

Review Article

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A Review on Use of Micronutrients in Tropical and Subtropical Fruit Crops

R. K. Jat¹, Mukesh Kumar^{2*}, Mohan Lal Jat³ and Jitendra Singh Shivran⁴

¹Department of Fruit Science, College of Horticulture,
SDAU, Jagudan, Mehsana, Gujarat, India

²Department of Natural Resource Management, College of Horticulture,
SDAU, Jagudan, Mehsana, Gujarat, India

³Department of Horticulture, College of Agriculture, CCS HAU, Hisar, Haryana, India

⁴Department of Horticulture, College of Agriculture, GBPU&T, Pantnagar,
Uttarakhand, India

*Corresponding author

ABSTRACT

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Plant nutrition plays a major role in quantitative and qualitative crop production in bringing sustainability and plants require seventeen essential elements for their normal growth and development. Among these, those elements required smaller in quantity is called micronutrients (Fe, Cu, Zn, Mn, B, Cl, Mo and Ni). Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants. Micronutrients are involved in plant metabolism, nutrient regulation, reproductive growth, chlorophyll synthesis, production of carbohydrates, fruit and seed development, *etc.* They have assumed increasing importance in crop production under present exploitative agriculture system. Intensive cultivation of high yielding varieties and use of high analysis fertilizers disturb the nutrient balance in soil. As results, micronutrients become limiting factor for crop production. Horticultural crops suffer widely by iron and zinc deficiencies followed by other micronutrients deficiencies. Due to these deficiencies some healthy orchards are turning into unproductive plantation with poor quality fruit. Micronutrients are to be necessarily taken up by the plants from soil or supplemented through chemical fertilizers or through other sources by soil application or foliar application for good growth and yield of crops. These also maximize the efficient use of applied major nutrients. The present study is an attempt to review the literature and explore the proper use of micronutrients to mitigate the deficiency of particular element that has effects on production potential of tropical and subtropical fruit crops.

Introduction

In recent years, micronutrients gained profound significance in intensive cropping system for attaining higher yield and productivity. Micronutrients (Fe, Cu, Zn, Mn, B, Cl, Mo and Ni) are regarded as essential plant nutrients taken up by the plants in relatively lesser quantity. The importance of

micronutrients in agriculture is truly well recognized and their uses have significantly contributed to the increased productivity of several crops (Tripathi *et al.*, 2015). The adequate supply of micronutrients with macronutrients increases the yield and quality of production. The continuous use of high analysis fertilizers to gain the higher production disturbs the nutrient balance in

soil. Micronutrients become limiting factor for crop production and their greater deficiencies causing serious concern in warning the sustainability of the intensive production systems. The deficiency of micronutrients has become major constraint to productivity, stability and sustainability of soils (Bell and Dell, 2008). Sometime, their acute deficiencies pose the problem of incurable nature (Kumar, 2002).

These also help in the uptake of major nutrients and play an active role in the plant metabolism process starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, hormone synthesis, nitrogen fixation and reduction (Das, 2003). These nutrients also play decisive roles in humans concerning with our physical and mental development and how we respond to diseases. In the countries or regions where staple foods consist mainly of cereals, roots, and tubers grown in nutrient-poor soils, human micronutrient deficiency is widespread.

Fruits contain a wide range of different compounds like minerals, vitamins, *etc.* and the nutritive value of fruit depends on its composition. Although fruit plays a very significant role in human nutrition, the composition of fruit is such that it is not recommended as a sole source of nutrition. However, it can be used advantageously to supplement deficiencies in other foods. Micronutrient amendments into soil for crop uptake could contribute in lowering the impact of their deficiency in humans (Cakmak, 2008).

