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INFLUENCE OF VARIOUS GROWTH REGULATORS AND CACL2 ON YIELD AND QUALITY IN STRAWBERRY CV. CHANDLER

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Abstract: The present investigation entitled Influence of various growth regulators and $CaCl_2$ on yield and quality in strawberry cv. Chandler was conducted in the Department of Horticulture, Khalsa College, Amritsar during 2016-2017. The runners of strawberry cv. Chandler were planted in the second fortnight of October with a spacing of 45x30 cm. The investigation was laid out in RBD with ten treatment combinations (GA_3 - 50, 75 and 100 ppm; NAA- 10,20 and 30 ppm; $CaCl_2$ -0.25 , 0.50 and 0.75 % and control) replicated thrice. Results of the study revealed that the application of growth regulators increased the yield parameters and improved the quality of strawberry. The maximum number of fruits (21.33), fruit set per cent (83.47) and fruit yield (344.11 g/plant) were recorded in the treatment T_3 (GA_3 100 ppm) respectively. Results also showed that T_6 treatment (NAA 30 ppm) was the remarkable treatment for physico-chemical properties of fruits with maximum fruit length (3.50 cm), fruit breadth (2.94 cm), TSS (7.76 °Brix), reducing sugars (4.61%) and total sugars (7.41%) respectively. Fruits also showed maximum weight (16.12 g), TSS: acid ratio (11.56), ascorbic acid content (63.71 mg/ 100g) and minimum acidity (0.54%) when the plants were treated with GA3 100 ppm.

Key Words: Gibberellic acid, Naphthalene acetic acid, 0Brix and Calcium chloride.

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INTRODUCTION

Strawberry (Fragaria x ananassa Duch.) belongs to family Rosaceae is a non-climacteric fruit which develops by simultaneous ripening of the number of separate berries of a single flower, adhering as the common unit on the common receptacle botanically called as "etaerio of achene" (Khunte et al 2014). The name "strawberry" may have derived from the practice of

using straw mulch for cultivation or it may have come from the Anglo-Saxon word "strew", meaning to spread (Kaur 2010). Cultivated strawberry is a dicotyledonous, perennial and low growing herb grown in most arable regions of the world. In India, a few plants of strawberry were brought in the early sixties by NBPGR Regional Station, Shimla, from where it is spread to the other states. Strawberry fruits are very popular among berries and are reported to have anti-oxidant, anti-cancer, anti-inflammatory and anti-neurodegenerative biological properties. These properties are mainly attributed to high fruit polyphenolic content, especially anthocyanins -the type of polyphenols quantitatively most important in strawberry fruits - as well as flavonoids, phenolic acids and vitamin C. The ellagic acid present in strawberry have cancer fighting properties (Xue et al 2001;Meyers et al 2003). The fresh strawberries are deep red in colour and is a profitable fruit crop in the shortest possible time as compared to the other fruits (Kumar et al 2012). This have traditionally been a popular delicious fruit for its flavour, taste, fresh use, freezing and processing. Strawberry gives quick and very high returns per unit area on the capital investment, as the crop is ready for harvest within 6 months of planting. Application of growth regulators has been practiced commercially to increase the production and quality of strawberry crop. They have been proved to be quite vital in enhancing fruit maturity, yield and fruit quality. Application of growth regulators has been practiced commercially to increase the production and quality of strawberry crop. They have been proved to be quite vital in enhancing fruit maturity, yield and fruit quality. Growth regulator treated fruits showed high contents of reducing sugars, amino acids and ascorbic acid (Mikhtelva and Petrovskya 1974). Gibberellic acid (GA3) stimulates the effect of long day lengths in short day plants by improving vegetative development and increasing runner production. It initiates early flowering and thus early fruit development (Kasim et al 2007; Paroussi et al 2002; Sharma and Singh 2009). The fruit set in strawberry can be improved with the foliar application of NAA at flower initiation stage. The application of NAA to emasculated flowers resulted in Parthenocarpic development of fruit and it also delayed ripening and anthocyanin accumulation of strawberry fruits (Villarreal et al 2009). Calcium chloride increases the leaf area index, average fruit weight and size of strawberry fruits (Dunn and Able 2006; Ramezanian et al 2009). Information is available on standardization on the use of growth regulators and protected conditions for successful strawberry cultivation under sub-tropical conditions of Punjab.

