PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol x(x): xx–xx
https://doi.org/10.14719/pst.3913

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

Efficacy of foliar versus soil application of micronutrients on the production of mango (*Mangifera indica* L.)

Srividhya S[1], Thilagam P[2*], Venilla MA[3*], Geetha K[4*] & Aneesa Rani MS[5*]

[1]Associate Professor (Hort.), Horticultural College & Research Institute, Paiyur, –635 112, India
[2]Associate Professor (Agrl. Entomology), HC&RI, Paiyur-635112, India
[3]Associate Professor (Agrl Extension), Krishi Vigyan Kendra, Papparapatty-636809, India
[4]Professor (PBG), RRS, Paiyur-635112, India
[5]Nodal Officer, Horticultural College & Research Institute, Paiyur-635112, India

*Email: thilagamp@tnau.ac.in

OPEN ACCESS

ARTICLE HISTORY
Received: 28 May 2024
Accepted: 04 June 2024
Available online
Version 1.0 : 07 July 2024

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE

Srividhya S, Thilagam P, Venilla MA, Geetha K, Rani MSA. Efficacy of foliar versus soil application of micronutrients on the production of mango (*Mangifera indica* L.). Plant Science Today (Early Access). https://doi.org/10.14719/pst.3913

Abstract

Soil test-based fertilizer recommendations were calculated for mango @1.25:0.60:0.90kg N: P2O5:K2O per tree and were applied for all eight treatments as per schedule in the Randomized block design in an experimental field. The pooled analysis of the results revealed that the application of Soil test based recommended dose of fertilizer application after harvest + Soil application of $FeSO_4$@ 200g + $ZnSO_4$@ 200g + $MgSO_4$@ 100g +$CuSO_4$ @50g + Borax @50g + $MnSO_4$ @ 50g+ Foliar spray (twice) of $ZnSO_4$ (0.3%) + $FeSO_4$ (0.5%) + $CuSO_4$(0.2%) + Mg SO_4(0.5%) + Borax (0.2%) + $MnSO_4$ (0.2%) at pre-flowering and marble stage recorded the maximum individual fruit weight (592 g) and highest yield kg per tree (380) followed by the T_1 + IIHR micronutrients spray (twice) with yield per tree of 336 kg/tree while the control STCR based RDF alone after harvest recorded 193 kg/tree. The leaf nutrients were analyzed after sprays of the application of T_1 + Soil application of micronutrients + Foliar Spray of micronutrients (Twice) recorded the highest leaf nutrient status of Nitrogen 1.55%, Phosphorus 0.224% and Potassium 1.39% and the highest micronutrients in leaf Iron (131.80 ppm), Zinc (20.50 ppm), Copper (37.50 ppm) and Manganese (199.20 ppm) higher as above treatment while, the control recorded lower value of Iron (66.30 ppm), Zinc (9.40 ppm), Copper (31.70 ppm) and Manganese (114.20 ppm).

Keywords

bangalora; foliar application; fruit set; leaf micronutrients; mango; STCR; yield

Introduction

With a captivating flavor and rich in vitamins A and C, the mango (*Mangifera indica* L.) has reigned as the "King of Fruits" for millennia (1). Cultivated in India for over 4,000 years mango thrives in the tropical and subtropical regions. Mango originated in the Indo-Burma region. India produces 20.7 million tonnes of mangoes across 22.6 lakh thousand hectares. This amounts to an impressive productivity of 9.1 tonnes per hectare. Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar, Gujarat, and Tamil Nadu are the leading mango-growing states within the country. Within Tamil Nadu, Krishnagiri, Dharmapuri, Vellore, Dindigul, Thiruvallur, and Theni districts are particularly renowned for their mango production. Krishnagiri district in Tamil Nadu is a key player and holds the top spot for mango production, boasting over 54,000 hectares of cultivated land and harvesting a staggering

4.07 lakh tonnes of mangoes annually and the productivity is about 5.15 tonnes ha^{-1}. The important mango-cultivated areas in the Krishnagiri district are Pochampalli, Hosur, Uthangarai, and Denkanikottai. To be precise, Pochampalli ranks first in position in Krishnagiri district. The deliciously popular mango varieties in this district are Alphonso, Bangalora, Banganapalli, Sendura, Mulgoa, and Neelum. Mostly the cultivated variety is Bangalora which is used for pulping industry in Krishnagiri (2). About Forty percent of the total mango pulp production in the country is from Krishnagiri district (3). Popular varieties like Alphonso and Bangalora flourish here, with Bangalora being widely used for pulping.

