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Review Article

A-Review on Role of Micro-Nutrients on Banana, Mango and Pomegranate

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ABSTRACT

India rank second in Horticulture produce in the world after china. Produces large varieties of fruit crops like mango, banana, citrus, guava, grapes papaya, sapota, and pineapple. Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants. The elements essential for plants are C, H, O, N, P, K, Ca, Mg, S, Fe, Cu, B, Mn, Mo, Zn, Cl. Out of these 16 elements, 9 essential elements have been classified as "macronutrients" as these are required in relatively large amount by the plants. These elements include C, H, O, N, P, K, Ca, Mg and S. The necessity of micronutrients (iron, copper, zinc, boron, manganese, magnesium and molybdenum) is only in traces, which is partly met from the soil or through chemical fertilizer or through other sources. Proper plant nutrition is essential for successful production of fruit crops. Micronutrients are involved in all metabolic and cellular functions. Plants differ in their need for micronutrients. In this review, we focus on the major functions of mineral micronutrients in banana, mango and pomegranate fruit production.

Keywords: *Fruit crops, Micronutrients, Function, growth, Yield, Quality*

INTRODUCTION

Banana (*Musa spp.*) belongs to Musaceae family is the most important fruit in the world. Banana is originated in tropical South and South East Asia. It is also known as apple of paradise, *Kalpataru*. It has nutritional, medicinal, industrial as well as aesthetic value in Hindu region. It is also a dessert fruit for millions apart from a staple food owing to its rich and easily digestible carbohydrates with a calorific value of 67-137/100 g edible fruit. It is a good source of vitamin ''A'' (190 IU per 100 g of edible portion) and vitamin ''C'' (100 mg/ 100g) and fair source of vitamin B and B2. Banana fruit is used as table purpose, vegetable making juice, jam and chips.

Mango (*Mangifera indica* L.) belongs to the Anacardiaceae family this plant is native to Indo-Burma region. It is also called as king of fruit. The fruit has been in cultivation in Indian sub-continental for well over 4000 years and has been the favourite of the kings and commoners.

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Mango fruit is used as table purpose, making juice, jam, jelly, lather and paste. Mango fruit is an rich source of vitamins, minerals and is famous for its excellent flavour, attractive fragrance and nutritional value.

Pomegranate (*Punica granatum* L.) belonging to the Punicaceae family, it is grown in tropical and sub-tropical regions. Originated in Indo-Burma region Iran and is extensively cultivated in the Mediterranean region since ages (Sheikh and Manjula, 2009). Pomegranate is used as table purpose, making juice, jam, jelly and paste. The fruit peel, tree stem and leaves and root bark are good source of secondary metabolites such as tannins, dyes and alkaloids (Mirdehghan & Rahemi, 2007). The edible part of the fruit is the seeds having a fleshy covering and called arils.

India rank second in Horticulture produce in the world after china. Produces large varieties of fruit crops like Mango, Banana, Citrus, Guava, Grapes Papaya, Sapota, Pineapple, Litchi, Jamun, Avocado and temperate fruits. Since the last 50 years a considerable research work has been done in the country on various aspects such as varieties, irrigation, quality improvement, manure and fertilizer management, weed management, spacing, post harvest etc for increase in yield and quality of fruit crops. The elements essential for plants are C, H, O, N, P, K, Ca, Mg, S, Fe, Cu, B, Mn, Mo, Zn, Cl. Out of these 16 elements, 9 essential elements have been classified as “macronutrients” as these are required in relatively large amount by the plants. These elements include C, H, O, N, P, K, Ca, Mg and S. Essential micronutrients include six elements *viz*. zinc, boron, manganese, iron, copper and molybdenum (Stevenson, 1986). The nutrient elements which are required comparatively in small quantities by plants their requirement vary from 0.1-0.5ppm are called as micro or minor nutrients or trace elements.

Essentiality and deficiency symptoms of Iron:

Plants require iron to create chlorophyll and to activate several enzymes as well as those involved in the oxidation /reduction processes of photosynthesis and respiration. Iron rise photosynthesis and carbohydrate synthesis and in reproductive development of fruit in organs of the plant acts as a strong sink (Sohrab et al. 2013). Iron is also essential for very important plant metabolic function i.e. chlorophyll synthesis, respiration, various enzymatic reaction and photosynthesis Given that the main product of photosynthesis is sugar, so increasing the photosynthesis, lead to increase the sugar compounds and cause more soluble solids in fruit juice (Ram & Bose 2000). Iron has been powerfully associated with protein metabolism. In addition, iron is part of protein ferredoxin and is required in nitrate and sulfate reductions. Iron deficiency in plant and soil due to lacking iron in the soil but usually because it is rendered unavailable for the uptake by an excess of manganese or phosphorous or alkaline soil conditions. Iron deficiency is a major problem of calcareous high pH soils. The universal deficiency symptoms include increase of light green chlorosis of all the tissues between the veins. Because iron does not move easily within the plant, older leaves can remain green while flushes of new growth are chlorotic.