MATERIALS AND METHODS

The present study entitled "Influence of various growth regulators and $CaCl_2$ on the vegetative growth and yield in strawberry cv. Chandler" was conducted in the nursery of Horticulture Department, Khalsa College, Amritsar during 2015 Amritsar represents the climatic conditions prevailing in the sub tropical humid zone of Punjab state. It receives an annual rainfall of 735 mm, the major portion of which falls from July to September. During winter, frost is of common occurrence while in summer, the atmospheric temperature occasionally reaches upto 480 C. The soil of experimental field was sandy loam in texture. The runners of strawberry were procured from the Bhangu strawberry farm, village Sahmana as bases of plant material. The runners were transplanted in well prepared raised beds each measuring 2 m x 1 m in size. The transplanting was done during second fortnight of October at a planting distance of 45 x 30 cm. Uniform dose of FYM @ 50 t /ha was applied to all plots before field bed preparations. The growth regulators were applied at fruit set and $CaCl_2$ was applied before harvest. There were ten treatments GA_3 (50 ppm, 75 ppm and 100 ppm), NAA (10 ppm, 20 ppm and 30 ppm) and $CaCl_2$ (0.25 %, 0.50 % and 0.75 %). In control the plants were sprayed with plain water. The treatments were replicated thrice. Data was analysed by RBD (Randomised Block Design). The various observations regarding plant height, leaf parameters, flower and fruit parameters were recorded. Observations were statistically analysed by Randomized Block Design.

RESULTS AND DISCUSSION

Number of flowers per plant

The maximum number of flowers per plant 25.56 was observed in plants treated with GA_3 100 ppm. Present results are in agreement with the findings of many researchers who revealed that gibberellic acid increased number of flowering truss and flowers in strawberry plant (Paroussi et al 2002). Similar results have been favoured by Kaur (2010), Haider et al (2012) and Uddin et al (2012) in strawberry. They observed that application of Gibberellic acid in strawberry produced maximum number of inflorescence per plant, number of flower per plant and number of flowers per inflorescence. The more number of flowers per plant and earliness in flowering were probably because of hormone application which accelerated the development of differentiated inflorescence and stimulated flowering. The research work of Thakur et al (1991),Gupta and Acharya (1993), Kumar et al (1996), Khokhar et al (2004), Singh et al (2005) and Ali and Gaur (2007) in strawberry supported the present findings. According to Prasad et al (2015) maximum number of

flowers from GA3 treatments was due to the fact that such treatments being rich in nutrients induced good vegetative growth and flower bunch hence initiated higher number of flowers. The plants treated with NAA (10, 20 and 30 ppm) registered 17.85, 19.89 and 21.27 flowers per plant. This might be due to the more number of flowering buds as the stimulus (florigen) converted vegetative bud to fruiting bud by the help of exogenously applied NAA. The results are similar with those of Thakur et al (1991).$CaCl_2$ (0.25 %, 0.50 % and 0.75 %) produced 16.84, 18.89 and 20.25 flowers which were more than control with 16.75 flowers respectively.

Number of fruits per plants

Results of the present study showed that maximum number of fruits per plant (21.33) were observed in plants treated with GA_3 100 ppm and it was followed by treatment T_2 (GA_3 75 ppm) with 20.34 number of fruits which were significant from all other treatments. Both of these treatments were at par with each other. Lowest number of fruits (12.08) were observed under control. Gibberellic acid showed higher number of fruits per plant when applied alone on strawberry plants, as compared to others. Same results have been shown by Kaur (2010) and Qureshi et al (2013). It is in conformation with the research work of Dhillon (2005) who also reported enhanced fruit set with GA_3 treatments. Tehranifer et al (1997) reported maximum berry setting with GA_3 50 ppm in strawberry cv. Chandler. Application of 75 ppm GA_3 provided maximum number of fruit in strawberry (Uddin et al 2012). Number of flowers were more in NAA treated plants due to more numbers of flowering stock which arised from those plants as the stimulus (florigen) converted vegetative buds to fruiting buds by the help of exogenously applied NAA. The results are similar with Thakur et al (1991).

