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Influence of foliar application of micro nutrients on chemical characteristics of Mango (*Mangifera indica* L.) cv. Amrapali

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Abstract
The present investigation "Influence of foliar application of micro nutrients on chemical characteristics of Mango (*Mangifera indica* L.) cv. Amrapali" was conducted at Main Experiment Station, Department of Horticulture, Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) during the year 2017-2018. The experiment was conducted in Randomized Block Design with eight treatments *i.e.* Control (water spray), $ZnSO_4$ 1%, $FeSO_4$ 1%, Borax 0.5%, $ZnSO_4$ 1% + $FeSO_4$ 1%, $ZnSO_4$ 1% +Borax 0.5%, $FeSO_4$ 1% + Borax 0.5% and $FeSO_4$ 1% +$ZnSO_4$ 1% + Borax 0.5% in three replications and considering one plants as a unit. The observations were recorded for chemicals attributes of mango fruit. The maximum number of fruits per shoot, fruit retention per cent, fruit yield (kg/tree), and minimum fruit drop were recorded with the application of $FeSO_4$ 1% +$ZnSO_4$ 1% + Borax 0.5% followed by $ZnSO_4$ 1% +Borax 0.5%. All the chemical characters were influenced by foliar spray of $ZnSO_4$ 1%, $FeSO_4$ 1%, Borax 0.5%, $ZnSO_4$ 1% + $FeSO_4$ 1%, $ZnSO_4$ 1% +Borax 0.5%, $FeSO_4$ 1% + Borax 0.5%, $FeSO_4$ 1% +$ZnSO_4$ 1% + Borax 0.5% in alone. The fruit length, width, fruit weight, volume, pulp weight, stone weight, pulp stone ratio were recorded maximum with the foliar application of $FeSO_4$ 1% +$ZnSO_4$ 1% + Borax 0.5% followed by $ZnSO_4$ 1% +Borax 0.5%. The maximum TSS, ascorbic acid, total sugars and minimum acidity content were observed with the foliar application of $FeSO_4$ 1% +$ZnSO_4$ 1% + Borax 0.5% followed by $ZnSO_4$ 1% +Borax 0.5%.

Keywords: foliar, micro nutrients, chemical characterstics, mango, amrapali

Introduction
The mango (*Mangifera indica* L.) is a considered to be the king of fruit. It is, undoubtedly, one of the choicest and most ancient fruits known to mankind. In India, it has always been a prized and favourite fruit throughout the recorded history of the country. The fruit not only finds a prominent mention in the old Sanskrit literature but almost all the foreigners, right from the Chinese pilgrims who travelled here in Seventh Century A.D. down to the modern writers, have spoken in glowing terms about this fruit. During the Mughal rule, mango was honoured with a real patronage. The well-known Lakh Bagh, known to be stocked with 1,00,000 mango tree, was planted near Darbhanga in Bihar state by Akbar. Some mango orchards planted during that period notable the Shalimar Garden of Lahore and Mughal Gardens at Pinjore near Chandigarh are still preserved and bear testimony to the high esteem this fruit enjoyed in the past. The mango occupies the same position in the tropical and sub-tropical regions, which in enjoyed by the apple in temperate region.
Several authorities have testified to the origin of mango in the Indo Burma region, where it has been in cultivation for at least 4000 years. This fruit has become deeply interwoven with religious rites and folklore of the inhabitants of this country due to its antiquity, popularity, and usefulness. It is a fruit par excellence for millions of people in the Orient, especiclly those in India. The mango which combine utility with beauty has the status of the national tree of India and is very rightly considered King among fruits grown in the country.

Materials & Methods
The present investigation "Effect of foliar application of micro nutrients on yield and quality of Mango (*Mangifera indica* L.) cv. Amrapali" was carried out at Main Experiment Station Horticulture, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) during the year 2017.

25 years old Uniform mango plants, planted at a distance of 2.5x 2.5 meters were used as experimental material in the present investigation. All the schedule based cultural practices were followed as per recommendations. The experiment was laid out in Randomized Block Design (R.B.D.) with 3 replications in the month of January, 2017. Two plants were taken as unit per treatment.

Chemical characters of fruit

1. Total Soluble Solids

The perusal of data presented in Table 1 indicated that the total soluble solids (TSS) content in ripe mango fruit pulp was significantly influenced by all treatments over control (T_1). The highest T.S.S (21.00^0 Brix) was observed with T_8 consist of foliar spray of $FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% followed by T_6 ($ZnSO_4$ 1%+ Borax 0.5%) and T_7 ($FeSO_4$ 1% + Borax 0.5%) which also improved the T.S.S. content appreciably over rest of the treatments. The lowest T.S.S content (17.21^0 Brix) was obtained in control (T_1).

