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Impact of Plant Growth Regulators on Growth, Yield and Quality of Strawberry *(Fragaria × ananassa* Duch.) cv. Winter Dawn

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out at the Horticulture Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology & Science, Prayagraj, (U.P.) - 211007 during the year 2022-23. The experiment was consisting of winter dawn variety of Strawberry with each comprising of ten treatments replicated thrice. Source of variables were NAA; GA_3 ; BA (benzyl adenine) and combination of them with control treatment taken as eleven treatments. The experiment was laid out in randomized block design by randomizing treatments in each replication. As far as the vegetative growth, flowering, fruit yield and quality of fruit is concerned, application of different treatment of plant growth regulators significantly enhanced the Plant height, Number of leaves per plant, Petiole length, Plant spread, Days taken to first flower, Number of flowers /plant, Fruit length, Fruit width, Number of fruits/plant, Fruit set (%), Yield per plot, Total soluble solids, Total acidity, Ascorbic acid and Fruit weight at all successive stages. Maximum Plant height

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(24.50cm), Number of leaves per plant (20.66), Petiole length (13.83cm), Plant spread (27.16) (E-W), (26.16) (N-S) ,were recorded in successive year with T_6 (GA_3 100ppm)Days taken to first flower (40.00 days), Number of flowers /plant (19.33), Fruit length (61.43mm), Fruit width (38.33 mm), Number of fruits/plant (16.66), Fruit set (87.66%), Yield per plot (Kg.) (2.33 Kg) Total soluble solids (TSS) (10.17), Total acidity (%)(1.33%), Ascorbic acid (58.66 mg/ 100 g) and Fruit weight (g) (41.33 g) were recorded in successive year with T_9 (BA 75ppm) and minimum vegetative growth, flowering, fruit yield and quality of fruit were observed in $T_{0.}$

Keywords: Strawberry; PGR; growth; quality.

1. INTRODUCTION

Strawberry (*Fragaria* x *ananassa* Duch.) is one of the most fascinating fruits of the world. It is a cross between two species of American wild strawberry: A large fruited species, *Fragaria chiloensis*, originally from Chile and *Fragaria virginiana*, originally from Virginia, USA. The chromosome no. of strawberry is 2n=2x= 56. Strawberry belongs to the family Rosaceae. The commercially cultivated strawberry is an octaploid species. The United States is the world"s largest producer of strawberries accounting for about 30 percent of the world strawberry production [1]. Strawberry is a popular soft fruit in India, cultivated in plains as well as in the hills up to an elevation of 3000 m in humid or dry regions. Its main center of cultivation is Nainital and Dehradun in Uttrakhand, Mahabaleshwar (Maharashtra), Kashmir Valley, Bangalore and Kalimpong (West Bengal). In recent years, strawberry is being cultivated successfully in plains of Maharashtra (around Pune, Nashik and Sangali towns), Haryana and Uttar Pradesh. The wide variation in climates within these regions and the wide adaptation of the strawberry plant permit harvesting and marketing, the fruit during greater part of the year.

Strawberry is a short-lived (3-5 yrs.), perennial, vigorous, stoloniferous herb growingto 10-20cm height with a spread of about 0.3-1.0m. Leaves are trifoliate on stalks which grow out from a central crown. Its crown is compacted stem, where many leaves are formed very close together. The leaflets are oval-egg shaped, deep green with coarse serrations. Flowers are white, 1-2cm wide, bisexual with approximately 30 stamens and approximately 300 pistils on a swollen, conical, yellowish receptacle. The first flower opens at the top and centre of the crown and produces the bigger fruits. Flowers that open later produce the small fruits. The true fruit of the strawberry is an achene, which is a small, dry seed loosely attached to the swollen ovary wall (receptacle). The roots are shallow so plants need regular moisture but not water logging [2].

There are many factors which influence plant health. PGR_S and micronutrients are such type of input factors. Plant Growth Regulators (PGR_S) have proven their role in augmenting yield and quality in many fruits. PGR are either synthetic or natural compounds or that modify plant physiological processes at very minute concentrations. Use of plant bio- regulators have plays an important role in vegetative growth, flowering, yield and quality.

