Bulletin of Biological and Allied Sciences Research
Section Plant Sciences, 2017.001:1-17.
March 2017|Volume 2|Article 1
Received 12 January 2017
Revised 28 February 2017
Published 16 March 2017

REVIEW ARTICLE

Role of Zinc Sulphate for Maize (*Zea mays* L.) and Mungbean (*Vigna radiata* L. Wilczek) yield improvement: A review

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ABSTRACT: Maize is an important cereal crop grown throughout the world for its grain and green fodder. It is used as food for human and feed for animals. Maize is a crop that is most susceptible to Zinc deficiency. The selection of high yielding cultivars and chemical fertilizer use is of high purity under intensive cropping system. Mungbean is being used as food and protein supplements. It is being cooked with vegetables, incorporated with bread and cakes, used as boiled or roasted in syrup. It is also generally used for vegetable dishes and sprout for egg rolls. The present review discussed about the use of zinc sulphate for the improvement of crop yield and quality of maize with mungbean in intercropping system. The present review revealed that plant uses Zinc in many of its vital processes such as protein synthesis, membrane's structure and functions, expression of genes and tolerance against oxidative stress. The impacts of zinc deficiency cannot be ignored as it has very much serious implication regarding immune system and growth. The use of Zinc for improvement of grain yield of maize and munbean plays an important role. Hence, it should be used as micro nutrient for improving output of maize and mungbean in sole and intercropping growing patterns.

Keywords: zinc sulphate, *Zea mays*, *Vigna radiata*, grain yield, intercropping, fertilizer

INTRODUCTION

MAIZE (*ZEA MAYS* L.)

Maize (*Zea mays* L.) grain is used as raw material for making an array of products and also being used for value addition. Its share in value addition to agriculture is 2.1 percent while in GDP is 0.4 percent. Area under maize has decreased to 1130 thousand hectares from 1168 thousand hectares in 2014-15. Due to which there was a decrease of 0.5%, i.e. the production has decreased from 4.944 million tons to 4.695 million tons. The decrease in production is due to decrease in area sown (Govt. of Pakistan, 2014-15). There was an increase of 6.2 % in yield of mungbean as compare to the production of last year. This increase was due to increase in area sown (Govt. of Pakistan, 2014-15). Keeping in view this situation, Pakistan has to increase per unit area yield on dwindling land to crop ratio. Maize is an important cereal crop grown throughout the world for its grain and green fodder. It is used as food for human and feed for animals. Its grain constitutes about grain protein 9.73%, grain oil 4.85%, grain crude fiber 9.43%, grain starch 71.96%; its green fodder contains fodder crude protein 10.35%, fodder cellulose 28.79%, fodder dry matter 40.17%, fodder crude fiber 26.84% and fodder moisture 9.09% (Ali *et al.*, 2014ab). Maize is a crop that is most susceptible to Zinc deficiency. The selection of high yielding

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cultivars, chemical fertilizer used is of high purity and intensive cropping system is usually followed. Zinc deficiency has become more prominent in last decade (Fageria *et al.*, 2002). Zinc has been reported for increasing grain yield of maize in whole world (Harris *et al*., 2007; Hossain *et al.*, 2008).

MUNGBEAN (*VIGNA RADIATA* L. WILCZEK)

Mungbean belongs to family Fabaceae. Mungbean is most important and readily available source for protein and various essential and vital micronutrients (Javed *et al*., 2014). Mungbean is an important legume crop cultivated throughout Pakistan, China, India and throughout most of South Asian countries. The grain of mungbean constitutes protein 24.5%, carbohydrates 59.9%, calcium 75mg, iron 8.5mg and β-carotene 49mg in 100m of dal of mungbean (Afzal *et al*., 2004). The micro nutrients including Zn and B are the most important nutrients to maintain proper and optimal plant growth of crop plants. The deficiency of micronutrients caused abnormalities in normal plant growth. The presence of Zn and B in the soil helps plant to uptake NPK properly and in adequate amount to maintain crop plant growth and production. The application of Zn and B in the intercropping of maize with legumes helps to improve soil nitrogen availability to plant roots. The presence of Zn and B in soil improved the soil fertility; Zn is also involved in the activation of various metabolic enzymes in the roots and plant body (Shojaei and Makarian, 2015).

