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**Research Article**

# INFLUENCE OF PLANT GROWTH REGULATORS ON STRAWBERRY (*FRAGARIA × ANANASSA*) Cv. CHANDLER UNDER ODISHA CONDITION

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**ABSTRACT**

An experiment was conducted to study the "influence of plant growth regulators on strawberry *cv*. Chandler under Odisha condition" during 2013-2014. The experiment was laid out in a randomized block design with ten treatments considering of control (water), $GA_3$ (25, 50 and 100 ppm), NAA (25, 50 and 100 ppm) and IAA (25, 50 and 100 ppm) and replicated thrice. Observations were recorded on different vegetative characters like plant height (cm), plant spread (cm), petiole length (cm), leaves per plant, runners per plant, different reproductive characters like days taken to first flower, days taken to fruit bud development, number of flowers per plant, number of fruits per plant and different fruit characters like Length: diameter ratio, Specific gravity, Juice (%), TSS (°Brix), Ascorbic acid (mg/100g), acidity. Treatment $GA_3$ @ 100 ppm gave the best results in terms of vegetative growth and runner production. Different yield attributing characters were found better in NAA@100 ppm whereas Physico-chemical characteristics were superior in the treatment 50 ppm NAA. But ascorbic acid content and acidity percentage were higher in $GA_3$ 50 ppm.



## INTRODUCTION

"*Fragaria*" belongs to family Rosaceae, is a genus of the perennial, creeping herbs, found growing in the wild in different climatic zones of the world (CSIR, 1956). The cultivated strawberry (*Fragaria ananassa* Duch.) is a monoecious octaploid hybrid of two largely dioecious, octaploid species, *Fragaria chiloensis* Duch. and *Fragaria virginiana* Duch. (Darrow, 1996; Galletta and Bringhurst, 1990; Larson, 1994). In *Fragaria*, the receptacle swells into the red-coloured fruit known as a strawberry and over its surface black dots are found, each dot being an individual true fruit. The individual true fruit are termed achenes. Strawberries have significantly high amounts of phenolic flavonoid phyto-chemicals called anthocyanin and ellagic acid. Scientific studies show that consumption of these berries may have potential health benefits against cancer, aging, inflammation and neurological diseases.

It is amongst the few crops, which give quick and very high returns per unit area on capital investment. $GA_3$ has been found to increase the vegetative growth of strawberry; Cycocel and NAA improved the yield and quality of strawberry (Thakur *et al*., 1991). Strawberry is a temperate fruit; its production in tropical and subtropical region is drastically low and the market price high. Due to these bottlenecks, the poor people cannot afford it and also farmers seldom go for its cultivation. Keeping this in view, the present studies on strawberry was carried out at department of Fruit science and Horticultural technology, College of Agriculture under the Orissa University of Agriculture and Technology, Bhubaneswar, Odisha to find out suitable growth hormone and its concentration for commercial production of good quality strawberry under tropical condition.

## MATERIALS AND METHOD

An experiment was conducted at the Department of Fruit science and Horticultural technology, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha during 2013-14 to find out the influence of plant growth regulators on growth, yield and quality of strawberry (*Fragaria ananassa* Duch.) cv Chandler. This region has tropical climate and falls in east and south east coastal zone having humid summers (May–June) and mild winter (December–mid-February) with annual rainfall of about 1542 mm restricted mainly to July–August months. Strawberry runners of almost equal size and vigour were transplanted

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during evening hours in medium size pots containing the growing media of sand: soil: farm yard manure (1:1:1). Soil was sandy-loam having pH 7.5, which was low in organic carbon (0.42%), medium in available phosphorus and high in potash. Healthy runners of cv. Chandler were procured from the garden of Dr. A.K. Das, Prof. and Head, Dept. of Vegetable science, OUAT, Bhubaneswar during October. All cultural practices were followed uniformly in the experimental pot. Experiment was laid out in randomized block design with ten treatments as following, $T_1$ -control(Water), $T_2$ - $GA_3$@ 25 ppm, $T_3$ - $GA_3$ @50 ppm, $T_4$ - $GA_3$@100 ppm, $T_5$ - NAA @25 ppm, $T_6$ – NAA@50ppm, $T_7$ – NAA@100ppm, $T_8$ - IAA @25 ppm, $T_9$ - IAA @50 ppm, $T_{10}$ - IAA@ 100 ppm and each treatment replicated thrice. Foliar spraying of growth regulators was done during mid-November and mid-January. Observations were recorded on different vegetative characters like plant height (cm), plant spread (cm), petiole length (cm), leaves per plant, runners per plant, different reproductive characters like days taken to first flower, days taken to fruit bud development, number of flowers per plant, number of fruits per plant and different fruit characters like Length: diameter ratio, Specific gravity, Juice (%), Total soluble solid (°Brix), Ascorbic acid (mg/100g), acidity. Plant height was measured from base of crown to tip with the help of a scale. Plant spread for North–South, and East–West direction was measured and averaged. Petiole length was measured from the base of the conjunction of the lamina with the help of a scale in first 2 basal leaves. Records were made on initiation and termination of flowering and fruiting .TSS was recorded with the help of refractometer. Juice contents were measured after crushing 20 randomly selected fruit from each harvest. Acidity was measured following standard procedures (AOAC, 1990).

