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Effect of foliar application of micronutrients on yield attributes, yield and chemical characters of mango (*Mangifera indica* L.) cv. Amrapali

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Abstract
An experiment on "Effect of foliar application of micronutrients on yield and Chemical characters of Mango (*Mangifera indica* L.) cv. Amrapali " was conducted at Main Experiment Station, Department of Horticulture, Post Graduate College Ghazipur (U.P.) during the year 2020-2024. 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 yield, Physical and chemical attributes of mango fruit. Maximum 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 physico-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, and fruit weight 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%.

Keywords: Foliar application, micronutrients, yield attributes, yield, chemical, *Mangifera indica* L

Introduction

India is the world's top mango producer, contributing 44% of the crop worldwide. There are promising opportunities to establish a thriving export business for this fruit, as well as its byproducts, such as bottled mango juice and canned mango slices, to other nations. As of right now, mangoes are exported to around 20 countries, while its goods are shipped to more than 40. The current outcome, though, is far too little. Thus, through the export of fresh mangoes and mango products, mango can bring in a sizable amount of foreign cash for India. Large areas exist where the cultivation of this desirable fruit could be explored and expanded in a way that is both profitable and beneficial. Numerous tropical, subtropical, and temperate fruit crops have demonstrated the effectiveness of micronutrients in promoting fruit set growth and development, controlling fruit drops, promoting fruit maturation and quality, and overcoming physiological and nutritional disorders. For the ovule to mature properly, the pollen tube to enlarge, and the number of fruit sets to rise, boron is essential. It facilitates calcium absorption and promotes effective calcium usage in plants. It also aids in the production of proteins. Boron affects a variety of plant processes, including hormone transport, the absorption of activated salts, flowering and fruiting processes, and pollen germination. Because of its effects on the directionality of pollen tube formation, it appears to be crucial for obtaining a satisfactory fruit set. [12] The "Costate" persimmon had an increase in fruit weight as a result of boric acid foliar spraying. Processes include protein synthesis, sugar transport, and carbohydrate metabolism involving the element boron. Fruit development and growth depend significantly on zinc. It is helpful for photosynthetic activity because it is one of the components needed to make chlorophyll. Zinc has an early and distinct impact on protein synthesis, nucleic acid metabolism, and cell division. It is a cofactor for more than 300 enzymes and proteins. Being involved in numerous enzymatic activities, it is a crucial trace element for plants and is required for healthy growth and development. Moreover, zinc controls how proteins and carbohydrates are metabolized. Furthermore, when zinc sulphate was administered foliarly rather than soil-wise, mango plants absorbed zinc at a higher rate. The benefits of zinc applied topically in boosting mango yield and enhancing fruit quality in terms of TSS and total sugars were mentioned. When it comes to the development of flavoprotein, iron is crucial. Improved Fe poly flavonoid activity promotes pigment production, including that of carotenoids and xanthophylls. Iron has a role in redox processes, or the transfer of electrons, which include cytochromes. During electron transfer, it oxidizes reversibly from Fe2+ to Fe3+ in this capacity. In the synthesis of numerous enzymes, including chlorophyll, iron serves as a catalyst. It is essential to several respiration, photosynthesis, and nitrate and sulphate reduction reactions.

Materials and Methods

The present investigation entitled "Effect of foliar application of micronutrients on yield and quality of mango (*Mangifera indica* L.) cv. Amrapali" was carried out at the Main Experiment Station, Department of Horticulture, P.G. College Ghazipur, under Veer Bahadur Singh Purvanchal University Jaunpur (U.P.) during the year 2020 -2024. The experimental participants in this study were 16-year-old, uniform mango plants that were separated by 2.5 × 2.5 m. In order to examine the effects of these treatments on the yield attributing characteristics, yield, and chemical characteristics of the Amrapali variety of mango, eight treatments total-seven micronutrients-were tested in a randomized block design with three replications: $ZnSO_4$ 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% along with the control. Fruit length, fruit width, fruit volume, fruit stone weight, pulp weight, pulp stone ratio, fruit drop, and fruit quantity per shoot are all noted.

Results and Discussion

A. Yield Attributes and yield of mango

Tables -1, -2, -3, and 4 show the weight, pulp weight, stone weight, and ratio of the mango fruit. These measurements clearly show that the application of T_8 ($FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5%) was found to be significant and increased all these parameters. The control group followed the recommended minimum pulp weight. The weight growth may be due to an increase in the absorption of water and nutrients, as well as an expansion of the intercellular spaces in the pulp. These kinds of outcomes align with the reported by Vejendla *et al*. (2008) [10], who showed that spraying $ZnSO_4$ at 0.75% increased pulp (71.90%) in mango cv. Amrapali. and also, Moazzam *et al*. (2011) [5] observed that foliar application of 0.4% $FeSO_4$ + 0.8% H_3BO_3 + 0.8% $ZnSO_4$ resulted in maximum pulp weight and less stone weight compared to control.