The cultivation of two or more than two crops at same time and area is much familiar among the small landholder farmers (Seran and Brintha, 2010 and Ijoyah, 2012), cereal and legumes are involved in this familiar collective intercropping systems (Ijoyah, 2012), unequivocally corn/soybean, corn/mungbean, corn/groundnuts, millet/groundnuts, rice/pulses and corn/ricebean (Osman *et al*., 2011 and Matusso *et al*., 2012). Various research scientists have performed experiments to evaluate the legume and cereal intercropping systems to compare intercropping with monocrop systems (Waddington *et al*., 2007; Sanginga & Woomer, 2009, Egbe, 2010; Seran & Brintha, 2010; Osman *et al*., 2011 and Ijoyah, 2012). Matusso *et al*. (2012) found that the Intercrop system, helps the crop plants to improve their growth, yield and production due to the efficient use of energy. The intercropping also helps the crop plants to absorb nutrients from soil and use sunlight much efficiently (Sullivan, 2003 and Sanginga & Woomer, 2009). Intercropping also help the crop plants to resist against disease, pathogens, weeds and insect/pest attack and also improve soil fertility and productivity (Sanginga & Woomer, 2009, Egbe, 2010; Seran & Brintha, 2010 and Gurigbal, 2010).

EFFECT OF ZINC SULPHATE ON MAIZE

An experiment was conducted to evaluate the effect of zinc and phosphorous on three different hybrids of maize, which showed an antagonistic effect between P on Zn, but if specific ratios of both fertilizers are used the maximum yield can be obtained (Bukvic *et al.*, 2003). Wang *et al.* (2004) reported that to mitigate the adverse effect of drought on maize plant zinc sulphate application should be ensured. In whole world, maize is directly a staple food for a large population and, through indirect usage as a fodder crop for animals; it is an essential component of worldwide food safety (Campos *et al.* 2004). Abunyewa and Mercer-Quarshie (2004) found that zinc sulphate application increased the maize yield significantly. Maize grain yield due to Zn

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application was ranged from 0.9 to 3.2 t ha^{-1} up to the increase in 108 % over the three-year period of experimentation. It was revealed by Prasad and Brooks (2005) that the growth and leaf area of corn directly affected by intercropping of corn with soybean.

Sekara *et al.* (2005) conducted an experiment with nine different crops (maize, red beet, field pumpkin, barley, common bean, white cabbage, chicory, common parsnip and alfalfa) to evaluate the copper and zinc uptake and allocation of these nutrients in the plant tissues. Red beet and field pumpkin were with highest zinc accumulation, especially in the leaves (64.97 and 119.14 mg kg^{-1} dry weight, respectively). The red beet, chicory and field pumpkin were with the highest zinc concentration ratios (shoots/roots): 2.0, 2.2, and 2.8. Leaves, grain and maize roots contained maximum zinc contents of 29.84 mg kg^{-1} dry weight, 35.55 mg kg^{-1} dry weight and 35.88 mg kg^{-1} dry weight, respectively. The maize stem contained the lowest zinc content ratios. Furlani *et al.* (2005) was found that zinc was used efficiently by cultivars of maize; and it significantly enhanced the shoot dry weight, plant height and zinc contents in maize plant.

Haris *et al.* (2007) concluded that application of $ZnSO_4$ as soil incorporation has increased the grain yield by 26% in maize and 16% in wheat across a wide range of environment of production. According to Hosseini *et al.* (2007) Zn and B have significant relationship with maize growth and concentration of tissue nutrient. Reddy and Reddi (2007) reported that the growth and yield of maize was improved under intercropping with green gram and groundnut as compared to sole cultivation of maize. Efficiency of internal nitrogen does not only depend upon its total amount taken up, but also the amount of other secondary nutrients especially the magnesium (Jones and Huber, 2007) and in micronutrients zinc is the mainly important one (Potarzycki and Grzebisz, 2009).