Usually, the micronutrients are applied through foliar spray to correct the micronutrient deficiencies in smaller amounts to improve the fruit quality in mangoes. The micronutrients become readily available to the plants by the foliar application than the soil application (4). Many experiments have been conducted earlier on foliar spray of micro-nutrients in different varieties of mango (5). Micronutrient deficiencies are a major obstacle for mango growers in Tamil Nadu. Zinc, boron, and iron deficiencies, often hidden and undetected, can significantly limit crop productivity and fruit quality. Foliar application emerges as a powerful tool to combat these challenges. This method offers several advantages: lower application rates compared to soil application, ensuring a more uniform distribution of nutrients across the orchard, and a quicker response from the trees due to direct nutrient delivery to the leaves. Foliar application is particularly effective in addressing hidden micronutrient deficiencies before they become visible problems in an orchard. By incorporating this technique, mango growers in Tamil Nadu can effectively address micronutrient deficiencies, leading to healthier trees, improved fruit quality, and ultimately, increased yields. Fertilizer through drip provides direct placement of essential and required nutrition into the active root zone, thus not only minimizing losses of expensive nutrients but also improving crop productivity and quality of farm produce (6). Farmers mainly use macronutrients and are also mostly incorporated with farmyard manure. Farmers are not aware of the mango physiology and hence they apply the macro fertilizer or organic manures once during the rainy season and they are not scientifically aware of the micronutrient contribution to the mango trees. Soil application has to be a steady stream of nutrients for mango trees. By incorporating micronutrients into the soil, nutrient resource use efficiency is promoted. This sustained release is crucial for overall plant health and development. Foliar application, on the other hand, acts like a targeted micronutrient boost. By spraying micronutrient solutions directly onto the leaves, we deliver a quick and effective dose exactly where it's needed.

STCR in mango promotes targeted fertilizer application based on soil analysis, potentially reducing unnecessary fertilizer use and associated costs. Improve resource use efficiency by applying only the necessary amount of fertilizer, reducing costs and environmental impact. STCR offers a data-driven approach to nutrient management for mango growers. The application of foliar as well as soil micronutrients along with the STCR-based fertilizer placement will augment the flowering, fruit set, and bountiful yield which is the aim of the present study.

Materials and Methods

A field experiment was conducted at a farmer's field in Bomasandhram village on the "Studies on the effect of micronutrient application on the yield and quality of Mango (*Mangifera indica* L.) cv. Bangalora" during the year 2019 to 2021. Soil test-based fertilizer recommendations were estimated and calculated for mango @1.25:0.60:0.90kg N: P_2O_5: K_2O per tree which were applied for all the eight treatments after harvest of the mango fruits as per schedule in Randomized block design. Eight treatments are followed as T_1: STCR-based RDF after harvest, T_2: T_1 + Soil application of $FeSO_4$@ 200g + $ZnSO_4$@ 200g + $MgSO_4$@ 100g +$CuSO_4$ @50g + Borax @50g + $MnSO_4$ @ 50g, T_3: T_1 +Foliar spray (twice) of $ZnSO_4$ (0.3%) + $FeSO_4$ (0.5%) + $CuSO_4$(0.2%) + Mg SO_4(0.5%) + Borax (0.2%) + $MnSO_4$ (0.2%) at pre-flowering and marble stage, T_4: T_1 + Soil application of micronutrients + Foliar Spray of micronutrients (Once), T_5: T_1 + Soil application of micronutrients + Foliar Spray of micronutrients (Twice), T_6: T_1 + Foliar spray of Zinc EDTA (0.2%) + Iron EDTA (0.2%) twice at pre-flowering and marble stage, T_7: T_1 + Soil application of Zinc EDTA @ 100g + Iron EDTA @ 100g, T_8: T_1 + IIHR Arka mango special @ 5g/liter twice before and after flowering. The leaf macronutrient NPK content and micronutrients like Fe, Mn, Zn, and Cu were estimated. The leaf nutrient content was analyzed before and after the experiment. The flowering and yield parameters were recorded after the fruit set. The quality parameters like the total soluble solids content in the pulp, yield parameters, and statistical analysis were carried out.