Essentiality and deficiency symptoms of Zinc:

Zinc deficiency is the major problem in Indian soil and limiting growth and yield in fruit crops. It commonly affects banana, custard apple, guava and mangoes. Zinc deficiency common problems often appear in spring when crops are growing quickly but have difficulty in absorbing nutrients from cold soil in winter envirment. Zinc is required for the synthesis of tryptophan a precursor of auxin thus helps in reducing fruit drop. Application of zinc at higher level increased the foliar zinc content which ultimately encourages the endogenous production of auxin there by reducing fruit drop (Meena et al. 2014). Zinc plays very important role in carbohydrate and proteins metabolism as well as it controls the plant growth hormone IAA and is essential component of dehydrogenase, proteinase, peptides enzymes, and promotes starch creation, seed maturation and manufacture.

Involvement of Zn in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis, consequently it increased tissue growth and development. It has vital role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Alloway, 2008). The severe stunting of leaves and shoots, which is so typical of zinc deficient crops is a consequence of low auxin levels in tissue. Young leaves are typically the most affected and are little, narrow, chlorotic and often rosetted due to breakdown of the shoot to elongate. Bloom spikes are small, misshapen and drooping. In young pine apple plants, zinc deficiency is indicated by the young heart leaves bunching together and then tilting horizontally. This condition is commonly known as *crook neck*. Older plants may develop yellow spots and dashes near the margins of older leaves that eventually coalesce into brown blister like blemishes giving the leaf surface uneven feel.

Essentiality and deficiency symptoms of Boron:

Boron is a large amount required for cell division and development in the growth regions of the plant near the tips of shoots and roots. It also affects sugar transfer and appears to be associated with some of the functions of calcium. Boron is useful for pollination and the development of viable seeds which in turn affect the normal development of fruit. Borex response was more positive due to boron which plays an vital role in translocation of carbohydrates, auxin synthesis to the sink and improved in pollen viability and fertilization Yadav et al. (2013). A shortage of boron also causes cracking and distorted growth in fruit. Boron is immobile nutrient does not easily move around the plant and therefore the effects of deficiency appears first, and are usually most acute in growing points, young tissues, root tips, young leaves and developing fruit. The fruits of boron deficient papaya are misshapen and bumpy due to the irregular fertilization and development of seeds within the fruit. Ripening is uneven and the developing fruit secrete pinkish white to brown latex. Premature shedding of male flowers and impaired pollen tube development can lead to poor fruit set.

Essentiality and deficiency symptoms of Copper:

Generally copper deficiency appears to be minimal in tropical fruit crops. Copper is necessary for photosynthesis, for the functioning of several enzymes, in seed development and for the production of lignin which gives physical strength to shoots and stems. Copper activates several enzymes in plant, helps in chlorophyll synthesis (Ram & Bose 2000). Copper is a vital element of numerous enzyme proteins like ascorbic acid, cytochrome, oxidase, oxidase, oxidase, diamine, and polyphenol oxidase. It also acts as a catalyst or part of many enzyme systems. It was also observed that calcium and copper must be present in plant cells for iron to function properly. The deficiency symptoms include restriction of terminal growth; die back of twigs, death of growing points and sometimes rosetting, and multiple buds form at the end of twigs. In pineapple, growth is severely stunted and leaves are narrow, U shaped in section, and curved downward at their tips. Tip necrosis occurs in some young leaves.

Essentiality and deficiency symptoms of Manganese:

Manganese is essential for chlorophyll formation for photosynthesis, respiration, nitrate assimilation and for the movement of several enzymes. Manganese is only moderately mobile in plant tissues so symptoms appear on younger leaves first, most often in those leaves just reaching their full size. Manganese availability is reduced in high pH calcareous soils but is often very high in the acid soils commonly chosen for tropical fruit production. Manganese deficiency causes a light green mottle between the main veins. A group of darker green is left bordering the main veins while the interveinal chlorotic areas become pale green or dull yellowish colour. Soil application of manganese can be not effective due to immobilization.