The two main reasons for enhancing micronutrients in grains of staple crops are improving production and nutritional quality enhancement of crop. Improvement of yield and quality enhancement of primary food crops can be gained through application of micronutrients in deficient soils. Crop yield, quality and health of human beings as well as domestic animals are greatly disturbed due to the deficiency of micronutrients (Malakouti, 2007). The yield losses in wheat were much high if zinc deficiency is there with prevailing drought conditions (Bagci *et al.*, 2007). Zinc application with different tillage operation methods not only increases the maize yield but also play vital role in water conservation (Marwat *et al.*, 2007). It was reported by Vesterager *et al.* (2008) that the intercropping of maize and cowpea is all ways beneficial for nitrogen deficit soils. Zeb and Arif (2008) evaluated the effect of different application methods of zinc application on yield and yield related attributes of maize and concluded that methods of zinc application significantly increased the plant height, grains ear^{-1}, ear length, 1000-grain weight, ear weight, grain yield and biological yield of maize. Soil applied Zn @ 15 kg ha^{-1} gave maximum plant height (187cm), the highest ear length (15 cm) and maximum cob weight (340 g), thousand grain weight (196 g), number of grains ear^{-1} (399), grain yield (4095 kg ha^{-1}), biological yield (12286 kg ha^{-1}). They concluded that soil applied zinc @ 15 kg ha^{-1} resulted in high yield and yield attributes of maize. Shivay *et al.* (2008) from an experiment evaluated that Zn coated urea increased the zinc concentration in yield of grain and straw and zinc uptake by rice.

Potarzycki and Grzebisz (2009) from a field experiment concluded the effect of zinc applied as foliar application on grain yield of maize.

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They found that the foliar application at 5th leaf stage resulted in significant increase in grain yield by 16% and 27% by using zinc @ 0.5 and 1.0 kg ha-1, respectively. Seed pelleting with $ZnSO_4$ (250 mg kg^{-1} seed) produced seeds with higher 1000-seed weights, seed weight per plant leading to 32.1% seed yield increase as compared to non-pelleted seeds or control treatment (Masuthi *et al*., 2009). Concentration of micronutrients is increased by foliar application especially in case of iron and zinc (Bybordi and Mamedov, 2010). Kanwal *et al.* (2010) evaluated the effect of optimum doses of zinc sulphate for selected maize hybrids and synthetic cultivars. It was concluded that grain zinc contents were found in hybrid as compared to synthetic variety. Potarzycki (2011) concluded that at anthesis stage zinc has a significant impact on chlorophyll index of maize leaf in cob and noted the role of zinc physiologically in nitrogen management. It was most obvious throughout its greater recovery amounting 94% from nitrogen fertilizer application @ 80 kg N ha^{-1}, and nitrogen recovery was only 78% for NPK alone. Vasconcelos *et al.* (2011) from a field experiment investigated the zinc uptake after application of $ZnSO_4$ solution by foliar spray at 3^{rd} and 5^{th} week after seeding in maize plants and before seeding, zinc sulfate solution was applied to soil. Zinc concentration in plant was increased by both methods but soil application was better than foliar one. It increased the zinc contents in maize plant by 2258 mg kg^{-1}. Aref (2011) conducted an experiment and found that Zn and B were found two major plant growth factors of corn. There was an antagonistic effects found between B and Zn. It was found that absence of B agreeable in the clay (zero and B spraying levels) helped the increase in leaf Zn contents, but the presence of B in the soils prevented from increasing the Zn content in leaf. Presence of B, caused to increase the B absorption in leaves by the applications of Zn; the B spraying helped in increasing B level in leaf due to the use of Zn in leaves. Due to a Zn and B antagonism, top amounts of Zn in the soils, prevented from increase of blade B agreeable by B application; as well Zn appliance prevented from B use affecting B concentration in the leaf.

