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Effect of Plant Growth Regulators on Morphology of Strawberry (*Fragaria X Ananassa*) Under Protected Cultivation

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ABSTRACT

Strawberry (Fragaria × ananassa) is a temperate fruit crop that has great potential. But it is growing in tropical and subtropical region also. Its growth affect by a number of physiological, genetic, and biochemical processes. Plant growth regulators are responsible for regulate plant growth and other physiological functions. The present experiment was conducted to find out the effect of plant growth regulators on the morphology of strawberry cv. Winter Dawn under protected cultivation. The experiment was conducted with ten treatments and three replications of each treatment in a Randomized Block Design (RBD). The treatment consisted of three different concentrations of plant growth regulators viz. T_1: NAA 25 ppm, T_2: NAA 50 ppm, T_3: NAA 75 ppm, T_4: $GA_3$25 ppm, T_5: $GA_3$50 ppm, T_6: $GA_3$75 ppm, T_7: CCC 500 ppm, T_8: CCC 750 ppm, T_9: CCC 1000 ppm, and T_{10}: Control. $GA_3$75 ppm and CCC 1000 ppm were observed to exhibit a significant effect on the morphological parameters. The result reveals that the maximum plant height (22.47cm), number of leaves (22.84), plant spread (32.96cm), leaf area (128.9cm^2), internodal length (13.17cm), number of days for flower initiation (66.64), number of flowers/plant (22.57), number of fruits/plant (20.10), number of fruit/truss were recorded in plants sprayed with GA_3 75 ppm. The minimum days taken in flowering (50.09 days) and highest crown diameter (1.33cm) were found in CCC 1000 ppm.

Keywords: *Strawberry, NAA, GA3, CCC, morphological parameters, protected cultivation, and Winter Dawn*

INTRODUCTION

Strawberry (*Fragaria* x *ananassa)* is a soft, luscious, nutritious, tasty, and perishable fruit which is grown in temperate climatic conditions where the plant behaves like a small perennial herb and also grown in a sub-tropical climate whose plant behaves as an annual [16, 20]**.** The commonly cultivated strawberry (*Fragaria* x *ananassa* Duch.) is considered a hybrid between *F. virginiana* and *F. chilonensis* which belongs to the Rosaceae family with basic chromosome number X=7 [12]. Botanically an octaploid (2n=56), dicotyledonous, low-growing herb grown in most arable regions of the world and enjoyed by millions of people in all kinds of climates [10]. It is propagated through the runners. It's red color due to the presence of anthocyanin, pelargonidin, 3-mono glucoside, and traces of cyanide [20]. Among the fruits, it is one of the most popular, delicate in flavour, rich in vitamins and minerals and gives the quickest return in the shortest possible time [19]. Strawberry fruits, in addition to being consumed fresh, are used to make jam and jelly because of the large content of pectin present [15]. It is grown commercially in Maharashtra, Punjab, Haryana, Karnataka, Madhya Pradesh, Jammu & Kashmir, Himachal Pradesh, and Uttarakhand in India [21] . Strawberry cultivation area in India is nearly 1000 ha, with an annual production of 8000 MT [b] . Strawberry covers approximately 200 acres of land in Haryana [a], and the Hisar district has emerged as a hub. Strawberry cultivation is gaining popularity throughout India, with Haryana leading the way in terms of both area and production. However, its marketing and profit are suffering as a result of a lack of desired fruit size and quality. With the goal of increasing strawberry production, marketability, and profit margins in mind, the current study was designed to determine the optimal concentration of plant growth regulators and their effect on the morphology of strawberry plants.

Among the plant growth regulators, naphthalene acetic acid (NAA) and gibberellins (GA_3) have been widely tested in modern agricultural systems due to their suitability for application at cheaper rates. The role of these plant growth regulators has been investigated in several fruits [4] . Gibberellic acid increases the quality parameters of strawberry fruit by inducing stem and internode elongation, seed germination, enzyme production during germination, and fruit setting and growth [10] . The application of gibberellic acid (GA3) has been shown to increase leaf size and petiole length, while auxins are also known to have similar effects [23] . NAA is effective in controlling several plant metabolic processes. NAA foliar sprays have been shown to control premature fruit drops and increase strawberry fruit size, delay ripening, and increase anthocyanin accumulation. It also increase the flowering period and improves fruit yield and quality [24] . Chlorocholine Chloride (CCC) is a gibberellin biosynthesis inhibitor that inhibits geranylgeranyl pyrophosphate cyclization to copy pyrophosphate. It is highly water-soluble and passively absorbed by all plant tissues, making it effective as a spray or drench. The present study was carried out with the objective of assessing the effect of plant growth regulators on the morphology of strawberries (Fragaria x ananassa) under protected cultivation.