Fruit set per cent

The data pertaining to fruit set per cent as influenced by growth regulators and CaCl2 revealed that the maximum fruit set (83.47 %) were recorded in T3 treatment. Minimum fruit set (72.17 %) was observed under control. The increased fruit set percent in treatments receiving GA3 application might be due to GA3 caused 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 increased the fruit set and number of berries per plant. It could also be due to the fact that GA3 application accelerated the development of differentiated inflorescence. (Paroussi et al 2002; Saima et al 2014). This might be related to the important role of auxins on fruiting of strawberry. Auxins in the pollen ensured that a rapid burst ovary growth accompanied by abscission of the stamens, petals usually followed

after pollination. Auxins increased the fruit set in fruits containing many ovules (Chesworth et al 1998). GA3 treated fruits showed more fruit set percentage than any other treatments. The present study is in accordance to that depicted by others scientists. Sharma and Singh (2009) and Kappel and McDonald (2007). Prasad et al (2015) in their research trial concluded that the application of GA_3 increased the fruiting in strawberry. This was due to the fact that maximum number of flowers from GA^3 treatments being rich in nutrients induced good vegetative growth and flower bunch hence initiated higher number of flowers per cent berry set. It could also be attributed to the improvement in the water retention in the medium, better uptake of nutrients and water, which might be increased by photosynthetic rate causing maximum berry production. Number of flowers were reported to a more in NAA treated plant due to more numbers of flowering stock arises from those plants as the stimulus (florigen) converted vegetative buds to fruiting buds by the help of exogenously applied NAA. The results are similar with Thakur et al (1991). The fruit set percentage also increased with the application of calcium chloride treatments which was in the range of 75.48 % to 76.43 %.

Yield

It was noted that GA_3 100ppm registered maximum fruit yield (324.85 gm/plant). Minimum fruit yield (118.37 gm/plant) was recorded in control. The higher yield might be due to the increased flowering and more fruit set with higher fruit weight (Muneshwar et al 2012). Saima et al (2014) reported that the higher yield might be due to the formation of more metabolites by large leaves in plants resulting in bumper flowering, fruit setting besides better vegetative growth. The application of GA_3 100ppm recorded maximum yield, closely followed by GA_3 50 ppm. These results are in confirmation with the findings of Zakhorova 1979; Singh and Phogat 1983 the same in strawberry. GA_3 100 ppm had a pronounced effect on the yield of strawberry crop. The increase in fruit yield possibly be due to the increased percentage of achene formation, setting higher number of fruits per plant, berry size and weight. The results of the present studies have been coroborated by the findings of Kalie et al (1980) and Rana (2001) who confirmed the findings of the present study. NAA treated plants registered more number of flowers due to more numbers of flowering stock which arised from those plants as the stimulus (florigen) converted vegetative bud to fruiting bud by the help of exogenously applied NAA. The results are similar with Thakur et al (1991) in strawberry.

Table 1: Effect of various growth regulators and $CaCl_2$ on flowering, fruiting and yield parameters in strawberry cv. Chandler

Treatments	Number of flowers per plant	Number of fruits per plant	Fruit set per cent	Yield (gm/plant)
T_1-GA_3 50ppm	23.64	19.47	82.32	230.01
T_2-GA_3 75ppm	24.60	20.34	82.68	269.31
T_3–GA_3 100ppm	25.56	21.33	83.47	344.11
T_4 –NAA 10ppm	17.85	13.69	76.65	175.24
T_5-NAA 20ppm	19.89	15.71	78.97	216.44
T_6-NAA 30ppm	21.27	16.83	79.15	232.33
T_7-$CaCl_2$ 0.25%	16.84	12.71	75.48	143.41
T_8-$CaCl_2$ 0.50%	18.89	14.89	78.84	173.48
T_9-$CaCl_2$ 0.75%	20.25	15.48	76.43	193.16
T_{10}-Control	16.75	12.08	72.17	128.95
CD (5%)	**0.48**	**0.63**	**2.69**	**15.65**