The characteristics contributing to flowering namely the number of panicles per m^2 canopy area and panicle length were recorded after flowering. The number of panicles was counted per square meter area at four different locations on a tree with the help of a wooden frame with 1m × 1m dimension and the mean was expressed in numbers. The length of the panicle was measured with the help of scale and thread at the full bloom stage. It was measured from the point of emergence to the apex of the panicle. The yield contributing attributes *viz*., number of fruits per tree, fruit yield, fruit weight, fruit girth, pulp weight, peel weight, and stone weight, were recorded after the fruit set and the results are furnished below (Table 1). The total soluble solids content in the mango pulp was estimated using an 'ERMA hand refractometer (ERMA®, Japan). TSS Readings were recorded in °Brix. The chlorophyll index was recorded using a portable Chlorophyll Meter (Opti-science model, CCM-200 plus). The CCM 200 plus measures chlorophyll content optical absorbance of light at wavelengths of 653 nm (Chlorophyll) and 931 nm (Near Infra-Red). Five readings were taken from each replication and the average value was computed using the method described by (7) samples were analyzed for Nitrogen,

Phosphorus, Potassium, EC, PH, and organic carbon content before the commencement of the experiment.

Leaf sample collection: Leaf samples were collected from the standard four- to seven-month-old matured leaves with petiole from the middle of non-flowering shoots at random from each treatment during the bud break stage as suggested by (8). The samples were dried in the shade and then in an oven at 60°C for 3 hours. The dried leaves were finely powdered using a mixture cum grinder and kept for the analysis of leaf nitrogen, phosphorus, and potassium content. The nitrogen content in the leaf sample was estimated by the *Micro-Kjeldahl* method (9). The phosphorus content in the leaf sample was estimated by the Vanadomolybdate method (10). The potassium content in the leaf sample was estimated using a flame photometer in the triple acid extract by following a standard protocol (11) and the mean values were expressed in percentage. The total micronutrients like Fe, Mn, Zn, and Cu were estimated using the atomic absorption spectrophotometer (AAS) in the triple acid extract method (10). The treatment schedule was given for all the replication trees as pre-flowering sprays and soil application and also during the marble stage except for the control. Statistical analysis of data was done by adopting statistical procedures (12).

Results and Discussion

The pooled analysis data of flowering and yield characters from 2019 to 2021 on the flowering, fruiting, and yield characters significantly differed between the treatments as presented in Table 1 and Figure 1. The mango leaf nutrient status after the foliar spraying is estimated by the above procedures and is given in Table 2.

The pooled results revealed that the application of soil test-based recommended dose of fertilizer after harvest + Soil application of $FeSO_4$@ 200g + $ZnSO_4$@ 200g + $MgSO_4$@ 100g +$CuSO_4$ @50g + Borax @50g + MnSO4 @ 50g+ Foliar spray (twice) of $ZnSO_4$ (0.3%) + $FeSO_4$ (0.5%) + $CuSO_4$(0.2%) + Mg SO_4(0.5%) + Borax (0.2%) + $MnSO_4$ (0.2%) at pre-flowering and marble stage recorded the maximum length of the panicle (39.86cm) followed by the treatment T_8 with 38.23 cm. The lowest length of the panicle was observed in the control T_1 at 26.09 cm. Soil

