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Influence of Foliar Application of Micronutrients and Vermicompost on some characteristics of crop plants

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ABSTRACT: Micro-nutrients such as iron, zinc and boron are essential for different biological functions that might be attributed to tree yield and fruit quality. It is also increased resistance to disease and insect pests and improved drought tolerance. Now it is a well-established fact that organic fertilizers provide enough requirements for proper growth of the crop plant and may enhance the uptake of nutrients, increase the assimilation capacity and will stimulate the hormonal activity as well. Vermicompost is also useful as it increases soil porosity, aeration and water holding capacity. Vermicompost increases the surface area, provides strong absorbability and retention of nutrients as well and retain more nutrients for a longer period of time. It has been found that soil amended with vermicompost had significantly greater soil bulk density and the soil does not become.

Key words: Tobacco, wheat, corn, Safflower

INTRODUCTION

Micro-nutrients. Micro-nutrients such as iron, zinc and boron are essential for different biological functions that might be attributed to tree yield and fruit quality (Shoeib, 2003). It is also increased resistance to disease and insect pests and improved drought tolerance (Tariq *et al.,* 2007). The essentiality of boron in plants is discovered by Gauch and Dugger (1953). Reduction in fruit set, fruit growth and yield in B deficient plant is reported in pear (Rease, 1989). Boron deficiency in peaches is characterized by a die-back of branches in spring (Woodbridge, 1955). Zn deficiency symptoms such as little leaf or rosette were described for peach (*Prunus percia*). Soil applications are not very effective because the roots of fruit crops occupy deep soil layers and zinc does not easily move in the soil therefore, foliar sprays are more effective (Chandler *et al.,* 1931). Iron plays an important role in chlorophyll biosynthesis pathway. Thus deficiency of this element reduced the net photosynthesis which causes huge reduction in fruit yield (Chandler *et al*., 1931). This article is review and the aims is influence of foliar application of micronutrients and vermicompost on some characteristics of crop plants

Iron (Fe). Iron (Fe) is the first microelement, which it is necessary for plant life. Grace established it in 1844 during removing of chlorosis in grape via iron sulfate sparing. Iron is essential for the activity of several enzymatic systems and plant components such as Catalase, Cytochrome, Frodoxin, Frichrome, Hematin, Hem and Cytochrome oxidase. In addition, it seems iron be involved in nucleic acids metabolism in chloroplast. Usually relation between iron and vegetative growth of fruit trees is more complex than other nutrient elements (Saatsi and Yamur, 2000).

Iron deficiency. Iron deficiency chlorosis is a common nutritional disorder chiefly associated with high pH or calcareous soils affecting plants, and a limiting factor for fruit agricultural production in many areas of the world (Abadia *et al*., 2011; Borowski and Michalek, 2011; Fernandez *et al.,* 2006). Iron deficiency impairs fruit quality and yield, and can ultimately lead to tree death (Alvarez-Fernandez *et al.,* 2003, 2006; Fernandez *et al.,* 2006). The foliar application of mineral nutrients using sprays, offers a method of supplying nutrients to higher plants more efficiently than methods involving root application when soil conditions are not suitable for Fe availability (Borowski and Michalek, 2011; Fernandez *et al.,* 2006; Erdal *et al.,* 2004). In calcareous soils, for example, Fe availability is usually very low and Fe deficiency widespread. Foliar spraying under these conditions could be much more efficient than any other applications of Fe to the soil (Amri and Shahsavar, 2009; Erdal *et al.,* 2004).Iron deficit in plants decreases the content of photosynthetic pigments.

Foliar fertilization of the plants with Fe-EDDHA (commercial name Sequestrene 138-Fe) treatment had higher leaf chlorophyll indexes than all other treatments(Borowski and Michalek, 2011; Crane *et al*., 2007; Larbi *et al*., 2006; Pestana *et al.,* 2001). Treatment by means of foliar Fe-EDDHA at the level of 50g per tree by adding two rows resulted in a significant increase in leaf chlorophyll content of peach (Sanz *et al.,* 2002). The most effective chelate for curing iron chlorosis in avocado in acid and alkaline soils is Fe-EDDHA. This chelate is stable from pH 4 to 10, whereas the stability of Fe-EDTA decreases above pH 7. (Salazar-Garcia, 1999).

