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# Effect of $GA_3$, urea and $ZnSO_4$ on growth and yield parameters of strawberry (*Fragaria* x *ananassa* Duch.) cv. SWEET CHARLIE under protected condition

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ABSTRACT : An experiment was conducted under protected condition to study the effect of foliar application of $GA_3$ (100 and 150 ppm), urea (1.0 and 1.5 %) and $ZnSO_4$ (0.5 and 1.0 %) on growth and yield of strawberry (*Fragaria* x *ananassa* Duch.) cv. SWEET CHARLIE. The results revealed that the applications of $GA_3$ at 150 ppm significantly influenced the growth related parameters *viz*., highest plant height (18.34 cm), maximum numbers of runners/plant (10.31), highest length of runners/plant (39.76 cm) and maximum number of leaves/plant (36.70) whereas, $GA_3$ at 100ppm significant effect on flowering parameters *viz*., minimum days to flowering (71.55), maximum number of flowers per plant (19.77) and maximum fruit set/plant (91.80 %) and yield parameters like, maximum number of fruit per plant (18.15), highest yield/plant was 0.17 kg and yield/plot was 4.19 kg. Therefore, from present investigation it can be emphasized that high concentration of $GA_3$ promote vegetative growth and moderate concentration significantly controls flowering and yield attributes in case of strawberry.

KEY WORDS : Foliar, $GA_3$, Urea, $ZnSO_4$, Growth, Yield, Strawberry, Protected

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Strawberry (*Fragaria* x *ananassa* Duch.) belongs to family Rosaceae and the most of cultivated varieties are octaploid (2n=56). It is known as one of the most attractive, delicious and refreshing fruit of the world and occupies a significant place in fruit growing. Most of the common cultivated varieties come from (*Fragaria* x *ananassa* Duch.) a hybrid between Virginia strawberries (*Fragaria* x *virginiana* Duch.) of Eastern North America and the widespread beach strawberry (*Fragaria* x *chiloensis* Duch.) of North and South America (Childers *et al*., 1995). It is a rich source of mineral and nutrients and anti cancer component called ellagic acid and it is also a very rich source of bioactive compounds including vitamin C, E, B, carotene and phenolic compounds. It contains numerous important dietary components and it is a rich source of vitamin C, (Riyaphan *et al*., 2005). Total world production of strawberries reached to 7.74 million metric tons in 2013 (Anonymous, 2013). Among plant growth regulators PGRs, gibberellic acid ($GA_3$) is a growth regulator, which stimulate the effect of long day lengths in short day plants by improving vegetative development and increasing

runner production. $GA_3$ progressively increases the plant height, canopy spread, leaf area, number of leaves, petiole length and induces stem elongation when applied exogenously to strawberry plants. It initiate early flowering and thus early fruit development thereby allows early harvesting. It also increases number of flowers per crown, fruit set percentage, total number of fruits per plant (Paroussi *et al*., 2002 and Sharma and Singh, 2009). Nitrogen (N) is the important element for plant growth, runner production and fruit bud formation. Nitrogen nutrition affects fruit firmness, quality and yield of strawberry. Therefore, nitrogen fertilization has to be carefully adjusted to the low demand of young plants during this period (Darnell, 2003). Zinc sulfate ($ZnSO_4$) gives good results in the form of foliar application and it is recommended for increasing the fruit quality and yield of strawberry, it also increases total soluble solid (TSS), leaf area, numbers of leaf, length of petiole, number of flower, fruit set, yield, and number of fruits per plant. It is a major component and activator of several enzymes involved in metabolic activities. Concentration of zinc, iron, manganese and phosphorus in soil solution are very important (Lewis, 1980).

## Research Procedure

The experiment was carried out in Hi-tech Horticultural Park, Green House Unit-2, Department of Horticulture College of Agriculture, Junagadh Agricultural University, Junagadh Gujarat, India during (November 2015 to May 2016). The area had sub-tropical climate charact-erized by high temperature (28°-32°C) accompanied by modera- tely high rainfall during (June-September) and low temperature (10°-20°C) in the (October-March). The soil medium black belongs to the "Saurashtra region", Junagadh district, Gujarat India. Sweet Charlie variety of strawberry was used in the experiment. Plant growth regulator gibberellic acid ($GA_3$) with two different concentration, macro nutrient nitrogen (urea) with two different concentration and micronutrient zinc ($ZnSO_4$) with two different concentration and control (water spray) were used as treatments, *viz*., $T_1$= $GA_3$ @ 100 ppm, $T_2$= $GA_3$ @ 150 ppm, $T_3$= urea 1.0 %, $T_4$= urea 1.5 %, $T_5$= zinc 0.5 %, $T_6$= zinc 1.0 %, $T_7$= Control (water spray) in the study. The experiment was laid out in a Complete Randomized Design with four replications. Thirty days old plans raised by tissue culture were shifted from indiamart, Kolkata, India and transplanted at the spacing of 30 cm x 30 cm in the experimental plots. Data were collected from three randomly selected plants for each plot; *viz*., plant growth characters, plant height, number of runners per plant, length of runners per plant and number of leaves per plant. Yield contributing characters and yield of strawberry number of flowers per plant, fruit set percentage, number of fruit per plant, weight of fruit per plant, fruit length, fruit diameter, yield per plant and yield per plot. $GA_3$ was applied as first spray after 30 days of transplanting and second spray 25 days after first sprouting. Urea was applied as first spray after 30 days of transplanting and second spray 25 days after first sprouting. $ZnSO_4$ was applied as first spray after 30 days of transplanting second spray 25 days after first sprouting. The values of all characters studied, were subjected to statistical analysis of variance. The determination of difference between the treatment mean at 0.05 and 0.01 levels of probability was done. Standard error of mean (S.E.$\pm$ ), critical difference (C.D.) at five and one per cent and co-efficient of variance (C.V. %) were worked out-for the interpretation of the results (Panse and Sukhatme, 1985).

