International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 7; Issue 6(I); June 2018; Page No. 13665-13668
DOI: http://dx.doi.org/10.24327/ijcar.2018.13668.2452

Research Article

EFFECT OF VARIOUS GROWTH REGULATORS AND $CaCL_2$ ON THE VEGETATIVE GROWTH AND YIELD IN STRAWBERRY cv. CHANDLER

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A R T I C L E I N F O

Article History:

Received 20th March, 2018
Received in revised form 27th April, 2018 Accepted 5th May, 2018
Published online 28th June, 2018

Key words:

Chandler, Gibberellic acid, Naphthalene acetic acid ,Calcium chloride, Yield,

A B S T R A C T

A field study was conducted in the Department of Horticulture, Khalsa College, Amritsar during 2015-2016 to study "Effect of various growth regulators and $CaCl_2$ on the vegetative growth and yield in strawberry cv. Chandler .The runners of strawberry cv. Chandler were planted in the second fortnight of October with a spacing of 45×30 cm. Two growth regulators (NAA and GA_3) and $CaCl_2$ were used in three concentrations and with ten treatment combinations replicated thrice. The investigation was laid out in RBD statistical design.Results of the study showed that the application of growth regulators increased the vegetative growth and yield parameters of strawberry. The maximum height of the plant (26.27 cm), number of leaves per plant (28.26), leaf area (118.61 cm^2), number of runners per plant (13.78), number of flowers per plant (25.56), number of fruits (21.33) and 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. Hence GA_3 improved the vegetative growth and yield of strawberry cv. Chandler.

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most popular fruit in the world which belongs to family Rosaceae and sub family Rosoideae. It 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). It is generally grown in hilly as well as cool climatic zones of India. It is grown in Maharashtra, Haryana, Punjab, Uttar Pradesh, lower hilly areas of Himachal Pradesh. Initially strawberry was grown in temperate zone of the country but now it has become possible in the sub-tropical zones (Asrey and Singh 2004; Kumar *et al* 2011). 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 as well as flavonoids, phenolic acids and vitamin C in strawberry fruit. The ellagic acid present in strawberry have cancer fighting properties (Xue *et al* 2001; Meyers *et al* 2003).

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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. Gibberellic acid (GA_3) 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). Hence keeping in view the above known facts the present study was undertaken.

MATERIALS AND METHODS

The present study entitled "Effect 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 2015-2016. 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 48^0 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 × 1 m in size. The transplanting was done during second fortnight of October at a planting distance of 45 × 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

Maximum plant height 26.27 cm was recorded under T_3 treatment (GA_3 100 ppm) which proved to be significantly higher than all other treatments. The height of plants under control was recorded to be minimum with 12.16 cm. This might pertain to the fact that gibberellins promote cell division and cell expansion which leads to increase in plant height. GA_3 enhance the cell division and cell elongation in plant stem and shoots. These results have been reported by Paroussi *et* al (2002), Kaur (2010), Uddin *et al* (2012)**,** Muneshwar *et al* (2012), Saima *et al* (2014), Ziba *et al* (2013) in strawberry. Prasad *et al* (2015) also concluded that application of GA_3 increased plant height, might be due to increased cell elongation due to which synthesis of auxin increased in the plant system and corresponding increased stem length. Similar findings have also been reported by Kumar *et al* (2012) in strawberry. Suvalaxmi *et al* (2016) also reported that exogenous application of gibberellins activated the sub apical meristem which leads to shoot elongation in strawberry. Plants treated with NAA 30 ppm and 20 ppm produced plant height of 21.16 cm and 18.66 cm respectively. This increase might pertain to the fact that auxin promoted cell elongation which as a consequence increased plant height. These results confirmed the earlier findings of Harhash and Obeed (2007) and Hesami and Abdi (2010) in date palm. Plants treated with $CaCl_2$ 0.75 % and 0.50 % produced plant height of 19.10 cm and 16.60 cm respectively which was more than control. Calcium chloride showed less increase in plant height as compared to other treatments. These present findings are in agreement with that of Andriolo *et al* (2010) who found no significant effect of calcium chloride on plant growth attributes. This might be due to cell division and expansion, connecting environmental stimuli to their suitable physiological responses.