Boron. Boron (B) is a micronutrient that is often thought to be toxic to many crops, even at low concentrations in leaves. However, deficiency of B is equally serious, and may be a problem in Arizona citrus. Certainly, many symptoms of B deficiency are apparent in Arizona citrus. The effects of B deficiency on vegetative growth of citrus are well known, and occur when leaf B concentrations are less than 15 ppm. Some of these symptoms include translucent or water-soaked flecks on leaves and deformation of those leaves, yellowing and enlargement of the midrib of older leaves, death and abortion of new shoots, dieback of twigs, and gum formation in the internodes of stem, branches and trunk (Reuther *et al.,* 1968). Many of these symptoms are seen in Arizona. Furthermore, the supply of B needed for reproductive growth in many crops is more than that needed for vegetative growth (Mengel and Kirkby, 1982, Marschner, 1986; Hanson, 1991), and the same may be true in citrus. Boron appears to accumulate in citrus peel to a much greater extent than in the leaves, ranging in lemon from 1600 to 3500 ug.g-1 (Sinclair, 1984). Concentrations of B also may be higher in flower parts as well. It is entirely possible that Arizona citrus appearing to have adequate B for vegetative growth may exhibit deficiency symptoms during flowering, fruit set, and fruit maturation. In citrus, B deficiency leads to low sugar content, granulation and excessive fruit abortion (Reuther *et al.,* 1968) as well as rind thickening; symptoms that are seen regularly in fruit grown here in Arizona. Increases in fruit set from B have been reported on 'Redblush' grapefruit (Maurer and Davies, 1993) and 'Hamlin' oranges, but no response on 'Lisbon' lemons (Karim *et al.,*1996).

Tobacco (*Nicotiana tabacum* L.). Tobacco (*Nicotiana tabacum* L.) belongs to the family Solanaceae, which is widely grown throughout the world for the manufacturing of cigarettes, cigars and bids also utilized for snuff, hokka and chewing purposes (Poustini and Shamel, 2000). The chemical composition of tobacco leaf plays an important role in the evaluation of tobacco quality such as nicotine, sugar, potassium, and chloride contents. The absolute and relative amount of these constituents not only depends upon on crop varieties, maturity, soil and climatic conditions and curing process, but also depends on the responsive mineral nutrition of tobacco, such as boron (Tariq, 2010). Boron is one of the deficient micronutrient after zinc in Pakistan (Rashid, 1996) and perhaps this micronutrient not only affect the yield but it also affect the marketing value of tobacco leaf. Boron deficiency as well as toxicity causes many physiological and biochemical changes within plants, most of which represent indirect effects. Perhaps the most important manifestation of boron deficiency is the reduction in yield and quality of crops, because boron cannot readily be redistributed within the plant in most species, even a brief disruption of soil nutrient supply results in growth depression and yield loss. The extent of yield loss dependents upon the duration of deficiency and the stage of plant growth at which it occurs (Dell and Huang, 1997). (Mahler, 2010) described the role of boron in conveying the sugar across membrane, cell differentiation and its development as well as in auxin metabolism. Boron is an essential nutrient for vascular plants, but high concentration is toxic and limits crop productivity. When plants are exposed to boron toxicity, it will cause reduction of leaf area, formation of chlorotic and necrotic patches in older leaves, delay of development and inhibition of plant growth (Nable, 1997). It has long been known that an optimum boron level for one species could be either toxic or insufficient for other species (Blevins and Lukaszewski, 1998). Researchers have identified a range of genotypic variation in response to boron toxicity with mechanisms including boron exclusion (Hayes and Reid, 2004) and an inherent ability to tolerate high boron levels in plant tissues (Torun, 2006). Boron deficiency is a wide spread agricultural problem in the world, which results in yield and quality loss of many crop species including tobacco (Shorrocks, 1997), and its deficiency and toxicity also affect the utilization of other micronutrients such as Zn, Cu, Fe, Mn and Mo (Tariq and Mott, 2006). Several studies reported that the supply of boron may affect the behavior of other micronutrients in plants, but the specific function of boron on the behavior of other micronutrients is not well defined. It is well understood that the boron chemistry in soil and its role in plant differs from other micronutrients, such as Zn, Cu, Fe, Mn and Mo, but its deficiency or excess may affect the solubility of these micronutrients in soil (Santra , 1989) and uptake by plants (Alvarez-Tinaut, 1980; Gomez Rodriguez ., 1981; Dave and Kannan, 1981; Tariq and Mott, 2006). However, information regarding the effect of boron on the uptake and transport of micronutrients (Zn, Cu, Fe, Mn and Mo) is insufficient.

Maize (*Zea mays*). Micronutrients play an active role in the plant metabolism process starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity and nitrogen fixation and reduction.