Table 1: Effect of foliar spray of nutrients on fruit weight.

Treatments	Fruit weight (g)		
	2021-22	2022-23	Average
T_1: Control (Water spray)	142.19	144.01	143.1
T_2: $ZnSO_4$ 1%	165.18	167.3	166.24
T_3: $FeSO_4$ 1%	155.08	157.07	156.075
T_4: Borax 0.5%	163.48	165.58	164.53
T_5: $ZnSO_4$ 1% + $FeSO_4$ 1%	158.25	160.28	159.265
T_6: $ZnSO_4$ 1% + Borax 0.5%	189.48	191.91	190.695
T_7: $FeSO_4$ 1% + Borax 0.5%	173.99	176.23	175.11
T_8: $FeSO_4$ 1% + $ZnSO_4$ 1%+ Borax 0.5%	201.05	203.64	202.345
S.Em ±	4.233	3.814	4.0235
CD at 5%	12.84	11.569	12.2045
CV	4.349	3.869	4.109

Table 2: Effect of foliar spray of nutrients on pulp weight.

Treatments	Pulp weight (g)		
	2021-22	2022-23	Average
T_1: Control (Water spray)	91.53	91.89	91.71
T_2: $ZnSO_4$ 1%	111.47	111.91	111.69
T_3: $FeSO_4$ 1%	96.94	97.32	97.13
T_4: Borax 0.5%	103.19	103.6	103.395
T_5: $ZnSO_4$ 1% + $FeSO_4$ 1%	100.41	100.8	100.605
T_6: $ZnSO_4$ 1% + Borax 0.5%	125.75	126.25	126
T_7: $FeSO_4$ 1% + Borax 0.5%	117.81	118.27	118.04
T_8: $FeSO_4$ 1% + $ZnSO_4$ 1%+ Borax 0.5%	132.84	133.36	133.1
S. Em ±	2.616	2.437	2.5265
CD at 5%	7.934	7.391	7.6625
CV	4.119	3.822	3.9705

Table 3: Effect of foliar spray of nutrients on stone weight.

Treatments	Stone weight (g)		
	2021-22	2022-23	Average
T_1: Control (Water spray)	24.58	24.85	24.715
T_2: $ZnSO_4$ 1%	26.28	26.57	26.425
T_3: $FeSO_4$ 1%	25.33	25.62	25.475
T_4: Borax 0.5%	25.72	26.01	25.865
T_5: $ZnSO_4$ 1% + $FeSO_4$ 1%	25.31	25.6	25.455
T_6: $ZnSO_4$ 1% + Borax 0.5%	28.68	29	28.84
T_7: $FeSO_4$ 1% + Borax 0.5%	28.22	28.54	28.38
T_8: $FeSO_4$ 1% + $ZnSO_4$ 1%+ Borax 0.5%	29.1	29.42	29.26
S. Em ±	0.586	0.657	0.6215
CD at 5%	1.778	1.992	1.885
CV	3.809	4.22	4.0145

Table 4: Effect of foliar spray of nutrients on pulp: stone ratio

Treatments	Pulp: stone ratio		
	2021-22	2022-23	Average
T_1: Control (Water spray)	3.72	3.7	3.71
T_2: $ZnSO_4$ 1%	4.24	4.21	4.225
T_3: $FeSO_4$ 1%	3.83	3.8	3.815
T_4: Borax 0.5%	4.01	3.98	3.995
T_5: $ZnSO_4$ 1% + $FeSO_4$ 1%	3.97	3.94	3.955
T_6: $ZnSO_4$ 1% + Borax 0.5%	4.38	4.35	4.365
T_7: $FeSO_4$ 1% + Borax 0.5%	4.17	4.14	4.155
T_8: $FeSO_4$ 1% + $ZnSO_4$ 1%+ Borax 0.5%	4.56	4.53	4.545
S. Em ±	0.091	0.089	0.09
CD at 5%	0.277	0.271	0.274
CV	3.843	3.794	3.8185

Table 5: Effect of foliar spray of nutrients on fruit yield.

