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Effect of foliar feeding of calcium and micro-nutrients on quality parameters of strawberry (*Fragaria* x *ananassa* Duch.) cv. Nabila under net tunnel

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Abstract
The experiment was conducted at Research Farm of Centre of Excellence on Protected Cultivation and Precision Farming under net tunnel, College of Agriculture, IGKV, Raipur (C.G.) to find out the beneficial effect of Ca and micro-nutrients on quality attributing parameters of strawberry cv. Nabila under net tunnel condition with ten treatments and three replications in Completely Randomized Block Design. 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%. As regards the quality parameters *i.e.* total soluble solids, TSS: acid ratio, total sugar, reducing sugar, non-reducing sugar and ascorbic acid content were recorded maximum under the treatment RDF + $ZnSO_4$ @ 0.6%, however the minimum acidity (0.42%) was recorded under the same treatment.

Keywords: Calcium, micro-nutrients, quality, strawberry etc.

Introduction
The cultivated strawberry (*Fragaria* × *ananassa* Duch.) is octaploid in nature (2n=8x=56). It belongs to the family Rosaceae. Botanically, strawberry fruit is termed as aggregate fruit and the edible part is succulent thalamus. It is mainly propagated through runners which is one year old. Its fruits are mainly consumed as dessert. In addition to fresh consumption, it is specially demanded by the fruit processing units for the preparation of jams, jelly, ice-creams, syrups, quick freezing and canning. It is one of the important fruit crops whose cultivation is having ample scope near the fruit preservation factories as well as big cities.

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. It has been widely adopted as the small fruits having 98% edible portion. Strawberry is a delicious fruit can be taken fresh as table fruit or in processed form.

It is good source of vitamin C and Iron. Fruit shape differs depending upon the variety. It may be conical, round and long to conical, conical with constricted base and cylindrical ground. The strawberry fruit contains 89-90% moisture, 0.7-9.2g protein, 8.4-9.2g carbohydrate, 0.5g fat, 59-120 mg vitamins C per 100g of fresh weight of fruit. The fruit of strawberry is good for those people suffering from anemia biliousness and indigestion. Among various soft fruits, strawberry is one of the most nutritious and delicious fruit and can be grown under various climatic conditions. The strawberry fruit contains 0.90 to 1.85% acidity the prominent being mallic and citric acid and 0.55% total sugar.

The nutrition status of strawberry plant plays a vital role in determining the quality of fruits since it is a very sensitive plant to nutritional balance (Mohamed *et al*., 2011) [9]. 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 quality of fruits. The beneficial effects of Ca on maintaining fruit quality and increasing shelf life are well documented by

many researchers (Bakshi *et al*., 2005) [2]. Mahnaz *et al*., 2010 [8]. Claimed that $ZnSO_4$ as a source of zinc had a positive effect in increasing TSS, acidity and Vitamin-C of strawberry fruits.

Methods and materials

The field experiment was undertaken 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.). The experiment was laid out in Randomized Block Design with three replications and ten treatments. 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%.

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.

Different quality parameters of strawberry *i.e.* total soluble solid, acidity, total sugar, reducing sugar, non-reducing sugar, TSS: acid ratio and ascorbic acid content were recorded.

Results and discussion

The results of experiment pertaining to various aspects of quality parameters are summarized as follows:

Total Soluble Solids (%)

The maximum total soluble solids (8.94%) was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), which was found significantly superior with rest of the treatments. The treatments T_1, T_4, T_7 & T_2 and T_1, T_3, T_7, T_9, T_6 & T_0 having respective total soluble solids 7.21, 7.51, 7.28 & 7.47 and 7.21, 7.07, 7.28, 7.08, 7.13 & 7.03 were observed statistically at par with each other under present investigation. The minimum total soluble solid (7.03%) was registered under T_0 (RDF + Control).

The increase in total soluble solids may be accounted to the hydrolysis of polysaccharides, conversion of organic acid in to soluble sugars and enhanced solubilization of insoluble starch and pectin present in cell wall and middle lamella. In conformity of this similar observations were reported by Kumar *et al*. (2010) [7], Bakshi *et al.* (2013a) [3], Bakshi *et al.* (2013b) [4] and Chaturvedi *et al.* (2005) [5] in strawberry, Singh and Chhonkar (1983) [15] and Singh and Brahmachari (1999) [16] in guava, Patel *et al.* (2010) [11] and Pathak *et al.* (2011) [10] in banana.

Acidity (%)

The minimum acidity (0.42%) was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), which was found significantly different with all other treatments. Moreover the treatments T_1, T_2, T_3, T_4, T_6, T_7 & T_9 having average acidity percent of 0.63, 0.62, 0.63, 0.63, 0.64, 0.63 & 0.64 were observed statistically at par with each other under present investigation. The maximum acidity (0.71%) was registered under T_0 (RDF + Control) showed significantly differences from rest of the treatments under the present investigation.