Micronutrient requirements of the maize (*Zea mays*) crops are relatively small and ranges between their deficiencies and toxicities in plants and soils are rather narrow. Expectation of higher maize productivity through the use of adequate amount of fertilizer nutrients may lead to become limiting to some micronutrients in the soil and most times due to their over mining by the crops and shortage of which often show the deficiency symptoms and yields are reduced (Das, 2000). Joshy (1997) reported the critical limit of some micronutrients on maize. He mentioned the critical limit for sulphur was 14 ppm, boron 95 ppm, zinc 82 ppm and for manganese 0 ppm for maize crop. These limits were obtained from plant samples which were grown on the soils which were below critical limit values. Micronutrients are becoming increasingly important to world agriculture as crop removal of these essential element increases. Soil and plant tissue tests confirm that these elements are limiting crop production over wide areas and suggest that attention to them is likely increase in the future. Micronutrient deficiencies are due to not only to low contents of these elements in the soil but more often to their unavailability to growing plants (Brady and Weil, 2002). Adhikary and Pandey (2007) suggested to apply 20 kg of S/ha to increase grain production of maize in acidic soils of Chitwan valley.

Safflower (*Carthamus tinctorius* L.). Safflower (*Carthamus tinctorius* L.) is oilseed plant that is adapted to the hot and dry regions. This is resistance to drought, salinity and heat stresses (Daju, 1993). Thus, in spite of country needs to import oil cultivate unsuitable conditions (against other plants such as canola and soybean). Safflower can play an important role in providing the required oil for country. Cultivation of Safflower is growing in the world and it is grown for power mechanization in many countries. In past, the culture this plant has been common in many parts of the world, especially in Middle East, but in recent years due to the availability of safflower oil, it is very important. While in the past, mainly safflower production was in order to take advantage of its pigment in the flowers. At present, the main goal of safflower production is oil extraction from its seeds and its oil has is good quality in various usage. Safflower oil has high quality because of unsaturated fatty acids (more than 78%), oleic acid and linoleic acid especially. One of the main reasons for the low acreage of safflower is low yield and economic outcome. Therefore, the availability of certified seeds with high production potential and support for purchasing seed oil plants by oil factories can be effective in country's oil needs (Weiss, 2000). Micronutrients such as manganese and zinc can be important role at nutrition of oil Safflower. In Safflower, zinc fertilizer should use at least once, twice or three times at one year and manganese can be used at least once at one year for crops and horticulture (Khoshgoftarmanesh *et al.,* 2010). It seems that critical level of zinc and manganese in soil is 1mg kg^{-1} and less than 10mg kg^{-1}, respectively (Marschner, 1995). Zinc also plays an important role in the production of biomass, grain yield, quality and quantity of oil of Safflower (Kaya and Higgs, 2002; Cakmak, 2008).

Wheat (*Triticum aestivum* L.). Wheat (*Triticum aestivum* L.) is an important cereal crop, source of staple food and thus the most important crop in food security prospective. Besides its tremendous significance, average yield is far below than developed countries (FAO, 2010), although the genetic potential of local varieties is not less than any country in the region. Major yield limiting factors includes delayed sowing, high weeds infestations, water shortage at critical growth stages and imbalance and non-judicious fertilizers use. The micronutrients play an important role I increasing crop yield. Micronutrients have prominent effects on dry matter, grain yield and straw yield in wheat (Asad & Rafique, 2000). Several reports indicate that either soil or foliar application of micronutrients have positive correlation with wheat yield (Rashid & Rafique, 1988; Wisal *et al.,* 1990; Habib, 2009; Wroble, 2009). Foliar spray of micronutrients is more effective to control deficiency problem than soil application (Torun *et al.,* 2001). Foliar application of B at reproductive stage enhanced grain yield of wheat (Wroble, 2009), while its deficiency caused male sterility resulting in grain set failure in wheat (Jamjod & Rerkasem, 1999). Various reports show that both soil application and spray of micronutrients are positively correlated with wheat yield (Wisal *et al.,* 1990; Wroble, 2009). Shaheen *et al*. (2007) stated that increased yield of wheat required Zn status of soils to be improved by Zn fertilization. In a study on soils with 2.95 and 0.93 mg kg^{-1} available Fe and Zn, respectively, Abbas *et al.* (2009) found that different Zn levels did not significantly affect plant height, but the effect of Zn application was statistically significant on spike length. Also, higher level of Zn application influenced the number of spikelets per spike, 1000- grain weight and straw yield significantly increased tiller number per unit area. Also, Wisal *et al.* (1990) and Wroble (2009) stated that both soil and foliar application of micronutrients were positively correlated with wheat grain yield and that they increased it. Several reports (Ziaeian *et al.,* 2002; Seilsepour, 2007; Khan *et al.,* 2010; Zeidaan *et al.*, 2010) showed that the application of Fe and Zn micronutrients increased the grain yield of wheat which is in agreement with the currentstudy. Shaheen *et al.* (2007) stated that enhancing wheat yield depended on improving Zn status of soil by Zn fertilization. Maralian (2009) reported that foliar application of Zn and Fe improved grain yield and the related traits of wheat compared to control and that out of the studied treatments, the highest grain yield was obtained from Fe+Zn treatment.