Total soluble solids

The data on the total soluble solids of fruits showed that the maximum TSS i.e. 7.76 per cent were found in the fruits produced by plants treated with NAA 30 ppm minimum TSS (6.16 %) was found under untreated plants. Results of these findings are confirmed by Kumar et al (2011) and Kumar et al (2012). They observed positive effect of NAA on TSS of strawberry fruits. This might be due to treatment effect on physiological accumulation of sugar and change in metabolism which eventually resulted in more retention of TSS (Khunte et al 2014). Abolfazl et al (2013) reported that the TSS was decreased as GA_3 concentration increased. The role of GA_3 on increasing TA was more important than that of TSS. From the data, it was observed that the plants treated with GA_3 produced fruits with higher TSS than control. The increase in TSS might be due to the conversion of starch and other polysaccharides. The results showed conformity with the findings of Bhautkar (1994) and Rana (2001) who also reported the maximum TSS with GA_3 100 ppm in cv. Chandler which is in line with the present findings. Higher TSS was detected in the fruits from the calcium chloride treatments than control. Calcium chloride treated strawberry demonstrated an increase in TSS thus finding is in accordance with the work of Dunn and Able (2006) who found an increase in TSS percentage with lower calcium doses. These results could be ascribed to increasing soluble matter in the juice by penetrated calcium chloride (Kadir 2004).

Acidity

The data on acidity level of fruits showed that the minimum acidity (0.54 %) was found in the fruits produced by plants under treatment T_1 whish was found significant. Maximum acidity was found under control. Data revealed that GA_3

significantly affected fruit juice acidity with the lowest value (0.54 %) while the highest acidity (0.84 %) was recorded in control plants. These findings are in conformity with Singh and Singh (1979) in strawberry. Increase in titratable acidity by GA_3 was due to the consumption of sugar in the form of energy to enhance the vegetative growth. The data given in table are clearly indicative of the fact that with the increase in concentration of growth regulators there is increase in acidity in strawberry plants. Abolfazl et al (2013) reported that the TSS was decreased as GA3 concentration increased in strawberry fruits. GA3 played a role in increasing titratable acidity. Calcium application decreased the acid content which ascribed an increase in TSS and ultimately reduced the acidity of fruit. Similar results were reported by Ahlawat et al (1985) in grapes.

TSS: acid ratio

The data relating to TSS: acid ratio as affected by GA3 and NAA are given in Table 4.5. From the data, it is clear that maximum TSS: acid found under treatment T1 GA3 50 ppm which was found to be significantly higher than all other treatments. Minimum TSS: acid ratio (7.34) was found under control treatment.

Reducing sugars

Results of the study showed that the plants with treatment T6 yielded fruits with maximum reducing sugars 4.61 per cent while minimum reducing sugars 3.45 per cent was observed in control. Results of these findings are confirmed by Kumar et al (2011) and Kumar et al(2012). They observed positive effect of NAA on TSS of strawberry fruits. The increase in reducing sugars with the application of NAA might be due to treatment effect on physiological accumulation of sugar and change in metabolism which eventually resulted in more retention of TSS. By the activity of invertase enzyme, which break down sucrose into fructose and glucose, hence resulting in increased reducing sugars (Khunte et al 2012).The plants treated with GA3 100 ppm recorded higher reducing sugars than control. The increase in reducing sugars with the application of GA3 might be due to the fact that GA3 was responsible for the synthesis of enzyme ?-amylase, which converted starch into sugars. The various concentrations of calcium chloride also resulted in maximum reducing sugars than control.

Total sugars

The data regarding total sugars depicted that they increased rapidly with increasing dose of Naphthalene acetic acid. It was noted that plants of T6 treatment yielded fruits with maximum total sugars as 7.41 per cent. Controlled conditions registered minimum total sugars as 5.86 per cent which was followed by treatment T7 with total sugars 6.11 per cent. Both these treatments were found to be at par with each other. This might be due to the treatment

effect on physiological accumulation of sugars and change in metabolism which eventually resulted in more retention of TSS and Total sugars. Results of these findings are confirmed by Kumar et al 2011 and Kumar et al 2012. The plants treated with GA3 produced fruits with high total sugar content than control (Khunte et al 2014). The enhancement in sugars of strawberry plants with growth regulators might be due to the fact that it checked vegetative growth, which in turn readily made available more carbohydrates to the developing berries and ultimately improved their sugar content. Evidently, the increase in sugars might be due to the conversion of starch and other polysaccharides into soluble sugars. These results are in line with the findings of Rana (2001) in strawberry cv. Chandler under sub-tropical conditions of Punjab .

