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Effect of micronutrients on quality and shelf-life of strawberry (*Fragaria x ananassa* Duch.) cv. chandler

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Abstract
Strawberry is one of the important and delicious fruit in the world. It has a unique place among cultivated berry fruits. It is a man-made hybrid which belongs to the family *Rosaceae* and its chromosome number 2n=8X=56. An experiment was conducted at Research field, Department of Horticulture, SHIATS, Allahabad, during the year 2015-2016. The experiment was laid out in Randomised Block Design having thirteen treatments of micronutrients at different levels and each micronutrient combination with three replications. The treatments consisted of $ZnSO_4$ (0.2%, 0.4%, 0.6%), Boron (0.2%, 0.4%, 0.6%), $FeSO_4$ (0.2%, 0.4%, 0.6%) and its combination of different levels. The results indicated that application of the 0.4% ($ZnSO_4$+ Boron+ $FeSO_4$) was found to be best in terms of maximum fruit yield per plot (g), maximum TSS (^{o} B) on 3rd day, 5th day and 7th day, minimum acidity (%) on 3rd day, 5th day and 7th day, pH on 3rd day, 5th day and 7th day was found from T_{11} and maximum TSC (%) on 3rd day, 5th day and 7th day from T_{10} treatment, maximum vitamin-C (g) on 3rd day, 5th day and 7th day and maximum shelf-life (at the room temperature) (2.51 days) T_{11} treatment. Studies indicated that pre-harvest foliar application of $ZnSO_4$, Boron and $FeSO_4$ are useful for improving the yield, quality and shelf-life of the fruits.

Keywords: Strawberry, micronutrients, quality and shelf - life

Introduction
The garden strawberry (*Fragaria x ananassa*. Duch) is a widely grown hybrid species of the genus *Fragaria*, collectively known as the strawberries and it is belongs to the family *Rosaceae*. The modern cultivated strawberry is one of the most delicious and short day plant. It is cultivated world wise for its fruit. The fruit is widely appreciated for its characteristic aroma, bright red colour, juicy texture and sweetness. It is consumed in large quantities either fresh or in such prepared foods as preserves like juice, ice creams, milkshakes and chocolates. Artificial strawberry flavourings and aromas are also widely used in many products like lip gloss, candy, hand sanitizers, perfumes and many others.

It is beneficial to anemic patients. Whiles (University of Illinois Extension (UIE 2013) [16] reported Strawberry consumption can reduce the risk of developing cancer by 50% due to high levels of Vitamin-C (30-100mg/100gms of fruit) as well as foliate and phyto chemical compound such as the ellagic acid present in the fruit. Fruit of strawberry is complete fruit with 98% edible portion and fruits are generally, are low calorie carbohydrate but abundant in Vitamin-C (Ayub *et al.*, 2010) [2]. It contains water-90%, calories-37%, protein-1.4%, carbohydrates-8%, crude fiber-1.5% in 100 grams of fruit.

Micronutrients are vital to the growth of plants, acting as catalyst in promoting various organic reactions taking place within the plant and their deficiencies often limit crop productivity in fruit crops. Application of zinc sulphate and ferrous sulphate are increased the fruit yield, acidity, TSS content, higher concentration of zinc sulphate resulted in enhanced shelf life of fruits at ambient temperature and higher concentration of ferrous sulphate had toxic effect on the plant and retarded the growth, yield and quality attributes. In the past, there was no need of micronutrients because these trace elements were naturally supplied by soil. But due to intensive cultivation, increase in salinity and soil pH in most of soils, these nutrients are present but are not available to plants (Ahmad *et al*, 2010). Zinc and Boron have important role on pollination, fruit set and yield (Motesharezade *et al*. 2001) [10] among the micronutrients. Boron plays important role in pollen tube growth which effect seed and fruit set and increase shelf life (Chaturvedi *et al.*, (2005) [3], Zinc plays an important role by increasing sugar and decreasing acidity (Abedy, 2001) [1]. Foliar application of zinc sulphate increased size, TSS, and juice of orange (Dixi and Gamdagin, 1998) [4]. Foliar application of Boron increased yield and fruit quality of grape (Donna, 1986) [5].

Application of Boron has increased yield and fruit quality, in raspberry (Wojcik, 2005) [15] decreased acidity in fruit of prune (Wojcik, 1999) [14]. Various experiment have been conducted earlier on foliar spray of micro nutrients in different fruit crops and shown significant response to improve yield and quality of fruits. The present study was conducted for the evaluation of pre harvest foliar application of zinc-boron-iron-on yield, quality and shelf-life of strawberry.

