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Impact of Foliar Application of Zn on Growth Yield and Quality Production of Citrus: A Review

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ABSTRACT

Citrus is one of most important fruit cultivated all over the world and it belongs to family Rutaceae. It is richest source of vitamin C. However, quality production of citrus is declining due to micronutrient deficiencies caused by alkaline pH, low organic matter and calcareous nature of soil. Zinc is essential for energy transmission, nitrogen metabolism and oxidation reduction reactions. It also improves the chlorophyll contents of leaves and play important role in enzymatic activities and essential for development and growth of fruits. It is also involved in regulating the protein and carbohydrate metabolism. There are many ways to mitigate Zinc deficiency under field conditions but the best and the easiest method is foliar application. The present review directly focuses on the impact of foliar application of Zn on growth, yield and quality of citrus fruit.

Keywords: *Citrus, Quality, Zinc and Foliar Application.*

INTRODUCTION

Globally, citrus is one of most important fruit which produce in about hundreds of countries (Rehman et al., 2020). It is native to SouthEast Asia, such as China, Thailand, Malaysia, Indonesia, Pakistan and India. It belongs to Rutaceae family with 140 genera and 1300 species having fundamental groups like mandarin, limes, orange, grapefruits, lemons and pummelos etc which are cultivated in subtropical and tropical areas (Bora et al., 2020). The total worldwide production of citrus is 139.80 million tons, over an area of 9.08 million hectares. It is richest supply of fiber, vitamin C, minerals and phyto-chemicals (Ladaniya, 2008).

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There is considerable authentication that it has antioxidant and anti-mutagenic properties and positive effect on bones, cardiovascular and immune system (Codoñer-Franch & Valls-Bellés, 2010). However, quality production of citrus is declining due to micronutrient deficiencies caused by alkaline pH, low organic matter and calcareous nature of soil (Rashid et al., 1997). Moreover, specifically deficiency of Zn is one of the major micro-nutrient deficiency in crops and soil which reduce the yield and quality of production, ultimately either direct or indirect negative effects on human health (Cakmak, 2008). Zinc is essential for energy transmission, nitrogen metabolism and oxidation reduction reactions (Cakmak, 2002). Many enzymes in plants like carbonic anhydrase, hydrogenase, cytochrome synthesis and ribosome's is affected by zinc (Tisdale et al., 1984). It also improves the chlorophyll contents of leaves and play important role in enzymatic activities and essential for development and growth of fruits. It is also involved in regulating the protein and carbohydrate metabolism (Katiyar et al., 2009). Moreover, foliar application of micronutrients is more dominant than soil application. It is very important strategy for management (Adnan et al., 2020) Foliar application of Zn had positive effect on fruit quality and yield of Kinnow mandarin, sweet orange and grapes (Razzaq et al., 2013). Foliar supply of Zn increases the biosynthesis of carotenoid and chlorophyll synthesis that are essential for proper performance of photosynthetic process (Mousavi, 2011). The present review directly focuses on the impact of foliar application of Zn on growth, yield and quality of citrus fruit.

1. Zinc Deficiency

The deficiencies of micronutrients are general due to alkaline pH, low organic matter and calcareous nature of soil (Rashid et al., 1997). Deficiencies of nutrients are turning healthy orchards into unproductive with low quality fruit because citrus is nutrient loving plant and cause serious nutrients problem. Zn deficiency is one of the major micro-nutrient deficiency in crops and soil which reduce the yield and quality of production; ultimately directly or indirectly cause negative effects on human health (Cakmak, 2008). Availability of Zn is inversely associated to pH of soil and its shortage is prominent on calcareous soils having pH > 8.0 (Srinivasa et al., 2008). Moreover, Soils with high percentage of phosphorous and silicon are also estimated to cause Zn deficiency. Insufficient supply of Zn causes negative effects on plants by stopping the tillering process, stunting growth, delaying crop maturity, chlorosis in younger and older leaves, poor quality of harvested products and sterility of spikelet (Hafeez et al., 2013).

2. Importance of foliar application of Zinc in citrus

Citrus is one of the important horticultural fruit crop growing all over world (Bilal et al., 2020). Foliar application of Zn is more dominant than soil application (Edward 2009; & Toor et al., 2020). Zinc can extremely enhance Kagzi lime fruiting and flowering quality (Venu et al., 2014). Foliar application is noticeably a perfect way of escaping the problems of nutrient availability. Citrus tree is deep rooted crop that's why application of micro-nutrients to soil may be of little value. The substitute way is to supply micronutrient through foliar spray (Alloway, 2008). Micronutrients like zinc (Zn) is very essential for physiological, optimal plant growth and biochemical pathways in citrus development. Plants required micronutrients in different amounts. Some of these elements are redox-active and are cofactors in many enzymes. They have enzyme-activating functions and play structural role in stabilizing proteins (Hansch & Mendel, 2009).

