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Effect of iron and zinc on fruit yield and quality of strawberry (*Fragaria anannassa*)*

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The strawberry (*Fragaria* × *anannassa* Duch) is essentially a temperate fruit but has adopted well under varied agro climatic conditions. Under temperate climatic conditions, strawberry behaves as perennial whereas under subtropical conditions, it behaves as an annual, with most of plantation dying during summer and monsoon (Shoemaker 1995). As strawberry has a high prospect for its cultivation in this region, there is an urgent need to standardize the cultural practices and to evaluate different fertilizer requirements for getting the higher yield and good quality fruits.

Micronutrient deficiencies often limit the productivity in many fruits. Micronutrient deficiency causing even 10% decrease in yield may be significant in terms of economic loss. Micro-elements are known to stimulate various physiological activities when present in very small quantities. Among them zinc is necessary for the formation of tryptophane (bound auxin), the precursor of IAA (Indole acetic acid) component of at least 2 enzyme systems, necessary for the formation of proteins and for the oxidation phase of respiration, as a catalyst and regulator in plant nutrition, cellular metabolism and respiration. Iron play a vital role in the formation of chlorophyll, and it also helps in absorption of nutrient elements. It is a structural component of porphyrin ring and also a structural component of nonheame molecules (ferredoxins). It is also a constituent of enzyme systems and so it helps for carrying out different enzymatic reactions in plants (Das 2006). Under certain conditions application of fertilizer in soil results in losses by leaching or fixation and thereby may not be responsive for rectifying the deficiency for immediate response. Thus foliar application of nutrients is only way left for supplying nutrients and rectifying deficiency in crop like strawberry in particular, which requires large quantities of fertilizers. This method of supplying nutrients to plants, not only increases crop yield but also results in the improvement in quality of the produce. Thus there is a need to standardize the concentration of iron and zinc for recommending as foliar spray in strawberry.

The experiment was conducted at Department of Horticulture, Allahabad Agricultural Institute, Allahabad during 2007–08 with the objective of determining suitable treatment. The experiment was laid out in a 3×3 RBD factorial comprising 9 treatments, i e T_0 [Z_oI_0 (0% + 0%)], T_1 [Z_0I_1 (0%+0.2%)], T_2 [Z_0I_2 (0% + 0.4%)], T_3 [Z_1I_0 (0.2% + 0%)], T_4 [Z_1I_1 (0.2% + 0.2%)], T_5 [Z_1I_2 (0.2% + 0.4%)], T_6 [Z_2I_0 (0.4% + 0%)], T_7 [Z_2I_1 (0.4% + 0.2%)], T_8 [Z_2I_2 (0.4% + 0.4%)]. Observations were recorded on yield/ha (tonnes/ha), acidity (%), total soluble solid (%), total sugar (%), and vitamin C (mg/100 g). The recommended dose of NPK were followed, ie 120: 80: 100 kg/ha and farmyard manure were also applied @ 30 tonnes/ha. The bed size of each treatment was 2 × m^2 with a plant spacing 30 cm × 45 cm. There were 16 plants in each bed. The runners were procured from the nursery of Rudrapur, Uttarakhand. The fruit quality (acidity, total sugar, vit. C and total soluble solid) were analyzed by the method as suggested in AOAC (1984). Five fruits/treatment/replication were taken for quality analysis.

The fruit yield was significantly influenced by various treatments (Table 1). The interaction between zinc and iron

Table 1 Effect of different levels of zinc, iron and their interaction on fruit yield (tonnes/ha) of strawberry

Levels of zinc (Z)	Levels of iron (I)			Mean (Z)
	I_0 (0.0%)	I_1 (0.2%)	I_2 (0.4%)	
Z_0 (0.0%)	17.19	22.24	22.49	20.64
Z_1 (0.2%)	23.82	24.62	25.79	24.74
Z_2 (0.4%)	24.42	24.62	29.16	26.07
Mean (I)	21.81	23.83	25.81	23.82
		F-test	SEd (±)	CD (P=0.05)
Zinc (Z)	S	0.10	0.22	
Iron (I)	S	0.10	0.22	
Interaction (Z × I)	S	0.18	0.38	

*Short note

Based on complete information of MSc thesis of the first author submitted to AAU, Allahabad during 2008

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Table 2 Effect of different levels of zinc, iron and their interaction on total soluble solids (%) of strawberry

Levels of zinc (Z)	Levels of iron (I)			Mean (Z)
	I_0 (0.0%)	I_1 (0.2%)	I_2 (0.4%)	
Z_0 (0.0%)	7.93	8.13	8.37	8.14
Z_1 (0.2%)	8.60	8.73	10.19	9.17
Z_2 (0.4%)	8.63	9.07	11.13	9.61
Mean (I)	8.39	8.64	9.90	8.98
		F-test	SEd (±)	CD at 5%
Zinc (Z)	S	0.10	0.22	
Iron (I)	S	0.10	0.22	
Interaction (Z × I)	S	0.18	0.39	

Table 4 Effect of different levels of zinc, iron and their interaction on acidity (%) of strawberry

Levels of zinc (Z)	Levels of iron (I)			Mean (Z)
	I_0 (0.0%)	I_1 (0.2%)	I_2 (0.4%)	
Z_0 (0.0%)	0.87	0.85	0.84	0.85
Z_1 (0.2%)	0.83	0.78	0.72	0.78
Z_2 (0.4%)	0.81	0.77	0.68	0.75
Mean (I)	0.84	0.80	0.75	0.79
		F-test	SEd (±)	CD at 5%
Zinc (Z)	S	0.01	0.03	
Iron (I)	S	0.01	0.03	
Interaction (Z × I)	S	0.02	0.04	

was found significantly superior to separate effect. Maximum fruit yield (29.16 tonnes/ha) was recorded in treatment Z_2I_2 (0.4% zinc + 0.4% iron), plant receiving 0.4% zinc and 0.4% iron and a minimum fruit yield (17.19 tonnes/ha) was recorded with Z_0I_0 (control). Ghosh and Besra (2000) also reported the similar result in mosambi.