Treatments	Fruit yield(kg/tree)		
	2021-22	2022-23	Average
T_1: Control (Water spray)	17.4	17.73	17.565
T_2: $ZnSO_4$ 1%	23.33	23.78	23.555
T_3: $FeSO_4$ 1%	18.59	18.95	18.77
T_4: Borax 0.5%	21.87	22.29	22.08
T_5: $ZnSO_4$ 1% + $FeSO_4$ 1%	21.19	21.6	21.395
T_6: $ZnSO_4$ 1% + Borax 0.5%	24.54	25.02	24.78
T_7: $FeSO_4$ 1% + Borax 0.5%	23.78	24.24	24.01
T_8: $FeSO_4$ 1% + $ZnSO_4$ 1%+ Borax 0.5%	25.24	25.73	25.485
S. Em ±	0.525	0.488	0.5065
CD at 5%	1.593	1.481	1.537
CV	4.136	3.733	3.9345

B. Chemical character of fruit

The maximum accumulation of total soluble solids (TSS) content in mango fruits was created by a T_8 total soluble solids content spray ($FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5%), whereas the control, as shown in Table 6, produced the lowest TSS content. It's possible that the fruit's total soluble solids (TSS) content rose because nutrients were needed for photosynthesis, which produced an accumulation of carbohydrates. This particularly applies to mango fruit. A suitable amount of zinc acted as a catalyst for the oxidation process and increased the auxin level. The increase in total soluble solids may have resulted from increased carbon absorption prompted by the injection of boric acid.

Table 6: Effect of foliar spray of nutrients on Total Soluble Solids content.

Treatments	Total Soluble Solids (0Brix)		
	2021-22	2022-23	Average
T_1: Control (Water spray)	17.31	17.35	17.33
T_2: $ZnSO_4$ 1%	19.94	19.98	19.96
T_3: $FeSO_4$ 1%	17.77	17.8	17.785
T_4: Borax 0.5%	18.43	18.47	18.45
T_5: $ZnSO_4$ 1% + $FeSO_4$ 1%	18.3	18.34	18.32
T_6: $ZnSO_4$ 1% + Borax 0.5%	20.95	21	20.975
T_7: $FeSO_4$ 1% + Borax 0.5%	20.59	20.63	20.61
T_8: $FeSO_4$ 1% + $ZnSO_4$ 1%+ Borax 0.5%	21.13	21.17	21.15
S. Em ±	0.478	0.434	0.456
CD at 5%	1.449	1.317	1.383
CV	4.287	3.887	4.087

Table 7: Effect of foliar spray of nutrients on fruit acidity.

Treatments	Acidity per cent		
	2021-22	2022-23	Average
T_1: Control (Water spray)	0.185	0.187	0.186
T_2: $ZnSO_4$ 1%	0.155	0.157	0.156
T_3: $FeSO_4$ 1%	0.18	0.182	0.181
T_4: Borax 0.5%	0.166	0.168	0.167
T_5: $ZnSO_4$ 1% + $FeSO_4$ 1%	0.172	0.174	0.173
T_6: $ZnSO_4$ 1% + Borax 0.5%	0.142	0.144	0.143
T_7: $FeSO_4$ 1% + Borax 0.5%	0.155	0.157	0.156
T_8: $FeSO_4$ 1% + $ZnSO_4$ 1%+ Borax 0.5%	0.134	0.136	0.135
S. Em ±	0.004	0.004	0.004
CD at 5%	0.011	0.012	0.0115
CV	3.972	4.307	4.1395

The results are in good agreement with those of Yadav *et al.* (2004) [11], they discovered that the highest TSS0Brix was produced by foliar spraying GA3 (1, 30 and 45 ppm), zinc (0.2%, 0.4%, 0.6%), and iron (0.2%, 0.4%, 0.6%) in conjunction with control on chemical characteristics in ber fruits cv. Banarasi. Vashistha *et al.* (2010) [9] achieved the maximum Total Soluble Solid by topically applying urea at 1%, $ZnSO_4$ at 0.4%, and borax at 0.4%. Bakshi *et al.* (2013) [1] topically administered 0.6% $ZnSO_4$ to the strawberry cultivar Chandler in order to get the highest TSS 0 Brix. Conversely, when treated with water spray (control), mango fruit (*Mangifera indica* L.) cv. Amrapali displayed the lowest TSS. Data on fruit acid content is provided in Table-7. Analysing the results showed that all treatments greatly decreased the fruit pulp's acidity when compared to the control. The different treatments applied have a significant impact on the amount of acidity present in mango fruits. T_8 displayed the lowest percentage of acidity with the foliar application of $FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5%, while the control treatment displayed the highest. Nutrients applied topically reduce the acidity of fruits. This event could be the result of a simultaneous increase in the translocation of carbohydrates and a metabolic conversion via the reversal of the glycolytic route used in respiration from acidity to sugar.