EFFECT OF ZINC SULPHATE ON MUNGBEAN

Mungbean is being used as food and protein supplements. It is being cooked with vegetables, incorporated with bread and cakes, used as boiled or roasted in syrup. It is also generally used for vegetable dishes and sprout for egg rolls. By using zinc and sulphur, nutritional quality of mungbean can be increased, as its protein contents such as methionine and cysteine are increased. So there will be improvement of food quality as nutrition point of view. It is one of legumes that have not been since fully utilized for competing the problem of malnutrition that is common in developing countries. A large portion of world's population of developing countries takes less amount of protein. However, consumption of legume protein is under potential due to less availability of essential amino acids in protein and also due to some other factors like anti-nutritional features related to proteins. Its protein isolates have been utilized for many functions like emulsification, foaming and water absorption. However if there are any advances then these protein isolates could be more desired food components (El-Adaway, 2000).

Mungbean which is commonly known as green gram is an essential pulse crop of Pakistan. This crop grows best on loamy soil at temperature range of 24-33 ^{0}C, but this crop is also able to grow well in saline and alkaline soils, as it has

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some degree of salt resistance. However, mungbean does not grow well in water logged soils. The average grain yield of Pakistan is 475 kg ha^{-1} (Anonymous, 2000-02). Botanically history as well as literature showed that mungbean was cultivated domestically in India where wild types are spread extensively as described by (Tomooka *et al.,* 2002). Guan *et al.* (2003) found that zinc uptake by mungbean seedlings was increased with the increase in amount of Zn and became stable when increased quantity of Zn was applied. Priming also improved the water use efficiency by 44% in plants under drought stress. Mungbean is rich in amino acid like Lysine, which is usually deficient in cereals. Although it has a number of returns in terms of crop management and food value, the area and production of mungbean is not increasing as compare to other cereals. But in recent years there is a steady growth of area and production of mungbean (Afzal *et al.*, 2004). Mungbean is a pulse crop under leguminoseae family, grown only for its seeds rich in protein. It is a C_3 plant that was invented in indo-Burma areas of Asia. As it is fast growing crop hence it is included in many cropping systems, in warmer and drier environments of lowland and sub-tropical areas (Hakim, 2008). Legumes are important source of protein, nutritive fiber and complex carbohydrates, and in whole world there is great concern about unconventional legumes (Sarwar *et al.,* 2004). The essential life process in plants which are influenced by Zinc are (a) nitrogen metabolism i.e. protein synthesis by nitrogen uptake; (b) photosynthesis i.e. carbon anhydrase activity and synthesis of chlorophyll; (c) resistance against abiotic and biotic stresses i.e. oxidative damage resistance (Alloway, 2004).

Kassab (2005) found that foliar application method for Fe, Mg, Mn and Zn has significantly increased the growth, yield and yield related parameters of mungbean. Cowpea produced higher forage as compared with cluster bean and rice bean with maize (Iqbal *et al.*, 2006). Except sulphur containing amino acids, the need of all other necessary amino acids can be fulfilled with the help of mungbean consumption (Khalil, 2006). Botanically history showed that Southeastern India between Krishna and Godavari rivers and areas of western Himalayan foothill are the locations where domestication of mungbean started (Fuller and Harvey, 2006). Besides the soil application of nutrients like K, Mg and Zn, foliar application gave effective results (Thalooth *et al.*, 2006). Ryan and El-Moneim, (2007) found that the increase in the Zn level caused increased grain yield in mungbean.