The perusal of data revealed significant effect of gibberellic acid on leaf number during the year of investigation. Maximum number of leaves (28.26) was counted in plants under T_3 treatment (GA_3 100 ppm). The lowest number of leaves (11.90) was found in control. This could be due to the fact that GA_3 increased cell division and cell elongation and a corresponding increase in epidermal and parenchyma's cell length. These findings are in accordance with those of Paroussi *et al* (2002) and Uddin *et al* (2012) in strawberry. This might also be due to the fact that the synthesis of amino acids in plants is accelerated by application of GA_3 which indirectly was exhibited by enhanced growth of strawberry plants and their parts. These results are in accordance with the findings of Kaur (2010), Saima *et al* (2014) and Suvalaxmi *et al* (2016) in strawberry. The plants with number of leaves 25.39 and 22.73 were recorded under NAA 30 ppm and 20 ppm respectively and these were found to be higher than control. It might be due to the fact that NAA have a direct role in leaf initiation as there is the transport of assimilates to the apex resulting in new leaves. The plants treated by various concentration of calcium chloride also showed higher number of leaves than control.

From the present study it was observed that T_3 treatment (GA_3 100 ppm) produced maximum (13.78) runners. This might be due to the GA_3 stimulated activity that redistributed the gibberellins in greater concentration in the crown region which later induced the runner emergence. This might also be due to the inhibition of flowering and corresponding increase in epidermal and parenchymatous cell growth (Denis and Bennett 1969). These results of the experiment are in close agreement with the findings of Kumar *et al* (2012) in strawberry. Joshi (2003) also reported the same in strawberry plants. The application of NAA and calcium chloride also resulted in higher runner production than control.

Table 1 Effect of GA_3, NAA and $CaCl_2$ on vegetative growth of strawberry cv. Chandler

Treatments	Plant height (cm)	Total leaf number per plant	Number of runners per plant
T_1-GA_3 50ppm	20.38	14.69	13.12
T_2-GA_3 75ppm	23.77	26.90	13.72
T_3-GA_3 100ppm	26.27	28.26	13.78
T_4-NAA 10ppm	15.28	14.19	11.52
T_5-NAA 20ppm	18.66	22.73	12.22
T_6-NAA 30ppm	21.16	25.39	12.48
T_7-$CaCl_2$ 0.25%	13.21	13.37	11.26
T_8-$CaCl_2$ 0.50%	16.60	16.63	11.84
T_9-$CaCl_2$ 0.75%	19.10	18.84	11.92
T_{10}-Control	12.16	11.90	10.85
CD (5%)	**0.77**	**1.22**	**0.38**

Results of the present study showed that the maximum number of flowers per plant 25.56 was observed in plants treated with GA_3 100 ppm. Gibberellic acid increased the 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. 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, Khokhar *et al* (2004), Singh *et al* (2005) and Ali and Gaur (2007) in strawberry supported the present findings. 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. $CaCl_2$ (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.

The data on the number of fruits per plants in strawberry as affected by various treatments are showed that the maximum number of fruits per plant (21.33) was observed in plants treated with GA_3 100 ppm and lowest number of fruits (12.08) were observed under control. 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.. 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 plant due to the stimulus (florigen) which converted vegetative buds to fruiting buds by the help of exogenously applied NAA. The results are similar with Thakur *et al* 1991.

Maximum fruit set (83.47 %) was recorded in T_3 treatment. Minimum fruit set (72.17 %) was observed under control. The increased fruit set percent in treatments receiving GA_3 application might be due to GA_3 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 GA_3 application accelerated the development of differentiated inflorescence. (Paroussi *et al* 2002; Saima *et al* 2014). GA_3 treated fruits showed more fruit set percentage than any other treatments. 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. Number of flowers were reported to be more in NAA treated plants due to more number of flowering stock arising 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 %.

It was noted that GA_3 100ppm registered maximum fruit yield (324.85 gm/plant) while the minimum fruit yield (118.37 gm/plant) was recorded in control. Results of the study showed that GA_3 has positive effect on increasing the fruit yield of strawberry. 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) also 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 results of the present studies have been corborated by the findings of Kalie *et al* (1980) and Rana (2001) The various concentrations of NAA also increased yield of strawberry than control. 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 2 Effect of GA_3, NAA and $CaCl_2$ flowering, fruiting and yield of 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**

CONCLUSION

From the results of the present study it can be concluded that the application of GA_3 100 ppm proved to be the best treatment in enhancing the plant vegetative characters and yield with maximum plant height, leaf number, leaf area, number of runners, flowers, fruits per plant, fruit set percent. Hence it is concluded that the GA_3 proved to be the best for the vegetative growth and yield of strawberry cv. Chandler.

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How to cite this article:

Barjinder Kaur and Amarjeet Kaur (2018) 'Effect of various growth regulators and cacl2 on the vegetative growth and yield in strawberry cv. Chandler', *International Journal of Current Advanced Research,* 07(6), pp. 13665-13668.
DOI: http://dx.doi.org/10.24327/ijcar.2018.13668.2452

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