Essentiality and deficiency symptoms of Magnesium:

Magnesium require for the metabolism of carbohydrates (sugars). It is an enzyme activator in the synthesis of nucleic acids (DNA and RNA). Magnesium is the metallic constituent of chlorophyll and regulates the uptake of other nutrients (Ram & Bose 2000). It regulates uptake of the other necessary elements, serves as a carrier of phosphate compounds throughout the plant, facilitates the translocation of carbohydrates (sugars and starches), and increase the production of oils and fats. Magnesium deficiency is most common on sandy coastal plain soils where the native magnesium content is low. The predominant symptom is interveinal chlorosis (dark green veins with yellow areas between the veins). The bottom leaves are always affected first. Magnesium deficiency has been a major worldwide problem in citrus production. Magnesium deficiency symptoms appear as a result of translocation of Mg from the leaves to the developing fruit, although there may also be a translocation from older leaves to young developing leaves on the same shoot.

Essentiality and deficiency symptoms of Molybdenum

Molybdenum is an essential part of two major enzymes in plants, nitrate reductase and nitrogenase, which are required for normal absorption of nitrogen. Optimum concentration of these micronutrients may be liable for improved protein content. Molybdenum deficiency is observed in many soils and, vegetables, pasture legumes and occasionally cereals, it is very rare in fruit crops. There are few reports that molybdenum deficiency called as yellow spot is observed in citrus.

EFFECT OF COMBINATION OF MICRONUTRIENTS ON FRUIT CROPS

Nutrient status of leaf

Mango

Many reports have shown higher nutrient status of leaf when applied the micronutrients in fruit crops. Sankar et al. (2013) reported that the highest N, P, K and B content were found to be higher in application of boric acid 0.02 per cent, while calcium content was maximum in calcium nitrate 0.06 per cent spray. The highest nitrogen content in mango leaves it may be due to the fact that boron use induced a higher stimulus effect on leaf nitrogen (Pandey & Sinha, 2006). The leaf nitrogen was increased by boron application might be the result of intensified nitrate uptake from soil and decreased activity of nitrate reductase (Kumar & Purohit, 2001). The observed highest phosphorus content in leaf it may be due to phosphorus uptake by leaves, phosphorus metabolism and translocation to plant. The maximum increased potassium per cent in mango leaves it may be due to the role of boron in encouragement of potassium absorption from soil rather than utilization in plant tissues (Sanna Ebeed & Abd El-Migeed, 2005). Highest calcium content observed in mango leaves because the foliar application applied calcium which was more absorbed by leaf and utilized for the physiological activity. This may be the cause for increased leaf calcium content. A similar result was obtained by Topcuoglu (2002). The higher values of boron in mango leaves it may be due to presence of boron necessary compounds in the cell which may have increased the mechanism of boron uptake, which is thought to be a non-metabolic process determined in plant by the formation of non-exchangeable boron complexes within the cytoplasm and cell wall. It was observed that the leaf nutrient status of mango increased with application of Zn (0.1 and 0.2%), Mn (0.1 and 0.2%) and Fe (0.1 and 0.2%). Application of Zn improved the leaf N and Zn content while Fe improved P and Fe and Mn improved the Mn and K contents Dutta and Dhua (2002).

Banana

Yadav et al. (2009) observed that the maximum nitrogen and iron content in leaves were recorded under the plants treated with higher levels of Fe-EDTA with common application of micro-elements and higher percentage of phosphorus, zinc, manganese and copper content in leaves were recorded in the treatments of higher ZnEDTA with common application of $MnSO_4$, $CuSO_4$ and Borax. It was observed maximum Zn content in leaf with RDF (200+90+200 NPK g/plant) + 40 g Zn EDTA + 20 g $MnSO_4$ + 5 g $CuSO_4$ + 10 g Borax/plant and maximum Fe content in leaf noted from RDF + 25 g $FeSO_4$ + 2 g $MnSO_4$ + 5 g $CuSO_4$ + 10 g Borax and RDF + 25 g Fe EDTA + 20 g $MnSO_4$ + 5 g $CuSO_4$ + 10 g Borax/plant Yadav et al. (2010).