Table 2 : Effect of various growth regulators and CaCl2 on flowering, fruiting and yield parameters on biochemical characters in strawberry cv. Chandler

Treatments	TSS (^{0}Brix)	Acidity (%)	TSS: acid (%)
T_1-GA_3 50ppm	6.31	0.54	11.56
T_2-GA_3 75ppm	6.27	0.62	10.09
T_3-$GA_3$100ppm	6.78	0.68	10.00
T_4-NAA 10ppm	7.53	0.72	10.44
T_5-NAA 20ppm	7.55	0.73	10.26
T_6-NAA 30ppm	7.76	0.76	10.23
T_7-$CaCl_2$0.25%	7.20	0.77	9.35
T_8-$CaCl_2$0.50%	6.83	0.79	8.61
T_9-$CaCl_2$0.75%	7.42	0.82	8.99
T_{10}- Control	6.16	0.84	7.34
CD (5%)	**0.44**	**0.04**	**0.97**

Ascorbic acid

Maximum ascorbic acid content (63.71 mg/100gm pulp)was found in fruits produced by plants of T3 treatment which proved to be significantly higher than all other treatments. It was followed by plants treated with T2 with 62.03 mg/ 100gm pulp ascorbic acid content. Plants under control treatment (T10) with minimum ascorbic acid content 57.50 mg/100gm pulp and both of these treatments were found to be at par with each other. Results of these findings are confirmed by Thakur et al (1991) who reported that GA3 application increased the ascorbic acid content but TSS decreased slightly in strawberry. This was due to the positive influence on the reproductive growth as evidenced by more TSS and juice per cent in fruits of auxin treated trees in comparison with control and other growth regulators. Similar findings are also reported by Singh and Phogat (1983); Kumar et al (2011) and Khunte et al (2014) in

strawberry fruits. While, Galactose is a precursor for ascorbic acid, it might be assumed that the increase in its level may be because of the conversion of the sugars. Increase in ascorbic acid content in strawberry by the application of various growth regulators has also been reported by Mikhteleva and Petrovskya (1974), Singh and Phogat (1983) and Dhillon (2005) in strawberry cv. Chandler. The plants treated by various concentrations of calcium chloride also showed higher ascorbic acid content than control. This might be due to the reason that calcium has promotory influence on vitamin C content (Kadir 2004). The concentration of calcium chloride delayed the rapid oxidation of ascorbic acid. Our findings are similar to that of Ramezanian et al (2009) who found high ascorbic acid in treated pomegranate plants. The reason for high ascorbic acid in calcium treated fruits might be due to the reason that metabolic activities were not fast as in untreated fruits. Therefore in untreated fruits the respiration rate and ethylene production were at higher rate due to which ascorbic acid constantly decreased rapidly as compared to calcium treated fruits.

Table 3: Effect of various growth regulators and CaCl2 on flowering , fruiting and yield parameters on sugars and ascorbic acid in strawberry cv. Chandler

Treatments	Reducing sugars (%)	Total sugars (%)	Ascorbic acid (mg/100gm)
T_1-GA_3 50ppm	4.11	6.86	60.13
T_2-GA_3 75ppm	4.12	6.93	62.03
T_3-$GA_3$100ppm	4.17	7.05	63.71
T_4-NAA 10ppm	4.48	7.10	57.82
T_5-NAA 20ppm	4.59	7.37	58.32
T_6-NAA 30ppm	4.61	7.41	59.26
T_7-$CaCl_2$0.25%	4.22	6.11	59.72
T_8-$CaCl_2$0.50%	4.30	6.21	59.56
T_9-$CaCl_2$0.75%	4.48	6.21	60.10
T_{10}- Control	3.45	5.86	57.50
CD (5%)	**0.42**	**0.32**	**0.63**

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