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Why Soil Application of Zinc is Important to Alleviate Zinc Deficiency?

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Abstract

Zinc deficiency in soils, plants and humans are widely realized across the globe. Management of Zn deficient soils is inevitable for sustaining the production and to achieve nutritional security. Soil and foliar applications are the most commonly used methods of Zn applications. In this article the advantages of soil application over foliar spray to mitigate Zn deficiency has been depicted. In foliar application, spraying beyond certain concentration injurious to crop and may not meet the total Zn requirement of the crops, results in soil Zn fertility decline, and repeated applications involves manpower and cost. Whereas soil application can be beneficial by its direct and residual effect to improve crop yield and meet the crop Zn requirement, single time application is sufficient for more than three crops and cost effective, improves the soil Zn fertility status. Therefore soil application of Zn is a viable option to alleviate Zn deficient soils.

Introduction

Zinc is one of the essential nutrient elements for plants, animal and human. The primary source of Zn in soil is chemical and physical weathering of parent rocks and minerals. Secondary natural inputs of Zn to soils arise because of atmospheric (e.g. volcanoes, forest fires, and surface dusts) and biotic (e.g. decomposition, leaching/wash-off from leaf surfaces) processes. Mean soil total Zn concentrations of 50 and 66 $\mu g\ g^{-1}$ are typical for mineral and organic soils, respectively, with most agricultural soils containing 10 - 300 μg Zn g^{-1} range (Alloway, 2008). Zinc availability in soil is influenced by soil texture, soil organic matter content, soil pH, red-ox potential, calcium carbonate content, moisture content, etc. Analysis of soils samples from different states of India indicated that on an average 44% of the samples were deficient in available Zn (Shukla and Behera, 2012). The extensive Zn deficiency might be due to intensive cropping and extensive use of NPK fertilizers without Zn application causes depletion of native soil Zn. Zn deficiency is resulting in substantial losses in crop yields and human nutritional health problems. About 25% of the world's population is at risk due to Zn deficiency and affects nearly 2.2 billion people worldwide. Further it is reported that areas with zinc deficient soils are often regions with widespread zinc deficiency in humans (Ganeshamurthy *et al.*, 2017). Therefore amelioration of Zn deficiency is essential to sustain the production system and to address the nutritional security goal of our nation.

Soil Application vs. Foliar Application

One of the problems in Zn fertilizer management is to predict the crop response to Zn fertilization and define the soil and plant Zn levels below which Zn fertilizer recommendation are to be made. The response of crops to Zn application depends on soil type, crops and genotype, agro-climatic conditions and severity of deficiency. Soil application and foliar sprays are the most commonly used methods of Zn application. Foliar sprays are given only when visual symptoms appear. Visual symptoms mostly appear in severely affected plants. When the deficiency is marginal, crop yields can be reduced by 20% or more without any visible symptoms. Further the lower efficiency of the foliar mode is primarily due to delayed cure of the deficiency as well as the low concentration of Zn in spray solution. Foliar spray can partially meet the crop requirement and leads to depletion of native soil Zn. This aggravates the problem of Zn deficiency in soil further. Moreover repeated application of Zn through foliar application involves man power and expensive. Soil application of Zn is reported to be efficient and effective method to alleviate Zn deficiency. Results from various field experiments revealed the superiority of soil application of Zn over foliar application.

Zinc Fertilization and Crop Yield

From the one year field experiment, single time soil Zn application (5, 10 15, and 20 kg Zn ha^{-1}) to vegetable cropping systems (tomato-French bean-cucumber; okra-onion- bottle gourd; chilli-ragi-amaranthus) increased yield from 10-30% due to its direct and residual effect (Figure 1). But significant improvement yield is noticed up to 10 kg Zn ha^{-1} application, whereas foliar spray of 0.5% $ZnSO_4$ (two times to each crop) recorded only 3-8% increases in yield (Figure 1). Similarly soil application of 5 to 10 kg Zn ha^{-1} before sowing is the most suitable method to manage Zn deficiency in many cropping systems (Shukla and Behra, 2012).