2. MATERIALS AND METHODS

The area of Prayagraj district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46^o C-48^o C and seldom falls as low as 4^{o}C- 5^{o}C. The relative humidity ranges between 20 to 94 %. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

The experiment was laid out in randomized block design by randomizing treatments in each replication with the objectives to find the best treatment for growth, yield and quality of strawberry. The treatments were **T_0** (Control),**T_1** (NAA@ 50 ppm),**T_2** (NAA@ 75 ppm),**T_3** (NAA@ 100 ppm),**T_4** (GA3@ 50 ppm),**T_5** (GA3@ 75 ppm),**T_6** (GA3@ 100 ppm),**T_7** (BA (6-benzyladenine) @ 25 ppm),**T_8** (BA (6-benzyladenine) @ 50 ppm),**T_9** (BA (6-benzyladenine) @ 75 ppm),**T_{10}** (NAA + GA +BA@ 50 +50 +25 ppm).

3. RESULTS AND DISCUSSION

The maximum plant height at 30,60,90 days was recorded as 9.50 cm, 16.33 cm and 24.50 cm with treatment T6 (GA3@100 ppm) and it was followed by 8.50 cm, 14.66 cm and 22.66 cm in T5 (GA3@75 ppm). The minimum plant height of 5.46 cm, 9.16 cm and 15.00 cm are recorded under T_0 (control).The maximum increase in plant height of strawberry due to treatment might be due to fact that gibberellins regulate the

growth by causing cell division and cell elongation in plant system. These results are in conformity with Rademabher [3].

The maximum plant spread at 30,60,90 days was recorded as13.50 cm, 22.00 cm, 27.16 cm (E-W), 13.00 cm, 22.66 cm and 26.16 cm (N-S) with treatment T6 (GA3@100 ppm) and it was followed by 12.33 cm, 21.33 cm ,24.5 cm (E-W) 11.66 cm, 20.66 cm and 23.33 cm (N-S) in T5 (GA3@75 ppm). The minimum plant height of 7.5cm 14.33cm,19.50cm (E-W) 7.83 cm, 15.83 cm and 19.50 cm (N-S) are recorded under T_0 (control). GA_3 has a great influence on over all plant growth and development and had a promoting effect on growth parameters. The reason responsible for this augmentation of growth is its effect on cell division and cell enlargement [4].

The maximum number of leaves at 30,60,90 days was recorded as 8.00 cm, 12.66 cm and20.66 cm with treatment T6 (GA3@100 ppm) and it was followed by 7.33cm, 12.33cm and 16.33cm in T5 (GA3@75 ppm). The minimum number of leaves of 2.66cm, 5.33cm and 9.66cmare recorded under T_0 (control). The maximum increase in plant height of strawberry due to treatment might be due to fact that gibberellins regulate the growth by causing cell division and cell elongation in plant system. These results are in conformity with Rademabher [3]. Qureshi et al. [5].

The maximum petiole length at 30,60,90 days was recorded as 6.66 cm, 10.66 cm and13.83 cm with treatment T6 (GA3@100 ppm) and it was followed by 5.66 cm, 10.00 cm and 12.83 cm in T5 (GA3@75 ppm). The minimum petiole length of 2.66 cm, 5.33 cm and 8.33 cmare recorded under T_0 (control).

The maximum increase in petiole length of strawberry due to treatment might be due to fact that gibberellins regulate the growth by causing cell division and cell elongation in plant system. These results are in conformity with Tripathi (2010).

Earliest flowering at 40.00 days was recorded in with treatment T9 (BA@75ppm) followed by treatment T8 (BA@50ppm) in 40.66 days. The maximum number of days taken by the plants treated with T0 (control) in 55.00 Minimum days required to initiate flower with treatment BA@ 75ppm may be due to its effect to cause rapid growth of flower primordium. Its role has been well proven in enhancing flowering in short day plants growing under inductive conditions (Singh, 2012). The synthesis of florigen is mediated through BA and also minimizing the days required opening first flower. Similar results were observed by many researchers who found early flowering in strawberry following spray of BA [6], Sharma and Singh, [7], Yadav et al. [8].

