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Response of foliar application of micro-nutrients on number of flowers, fruits and yield per plant of strawberry (*Fragaria* x *ananassa* Duch.) cv. Nabila under net tunnel condition

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Abstract
An experiment was conducted to study the response of foliar spray of micro-nutrients on number of flowers, fruits and yield per plant of strawberry cv. Nabila under net tunnel with different concentration of micro-nutrient spray as treatments and replicated thrice in a Randomized Completely Block Design. The treatment consisted ten different concentrations of calcium and micro-nutrients along with recommended dose of fertilizers *viz.* T_0: RDF + control (Water spray), T_1: RDF + $CaCl_2$ @ 0.4%, T_2: RDF + $CaCl_2$ @ 0.6%, T_3: RDF + $CaCl_2$ @ 0.8%, T_4: RDF + $ZnSO_4$ @ 0.4%, T_5: RDF + $ZnSO_4$ @ 0.6%, T_6: RDF + $ZnSO_4$ @ 0.8%, T_7: RDF + $FeSO_4$ @ 0.4%, T_8: RDF + $FeSO_4$ @ 0.6% and T_9: RDF + $FeSO_4$ @ 0.8%. The data revealed that the maximum number of flowers per plant and maximum number of fruits per plant were recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%) whereas the minimum was recorded under the treatment T_0 (RDF + water spray). As regard the yield, highest yield (1.17 kg/plant) was obtained under the treatment RDF + $ZnSO_4$ @ 0.6% followed by treatment RDF + $FeSO_4$ @ 0.6% and minimum yield was found under control (T_0).

Keywords: strawberry, Nabila, foliar application, micro-nutrients, number of flowers, number of fruits

Introduction
Strawberry (*Fragaria* x *ananassa* Duch.) is one of the most important temperate fruit, belongs to the family Rosaceae but it can also be grown in tropical and sub-tropical climate. Strawberry plant shows maximum growth and development at an optimum day temperature of 22 to 23 ^{0}C and night temperature 7 to 13 ^{0}C. Frost as well as winter injury are very harmful to the plant and seriously reduces yield of berries. Sandy loam soil with a pH range of 5.5 to 6.5 is suitable for better plant growth and development.

Nutritionally, strawberry contains low calorie carbohydrate and a potential source of vitamin C and fibers. It contains more vitamin C than oranges. The chemical composition of strawberry is ascorbic acid (64.0mg), water (91.75g), protein (0.61g), fat (0.37g), carbohydrate (7.02g), fiber (2.3g), calcium (14.0mg), potassium (166.0 mg/160g) and vitamin-A (27 IU).

In India the total area of strawberry is 1000 ha with production of 5000 MT (Anonymous, 2016) [1]. In India, Maharashtra is the leading State in production of strawberry fruits. It is also commercially grown in Haryana, Punjab, Uttar Pradesh, Jammu and Kashmir, Uttarakhand and lower hills of Himachal Pradesh.

The nutrition status of strawberry plant plays a vital role in determining the yield and yield attributing parameters since it is a very sensitive plant to nutritional balance (Mohamed *et al*., 2011) [6]. An optimal fertilization is contributive in obtaining high yield of good quality and high biological value. Both calcium and micro-nutrients are well known to ameliorate yield and yield attributing parameters.

Methods and Materials
The field experiment was carried out during the year 2017-18 at Research Farm of Centre of Excellence on Protected Cultivation and Precision farming under net tunnel, College of Agriculture, IGKV, Raipur (C.G.). It is situated between 22º 33' N to 21º14'N Latitude and 82º 6' to 81º38'E Longitude. The average elevation of the place is 307 meters above the mean sea level. The soil of experimental field was clay-loam having pH 7.7.

Strawberry cv. Nabila was taken for experiment and planted at spacing of 30 X 30cm in raised bed inside the net tunnel. Three different concentrations of ca and micro-nutrients were applied as foliar feeding at 30 and 60 days after planting of strawberry plants.

The experiment was laid out in Randomized Completely Block Design with three replications and ten treatments. The treatment consisted ten different concentrations of Ca and micro-nutrients along with recommended dose of fertilizers *viz.* T_0: RDF + Control (water spray), T_1: RDF + $CaCl_2$ @ 0.4%, T_2: RDF + $CaCl_2$ @ 0.6%, T_3: RDF + $CaCl_2$ @ 0.8%, T_4: RDF + $ZnSO_4$ @ 0.4%, T_5: RDF + $ZnSO_4$ @ 0.6%, T_6: RDF + $ZnSO_4$ @ 0.8%, T_7: RDF + $FeSO_4$ @ 0.4%, T_8: RDF + $FeSO_4$ @ 0.6% and T_9: RDF + $FeSO_4$ @ 0.8%.

All the experimental plants were uniformly maintained and same cultured practices were provided *i.e.* fertilization, irrigation and plant protection measures during whole period of investigation. Irrigation and fertilizers has been provided to the plants through the drip system of irrigation.