Table 1: Effect of foliar spray of nutrients on Total Soluble Solids content.

Treatments	Total Soluble Solids (^{0}Brix)
T_1 : Control (Water spray)	17.21
T_2 : $ZnSO_4$ 1%	19.82
T_3 : $FeSO_4$ 1%	17.66
T_4 : Borax 0.5%	18.32
T_5 : $ZnSO_4$ 1% + $FeSO_4$ 1%	18.19
T_6: $ZnSO_4$ 1% + Borax 0.5%	20.83
T_7 : $FeSO_4$ 1% + Borax 0.5%	20.47
T_8 : $FeSO_4$ 1%+ $ZnSO_4$ 1% + Borax 0.5%	21.00
S. Em ±	0.10
CD at 5%	0.30

2. Acidity

The data presented in Table 2 showed the variation in per cent acidity in fruit pulp of mango cv. Amrapali. A perusal of data showed significant reduction of acidity in all the treatments in comparision to control. The minimum fruit acidity (0.135%) was recorded with the spray of $FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% followed by T_6 with $ZnSO_4$ 1%+ Borax 0.5%. The maximum (0.186%) acidity was recorded in control (T_1).

Table 2: Effect of foliar spray of nutrients on fruit acidity.

Treatments	Acidity per cent
T_1 : Control (Water spray)	0.186
T_2 : $ZnSO_4$ 1%	0.159
T_3 : $FeSO_4$ 1%	0.181
T_4 : Borax 0.5%	0.167
T_5 : $ZnSO_4$ 1% +$FeSO_4$ 1%	0.173
T_6: $ZnSO_4$ 1% +Borax 0.5%	0.143
T_7 : $FeSO_4$ 1% +Borax 0.5%	0.156
T_8 : $FeSO_4$ 1%+ $ZnSO_4$ 1% +Borax 0.5%	0.135
S. Em ±	0.00
CD at 5%	0.01

3. Ascorbic acid (mg/100 g pulp)

Ascorbic acid content of fruit was determined according to the method described in A.O.A.C. (1975). It is evident from data presented in Table 3 that the ascorbic acid content in pulp was considerably influenced by the foliar application of different micro-nutrients. All the treatments significantly increased the ascorbic acid content. The highest ascorbic acid content (31.01 mg/100g pulp) was obtained with the foliar spray of $FeSO_4$ 1%+ $ZnSO_4$ 1% +Borax 0.5% followed by T_6 ($ZnSO_4$ 1% +Borax 0.5%) which were found significantly at par. However, lowest ascorbic acid (25.97 mg/100g pulp) was estimated under control (T_1).

Table 3: Effect of foliar spray of nutrients on ascorbic acid content.

Treatments	Ascorbic acid (mg/100 g pulp)
T_1 : Control (Water spray)	25.97
T_2 : $ZnSO_4$ 1%	29.35
T_3 : $FeSO_4$ 1%	26.43
T_4 : Borax 0.5%	28.47
T_5 : $ZnSO_4$ 1% +$FeSO_4$ 1%	27.12
T_6: $ZnSO_4$ 1% +Borax 0.5%	30.87
T_7 : $FeSO_4$ 1% + Borax 0.5%	30.29
T_8 : $FeSO_4$ 1% + $ZnSO_4$ 1% + Borax 0.5%	31.01
S. Em ±	0.08
CD at 5%	0.25

4. Reducing sugars

It is apparent from the data presented in Table4 that maximum reducing sugar content (2.70%) was obtained in T_8 by foliar spray of $FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% followed by T_6 $ZnSO_4$ 1% +Borax 0.5%. The lowest (2.09%) reducing sugar was recorded under control (T_1). Borax @ 0.5% alone was also effective to increase reducing sugar per cent in fruit. The treatments T_8, T_7, T_4 and T_5 were found significantly at par.

Table 4: Effect of foliar spray of nutrients on reducing sugars.