Materials and methods

The present experiment was conducted at Research field, Department of Horticulture, Allahabad School of Agriculture, SHIATS, Allahabad, during 2015-2016, in a Randomized Block Design replicated with thrice. Healthy and disease free runners of cv. Chandler were planted on flat bed system in first week of November 2015, maintaining a spacing of 30cm X 45cm. The micronutrients solutions were prepared as per the requirement and sprayed to each treatments and replication at 30 days intervals and observations recorded after harvest the fruits. The recommended package of practices was followed for raising the successful crop. Data on fruit yield, quality and shelf life of strawberry characters were recorded. Treatments are thirteen *viz*, T_0 control, T_1 ($ZnSO_4$ 0.2%), T_2 (0.2% Boron), T_3 ($FeSO_4$ 0.2%), T_4 ($ZnSO_4$ 0.4%), T_5 (0.4% Boron), T_6 ($FeSO_4$ 0.4%), T_7 ($ZnSO_4$ 0.6%), T_8 (0.6% Boron), T_9 (0.6% $FeSO_4$), T_{10} 0.2% ($ZnSO_4$+ Boron+ $FeSO_4$), T_{11} 0.4% ($ZnSO_4$+ Boron+ $FeSO_4$), T_{12} 0.6% ($ZnSO_4$+ Boron+ $FeSO_4$).The prepared solutions of Zinc sulphate, Boron and Ferrous sulphate sprayed on the foliage of the plants with help of the hand sprayer, all the cultural operations and plant protection measures were followed uniformly for all the treatments during the entire period of the experimentation.

Observations were recorded on increase in yield, quality (Total soluble solids, total sugars, total titrable acidity, pH and Vitamin-C and Shelf-life under ambient temperature conditions (20±5º C). Shelf-life (Number of days), Fruit yield/plot (g) was recorded by weighing balance, P^H was measured with help of, P^H scale, TSS (˚B) was measured by Erma Hand refractometer, TSC (%), acidity (%) and Vitamin-C (mg/100gm) was determined by the methods outlined by S. Ranganna (1995) [11], Hand book of Analysis and Quality Control for Fruit and Vegetable Products. The data obtained was statistically analyzed by Panse and Sukhatme (1985).

Results and discussion

From the current study it is observed that supplement of zinc, boron and iron 0.4% ($ZnSO_4$+ Boron+ $FeSO_4$) through foliar application; it increases the yield and quality of strawberry. Turemis *et al.* (1998) [13] also observed a significant increase in flowers and fruits with $FeSo_4$. Maximum fruit yield/plot was found T_{11} (138.50 g) and minimum T_0 (135.85 g) Chaturvedi *et al.* (2005) [3] also reported similar results 0.4% ($ZnSO_4$+ Boron+ $FeSO_4$). Increase in fruit size with the application of $ZnSO_4$ was reported by Samant *et al.* (2008) [12]. Mohamed *et al.* (2011) [9] also observed maximum mean values for most of physical fruit characters of strawberry cv. Sweet Charlie with high rates of zinc. The maximum fruit yield per plot was found from T_{11} (1010.50 g) and minimum T_0 (467.30 g), The maximum TSS on 3rd day (10.18˚B), 5th day (9.56º B), 7th day (9.12º B) was found from T_{11} and minimum TSS on 3rd day (8.15˚B), 5th day (7.47º B), 7th day (6.91º B) was observed from $T_{0.}$ The maximum TSC on 3rd day (8.65%), 5th day (8.56%), 7th day (8.34%) was observed T_{10}, minimum on 3rd day (7.51%), 5th day (7.44%), 7th day (7.30%) was found from T_0. The maximum Total Titrable acidity on 3rd day (1.21%), 5th day (1.06%), 7th day (0.97%) was observed T_0, minimum on 3rd day (0.44%), 5th day (0.43%), 7th day (0.35%) was found from T_{11}(Table-1). The maximum pH on 3rd day (3.91), 5th day (3.75), 7th day (3.52) was found from T_{11} and minimum pH on 3rd day (3.32), 5th day (3.21), 7th day (3.05) was observed from $T_{0.}$The Maximum Vitamin-C on 3rd day (51.63 mg), 5th day (51.26 mg), 7th day (50.23mg) was found from T_{11} and minimum on 3rd day (50.28mg), 5th day (49.38 mg), 7th day (48.31mg) was found from $T_{0,}$ Mahnaz *et al.* (2010) [8] also reported similar results. The maximum shelf-life (Number of days) was found T_{11} (2.51 days) and minimum T_0 (1.63 days) (Table-2). These results are in consonance with findings of Kumar *et al.* (2010) [6]. Effect of pre-harvest foliar application of micronutrients (Zn, Bo, Iron) on yield, quality and shelf-life of strawberry cv. Chandler.

