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Nidhi Kamboj
Department of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

RS Malik
Department of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Deepika
Department of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Correspondence
Nidhi Kamboj
Department of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Residual effect of applied Zinc, Boron and phosphorus on post-harvest nutrient availability status of soil

Nidhi Kamboj, RS Malik and Deepika

Abstract
A screen house experiment was conducted on green gram to determine the effect of zinc (Zn), boron (B) and phosphorus (P) on post-harvest analysis of the soil. The plants were raised in pots having 4 kg of light textured soil (sand). In each pot four level of boron (0, 0.25, 0.5 and 1.0 mg kg^{-1}) along with four level of zinc (0, 5, 10 and 15 mg kg^{-1}) and in second set same four level of boron with five level of phosphorus (0, 25, 50, 75 and 100 mg P_2O_5 kg^{-1} soil) were applied with three replication. The results showed that with each graded level of boron application soil boron and phosphorus concentration increased and zinc concentration decreased. Similarly, application of phosphorus increased the availability of soil boron and phosphorus concentration and decreased zinc concentration whereas, zinc showed negative relation with these two nutrients and decreased their availability in soil.

Keywords: Availability, boron, phosphorus, post-harvest analysis, zinc

Introduction

Soil fertility and productivity is very important to govern the production and economy of any country. Soil fertility and productivity helps to meet the food requirement of increasing population. So, it is very important these days to take out the step for improving the soil fertility and productivity. Although, there are many factors which affect the soil fertility and productivity of the soil, but the major cause of depletion of soil productivity is intensive agriculture in which farmers use fertilizers in unbalanced and improper manner. Due to continuous use of one or more nutrients irrespective of their recommended doses, their accumulation occur in soil which further affect the availability of other nutrients. Application of fertilizers in balanced amount was the first and foremost requirement for better crop production. Sometimes there is no deficiency of nutrients in soil but presence of other nutrients in excess creates deficiency of a particular nutrient. In some cases some nutrients also behave synergistically and increase the availability of other nutrients.

Among the micronutrients essential for plants next to zinc, the deficiency of boron is quite widespread in several areas of India thereby limiting crop yield. Its deficiency is found in nearly 33% areas (which has now increased to 52% (Singh, 2012) [16] of the country which are highly calcareous, leached, sandy, red and laterite soil. In Haryana soils also 3.3% boron deficiency was recorded (Shukla *et al*., 2015) [15].

Green gram requires relatively larger amounts of phosphorus and micronutrients particularly Fe, Zn and B than the other crops (Laltlanmiwia *et al.*, 2004) [6]. Moreover, adequate supply of P and Zn in early stage of plant growth is important for the development of roots as well as for seed formation and yield. Boron is also necessary for the transformation of sugars, starches, phosphorus etc. and helps in the absorption of nitrogen and formation of nodules (Singh *et al.*, 2006) [17].

In Haryana, rice-wheat is the major cropping system where it is advocated that P and Zn in soil should be applied. However, with their continuous application, build up of available P and Zn may take place in soils over a period of time and perhaps alter the chemical equilibrium of micronutrients and their chemical pools, thus, affecting availability and uptake to plants. Green gram requires an adequate supply of available boron, especially during flowering and seed development. Considering the increasing importance of B, Zn and P as limiting nutrient specifically in pulse crop, an investigation was carried to find the residual effect of application of zinc, boron and phosphorus on post harvest status of soil nutrients availability.

