic acid biosynthesis during early fruit development and has got the support from (Singh *et al*., 2016) [37].

Total Sugar (%)

The maximum sugar percentage (8.40) was found in treatment T_7 (Triacontanol @ 30 ppm), followed by (8.27) in treatment T_8 (Triacontanol @ 40 ppm) and the minimum 6.27) was recorded in treatment T_1 (Gibberellic acid @ 50 ppm). These results have got the support from (Singh *et al*., 2017) [38] and (Mandal *et al*., 2020) [39]. They reported that the respective increase in total sugar is attributed to enhanced photosynthesis, chlorophyll content, and activity of sugar metabolizing enzymes.

Ascorbic acid

The maximum ascorbic acid content (4.87) was found in treatment T_6 (Paclobutrazol @ 75 ppm), then followed by (4.07) in treatment T_2 (Gibberellic acid @ 75 ppm). Whereas, the minimum ascorbic acid content was found in treatment T_8 (Triacontanol @ 40 ppm) with (2.46). This finding correlates with the findings of (Kumar and Singh, 2019) [40].

pH

The maximum pH of 5.49 was found in the fruits of treatment T_4 (Paclobutrazol @ 25 ppm), followed by 5.22 found with treatment T_9 (Triacontanol @ 50 ppm). The minimum pH was found in treatment T_1 (Gibberellic acid @ 50 ppm) which is (3.00). The respective increase in pH is due to slowed synthesis of organic acids like citric acid and malic acid, which are responsible for the sour taste and low pH in fruits. As same was reported by (Sharma *et al*., 2018) [36].

Table 4: Response of Strawberry cv. Winter Dawn to Plant Growth Regulators for TSS (° Brix, Acidity, Total sugar, Ascorbic acid, and pH under protected conditions

Treatment	TSS	Acidity (%)	Total sugar	Ascorbic acid	pH
T_0	7.90	0.67	7.30	3.47	3.53
T_1	5.97	0.50	6.27	3.80	3.00
T_2	6.10	1.23	7.13	4.07	3.13
T_3	9.27	0.83	7.27	2.87	3.47
T_4	3.78	1.30	6.53	3.57	5.49
T_5	3.10	0.90	6.50	3.23	3.65
T_6	4.20	0.57	7.10	4.87	3.07
T_7	8.03	1.07	8.40	3.90	4.90
T_8	3.93	0.77	8.27	2.46	4.70
T_9	5.57	0.80	7.43	3.32	5.22
F test	S	S	S	S	S
SEm	0.38	0.23	0.42	0.34	0.47
CD (5%)	1.13	0.69	1.26	1.00	1.39
CV	11.34	43.22	10.26	16.71	20.04

Conclusion

According to our experimental results it is concluded that the treatment T_1 (Gibberellic acid @ 50 ppm) performed best in terms of plant height and number of leaves. However, treatment T_2 (Gibberellic acid @ 75 ppm) had the maximum number of runners, earliness in flowering and number of flowers. The maximum duration of harvesting was seen in treatment T_7 (Triacontanol @ 30 ppm) and it was also found best for other yield parameters.

The treatment T_3 (Gibberellic acid @ 100 ppm) was found to be effective in terms of TSS° Brix. While as, the treatment T_7 (Triacontanol @ 30 ppm) was found best for acidity and total sugar content. Moreover, treatment T_6 (Paclobutrazol @ 75 ppm) showed the best performance for Vitamin C content.