Table 1: Pooled analysis of the effect of the application of micronutrients on the flowering and yield characteristics of the mango cv. Bangalora

Treatments	Length of panicle (cm)	Number of panicles/m²	Chlorophyll index	Fruit Length (cm)	Fruit Girth (cm)	Individual fruit weight (gm)	No. of fruits/ tree	Yield /tree (kg)	TSS °brix
T_1:Soil test based fertilizer recommendations after harvest	26.1	20.9	31.8	16.4	19.0	382	480	193	16.4
T_2: T_1 + Soil application of $FeSO_4$@ 200g + $ZnSO_4$@ 200g + $MgSO_4$@ 100g +$CuSO_4$ @50g + Borax @50g + MnSO4 @ 50g	29.0	25.7	32.9	18.9	20.8	418	509	212	18.0
T_3: T_1 +Foliar spray (twice) of $ZnSO_4$ (0.3%) + $FeSO_4$ (0.5%) + $CuSO_4$(0.2%) + Mg SO_4(0.5%) + Borax (0.2%) + MnSO4 (0.2%) at pre-flowering and marble stage,	30.4	28.9	35.9	20.6	23.0	461	585	251	17.9
T_4: T_1 + Soil application of micronutrients + Foliar Spray of micronutrients (Once)	31.4	31.4	38.3	21.3	24.6	503	579	292	18.7
T_5: T_1 + Soil application of micronutrients + Foliar Spray of micronutrients (Twice)	39.9	36.2	45.7	24.3	26.9	592	616	380	20.6
T_6: T_1 + Foliar spray of Zinc EDTA (0.2%) + Iron EDTA (0.2%) twice at pre-flowering and marble stage	35.2	30.6	34.1	23.1	25.2	487	581	281	18.9
T_7: T_1 + Soil application of Zinc EDTA @ 100g + Iron EDTA @ 100g	37.1	31.8	38.1	21.1	24.2	485	627	316	19.9
T_8: T_1 + IIHR Arka mango special @ 5g/liter twice before and after flowering	38.2	36.6	41.3	20.9	22.9	522	647	336	18.9
SEd	2.06	2.47	2.31	1.24	1.50	21.4	36.8	22.2	1.23
CD @5%	4.40	5.31	4.97	2.65	3.22	46.6	79.0	47.6	2.64

Table 2: Effect of micronutrient application on the Leaf NPK and micronutrient content in mango variety Bangalora

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
T1	0.97	0.145	0.87	66.3	9.40	114	31.7
T2	1.05	0.174	1.15	85.2	10.9	136	32.5
T3	1.12	0.204	1.15	97.5	14.2	158	33.5
T4	1.36	0.214	1.28	124	18.9	189	35.4
T5	1.55	0.224	1.39	132	20.5	199	37.5
T6	1.18	0.201	1.29	92.5	16.1	165	34.4
T7	1.19	0.185	1.22	85.6	13.2	155	35.7
T8	1.25	0.208	1.30	115	19.9	177	36.0
SEd	0.128	0.089	0.170	5.63	1.96	10.5	3.27
CD @5%	0.273	0.191	0.365	12.1	4.21	22.7	7.01