The improvement in quality of fruit might be due to the catalytic action of micronutrients particularly at higher concentrations. Hence the foliar application of micronutrients quickly increased the uptake of macronutrients in the tissues and organs and

improves fruit quality (Anees *et al.*, 2011). To ensure better growth, yield and quality through correcting deficiencies of micronutrients in fruit crops, foliar application of micronutrient is one of the tools and this method allows multiple applications at different time. In addition, there is reduced concern for nutrient loss, tie up, or fixation when compared to soil applications.

Micronutrients

Micronutrients, which include Fe, Cu, Zn, Mn, B, Cl, Mo and Ni, are required in smaller amounts than the other essential nutrients or those essential elements required less than 0.1 per cent of plant dry matter is called micronutrient. The deficiencies of micronutrient may result in poor responses to the macronutrients. Deficiencies occur where soils are inherently poor in micronutrients or where soils have been degraded. Micronutrient deficiencies are often related to soil pH. The functions and deficiency symptoms of important micronutrients observed in fruit crops discussed as under.

Iron (Fe)

Fe is an important element for the synthesis of chlorophyll. Plants deficient in Fe may exhibit pale colour of the younger leaves and veins remains green or interveinal chlorosis of the whole leaves. Moreover, papery white colour of the younger leaves occur under severe deficiency.

Zinc (Zn)

Zn plays a role in the regulation of plant growth and transformation of carbohydrates and is required for nucleic acid synthesis and enzyme activation. Common deficiency of Zn is interveinal chlorosis, first appear on the middle to young leaves. Rosetting commonly occurs in citrus fruit trees.

Copper (Cu)

Cu is an essential part of the enzyme system that utilizes carbohydrates and proteins and is important for reproductive growth. Cu deficient plants may show dieback of shoot tips and old leaves develop brown spots. Male flowers sterility, delay flowering and senescence are the most important effects of copper deficiency.

Manganese (Mn)

Mn is essential for some enzyme activity and takes part in oxidation-reduction processes. When it is deficient, the symptoms are similar to Fe deficiency, with pale young leaves and green veins. Sometimes brown, black or grey spots are observed next to leaf veins.

Boron (B)

B is required for nucleic acid synthesis, pollen germination and the growth of the pollen tube. B promotes root development, enzyme activity and is associated with lignin synthesis, sugar transport, seed and cell wall formation, calcium uptake and proper water relations.

It imparts the drought tolerance to the crops. B deficient plants show curled, brittle leaves and discolored or cracked fruits. Leaf symptoms are usually found on leaf tips and terminal buds or youngest leaves, which become discoloured and may die under acute conditions of B deficiency.

Generally, soils contain sufficient levels of micronutrients to meet crop demands; however, in some areas micronutrients shortage occur and may limit yields. Some crops have a higher demand for certain micronutrients than others and should be considered in determining whether a micronutrient fertilizer should be applied or

not. The relative responses of important tropical and subtropical fruit crops to micronutrients are reviewed as below.

Mango

Nehete *et al.*, (2011) concluded that foliar application of ZnSO₄ 1 % + FeSO₄ 1 % + borax 0.5 % gave significantly maximum average fruit weight (0.295 kg), total number of fruits per tree (168) and yield (49.54kg/tree). Whereas, maximum total sugar (16.67%), reducing sugar (6.03%), TSS (19.00 °Brix) and ascorbic acid (32.80 mg/100g) were also recorded in the same treatment in mango cv. Kesar. Bhatt *et al.*, (2012) reported that the trees sprayed with 0.5% borax showed maximum fruit yield, fruit weight, fruit volume, TSS, reducing sugar, non-reducing sugar and ascorbic acid content in mango.

Krishnamoorthy and Hanif (2015) concluded that application of NPK @ 1.0:1.0:1.5 kg per tree + 50 kg FYM + foliar application of micronutrient formulation @ 0.5 per cent resulted in higher growth, yield and quality parameters. The yield per hectare was 20.99 percent higher than the application of NPK alone followed by 10.22 per cent yield increase obtained with foliar spraying of sulphate of potash 2 per cent than the control.