Table 1: Effect of Micronutrients on Yield, TSS (ºB), TSC (%) and Total Titrable acidity (%) of strawberry cv. Chandler.

Treatment	Fruit yield per plot (g)	Total soluble solids (˚Brix)			Total Sugar Content (%)			Total titrable acidity (%)		
	120 DAT Mean	3rd day	5th day	7th day	3rd day	5th day	7th day	3rd day	5th day	7th day
Control – (T_0)	467.30	7.82	7.47	6.91	7.51	7.44	7.30	1.21	1.06	0.97
$ZnSO_4$(0.2%)– (T_1)	606.75	8.52	7.91	7.19	7.76	7.66	7.44	1.02	0.84	0.82
Boron(0.2%)– (T_2)	763.55	9.21	8.71	8.51	8.15	8.09	7.88	0.81	0.64	0.63
$FeSO_4$(0.2%)– (T_3)	808.85	9.38	8.94	8.65	8.29	8.23	7.98	0.72	0.63	0.55
$ZnSO_4$(0.4%)– (T_4)	908.15	9.70	9.28	8.86	8.49	8.43	8.13	0.62	0.55	0.45
Boron(0.4%)– (T_5)	708.95	8.85	8.30	7.78	7.88	7.82	7.57	0.93	0.76	0.71
$FeSO_4$(0.4%)– (T_6)	841.35	9.52	9.01	8.76	8.39	8.33	8.03	0.66	0.61	0.52
$ZnSO_4$(0.6%)– (T_7)	727.70	8.98	8.54	7.96	7.97	7.92	7.76	0.85	0.70	0.70
Boron(0.6%)– (T_8)	664.60	8.66	8.12	7.56	7.78	7.71	7.52	0.93	0.81	0.80
$FeSO_4$(0.6%)– (T_9)	582.60	8.39	7.72	7.04	7.67	7.58	7.37	1.06	0.94	0.90
$ZnSO_4$+Boron+ $FeSO_4$(0.2%)– (T_{10})	948.40	9.96	9.43	8.99	8.65	8.56	8.34	0.60	0.51	0.43
$ZnSO_4$+Boron+$FeSO_4$(0.4%)– (T_{11})	1010.50	10.18	9.56	9.12	8.58	8.50	8.27	0.44	0.43	0.35
$ZnSO_4$+Boron+$FeSO_4$(0.6%)– (T_{12})	542.10	8.15	7.59	6.97	7.58	7.50	7.29	1.12	1.04	0.93
CD (P = 0.05)	0.02	0.444	0.201	0.136	0.111	0.139	0.203	0.059	0.058	0.036

Table 2: Effect of Micronutrients on p^H, Vitamin- C and Shelf-life of strawberry cv. Chandler

Treatment	p^H			Vitamin-C			Shelf-life (Number of days)
	3rd day	5th day	7th day	3rd day	5th day	7th day	
Control – (T_0)	3.32	3.21	3.05	50.28	49.38	48.31	1.63
$ZnSO_4$(0.2%)– (T_1)	3.41	3.30	3.14	50.92	50.09	48.73	2.02
Boron(0.2%)– (T_2)	3.54	3.45	3.32	51.39	50.63	49.38	2.27
$FeSO_4$(0.2%)– (T_3)	3.61	3.52	3.36	51.48	50.73	49.53	2.31
$ZnSO_4$(0.4%)– (T_4)	3.63	3.54	3.39	51.56	50.95	49.81	2.34
Boron(0.4%)– (T_5)	3.49	3.34	3.23	51.23	50.31	49.02	2.14
$FeSO_4$(0.4%)– (T_6)	3.74	3.61	3.42	51.53	50.86	49.67	2.33
$ZnSO_4$(0.6%)– (T_7)	3.51	3.41	3.26	51.30	50.43	49.21	2.19
Boron(0.6%)– (T_8)	3.43	3.36	3.18	51.19	50.22	48.86	2.08
$FeSO_4$(0.6%)– (T_9)	3.36	3.25	3.11	50.83	49.76	48.66	1.93
$ZnSO_4$+Boron+ $FeSO_4$(0.2%)– (T_{10})	3.8	3.66	3.44	51.6	51.2	49.91	2.41
$ZnSO_4$+Boron+$FeSO_4$(0.4%)– (T_{11})	3.91	3.75	3.52	51.63	51.26	50.23	2.51
$ZnSO_4$+Boron+$FeSO_4$(0.6%)– (T_{12})	3.33	3.25	3.09	50.71	49.63	48.53	1.82
CD (P = 0.05)	0.042	0.052	0.036	0.116	0.041	0.203	0.05

