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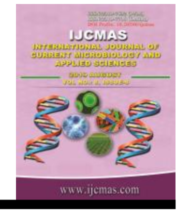

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A Research Review on Use of Micronutrient in Fruit Crops

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A B S T R A C T

Fruit Crops yield and quality significantly increase with the use of micronutrients such as zinc (Zn), iron (Fe), Calcium (Ca) Magnesium (Mg) Boron (B), Copper (Cu), Manganese (Mn), etc. Zinc (Zn) has an important metabolically role in plants vegetative and reproductive phases; growth and development; is therefore called an essential trace element or a micronutrient. Calcium plays a critical role for the growth of fruit quality; while magnesium is an important component for chlorophyll and Iron involved in chlorophyll production; Boron for proper flower development and pollen germination; Copper and Manganese both helps in photosynthesis process and Mg also helps in nitrogen metabolism of carbohydrates and proteins and respiration. Micronutrient influences the activity of many metabolic enzymes, as well as the metabolism of several hormones. They are important co-factors found in the structure of certain enzyme and hormones. Use of micronutrients in fruit crops is an important management practice where much misinformation exists, by doing so, you can prevent deficiencies of micronutrients before they occur and reduce inefficient use of applied micro nutrients. There is so many research reviews indicated that the necessity and management of micro nutrients in fruit crops for better growth of vegetative, reproductive and physiological parameters. The aim of this review paper is to know the use of micronutrient in various fruit crops for growth, yield, quality and better shelf life. Also provide a ready source of literature review for researchers involved in Horticultural as well as agricultural sciences.

Keywords

Micro Nutrient, Growth, Yield, quality and Shelf life of fruit

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Introduction

Micronutrient deficiency is severing problem in soil and plants worldwide (Imtiaz, *et al.*, 2010) while appropriate quality of micronutrients is necessary for better growth, better flowering, higher fruit set, higher yield, quality and post-harvest life of horticultural products (Ram and Bose, 2000; Raja, 2009, Sourour *et al.*, 2000; Shekhar *et al.*, 2010) while its deficiency leads in lowering the productivity (Zagade, 2017). Beside major plant nutrients there is eight essential nutrients which is required by plants in very small quantity, known as micronutrients *viz.*, copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), zinc (Zn), boron (B), and chlorine (Cl). Still, other elements like selenium (Se), silicon (Si), and sodium (Na) are regarded as nonessential, although they have been found to enhance growth and confirm other benefits to plants (Datnoff *et al.,* 2007; Marschner 2012). Dependent on the enzyme, Fe, Mn, Zn, Cu, Ni, Mo, and Cl all participate in the functioning of different enzymes, including DNA/RNA polymerases, N-metabolizing enzymes, superoxide dismutases, catalases, dehydrogenases, oxidases, ATPases and numerous other enzymes involved in redox processes (Broadley *et al.,* 2012). Boron is important micro nutrient required for good quality and high yield of crops (Dale and Krystyna, 1998, Mahmoud M. Shaaban 2010). It involved in the synthesis and integrity of cell wall, cell wall lignification, metabolism of RNA, carbohydrate, phenol and Indole Accetic Acid (IAA), respiration and cell membrane integrity (Parr and Loughman, 1983). Boron is exclusive as a substance in this the brink between deficiency and toxicity is narrows (Mortvedt *et al.,* 1991). Boron Deficiency found to affect plant growth and reduced yield (Dell and Huang, 1997, Carpena *et al.,* 2000) better growth and yield was obtained when crops were supplied with Boron (Oyinlola, 2005, Shaaban *et al.,* 2004). Single foliar boron application is effective in increasing B concentration in flower buds, higher B concentrations, however, can improve fruit set in sweet cherry, so the possible positive effects can easily cover the costs. Nutrition with boron can be more useful especially when fruit set is low and can be in function of controlling tree vigor (Valentina Usenik and Franci Stampar, 2007). Flower clusters have a high demand for boron (B) during blossoming if fruit set is to be fully effective (Hanson and Proebsling, 1996). Application of B sprays is often used to ensure that sufficient amounts of B are available for flower fertilization, fruit set, and early fruit let development (Peryea, 1992; Zude *et al.,* 1998; Hanson *et al.,* 1985; Stover *et al.,* 1999; Nyomora *et al.,* 1999; Štampar *et al.,* 1999; Solar *et al.,* 2001). Flower buds are a preferential sink for B mobilization after foliar application (Sanches and Righetti, 2005). Zinc (Zn) is another important essential micronutrient which helps in the formation of tryptophan, a precursor of IAA responsible for growth stimulation (Mallick and Muthukrishnan, 1979) and plays a vital role in synthesis of carbonic anhydrase enzyme which helps in transport of CO_2 in photosynthesis (Alloway, 2008) and directly or indirectly required by several enzyme systems and synthesis of auxin. Magnesium is the metallic constituent of chlorophyll and regulates the uptake of other nutrients (Ram and Bose, 2000). Iron increases photosynthesis and carbohydrate synthesis and in reproductive growth of fruit in organs of the plant acts as a strong sink (Sohrab *et al.,* 2013).