Pawar and Singh (2018) showed that the application of RDF + foliar spray of ZnSO₄ @ 0.4 % + CuSO₄ @ 0.2 % + boric acid @ 0.2 % (2 sprays at just before flowering and marble stage) was found to be most effective for increasing number of fruits per panicle at pea and marble stage (9.67 and 4.58, respectively), yield per plant (271.51 kg), yield per hectare (27151 kg), per cent increase in yield (56.40 %), TSS (18.51 °Brix), total sugar (12.88 %), ascorbic acid content (43.62 mg/100 g pulp) with reduced acidity (0.149 %).

The higher fruit weight (221.98 g), fruit length (10.87 cm) and fruit width (6.54 cm) were observed with the application of RDF + 10 % sea weed sap (2 sprays at panicle emergence and marble stage) + ZnSO₄ @ 200 g + CuSO₄ @ 100 g + boric acid @ 100 g (soil application). Almost similar results were recorded by use of RDF + foliar spray of 0.4 % zinc sulphate + copper sulphate (0.2 %) + borax (0.2 %) and application of RDF + foliar spray of 0.4 % zinc sulphate + boric acid (0.2 %) in mango (Haldavnekar *et al.*, 2018)

Banana

Jeyabaskaran and Pandey (2008) stated that soil application of Fe (5 g FeSO₄ per plant at 3 MAP), foliar applications of Zn (0.5 % ZnSO₄ each at 3, 5 and 7 MAP) and B (10 ppm boric acid each at 3, 5 and 7 MAP) with recommended dose of NPK (N: P₂O₅ : K₂O - 200 : 50 : 400 g per plant) produced the highest bunch weight and best quality fruits. Pathak *et al.*, (2011) concluded that foliar application of ZnSO₄ 0.5 % + FeSO₄ 0.5 % gave significantly maximum fingers per bunch (129.20), hands per bunch (9.20), bunch weight (16.30 kg) and yield (40.75 t/ha). Whereas, maximum TSS (25.66 °Brix) and total sugar (17.86 %) were found by foliar application of FeSO₄ 0.5 % and non-reducing sugar (10.04 %) was recorded with foliar application of ZnSO₄ 0.5 % + FeSO₄ 0.5 % in banana cv. Martaman. Krishnamoorthy and Hanif (2017) revealed that the highest pseudostem height (2.48 m), pseudostem girth (76 cm), number of leaves per plant (18), leaf area index(4.72), finger weight (123 g), bunch weight (20.10 kg) and TSS (16.6 °Brix) were recorded with application of Arka banana special micronutrients followed by foliar application micronutrients and soil application. The Arka banana special application through soil application 250 ml solution (%) on 45 days after planting, followed by foliar application 0.5 per cent on

5, 6, 7 and at shooting on hands recorded significantly highest yield (45.23 t/ha) over other two micronutrient application. Premalatha and Suresh (2019) indicated that foliar application of micronutrients mixture as 3 per cent micronutrient mixture and as 2 per cent micronutrient mixture with 3 times of spraying at 2, 4 and 6 months after planting significantly enhanced the quality attributing parameters of Nendran banana.

Papaya

Shekhar *et al.*, (2010) observed that foliar application of 0.25 % CuSO₄ + 0.25 % MnSO₄ + 0.1 % borax gave maximum number of fruits per plant (30.67), average fruit weight (1.30 kg), fruit yield (40.40 kg/plant) as well as improved TSS (9.60 °Brix) and total sugar (9.72 %) with minimum acidity (0.053 %) in papaya cv. Washington. Singh *et al.*, (2012) revealed that maximum fruit weight (1.43 kg), number of fruits per plant (25.92) and yield (37.20 kg/plant) were recorded with the foliar application of borax 0.50 % + ZnSO₄ 0.25 %. Similarly, maximum TSS (6.81 °Brix), total sugar (6.88%), reducing sugar (6.35%) and non-reducing sugar (0.53%) were recorded in the same treatment in papaya cv. Ranchi. Parmer *et al.*, (2017) recorded maximum growth characters like plant height, plant girth and leaf area and minimum days required for first flower initiation when papaya var. Red Lady plants were treated with 100 % RDNK (200:250 g/plant) applied in 8 equal splits starting from 2nd month after planting in 30 days interval with foliar application of 1 % Grade-IV micronutrient at 2nd, 4th, 6th and 8th month after planting. Monika *et al.*, (2018) revealed that foliar application of calcium [0.5 % Ca (NO₃)₂], sulphur(0.5 % K₂SO₄) and micronutrients (zinc sulphate @ 0.5 % and boric acid @ 0.1 %) along with the recommended dose of fertilizers recorded significantly the highest number of fruits