It is concluded that pre harvest foliar application of three times spraying (1st at 30 DAT, 2nd at 60 DAT, 3rd at 90 DAT) 0.4% ($ZnSo_4$+ Boron+ $FeSo_4$) resulted maximum Post harvest characters yield, Quality characters (TSS, TSC, Total titrable acidity, Vitamin-C and P^H) and Shelf-life.

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References

1. Abedy A. Effects of zinc sulphate and citric acid spray on fruit characteristics of tomato cultivar ˊ Urbana ̀. Msc. Thesis, Shiraz University, 2001.
2. Ayub M, Javid U, Muhammad A, Zeb A. Evaluation of strawberry juice preserved with chemical preservatives at refrigeration temperature. International Journal of Nutrition and Metabol. 2010; 2(2):027-032.
3. Chaturvedi OP, Singh AK, Tripathi VK, Dixit AK. Effect of zinc and iron on growth, yield and quality of strawberry cv. Chandler. Acta Horticulturae. 2005; 696:237-40.
4. Dixi CX, Gamdagin R. Effect of foliar application of zinc and iron chlorosis and yield of Kinnow. Pro. Hort. Sci. 1998; 10(1):13-19.
5. Donna P. Foliar fertilization in grapevine growing for the treatment of some physiological disorders. Horticultural Abs. 1986; 56:1.
6. Kumar S, Yadav M, Singh GK. Effect of iron and zinc on fruit yield and quality of strawberry (*Fragaria ananassa)*. Indian Journal of Agricultural Science. 2010; 80(2):171-3.
7. Kumar R, Tripathi VK. Influence of NAA, GA_3 and boric acid on growth, yield and quality of strawberry cv. Chandler. Department of Horticulture, C.S. Azad University of Agriculture and Technology, Kanpur-208 002 (U.P.), published on 3 April, 2012. 2009; 41:113-115.
8. Mahnaz A, Saeid E, Enayat T. Interaction of paclobutrazol, boron and zinc on vegetative growth, yield and fruit quality of strawberry (*Fragaria X ananassa* Duch. cv. Selva). Journal of Biology and Environment Science. 2010; 4:67-75.
9. Mohamed RA, Abd EI-Aal HA, Abd EI-Aziz MG. Effect of phosphorus, zinc and their interactions on vegetative growth characters, yield and fruit quality of strawberry. Journal of Horticulture Science and Ornamental Plants. 2011; 3(2):106-14.
10. Motesharezade B, Malakuty MJ, Nakhoda B. Effects of N, Zn and B sprays on photochemical efficiency of sweet cherry. Hort. Newsletter. 2001; 12:106-111.
11. Ranganna S. Hand book of Analysis and Quality Control for Fruit and Vegetable Products, Tata McGraw Hill Publishing Company Limited, New Delhi, 1995, 24.
12. Samant D, Mishra NK, Singh AK, Lal RL. Effect of micronutrients sprays on fruit yield and quality during storage in ber cv. Umran under ambient conditions. Indian Journal of Horticulture. 2008; 65(4):399-404.
13. Turemis N, Ozguven AI, Paydas S, Idem G, Kundan AB *et al.* Effect of sequestrone EF-138 foliar and /or soil application on yield and earliness of some strawberry cultivars in the sub-tropics. Acta Horticulture. 1998; 441:369-74.
14. Wojcik P. Effect of boron fertilization of Dabrowicka prune trees on growth, yield and fruit quality. J Plant Nutr. 1999; 22(10):1651-1664.
15. Wojcik P. Response of primo cane- fruiting Polana red raspberry to boron fertilization. J Plant Nutr. 2005; 28:1821-1832.
16. University of Illinois Extension Fact Sheet. Strawberry and more. Urban Program Network, 2013. Available from: http://www.urbanext.uiuc.edu/strawberries/nutrition.html (accessed 24 September 2013).