## RESULTS AND DISCUSSION

### *Influence of plant growth regulators on vegetative growth of strawberry plant*

It is clear from the data depicted in the table-1 that, there was significant effect of growth regulators on growth and runner production of plant.

**Table 1** Influence of plant growth regulators on vegetative growth and runner production of strawberry cv. Chandler under Odisha condition.

| Treatments | Plant height (cm) | Plant spread (cm) | Petiole length (cm) | Leaves/plant | Runners/ plant |
|---|---|---|---|---|---|
| $T_1$ | 12.2 | 25.1 | 6.3 | 13.1 | 1.0 |
| $T_2$ | 18.9 | 31.0 | 10.3 | 15.1 | 2.3 |
| $T_3$ | 20.8 | 33.2 | 12.6 | 17.3 | 2.6 |
| $T_4$ | 25.3 | 35.7 | 13.2 | 20.8 | 3.2 |
| $T_5$ | 13.8 | 26.1 | 7.8 | 14.6 | 1.0 |
| $T_6$ | 14.2 | 26.9 | 7.9 | 15.8 | 1.1 |
| $T_7$ | 16.6 | 28.7 | 8.4 | 15.2 | 1.6 |
| $T_8$ | 12.4 | 25.4 | 7.2 | 13.6 | - |
| $T_9$ | 12.9 | 26.1 | 7.1 | 14.2 | - |
| $T_{10}$ | 13.5 | 26.7 | 7.1 | 14.8 | - |
| SE (m)± | 0.29 | 0.36 | 0.26 | 0.27 | 0.08 |
| CD (1%) | 1.19 | 1.4 | 1.09 | 1.10 | 0.3 |

Maximum plant height was obtained from treatment $T_4$, $GA_3$@100ppm (25.3 cm) which was significantly differ from all other treatments where as minimum plant height was obtained from control. In case of plant height, NAA and IAA do not show the significant response. This might be due to the fact that exogenous application of gibberellin activated the sub apical meristem which leads shoot elongation. The rosette habit and dwarf shoots are formed on account of inactivation of sub apical meristem. This result is congruent with Guttridge, 1970; Guttridge and Thompson, 1964; Martinez *et al*., 1994. Strawberry plants usually do not have distinct above ground stem, and hence vegetative growth following GA application is essentially reflected as increase in crown height (Sharma *et al*; 2009).

Plant spread was maximum in the treatment $T_4$, $GA_3$@100ppm (35.7 cm) which was significantly differs from all other treatments. Whereas minimum plant spread was obtained from control (T1) 25.1cm. This might be due to spraying of Gibberellins which induced the growth by cell division, cell enlargement or both. These finding are also in conformity with Martinez, 1994; Singh and Kaul, 1970.

Maximum petiole length was obtained from $T_4$, $GA_3$@100ppm (13.2 cm) which was significantly differ from all other treatments whereas; minimum petiole length was obtained from control ($T_1$) 6.3cm. Gibberellins induced increase in length of petiole might be due to changes in cellular microtubule. Similar result is also obtained by Singh and Kabul, 1970.

Maximum numbers of leaves (20.8) was found from treatment $T_4$, $GA_3$@100ppm. This might be due to fact that the synthesis of amino acids in plants is accelerated by application of GA3 which was indirectly exhibited by enhanced growth of strawberry plants and their parts. Whereas minimum numbers of leaves (13.1) was obtained from control (T1). This result is similar with Guttridge and Thompson, 1964.

Strawberry is commercially propagated by runners and runner production management is an important cultivation practices in strawberry production technology. Maximum numbers of runners (3.2) were produced from the plant treated with $GA_3$@100 ppm ($T_4$). This might be due to $GA_3$ stimulated activity that redistributed the gibberellins in greater concentration in the crown region which later induced the runner emergence. But the minimum numbers of runner (1) were produced in control which was at par with treatment $T_5$ and$T_6$. These results are in conformity with Martinez *et al*., 1994. Application of $GA_3$ to one year old strawberry plants promotes vegetative growth and runner production. This may be due to inhibition of flowering and corresponding increase in epidermal and parenchymatous cell growth (Denis and Bennett, 1969). These results of the experiment were are in close agreement with Kumar Rajesh *et al*, 2012, Singh and Randhawa 1959, Singh and Koul, 1967. The increment in plant growth due to $GA_3$, application may be due to fact that $GA_3$, enhances the endogenous level of auxins in plant (Nitsch and Nitsch, 1961).

