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Effect of soil and foliar application of multi-micronutrients on fruit quality, shelf life of fruits and nutrient content of leaf of mango (*Mangifera indica* L.) var. Amrapali

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Abstract
The present investigation was carried out at Horticultural Research Farm, Department of Horticulture, BACA, AAU, Anand during the year 2014-15 to study the "Effect of soil and foliar application of multi-micronutrients on fruit quality, shelf life of fruits and nutrient content of leaf of mango (*Mangifera indica* L.) var. Amrapali". The experiment was laid out in Randomized Block Design with factorial concept with three levels of soil application *viz*., S_1 (control), S_2 (200 g/tree multi-micronutrient Grade-V) and S_3 (400 g/tree multi-micronutrient Grade-V) and three level of foliar application *viz*., F_1 (control), F_2 (1% Spray of multi-micronutrient Grade-IV) and F_3 (2% Spray of multi-micronutrient Grade-IV) and replicated thrice. Multi-micronutrients were sprayed at three stages *i.e*. at flower bud initiation, at full bloom stage and at pea stage. Among fruit quality parameters *viz*., TSS (21.37 °Brix), reducing sugar (8.04%), non-reducing sugars (10.46%), total sugars (18.28%), ascorbic acid (41.17 mg/100g), minimum acidity (0.134%) and highest shelf life of fruits (12.71 days) were recorded in treatment 1% spray of multi-micronutrient Grade-IV (F_2). Whereas, significantly maximum nutrients content *viz*. iron (635.85 mg kg^{-1}**)**, manganese (164.81 mg kg^{-1}), zinc (218.70 mg kg^{-1}) and copper (58.56 mg kg^{-1}) in leaf recorded under treatment F_3 (2% spray of multi-micronutrient Grade-IV).

Keywords: nutrients, shelf life, multi-micronutrients, quality

Introduction
Mango (*Mangifera indica* L.) is national fruit of India due to its delicious taste and flavour. Amrapali is famous for excellent quality of fruit and regular bearing habit. Fruits are green, apricot yellow, medium sized, sweet in taste with high T.S.S. and pulp content (75%), while flesh is fibreless and deep orange red. Iron is necessary for many enzymatic functions and act as a catalyst for the synthesis of chlorophyll, protein and regulates the respiration. It is essential for the development of young growing parts of the plant. Manganese (Mn) is regarded as an activator of many different enzymatic reactions and takes part in photosynthesis. Manganese plays an important role in carbohydrate metabolism, protein synthesis and internodes elongation. Its deficiency produces small and narrow leaves, shorter shoot internodes and terminal dieback (Ryugo, 1988) [12]. Copper is essential for plant growth and activation of many enzymes. A copper deficiency interferes with protein synthesis and causes a buildup of soluble nitrogen compounds. Boron deficiencies are mainly found in acid soils, sandy soils in regions of high rainfall or under irrigation and those soils with low soil organic matter (Brown *et al.*, 1995) [4].

Materials and methods
The experiment was conducted at Horticultural Research Farm and P. G. Laboratory, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *Rabi-Summer* season of the year 2014-15. There were nine treatments embedded in Randomized Block Design with factorial concept replicated thrice with two trees selected per treatment. Fifty four uniform size tree of mango var. Amrapali were selected and laid out in Randomized Block Design with factorial concept with three levels of soil application viz., S_1 (control), S_2 (200 g/tree multi-micronutrient Grade-V) and S_3 (400 g/tree multi-micronutrient Grade-V) and three level of foliar application *viz.*, F_1 (control), F_2 (1% Spray of multi-micronutrient Grade-IV) and F_3 (2% Spray of multi-micronutrient Grade-IV).

There were nine treatments combinations, 3 of soil applications and 3 of foliar applications of multi-micronutrients. In Grade IV available nutrients in percent 4.0 (Fe), 1.0 (Mn), 6.0 (Zn), 0.5 (Cu), 0.5 (B) and in Grade V available nutrients in percent 2.0 (Fe), 0.5 (Mn), 5.0 (Zn), 0.2 (Cu), 0.5 (B). Multi-micronutrients were sprayed at three stages i.e.at flower bud initiation (26th January, 2015), at full bloom stage (15 February, 2015) and at pea stage (5th March, 2015) whereas soil application of multimicronutrients was done on 12th March 2015. Then mature (tapka stage) and uniform sized fruits were harvested from the respective trees and carried out biochemical analysis in the laboratory.

Results and Discussion

The results obtained from the present investigation was conducted on the effect of soil and foliar application of multi-micronutrients influenced on fruit quality, shelf life of fruits and nutrient content of leaf of mango fruit are presented in Table 1 and 2.

