Influence of Plant Growth Regulators on Yield and Qualitative Parameters in Strawberry (*Fragaria x anannasa*) cv. Winter Dawn under Protected Cultivation

ABSTRACT: The present investigation was carried out during 2021-2022 to find out the effect of plant growth regulators on yield and qualitative parameters in strawberry (*Fragaria x anannasa*) cv. Winter Dawn under protected cultivation at Precision Farming Development Centre (PFDC), Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experiment was conducted with ten treatments using randomized block design. Each treatment had three replication. The treatment consisted of three different concentration 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. The yield and quality of strawberry were significantly influenced by plant growth regulators. The highest quality of fruit in term of berry weight (16.57g), berry breadth (2.87cm), berry length (3.97cm), TSS (9.38^{o}Brix), TSS/acid ratio (14.89) and ascorbic acid (60.13mg/100g) were observed in T_9 treatment which was consist cycocel@1000 ppm while GA_3@75 ppm gave maximum results in terms of marketable yield (88.27%), yield per plant (304.26g) and anthocyanin (5.67mg/100g) in strawberry fruit.

Key words: Plant growth regulators, quality, strawberry, Winter Dawn, yield.

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INTRODUCTION:

The cultivated strawberry (*Fragaria x ananassa* Duch.) is one of the luscious and soft fruits of the world. It is a hybrid of two Native American species *Fragaria chilonensis* and *Fragaria*

*virginiana*and belongs to the Rosaceae family. All cultivated varieties are octoploid (2n=56). Botanically it is an aggregate fruit which is highly perishable in nature. In temperate climate condition, its plants behave like a small perennial herb with shallow root system whereas in sub-tropical climate it behaves as annuals. It has short stem know as crown. The crown produces leaves at very close interval along the stem axis and flowers at terminal position on stem axis. The edible portion of strawberry includes the ripened receptacle and achenes (true fruit and seed). Strawberry is usually propagated through runners. Strawberry is rich source of vitamins and minerals and coupled with delicate flavor, the red color of the fruit is mainly due to the presence of the anthocyanin, pelarogonidin, 3-monoglucoside and traces of cyaniding (Srivastav, A., *et al*., 2018).

It is commercially grown in Maharashtra, Punjab, Haryana, Karnataka, Himachal Pradesh, Madhya Pradesh, Jammu & Kashmir and Uttarakhand in India (Thakur *et al.*, 2017). Strawberry cultivation area in India is nearly 1000 ha, with an annual production of 20,000 MT (pib.govt.in, 2020-21). Strawberry covers approximately 200 acres of land in Haryana (Hortharyana 2018-19), 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. Application of growth regulators has been practiced commercially to increase the production and quality of crops. Plant hormones are a small group of signaling molecules that plays a vital role in various morphological, photosynthetic, biochemical and developmental processes in crop plants (Nazir, *et. al*., 2019). The growth and quality of fruits depends on different attributes which are closely associated with nutrient uptake by the plant and also with PGR's.

GA_3 has been found to increase the vegetative growth of strawberry; Cycocel and NAA improved the yield and quality of strawberry. Although, the use of Cycocel (CCC) was reported to

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reduce plant height by which fruit yield is positively increased (Tiwari, A.K., *et.al.* 2017). Use of GA_3 in strawberry has been reported in early flowering, increased duration of flowering, harvesting and yield. It increases yield and quality of fruits, helps in cell elongation and cell enlargement, increases vegetative growth and minimizes time of maturity and increases fruit set. Application of NAA increases fruit size and delays ripening and increases anthocyanin accumulation in strawberry fruits. It also increases duration of flowering, improves yield and quality of fruits (Yadav, I., *et.al.* 2017). 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 yield and quality of strawberry.