Table 8: Effect of foliar spray of nutrients on total sugars.

Treatments	Total sugars (%)		
	2021-22	2022-23	Average
T_1: Control (Water spray)	13.62	13.67	13.645
T_2: $ZnSO_4$ 1%	16.28	16.34	16.31
T_3: $FeSO_4$ 1%	14.29	14.35	14.32
T_4: Borax 0.5%	15.71	15.78	15.745
T_5: $ZnSO_4$ 1% + $FeSO_4$ 1%	15.25	15.31	15.28
T_6: $ZnSO_4$ 1% + Borax 0.5%	17.13	17.21	17.17
T_7: $FeSO_4$ 1% + Borax 0.5%	16.78	16.85	16.815
T_8: $FeSO_4$ 1% + $ZnSO_4$ 1%+ Borax 0.5%	17.54	17.62	17.58
S. Em ±	0.392	0.359	0.3755
CD at 5%	1.19	1.087	1.1385
CV	4.296	3.908	4.102

The percentage of acidity in fruits treated with nutrients was lower; this could be because the nutrient spray induced early ripening, which may have resulted in acid breakdown. Hasan and Jana (2000) [4] similarly documented similar findings, concluding that Litchi CV's acidity content had been considerably lowered. Bombai with 1.0% foliar $ZnSO_4$ and Pal *et al.* (2008) [6] observed reduced fruit acidity in guava cultivars. Sardar with urea (1.0%, 2.0%), potassium (0.5%, 1.0%), borax (0.1%, 0.2%), and $ZnSO_4$ (0.2%, 0.4%), applied topically. The data presented in Table 7 demonstrated the impact of foliar nutrition spraying on ascorbic acid content by clearly indicating that ascorbic acid content was significantly altered by various micro-nutrient spraying in comparison to control. Notably, the control group produced the least quantity of ascorbic acid, whereas the T_8 foliar spray (1% $FeSO_4$ + 1% $ZnSO_4$ + 0.5%) produced the most. Fruit juices had larger concentrations of ascorbic acid because they synthesized more catalytic activity from coenzymes and enzymes, which are typical of ascorbic acid production. Adequate zinc concentrations raise the auxin content and act as a catalyst for oxidation.

These findings are in good agreement with the findings of the Singh and Maurya (2003) [8] study, which concluded that the mango variety had the greatest ascorbic acid content and showed a significant increase in ascorbic acid content. Rajak *et al.* (2010) [7] used foliar treatment of $ZnSO_4$ @ 0.4%, $FeSO_4$ @ 0.4%, $MgSO_4$ @ 0.2%, and Boric acid @ 0.2% in Mallika to report the maximum response in mango cv. Amrapali with a topical application of 0.8% Borax and 0.6% $ZnSO_4$ in ascorbic acid content (mg/100 g pulp).

Comparable patterns in the increase in the mango fruit's overall sugar content were also seen in response to the different treatments, as indicated in Table-8. The highest reducing sugars, non-reducing sugars, and total sugar content were measured with the T_8 ($FeSO_4$ 1%+ $ZnSO_4$ 1%+ Borax 0.5%) spray; the lowest was found in the control. The potential reason for the rise in sugar percentage could be the involvement of micronutrients in the process of transferring additional sugar to the fruits. According to reports, when these nutrients are present, starch is converted more quickly into sugar (source to sink). The findings of Ghosh and Besrai (2000) [3], who found the largest total sugar content in the sweet orange CV, support the results. In addition, Bhowmick *et al*. (2012) [12] reported maximum total sugars and non-reducing sugar with the treatment of $ZnSO_4$ @ 1.0% in mango cv. Mosambi with foliar spray of Boron @ 0.2% Zinc @ 0.5%.

Conclusion

In conclusion, the application of T_8 ($FeSO_4$ 1% + $ZnSO_4$ 1% + Borax 0.5%) significantly enhanced the yield attributes and chemical characteristics of mango fruits. The treated fruits exhibited increased weight, pulp weight, and favorable stone-to-pulp ratios, likely due to improved nutrient and water absorption. Furthermore, T8 treatment resulted in the highest levels of total soluble solids (TSS), reduced acidity, and elevated ascorbic acid content compared to the control. These enhancements are attributed to the catalytic role of micronutrients in photosynthesis, carbohydrate metabolism, and early ripening processes. Overall, the study highlights the efficacy of micronutrient sprays in improving mango fruit quality and yield.

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