## Research Analysis and Reasoning

The findings of the present study as well as relevant discussion have been presented under following heads :

**Growth parameter :**

Plant growth parameters were significantly influenced by $GA_3$, urea, and $ZnSO_4$ as foliar. Among different treatments $GA_3$ at 150 ppm was recorded to be most effective in growth parameter. Data presented in Table 1 showed that the maximum plant height 18.34 cm was found in treatment $T_2$ ($GA_3$ 150 ppm) and the minimum plant height 10.50 cm was recorded in treatment $T_7$ (water spray) in 120 DAT. The increase in plant height is due to the increase in the cell elongation with the application of $GA_3$ which might be due to increased synthesis of auxin in the strawberry plant system (El-Shabasi *et al*., 2008). Similar findings were reported by Saied *et al.* (2012) and Kumari and Mehta (2015).

Data presented in Table 1 showed that the maximum numbers of runners per plant 10.31 were recorded in treatment $T_2$ ($GA_3$ 150 ppm) where the minimum numbers of runners per plant 3.94 were found in treatment $T_7$ (water spray) it 120 DAT. The possible reason may be that $GA_3$ application increases the cell number and cell

enlargement which might have resulted in increased leaf area, crowns number and runner production. Increased leaf area may also be due to increased length of upper and lower epidermal cells in leaf lamina (Pathak and Singh, 1976). Similar findings were reported by Saied *et al.* (2012) and Hossain (2012).

The data presented in Table 1 clearly showed that the maximum length of runners per plant 39.76 cm were recorded in treatment $T_2$ ($GA_3$ 150 ppm) where the minimum length of runners per plant 15.46 cm were found in treatment $T_7$ (water spray) in 120 DAT. The possible reason may be that $GA_3$ application increases stem length here in this case runner length the cell number and cell enlargement. Increased leaf area may also be due to increased length of upper and lower epidermal cells in leaf lamina (Pathak and Singh, 1976). Similar findings were reported by Saied *et al.* (2012).

The data presented in Table 1 indicate that number of leaves per plant was influenced by different treatment at different stage of reproductive growth at 120 DAT. The maximum number of leaves per plant 36.70 were recorded in treatment $T_2$ ($GA_3$ 150 ppm) and the minimum number of leaves per plant, 20.22 were found in treatment $T_7$ (water spray) at 120 DAT. Application of $GA_3$ significantly increased photosynthesis because of increased vegetative growth and uptake of nutrients which are components of many metabolically active compounds and participate in several physiological and biochemical functions. The present results are also in corroborating with the findings of Yuan and Xu (2001) and Misratia *et al*. (2013).

**Flowering parameters :**

Flowering parameters were significantly influenced by $GA_3$, urea, and $ZnSO_4$ as foliar. Significant variation was found in respect of days for flowering from transplanting.

The data presented in Table 2 indicate that days to flowering was influenced by different treatments. The treatment $T_1$ ($GA_3$ 100 ppm) taken minimum days 71.55 for days to flowering and treatment $T_7$ (water spray) taken maximum days 95.75 for days to flowering. The present results are in conformity with work of Ozguven and Kaska (1992).

**Table 1 : Effect of $GA_3$, urea and $ZnSO_4$ on growth parameters of strawberry cv. SWEET CHARLIE**

| Sr. No. | Treatments | Plant height (cm) | Number of runners per plant | Length of runners (cm) | Number of leaves per plant |
|---|---|---|---|---|---|
| $T_1$ | 100 ppm $GA_3$ | 16.71 | 8.09 | 34.80 | 31.48 |
| $T_2$ | 150 ppm $GA_3$ | 18.34 | 10.31 | 39.76 | 36.70 |
| $T_3$ | 1.0 % Urea | 15.18 | 6.96 | 29.28 | 28.78 |
| $T_4$ | 1.5 % Urea | 15.35 | 7.08 | 32.31 | 31.14 |
| $T_5$ | 0.5 % $ZnSO_4$ | 13.58 | 6.68 | 26.02 | 28.20 |
| $T_6$ | 1.0 % $ZnSO_4$ | 14.81 | 6.94 | 28.54 | 30.51 |
| $T_7$ | Control | 10.50 | 3.94 | 15.46 | 20.22 |
| C.D. (P=0.05) | | 0.61 | 0.49 | 1.52 | 1.90 |