### *Influence of plant growth regulators on flowering and fruiting*

Data on days taken to produce first flower, fruit bud development, no of flowers/plant and no of fruits/plant depicted in Table 2 showed that there was significant impact of growth regulators on strawberry.

**Table 2** Influence of plant growth regulators on flowering & fruiting on strawberry *cv*. Chandler under Odisha condition.

| Treatments | Days taken to first flower | Days taken to fruit bud development | Number of flower/ plant | Number of fruit/ plant |
|---|---|---|---|---|
| $T_1$ | 65.3 | 72.6 | 15.2 | 13.5 |
| $T_2$ | 62.8 | 68.1 | 15.7 | 14.7 |
| $T_3$ | 64.6 | 74.3 | 16.1 | 14.1 |
| $T_4$ | 68.2 | 75.8 | 18.8 | 15.1 |
| $T_5$ | 55.4 | 59.1 | 21.5 | 16.9 |
| $T_6$ | 52.6 | 55.8 | 22.8 | 18.4 |
| $T_7$ | 50.1 | 54.3 | 24.1 | 22.5 |
| $T_8$ | 60.1 | 66.5 | 21.6 | 17.2 |
| $T_9$ | 58.2 | 64.3 | 20.5 | 16.1 |
| $T_{10}$ | 57.3 | 64.1 | 19.1 | 15.8 |
| SE (m)± | 0.28 | 0.27 | 0.27 | 0.24 |
| CD (1%) | 1.14 | 1.1 | 1.12 | 0.9 |

Minimum days taken to produce first flower (50.1) from planting were obtained from the treatment $T_7$, NAA @100ppm but strawberry plant took 18.1 days more to produce flower when sprayed with $T_4$, $GA_3$@100 ppm that was 68.2 days from planting which was maximum. This is because generally auxin and particularly NAA induce flowering by stimulating florigen which moved from petiole to growing tip and convert vegetative bud to flowering bud. The results are congruent with Thakur *et al*, 1991.

Minimum days taken for fruit bud development (54.3 days) from planting was obtained from the treatment $T_7$, NAA @100ppm but strawberry plant took 21.5 days more to produce fruit bud when sprayed with $GA_3$@100 ppm and it was recorded to be 75.8 days which was maximum. Fruit set refers to the changes in the ovary leading to the development of the fruit. These changes are usually induced after pollination and fertilization which is triggered by NAA. The results are congruent with Thakur *et al*, 1991 and Diwedi *et al*, 2002 and Kumar *et al*, 2011.

Strawberry plants sprayed with NAA@100ppm possessed maximum number of flowers (24.1). Whereas, minimum number of flowers (15.2) was obtained from the control. Numbers of flowers are more in NAA treated plant due to more numbers of flowering stock arises from those plants as the stimulus (florigen) convert vegetative bud to fruiting bud by the help of exogenously applied NAA. The results are similar with Thakur *et al*, 1991.

In the treatment having NAA @ 100ppm, 93% flower converted to marketable fruits. Out of 24.1 numbers of flowers, 22.5 numbers of fruits were obtained from the above said treatment which was found to be maximum. In strawberry due to indeterminate growth habit of inflorescence, size and number of fruit reduces in the later condition. But spraying NAA can reduces this incidence and provide economic yield to the farmer (Kumar *et al.*, 2011). Minimum numbers of fruits (13.5) was found in control. Fruit set from flowering depend upon the external and internal plant factors. Maintain proper C: N ratio of the plant, providing exact quantity of nutrient and hormonal balance leads to more fruit set and all these phenomenons are directly and somewhere indirectly auxin related.

***Influence of plant growth regulators on fruit quality***

As far the quality of the fruit is concerned the data represented in table 3 showed that growth regulators application influenced on the physical and chemical characteristics of strawberry fruits.

The maximum fruit length diameter ratio 2 which was significantly differ from all other treatments that obtained from treatment T6, NAA@50ppm which was at par with treatment $T_7$(1.72). Minimum of this trait was obtained in the control and IAA@100ppm. Recently, molecular analyses have confirmed the prominent role played by auxin signaling in triggering and coordinating the transition from flower to fruit. The growth of the ovary is blocked before pollination and that auxin is involved in derepression of ovary growth after fertilization (Pandolfini, 2007). So fruit size increases with exogenous application of NAA with a particular concentration. This result is similar with Kumar *et al* 2011, Khunte *et al*, 2014.