Biological fertilizers. Excessive use of fertilizers will cause environmental pollution and will destroy the balance of the ecosystem that is one of the major problems (Mishra, 2004). Thus, biological fertilizers can be considered a suitable solution for overcoming this problem, further by adding beneficial organisms to improve soil fertility and increasing fertilizer planting beds in hydroponic greenhouses and also increase the qualitative and quantitative products. In fact, using organic fertilizers like vermicompost and mycorrhizal fungi can be used in a sustainable agricultural system (Saleh Rastin, 2001).

Vermicompost. The use of synthetic fertilizers causes a great impact on the environment and the cost of these fertilizers is increasing over the years. The farmers need to raise the crops by organic farming that will reduce the costs and will decrease the impact on the environment. In addition, organic farming will reduce the additional burden of environmental pollution that is caused while manufacturing these synthetic fertilizers at the source (Rathier and Frink, 1989). Now it is a well-established fact that organic fertilizers provide enough requirements for proper growth of the crop plant and may enhance the uptake of nutrients, increase the assimilation capacity and will stimulate the hormonal activity as well (Tomati *et al.,* 1990; Grapelli *et al.,* 1985). Vermicompost is also useful as it increases soil porosity, aeration and water holding capacity. Vermicompost increases the surface area, provides strong absorbability and retention of nutrients as well and retain more nutrients for a longer period of time. It has been found that soil amended with vermicompost had significantly greater soil bulk density and the soil does not become compacted (Lunt and Jacobson, 1994; Martin, 1976).

Earthworms. Earthworms digested the organic waste and convert to vermicompost with high porosity, water absorption and retention water that improved growth plant and increased of crop yield (Arancon, 2004). Edward and Batz (1992) found that earthworms were increased significantly plant growth in culture media.

Plant growth. The use of vermicompost appears to affect plant growth in ways that cannot be directly linked to physical or chemical properties (Dash and Petra, 1979). However, the improvements in physical and chemical structure of the growth media are attributed to the increase in plant growth. It is argued that growth promotion may be due to micro flora associated with vermicomposting that induce hormone-like activity on the production of metabolites (Parle, 1963; Tomati *et al.,* 1987; Atiyeh *et al.,* 2002).

Influence of vermicompost on the physic-chemical and biological properties of soil

The results of several long-term studies have shown that the addition of compost improves soil physical properties by decreasing bulk density and increasing the soil water holding capacity (Weber, 2007). Moreover, in comparison with mineral fertilizers, compost produces significantly greater increases in soil organic carbon and some plant nutrients (García-Gil, 2000, Bulluck, 2002, Nardi, 2004, Weber, 2007). The use of organic amendments such as traditional thermophilic composts has been recognized generally as an effective means for improving soil aggregation, structure and fertility, increasing microbial diversity and populations, improving the moisture-holding capacity of soils, increasing the soil cation exchange capacity (CEC) and increasing crop yields (Zink and Allen, 1998). Vermicompost contains most nutrients in plant-available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium (Orozco, 1996). Vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium (NPK) and micro nutrients, microbial and enzyme activities and growth regulators (Parthasarathi and Ranganathan 1999; Chaoui, 2003) and continuous and adequate use with proper management can increase soil organic carbon, soil water retention and transmission and improvement in other physical properties of soil like bulk density, penetration resistance and aggregation (Zebarth, 1999) as well as beneficial effect on the growth of a variety of plants (Atiyeh, 2002). Vasanthi and Kumarasamy (1999) who found significant increase in CEC of the soil treated with vermicompost plus NPK. Decreased pH was observed in the soils treated with enriched compost of industrial wastes, after harvest of ragi and cowpea (Srikanth, 2000). Vasanthi and Kumarasamy (1999) and Srikanth, (2000) where the incorporation of various enriched compost, vermicompost. Increased available NPK in the soils were observed where the soils were treated, respectively, with enriched compost from different organic wastes, FYM, vermicompost and vermicompost plus NPK after the harvest of rice, ragi and cowpea (Vasanthi and Kumarasamy, 1999; Srikanth, 2000; Sailajakumari and Ushakumari, 2002; Chaoui, 2003).

