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Effect of the Application of Nitrogen, Zinc and Boron on Soil Properties and Available Nutrients Status after the Harvest of Wheat

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ABSTRACT: A field investigation was carried out at Palampur with sixteen treatment combinations consisting of four levels of N (0, 50,100 and150 per cent of recommended dose), two levels of Zn (0 and 10 kg ha^{-1}) and two levels of B (0 and 1 kg ha^{-1}) in factorial randomized block design. Application of N, Zn and B significantly increased their respective available contents in soil after wheat harvest. Nitrogen application also had positive effect on available P K and Zn. There was a consistent increase in available N content after wheat harvest with increasing levels of N. In case of P, the differences between N levels were narrow enough and 50 per cent recommended N over control, 100 per cent N over 50 per cent N and 150 per cent over 100 per cent N could not significantly influence available P content of soil. The available K and Zn contents of the soil were significantly increased upto 100 per cent recommended dose of nitrogen. Highest grain (45.83 q ha^{-1}) yield of wheat was recorded under 150 per cent of recommended dose of nitrogen which was 84.8 per cent higher than control. Application of 10 kg Zn ha^{-1} increased the grain yield by 9.7 per cent. Similarly, boron application @ 1 kg ha^{-1} increased grain yield by 8.1 per cent.

Key words: Nitrogen, zinc, boron, wheat

Introduction

Fertilizers are the kingpins for increasing the productivity of the crops. However, continuous heavy application of only one nutrient disturbs the nutrient balance and leads to depletion of other nutrients as well as the under-utilization of nutrients supplied through fertilizers. Single nutrient approach has often caused reduced fertilizer use efficiency and consequent problems of multiple nutrients deficiencies in cereal-based cropping systems. Nitrogen is one of the major plant nutrients and is an essential constituent of all living cells. It plays a number of functions in the plant growth. Its importance in crop production is emphasized by the knowledge that nitrogen generally occurs in relatively small quantities in soils in the available forms and is used

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in large quantities. During the last half-decade or so while fertilizer nitrogen consumption has touched new heights, the production of both rice and wheat has shown a trend of plateauing. Deterioration of soil fertility is often observed in crops/cropping system, even with adequate use of NPK fertilizers which highlights the importance of micronutrients in crop production. Sustaining supply of deficient micronutrients along with macronutrients is a key to maximize productivity gains from macronutrients.

Nearly 50 per cent of the Indian soils are deficient in zinc and likely to respond to its application. Deficiency of boron (33 per cent) follows zinc with one-third of the soil samples falling in deficient category (Katyal *et al*. 2004). Responses to applied zinc and boron have been obtained across the soils in different agro-ecological regions of country. In view of imparting sustainability to the crops and cropping systems, incorporation of these products along with major NPK fertilizers open up new area of research. Their application in soil is expected to not only improves the crop productivity but influences soil properties, their own status and the status of other nutrients as they leave considerable residues in the soil. Keeping these facts in view, the present investigation has been planned to study the influence of N, Zn and B application on their soil available status after the harvest of wheat under mid hill conditions of Himachal Pradesh. Effect of application of nitrogen, zinc and boron on micronutrients concentration and uptake in grain and straw of wheat were reported earlier (Kapoor et al. 2016).

Materials and Methods

The field experiment was conducted at the Experimental Farm of the Department of Soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (32^0 $6'$ N latitude 76^0 $3'$ E longitude and 1290 m altitude) during *rabi 2010*-2011. The area is characterized by wet temperate climate having severe winter and mild summer with mean annual temperature from 10.4^0C in January to around 30^0C during May-June. The average annual rainfall ranges between 1500 to 3000 mm, out of which about 80 per cent is received during June to September. The

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mean relative humidity in the region varies from 29 to 84 per cent, the minimum being in April and maximum in July and August. The soil of experimental site was *Typic hapludalf* and acidic in reaction with pH value of 5.3. The experimental soil was silty clay loam in texture, medium in organic carbon (8.9 g/kg), low in available N (250.9 kg/ha) and medium in available P (18.3 kg/ha) and K (141 kg/ha). The contents of DTPA extractable Fe (28 mg/kg), Mn (20.8 mg/kg) and Cu (0.74 mg/kg) were adequate whereas DTPA Zn (0.68 mg/kg) was marginally adequate and hot water soluble B (0.43 mg/kg) was insufficient. Sixteen treatment combinations comprising of four levels of nitrogen (0, 50,100 and 150 per cent of recommended dose of N), two levels of zinc (0 and 10 kg ha^{-1}) and two levels of boron (0 and 1 kg ha^{-1}) were tested in RBD with three replications.

Recommended dose of N, P_2O_5, K_2O for wheat was 120, 60, 30 kg ha^{-1}. Half dose of N and full dose of P, K, Zn and B were applied at sowing time. The remaining half dose of N was top dressed at 30 DAS. The sources of N, P, K, Zn and B were urea, single superphosphate, muriate of potash, zinc oxide and borax, respectively. The wheat variety 'HPW-155' was sown on 29th November 2010 and harvested on 25th May 2011. The crop was grown with recommended package of practices under irrigated conditions. The yield was recorded at harvest. After the harvesting of wheat crop, plot-wise composite soil samples from 0 – 0.15 m depth were collected with the help of stainless steel auger from each plot. The collected soil samples were air-dried, ground, passed through 2 mm sieve and finally stored in polythene bags for determination of various chemical parameters. For organic carbon determination the samples were passed through 0.5 mm sieve. The methods used for various chemical analyses in laboratory are given in Table 1.