MATERIALS AND METHODS

The present study was conducted at Precision Farming

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Development Centre (PFDC), Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University (CCS HAU), Hisar during 2021-2022. Hisar is situated at an altitude of 215m (705ft) above mean sea level with coordinates of 29º 09´N latitude and 75º 42´E longitudes in western Haryana. The region is part of the alluvial Ghaggar - Yamuna plain and its southern and western portions mark a gradual transition to the desert. An experiment was conducted using foliar application of plant growth regulators with different concentrations where planting materials (runners) of Winter Dawn variety were obtained from Saharwa village of Hisar district (Haryana). Runner plants were planted in October in raised beds at a distance of 25 x 30 cm. The experiment was laid out in a randomized block design with ten treatments and each treatment was replicated thrice. The various combination of PGRs were: T_1-Naphthalene Acetic acid (NAA) 25 ppm, T_2-Naphthalene Acetic acid (NAA) 50 ppm, T_3-Naphthalene Acetic acid (NAA) 75 ppm, T_4-Gibberellic acid (GA_3) 25 ppm, T_5- Gibberellic acid (GA_3) 50 ppm, T_6-Gibberellic acid (GA_3) 75 ppm, T_7-Cycocel (CCC) 500 ppm, T_8-Cycocel (CCC) 750 ppm, T_9-Cycocel (CCC) 1000 ppm, T_{10}-Control. Foliar spraying of plant growth regulators was done at 30 and 45 days after planting. The required quantity of plant growth regulators was measured by digital analytical electronic balance and dissolved in a solvent and then the final volume made up to one-litre with distilled water. The chemical was sprayed with the help of a knapsack sprayer.

Observations on various morphological parameters were recorded by using the standard method. The data on all the morphological parameters was tabulated and subjected to statistical analysis using the method of analysis of variance (ANOVA) for Randomized Block Design (RBD) by Fisher and Yates (1963). Whenever the 'F' test was found significant for comparing the means of two treatments, critical differences (C.D. at 5%) were worked out.

RESULTS AND DISCUSSION

The effect of plant growth regulators on morphology of strawberry is presented in Table 1 and Table 2. Different combinations of plant growth regulators exhibit significant influence on the morphological characteristics of strawberry plant. From this study, maximum plant height (22.47cm) number of leaves (22.84) and maximum plant spread (32.96cm) were observed in GA_3@75 ppm and lowest in CCC@1000 ppm. The reason for maximum plant height with the application of GA_3@75 ppm may be due to that Gibberellins control strawberry plant growth by inducing cell elongation and accelerated cell division, which may be the cause of the maximum rise in plant height, which also lengthens strawberry mature petioles [17]. This treatment was also found to be best for producing leaf area (128.90cm2), internodal length (13.17cm), number of flowers (22.57), number of fruit/plant (21.10) and number of fruit/truss (5.50) in strawberry.

Table 1. Effect of plant growth regulators on plant height, number of leaves and plant spread of strawberry cv. Winter Dawn.

Treatments	Plant height (cm)			Number of leaves			Plant spread (cm)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1 (NAA 25 ppm)	9.80	15.31	18.21	8.57	13.39	16.74	18.24	22.27	24.79
T_2 (NAA 50 ppm)	10.10	15.89	19.17	9.71	15.52	17.92	19.34	23.75	25.72
T_3 (NAA 75 ppm)	10.54	16.47	19.52	10.41	17.21	19.20	20.90	24.40	27.17
T_4 (GA_3 25 ppm)	11.39	17.27	20.42	10.29	16.87	18.65	21.35	25.53	28.52
T_5 (GA_3 50 ppm)	11.98	17.80	21.10	11.48	18.36	20.60	23.45	27.50	30.14
T_6 (GA_3 75 ppm)	12.44	18.29	22.47	12.61	20.32	22.84	25.50	30.46	32.96
T_7 (CCC 500 ppm)	9.16	13.90	15.22	7.22	9.88	12.71	16.77	20.46	22.34
T_8 (CCC 750 ppm)	8.94	13.53	14.81	6.49	9.02	12.09	15.58	19.17	21.32
T_9 (CCC 1000 ppm)	8.61	13.22	14.37	5.98	8.25	11.61	15.00	18.51	20.80
T_{10} (Control)	9.58	14.27	16.69	7.84	10.45	13.59	17.93	21.71	23.71
C.D. @ 5%	0.49	0.65	0.76	0.25	0.72	0.93	1.16	0.88	1.24
S.Em±	0.16	0.22	0.25	0.08	0.24	0.31	0.39	0.29	0.41

