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Differential responses of Fe, Zn, B, Cu and Mg on growth and quality attributes of fruit crops

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Abstract
Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants. There requirement by plants is in trace amounts. Boron, iron, copper, zinc, manganese, magnesium and molybdenum constitute main micronutrients required by different fruit crops in variable quantities. The requirement of micronutrients is partly met from the soil or through chemical fertilizer or through other sources. Various physical and metabolic functions are governed by these mineral nutrients. Boron is particularly essential in pollen germination, copper plays major role in photosynthesis and increases sugar content in fruits, chlorophyll synthesis and phosphorus availability is enhanced by manganese, iron acts as an oxygen carrier and promotes chlorophyll formation, while, zinc aids plant growth hormones and enzyme system. The significance of micronutrients in growth as well as fruit quality of various fruit crops is briefed here attributes wise.

Keywords: Fruit, micronutrients, growth, yield, quality

Introduction

The nutrient elements which are required comparatively in small quantities are called as micro or minor nutrients or trace elements. Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants. The requirement of micronutrients (boron, iron, copper, zinc, manganese, chloride and molybdenum) is only in traces, which is partly met from the soil or through chemical fertilizer or through other sources. The major causes for micronutrient deficiencies are intensified agricultural practices, unbalanced fertilizer application including NPK, depletion of nutrients and no replenishment. Horticultural crops suffer widely by zinc deficiency followed by boron, manganese, copper, iron (mostly induced) and Mo deficiencies. Cl, Cu, Fe and Mn are involved in various processes related to photosynthesis and Zn, Cu, Fe, and Mn are associated with various enzyme systems; Mo is specific for nitrate reductase only. B is the only micronutrient not specifically associated with either photosynthesis or enzyme function, but it is associated with the carbohydrate chemistry and reproductive system of the plant Suman *et al.*, (2017) [34]. Micronutrients are key elements in plants growth and development. These elements play very important role in various enzymatic activities and synthesis. Their acute deficiencies sometimes posses the problem of incurable nature (Kumar, 2002) [30]. These micronutrients 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) [12]. Micronutrients are completely available to the plant and thus particularly effective because they are not fixed or diluted in large volumes of soil. However overdosing or application at undesired time can let to crop damaging. The significance of micronutrients in growth as well as physiological functions of horticultural fruit crops are briefed here nutrient wise. The sufficient amount of micronutrients necessary for better plant growth which resulted in higher yield due to increased growth, better flowering and higher fruit set (Ram and Bose, 2000) [43]. 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) [3]. Nowadays, micronutrients are gradually gaining momentum among the fruit growers because of their beneficial nutritional support and at the same time ensure better harvest and returns. The demand for increasing fruit production will require a thorough knowledge on the relationship between micronutrients and crop growth. Foliar micronutrient is one tool to maintain or enhance plant nutritional effects are seen and deficiencies can be status during the growing season. Often quick corrected before yield or quality losses occur. Foliar fertilization also allows for multiple application timings post planting. In addition, there is reduced concern for nutrient loss, tie up, or fixation when compared to soil applications. The available information regarding the impact of micronutrients on fruit crops is scanty. Based on this background, the present review was compiled to study the role of micronutrients and its effect on different fruit crops.