Materials and Methods

A screen house experiment was conducted during *Kharif* season at CCSHAU, Hisar. Bulk soil samples of (0-15 cm depth) were collected from village Balsamand district Hisar. The soil samples were air dried ground and passed through 2 mm sieve and analysed for physico-chemical properties and initial nutrients status using standard methods. The soil used in pot had pH – 7.90, EC-0.17dSm^{-1}, organic carbon – 0.09%, DTPA – Zn 0.36 mg kg^{-1}, available phosphorus 8.1 kg ha^{-1} and hot water soluble B – 0.5mg kg^{-1}.Four kg thoroughly mixed sand soil was filled in each pot and placed in completely randomized block design in the screen house. In total the experiment included 16 treatments with three replication in a factorial combination of four levels of zinc 0, 5, 10 and 15 mg Zn kg^{-1} soil through $ZnSO_7.H_2O$ and four level of boron 0, 0.25, 0.5 and 1.0 mg B kg^{-1} soil through Borax {$Na_2B_4O_7.10H_2O$} and 20 treatments with three replication in a factorial combination of four levels of boron 0, 0.25, 0.5 and 1.0 mg B kg^{-1}soil through Borax {$Na_2B_4O_7.10H_2O$} and five level of phosphorus 0, 25, 50, 75 and 100 mg P_2O_5 kg^{-1} soil) through potassium orthophosphate {KH_2PO_4}. Recommended doses of nitrogen and potassium were uniformly applied as basal in each pot.

After harvesting of green gram crop, soil samples were collected from each pot and analyzed for physico-chemical properties and available Zn, P and B by DTPA extraction method (Lindsay and Norwell, 1977) [7], Olsen method (Olsen *et al*., 1954) [11] and Azomethine-H reagent method (Berger and Troug, 1939) [3], respectively. Zinc in the extract was estimated by using atomic absorption spectrophotometer. Phosphorus and boron were estimated by colorimetrically on spectrophotometer.

Results and Discussion

Post-harvest soil nutrient concentration under boron application

Boron

In case of boron application, with each increasing level of boron application there was a significant increase in boron concentration in soil and it was found to vary from 0.95 mg B kg^{-1} under control to 2.94 mg B kg^{-1} at B level 1 mg B kg^{-1} of soil (Figure 1). Saleem *et al*. (2011) [13] also observed that boron fertilizer application at the rate of 3 kg B kg^{-1} significantly increased the residual B content in soil after harvesting of first season rice crop. Meshram *et al*. (2017) [9] also reported that residual available boron content in soil after harvesting of soybean crop was increased with increasing level of applied boron.

Phosphorus

Boron showed synergistic effect on post harvest availability of phosphorus. With increase in level of B application, phosphorus concentration in soil also increased from 13.96 kg ha^{-1} under control to 18.83 kg ha^{-1} at 1.0 mg B kg^{-1} of soil (Figure 1).Shamsuddoha *et al*. (2011) [14] also found that increased application of boron increased the post harvest availability of phosphorus from 15.72 ppm under control to 19.02 ppm at a level of applied boron i.e. 2 kg B ha^{-1}. Also (Aref, 2007) [1] noticed that boron application to a certain level (4kg ha^{-1} B) increase the residual P in soil.

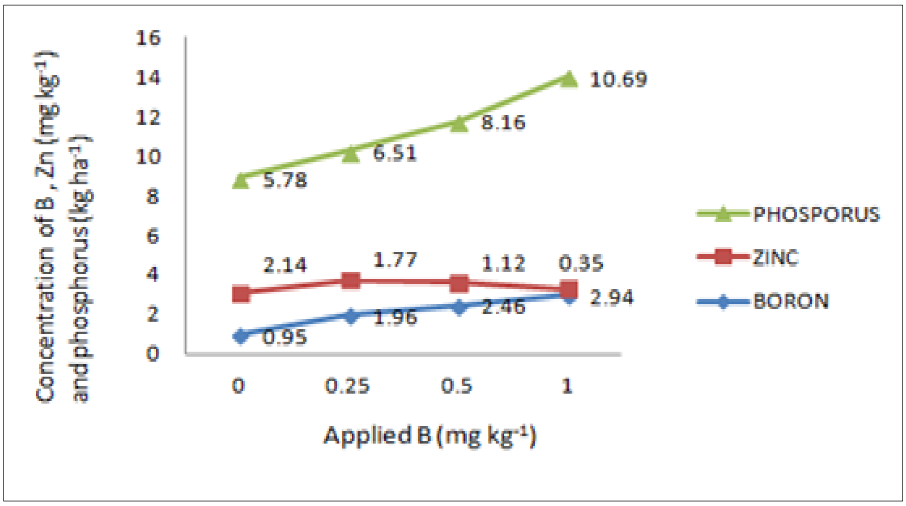

Fig 1: Influence of boron application on Post harvest soil nutrients concentration