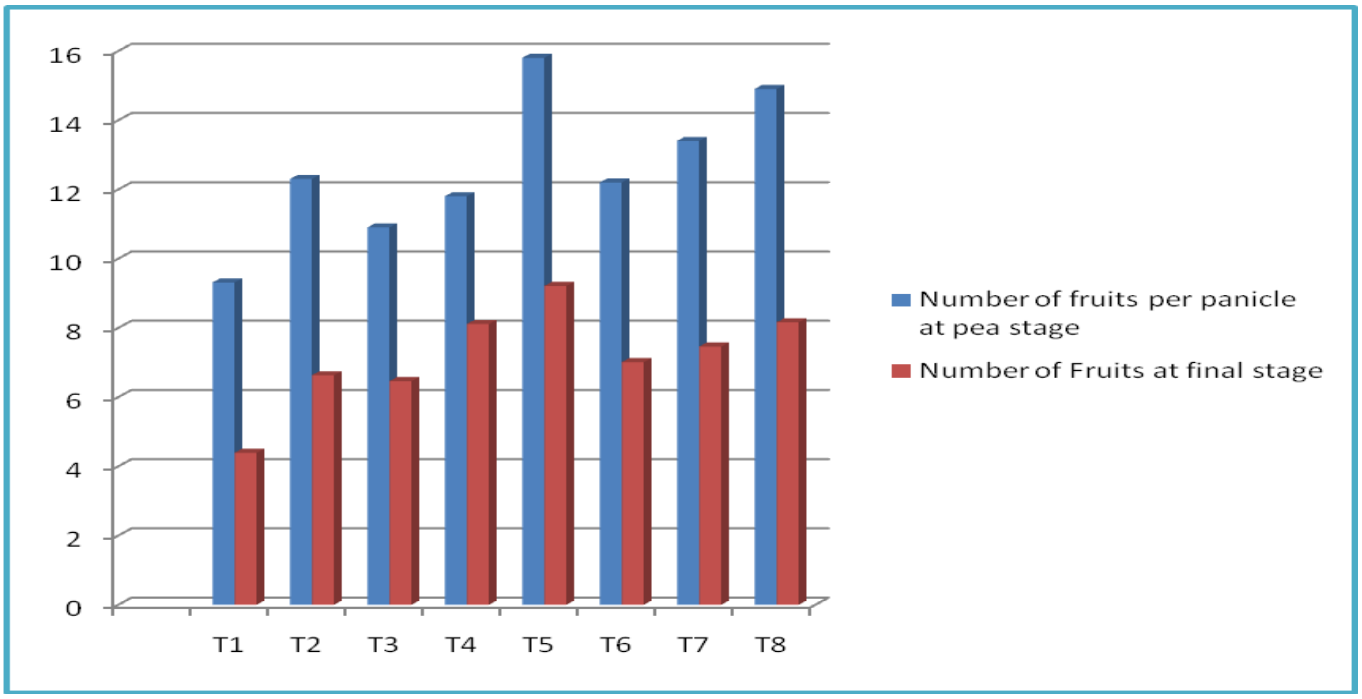

Figure 1 : Influence of soil and foliar application of micronutrients on fruit set at pea stage and final stage

test-based recommended dose of fertilizer application after harvest + Soil application of $FeSO_4$@ 200g + $ZnSO_4$@ 200g + $MgSO_4$@ 100g +$CuSO_4$ @50g + Borax @50g + MnSO4 @ 50g+ Foliar spray (twice) of $ZnSO_4$ (0.3%) + $FeSO_4$ (0.5%) + $CuSO_4$(0.2%) + Mg SO_4(0.5%) + Borax (0.2%) + MnSO4 (0.2%) at pre-flowering and marble stage recorded the maximum number of fruits per panicle at pea stage (15.8) on par with the treatment T_8 with 14.86. The lowest fruits per panicle at the pea stage was observed in the control T_1 with 9.30.

Soil test based recommended dose of fertilizer application after harvest + Soil application of $FeSO_4$@ 200g + $ZnSO_4$@ 200g + $MgSO_4$@ 100g +$CuSO_4$ @50g + Borax @50g + $MnSO_4$ @ 50g+ Foliar spray (twice) of $ZnSO_4$ (0.3%) + $FeSO_4$ (0.5%) + $CuSO_4$(0.2%) + Mg SO_4(0.5%) + Borax (0.2%) + MnSO4 (0.2%) at pre-flowering and marble stage recorded the maximum number of fruits per panicle at final stage (9.20) on par with the treatment T_4 with 8.11. The lowest fruits per panicle at the final stage was observed in the control T_1 with 4.38. The yield contributing characters like the length of the fruit and girth were highest in the same T_5 treatment with (24.28 cm), the girth of the fruit (26.87cm) followed by T_6 with STR-based RDF after harvest + foliar spray of Zinc EDTA (0.2%) + Iron EDTA (0.2%) twice at pre-flowering and marble stage with 23.12 and 25.22 cm respectively.