The yield and yield attributing parameters *i.e.* Number of flowers per plant, fruits per plant and yield (kg/plant) of different treatments were recorded and analyzed.

Results findings and discussion

The results pertaining to various aspects of yield and yield attributing parameters is summarized as follows:

Yield (kg/plant)

Yield per plant (kg) was ranged from 0.21 to 0.62 kg under the different treatments. The highest yield (1.17 kg/ plant) was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), which was significantly differs with other treatments. The treatments T_2, T_4 & T_7 and T_1, T_2, T_3 & T_6 and T_1, T_9, T_3 & T_6 having respective yield of 0.98, 1.03 & 1.00 and 0.94, 0.98, 0.94 & 0.94 and 0.94, 0.93, 0.94 & 0.94 were found non-significant different with each other under present investigation. The minimum fruit yield (0.69 kg/ plant) was recorded under the treatment RDF + Control (T_0).

Significantly the highest yield 1.17 kg/ plant was obtained from the plants treated with RDF + $ZnSO_4$ @ 0.6% compared to all other treatments. However the lowest yield (0.69 kg/ plant) was observed under control. The increase in fruit yield could be attributed to increased size, diameter and fruits weight. Moreover, probably there was a greater diversion of photosynthates to sink (Fruit), which ultimately added to the fruit yield. Similar results were also obtained by Bakshi *et al.* (2013a) [2], Bakshi *et al.* (2013b) [3] and Mehraj *et al*. (2015) [5] in strawberry.

Yield attributing parameters

Number of flowers per plant

The maximum number of flowers per plant (43.90) was noticed under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), which was found significantly differ with the treatments T_8 (RDF + $FeSO_4$ @ 0.6%) having average number of flowers per plant 42.57. Moreover the treatments T_2 & T_7 and T_2, T_4 & T_7 and T_3, T_6 & T_9 having respective number of flowers per plant 41.20 & 40.83 and 41.20, 40.47 & 40.83 and 38.47, 38.90 & 38.87 were found non-significant different with each other under present investigation. The minimum number of flowers per plant (35.90) was recorded under the treatment RDF + Control (T_0), which was found significantly differs with other treatments.

The number of flowers per plant varied between 35.90 and 43.90. Maximum number of flowers per plant (43.90) was observed under the treatment T_5, while minimum (35.90) was recorded under control. This might due to the effect of Zn, as zinc increases the cell elongation and division. Zinc is helpful in chlorophyll synthesis which increases photosynthetic activities of leaves, which leading to development of primary flowers, production of viable flowers. Similar results were also obtained by Chaturvedi *et al.* (2005) [4], Bakshi *et al.* (2013a) [2], Bakshi *et al.* (2013b) [3], Mehraj *et al*. (2015) [5] and Singh *et al*. (2015) [7] in strawberry.

Table 1: Response of foliar application of Ca and micro-nutrients on number of flowers/ plant, number of fruits/ plant and yield/ plant of strawberry cv. Nabila under net tunnel

Treatments	Number of flowers/ plant	Number of fruits/ plant	Yield (kg/ plant)
RDF + Water spray (Control)	35.90^{a}	31.53^{a}	0.69^{a}
RDF + $CaCl_2$ @ 0.4%	37.50^{b}	33.53^{ab}	0.94^{bc}
RDF + $CaCl_2$ @ 0.6%	41.20^{de}	37.87^{fg}	0.98^{cd}
RDF + $CaCl_2$ @ 0.8%	38.47^{bc}	34.87^{cde}	0.95^{bc}
RDF + $ZnSO_4$ @ 0.4%	40.57^{d}	36.53^{d}	1.03^{de}
RDF + $ZnSO_4$ @ 0.6%	43.90^{g}	41.53^{h}	1.17^{f}
RDF + $ZnSO_4$ @ 0.8%	38.90^{c}	34.53^{cd}	0.94^{bc}
RDF + $FeSO_4$ @ 0.4%	40.83^{de}	36.87^{ef}	1.00^{d}
RDF + $FeSO_4$ @ 0.6%	42.57^{f}	39.53^{gh}	1.07^{e}
RDF + $FeSO_4$ @ 0.8%	38.87^{c}	34.53^{cd}	0.93^{b}
SE(m) ±	0.40	0.76	0.02
C.D. at 5%	1.20	2.28	0.05

1. RDF – Recommended dose of fertilizers
2. The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD- value comparison of treatment means.

Conclusions

The maximum number of fruits per plant in strawberry cv. Nabila under net tunnel condition was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%) which was recorded 41.53 per cent higher as compared to control. Based on the results of the present investigation, it can be concluded that the foliar application of $ZnSO_4$ @ 0.6% along with recommended dose of fertilizers was found best treatment, by which yield and yield attributing parameters of strawberry can be significantly influenced.

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