(34.21), fruit weight (1.39 kg), fruit length (29.96 cm) and fruit circumference (41.34 cm). The fruit yield (47.54 kg/plant) recorded in this treatment was 28.21 per cent higher than control in spite of the incidence of PRSV (31.26 %). Singh *et al.*, (2018) revealed that foliar application of copper sulphate 0.25% + manganese sulphate 0.25% + NAA 30 ppm + GA₃ 60 ppm attained maximum pooled value in terms of plant height (139.99 cm), stem girth (42.69 cm), number of leaves (29.52) whereas minimum days taken for initiation of first flower (103.83) with the spray of copper sulphate 0.25% + manganese sulphate 0.25 %.

Guava

Bhoyar and Ramdevputra (2012) revealed that maximum fruits per shoot (3.6) and fruit yield (57.1 kg/tree), TSS (13.6 °Brix), total sugar (7.9 %) and minimum acidity (0.38%) were recorded when trees did foliar application of 0.5 % ZnSO₄ + 0.5 % FeSO₄ + 0.3 % borax. Whereas, minimum fruit drop (53.6 %) was recorded with foliar application of 0.5 % FeSO₄ + 0.3 % borax, maximum ascorbic acid content (225.0 %) was recorded with 0.5 % FeSO₄ and pectin (0.65 %) was recorded with 0.3 % borax in guava cv. L-49.

Gaur *et al.*, (2014) reported maximum fruit length (6.07 cm), fruit width (5.92 cm), fruit weight (98.48 g), TSS (11.7 °Brix), total sugar (7.51 %), ascorbic acid (172 mg/100g) with minimum acidity (0.3 %) by foliar application of 0.4% borax on winter season guava cv. L-49. Foliar application of 0.4 % borax + 0.8 % FeSO₄ increased yield and quality parameters as reported by Hadda *et al.*, (2014) in guava. Shreekant *et al.*, (2017) recorded maximum yield and yield attributing characters with foliar application of borax 1.0 per cent. Zagade *et al.*, (2017) recorded maximum number of fruits per tree (170), yield per tree (35.57 kg), yield per hectare (14.22 t), TSS (11.80 °Brix), reducing sugar

(4.52 %) and total sugar (7.40 %) when guava plants were treated with foliar spray of zinc sulphate @ 1 % treatment. However, maximum weight of fruit (193 g) and weight of pulp (153.60 g) were observed with application of CuSO₄@ 1% + FeSO₄@ 1% + ZnSO₄@ 1% + borax@ 0.5 % treatment and minimum acidity (0.35%) were observed with application of ferrous sulphate @ 1 % treatment.

Sapota

Saraswathy *et al.*, (2002) concluded that soil application of 50g ZnSO₄ + 25g borax per tree along with foliar spray of ZnSO₄ 0.5% + borax 0.3% gave significantly maximum single fruit weight (86.52g), number of fruits per tree (930) and yield (59.13 kg/tree). Whereas, maximum TSS (23.25°Brix), total sugar (11.80%), reducing sugar (9.41%) and ascorbic acid (3.65mg/100g) were also recorded with the same treatment in sapota cv. PKM-1. The morphophysiological parameters like photosynthetic rate, transpiration rate and stomatal conductance were increased by higher level of micronutrients *i.e.* FeSO₄ 2% + ZnSO₄ 2 % + borax 1 % treatment (Ghumare *et al.*, 2013). The foliar application of 0.5 % ZnSO₄ + 0.5 % FeSO₄ + 0.3 % borax shown significant increase of plant vegetative growth parameters and yield over control (Thirupathaiah *et al.*, 2017).