The nutrients required in large quantity are supplied through soil application (Fageria *et al.,* 2009) but nutrients needed in lower quantity can be better absorbed through foliar spray (Fageria *et al.,* 2009; Girma *et al.,* 2007). Best timing for foliar sprays should be one or more of the followings; i) at a new flush, ii) after fruit harvesting, iii) pre-anthesis/2-3 weeks prior to fruit bud differentiation, iv) at full bloom, and v) at the small fruit formation stage. Due to restricted mobility of iron, zinc and boron in plant tissues and keeping in view plant physiology, the authors are of the view that as orchard crops try to accumulate maximum amounts of essential nutrients before flower formation so micronutrients foliar sprays should be made preferably after fruit harvest and before flower formation in addition to recommended deficiency doses already applied through soil.

Foliar sprays can prevent or correct a problem with relatively small amounts absorbed by the foliage but at the same time, it has also been recognized that root uptake must be maximized in order to obtain the most benefit from foliar sprays. For details about different aspects of foliar nutrition, readers may refer to various reviews (Haynes and Goh, 1977; Slowik and Swietlik, 1978; Kannan, 1980). Mineral nutrients enter into leaves in three steps (Frank, 1967) involving: (1) penetration through the cuticle and epidermal walls; (2) adsorption on the surface of the plasma lemma, and (3) passage through the plasma lemma into the cytoplasm. Discontinuities and cracks in the epicuticular waxes, however, open a pathway for penetration of leaf-applied nutrients. Encouraging Reviews of micronutrient application on growth, yield and quality of various fruits crops have been reported by the earlier researcher. Micronutrient deficiency found to affect plant growth and reduced yield of fruit crops. The main objective of this paper to review different hypothesis and experimental results on micronutrient functions.