The reduction in acidity might be due to the metabolic changes with fast conversion of organic acids into sugars and their derivatives and utilization as respiratory substrate during growth and development of fruits, which was stimulated by iron and zinc spray. The present findings collaborates with the findings of Kumar *et al*. (2010), Bakshi *et al.* (2013a) [3], Bakshi *et al.* (2013b) [4] and Chaturvedi *et al.* (2005) [5] in strawberry, Singh and Chhonkar (1983) and Singh and Brahmachari (1999) [16] in guava, Patel *et al.* (2010) and Pathak *et al.* (2011) [10] in banana.

TSS: acid ratio

The maximum TSS: Acid ratio (13.63) was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), which was found statistically at par with different with T_5 (RDF + $FeSO_4$ @ 0.6%) having an average TSS: Acid ratio (12.84). The treatments T_1, T_2, T_3, T_4, T_6, T_7 & T_9 having respective TSS: Acid ratio of 11.31, 11.93, 11.31, 11.63, 11.38, 11.32 & 11.35 were observed statistically at par with each other under the present investigation. The minimum TSS: Acid ratio (10.09) was registered under T_0 (RDF + Control) showed significantly differences from rest of the treatments under the present investigation.

The increase in TSS: Acid ratio is due to increase in TSS and decrease in acidity with foliar application of $FeSO_4$ and $ZnSO_4$. In conformity of this similar observations were reported by Kumar *et al*. (2010), Bakshi *et al.* (2013a), Bakshi *et al.* (2013b) and Chaturvedi *et al.* (2005) [5] in strawberry, Singh and Chhonkar (1983) and Singh and Brahmachari (1999) [16] in guava, Patel *et al.* (2010) and Pathak *et al.* (2011) [10] in banana.

Total sugar (%)

The maximum total sugar (7.13%) was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), which was found at par with T_8 (RDF + $FeSO_4$ @ 0.6%) having an average total sugar (6.94%). The treatments T_1, T_2, T_4, T_6, T_7 & T_9 and T_1, T_2, T_3, T_6, T_7 & T_9 having average total sugar percent of 6.24, 6.28, 6.67, 6.32, 6.33 & 6.25 and 6.24, 6.28, 6.19, 6.32, 6.33 & 6.25 were observed statistically at par with each other under the present investigation. The minimum total sugar percent 5.81 was registered under T_0 (RDF + Control), which were at par with treatment T_1, T_3 & T_9 having average total sugar percent of 6.24, 6.19 & 6.25.

The increase in total sugar may be accounted due to the hydrolysis of polysaccharides, conversion of organic acid into soluble sugars and enhanced solubilization of insoluble starch and pectin present in cell wall and middle lamella which is influenced by Fe and Zn spray. In conformity of this similar observations were reported by Kumar *et al*. (2010) [7], Bakshi *et al.* (2013b) [4], M. Kazemi (2014) in strawberry, Singh and Chhonkar (1983) [15] and Singh and Brahmachari (1999) [16] in guava, Patel *et al.* (2010) [11] and Pathak *et al.* (2011) [10] in banana, Shrivastava (1969) [13] and Shrivastava (1970) [14] in pineapple, Rai *et al.* (1988) in other fruits.

Reducing sugar (%)

The maximum reducing sugar (5.26%) was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), followed by T_8 (RDF + $FeSO_4$ @ 0.6%) having an average reducing sugar percent of 6.09%. All the treatments were found significantly different with each other except T_2 & T_7 and T_6 & T_9 having respective percent of reducing sugar of 4.48 & 4.50 and 4.57 & 4.55 were observed statistically at par with each other under the present investigation. The minimum reducing sugar (4.16%) was registered under T_0 (RDF + Control).

The increase in reducing sugar may be accounted due to the hydrolysis of polysaccharides, conversion of organic acid in to soluble sugars and enhanced solubilization of insoluble starch and pectin present in cell wall and middle lamella which is influenced by Zn and Fe spray. In conformity of this similar observations were reported by Kumar *et al*. (2010) [7], Bakshi *et al.* (2013b) [4], M. Kazemi (2014) in strawberry, Singh and Chhonkar (1983) [15] and Singh and Brahmachari (1999) [16] in guava, Patel *et al.* (2010) [11] and Pathak *et al.* (2011) [10] in banana, Shrivastava (1969) [13] and Shrivastava (1970) [14] in pineapple, Rai *et al.* (1988) in other fruits.

Non-reducing sugar (%)

The maximum non-reducing sugar (1.87%) was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), which was found at par with treatment T_8 & T_4 having an average non-reducing percent of 1.85 & 1.85 respectively. Similarly the treatments T_1, T_3 & T_7 and T_3, T_4, T_7 & T_8 having respective non-reducing percent of 1.82, 1.84 & 1.83 and 1.84, 1.85, 1.83 & 1.85 were observed statistically at par with each other under the present investigation. The minimum non-reducing sugar (1.65%) was registered under T_0 (RDF + Control).