References

1. Ali M, *et al*. Triacontanol spray mediated plant growth and productivity in fruit crops: a review. The Pharma Innovation Journal. 2021;10(7):789-792.
2. Ahmed ME, El-Latif A, Al-Ballat IA, *et al*. Effect of gibberellic acid concentrations and runners removal rates on yield and quality of frigo strawberry plantations. Menoufia Journal of Plant Production. 2017;2(5):395-406.
3. Sharma RR, Singh R. Gibberellic acid influences the production of malformed and strawberry (*Fragaria* × *ananassa* Duch.). Scientia Horticulturae. 2009;119(4):430-433.
4. Paroussi G, Voyiatzis DJ, Paroussis E, *et al*. Growth, flowering and yield responses to GA_3 of strawberry grown under different environmental conditions. Scientia Horticulturae. 2002;96(1):103-113.
5. Turner JN. Application of gibberellic acid to strawberry plants at different stages of development. Nature. 1963;197:95-96.
6. Naeem M, *et al*. Effect of triacontanol on growth and yield of strawberry plants. Journal of Plant Nutrition. 2012;35(10):1474-1483.
7. Black BL, *et al*. Paclobutrazol application and timing and rate affect on strawberry plant growth and fruiting. HortScience. 2008;43(4):1154-1158.
8. Zurawicz E, Masny A, Basak A. Productivity stimulation in strawberry by application of plant bioregulators. Acta Horticulturae. 2004;653:155-159.
9. Saima Z, Sharma A, Umar I, Wali VK. Effect of plant bio-regulators on vegetative growth, yield and quality of strawberry cv. Chandler. African Journal of Agricultural Research. 2014;9(22):1694-1699.
10. Kumar S, Tripathi A. Influence of NAA, GA_3 and boric acid on growth, yield and quality of strawberry cv. Chandler. Progressive Horticulture. 2009;41(1):113-115.
11. Vishal VC, Thippesha D, Chethana K, Maheshgowda BM, Veeresha BG, Basavraj AK. Effect of various growth regulators on vegetative parameters of strawberry (*Fragaria* × *ananassa* Duch.) cv. Sujatha. Research Journal of Chemical and Environmental Sciences. 2016;4:68-71.
12. Ughareja A, Pandya Y. Studies on the effect of plant growth regulators on growth, and yield of strawberries cv. Winter Dawn under protected cultivation. International Journal of Agriculture and Animal Production. 2023;3(2).
13. El-Shabasi MSS, Ragab ME, El-Oksh II, *et al*. Response of strawberry plants to some growth regulators. Acta Horticulturae. 2008;842:725-728.
14. Swamy GS. Effect of gibberellic acid on growth and yield of strawberry (*Fragaria* × *ananassa*) cv. Chandler. Asian J Hortic. 2013;8(1):167-169.
15. Sakamoto T, Miura K, Itoh H, Tatsumi T, Ueguchi-Tanaka M, Ishiyama K, *et al*. An overview of gibberellin metabolism enzyme genes and their related mutants in rice. Plant Physiol. 2004;134(4):1642-1653.
16. Weaver RJ, McCune SB. Gibberellin effect on fruit-set and development in seedless grapes. Proc Am Soc Hortic Sci. 1959;73:245-258.
17. Amin MN, Sarker B, Uddin MS. Effect of gibberellic acid on growth and yield of papaya. J Agric Rural Dev. 2008;6(1-2):99-104.
18. Sponsel VM, Hedden P. Gibberellin biosynthesis and inactivation. In: Davies PJ, editor. Plant hormones: biosynthesis, signal transduction, action!. Dordrecht: Kluwer Academic Publishers; 2004. p. 63-94.
19. Kumar R, Singh N, Rai M. Effect of plant growth regulators on growth and yield of tomato (*Solanum lycopersicum* L.). Indian J Hortic. 2012;69(3):407-410.
20. Panse VG, Mehta A, Rane DA. Response of brinjal to growth regulators. South Indian Hortic. 2013;61(1):35-38.
21. Meena ML, Meena OP, Meena SL, Meena DS. Effect of growth regulators on growth, flowering and yield of okra (*Abelmoschus esculentus* L.). Ann Agric Res. 2015;36(3):313-317.
22. Rajesh RK, Reddy YN, Devi GS. Influence of gibberellic acid and NAA on runner production in strawberry. Int J Agric Sci. 2012;8(1):126-129.
23. Paroussi G, Drogoudi P, Voyiatzis D. Influence of gibberellic acid and photoperiod on flowering in strawberry under protected cultivation. Sci Hortic. 2022;297:110920.
24. Kumar D, Sharma N, Singh B. Effect of plant growth regulators on flowering and fruiting of strawberry. J Hortic Sci. 2014;9(2):134-137.
25. Thakur A, Sharma D, Thakur M. Effect of plant growth regulators on flowering and fruiting of strawberry under mid-hill conditions. Int J Curr Microbiol Appl Sci. 2017;6(4):2260-2266.
26. Pang XF, Zhao YJ, Wang M, Zhao YH, Zhang XH, Liu JQ. Triacontanol increases yield and improves fruit quality in strawberry. J Plant Nutr. 2020;43(4):497-509.
27. Kumar R, Singh N, Rai M. Effect of triacontanol on growth and yield of strawberry under protected conditions. Indian J Hortic. 2013;70(1):120-124.
28. Choudhary A. Effect of triacontanol on growth, flowering and yield attributes of strawberry (*Fragaria* × *ananassa* Duch.). Int J Environ Agric Biotechnol. 2023;8(2):371-375.
29. Khunte SP, Patil AB, Bhongale RS. Effect of plant growth regulators on fruit size and yield of strawberry. *Asian J Hortic*. 2014;9(2):400-403.
30. Rani G, Singh S, Thakur A. Effect of triacontanol on growth and yield of strawberry cv. Chandler. Prog Hortic. 2005;37(2):389-391.
31. Singh A, Kumar R, Meena OP. Studies on effect of plant growth regulators on fruiting behavior in strawberry. *J Agric Sci*. 2016;8(4):197-202.

32. Mehta K, Patel HC, Patel BN. Response of strawberry to plant growth regulators under greenhouse conditions. Int J Agric Sci. 2012;8(1):90-93.
33. Verma S, Singh A, Rani A. Role of triacontanol on photosynthesis and yield in strawberry. J Pharmacogn Phytochem. 2020;9(4):1577-1580.
34. Anitha B, Kanthaswamy V, Selvaraj Y. Effect of gibberellic acid and ethrel on fruit quality in tomato. *South Indian Hortic*. 2005;53(1-6):126-129.
35. Khatoon S, Sharma R, Srivastava R. Influence of plant growth regulators on biochemical attributes and quality of strawberry (*Fragaria* × *ananassa* Duch.) under protected cultivation. Int J Curr Microbiol Appl Sci. 2021;10(2):3104-3111.
36. Sharma M, Singh A, Rani P. Effect of plant bioregulators on growth, yield and quality of strawberry (*Fragaria* × *ananassa* Duch.) cv. Chandler. *J Pharmacogn Phytochem*. 2018;7(6):2692-2696.
37. Singh A, Sharma S, Meena OP. Effect of growth regulators on quality parameters of strawberry (*Fragaria* × *ananassa* Duch.). Int J Chem Stud. 2016;4(5):75-78.
38. Singh J, Kaur A, Verma R. Effect of foliar spray of growth regulators on total sugars and TSS in strawberry (*Fragaria* × *ananassa* Duch.). Plant Arch. 2017;17(2):1125-1128.
39. Mandal J, Ghosh SN, Bera B. Effect of different plant growth regulators on yield and quality of strawberry (*Fragaria* × *ananassa* Duch.) cv. Sweet Charlie. J Appl Hortic. 2020;22(3):225-230.
40. Kumar V, Singh S. Effect of paclobutrazol and gibberellic acid on quality and biochemical attributes of strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter Dawn. J Agric Sci. 2019;11(1):142-147.