Effect of micronutrients on growth parameters

The combined application of 25 kg FYM + 0.5 kg Neem cake per plant and 25 kg $ZnSO_4$ per hectare improved the plant height, plant girth and total functional leaves after 60 days of application in banana. (Subramanian and Pillai, 1997) [53]. Asad *et al.* (2013) [6] found that application of 1.00g micronutrients + 0.3 ml P/L (phosphoric acid/litre) at full bloom + fruit set recorded the highest values of shoot length, shoot diameter, leaf area and chlorophyll content of leaves in Le-Conte pear in both seasons. Similar results were quoted by Mohamed and Ahmed (1991) [36] on "Anna" apple, Naiema (2006) [37] on pear. Also, El-Khawaga (2007) [19] on olive, Amer *et al.* (2010) [2] On "Toffahy and Balahy" Indian ber trees and El-Sisy (2011) [21] on guava trees reported that micronutrient spray was effective in increasing leaf area. Dhaker *et al.* (2013) [15] showed that combined effect of foliar spray of borax (0.6%) and FYM (50Kg/tree) was found significant pertaining to gain in tree height (49.20 cm), stem girth (2.75 cm) compare to control in bael. Asad (2014) [5] found that spraying "Anna" apple trees with CPPU (Sitofex) and micronutrients had positive effect on shoot diameter, shoot length, shoot number and leaf area than control in both seasons. It was found that spraying with 15 ppm CPPU + 10g Fe + 7g Mn + 10.5g Zn/ 20lt. water recorded the highest values of shoot diameter (0.86 and 0.88 cm), shoot length (18.8 and 18.9 cm), shoot number (16.4 and 17.1) and leaf area (28.4 and 28.8 cm^2). Maximum seasonal growth in tree height (12.23%) was recorded with foliar spray of Zn @ 0.03% on fruit set while maximum percent increase in stem girth (14.26%) was observed with foliar application of Zn @ 0.01% two weeks after fruit set on guava cv. Pant Prabhat. Increased plant height can be accredited to the role of zinc in tryptophan synthesis, which is a precursor of auxin resulting in increased apical growth (Kumar *et al.*, 2015) [29]. Awasthi *et al.* (1975) [7] reported similar results in litchi. Alila *et al.*, (2004) [1] reported that the foliar application of micronutrients i.e., FeSO4 (0.2%) and boric acid (0.1%) on papaya cv. Ranchi at 2nd and 4th month after transplanting. They observed that the growth parameters (plant height, basal diameter and number of leaves per plant) significantly increased under the micronutrients treatment in comparison to the control. Pathak *et al.*, (2011) [41] reported that combined application of Fe (0.5%) and Zn (0.5%) showed the best response on plant growth in terms of plant height, basal girth of pseudo stem and number of leaves produced per plant and minimum duration between emergences of two successive leaves in banana. Modi *et al.*, (2012) [35] revealed that individual application of ZnSO4 (0.5 per cent) and borax (0.3 per cent) exerted great influence on plant height, stem girth and number of leaves as well as earlier initiation of flower bud and minimum days taken from fruit setting to first harvest of papaya (*Carica papaya* L.) cv. Madhu Bindu. Singh *et al.*, 2005) [46] observed that the foliar application of zinc (0.25% and 0.5% ZnSO4) at two month from transplanting significantly increased the plant growth, number of leaves per plant and length of petiole (5th leaf) in papaya. Yadav *et al.*, (2007) [56] studied the effect of three sprays (2nd week of May, last week of June and second week of August) of zinc sulphate 0.75 per cent on sweet orange fruit trees in term of plant growth and fruit drop. Application of 0.75 per cent zinc sulphate (three sprays) resulted in better growth.

Effect of micronutrients on physical parameters and yield parameters

Grape yield was exceptionally higher in response to foliar application of Mg, Fe and B compared to other treatments. 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 (Usha and Singh, 2002) [55]. Spray of 1.00g micronutrients + 0.3 ml P/L (phosphoric acid/litre) at full bloom + fruit set significantly increased fruit weight (242.50g), fruit length (9.24cm), fruit diameter (8.08cm), fruit firmness (17.76 Ib/in^2) and yield (53.15kg/tree) in Le-Conte pear (Asad *et al.* 2013) [6]. El-Seginy *et al.* (2003) [20] found that the chelated Fe, Zn and Mn at all rates increased total yield as compared with control of Anna apple trees. El-Sisy (2011) [21] noticed that foliar or soil application of guava trees with mixture of chelated or sulphate (Fe + Zn + Mn) in high rate (3000 ppm) added twice annually was the best treatment for enhancing yield. Datir *et al.* (2012) [13] found that application of amino acid-micronutrient chelate like Zn, Fe, Cu and Mn at the concentration of 1.5% and 2.0% resulted in more fruits per plant and more total yield per plant of chilli plants. Combined effect of foliar spray of borax (0.6%) and FYM (50Kg/tree) was found significant pertaining to gain in fruit weight (980.0 g) and fruit yield (36.34 q/ha) compare to control in bael (Dhaker *et al.* 2013) [15]. The increase in yield by boron application may be accredited to the positive effect of boron on increasing the rates of carbohydrate and RNA metabolism (Parr and Loughman, 1983) [40] as well as on accelerating the transport of photosynthates from the leaves to the developing fruits (Rajput and Chand, 1975) [44]. Chauhan and Gupta (1985) [11] reported similar results in ber. Rajput *et al.*, (1976) [50] studied that boron and zinc application in guava significantly increased the total yield. Asad (2014) [5] revealed that highest fruit weight (199.2 and 199.6g), fruit length (6.87 and 6.91 cm) and fruit diameter (5.54 and 5.68 cm), fruit set percentage (21.92 and 24.21) and fruit yield (36.8 and 37.8 Kg) was obtained with 15 ppm CPPU + 10g Fe + 7g Mn + 10.5g Zn/ 20lt. water in "Anna" apple trees in both seasons of study. El-Barkooky (1985) [17] and Greene (1989) [23] on apple, Jindal and Sharma (1986) [26] on plum, Biasl *et al.* (1991) [9] And Lowes and Woolley (1992) [33] on kiwi, Kabeel (1999) [27] on persimmon and Guirguis *et al.* (2003) [24] on pear trees found that spraying with CPPU and micronutrients had positive effect on fruit set percentage and fruit yield. There was no effect on orange fruit yield with Zn foliar application as reported by Boaretto *et al.* (2002) [10]. In sweet cherry there was a general trend for fruit set and yield to be higher in the Zn + B treatment trees compared to the control trees (Usenik and Stampar, 2002) [52]. In apple orchard the foliar spray of micronutrients influenced the yield. The yield was doubled and the mean of five years produce reached 70 t/ha. In spite of high yield there were no problems with alternate bearing (Stampar *et al.*, 2002) [52-54]. In mango, the percent of fruit set (0.36) and number of panicle/shoot (2.33) were found to be significantly higher in 1% $ZnSO_4$ treatment (Daulta *et al.*, 1981) [14]. Singh and Rajput (1976) [50] found highest fruit set under 0.8% $ZnSO_4$ in mango cv. Samar Bahist Chausa. Average fruit length (4.52 cm), breadth (5.77 cm) and weight