In relation of number of flowers Treatment T_9 (BA @ 75ppm) recorded the maximum number of flowers [19.33] over all other treatments and it was followed by [18.66] in T8 (BA@50ppm) where asT_0 (Control) treatment had the minimum number of flowers [11.66]. Increase in number of flowers per plant with the use of BA might be due to fact that benzyle adenine causes the production of large number of flowers with rapid elongation of peduncle, leading to full development of flower buds having all reproductive parts functional which increases the fruit set and number of berries per plant. It could also be due to the fact that BA application accelerates the development of differentiated inflorescence. Similar results have been reported by Tripathi and Shukla [6]; Prasad et al. (2012) and Saima et al.(2014).

In relation of number of fruits Treatment T_9 (BA @ 75ppm) recorded the maximum number of fruits [16.66] over all other treatments and it was followed by [15.33] in T8 (BA@50ppm) where asT_0 (Control) treatment had the minimum number of fruits [8.66]. Increase in number of fruits per plant with the use of BA might be due to fact that benzyle adenine causes the production of large number of fruits with rapid elongation of peduncle, leading to full development of flower buds having all reproductive parts functional whichincreases the fruit set and number of berries per plant. It could also be due to the fact that BA application accelerates the development of differentiated inflorescence.

In relation of fruit set (%) Treatment T_9 (BA @ 75ppm) recorded the maximum number of fruits set (%) [87.66] over all other treatments and it was followed by [83.10] in T8 (BA@50ppm) where asT_0 (Control) treatment had the minimum number of fruits set (%) [63.83]. It is mainly due to the positive effect of the combination of BA on metabolic activity of plant. Similar findings were reported by Qureshi et al. [5] and Bhople et al. [9].

Table 1. Impact of plant growth regulators on plant height, plant spread, no. of leaves, petiole length, days to flowering and no. of flower/plant in strawberry

Treatment	Plant Height (cm)			Plant Spread (cm)						No. of leaves			Petiole Length			Days to flowering	No. of flower/plant
	30 DAP	60 DAP	90 DAP	30 DAP		60 DAP		90 DAP		30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP		
				E-W	N-S	E-W	N-S	E-W	N-S								
T_0	5.46	9.16	15	7.50	7.83	14.33	15.83	19.83	19.50	2.66	5.33	9.66	2.66	5.33	8.33	55	11.66
T_1	5.5	10.66	16.1	9.16	9.50	16.50	18.83	22.13	20.66	4.33	8.66	12.33	3.5	7.33	9.33	45.66	15.00
T_2	6	11.06	15.86	9.50	10.50	16.83	19.66	23.66	21.16	5.33	10.66	13.33	3.83	7.66	9.66	44.66	15.33
T_3	6.36	11.56	16.66	10.16	10.66	17.83	18.33	23.33	21.00	5.33	10	14.33	4.33	8.33	10.83	45.33	16.33
T_4	6.83	12.5	18.5	11.50	11.33	20.16	19.50	23.16	22.66	5.66	11.66	15.33	5.33	9.33	11.66	43.66	16.33
T_5	8.5	14.66	22.66	12.33	11.66	21.33	20.66	24.50	23.33	7.33	12.33	16.33	5.66	10	12.83	44.66	16.00
T_6	9.5	16.33	24.5	13.50	13.00	22.00	22.66	27.16	26.16	8.00	12.66	20.66	6.66	10.66	13.83	46	17.33
T_7	7.33	14.06	17.5	10.00	8.66	16.50	17.50	22.50	21.00	5.33	10.66	12.66	4.5	8	10	43	18.00
T_8	8.9	14.23	17.93	11.16	9.66	16.83	17.66	22.83	21.33	6.00	11.33	13.33	4.66	8.33	11.5	40.66	18.66
T_9	8	14	18.33	11.5	10.00	17.33	17.00	23.83	21.66	6.33	11.00	14	5.16	8.66	12	40	19.33
T_{10}	7.9	14.5	19.66	12.16	11.66	17.33	19.00	25.00	22.66	6.66	11.33	16.66	5.33	9.33	12.16	44	17.33
F – Test	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	**S**
S.E. (M)	0.58	0.4	0.47	0.28	0.39	0.44	0.49	0.29	0.86	0.35	0.4	0.49	0.29	0.4	0.42	1.18	**0.81**
C.D.	1.74	1.18	1.4	0.85	1.17	1.33	1.46	0.86	2.31	1.04	1.19	1.46	0.88	1.21	1.25	2.2	**2.03**