Major Response of micronutrient in fruit crops

Response of micro nutrient on Vegetative growth of fruit crops

Many reports have shown higher vegetative growth when applied the micronutrients in fruit crops. John Wooldridge, 2002 tested that under trace element-deficient, pot trial conditions over a 21-month, post-planting period, a combination of fritted trace element carrier, mixed into the sand soil at the rate of 100 gm^3 before planting, followed by a program of alternating Mn + Zn and B +Cu foliar sprays, promoted improved vegetative growth in nursery-grown Braestar/M793 apple trees. Similarly trees Dawood *et al.*, 2001 confirm that foliar application of Zn increases vegetative growth of young sweet orange. Singh *et al.*, (2005) reported that use of micro nutrients (Boron and Zinc) as Borax and Zinc sulphate (0.25 and 0.50 percent respectively) increased plant growth when they are applied in combination or alone in papaya cv. Ranchi. Rajaie, M. *et al.*, 2009 studied the impact of different concentration of zinc (Zn) and boron (B) on growth and mineral composition of lemon seedlings (*Citrus Aurantifolia* L.) he found that the Fresh and dry plant weights of the control treatment were strongly decreased with B levels higher than 5 μg g-1 of soil. Zn treatments reduced B accumulation and the associated inhibitory effect on plant growth. Increased B level in soils enhanced the concentration of B in plant shoots to a greater extent in the absence of applied Zn. The best plant production was achieved when 2.5 and 10 μg g-1 soil of B and Zn were applied simultaneously. This combination was associated with the highest uptake of Zn, nitrogen (N), phosphorous (P), potassium (K), iron (Fe), manganese (Mn) and copper (Cu), suggesting that the combination resulted to a suitable condition in which plants had a well-balanced nutritional status. Jasrotia, *et al.*, (2014) found that the foliar Application of Zinc (0.6% $ZnSo_4$) in Combination with Boron (0.6% Boric Acid) resulted in the significantly influenced the shoot extension growth and chlorophyll content in the olive leaf while Razzaq, K. *et al.*, 2013 found that the foliar application of Zn as 0.6% zinc sulfate had a positive effect on vegetative and reproductive growth in 'Kinnow' mandarin.

Response of micro nutrient on initial fruit set (%), fruit retention (%) and fruit drop (%)

Many review reports have indicated that significant effect of micronutrients on initial fruit set, fruit retention, and fruit drop. Singh and Vashistha (1997) advocated that application of 0.5% borax ($Na_2B_4O_7$. $10H_2O$) and 0.5% zinc sulphate was obtained most effective to minimize fruit drop percentage in ber *cv*. Seb. Banik *et al.,* (1997) noted that foliar application of Zinc, Iron and Boron each at 0.1, 0.2 and 0.4 percent respectively, significantly influenced the flowering and fruiting of 13-year-old mango *cv*. Fazli. Kundu and Mitra (1999) observed foliar application of 1.0% borax 0.3 percent copper influenced the fruit set (%) and hastened the fruit ripening. Sinha *et al.,* (1999) reported foliar application of 0.1% borax and 0.8% zinc sulphate reduced the fruit drops and increased the fruit retention (%) in Litchi cv. Purbi. Ali *et al.,* (1991) reported that spraying of nutrients & their combination at urea 2 percent, potassium sulphate 1%, zinc sulphate 0.4 percent, and borax 0.2 percent were found effective to increase the yield per tree in guava cv. Allahabad safeda. Kamble *et al.,* (1994) stated that foliar spray of Iron, Manganese, Zinc, and Boron increased percent fruit set and fruit retention in ber (*Z. mauritiana* Lamk.) cv. Banarasi karaka. Razzaq, K. *et al.,* 2013 found that the foliar application of zinc sulfate significantly increased number of fruits and fruit weight in 'Kinnow' mandarin. Similar results have been reported by Shawky *et al.,* (1990) and Ismail (1994) who found that foliar application of Zn increased the yield of 'Navel' and 'Valencia' oranges. Application of B prior to flowering increased fruit set of olive 'Manzanillo' (Perica *et al.,* 2001). Boron sprays after bloom increased fruit set and yield of the apple cultivar 'Elstar' (Wojcik *et al.,* 1999) and sprays at the pink flowering stage increased flower cluster and early-season leaf B concentrations of the apple 'Scarlet Gala' (Peryea *et al.,* 2003). Foliar applications of B before full bloom or after harvest increased fruit set and fruit yield of 'Conference' pear (Wojcik and Wojcik, 2003). Das *et al.,* (2000) reported the effect of foliar spray of zinc sulfate (0.5 or 1.0%) aqueous solution at 25-27 days after fruit set on the fruit quality of guava cv. 'Allahabad Safeda'. Fruits were analyzed 15, 54 and 93 days after spraying resulted in both zinc sulfate concentrations increased the total, reducing and non-reducing sugar content of fruits. Greater increase, however, were recorded for 1.0%. They also recorded fruit sweetness due to zinc sulphate starter 15 days spraying when the fruits were in the early development stage. Sharma *et al.,* (2002) reported that combination application of 0.50 per cent ZnSO4 and 20 ppm 2,4-5T on 10 years old Kagzi lime (*C. aurantifolia*) resulted in the highest fresh weight (51.84 g), volume of fruit (44.60 ml), number of seeds per fruit (15.05), acidity (9.20%), ascorbic acid content (49.83 mg/100 ml juice) and TSS (10.18%), whereas, combined application of 0.50% zinc sulphate and 50 pm GA3 resulted in the highest juice content (57.36%). Application of zinc at higher level increased the foliar zinc content which ultimately encourages the endogenous production of auxin thereby reducing fruit drop (Meena *et al.,* 2014).