Zinc

With zinc, antagonistic effect of boron was recorded and increased level of boron significantly decreased the post harvest availability of zinc. With increased boron application from 0 to 1.0 mg kg^{-1} the zinc concentration in soil decreased significantly from 2.14 mg Zn kg^{-1} to 0.35 mg Zn kg^{-1} (Figure 1). Hosseini *et al*. (2007) [4] observed that in soils where availability of Zn is low and boron availability is high than plants must be supplied with adequate Zn as increased boron concentration reduce the zinc availability in soil.

Post-harvest soil nutrients concentration under phosphorus

Similarly, in case of phosphorus application, post-harvest availability of boron and phosphorus increases and zinc availability decreased. The result of post harvest analysis of soil revealed that with graded level of phosphorus application boron concentration in soil was found to increase significantly at each level up to 2.38 mg kg^{-1} when P was applied at the rate of 100 mg P kg^{-1} over control i. e 1.20 mg B kg^{-1} (Figure 2). Concentration of phosphorus in soil after harvesting of crop increased at each level of applied P and its concentration ranged from 11.81 P kg ha^{-1} in control to 22.30 kg ha^{-1} where P was applied at the rate of 100 mg P kg^{-1} (Figure 2). Patel *et al*. (2014) [12] also found the significant increase in post harvest phosphorus availability under P_3 (25 kg P2O5 ha-1+ PSB) treatment over control. In general, it was only due to the residual available status of phosphorus in soil after crop harvest which showed considerable improvement over initial status.

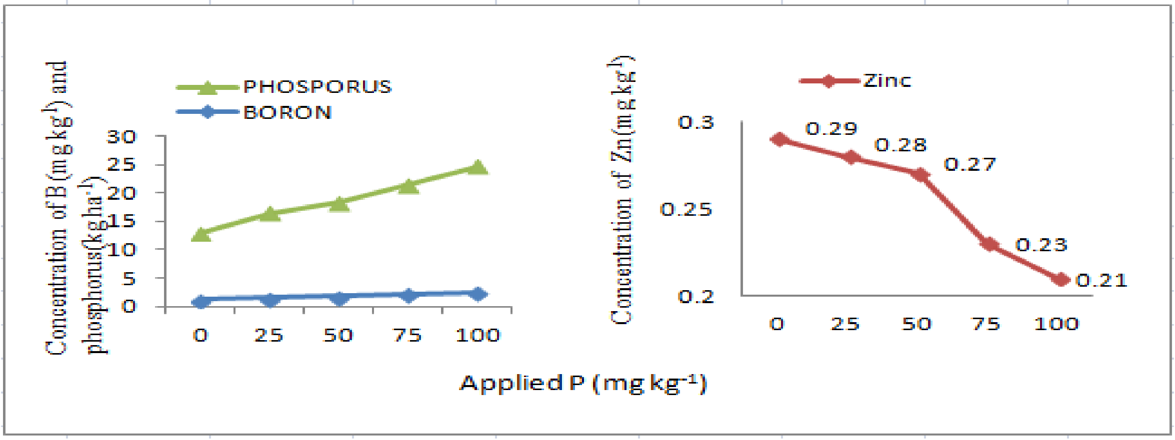

Fig 2: Influence of phosphorus application on Post harvest soil nutrients concentration

With increasing level of P application from 0 to 100 mg kg^{-1} Zn concentration decreased significantly from 0.29 mg Zn kg^{-1} under control to 0.21 mg Zn kg^{-1} at 100 mg P kg^{-1} of soil (Figure 2). The findings of Meena *et al.* (2017) [8] also emphasise that high level of phosphorus in soil may induce zinc deficiency in the soil after harvesting of soybean crop.