Soil test-based recommended dose of fertilizer application after harvest + Soil application of $FeSO_4$@ 200g + $ZnSO_4$@ 200g + $MgSO_4$@ 100g +$CuSO_4$ @50g + Borax @50g + MnSO4 @ 50g+ Foliar spray (twice) of $ZnSO_4$ (0.3%) + $FeSO_4$ (0.5%) + $CuSO_4$(0.2%) + Mg SO_4(0.5%) + Borax (0.2%) + MnSO4 (0.2%) at pre-flowering and marble stage had maximum Individual fruit weight (591.63g) and yield kg per tree (380.32) on par with the T_1 + IIHR Arka mango special @ 5g/liter twice before and after flowering with yield per tree of 336.40 kg/tree while the control STR based RDF after harvest recorded lowest yield of 193.40kg/tree.

Applying micronutrients alone or in combination directly to mango trees through foliar spraying can significantly influence their internal processes. This method impacts various physiological functions and enzyme activity within the tree. The benefits are twofold: improved photosynthesis and increased fruit retention. Zinc, involved in auxin synthesis, contributes to better photosynthesis, which in turn leads to greater starch accumulation in the developing fruits. Boron further enhances this process by aiding in the efficient transport of starch to the fruit. Additionally, foliar application influences auxin balance, a plant hormone crucial for regulating fruit drop. By promoting fruit retention, this method leads to a higher overall number of fruits per tree. In essence, foliar micronutrient application offers a powerful tool for mango growers, promoting both tree health and improved fruit production. Similar results were observed in (13) and (14) in mango and (15) (16).

Micronutrients, particularly zinc (Zn) which plays a vital role in auxin production, contribute to regulating fruit drop. By influencing hormonal balance within the tree, micronutrients help prevent premature fruit abscission, leading to a greater number of fruits reaching maturity and ultimately boosting yield. Beyond reducing fruit drop, micronutrients like zinc (Zn) and boron (B) also play a well-established role in promoting starch formation and its efficient transport within the plant. This enhanced metabolic activity leads to the development of larger, heavier fruits, further contributing to the overall yield increase. The bountiful increase in fruit yield (kg/tree) is a synergistic effect of an increase in number of fruits because of a reduction in fruit drop *vis-a-vis* higher fruit weight by the direct effect of foliar spray of micronutrients in mango cv. Bangalora. Promoting the starch formation followed by rapid transportation of carbohydrates in plants activated by micronutrients like Zinc and Boron is well established. Boron travels within the plant's phloem, a specialized transport system, using "filter plates" to

ensure it reaches developing areas like fruits. This targeted delivery strengthens the nuclear membrane within mango tree cells. It influences ribonucleic acid (RNA), the blueprint for protein production, potentially impacting how the tree utilizes sugars for growth and fruit development (17). By potentially aiding in sugar incorporation, Boron contributes to better fruit quality and yield. These findings are following the reports of (18) in Litchi and (19) in mango. It has been reported that a spray of Copper + Boron + Zinc was most effective in increasing the fruit weight & yield of mango (20). This study indicated that single chemical or chemical nutrients did not influence fruit yield. The results conform with those of (21), (22) and (23) in mango.