MATERIALS AND METHODS:

The present study was carried out at Precision Farming Development Centre (PFDC), Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University (CCS HAU), Hisar during 2021-2022. Hisar is located at an altitude of 215m (705ft) above MSL with coordinates of 29^{o} 09´N latitude and 75^{o} 42´E longitudes in western Haryana. This region is part of alluvial Ghaggar – Yamuna plain and its southern and western portion mark a gradual transition to the desert. An experiment was conducted using foliar spray of PGRs viz. Naphthalene Acetic acid (NAA), Gibberellic acid (GA_3) and Cycocel (CCC) with different concentration (Table 1) where planting material (runners) of Winter Dawn variety were obtained from Saharwa village of Hisar district (Haryana). The strawberry runners with uniform size were planted in month of October at a distance of 25 x 30 cm on raised bed. The experiment was laid out in randomized block design (RBD) with ten treatments where each treatment replicated thrice. The various combination of PGRs were: T_1-Naphthalene Acetic acid (NAA) 25 ppm,

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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 spray of PGRs was done at 30 and 45 days after planting. The required dose of PGRs was measured by digital analytical electronic balance and dissolved in a solvent and then the final volume was made up to one liter using distilled water. Growth regulators was sprayed with the help of knap sack sprayer. Observations were recorded by using standard method. The data of yield and qualitative parameters was tabulated and subjected to statically analysis using method of analysis of variance (ANOVA) for Randomized Block Design (RBD) by Fisher and Yates (1963). Whenever 'F' test was found significant for comparing the means of two treatment, critical difference (C.D. at 5%) were worked out.

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RESULT AND DISCUSSION:

There were significant differences among the treatments of naphthalene acetic acid, gibberellic acid, and cycocel on yield and qualitative traits in strawberry cv. Winter Dawn under protected cultivation. The table 1 revealed that the application of gibberellins and cycocel significantly influenced the number of fruit per plant, berry length, berry breadth, berry weight, marketable yield, unmarketable yield and yield per plant. Different combinations of plant growth regulators exhibit significant influence on yield and qualitative traits of strawberry fruit. The maximum number of fruit per plant (21.10), yield per plant (304.26g), and marketable yield (88.27%) were found in GA_3 75ppm. The increase in the number of fruits per plant can be attributed to the vigorous growth of plants treated with gibberellins, which accumulate more starch, carbohydrates, and photosynthates, resulting in a greater number of berries per

plant. This result is in line with the findings of Khalid *et al*. (2013) and Saima *et al.* (2014) in strawberry crop. The increase in fruit yield per plant in gibberellin-treated plants could be attributed to increased vegetative growth, which allows for greater fruit set and weight. The yield attributes on the sink capacity of crop is determined by its vegetative growth throughout the life cycle of plants. Vigorous growth is associated with higher sink capacity of a crop. This result is in conformity with the findings of Asadi *et al.* (2013), Saima *et al*. (2014), and Tanuja *et al*. (2019).

The highest marketable yield with GA_3 75ppm because gibberellic acid regulates the movement of metabolites from the sink to the source (Iqbal *et al.,* 2011). By stimulating enzymes needed during the post-fertilization stage, the exogenous injection of GA_3 may control this balance in favour of fruit-forming metabolic processes, improving fruit setting and ultimately leading to the greatest number of fruits/plant (Sharma and Sharma, 2004). A further benefit of using GA_3 on strawberry blooms is reported to be improved pollen germination (Paroussi*et al.,* 2002). GA3 at all concentrations produced significantly longer fruits over the control. The earlier cell elongation and cell division at apical region by GA_3 might have contributed to increased fruit length which was also explained by Moore *et al*. (1970). The maximum berry breadth (2.87cm), berry length (3.97cm) and berry weight (16.57g) were obtained in cycocel 1000ppm. The increase in breadth, length and weight of berries with the application of CCC might be due to greater supply of photosynthates to the berries. This may also be due to lower percentage of fruit set and lower number of fruits which enables fruit growth to its maximum extent. The current results are in correspondence with the findings of Saima *et al*. (2014).

Table 1. Effect of plant growth regulators on yield parameters in strawberry cv. Winter Dawn