Pomegranate

Hasani et al. (2010) observed that the 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. According to the results, the suitable combination of these two micronutrients for studied characters of pomegranate under prevailing conditions was foliar spray of 0.6% MnSO4 and 0.3% $ZnSO_4$. Hamouda et al. (2016) observed that the highest values of leaf content from N and Ca under foliar spraying with 1600 ppm Mn and highest values of leaves K, Mn and Zn content under1000ppm Fe foliar spray. It was reported that the highest leaf area and chlorophyll content under interaction effect of manganese and calcium rates displayed that application of 60 mg Mn.l-1 and 100 mg Ca.l-1. These results are owing to the use of macro and micronutrients which play an important role in the symbol of critical auxins that increase cell division and increase chlorophyll content in the leaf, which works to increase leaf area Waleed et al. (2014).

EFFECT OF MICRONUTRIENTS ON GROWTH PARAMETERS

Mango

Singh and Rajput (1976) reported that the different levels of $ZnSO_4$ increased the length of terminal shoot, number of leaves and leaf area per shoot of mango tree indicated that both Zinc and Boron promoted vegetative growth in terms of plant height, trunk girth and spread of young plants.

Banana

Krishnamoorthy and Hanif (2017) it was observed that maximum pseudo stem height and leaf area index with the application of micronutrients @ 250 ml of 0.5%, Arka banana special through soil. It was reported that combined spraying of Zn (0.5%) + Fe (0.5%) showed highest basal girth (74.50cm) at shooting Pathak et al. (2011). It was observed beneficial effect of micronutrients on height of pseudostem at shooting Anon (2005).). It was reported that the beneficial effect of micronutrients and their combination on pseudostem girth and number of leaves at shooting was also recorded maximum (13.4) in combined spraying of Fe (0.5%) +Zn (0.5%) Manda et al. (2002). Improvement in growth of banana plant may be due to improvement of photosynthetic and other metabolic activities which lead to an increase in various plant metabolites responsible for cell division and cell elongation. Boron increases photo synthetic activity and respiration in plants and thus improves the growth (Lal & Rao. 1954).

Pomegranate

Hamouda et al. (2016) observed that spraying of micronutrients (Fe, Mn, and Zn) led to increase in the activities of the vegetative growth**,** consequently led to absorb more nutrients. It was reported that foliar spraying of GA3 (75 ppm) + Boron (0.5%) recorded significant maximum length of fruit (8.71 cm), diameter of fruit (9.40 cm), volume of fruit (554.40 ml), number of aril (416.00), number of aril (76.74%), number of aril per fruit (864.00), and minimum rind thickness (0.78mm), rind percentage (24.09) are observed in GA3 (75 ppm) + Boron (0.5%) compared to control. This seems to be the role of gibberellins in cell division and elongation in longitudinal direction and also may be reduced or suppress the radial growth which might influenced the fruit size was recorded in spraying of GA3 (75 ppm) + Boron (0.5%). It seems that foliar sprays of boron improved the diameter of fruit which may have brought beneficial effects on fast growing meristematic tissues. It may also affect cell division, development and carbohydrate metabolism in pomegranate who observed that application of boron helps in rising diameter of fruit which confirms present findings. Maximum volume of fruit may be due to influence of GA3 which increased the cell wall plasticity thus creating water diffusion pressure deficit, which might resulted in increased water uptake, thereby causing cell elongation. The increase in volume of fruits could be due to nature of gibberlic acid which is to promote the growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugars which reduces the cell water potential, resulting in the entry of water into the cell and causing the elongation in pomegranate. Maximum number of aril per fruit it could be attributed to GA3 play the role in multiplication and elongation of cells in the fruits Gaikwad et al. (2019).

EFFECT OF MICRONUTRIENT ON YIELD AND YIELD PARAMETERS

Mango

Haldavnekar et al. (2018) observed that the maximum number of fruits/tree (240.67) and yield (64.04 kg/tree) under RDF + Foliar spray of 0.4% zinc sulphate + copper sulphate (0.2%)+ Borax (0.2%), spraying at now before flowering and marble stage of fruit growth recorded the maximum number of fruits/tree (240.67) and yield (64.04 kg/tree) in Alphonso cultivar of mango. The sprayed of micronutrients when alone or in combination involved directly in different physiological processes and enzymatic activity. This may have resulted into superior photosynthesis, better accumulation of starch in fruits. It was observed that the maximum fruit weight, fruit volume, numbers of fruits per tree, fruit yield of fruits per tree, fruit yield per hectare and fruit retention per panicle under the treatment (1% spray of multi micronutrient) Singh et al. (2017). The maximum preservation of fruits per panicle it may be due to boron which play vital role in pollen germination and pollen tube growth and development which is associated with superior pollination, fertilization and fruit setting (Thompson and Batjer 1950). Application of zinc would have promoted the auxin synthesis in the plant system which might delayed the formation of abscission layer during early stage of fruit development (Nason & McElroy (1963).