Table 2. Effect of plant growth regulators on crown diameter, leaf area, Internodal length, number of flower/plant, number of fruit/plant and number of fruit/truss in strawberry cv. Winter Dawn

Treatments	Crown diameter (cm)			Leaf area (cm^2)			Internodal Length (cm)	Flower initiation (Days)	No of flowers/plant	No of fruit /plant	No of fruit/truss
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS					
T_1 (NAA 25 ppm)	0.934	1.034	1.151	80.43	102.25	118.34	6.58	56.73	18.03	16.27	4.20
T_2 (NAA 50 ppm)	0.925	1.005	1.131	83.31	105.48	121.20	7.34	59.53	18.95	17.19	4.46
T_3 (NAA 75 ppm)	0.893	0.975	1.115	87.38	108.21	121.83	7.90	61.27	20.74	18.24	4.77
T_4 (GA_3 25 ppm)	0.869	1.031	1.150	81.50	104.77	123.86	10.84	61.71	21.57	18.90	4.91
T_5 (GA_3 50 ppm)	0.845	9.970	1.063	85.91	108.89	128.30	11.23	64.61	21.93	19.50	5.23
T_6 (GA_3 75 ppm)	0.819	0.976	1.036	90.34	113.66	128.90	13.17	66.64	22.57	21.10	5.50
T_7 (CCC 500 ppm)	0.973	1.104	1.256	68.63	94.53	104.37	3.83	55.31	17.16	15.40	4.06
T_8 (CCC 750 ppm)	0.987	1.140	1.286	65.70	91.83	101.79	3.15	52.75	16.72	14.70	3.88
T_9 (CCC 1000 ppm)	1.005	1.181	1.328	64.56	88.75	99.61	1.83	50.09	16.01	13.40	3.71
T_{10} (Control)	0.944	1.082	1.193	71.71	96.48	110.57	5.81	64.22	15.77	13.10	3.58
C.D. @ 5	0.046	0.041	0.051	3.62	4.10	4.96	0.28	0.71	0.91	0.53	0.20
S.Em±	0.015	0.013	0.017	1.20	1.36	1.63	0.09	0.24	0.30	0.21	0.07

Plant spread increased could be due to increased length and upright growth of leaf petioles, which lean outwards, resulting in greater plant spread, and GA_3 also acts as a substitute for growth promoting substances that are normally produced under long-day conditions [9, 14]. The increased number of leaves may be attributed to an increase in the length of epidermal and parenchymal cells, a faster rate of cell division, and cell elongation in strawberry shoot sub-apical meristems, which may result in the production of more leaves[1, 9]. Different concentration of gibberellic acid has a positive effect on leaf area. The increase in leaf area could be attributed to an increase in cell division and cell expansion caused by gibberellin application, which results in a rapid increase in leaf length and breadth, resulting in a larger leaf surface area [14]. It seems that gibberellic acid specifically stimulates the stolon-forming system as well as causing elongation of non-stolonous stem tissue [7, 8]. It is also evident from the data given in Table 2 that the maximum number of flowers (22.57) was recorded in treatment T_6. The increased number of flowers in GA_3-treated plants could be due to accelerated inflorescence development, which could increase the number of flowers per plant [2, 9]. The increased number of fruit/trusses could be attributed to the increased flower node in the GA_3-treated plant [13].

An inquisition of data presented in Table 2 revealed that different concentration of plant growth regulators has significant effect on crown diameter. The plants treated with treatment T_9 produced the maximum crown diameter (1.328cm). Crown diameter increase may be due to the fact that the nutrients produced during vegetative growth are stored in the crown [5].

Flower initiation was influenced significantly by the various treatment combinations. The minimum number of days for flower initiation (50.09) was observed in T_9 which was statistically significant with treatment T_8, whereas the maximum number of days for flower initiation was recorded in T_6 which was statistically at par with treatment T_5. This could be because cycocel suppressed vegetative growth, resulting in early attainment of required flower bud differentiation [14]

CONCLUSION

From the present studies, it is concluded that foliar application of GA_3@75 ppm at 30 and 60 DAS resulted in improved maximum morphological parameters while CCC increased crown diameter with decreased plant height. These results could be utilized to assess the impact of plant growth regulators on various strawberry cultivars grown under protected agriculture in the future.

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