Kaya *et al.* (2007) found results in common bean (*Phaseolus vulgaris* L.), seed priming with Zn significantly boosted the yield and yield related Attributes. Plants take nutrients by roots but these nutrients can be supplied with the help of foliar application. This method is new and notorious one; nutrients are applied in form of liquid directly to leaves of plants (Baloch *et al.*, 2008). For chickpea Harris *et al.* (2008) evaluated that priming with a diluted solution of zinc sulphate (0.05 %) was promising, yield increase was 10 to 122% more (with an average of 48% from nine trials) as compared with non-primed seeds with a benefit cost ratio of 1500. Mungbean can grow well and gives better yield without any application of nitrogenous fertilizers, as mungbean is capable of fixing atmospheric nitrogen with the help of symbiotic relationship. It enhances fertility status through fixing atmospheric nitrogen in soil by 63-342 kg ha^{-1} (Kaisher *et al.*, 2010). Mungbean is used for cooking as a vegetable and its vegetative parts are used as a feed for livestock. It has ability to fix Nitrogen biologically @ 63-342 kg ha^{-1}

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(Mahmood and Athar, 2008; Mandal *et al.*, 2009; Kaisher *et al.*, 2010).

Kumar *et al.* (2010) from an experiment, evaluated the effect of Zn from zinc sulphate on the mungbean grown in saline environment, it was concluded that Zn application significantly hampers the suppressing effects of salinity on the plants. Mungbean holds an important position among other grain legumes in Asia (Quddus *et al.*, 2011) and traditionally grown in Pakistan too (Abbas *et al.*, 2011). Proper plant nutrition is one of important factors involved in boosting yield as well as quality of the crop. Quddus *et al.* (2011) reported from an experiment that higher grain yield was recorded for Zn @ 1.5 kg ha^{-1} and B @ 1 kg ha^{-1} treatments, therefore it was suggested that these dosages of fertilizers may be used for the improvement of crop yield and production.

Ali and Mahmoud (2012) found significant increase in yield relating attributes ha^{-1} as compared to control. 500 PPM Zn concentration level was found to be best as compared to the other concentrations. Manivasagaperumal *et al.* (2012) found Zinc concentrations of 50 and 100 mg kg^{-1} were found best for overall nutrient content, growth and dry matter yield as compared with other concentrations which did not enhanced the yield and growth of mungbean. Ali *et al.* (2008) found that 5 kg ha^{-1} Zn application with N: P: K ratio of 0:90:60 kg ha^{-1} gave the highest mungbean yield of 516 kg ha^{-1}.

From an experiment by Usman *et al.* (2014) concluded as the highest green gram seed yield was recorded for 20 kg ha^{-1} $ZnSO_4$ application in soil. Shojaei and Makarian (2015) investigated the application of nano-sized and non-nano zinc oxide (ZnO) through foliar appliance on yield and yield related traits of mungbean. It was suggested that the foliar ZnO application as nano particles can enhance the crop of mungbean. Similar good results were obtained by Khudsar *et al.* (2008) when zinc was supplied at adequate rates in pigeon pea.

The application of RDF + Zn ($ZnSO_4$) @ 18 kg ha^{-1} + B (Boric acid) @ 4 kg ha^{-1}shown significantly high impact on growth i.e. branches per plant, plant height, number of leaves per plant, and yield related attributes i.e. pod length, pod yield per plant, number of pods per plant, pod yield ha^{-1} of French bean and were on par to application of RDF + Zn (Zinc sulphate) @ 12 kg ha^{-1} + B (boric acid) @ 4 kg ha^{-1} as compared to other treatments and control (Hamsa and Puttaiah, 2012). Pathak and Pandey, (2010) by foliar application of zinc found that pollen producing capacity, size of anthers, viability and size of pollen grains were increased. Foliar application of Zinc also increased the grain yield and vigor. The use of Cu and Zn significantly improve maize grain yield, dry matter production of maize, uptake and the concentration of organic and inorganic compounds in the plant body for storage and improvement in crop plant yield and production (Eteng *et al.*, 2014).