Post-harvest soil nutrients concentration under Zinc

The result of post-harvest analysis of soil revealed that with graded level of zinc application boron concentration in soil decreased significantly at each level. The decrease in boron concentration was 1.83 mg kg^{-1} when Zn was applied at the rate of 15 mg Zn kg^{-1} over control i.e 2.25 mg B kg^{-1} (Figure 3). The results were in agreement with those of Mullah *et al.* (2015) [10] in which they found that after harvesting of rice crop the highest application of zinc lead to decrease in boron availability.

Similarly, after crop harvesting, the zinc application in soil showed significant decrease in soil P status. Concentration of phosphorus in soil after harvesting of crop decreased at each level of applied Zn and its concentration ranged from 9.71 kg P ha^{-1} in control to 5.28 kg P ha^{-1} where Zn was applied at the rate of 15 mg Zn kg^{-1} (Figure 3). Similar finding were reported by Balai *et al.* (2017) [2]. This may be due to the formation of insoluble zinc phosphate which reduce the availability of phosphorus when zinc is present in high concentration.

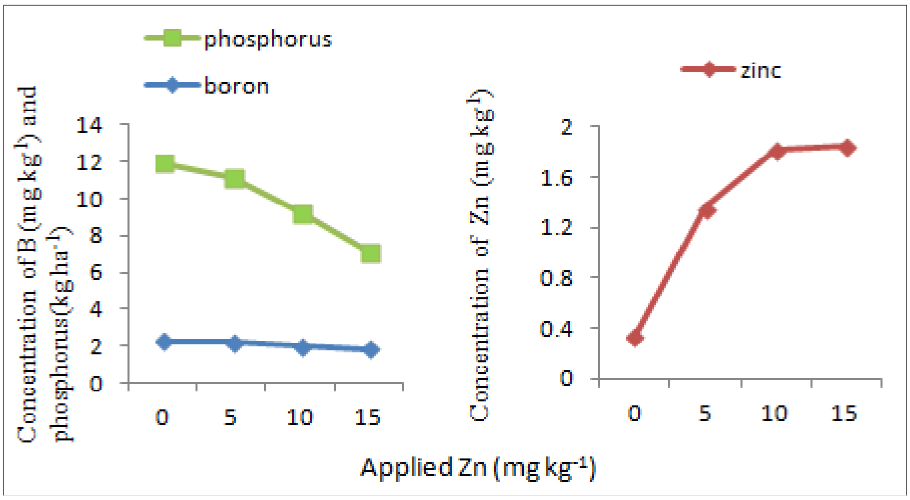

Fig 3: Influence of Zinc application on Post harvest soil nutrients concentration

The result of effect of Zn fertilizer on zinc concentration in soil after harvesting of crop revealed that with increasing level of Zn application from 0 to 15 mg kg^{-1} Zn concentration increased significantly from 0.34 mg Zn kg^{-1} under control to 1.85 mg Zn kg^{-1} at 15 mg Zn kg^{-1} of soil (Figure 3). Mullah *et al.* (2015) [10] also found that post harvest Zn status of soil improved with the application of zinc. Keram *et al.* (2012) [5] also found that significant and highest DTPA-Zn status (0.97 mg kg-1) of soil was recorded with the application of 20 kg Zn kg^{-1}.

Conclusion

Application of B have positive effect on post-harvest availability of both phosphorus and boron. So, this suggest that when boron fertilizer is added to soil, less phosphorus is added in next crop. Application of B with Zn have negative impact on its availability in soil after harvesting of crop. P have synergistic relationship with B whereas zinc behaved antagonistically to both P and B. So, with the application of zinc B toxicity can be alleviated on B rich soil.

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