**Table 2 : Effect of $GA_3$, urea and $ZnSO_4$ on flowering and yield parameters of strawberry cv. SWEET CHARLIE**

| Sr. No. | Treatments | Flowering parameters | | | Yield parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Days to flowering | Number of flowers per plant | Fruit set (%) | Number of fruit per plant | Yield per plant (kg) | Yield per plot (kg) | Fruit yield (kg/ha) | CBR |
| $T_1$ | 100 ppm $GA_3$ | 71.55 | 19.77 | 91.80 | 18.15 | 0.17 | 4.19 | 9,418 | 1:2.7 |
| $T_2$ | 150 ppm $GA_3$ | 78.58 | 18.36 | 81.59 | 14.97 | 0.12 | 2.80 | 6,648 | 1:1.8 |
| $T_3$ | 1.0 % Urea | 77.91 | 16.67 | 80.68 | 13.43 | 0.10 | 2.46 | 5,540 | 1:1.6 |
| $T_4$ | 1.5 % Urea | 81.39 | 17.55 | 81.64 | 14.29 | 0.11 | 2.63 | 6,094 | 1:1.8 |
| $T_5$ | 0.5 % $ZnSO_4$ | 73.35 | 15.89 | 79.07 | 12.54 | 0.09 | 2.26 | 4,986 | 1:1.4 |
| $T_6$ | 1.0 % $ZnSO_4$ | 76.33 | 16.86 | 78.43 | 13.20 | 0.10 | 2.41 | 5,540 | 1:1.6 |
| $T_7$ | Control | 95.75 | 10.84 | 61.08 | 6.57 | 0.04 | 0.92 | 2,216 | 1:0.6 |
| C.D. (P=0.05) | | 5.01 | 0.90 | 4.38 | 0.80 | 0.01 | 0.25 | -- | -- |

The number of flowers per plant was efficiently influenced by different treatments at various stages, the maximum number of flowers per plant 19.77 was found in treatment $T_1$ ($GA_3$ 100 ppm) and the minimum number of flowers per plant 10.84 was recorded in treatment $T_7$ (water spray). This might be due to as the gibberellic acid ($GA_3$) is a growth regulator which stimulates the effect of long day lengths in short day plants by improving vegetative development and it also increases number of flowers per crown and total number of fruits per plant, similar opinions were also put forwarded by Paroussi *et al.* (2002)

The data presented in Table 2 showed that the maximum fruit set percentage per plant 91.80 was recorded in treatment $T_1$ ($GA_3$ 100 ppm) and the minimum number of flowers per plant 61.08 was recorded in treatment $T_7$ (water spray). It could be due to the fact that $GA_3$ application accelerated the development of differentiated inflorescence (Camarago *et al.*, 1995).

**Yield parameters :**

The data presented in Table 2 indicate that number of fruit per plant was influenced by different treatments at different stages of reproductive growth at 130 DAT. The maximum number of fruit per plant 18.15 was recorded in treatment $T_1$ ($GA_3$ 100 ppm) and the minimum number of fruit per plant 6.57 was recorded in treatment $T_7$ (water spray). Treatment $T_1$ ($GA_3$ 100 ppm) showed the highest number of fruits per plant which was significantly greater than other treatments. The results are in conformity with the work of Sharma and Singh (1990). Similar trend was also put forwarded by Miranda *et al*. (1990).

The fruit yield per plant was efficiently influenced by different treatments at various stages of reproductive growth. By the statistical analysis of data as inscribed in Table 2 it is evident that the consecutive increase in fruit yield per plant at 130 DAT at different interval of picking. Picking were recorded as peak fruiting stage, where the significant maximum yield per plant 0.17 kg recorded in treatment $T_1$ ($GA_3$ 100 ppm) and the minimum yield per plant 0.04 kg recorded in treatment $T_7$ (water spray). Similar results were obtained by Zakharova (1979).

The data on fruit yield per plot as influences by different treatments presented in Table 2, the significant maximum yield per plot 4.19 kg recorded in treatment $T_1$ ($GA_3$ 100 ppm) where the minimum yield per plot 0.92 kg recorded in treatment $T_7$ (water spray). Similar results were taken by Zakharova (1979).

The data presented in Table 2 indicate that fruit yield per hectare was influenced by different treatments at different stage of reproductive growth at 130 DAT. The maximum fruit yield per hectare 9,418 kg was recorded in treatment $T_1$ ($GA_3$ 100 ppm) and the minimum yield per hectare 2,216 kg was recorded in treatment $T_7$ (water spray). Treatment $T_1$ ($GA_3$ 100 ppm) showed the highest fruit yield per hectare which was significantly greater than other treatments. The results are in conformity with the work of Sharma and Singh (1990). Similar trend was also put forwarded by Miranda *et al*. (1990).

The data on cost benefit ratio as influenced by different treatments are presented in Table 2, the significant maximum cost benefit ratio 2.7 was recorded in treatment $T_1$ ($GA_3$ 100 ppm) where the minimum cost benefit ratio 0.6 recorded in treatment $T_7$ (water spray).

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