Citrus

Venu *et al.*, (2014) stated that the maximum fruit set (49.33 %), number of fruits per shoot (8.53 %), number of fruits per tree (925.0), fruit yield (27.07 kg/plant) and minimum fruit drop (24.33 %) were recorded with the foliar application of ZnSO₄ 0.5 % + FeSO₄ 0.4 % + borax 0.4 % in acid lime cv. Kagzi. Gurung *et al.*, (2016) concluded that foliar application of GA₃@ 15 ppm along with zinc (0.5%) and

boron (0.1%) improved growth morphology, fruit yield and fruit yield attributes with better quality in Darjeeling Mandarin. Soni *et al.*, (2017) revealed that foliar application of CuSO_4 (0.4 %) at pea stage and gravel stage increased the fruit retention to the extent of 46 per cent as compared to control 23 per cent only.

The maximum number of fruits per plant (598.67), fruit retention (25.95 %), size of fruits (fruit length 6.28 cm and breadth 7.15 cm), average fruit weight (163.67 g) and fruit yield per plant (97.83 kg) was recorded along with minimum June (39 %) and pre-harvest (12 %) fruit drop when Kinnow mandarin plants were sprayed with urea 1.0 % + K_2SO_4 1.0 % + ZnSO_4 0.5 % + FeSO_4 0.5 % + H_3BO_3 0.2 % (Reetika *et al.*, 2018). Tagad *et al.*, (2018) stated that foliar spray of GA_3 (50 ppm) + ZnSO_4 (1%) + FeSO_4 (1%) improved fruit quality parameters of acid lime.

Pomegranate

Hasani *et al.*, (2012) studied the effects of zinc and manganese as foliar spray on pomegranate yield, fruit quality and leaf minerals. They stated that the Mn sprays had positive significant effects on the fruit yield, the aril/peel ratio, TSS, weight of 100 arils, juice content of arils, anthocyanin index, fruit diameter and leaf area. Zn effects were also significant for TSS, TSS/TA ratio, juice content of arils and leaf area. Foliar spray of Mn significantly increased Mn and N but decreased Zn and Cu concentrations in leaves. Moreover, foliar sprays of Zn significantly increased Zn but decreased Mn and P concentrations in the leaves. Dhurve *et al.*, (2018) studied the effect of foliar application of Zn and B on yield parameters and found that highest number of fruit per plant (57.67), fruit weight (301.74 g) and yield/plant (18.44 kg) in foliar spray of 0.4 % boric acid + 0.4 % zinc sulphate treatment. Gawade *et al.*, (2018)

conducted an experiment at Mahatma Phule Krishi Vidyapeeth, Rahuri on pomegranate and recorded maximum yield (26.87 kg/plant), number of fruits (101.33) and average weight of fruit (272.00) in recommended dose of fertilizers (625 N: 250 P: 250 K g per tree) along with each 5 sprays of Sujala (NPK 19:19:19 @ 0.5 %) and micronutrient mixture “Microla” (0.2 %) treatment followed by RDF alongwith Sujala, Microla (3 sprays) and phosphate solubilising bacteria “Biola” treatment. Yadav *et al.*, (2018) revealed that application of 0.4 per cent zinc sulphate + 0.4 per cent boric acid + 0.4 per cent ferrous sulphate significantly increased fruit diameter, fruit weight, fruit volume, number of arils per fruit, fruit set percent, number of fruit per plant and yield as compared to control which was closely followed by zinc sulphate @ 0.4 per cent + boric acid @ 0.4 per cent + ferrous sulphate @ 0.2 per cent treatment.