Soil test based recommended dose of fertilizer application after harvest + Soil application of $FeSO_4$@ 200g + $ZnSO_4$@ 200g + $MgSO_4$@ 100g +$CuSO_4$ @50g + Borax @50g + MnSO4 @ 50g+ Foliar spray (twice) of $ZnSO_4$ (0.3%) + $FeSO_4$ (0.5%) + $CuSO_4$(0.2%) + Mg SO_4(0.5%) + Borax (0.2%) + MnSO4 (0.2%) at pre flowering and marble stage had maximum TSS of 20.63°brix and lowest 16.48°brix in control T_1 soil test based recommended dose of fertilizer application. These observations were helped by the previous findings of various renowned workers (24), (19), (25). The enhancement in the quality of fruit could be due to the catalytic action of micronutrients particularly at higher concentrations. The micronutrients act like tiny catalysts within the plant, speeding up important chemical reactions. This could lead to better sugar production, richer flavor development, and more vibrant fruit colors.

Hence, holistic application methods like the foliar application and soil application of micronutrients quickly increased the uptake of macronutrients in the tissues and organs of the mango plants, decreased the nutritional deficiencies, and improved the fruit quality. The leaf nutrient status studies in mangoes provide valuable insights into the intricate relationship between a tree's internal chemistry and its ability to produce bountiful harvests. By utilizing this knowledge, mango growers can make informed decisions about nutrient management, ultimately unlocking the full potential of their orchards.

The leaf nutrient status was analyzed after the treatment sprays and results revealed that the application of T_1 + Soil application of micronutrients + Foliar Spray of micronutrients (Twice) recorded the highest leaf nutrient status of Nitrogen 1.55%, Phosphorus 0.224%, and Potassium 1.39%. The micronutrients like Iron, Zinc, Copper, and Manganese were analyzed by the atomic absorption spectrophotometer and the application of T_1 + Soil application of micronutrients + Foliar Spray of micronutrients (Twice) recorded maximum content of Iron (131.80 ppm), Zinc (20.50 ppm), Copper (37.50 ppm) and Manganese (199.20 ppm) and the control recorded least content of Iron (66.30 ppm), Zinc (9.40 ppm), Copper (31.7 ppm) and Manganese(114.20ppm)(5) also reported that the spray of Cu + B + Zn was most effective in increasing the fruit weight and yield of the mango.

Conclusion

The study concludes that an application of soil test-based recommended dose of fertilizer application after harvest + application of T_5 at pre-flowering and marble stage recorded the individual maximum fruit weight in (591.63g) and highest yield kg per tree (380.32) and recorded maximum leaf nutrient status of Nitrogen, Phosphorus, Potassium and micronutrient content of Iron, Zinc, Copper and Manganese while the control soil test based recommended dose of fertilizer application alone after harvest recorded only 193.40 kg/tree. The STCR-based fertilizer recommendations and micronutrients through the soil application and foliar sprays while at pre-flowering and marble stages recorded the maximum fruit characters, yield, and quality. The treatment findings help the mango farmers to get a bountiful harvest with ample leaf nutrient status and soil nutrients, which protects the overall health and sustainability of the mango orchards.

Acknowledgements

The authors thankfully acknowledge the research support rendered by the Regional Research Station, Paiyur, Tamil Nadu Agricultural University, and for the farmer Mr. M. D. Madhavan, Bommasandhram to render his farm for carrying out the research work in mango.

Authors' contributions

The authors mentioned in the research paper contributed to the research in way of layout, design, observations, lab analysis, and interpretation of the results to prepare the manuscript.

Compliance with ethical standards

Conflict of interest: The authors have declared that no conflict of interest exists.

Ethical issues: None.

References

1. De Candolle A. Origin of cultivated plants. D. Appleton;1885. https://doi.org/10.5962/bhl.title.29067
2. Palanivel V, Muthukumar CM, Gurusamy M. A study on cultivation and marketing of mangoes in Krisnagiri district. Int J Adv Eng Recent Tech. 2015;2:31-43.
3. Sengodi R. Fruit Processing Industries In Krishnagiri District: On Overview. International Journal of Innovative Research and Advanced Studies. 2016;3(4):67-74
4. Ling F, Silberbush M. Response of maize to foliar vs. soil application of nitrogen-phosphorus-potassium fertilizers. Journal of plant nutrition. 2002;25(11):2333-42. https://doi.org/10.1081/PLN-120014698
5. Nehete DS, Padhiar BV, Shah NI, Bhalerao PP, Kolambe BN, Bhalerao RR. Influence of micronutrient spray on flowering, yield, quality and nutrient content in leaf of mango cv. Kesar. Asian Journal of Horticulture. 2011; 6(1): 63-67
6. Kaleeswaran M, Senthivel T, Soundarapandian M. Study on consumer preference and marketing strategies of mango varieties