(50.20g) significantly improved with combined spray of 0.5% $ZnSO_4$ + 10 ppm NAA + 25ppm GA_3 while highest fruit yield (107.2kg/tree) was observed with 0.5% $ZnSO_4$ + 0.4% $CuSO_4$ + 10 ppm NAA in aonla cv. NA10 (Singh *et al.*, 2007) [48]. Singh *et al.* (2001) [47] found that combined spray of 0.5% $ZnSO_4$, 0.2% borax and 0.4% $CuSO_4$ significantly improved the yield and fruit size of aonla cv. Francis. Kumar *et al.* (2004) [31], and Arora and Singh (1971) [4] reported similar results in litchi and guava respectively. In Phalsa, significantly higher fruit size (length and breadth) was analyzed by foliar spray of $ZnSO_4$ @ 0.4% (Singh *et al.*, 2015) [49]. Similar results have been reported by Singh *et al.* (2001) [47] in aonla and Kumar *et al.* (2004) [31] in litchi. Kaur *et al.*, (2016) [28] found that minimum fruit drop per cent and maximum fruit retention were recorded with foliar application of $MgSO_4$ (0.6%) in Kinnow mandarin. Eiada *et al.*, (2013) [16] investigated the influence of spraying manganese and zinc solutions on Salemy pomegranate. Zinc was applied at 0 (Zn0), 1.5 (Zn1.5), 3% (Zn3) levels. The obtained results showed that 60 mg/l manganese with 3% zinc recorded the highest fruit weight (188.88 and 187.97 g) in the first and second seasons, respectively.