EFFECT OF ZINC SULPHATE ON INTERCROPPING

Ahmad *et al.* (2001) and Jeranyama *et al.* (2000) from an experiment concluded that the intercropping of corn and soybean did not cause any loss of corn yield compared with maize cultivated alone. Li *et al.* (2001) reported higher and significant improvement in the yield and production of maize in intercropping cultivation with cowpea. Ennin *et al.* (2002) found that the grain yield of maize was improved by intercropping of maize with soybean with alternative rows with single row planting caused increase in green fodder yield and total dry matter yield of maize. It was reported by Mshelia *et al.* (2004) that the intercropping of

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maize and groundnut caused the improvement in grain yield of both maize and groundnut as compared with their single growing. In an experiment by Thwala and Ossom (2004) they reported that the maize with groundnut and soybean, caused decrease in grain yield of maize as compared to sole growing of maize either with one of the legume crop. The maize crop yield was decreased due to the intense crop competition of legumes with maize. Hussain *et al.* (2006) conducted an experiment to study the impact of Zn application in Mungbean-maize-rice cropping system for 3 years. It was revealed that zinc application increased the yield, zinc and Nitrogen contents of all the crop grains.

Also, it was found by Dahmardeh *et al.* (2010) that intercropping of maize and cowpea caused to increase phosphorous (P), Potassium (K) and nitrogen (N) level of NPK deficit soils. Banik and Sharma (2009) and Saleem *et al.* (2011) found that there is an increase in maize crop yield in intercropping pattern with legumes. In general, synergistic of plant growth and nutrient concentration are antagonistic in nature. Zinc application significantly increased the iron and manganese uptake in maize (Aref, 2010). It was reported by Egbe *et al.* (2010) that the intercropping of corn with cowpea caused the reduction in cob dry weight, grain weight, dry plant biomass ear length and diameter of ear in corn. Hamdollah, (2012) reported that maize intercropping with cowpea in double row strips results in higher crude proteins, green fodder yield and total dry matter yield. The growing of maize + cowpea was carried out in an experiment and reported increase in grain yield of maize in intercropping with cowpea. Corn has been grown in intercropping with various legumes to improve crop yield and production (Ijoyah, 2012).

Adesoji *et al.* (2013) found that the increase in the cell size, cell division and cell number due to much use of nitrogen to enhance the growth of maize under intercropping of maize with legume crops. Ali *et al.* (2013) suggested that the use of organic and inorganic fertilizers forth with zinc application significantly improve the crop yield of corn as compared to only application of inorganic fertilizer. It has been estimated that the inorganic fertilizer applications are actual expensive, required suitable administration to access proper crop plant yield. The Agro-management practices for crop yield and quality superiority of corn hybrids.

EFFECT OF $ZNSO_4$ IN PLANT GROWTH

Plants use Zn in many of its vital process such as protein synthesis, membrane's structure and functions, expression of genes and tolerance against oxidative stress (Cakmak, 2000). The impacts of zinc deficiency cannot be ignored as it has very much serious implication regarding immune system and growth. Hence this is very crucial issue in South Asia where due to poverty and rice consumption as staple food, almost 95% population is at risk (Brown & Wuehler, 2000). Abdo (2001) reported that the foliar application of Zn and B improve seed formation, number of seed and seed yield per plant in mungbean. Seed coating is a unique practice, by use of different materials such as fertilizers, plant growth hormones, nutritious essentials and pesticides are applied to seed by adhesive agents, which aid the seed to increase the germination and performance of seed (Freeborn *et al.* 2001).