3. Effect of Zn on Growth, Yield and Quality of Citrus

Zinc takes part in lots of physiological processes and its inadequate dose can affect crop growth and yield. Razzaq et al. (2013) conducted a research to evaluate the effects of foliar spray of $ZnSO_4$ on growth, production and quality of 'Kinnow' mandarin. Leaf manganese, calcium and nitrogen were recorded maximum in those trees which were treated with 0.2% $ZnSO_4$, iron and phosphorus were recorded maximum with 0.6% $ZnSO_4$ and zinc and potassium were seen highest with 0.8% $ZnSO_4$ application. $ZnSO_4$ at the rate of 0.6% gave maximum plant vegetative parameters and physico-chemical analysis of fruits as compared to all other treatments. Foliar application of 0.6% $ZnSO_4$ improved the nutrients, productivity and growth with superior quality of fruit in 'Kinnow' mandarin. Ahmad et al. (2012) conducted an experiment to examine the effect of foliar spray of Zn and B on the tree growth, leaf mineral status, quality and productivity of citrus fruit cv. Feutrell's Early (*Citrus reticulata* Blanco). Plants were treated with $ZnSO_4$ and H_3BO_3 either combine or alone. Foliar application of zinc and boron highly increased the leaf potassium, manganese, iron, boron and zinc. Foliar spray of 0.5% zinc sulphate + 0.3% boric acid at fruiting stage enhanced fruit weight, tree height, juice weight %, leaf size, TA and SSC and also bring leaves level from low to maximum. At stage of premature the foliar spray of 0.5% zinc sulphate + 0.3% boric acid enhance the amount of non-reducing, total sugars and ascorbic acid quantity in fruit. Results showed that at fruiting stage the combined spray of 0.5% zinc sulphate + 0.3% boric acid enhanced the zinc and boron concentration in leaves, vegetative growth, production and quality parameters of fruit. Aisha et al. (2015) investigated the effect of foliar spray of micronutrients (Cu, Zn and B) on the enhancement in yield of fruit and photosynthetic attributes of citrus (Kinnow) trees. For this purpose, two sites of Punjab (Sargodha and Toba Tek Singh) were selected. The different levels of foliar application were (0.1, 0.2 and 0.3%) of zinc, boron and copper at 3 different growth stages and application of macronutrients as recommended doses. Application of micronutrients significantly enhanced transpiration rate, photosynthetic rate, caroteniods, chlorophyll "a", "b" and stomata conductance in equally sites. The levels of 0.3, 0.1 and 0.2% were very efficient in the improvement of fruit yield and good fruit quality. Rahman and Haq (2006) conducted research on the effectiveness of foliar application of zinc, manganese and boron on the yield of sweet orange (cv. "Red Blood") and leaf nutrient contents along with to discover their critical amount. Application of zinc, manganese and boron alone and in different mixture as foliar application supply as of sulfate salts and H_3BO_3 at the rate of 0.04, 0.2 and 0.4 kg ha^{-1}, respectively in 400 L of water. Foliar applications of zinc, manganese and boron highly increased yield of fruit. Concentration of zinc, manganese in leaf was also increased with the foliar application of the relevant micronutrients but boron in leaf was not highly influenced by boron application. Critical amount of zinc, manganese and boron in leaves were seen to be 22, 25 and 29 mg kg^{-1}, respectively. It may be executed that the amount of leaf concentrations of zinc, manganese and boron mentioned over provide as point for the nutrient status of sweet orange plants. Bhati et al. (2016) executed an experiment to determine the effectiveness of plant growth regulators and Zn on yield and fruiting parameters of acidic lime (*Citrus arantifolia* S.). Treatment includes a combination of NAA, GA_3, Zn and control spray sprays. In total, fifteen treatments were implemented. Along with all treatments Zn 1.0% + GA_3 100 ppm + NAA 200 ppm foliar spray was seen to be the better for fruit retention (65.70%), fruit set (49.67%), fruit length (4.22 cm), fruit volume (36.83 ml), rind thickness (1.69 mm), fruit diameter (4.11 cm), juice percentage (49.00%), fruit weight (39.07 g) and number of fruits $plant^{-1}$ (976.33). A set of fruits from low flower initiation (25.00 days), fruit fall (34.29%) and fruit maturity (145.00 days), quality parameters such as total sugars, ascorbic acid (32.00 mg) and TSS (8.33 ^{o}B) were also enhanced and acidity (6.42%) were decreased with zinc 1.0% + GA_3 100 ppm + NAA 200 ppm. Tariq et al. (2007) conducted an experiment to determine the effect of foliar spray of blood red variety on sweet orange leaf composition, yield and fruit quality. Zn, Mn and B were applied as foliar sprays at 0.04, 0.2 and 0.4 kg ha^{-1}, 0.4 kg surfactant ha^{-1} and 1.56 kg N ha^{-1} urea in water of 400 L. Highest yield of fruit was noted when sprayed with 0.2 kg Mn ha^{-1} and 0.4 kg Zn ha^{-1} with 0.4 kg surfactant ha^{-1} and 1.56 kg N ha^{-1} in the presence of water of 400 L. Minimal peels in percentage were recorded with B and only 7n + Mn with minimum % rag, greatest fruit size with B + Zn and greatest fruit size with Mn + Zn. likewise, the juice (%) in sweet orange was highly increased from B alone, and the reduction of vitamin C content and sugar by B + Zn only by foliar application recommended that every micronutrient differed in the citrus fruit quality. Foliar application of Zn, Mn and B along with urea highly increased the concentrations of Mn and Zn in leaves of citrus trees, but the content of B was not influenced by the leaf sprays. Therefore, it is recommended that Mn + Zn or B + Zn in combination with urea and surfactant can be used as a spray to achieve highest yield of fruit and good citrus fruit quality under current situation.