The maximum specific gravity 2, which was significantly differ from all other treatments which obtained from $T_6$, NAA @50ppm which was at par with treatment $T_7$(1.58), whereas minimum specific gravity was obtained from the control and IAA @ 100ppm. Increasing in sink strength and total solid results in increasing the specific gravity. This result is similar with Kumar *et al* 2011, Khunte *et al*, 2014.

Highest juice percentage 94.6% was found in from the fruit taken from the plants which were sprayed with NAA @ 50 ppm ($T_6$) which was at par with treatment $T_7$(93.8%). Whereas, minimum juice percentage was found in treatment $T_1$ (control). This result is similar with Kumar *et al* 2011, Khunte *et al*, 2014. This might be due to the increased vascularization in the pedicel and/or due to the increased sink strength and/or reduced senescence and respiration from the fruit.

Maximum TSS 12.5 °Brix was possessed by the fruit harvested from the plant treated with NAA @50ppm ($T_6$), whereas minimum TSS was found from the fruits of $T_1$ (control) which was at par with treatment $T_7$(12.1). This result is similar with Kumar *et al* 2011; Kumar *et al.*, 2012 and Khunte *et al*, 2014. This might be due to the treatment effect on physiological accumulation of sugar and change in metabolism which eventually resulted in more retention of TSS and total sugars. By the activity of invertase enzyme, which break down sucrose into fructose and glucose, hence resulting in increased reducing sugars.

The data are presented in table 3 revealed that the treatments had significant effect on ascorbic acid of fruits. The maximum ascorbic acid (63.41mg/ 100g) was observed in treatment $T_3$ (50 ppm $GA_3$) while the minimum ascorbic acid of fruit (50.8 mg/100g) was observed under treatment $T_5$, (NAA@25ppm). Similar findings are also reported by Singh and Phogat (1983); Kumar *et al.*, 2011 and Khunte *et al*, 2014. This is due to positive influence on sink strength (reproductive growth) as evidenced by more TSS and juice mass (%) in fruit of auxin treated trees in comparison with control and other growth regulators like $GA_3$.

**Table 3** Influence of plant growth regulators on fruit quality of strawberry cv. Chandler under Odisha condition

| Treatments | Length: diameter ratio | Specific gravity | Juice (%) | Total soluble solid (° Brix) | Ascorbic acid (mg/100g) | Acidity |
|---|---|---|---|---|---|---|
| $T_1$ | 1.1 | 1.12 | 70.8 | 5.8 | 53.40 | 0.63 |
| $T_2$ | 1.27 | 1.09 | 84.3 | 7.3 | 63.03 | 0.74 |
| $T_3$ | 1.25 | 1.12 | 83.1 | 7.8 | 63.41 | 0.75 |
| $T_4$ | 1.24 | 1.14 | 81.2 | 8.2 | 61.10 | 0.70 |
| $T_5$ | 1.3 | 1.14 | 92.8 | 10.1 | 50.80 | 0.60 |
| $T_6$ | 2.0 | 2.0 | 94.6 | 12.5 | 51.80 | 0.61 |
| $T_7$ | 1.72 | 1.58 | 93.8 | 12.1 | 55.10 | 0.64 |
| $T_8$ | 1.4 | 1.16 | 92.4 | 9.4 | 58.30 | 0.68 |
| $T_9$ | 1.3 | 1.14 | 91.8 | 9.8 | 55.60 | 0.65 |
| $T_{10}$ | 1.1 | 1.0 | 91.6 | 10.2 | 57.20 | 0.67 |
| SE (m)± | 0.11 | 0.05 | 0.40 | 0.34 | 1.08 | 0.05 |
| CD (1%) | 0.4 | 0.20 | 1.64 | 1.3 | 2.1 | 0.29 |

The maximum acidity of fruit juice (0.75 %) was observed in treatment $T_3$, (50 ppm $GA_3$) while the minimum acidity of fruit juice (0.60 %) was observed with treatment $T_5$, (25 ppm NAA). Similar findings are also reported by Singh and Singh (1979); Kumar *et al.* (2012) and Khunte *et al*, 2014. Increasing in Titrable acidity by $GA_3$ was due to the consumption of sugar in form of energy to enhance the vegetative growth.

## CONCLUSION

From the aforesaid discussion it is revealed that strawberry respond significantly well to the growth regulators with respect to its yield and yield attributing characters. So, for the tropical condition of Odisha, farmers are advised to for one spraying of $GA_3$@100 ppm as foliar spray once in mid November and one spray of NAA @ 100ppm in mid February in normal production practices for good vegetative growth and to get higher yield with commercial quality fruit.

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