Further this treatment has also enhanced TSS/Acid ratio, ascorbic acid, juice per cent and sensory score and significantly reduced days taken to first harvesting, total days taken to complete harvesting and acidity per cent of fruits. Gaikwad *et al.*, (2019) revealed that foliar application of GA_3 @ 75 ppm and boron 0.3 % at 90, 105 and 135 days after flowering may be beneficial for producing higher yield and yield attributing characters.

Aonla

Khan *et al.*, (2009) studied the effect of foliar application of micronutrients and thiourea on vegetative growth, fruit yield and quality of aonla cv. Narendra Aonla-6 and concluded that maximum vegetative growth (plant height, girth and spread), fruit retention, yield, size, weight and volume of fruits were obtained with foliar application of ZnSO_4 (0.5 %) + thiourea (0.1 %), closely followed by borax (0.25 %) + thiourea (0.1 %). Meena *et*

al., (2014) observed highest plant height increment (0.95 m), canopy spread E-W and N-S increment (0.89 m and 0.86 m), canopy height increment (0.93 m), fruit volume (44.10 ml), fruit length (4.20 cm), fruit diameter (4.46 cm), pulp thickness (1.41 cm), reducing sugar (3.56 %), non-reducing sugar (2.99 %), juice (78.22 %), fruit weight (45.20 g) and yield per tree (42.70 kg) with the combined spray of 0.6 % calcium nitrate + 0.4 % borax + 0.8 % zinc sulphate followed by 0.3 % calcium nitrate + 0.2 % borax + 0.4 % zinc sulphate treatment. Mishra *et al.*, (2017) concluded that foliar feeding of CuSO₄ (0.4%) + ZnSO₄ (0.25%) + borax (0.25%) gave best result for the production of maximum fruit yield and better quality of aonla fruits. Patel *et al.*, (2018) stated that foliar application of CuSO₄ (0.4 %) + ZnSO₄ (0.5 %) improved yield and yield attributing characters.

Ber

Kamble *et al.*, (1994) indicated that foliar spray of iron, manganese, zinc, and boron increased fruit set (%) and fruit retention. Meena *et al.*, (2008) stated that foliar application of ferrous sulphate and borax at pea stage @ 0.6 per cent produced maximum average fruit weight, fruit length, fruit breadth, pulp weight, stone weight, pulp to stone weight ratio, fruit yield and net returns and benefit cost ratio of ber than the control and 0.3 per cent spray in ber. Yadav *et al.*, (2008) recorded maximum fruit quality parameters when ber trees treated with soil application of 40 g FeEDTA /plant.

Grape

Grape yield was exceptionally higher in response to foliar application of Mg, Fe and B compared to other treatments. The improved yield in response to B and Mg was related to an increase in the berry weight, while in case

of Fe it was related to an increase in the number of berries/bunch. Fruit quality of grape in terms of total soluble solids, acidity, juice and tannin content was better for nutrient (B, Fe, Urea and Mg) sprayed as compared to control in grapevines (Usha and Singh, 2002). Subramoniam *et al.*, (2006) observed higher juice content, TSS, titratable acidity, specific gravity, total sugar and TSS/acidity ratio by application of recommended dose of N, P and K fertilizers along with foliar sprays of ZnSO₄ (0.2 %) + boric acid (0.2 %) + FeSO₄ (0.2 %) + MnSO₄ (0.2 %) + MgSO₄ (0.5 %) + CaCl₂ (0.5 %) + KNO₃ (0.5 %) + urea (1 %) at blooming and 15 days after blooming stages. From the foregoing reviews, it can be concluded that the role of micronutrients have a significant effect on fruit plants and their application in adequate quantity through foliar and/or soil application with the required recommended dose of fertilizers (NPK) significant improves in vegetative growth, fruit yield and quality of fruit crops.

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