Reduced consumption of chemical fertilizers

The use of vermicompost organic fertilizer with chemical fertilizer could be reduced consumption of chemical fertilizers. Andhikari and Mishra (2002) showed in that the combined application of vermicompost organic manure with urea chemical fertilizer can reduce by 50 percent the amount of urea in the field conditions. Also the yield was 12% higher than treatments that only received fertilizer. Behera *et al.* (2007) showed that the use of 2.5 ton ha^{-1} vermicompost manure fertilizer with 50 percent fertilizer recommendations for wheat, grain yield in 4.08 ton ha^{-1}. While the in treatments of only the fertilizer was added to yield 4.87 ton ha^{-1}, respectively.

There were significant differences between these two treatments that probably due was to low consumption of vermicompost. Gopinath *et al.* (2008) concluded that the treatments that received manure vermicompost were significantly increased in grain yield compared to control. While the maximum grain yield was obtained of treatment had received only fertilizer.

Biological properties. Vermicomposts have many outstanding biological properties. They are rich in bacteria, actinomycetes, fungi (Edwards, 1983; Tomati *et al.,* 1987; Werner and Cuevas, 1996) and cellulose-degrading bacteria (Werner and Cuevas, 1996). In addition, Tomati *et al.* (1983) reported that earthworm castings, obtained after sludge digestion, were rich in microorganisms, especially bacteria. Nair *et al* (1997) compared the microorganisms associated with vermicomposts with those in traditional composts. The vermicomposts had much larger populations of bacteria (5.7 × 107), fungi (22.7 × 104) and actinomycetes (17.7 × 106) compared with those in conventional composts. The outstanding physico-chemical and biological properties of vermicomposts makes them excellent materials as additives to greenhouse container media, organic fertilizers or soil amendments for various field horticultural crops.

Plant growth regulator production in vermicomposts. There is a very substantial body of evidence demonstrating that microorganisms, including bacteria, fungi, yeasts, actinomycetes and algae, are capable of producing plant growth hormones and plant growth regulators (PGRs) such as auxins, gibberellins, cytokinins, ethylene and abscisic acid in appreciable quantities (Arshad and Frankenberger, 1993; Frankenberger and Arshad, 1995). Many of the microorganisms that are common in the rhizospheres of plants can produce such plant growth-regulating substances, for instance Barea *et al* (1976) reported that, of 50 bacterial isolates obtained from the rhizosphere of various plants, 86% could produce auxins, 58% gibberellins and 90% kinetin-like substances. There have been many studies of the production of plant growth-regulating substances by mixed microbial populations in soil, but there are relatively few investigations into their availability to plants, and persistence and fate in soils or documenting reliably their effects on plant growth (Arshad and Frankenberger 1993). Several workers have shown that PGRs can be taken up by plants from soil in sufficient quantities to influence plant growth. It was shown that auxins produced by *Azospirillum brasilense* could affect the growth of graminaceous plants (Kucey, 1988). There is increasing evidence that microbially-produced gibberellins can influence plant growth and development (Mahmoud *et al.,* 1984; Arshad and Frankenberger, 1993).

Increased vigor of seedlings has been attributed to microbial production of cytokinins by Arthrobacter and Bacillus spp in soils (Jagnow, 1987).

Since the process of vermicomposting increases microbial diversity and activity dramatically, it is possible that vermicomposts could be a definitive source of plant growth regulators produced by interactions between microorganisms and earthworms, which could contribute significantly to enhancement of plant growth, flowering and yields. The first suggestion that earthworms might produce plant growth regulators was by Gavrilov (1963). The presence of plant growth-regulating substances in the tissues of *Aporrectodea caliginosa*, *Lumbricus rubellus* and *Eisenia fetida* was confirmed by Nielson (1965) who isolated indole substances from earthworms and reported increases in growth of peas due to the earthworm extracts. He also extracted a similar substance that stimulated plant growth from *Aporrectodea longa, Lumbricus terrestris,* and *Dendrobaena rubidus* but his experiments did not exclude the possibility of PGRs that he found being produced by microorganisms living in the earthworm guts and tissues. Graff and Makeschin (1980) tested the effects of substances produced by *L. terrestris, A. caliginosa* and *E. fetida* on the dry matter production of ryegrass. They added eluates from pots containing earthworms to pots containing no earthworms planted with ryegrass.

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