Total soluble solids increased with the concentration of zinc, iron and their interaction (Table 2). The interaction between zinc and iron showed significant effect, and maximum total soluble solids (11.13%) were observed with Z_2I_2, plants receiving 0.4% zinc and 0.4% iron spray. Minimum total soluble solids (7.93%) were recorded with Z_0I_0 (control). The quality of fruit in terms of total soluble solids was improved with the different levels of zinc, iron and their interaction. Foliar application of zinc increased the total soluble solids as reported by Arora and Singh (1970) in guava. This was ascribed to the auxin synthesis by zinc, which in terms increased metabolites available for total soluble solid formation. The foliar application of iron also increased the total soluble solids. Similar result was reported by Chaturvedi *et al.* (2005) in strawberry.

The interaction between zinc and iron was found significant and maximum total sugars (7.83%) were observed with Z_2I_2, plant receiving 0.4% zinc and 0.4% iron spray (Table 3). Minimum total sugars (5.83%) could be noticed with Z_0I_0 (control). Total sugars of strawberry fruits increased with different levels of zinc and iron and their interaction. Increase in total sugars was found associated with increasing in reducing sugar and non-reducing sugar.

Acidity was significantly affected by various treatments (Table 4). Acidity content decreased with the zinc, iron and their interaction. The interaction between the zinc and iron was found to be more significant then separate effect. The plants receiving 0.4% zinc and 0.4 iron (Z_2I_2) resulted in minimum acidity (0.68%) which was at par with 0.2% zinc and 0.4% iron spray, ie (Z_1I_2). Maximum acidity (0.87%) was found with (Z_0I_0) (control). Acidity content of fruit decreased with the different levels of zinc, iron and their interaction. Zinc and iron application decrease the acid content, which might be due to the increase in total soluble solids and ultimately reduced the acidity of fruit. Similar result reported by Ahlawat *et al*. (1985) in Beauty Seedless grape.

The data showed significant effect with respect to different level of zinc, iron and their interaction on ascorbic acid content (Table 5). The interaction between zinc and iron was

Table 3 Effect of different levels of zinc, iron and their interaction on total sugars (%) of strawberry

Levels of zinc (Z)	Levels of iron (I)			Mean (Z)
	I_0 (0.0%)	I_1 (0.2%)	I_2 (0.4%)	
Z_0 (0.0%)	5.83	6.50	6.60	6.31
Z_1 (0.2%)	6.63	7.40	7.70	7.24
Z_2 (0.4%)	6.70	7.50	7.83	7.34
Mean (I)	6.39	7.13	7.38	6.97
		F-test	SEd (±)	CD at 5%
Zinc (Z)	S	0.03	0.06	
Iron (I)	S	0.03	0.06	
Interaction (Z × I)	S	0.05	0.11	

Table 5 Effect of different levels of zinc, iron and their interaction on ascorbic acid (mg/100 g) of strawberry

Levels of zinc (Z)	Levels of iron (I)			Mean (Z)
	I_0 (0.0%)	I_1 (0.2%)	I_2 (0.4%)	
Z_0 (0.0%)	50.79	52.79	54.76	52.78
Z_1 (0.2%)	56.79	59.46	62.60	59.62
Z_2 (0.4%)	57.46	60.21	63.12	60.26
Mean (I)	55.02	57.49	60.16	57.55
		F-test	SEd (±)	CD at 5%
Zinc (Z)	S	0.11	0.23	
Iron (I)	S	0.11	0.23	
Interaction (Z × I)	S	0.19	0.40	

found to be significant and maximum ascorbic acid content (63.12 mg/100 g) was recorded with Z_1I_2, fruits receiving 0.4% zinc and 0.4% iron. Minimum ascorbic content (50.79 mg/100 g) was noticed with Z_0I_0 (control). It was also observed that ascorbic acid content increased with the different levels of zinc, iron and their interaction. The zinc and iron application increased the ascorbic acid synthesis. Singh and Singh (1981) reported that 2 foliar applications of B, Mn, Cu, Fe and Zinc increased the flower bud formation which resulted in increase in fruit size, yield, sugar and vitamin C content of fruit and in guava.

SUMMARY

An experiment was conducted during 2007–08 at Allahabad to determine suitable treatment for yield and quality improvement in 'Chandler' strawberry (*Fragaria* × *anannassa Duch*). Different levels of zinc, iron and their combinations were taken as treatments. All the treatments [T_0 (Z_oI_0 (0%+ 0%], T_1 [Z_0I_1 (0%+0.2%)], T_2 [Z_0I_2 (0% + 0.4%)], T_3 [Z_1I_0 (0.2% + 0%)], T_4 [Z_1I_1 (0.2% + 0.2%)], T_5 [Z_1I_2 (0.2% + 0.4%)], T_6 [Z_2I_0 (0.4% + 0%)], T_7 [Z_2I_1 (0.4% + 0.2%)], T_8 [Z_2I_2 (0.4% + 0.4%)] were applied as foliar application on the plants. The treatment T_8 [Z_2I_2 (0.4% + 0.4%] showed better results for yield/ha (29.16 tonnes), acidity (0.68%), total soluble solid (11.13%), total sugar (7.83%), and vitamin-C (63.12 mg/100 g).

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