in western zone of Tamil Nadu. International Journal of Current Microbiology and Applied Sciences. International Journal of Current Microbiology and Applied Sciences. 2019;8(12):2448-57. https://doi.org/10.20546/ijcmas.2019.812.2882019;8(12):2448-57.

7. Monje OA, Bugbee B. Inherent limitations of nondestructive chlorophyll meters: a comparison of two types of meters. Hort Science.1992;27(1):69-71. https://doi.org/10.21273/hortsci.27.1.69
8. Bhargava BS, Chadha KL. Leaf nutrient guide for fruit crops. pp. 973-1030. In Advances in Horticulture - Fruit Crops. K.L. Chandha and O.P. Pareek. Malhotra Pub. House, New Delhi.1993
9. Humphries.Mineral components and ash analysis.Springer and Verlag.Berlin. 1956; 1:468-502. https://doi.org/10.1007/978-3-662-25300-7_17
10. Jackson ML. Soil chemical analysis, Pentice Hall of India Pvt. Ltd., New Delhi, India. 1973;498:151-4.
11. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay.1966.
12. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. ICAR. New Delhi. 1985.
13. Singh J and Maurya AN. Effects of micronutrients on the quality of fruits of mango cv. Mallika. Prog Hort. 2003;35 (1): 92-94. https://doi.org/10.5958/2249-5258.2017.00020.3
14. Dutta P. Effect of foliar boron application on panicle growth, fruit retention and physio-chemical characters of mango cv. Himsagar. Indian J Hort. 2004; 61 (3): 265-266.
15. Jeyabaskaran KJ, Pandey SD. Effect of foliar spray of micronutrients in banana under high soil pH condition. Indian Journal of Horticulture. 2008; 65(1):102-105
16. Vijayalakshmi D, Srinivasan PS. Induction of flowering in 'OFF' year mango cv. Alphonso as influenced by chemical and growth regulators. Annals of plant physiology.1998;12: 93-97.
17. Marschner H, editor. Marschner's mineral nutrition of higher plants. Academic Press; 2011.
18. Sarkar GK, Sinha MM, Mishra RS, Srivastava RP. Effect of foliar application of mineral elements on cracking of Litchi fruit. Haryana J Hort Sci. 1984;13(12):18-21.
19. Rath S, Singh RL, Singh DB. Effect of boron and zinc sprays on the physicochemical composition of mango fruits. Punjab Hort J. 1980; 2: 33-35.
20. Kundu S, Mitra SK. Response of guava to foliar spray of copper, boron, and zinc. Ind.Agriculturist. 1999;43(1-2):49-54.
21. Banik BC, Sen SK. Effect of three levels of zinc, iron, boron and their interactions on growth, flowering, and yield of mango cv. Fazli. Hortic J. 1997; 10(1):23-29.
22. Dutta P, Dhua RS. Improvement on fruit quality of Himsagar mango through application of zinc, iron and manganese. Hort J 2002;15(2):1-9.
23. Singh J, Maurya AN. Effects of micronutrients on the quality of fruits of mango cv. Mallika. Prog Hort. 2000;35 (1): 92-94. https://doi.org/10.5958/2249-5258.2017.00020.3
24. Singh RR, Rajput CBS. Effect of various concentrations of zinc on vegetative growth characters, flowering, fruiting and physico-chemical composition of fruits in mango cv. Haryana J Hort Sci. 1977;6:10–14.
25. Syamal MM, Mishra KA. Effect of NPK on growth, flowering and quality of mango. Acta Hort. 1989;231:276-281.