Ashraf et al. (2013) described that drop of citrus fruit is a major cause of fruit fall, mostly due to imbalance hormones in trees. This imbalance occurs as the effect of lack of nutrients in plant soil, insect pest attacks and water scarcity. Consequently, growth regulators [salicylic acid (SA) and 2,4-D] and nutrients [zinc (Zn) and potassium (K)] and citrus fruits have been experimented with to improve fruit yield and control fruit fall in Pakistan, Punjab Citrus has fallen in four selected places along the way. Foliar spray of SA, 2, 4-D, Zn and K highly improved fruit juice content, fruit weight, acidity, ascorbic acid, total soluble solids (TSS) and TSS / acid ratio and minimize fruit fall. The spray of Zn + 2, 4-D + 2, 4-D and Zn + K + SA has shown valuable effects on all parameters. (Swietlik, 1996) described efficient way of supplying zinc to fruit plants is required to combat the prevalent shortage of this nutrient worldwide. Foliar applications are more efficient, zinc plants that absorb foliage are not readily replaced, frequent spray applications are required, and the capacity of leaf application to reduce zinc shortage in all parts of plant is reduced. The situation under which trees respond to zinc application in terms of yield, quality of fruit and fruit growth are not understood. Zn foliar application is very beneficial before synthesis in yield of citrus and grapes fruits.

Amiri et al. (2008) conducted a research on benefit of $ZnSO_4$ and $MnSO_4$ foliar spraying in 1 'Valencia' orange for four years and 2 'Ruby Red' grapes. Three sprays of metal Zn and Mn at equal concentrations of 216 and 168 ppm, respectively. The Valencia exchange tree, controlled by the leaf Zn, ranges from 13–26 ppm in experiment 1 to dry weight and zinc drop patterns affect 1–2% of the plant canopy. Leaf Zn levels in control of grapefruit vary from 12–31 and 17–46 ppm. Experiment 2 observed no symptoms of zinc scarcity on tree and the characteristics of B in Experiment 3 were inconsistent and ambiguous. Zn leaves are effective in correcting the symptoms of Zn deficiency and maximizing leaf Zn content. Both grapefruit and orange trees ineffective to respond to zinc spray in terms of number of fruits, yield, width and canopy height and average fruit weight. Leaf manganese deficiencies patterns of control vary from 25 to 39 ppm were observed each experiment. There is no benefit from Mn sprays even if they increase leaf manganese level. Over the years, Mn and Zn have been transformed into new leaves by spraying them to increase their density to 2–5 ppm. Earlier applications of Zn through foliar spray have optimistic impact on the leaf concentration of orange trees and mandarin (Sayed et al., 2004). Likewise, this increase in leaf Zn content in treated plants was due to application of zinc in the form of $ZnSO_4$. Yaseen & Ahmad (2010) reported that foliar spray markedly improved the yield as compare to those trees which was not sprayed. Ghayekhloo & Sedaghathoor (2015) conducted an experiment to determine the best source of Mn, Zn and Fe spray of Miagava tangerine trees for realizing the maximum yield per unit area with the highest quality with eight treatments including different ratios of three micronutrient sources (iron chelate, zinc chelate and Manganese chelate). The trees were sprayed at two stages with three different concentrations. The measured traits included fruit and fruit skin fresh and dry weight, acidity, vitamin C, sugar and fruit Zn, Fe and Mn content. Different treatments significantly increased fruit fresh and dry weight, Fe content, Mn content, sugar and vitamin C of fruits, so that the treatment of Zn + Fe + Mn had the highest indices of these traits in the fruits. Yadav et al. (2011) evaluated the effect of urea, zinc sulphate and borax on flowering, fruiting and yield of acid lime. The result revealed that foliar spray of urea 1.5% + borax 0.6% + ZnSO40.5% was found to be the best for maximum increase in plant-height (0.32 m), plant spread in north-south (0.37 m), plant spread in east-west (0.33 m), number of flower per plant (1977.33), fruit set (63.28%), number of fruit per plant (985.00) and reduced fruit drop (36.14%) which ultimately increased the yield of fruit per plant (45.40 kg) compared to other treatments.

CONCLUSION

Our review has demonstrated that Zn is the most important factor limiting citrus crop production but negative effects of citrus deficiency can be minimized by the foliar application of Zn. Moreover, foliar application of zinc significantly improves growth, yield, production and quality of citrus.

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