Effect of micronutrients on quality parameters

Asad *et al.* (2013) [6] found that application of 1.00g micronutrients + 0.3 ml P/L (phosphoric acid/litre) at full bloom + fruit set recorded the maximum values of total soluble solids, titrable acidity and T.S.S/Acid ratio with lowest values of percentage of total sugars. Favorable responses are also obtained by Mohamed and Ahmed (1991) [36] who reported that applying the three elements together (Cu+Zn+Fe) at the higher rate was also accompanied with an improve in total soluble solids in apple trees. The maximum values of fruit TSS (13.8 and 13.9%), acidity (0.42 and 0.43%) and total sugars (42.28 and 42.58%) were obtained from “Anna” apple trees sprayed with 15 ppm CPPU + 10g Fe + 7g Mn + 10.5g Zn/ 20lt.water in both the seasons (Asad, 2014) [5]. 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) [55]. Stamper *et al.* (2002) revealed that analysis of soluble solids, fructose, glucose, sucrose, malic acid and citric acid indicated that the produced fruits of apple were of high quality despite greater yields. Daulta *et al.* (1981) [14] found that quality of mango fruit increased in terms of pulp/stone ratio (6.62) and TSS (22.2%) was recorded with the application of 0.6% $ZnSO_4$ and 0.8% $ZnSO_4$ respectively. Singh and Rajput (1976) [50] reported improvement in pulp/stone ratio and quality in mango cv. Samar Bahist Chausa when $ZnSO_4$ was used at 0.8% concentration. Policarpo *et al.* (2002) [42] reported foliar application of macro and micro nutrients significantly improved fruit quality of peach regarding total acidity, pH, soluble solids and surface red colour. Maximum TSS (12.20%), ascorbic acid (675.0 mg/100 g juice), reducing sugar (3.41%), non-reducing sugar (2.30%), total sugar (5.71%), total phenols (186.00 mg/100 g juice) and minimum acidity (1.44%) was recorded with combined spray of 0.5% $ZnSO_4$ + 0.4% $CuSO_4$ + 10 ppm NAA in aonla cv. NA10 (Singh *et al.*, 2007) [48]. Kundu and Mitra (1999) [32] reported similar results with foliar application of 0.3% Cu, 0.1% borax and 0.3% Zn in guava. Singh *et al.* (2001) [47] found that combined spray of 0.5% $ZnSO_4$, 0.2% borax and 0.4% $CuSO_4$ significantly improved TSS, sugars and ascorbic acid content of aonla cv. Francis. The maximum TSS, reducing sugar, non-reducing sugar, total sugar and minimum acidity have been observed with foliar spray of $ZnSO_4$ @ 0.4% in Phalsa (Singh *et al.*, 2015) [49]. The results are in agreement with the findings of Ghanta and Dwivedi (1993) in banana, Singh *et al.* (1995) [51] in ber and Yadav *et al.* (2010) [57] in aonla. Hasani *et al.*, (2012) [25] observed maximum aril/peel ratio with foliar spray of $MnSO_4$ @ 0.6% in pomegranate. Bakshi *et al.*, (2013) [8] reported that the plants treated with 0.6 per cent ZnSO4 showed highest TSS (8.310B), ascorbic acid (60.88 mg/100 g pulp), TSS/acid ratio (11.70) and lowest acidity (0.716%). of strawberry cv. Chandler.

Effect of micronutrients on leaf and fruit mineral content

Asad *et al.* (2013) [6] revealed that application of 1.00g micronutrients + 0.3 ml P/L (phosphoric acid/litre) at full bloom + fruit set significantly enhanced all mineral contents (Fe, Zn, Mn, Cu and B) in leaves as well as in fruits of Le-Conte pear. Mohamed and Ahmed (1991) [36] reported that supplying trees of “Anna” apple with three micro-nutrients (Zn, Fe and Cu) raised leaf content of zinc, iron and copper. Amer *et al.* (2010) [2] found that soil applied micronutrients (Cu, Zn, Mn and Fe) increased their concentration in leaves of Toffahy and Balahy Indian ber trees. El-Sisy (2011) [21] reported that micronutrient application in guava trees significantly increased fruit mineral content (Fe, Mn and Zn) as compared with control. However, fruits of grapes were not significantly affected by either soil or foliar application of $FeSO_4$ and $ZnSO_4$ (El-Gazzar *et al.*, 1979) [18]. In “Anna” apple trees, highest value of leaf Fe (112.76 and 116.77 ppm), Mn (84.6 and 88.8 ppm) and Zn (40.4 and 40.6 ppm) was recorded with 15 ppm CPPU + 10g Fe + 7g Mn + 10.5g Zn/ 20lt. water in both seasons of study (Asad, 2014) [5]. Boaretto *et al.* (2002) [10] showed that foliar fertilization of Zn increased leaf Zn concentration to within the adequate range in orange fruits. It was found that two sprays of copper in June and September were enough for copper supply of apple trees while Mn and B applications gave better results when repeated several times during the growing period (Naseri *et al.*, 2002) [38]. Natale *et al.* (2002) [39] showed excellent co-relation of the fruit production with foliar chemical analysis of guava in Brazil conditions. Maximum yield was associated to N;22-26; P:1.5-1.9; K:17-20; Ca:11-15; Mg:2.5-3.5; S:3.0-3.5 g/kg, B:20-25; Cu:10-40; Fe:50-150; Mn: 180-250; Zn: 25-35 mg/kg DW (dry weight) in the leaves of the “Rica” guava.

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