Treatments	Reducing sugars (%)
T_1 : Control (Water spray)	2.09
T_2 : $ZnSO_4$ 1%	2.44
T_3 : $FeSO_4$ 1%	2.15
T_4 : Borax 0.5%	2.35
T_5 : $ZnSO_4$ 1% + $FeSO_4$ 1%	2.22
T_6 : $ZnSO_4$ 1% +Borax 0.5%	2.57
T_7 : $FeSO_4$ 1% + Borax 0.5%	2.51
T_8 : $FeSO_4$ 1%+ $ZnSO_4$ 1% + Borax 0.5%	2.70
S. Em ±	0.16
CD at 5%	0.49

5. Non-reducing sugar

Data with respect to non-reducing sugar was presented in Table- 5 clearly indicated that all nutrients and their combination were found effective to increase non-reducing sugars in mango fruit. The maximum non-reducing sugar (14.80%) was recorded in T_8 with foliar spray of $FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% in T_8 followed by $ZnSO_4$ 1% +Borax 0.5% in T_6 which were found significantly at par. The minimum non-reducing sugar (11.49%) was recorded under control (T_1).

Table 5: Effect of foliar spray of nutrients on non-reducing sugar.

Treatments	Non reducing sugar (%)
T_1 : Control (Water spray)	11.49
T_2 : $ZnSO_4$ 1%	13.79
T_3 : $FeSO_4$ 1%	12.10
T_4 : Borax 0.5%	13.32
T_5 : $ZnSO_4$ 1% + $FeSO_4$ 1%	12.99
T_6 : $ZnSO_4$ 1% + Borax 0.5%	14.52
T_7 : $FeSO_4$ 1% + Borax 0.5%	14.23
T_8 : $FeSO_4$ 1% +$ZnSO_4$ 1%+ Borax 0.5%	14.80
S. Em ±	0.16
CD at 5%	0.49

6. Total sugars

An examination of data regarding total sugars content of fruit

in, pulp presented Table 6 clearly showed that spraying of micro-nutrients were markedly increased the total sugars content over control.

Table 6: Effect of foliar spray of nutrients on total sugars.

Treatments	Total sugars (%)
T_1 : Control (Water spray)	13.58
T_2 : $ZnSO_4$ 1%	16.23
T_3 : $FeSO_4$ 1%	14.25
T_4 : Borax 0.5%	15.67
T_5 : $ZnSO_4$ 1% +$FeSO_4$ 1%	15.21
T_6: $ZnSO_4$ 1%+ Borax 0.5%	17.09
T_7 : $FeSO_4$ 1%+ Borax 0.5%	16.74
T_8 : $FeSO_4$ 1%+ $ZnSO_4$ 1% + Borax 0.5%	17.50
S. Em ±	0.08
CD at 5%	0.24

The maximum total sugar (17.50%) was obtained with the foliar application of $FeSO_4$ 1% +$ZnSO_4$ 1%+ Borax 0.5% in T_8. This was closely followed by $ZnSO_4$ 1%+ Borax 0.5% and minimum total sugar (13.58%) was estimated under control (T_1).

Summary & Conclusion

Maximum accumulation of total soluble solids (TSS) content in mango fruits was recorded with spray of T_8 ($FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5%), while minimum total soluble solids (TSS) was obtained with the control shown in Table 4.12 and fig. 4.12 Total Soluble Solids content of fruit may be uncreased due to fact that nutrients have played an important role in photosynthesis which ultimately lead to the accumulation of carbohydrates and attributed to increased TSS of mango fruit. The adequate amount of zinc improved the auxin content and it also acted as catalyst in oxidation process. Increase in the Total Soluble Solids may be because of more carbon assimilation promoted by application of boric acid. The results are in closed conformity with the finding of Yadav *et al.* (2004) obtained maximum TSS^{0}Brix with foliar spray of GA_3 (15, 30 and 45 ppm), zinc (0.2%, 0.4%, 0.6%) and Iron (0.2%, 0.4%, 0.6%) along with control on chemical characteristics in ber fruits cv. Banarasi. Vashistha *et al.* (2010) obtained maximum Total Soluble Solid with the foliar application of urea @ 1%+ZnSO4 @ 0.4%+Borax @ 0.4% Bakshi *et al.* (2013)obtained maximum TSS ^{0}Brix of strawberry cv. Chandler with the foliar application of 0.6% $ZnSO_4$. Whereas minimum TSS was noted with water spray (control) in mango fruit (*Mangifera indica* L.) cv. Amrapali.