The response of micronutrient on physical characters of fruits

Singh *et al.,* (1983) found that foliar spray of 3.0 percent urea and 0.3 percent boric acid increased the size of fruit in guava cv. Lucknow-49. Pandey *et al.,* (1990) reported that in ber cv. Banarasi karaka, fruit weight and volume increased continuously throughout the development period and specific quality decrease markedly up to 45 days after fruit setting and then stabilized until harvest. Sarangi *et al.,* (1992) advocated that in case of Cape gooseberry both weight and volume increased with an increasing number of days from fruit set. Chaitanya *et al.,* (1997) reported that foliar feeding of 0.3 per cent zinc sulphate and above increased the length and diameter of fruit in guava cv. Lucknow-49. Rao *et al.,* (2004) spraying

K_2SO_4 (2.0%) and $ZnSO_4$ (0.4%) at the time of fruit setting stage proved most effective in reducing fruit drop and increasing yield in ber cv. Banarasi karaka. Jay Kumar *et al.,* (2008) observed that the use of micronutrients Zinc and Boron as a foliar spray as well as soil application on 4 and 8 months after planting increased plant growth in Papaya cv. Coimbatore- 6. Meena *et al.,* (2008) reported that the application of $FeSO_4$ and borax at par stage @ 0.6% produced maximum average fruit weight, pulp weight stone weight pulp stone ratio and yield. Zhang Cheng Hao Lim (2010) reported that the combined spraying of borax 0.1% along with $ZnSO_4$ 0.003% and phosphorus 0.6% in paprika (*Capsicum annum* L.) increased the fruit size and weight. In apples pink flowering timing for B, sprays are often used because of the importance of adequate B for proper pollen tube growth; flower fertilization, fruit set, and early fruit let development (Peryea, 2002).