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Treatments	No. of fruit/plant	Berry length (cm)	Berry breadth (cm)	Berry weight (gm)	Yield/plant (g)	Marketable fruit (%)	Unmarketable fruit (%)
T_1 (NAA 25 ppm)	16.27	3.32	2.60	12.73	207.11	79.89	20.11
T_2 (NAA 50 ppm)	17.19	3.40	2.52	12.97	222.95	80.54	19.46
T_3 (NAA 75 ppm)	18.24	3.51	2.45	13.27	242.04	82.43	17.57
T_4 (GA_3 25 ppm)	18.90	3.59	2.37	13.57	256.47	83.64	16.36
T_5 (GA_3 50 ppm)	19.50	3.71	2.29	13.95	272.02	86.38	13.62
T_6 (GA_3 75 ppm)	21.10	3.79	2.21	14.42	304.26	88.27	11.73
T_7 (CCC 500 ppm)	15.40	3.84	2.72	16.07	247.47	76.14	23.86
T_8 (CCC 750 ppm)	14.70	3.91	2.79	16.30	239.61	77.96	22.04
T_9 (CCC 1000 ppm)	13.40	3.97	2.87	16.57	222.02	79.36	20.64
T_{10}(Control)	13.10	2.90	2.08	12.32	161.39	74.37	25.63
C.D. @ 5%	0.53	0.17	0.09	0.45	12.13	3.38	0.96
S.Em±	0.21	0.05	0.03	0.15	4.05	1.13	0.32

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The data presented in table 2 showed that there was significant difference between different plant growth regulators but there were no significant differences between different treatments. The maximum and minimum titratable acidity (0.89% and 0.63%) were recorded in control and CCC@1000ppm respectively. The reduction in titratable acidity could be attributed to the conversion of more organic acids and photosynthates into sugars during the fruit ripening stage (Saima *et al*., 2014, and Rajesh *et al*., 2012a).

Table 2. Effect of plant growth regulators on qualitative parameters in strawberry cv. Winter Dawn

Treatments	TSS (^{o}Brix)	Titratable acidity (%)	TSS/acid ratio	Ascorbic acid (mg/100gm)	Anthocyanin (mg/100g)
T_1 (NAA 25 ppm)	8.81	0.80	11.00	52.02	59.61
T_2 (NAA 50 ppm)	8.60	0.79	10.84	53.96	62.23
T_3 (NAA75 ppm)	8.42	0.78	10.75	55.15	65.02
T_4 (GA_3 25 ppm)	7.91	0.82	9.84	53.73	63.86
T_5 (GA_3 50 ppm)	7.70	0.83	9.24	55.29	65.15
T_6 (GA_3 75 ppm)	7.51	0.85	8.57	56.99	67.33
T_7 (CCC 500 ppm)	8.57	0.66	12.98	58.21	56.55
T_8 (CCC 750 ppm)	8.78	0.64	13.71	59.8	57.17

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T_9 (CCC 1000 ppm)	9.38	0.63	14.89	60.13	58.17
T_{10}(Control)	7.40	0.89	8.27	50.17	54.95
C.D. @ 5%	0.36	0.04	0.62	2.56	2.45
S.Em±	0.01	0.12	-	0.85	0.81

The highest ascorbic acid (60.13mg/100g), TSS (9.38^o Brix) and TSS\acid ratio (14.89) was found in CCC 1000ppm. The higher ascorbic acid content could be attributed to the effect of growth regulators on biosynthesis from its precursor glucose-6-phosphate, which may increase ascorbic acid content (Tripathi and Shukla, 2007). Whileincrease in sugar and TSS content of fruits with plant bio-regulators treatments, particularly CCC, could be attributed to the rapid metabolic transformation of starch and pectin into soluble sugars and the rapid translocation of sugars from leaves to developing fruits by reducing plant vegetative growth. The increase in total sugar content resulted in a higher TSS/acid ratio (Sevan *et al.*, 2014). In strawberry fruits, the maximum anthocyanin content (67.33mg/100gm) was recorded in treatment T_6 (GA_3 75 ppm), whereas the minimum anthocyanin (54.95mg/100g) was observed in treatment T_{10} (control). Montero *et al.* (1998) discovered increased anthocyanin content with increasing GA_3 concentrations, which could be due to either direct or indirect involvement of GA_3 in the synthesis of anthocyanin pigment or its precursor, or involvement in the movement of its precursor. Furthermore, the higher anthocyanin levels observed in this study could be attributed to increased carbohydrate accumulation as a result of increased photosynthesis under the influence of plant growth regulators.

CONCLUSION:

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From the present study, it is concluded that foliar application of GA_3@75 ppm resulted in improved yield and anthocyanin while CCC@1000ppm improve the quality of strawberry. 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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