The effect of soil application of multimicronutrients was found non-significant on effect on total soluble solid whereas different levels of foliar application manifested their significant influence on total soluble solid. Treatment F_2 (1% spray of multimicronutrient Grade-IV) gave the maximum total soluble solid (21.37 °Brix). An increase in total soluble solid might be due to zinc increase the synthesis of tryptophan that is a precursor of auxin. It plays a key role in protein synthesis, sugar metabolism and maintains the integral structure. On the other hand, boron may be associated with the cell membrane where it could be complex with sugar molecules and facilitates its passage across the membrane that might be the reason for increased total soluble solids. Similar results were found by Vashistha *et al.* (2010) [15], Bhowmick and Banik (2011) [3] and Nehete *et al.* (2011) [10] in mango. The interaction effect of soil and foliar application with respect to total soluble solid was found to be non-significant.

A perusal of data (Table 1) revealed that different level of soil application of multimicronutrients did not exerted its significant influence on reducing sugar. An examination of data mentioned that various levels of foliar application exerted their significant effect on reducing sugar. Application of 1% spray of multimicronutrient Grade-IV (F_2) recorded significantly the maximum reducing sugar (8.04%). This might be due to zinc promotes hydrolysis of starch into sugars and acts as a catalyst in oxidation-reduction processes in plants. Mango possesses climacteric phenomenon which triggers the dramatic changes in respiration. These results are in close conformity with the findings of Nehete *et al.* (2011) [10], in mango, Jat and Kacha (2014) [8] in guava and Chandra and Singh (2015) [5] in aonla. The interaction effect of soil and foliar application with respect to reducing sugar was found to be non-significant.

The effect of soil application of multimicronutrients was found non-significant on effect on non-reducing sugar whereas different levels of foliar application manifested their significant influence on non-reducing sugar. The highest non-reducing sugar (10.46%) was observed in treatment F_2 (1% spray of multimicronutrient Grade-IV). It was observed that the proportion of reducing sugar content was less as compared to non-reducing sugar at ripe stage supporting with the finding of Nehete *et al.* (2011) [10] in mango, Jat and Kacha (2014) [8] in guava, Lal and Ahmed (2012) [9] in pomegranate and Chandra and Singh (2015) [5] in aonla. The interaction effect of soil and foliar application on non- reducing sugar was found to be non-significant.

The data presented in (Table 4.10) showed that different levels of soil application of multi-micronutrients were found unable to create their significant influence on total sugar. Whereas, different levels of foliar application manifested their significant effect on total sugar. The highest total sugar (18.28%) was observed in treatment F_2 (1% spray of multi-micronutrient Grade-IV). It might be due to multi-micronutrients may increase the mobilization of carbohydrates from source of fruit. An association of zinc with synthesis of auxins in plants play a vital role along with the increase in enzymatic activities. This leads the biochemical reactions including conversion of complex food materials *i.e.* starch into simple substances like sugars. These findings are accordance by the results obtained by Vashistha *et al.* (2010) [15], Bhowmick and Banik (2011) [3], Nehete *et al.* (2011) [10], and Lal and Ahmed (2012) [9] in pomegranatand Chandra and Singh (2015) [5] in aonla. The interaction effect between soil and foliar application of multimicronutrients on total sugar was found to be non-significant.

A perusal of data (Table 1) revealed that ascorbic acid was not influenced by different levels of multimicronutrients and different levels of foliar application manifested their significant influence on ascorbic acid. Treatment F_2 (1% spray of multimicronutrient Grade-IV) gave the maximum ascorbic acid (41.17 mg/100g). An increase in ascorbic acid content was due to catalytic activity of zinc, iron and boron on its bio-synthesis from its precursor (glucose-6-phosphate) or inhibition of its conversation into dehydro ascorbic acid by enzyme ascorbic acid oxidation or both. Similar results were also observed by Vashistha *et al.* (2010) [15], Bhowmick and Banik (2011) [3], Nehete *et al.* (2011) [10], Bhatt *et al.* (2012) [2] in mango, Babu and Yadav (2005) [1] in mandarin and Chandra and Singh (2015) [5] in aonla. The interaction effect of soil and foliar application multimicronutrients with respect to ascorbic acid was found to be non-significant.

The data presented in (Table 1) showed that different levels of soil application were found unable to create their significant influence on acidity. While, foliar application was found significant influence on acidity. The lowest acidity (0.134%) was registered in treatment 1% spray of multimicronutrient Grade-IV (F_2). It might be due to zinc helps in enzymatic reactions like transformation of carbohydrates, activity of hexokinase and formation of cellulose and change in sugar are consider due to its action on zymohexose (Dutta and Dhua, 2002). Whereas, boron is associated in the carbohydrate transport within the plant. The sugars are transported more readily across cell membrane as a borate complex. The present study is partially supported with the findings of Vashistha *et al.* (2010) [15], Bhowmick and Banik (2011) [3], Nehete *et al.* (2011) [10], in mango, Babu and Yadav (2005) [1] in mandarin and Chandra and Singh (2015) [5] in aonla. An interaction effect of soil and foliar application on acidity was found to be non-significant.