Banana

Pathak et al. (2011) observed that the earliest shooting, minimum days to bunch harvest, also the crop duration under foliar application of $ZnS0_4$ (0.5%) and recorded maximum crop duration, produced highest bunch weight, yield B:C ratio number of fingers and hands the longest bunch, finger length, breadth and days to ripening under combined spraying of ZnS04 (0.5%)+FeS04 (0.5%) in banana.

Pomegranate

Gaikwad et al. (2019) reported that highest length of fruit, diameter of fruit, volume of fruit, average weight, number of fruit per plant, weight of fruit per plant, yield (mt/ha) number of aril in 100 g, aril percentage, aril to rind ratio and number of aril per fruit under spray of GA3 (75 ppm) + Boron (0.3%) in cv. Bhagwa. It was observed that the highest fruit yield under 0.6% $MnSO_4$ + 0.3% $ZnSO_4$ Hasani et al. (2010). It was reported that the increase in diameter of fruit, fruit weight, fruit volume, number of arils per fruit, fruit set percent, number of fruit per plant and yield over under foliar spry of 0.4 per cent zinc sulphate + 0.4 per cent boric acid + 0.4 per cent ferrous sulphate in Sindhuri variety of pomegranate. It was observed that the foliar spray of calcium at 100 mg.l-1 and manganese at 60 mg.l-1 increased significantly highest fruit set percentage; yield compared over control at both seasons Yadav et al. (2018). It was also observed that the spray of calcium increased fruit set, fruit weight, and consequently increased the yield Hassan et al. (2010).

EFFECT OF MICRONUTRIENTS ON QUALITY PARAMETERS

Mango

Anees et al. (2011) observed that maximum pulp weight, total soluble solids, ascorbic acid , non-reducing sugars, less stone weight along with low acidity total sugars, reducing sugar and non-reducing sugars under sprayed with 0.4% $FeSO_4$ + 0.8% H_3BO_3 + 0.8% $ZnSO_4$. The improvement in quality of fruit might be due to the catalytic action of micronutrients particularly at high concentration. Hence, the foliar application of micronutrients rapidly improved the uptake of macronutrients in the tissues and organs of the mango plants, decreased the nutritional deficiencies and improved the fruit quality in mango. It was reported that tremendous enhancement in total sugars, TSS and ascorbic acid applied zinc or boron each at the rate of 0.2-0.8% in cv. Langra trees at full bloom stage and Rath et al. (1980). It was reported that the significant strengthening in total soluble solids and total sugars of mango fruit due to application of different concentrations of boric acid Singh et al. (1987). It was also observed that the highest TSS, total sugars (%), reducing sugar (%), non-reducing sugar (%), ascorbic acid (mg/100g), carotenoids (mg/100g), sugar acid ratio and lowest values of acidity under application of boric acid 0.02 per cent Sankar et al. (2013).

Banana

Pathak et al. (2011) reported that the maximum sugar acid ratio (41.698), non-reducing sugar (10.040%) also showed considerable improvement on total soluble solids (25.53°Brix) and total sugar (17.241%) content of pulp under foliar spraying of Fe (0.5%) and Zn (0.5%). It was reported that maximum total soluble solids, reducing sugar, non-reducing sugar, total sugar, ascorbic acid, pulp-peel ratio and minimum acidity per cent weight of peel under the treatment (RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5 %)) Panigrahi et al. (2018).

Pomegranate

Hamouda et al. (2016) observed that the highest TSS, total sugars (g/100g FW), anthocyanin content of fruit juice was gained from shrubs receiving the high level of Zn at 2000ppm foliar spray. The improvements of pomegranate fruit quality it might be due to the role of these elements in increasing the photosynthesis process efficiency, led to enhance the sugar compounds and cause more soluble solids in fruit juice. Hasani et al. (2010) observed that the increasing juice content of arils, anthocyanin index and TSS under combination of manganese sulfate at 0.6% and zinc sulfate at 0.3%. It was reported that the maximum increase 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 in Sindhuri variety of pomegranate under foliar spry of 0.4 per cent zinc sulphate + 0.4 per cent boric acid + 0.4 per cent ferrous sulphate Yadav et al. (2018). It was reported that the minimum splitting percentages on trees spray with the highest concentration of calcium (100mg.l-1) Waleed et al. (2014).

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