The increase in non-reducing sugar may be accounted due to the hydrolysis of polysaccharides, conversion of organic acid in to soluble sugars and enhanced solubilization of insoluble starch and pectin present in cell wall and middle lamella which is influenced by Zn and Fe spray. In conformity of this similar observations were reported by Kumar *et al*. (2010) [7], Bakshi *et al.* (2013b) [4], Kazemi (2014) in strawberry, Singh and Chhonkar (1983) [15] and Singh and Brahmachari (1999) [16] in guava, Patel *et al.* (2010) [11] and Pathak *et al.* (2011) in banana, Shrivastava (1969) [13] and Shrivastava (1970) [14] in pineapple, Rai *et al.* (1988) [12] in other fruits.

Ascorbic acid (%)

The maximum ascorbic acid (63.89 mg/100g) was recorded under the treatment T_5 (RDF + $ZnSO_4$ @ 0.6%), which was superior over rest of the treatments. The treatments T_3, T_4 & T_8 and T_3, T_4, T_1 & T_9 and T_4, T_1, T_9, T_6 & T_7 having respective ascorbic acid of 62.06, 61.84 & 62.32mg and 62.06, 61.84, 61.58 & 61.37mg and 61.84, 61.58, 61.37, 61.18 & 61.16mg were observed statistically at par with each other under the present investigation. The minimum ascorbic acid (59.27 mg/100g) was registered under T_0 (RDF + Control).

Table 1: Effect of foliar feeding of ca and micro-nutrients on total soluble solids, acidity, TSS: acid ratio and ascorbic acid content of strawberry cv. Nabila under net tunnel

Treatments	TSS (%)	Acidity (%)	TSS: Acid ratio	Ascorbic acid (mg/100 g)
RDF + Water spray (Control)	7.03^{a}	0.71^{a}	10.09^{a}	59.27^{a}
RDF + $CaCl_2$ @ 0.4%	7.21^{ab}	0.63^{b}	11.31^{b}	61.58^{cd}
RDF + $CaCl_2$ @ 0.6%	7.47^{b}	0.62^{b}	11.93^{b}	60.50^{bc}
RDF + $CaCl_2$ @ 0.8%	7.07^{a}	0.63^{b}	11.31^{b}	62.06^{de}
RDF + $ZnSO_4$ @ 0.4%	7.51^{b}	0.63^{b}	11.63^{b}	61.80^{cde}
RDF + $ZnSO_4$ @ 0.6%	8.94^{d}	0.42^{d}	13.63^{c}	63.89^{f}
RDF + $ZnSO_4$ @ 0.8%	7.13^{a}	0.64^{b}	11.38^{b}	61.18^{bc}
RDF + $FeSO_4$ @ 0.4%	7.28^{ab}	0.63^{b}	11.32^{b}	61.16^{bc}
RDF + $FeSO_4$ @ 0.6%	7.88^{c}	0.56^{c}	12.84^{c}	62.32^{e}
RDF + $FeSO_4$ @ 0.8%	7.08^{a}	0.64^{b}	11.35^{b}	61.37^{cd}
SE(m) ±	0.10	0.02	0.27	0.23
C.D. at 5%	0.30	0.05	0.82	0.70

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.

Table 2: Effect of foliar feeding of Ca and micro-nutrients on sugar content of strawberry cv. Nabila under net tunnel

Treatments	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
RDF + Water spray (Control)	5.81^{a}	4.16^{a}	1.65^{a}
RDF + $CaCl_2$ @ 0.4%	6.24^{abc}	4.42^{c}	1.82^{de}
RDF + $CaCl_2$ @ 0.6%	6.28^{bc}	4.48^{d}	1.80^{d}
RDF + $CaCl_2$ @ 0.8%	6.19^{ab}	4.35^{b}	1.84^{ef}
RDF + $ZnSO_4$ @ 0.4%	6.67^{cd}	4.82^{f}	1.85^{fg}
RDF + $ZnSO_4$ @ 0.6%	7.13^{e}	5.26^{h}	1.87^{g}
RDF + $ZnSO_4$ @ 0.8%	6.32^{bc}	4.57^{e}	1.75^{c}
RDF + $FeSO_4$ @ 0.4%	6.33^{bc}	4.50^{d}	1.83^{ef}
RDF + $FeSO_4$ @ 0.6%	6.94^{de}	5.09^{g}	1.85^{fg}
RDF + $FeSO_4$ @ 0.8%	6.25^{abc}	4.55^{e}	1.70^{b}
SE(m) ±	0.15	0.01	0.01
C.D. at 5%	0.44	0.02	0.02

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.

The significant variations among various treatments have been reported under the present investigation. In conformity of this similar observations were reported by Kumar *et al*. (2010) [7], Bakshi *et al.* (2013a) [3], Bakshi *et al.* (2013b) [4]. And Chaturvedi *et al.* (2005) [5] in strawberry, Singh and Chhonkar (1983) [15] and Singh and Brahmachari (1999) [16] in guava, Patel *et al.* (2010) [11] and Pathak *et al.* (2011) [10] in banana.

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