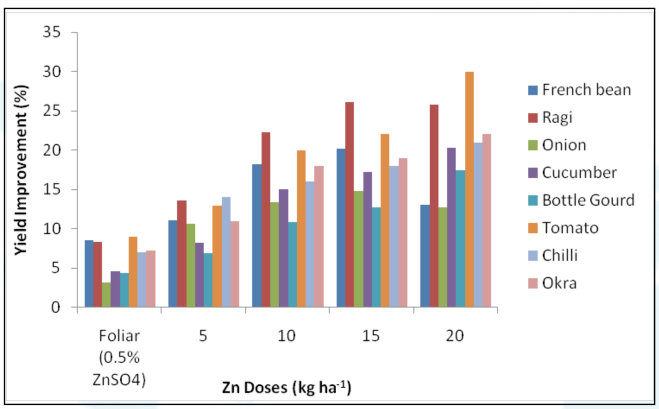

Figure 1: Yield Improvement in Various Crops Due to Zn Application

Soil Application of Zn on Its Availability and Uptake

Increasing soil application of Zn up to 20 kg ha^{-1} improved the Zn uptake in these crops. The Zn uptake of these crops nearly ranged from 100-700 g ha^{-1} (Table 1). Under control treatment (no Zn application) showed the lesser Zn uptake values and maximum Zn uptake was recorded at higher Zn application. This might be due to improved yield and Zn content in crops due to higher doses of Zn application in soil.

Table 1: Direct and residual effect of application of zn in various crops

Crop	Yield (t ha^{-1})	Zn uptake (g ha^{-1})
Tomato	55.5-72.2	529-685
Chilli	19.5-23.5	410-514
Okra	13.9-16.9	387-492
French bean	12.4-14.9	320-427
Onion	28.3-32.7	199-309
Ragi	2.87-3.62	307-422
Cucumber	32.6-38.8	212-283
Bottle gourd	28.3-32.4	206-275
Amaranthus	9.29-10.8	88-119

Even after one year and harvest of three crops, soil application of Zn up to 20 kg Zn ha^{-1} DTPA soil Zn content has also increased from 0.88-2.25 mg kg^{-1} (Figure 2). In case of foliar application, it was maintained up to 0.91 mg kg^{-1} soil. Continuous cropping for one year without Zn application resulted in reduction of the DTPA soil Zn from 0.88 to 0.82 mg kg^{-1} (Figure 2).

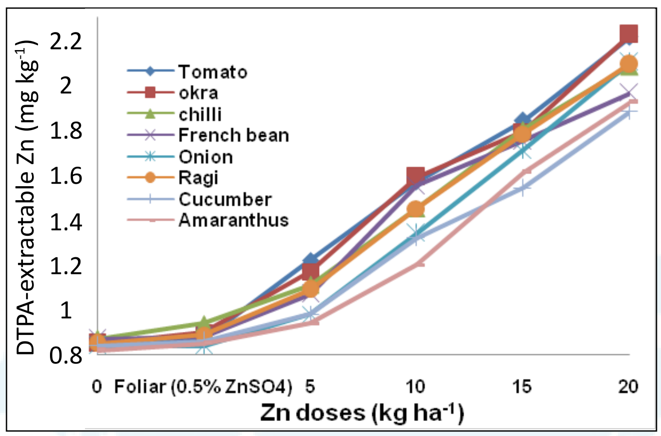

Figure 2: Soil DTPA Zn after Harvest of the Crops

Advantages of Soil Application are:

- Significant improvement in crop yield;
- Fulfils the Zn requirement of crops;
- Zn dosage level can be fixed as per the crop requirement;
- Improves the Zn fertility status of the soil;
- Residual soil applied Zn is useful to subsequent crops; and
- Single time application requires less manpower and cost.

Conclusion

Zinc requirement of crops vary under different agro-climatic and management conditions. The response of crops to Zn applications under Zn deficient soils is evidenced from many studies. However, one or two foliar application cannot meet the Zn requirement of crops and also leads to depletion of native soil Zn of deficient soils. Frequent foliar application is expensive. While soil application of Zn improves crop yield, enhances the Zn fertility status of the soil, and fulfills the Zn requirement of crops, residual Zn also useful for subsequent crops and cost effective. Therefore it is concluded that soil application of Zn is suitable option for mitigation and management of Zn deficient soils. If soil is of high pH and calcareousness, proper measures to be taken for reducing pH and calcareousness before Zn application.

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