Soils of Pakistan are immature, low in organic matter, excess salts, high pH, coarse texture and more sodium adsorption ratio on cation exchange site of soil particles. Zinc deficiency is there in many crops of Pakistan like maize, cotton and rice etc. (Rashid and Rafique, 2002). Leaf browning occurs as consequences of low

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Zn availability in soil in rice (Qadar, 2002). Tariq *et al.* (2002) found that there was an increase in yield and yield related parameters with increased application of zinc as compare to control. It also increased zinc level in soil, grains and leaves of maize. Highest grain yield of 2410 kg ha^{-1} and maximum grain zinc uptake of 360.1 was reported where Zinc @ 15 kg ha^{-1} was used. Wenger *et al.* (2002) evaluated the zinc uptake potential of two crops: maize and tobacco. They found that only a small amount of zinc was transferred to seeds of tobacco and maize cobs. Zinc is very essential micronutrient which is needed by both plant and human. It is very crucial for many enzymes that catalyze many metabolic reactions in all crops. Growth and development of crop may be depressed by absence of specific enzymes due to deficiency of this micro nutrient in plant tissue (George and Schmitt, 2002). In developing countries among top 10 leading life risking factors zinc deficiency ranks at 5th. Even on worldwide scale it is on 11th position among top 20 life risking factors. According to WHO, 8,00,000 deaths in whole world each year are attributed to deficiency of zinc and there is loss 28 million lives per annum (Anonymous, 2002).

In plants, deficiency of zinc not only decreases the quality but also the yield of crop. Hence the agronomic practices and soil environment should be conductive to the occurrence of micronutrient deficiency in plants. Production of low micronutrient products has created problems about micronutrient deficiency related health hazards especially in developing countries of world (Graham & Welch, 2002). Zinc deficiency is the most extensive disorder among various crops. This deficiency of micronutrient regularly occurs in maize which is very prone to low zinc supply (Tariq *et al.*, 2002). Zn application increased the yield and quality of many other crops including wheat (Hu *et al.*, 2003); rice (Liu *et al.*, 2003). Latha (2003) reported that the organic fertilizers in the form of FYM, biogas slurry and poultry manure accomplished with capricious levels of $ZnSO_4$ caused the change in uptake of NPK and micro-nutrients at various growth stages of corn i.e., vegetative, anthesis/tasseling and harvesting stages. The application of Zn caused the increase in the uptake of macro and micronutrients at all stages of maize growth. Gupta *et al.* (2003) found that an increase of 14.8% yield was gained by soil application of 2.5 mg kg^{-1} of $ZnSO_4$ followed by 10.8% by two foliar applications of 0.5% $ZnSO_4$ solution as compared to the control. Zn and N contents of the seed were also increased.

In many studies it was showed that application of Zn at various concentrations significantly enhanced the dry matter yield and Zn concentration taken up by the plants although more increase in Zn application did not increase the dry matter (Obrador *et al.*, 2003). A large number of world's population that accounts one half of total, especially children and women are suffering from micronutrients starvation in developing countries, the so-called hidden hunger (Welch & Graham, 2004). Physiological impacts of micronutrients regarding many body functions are very complicated. Deficiency of Zinc poses very serious threat to immune system impairment and other consequences, increased occurrence of other childhood infections like diarrhea and pneumonia, poor growth and development. Many other maternal health and pregnancy issues also occur due to its deficiency (Michael, 2004).

In barley seed priming with zinc enhanced the germination and seedling growth. Seed priming also caused marked increase in mineral (Zn and P) uptake and accumulation of dry matter in barley (Ajouri *et al.*, 2004). Shaver and Westfall (2005) found that industrial by product have low water solubility and are not a good and efficient for plants. They observed that with passage of time as residual Zn; more zinc became available to plant when it was exposed to the soil environment and it became soluble in water. Across the board research that has been conducted in last decade to assess the impact of micronutrients on crop's quality and yield (Malakouti *et al.*, 2005). Treating seed with micronutrients is a simple and economical method for improvement of micronutrients in plant nutrition (Johnson *et al.*, 2005). Foliar application of micronutrient is more efficient one than soil fertilization (Malavolta, 2006).