A perusal of data (Table 1) revealed that different level of soil application do not exerted its significant influence on shelf life. Difference observed in shelf life of mango fruit due to different levels of foliar application was found significant. The highest shelf life (12.71 days) was recorded in treatment 1% spray of multimicronutrient Grade-IV treatment (F2). The increase in shelf life of mango fruits might be due to increase in concentration of boron of middle lamella of cell wall which provide physical strength to cell wall and improve fruit colour development and appearance. These findings are in accordance with the findings of Bhatt *et al*. (2012) [2] and Singh *et al*. (2012) [14] in mango. The interaction effect between soil and foliar application on shelf life was found to be non-significant.

Table 1: Effect of soil and foliar application of multimicronutrient on fruit quality and shelf life of mango var. Amrapali

Sr. no.	Treatments	Total soluble solids (°Brix)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Ascorbic acid (mg/ 100 g pulp)	Acidity (%)	Shelf life (Days)
Soil application (S)								
S_1	Control	19.65	6.82	9.82	16.96	38.21	0.152	11.26
S_2	200 g/tree multimicronutrient (Grade-V)	20.29	7.04	9.88	17.20	38.96	0.147	11.38
S_3	400g/tree multimicronutrient (Grade-V)	20.57	7.14	9.95	17.39	39.44	0.144	11.45
S.Em. ±		0.54	0.20	0.28	0.47	1.00	0.004	0.30
C.D. at 5%		NS	NS	NS	NS	NS	NS	NS
Foliar application (F)								
F_1	Control	18.92	5.95	9.20	16.07	36.03	0.162	10.29
F_2	1% Spray of multimicronutrient (Grade-IV)	21.37	8.04	10.46	18.28	41.17	0.134	12.71
F_3	2% Spray of multimicronutrient (Grade-IV)	20.22	7.01	9.99	17.21	39.39	0.146	11.09
S.Em. ±		0.54	0.20	0.28	0.47	1.00	0.004	0.30
C.D. at 5%		1.62	0.62	0.84	1.42	3.02	0.012	0.91
S × F interaction								
S.Em.±		0.93	0.36	0.48	0.82	1.74	0.007	0.52
C.D. at 5%		NS	NS	NS	NS	NS	NS	NS
C.V. %		8.05	8.89	8.53	8.29	7.78	7.78	8.03

The data presented in (Table 2) mentioned that various levels of soil application were found unable to exert their significant effect on nutrient (Fe, Mn, Zn and Cu) content in mango leaf. Whereas, foliar application were found significant effect on nutrient (Fe, Mn, Zn and Cu) content in mango leaf after spray. The significantly maximum nutrient content in leaf iron (635.85 mg kg^{-1}), manganese (164.81 mg kg^{-1}), zinc (218.70 mg kg^{-1}) and copper (58.56 mg kg^{-1}) were recorded under 2% spray of multimicronutrient Grade-IV (F_3). The increase in nutrient content in mango leaf after spray might be due to absorption of sprayed multimicronutrients. The present study is partially supported with the findings of Nehete *et al.* (2011) [10], Sanna *et al*. (2005) and Hamdy *et al*. (2007) in mango. The interaction effect between soil and foliar application was found to be non-significant on multimicronutrients (Fe, Mn, Zn and Cu) content in leaf after spray.The different levels of soil and foliar application of multimicronutrients also unable create significant effect on boron content of leaf after spray.

Table 2: Effect of soil and foliar application of multimicronutrient on nutrients content of leaf after spray of mango var. Amrapali

Sr. no.	Treatments	Iron (mg kg^{-1})	Manganese (mg kg^{-1})	Zinc (mg kg^{-1})	Copper (mg kg^{-1})	Boron (mg kg^{-1})
Soil application (S)						
S_1	Control	520.42	124.81	156.46	39.09	274.17
S_2	200 g/tree multimicronutrient (Grade-V)	553.35	129.61	163.35	40.97	258.57
S_3	400g/tree multimicronutrient (Grade-V)	561.78	134.66	170.06	41.52	238.07
S.Em. ±		23.77	5.21	6.72	1.72	10.56
C.D. at 5%		NS	NS	NS	NS	NS
Foliar application (F)						
F_1	Control	423.33	98.73	109.88	22.00	234.64
F_2	1% Spray of multimicronutrient (Grade-IV)	576.37	125.54	161.30	41.02	273.01
F_3	2% Spray of multimicronutrient (Grade-IV)	635.85	164.81	218.70	58.56	263.16
S.Em. ±		23.77	5.21	6.72	1.72	10.56
C.D. at 5%		71.26	15.62	20.15	5.15	NS
S × F interaction						
S.Em.±		41.17	9.02	11.64	2.97	18.29
C.D. at 5%		NS	NS	NS	NS	NS
C.V. %		13.08	12.05	12.34	12.73	12.33

Conclusion

From the above results it can be concluded that three spray each of 1% multimicronutrient (Grade-IV) at flower bud initiation, at full bloom stage and at pea stage recorded maximum total soluble sugar, reducing sugar, non-reducing sugar, total sugar, ascorbic acid, shelf life and minimum aicdity of mango fruits var. Amrapali. Whereas nutrient content of leaf after spray were recorded maximum under the treatment of 2% multimicronutrient (Grade-IV).

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