Table 2. Impact of plant growth regulators on no. of fruit/plants, fruit set %, fruit length, fruit width, fruit weight, TSS, and B:C ratio in strawberry

Treatment	No of fruit /plants	Fruit set %	Yield/plot (kg)	Fruit length (mm)	Fruit width (mm)	Fruit weight (g)	TSS (^{0}B)	Acidity %	Ascorbic acid (mg/100g)	B:C Ratio
T_0	8.66	63.83	0.80	37.1	30.16	13.33	5.33	0.6	51.5	2.14
T_1	11.33	66.33	1.08	38.8	31.06	17.33	8.33	0.6	53.83	2.89
T_2	13	77.93	1.30	40.8	31.50	18.66	8.33	0.83	53.83	3.46
T_3	14	80.86	1.83	41.5	32.16	22.66	8.50	0.9	54.5	4.9
T_4	11	75	1.80	51.5	32.66	24.66	7.67	0.86	54.83	4.66
T_5	12	81.66	1.86	52.33	34.50	27.33	7.83	1.03	56.16	4.74
T_6	12.66	76.66	2.00	51.83	35.16	27.33	8.50	0.86	56.83	5.01
T_7	14	82	2.10	54.5	36.16	37.33	9.50	0.8	56	5.62
T_8	15.33	83.1	2.13	60.66	37.00	38.66	9.50	1.06	57.16	5.7
T_9	16.66	87.66	2.33	61.43	38.33	41.33	10.17	1.33	58.66	6.21
T_{10}	12.66	63.83	0.80	51.43	36.33	37.33	8.00	0.6	56.83	4.16
F – Test	S	S	S	S	S	S	S	S	S	
S.E. (M)	0.90	5.04	0.21	1.12	0.55	1.21	0.63	0.19	0.56	
C.D.	1.89	10.6	0.45	2.37	1.97	2.56	1.32	NA	1.19	

In relation of yield per plot Treatment T_9 (BA @ 75ppm) recorded the highest yield per plot (kg) [2.33] over all other treatments and it was followed by [2.13] in T8 (BA@50ppm) whereasT_0 (Control) treatment had the lowest yield per plot (kg) [0.80]. Above findings corroborate the results in strawberry Yadav et al. [8]; Ahire and Gaikwad (2018). The increase in yield might be due to increased fruit set/plant, berry size and berry weight. Similar findings were also reported by Rajbhar et al. (2015) with the application of gibberellic acid (BA) @ 100ppm.

In relation of fruit length (mm) Treatment T_9 (BA @ 75ppm) recorded the maximum fruit length (mm) [61.43] over all other treatments and it was followed by [60.66] in T8 (BA@50ppm) where as T_0 (Control) treatment had the minimum fruit length [37.10]. Increase in fruit length (mm) following use of BA might be due to its effect in cell division and cell elongation. BA is also reported to promote growth by increasing plasticity of cell wall followed by hydrolysis of starch into sugar which reduces cell wall potential, resulting in the entry of water into the cell and causing its elongation [10].

In relation of fruit width Treatment T_9 (BA @ 75ppm) recorded the maximum fruit width (mm) [38.33] over all other treatments and it was followed by [37.00] in T8 (BA@50ppm) where as T_0 (Control) treatment had the minimum fruit length [30.16]. Increase in fruit diameter following use of BA might be due to its effect in cell division and cell elongation. BA is also reported to promote growth by increasing plasticity of cell wall followed by hydrolysis of starch into sugar which reduces cell wall potential, resulting in the entry of water into the cell and causing its elongation [10].

In relation of fruit weight (gm) Treatment T_9 (BA @ 75ppm) recorded the maximum fruit weight (gm) [41.33] over all other treatments and it was followed by [38.66] in T8 (BA@50ppm) where asT_0 (Control) treatment had the minimum fruit weight (gm) [13.33]. Increment in fruit weight (g) in Treatment T_9 (BA 75 ppm) might be due to its role in plant metabolism (Chaturvedi et al. [11,12] in terms of better supply of water, nutrients and other compounds vital for their proper growth and development [13,14].

In relation of TSS (Brix) Treatment T_9 (BA@75ppm) recorded Maximum TSS [10.17 Brix] over all treatments and it was followed by [9.50] in T8 (BA@50ppm) where-as T_0 (Control) treatment had the Minimum TSS [5.33 Brix]. Maximum TSS in treatment- BA might be attributed to rapid mobilization of sugars and other soluble solids to developing fruits Singh and Singh [15].