The response of micronutrient on the yield of fruits

Ingle *et al.,* in 1993 reported the use of Borax 0.2 percent and Zinc sulphate 0.4 per cent as foliar spray increase fruit yield in Guava cv. Lucknow- 49 and Chaitanya *et al.,* (1997) also confirm the same. Kundu and Mitra (1999) also confirm that foliar application of 1.0 per cent borax and 0.3 per cent zinc sulphate 0.3 per cent copper increased the fruit yield in guava. Panwar *et al.,* (1994) noted that foliar spray of Borax 0.1 per cent significantly increased the yield of aonla cv. Banarsi. Stampar *et al.,* (1999) advocated that foliar application of borax, zinc and phosphorus (0.2 per cent), increased the yield up to 30 per cent in apple. Rao *et al.,* (2004) reported that the application of potassium sulphate (2.0%) and zinc sulphate (0.4%) with a concentration of 200 ppm NAA increasing fruit yield in ber cv. Banarasi karaka. Meena *et al.,* (2008) reported that the application of borax and ferrous sulphate @ 0.6% produced the high yield in ber cv. Gola. Jafarpour and Poursakhi 2011 revealed that the positive effect of foliar application in spring and fall on the yield increase was superior to the control, but the highest yield was obtained in the foliar application in the fall+ spring. In spite of the increased yield through localized fertilization treatment and foliar application in the fall+ spring, no decrease was observed in fruit texture firmness. However, the specific weight of fruits and the TSS/TA ratio were increased. Sajid *et al* 2010 revealed that the foliar application of zinc in combination with boron may be applied in order to increase the production and to control the decline of a citrus orchard in order to get high-quality fruit Production, yield and extend the bearing life of citrus plants. Mustafa *et al.,* 2013 revealed that application of 25kg F.Y.M.+ ½ NPK+ $ZnSO_4$ +$CuSO_4$+$FeSO_4$ (T4) produced maximum fruit yield and fruit size as well as nutrient content in aonla. Mirzapour and Khoshgoftarmanesh (2013) study the performed to investigate the effectiveness of soil and foliar application of iron (Fe) and zinc (Zn) fertilizer on pomegranate (*Punica granatum* L cv. 'Ghojagh') in a calcareous soil. Results were reviled soil application of FeEDDHA and ZnSO4.7H2O, particularly as localized placement, is an appropriate and effective approach to improve the yield and fruit quality of pomegranate in the calcareous soils. Razzaq, K. *et al.,* 2013 found that the foliar application of zinc sulfate significantly increased yield in 'Kinnow' mandarin. The increase in fruit weight, size and peel thickness of 'Kinnow' mandarin fruit with foliar application of Zn might be associated with the role of Zinc in the synthesis of tryptophan, a precursor for the synthesis of indoleacetic acid (Cakmak *et al.,* 1989). These results confirm the previous findings of Sahota and Arora in 1981 who stated that foliar application of Zn increased the fruit yield by increase in fruit weight and size in sweet orange. Eman *et al.,* (2007) also reported that Zn spray increased the peel thickness in ‘Washington Navel’ oranges.

The response of micronutrient on Quality characters of fruits

Ahlawat and Yamdogni (1981) to narrate that the seven spray of potassium sulphate at 1% increased the percentage of total sugar in the fruit of guava cv. Safeda. Singh *et al.,* (1983) reported that foliar spray of 0.3% borax along with 3.0% urea increased the total soluble solids (T.S.S.) and sugar content in guava cv. Lucknow-49. Brahmachari and Kumar (1997) observed that foliar spray of 1.0 per cent zinc sulphate, 0.4 per cent borax and 2 per cent calcium nitrate increased the T.S.S. and ascorbic acid content in Litchi fruit. Kundu and Mitra (1999) reported that foliar application of 0.3 per cent copper 0.1 per cent borax and 0.3 per cent zinc the T.S.S. ascorbic acid, total sugar in lemon. Singh *et al.,* (2007) found out the application of borax (0.2%), zinc sulphate (0.6%) on aonla and found that zinc at 0.6% was most effective in increasing the T.S.S. ascorbic acid content. Meena *et al.,* (2008) observed that application of ferrous sulphate and borax at (0.6%) fruit setting time increased the T.S.S. and total sugar and decreased the acidity content in ber fruit cv. Gola. (Maribela Pestana, *et al.,* 2001) evaluated that the concentrations of phosphorous (P) and magnesium (Mg) in flowers were correlated with those in leaves, and were also predictive of the chlorophyll content of leaves 60 days later. However, by 120 days after full bloom, these effects were masked, possibly by a fertilizer application carried out by the farmer. The iron (Fe) concentration in flowers was correlated with chlorophyll measured either 60 or 120 days after full bloom. These parameters can, therefore, be used to predict the appearance of iron chlorosis. Fresh weight and diameter of fruit were related to flower P, Mg, and manganese (Mn) concentrations, while the percentage of citric acid in the fruit juice was inversely correlated with Fe flower concentrations. Hasani, M. *et al.,* 2012 examine the response of foliar spray of zinc and manganese sulfates on the fruit yield and quality as well as leaf nutrients concentration of pomegranate, he observed 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. Foliar sprays of Zn significantly increased Zn but decreased Mn and P concentrations in the leaves. Shad Khan Khalil *et al.,* 2011 reported that B is important for the sufficient quantity needed for the proper growth, development, fertilization growth, and nut yield and nut quality in pecan. Wojcik and Wojcik 2006 examine response of sweet cherries (*Prunus avium* L.) to boron (B) fertilization, result was found that B fertilization had no effect on vigour and yield of sweet cherry trees despite increased concentration of this microelement in flower and leaf tissues. Mean fruit weight, titratable acidity, and fruit sensitivity to cracking also were not influenced by B fertilization. Pawel Wojcik 2005 results obtained showed that soil or foliar application of B did not affect vigour and yield of ‘Bluecrop’ high bush blueberries grown on coarse-textured soil poor in water-soluble Boron. Saadati *et al.,* 2013 reported that foliar application of zinc sulphate, boric acid, and their combination significantly promoted soluble sugar and oil contents of olive fruits. Results showed that utilization of microelements such as B and Zn were capable to enhance both the quantity and quality of oil content such as oleic acid and phenolic compounds in olive fruits in semiarid areas.