In aleurone layer and embryo, seed stores more zinc contents, while this concentration become lowers in endosperm of the seed (Ozturk *et al.*, 2006). Soil acidification may be resulted due to application of S containing fertilizers and this may eventually affect the availability of many other nutrients' uptake (Havlin *et al.*, 2007). Harris *et al.* (2007) from an experiment on maize explained that priming with 1% $ZnSO_4$ solution (for 16 h) has improved grain yield, crop growth and grain zinc contents. Application of higher doses of zinc as zinc oxide for acidic and alkaline soil, than that of normal soils, caused increase in yield of wheat (Shaheen *et al.*, 2007). Similar results were found by Abd-El-Hady (2007) for barley grown under salinity conditions. Cakmak (2008) concluded that deficiency of zinc in soil is only cause of zinc deficiency in humans. The only possible solution is to overcome this problem were agronomic biofortification of diet with zinc and genetic bio fortification. Genetic approach is long term process but it is sustainable approach and cost effective. Agronomic approach is time efficient to minimize zinc deficiency in population across the world. By adopting distinctive application techniques, nutrients can be made available to plants. These include soil application, foliar spray and priming. All these methods have some merits and demerits (Ali *et al.*, 2008).

Crop which was given urea coated with $ZnSO_4$ @ 2.0% shown maximum behavior with respect to yield. Foliar application of zinc gives good and promising results for maize hybrids grown on newly reclaimed loamy soils (Mohamed *et al.*, 2008). In crop productivity, the unavailability of crop nutrients is one of major problem. There is deficiency of both micro and macro nutrients, that can be achieved through many management practices (Ali *et al.*, 2008). Zinc is taken in the form of Divalent Cation and is very vital for healthy growth of plants, humans and animals. It is also involved in proper functioning of many other important enzymes like Aldolase, dehydrogenases and isomerases. It is also involved in energy production in Krebs cycle. In Iran soils are high in pH and calcareous in nature and such conditions reduce uptake availability of micronutrients due to low solubility. Inadequate amount of zinc reduces the yield and quality of crop. Zinc and phosphorous plays an antagonistic effect to each other in soil and plant. As soil uptake for phosphorus is increased the uptake for zinc is reduced. Hence, to have better crop yield quality efficient utilization of zinc is an essential requirement (Mousavi *et al.*, 2011).

The deficiency for micronutrients is a limiting factor in many crop plants. Among many other micronutrients, zinc is constituent of many enzymes, and holds competent position in plant's nutrition (Khourgami and Fard, 2012) by playing vital role in functioning of plant's metabolism (Taunk *et al.*, 2012). Soil and seed application of micronutrients has given very much promising results in many crops (Farooq *et al.*, 2012). Khourgami and Fard, (2012) by using different zinc levels found that seed yield,

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Received 12 January 2017
Revised 28 February 2017
Published 16 March 2017

1000-grain weight and harvest index were higher in case of zinc applied treatments. Seed treatments with micronutrients can be performed either by soaking the seeds in the solution containing micronutrients or by seed coating or pelleting with micronutrients of known concentration for a certain time period (Farooq *et al.*, 2012). Micronutrients play a vital role as a major nutrient in plant's nutrition. As a major nutrient, plant grown on micronutrient-deficient soils showed a decrease in growth and yield. To evaluate the residual effect of zinc and boron on transplanted rice and French bean an experiment was conducted during Rabi 2007-08 at Sagara taluk, Shimoga district Karnataka state. This experiment comprised of 7 treatments and 3 replications. Soil pH in dry areas declines with the application of Zn fertilizers and it enhances the root absorption for minerals and also improved activity of plant growth regulator. Enhanced plant's nutrition increases the photosynthesis efficiency and assimilates production at seed filling stage which leads to maximize the yield and yield related components (Dashadi *et al.*, 2013).

CONCLUSION

It was concluded from all above discussion that plant uses Zn in many of its vital processes such as protein synthesis, membrane's structure and functions, expression of genes and tolerance against oxidative stress. The impacts of zinc deficiency cannot be ignored as it has very much serious implication regarding immune system and growth. The use of Zinc for improvement of grain yield of maize and munbean plays an important role. Hence, it should be used as micro nutrient for improving output of maize and mungbean in sole and intercropping growing patterns.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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