Treatment T_9 (BA@75ppm) recorded highest acidity [1.33] over all treatments and it was followed by [1.06] in T8 (BA@50ppm) where-as T_0 (Control) treatment had the lowest. The decrease in acidity in boron treated plants (Treatment- BA 75 ppm) might be due to their better utilization in respiration and rapid metabolic transformation of organic acids into sugars Kumar et al. [16] and Tripathi et al. (2011).

4. CONCLUSION

From the above experiment finding it may be concluded that the treatment T_6 (GA3@ 100 ppm) was found to be best in the terms of Vegetative growth viz,. Plant height, Plant Spread, Petiole length, No. of leaves per plant.

The treatment T_9 (BA @ 75 ppm) was found to be best in the terms of Floral characters, Yield Parameters and quality parameter viz,. Days to first flowering, No. of fruits, No. of flowers, Fruit set, Yield per plot, Fruit weight, Fruit Length, Fruit Width, T.S.S, Acidity, Ascorbic acid.

The treatment T_9 (BA @ 75 ppm) gave highest net profit with highest B:C ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Morgan. Growth, yield and quality of Rosa hybrid L. as influenced by various micronutrients. Pak J Agric Sci. 2012; 47(1):5-12.
2. Vishal et al. Interaction of Paclobutrazol, Boron and Zinc on vegetative growth, yield and fruit quality of Strawberry cv. Selva. J Biol Environ Sci. 2016;4(11):67-75.
3. Rademabher 2000 Effect of plant bio-regulators on growth, yield and quality of strawberry (*Fragaria x ananassa* Duch) cv. Sweet Charlie. Res J Agric Forestry Sci. 2018;6(2):6-8.
4. O" Neil and Ross (GA3) on strawberry growing in the greenhouse. Colture Protette. 2002;19(10):59-68.

5. Qureshi et al. Effect of photoperiod and growth regulators on vegetative growth, flowering and yield of strawberry. PhD Thesis, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP), India; 2013.
6. Tripathi, Shukla. Influence of pre- harvest application of calcium and micro-nutrients on growth, yield, quality and shelf-life of strawberry cv. Chandler. Indian J Agric. Sci. 2008;83(8):831-835.
7. Sharma, Singh. Performance of some strawberry (*Fragaria x ananassa* Duch.) cultivars under Jammu conditions. Prog Horticult. 2009;37:163-165.
8. Yadav, et al. Effect of foliar application of nutrients on the yield and fruit quality of winter season guava cv. L-49. Haryana J Horticult Sci. 2017;30(1/2):6-7.
9. Bhople et al. Effect of pre-harvest application of micro-nutrients on quality of guava (*Psidium guajava* L.) cv. Sardar. HortFlora Res Spectrum. 2019;1(1):60-63.
10. Richard, The influence of exogenous hormone on the flowering and fruiting of Strawberry (*Fragaria x ananassa* Duch). J Biol Agric Healthcare. 2006;2(4):2224-3208.
11. Chaturvedi et al. The strawberry: composition, nutritional quality, and impact on human health. Nutrition. 2005);28(1):9–19.
12. Chaturvedi OP, Singh AK, Tripathi VK, Dixit AK. Effect of zinc and iron on growth, yield and quality of strawberry cv. Chandler. Acta Hortic. 2005;696:237-240.
13. Datta, Banik. Growth and morphogenesis of the strawberry as related to auxin. American Journal of Botany. 2007;;37:211–215.
14. Datta P, Banik AK. Effect of foliar feeding of nutrients and plant growth regulators on physic-chemical quality of sardar guava grown in red and lateritic tract of West Bengal. Acta Hortic. 2007;735.
15. Singh, Singh. GA3 influences incidence of fruit malformation, berry yield and fruit quality in strawberry (Fragaria × ananassa Duch.). Acta Horticulture. 2009;842: 737-740.
16. Kumar et al. Effect of GA3 and plant growth promoting rhizobacteria on growth, yield and fruit quality of strawberry (Fragaria × ananassa Duch.) cv. Chandler. International Journal of Advanced Research. 2012;3(11):312–317.

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