Jasrotia *et al.,* (2014) found that the foliar Application of Zinc (0.6% ZnSo4) in Combination with Boron(0.6% Boric Acid) resulted in the significantly influenced Fruit Size, Fruit weight and Volume, Pulp: Stone Ratio and oil content in olive cv. Frontoio. Razzaq *et al.,* 2013 found that the foliar application of zinc sulfate significantly influenced physical and chemical fruit quality characteristics in 'Kinnow' mandarin. Chandler. Waskela *et al.,* (2013) reported that, the maximum weight (187.18 g), length (7.06 cm) and width (7.09 cm), high pulp (96.91%), pulp: seed ratio (32.09), of fruit was obtained with the foliar application of 0.75% zinc sulphate in guava cv. Dharidar.

The response of micronutrient on the shelf life of fruit

Gupta *et al.,* (1989) to informed that 6.7 % pathological weight loss after room condition and Gupta and Mehta (1998) reported that untreated fruits of ber cv. Gola can be stored for 12-15 days with 7.64 percent weight loss whereas kathali cultivar of ber can be stored for 8-9 day with about 15 per cent weight loss. Usha and B.K. Singh (2002) reported that the effect of foliar spray of Iron (Fe at 0.2%) and boron (Bat 0.4%), magnesium (mg at 0.02%) improved the quality of grape cv. perlette significantly increased in the berry weight. Singh *et al.,* (2007) the application of potassium sulphate 0.6 per cent borax (1.3%) was most effective in increasing the T.S.S. ascorbic acid content and shelf life. Yadav and Sharma (2009) reported that sprayed of 10 days intervals, K_2SO_4 1.5% or 2.0% on the ber fruit cultivar Umran increasing the T.S.S. total sugar and observed the acidity content decreased the lowest acidity was found in 15 days of storage. Jawandha *et al.,* (2009) reported that the effect of Boran (0.1%) with $CaCl_2$ (2%) pre-harvest application maintained very good fruit quality and prolonged shelf life for 20 days under open storage conditions. Zhang Lim Yong Sup (2010) informed that the application nutrient solution (B-3.5% + CU- 0.0005% + mg- 3.5% + P-6%) in ber fruit increasing the quality of ber fruit, T.S.S. and Shelf life also and enhanced the acidity ascorbic acid. Mishra *et al.*, 2017 observed that the foliar application of $CuSO_4$ (0.4%) + $MnSO_4$ (0.5%) + $ZnSO_4$ (0.4%) obtained the maximum fruit yield and better quality of Aonla fruits.

In conclusion, from the above mentioned reviewed it is concluded that the role of micronutrient have a significant effect on fruit plants and significantly improves the vegetative growth, fruit yield, quality and shelf life of fruit crops. Use of micronutrients will continue to increase in the near future and depending primarily upon the economic benefits.

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