The data on acid content of fruits was presented in Table 2. A perusal of data showed significant reduction of fruit pulp acidity in all the treatments in compression to the control. The use of different treatments significantly influence the acidity percentage in mango fruits. The minimum acidity percentage was noted in T_8 with the foliar application of $FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5%, whereas, maximum was noted in control treatment. Acidity of fruit decrease with the foliar application of nutrients, might be due to increase in translocation of carbohydrates and increase metabolic conversion from acidity to sugar by the reaction involving reversal of glycolytic way path used in respiration or both simultaneously. The per cent acidity was reduced with nutrients treated fruits, which might be due to early ripening induced by the nutrient spray during which degradation of acid might have occurred. The similar results were also reported by Hasan and Jana (2000) [4] found significant reduce the acidity content in litchi cv. Bombai with foliar application of $ZnSO_4$ @ 1.0% and Pal *et al.* (2008) [13] noted less acidity of fruit in guava cv. Sardar with foliar application of urea (1.0%, 2.0%), potassium (0.5%, 1.0%), Borax (0.1%, 0.2%) and $ZnSO_4$ (0.2%, 0.4%).

The effect of foliar spray of nutrients on ascorbic acid content have been evident from data presented in Table 3 clearly indicated that ascorbic acid content was significantly influenced by different micro-nutrients spraying as compared to control. Significantly the maximum amount of ascorbic acid was found with the foliar spray of T_8 ($FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5%), whereas, minimum was recorded with control. The increased ascorbic acid content of fruit juice was due to increased synthesis of catalytic activity by enzyme and coenzyme, which are represented the ascorbic acid synthesis. The adequate amounts of zinc improve the auxin content and it also acted as catalyst in oxidation process. These findings are closely confirmed the results of a significant improvement in ascorbic acid content by Singh and Maurya (2003) noted greatest ascorbic acid content from mango cv. Mallika with foliar application of $ZnSo_4$ @0.4%, $FeSO_4$ @ 0.4%, $MgSO_4$ @ 0.2% and Boric acid @ 0.2% and also Rajak *et al.* (2010) noted maximum response in mango cv. Amrapali in ascorbic acid content (mg/100 g pulp) with foliar spray of $ZnSO_4$ @ 0.6% and Borax @ 0.8%.

The similar pattern in respect to total sugars content was also noted for increase total sugars content in mango fruit as influenced by different treatments presented in Table-4, Table-5 and Table-6. The highest reducing sugars, non-reducing sugar and total sugar content was recorded with the spray of T_8 ($FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5%), and minimum was recorded in control. The increased in sugar per cent may be due to involment of micronutrients in the translocation of more sugar to the fruits. It has been reported that there is a greater conversion of starch into sugar (source to sink) in the presence of these nutrients. The results are confirmed by the finding of Ghosh and Besrai (2000) obtained maximum total sugars in sweet orange cv. Mosambi with foliar spray of Boron @ 0.2% Zinc, @ 0.5% and iron @ 0.4% and also Bhowmick *et al.* (2012) noted maximum total sugars and non-reducing sugar with the application of $ZnSO_4$ @1.0% in mango cv. Amrapali.

Conclusion

The maximum total soluble solids was noted with the application of T_8 -$FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% followed by T_6 -$ZnSO_4$ 1%+ Borax 0.5% in mango fruit.

The minimum acidity percentage was noted under T_8 -$FeSO_4$ 1%+ $ZnSO_4$ %+Borax 0.5% followed by T_6 -$ZnSO_4$ 1%+ Borax 0.5% in mango fruit and maximum with water spray.

The maximum ascorbic acid content was recorded with the use of T_8 -$FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% followed by T_6 -$ZnSO_4$ 1%+ Borax 0.5% and minimum with water spray in mango fruit.

The highest reducing sugars content was obtained with the foliar application of T_8 -$FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% followed by T_6 -$ZnSO_4$ 1%+ Borax 0.5%and minimum with water spray in mango fruit.

The highest non-reducing sugar content was obtained with the foliar application of T_8 -$FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% followed by T_6 -$ZnSO_4$ 1%+ Borax 0.5% and minimum with water spray in mango fruit.

The highest total sugar content was obtained with the foliar application of T_8-$FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% followed by T_6-$ZnSO_4$ 1%+ Borax 0.5% and minimum with water spray in mango fruit.

Based on the present investigation it can be concluded that foliar application of $FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% from the overall experimental finding was proved to be mass effective to decrease fruit drops, increase fruit retention, fruit yield (kg/tree), physico-chemical attributes of fruit viz. fruit length, fruit width, fruit volume, fruit weight, pulp weight, stone weight, pulp: stone ratio, total soluble solids, ascorbic acid (Vitamin C), reducing sugars, non-reducing sugar, and maximum total sugars besides, acidity in the fruit was drastically reduced. Therefore, foliar application of $FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5% at panicle initiation and at pea stage can be recommended to mango growers of eastern Uttar Pradesh for higher fruit yield and better quality traits.

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