Table 1. Methods used for determination of different physico-chemical soil properties

Property	Method	Reference
Texture	International pipette method	Piper (1966)
Soil reaction (pH)	1:2.5 (soil:water suspension)	Jackson (1973)
Cation exchange capacity	Neutral normal NH_4OAc extraction	Jackson (1973)
Organic carbon	Rapid titration method	Walkley and Black (1934)

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Available nitrogen	Alkaline permanganate method	Subbiah and Asija(1956)
Available phosphorus	Extraction of soil with 0.5M $NaHCO_3$ (pH 8.5)	Olsen *et al*. (1954)
Available potassium	1N Ammonium acetate (pH 7.0) method	Black (1965)
DTPA extractable Fe, Mn, Zn and Cu	Atomic absorption spectrophotometer (AAS)	Lindsay and Norvell (1978)
Boron	Carmine method	Hatcher and Wilcox (1950)

Results and Discussion

Organic carbon (OC) and cation exchange capacity (CEC)

A glance at the data in Table 2 revealed that the organic carbon content of the soil under study varied from 8.59 g kg^{-1} under N_0 (no application of nitrogen, control) to 8.83 g kg^{-1} under super optimal dose of nitrogen, N_{150} (150% of recommended dose of N). However, differences in the organic carbon content of the soil under different levels of nitrogen application were not significant. Further, neither zinc nor boron application influenced organic carbon significantly. Such an effect of application of nitrogen as well as zinc and boron on organic carbon after first season of the crop was obvious. However, repeated applications of these nutrients in the subsequent years may result in significant build up of organic carbon in soil. Similar effect of B on organic carbon content was also observed by Agarwal *et al*. (2007) and that of Zn application by Keram *et al*. (2012). Like organic carbon, cation exchange capacity of the soil was not significantly influenced due to N, Zn and B levels. Cation exchange capacity mainly depends upon organic matter and presence of exchangeable cations. Since the organic carbon was not affected significantly, no significant change in CEC could be expected.

Table 2. Effect of nitrogen, zinc and boron on soil properties and available N, P and K (kg ha^{-1}) after wheat harvest

Treatment	OC (g kg^{-1})	CEC (c mol (p+) kg^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Nitrogen (% of recommended dose)					
0 (N_0)	8.59	10.10	244.4	16.7	137.3
50 (N_{50})	8.66	10.27	257.4	17.5	143.0
100 (N_{100})	8.75	10.30	273.3	18.7	149.7
150 (N_{150})	8.83	10.32	281.2	19.4	149.9
LSD (P=0.05)	NS	NS	10.6	1.6	4.9
Zinc (kg ha^{-1})					
0 (Zn_0)	8.71	10.21	262.2	17.6	144.6
10 (Zn_{10})	8.71	10.28	266.0	18.6	145.4
LSD (P=0.05)	NS	NS	NS	NS	NS
Boron (kg ha^{-1})					
0 (B_0)	8.69	10.20	263.4	17.9	145.1
1 (B_1)	8.73	10.29	264.7	18.2	144.9
LSD (P=0.05)	NS	NS	NS	NS	NS

Macronutrients

A perusal of the data (Table 2) revealed that after the harvest of wheat crop (*rabi*, 2010-11), the available N content of the soil was increased over its initial status with the addition of N fertilizer whereas, it decreased when no N was applied (N_0). There was a consistent increase in available N content after wheat harvest with increasing levels of N. Application of 50, 100 and 150 per cent of recommended N dose increased available nitrogen content in soil by 5.3, 11.8 and 15.0 per cent, respectively over control. Several workers have reported such an increase in mineralisable-N due to levels of incremental N (Kumar 2008). However, 150 per cent N could not significantly increase available N content over 100 per cent N application.

Available P content of the soil increased significantly with the increasing dose of N. However, the differences between levels were narrow enough and 50 per cent recommended N over control, 100 per cent N over 50 per cent N and 150 per cent over 100 per cent N could not

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significantly influence available P content of soil. The increase in available P content with increase in N levels may be due to increased crop growth, which might have led to more root exudates and ultimately solublised more soil P, thus, registering increased available P.

The available K content of the soil was significantly increased upto 100 per cent recommended dose of nitrogen (N_{100}). Application of 50 and 100 per cent of recommended N dose increased available potassium status of soil by 4.1 and 9.0 per cent, respectively over control. Such an increase in available K with nitrogen application might be due to the increase in the concentration of NH_4^+ ion in the soil solution which would have replaced K from the clay complexes. Application of Zn and B could not significantly influence the available NPK status of soil after the harvest of wheat.

Micronutrients

Application of graded levels of N significantly increased available Zn content in soil after wheat harvest as compared to control. However, the increase was consistent only upto the application of 100 per cent recommended dose of nitrogen (N_{100}). 150 per cent recommended N dose had not significantly increased Zn content over 100 per cent recommended N dose. Application of 50, 100 and 150 per cent of recommended N dose increased the available Zn status of soil by 6.7, 13.5 and 18.6 per cent, respectively over control. Similar results were reported by Keram *et al*. (2012). There was significant increase in available Zn with application of Zn @ 10 kg ha^{-1} by 11.4 per cent over no zinc application. This might be due to the considerable exchange of Zn^{2+} on the clay complexes with other cations on its addition. The results are in accordance with the findings of Kulandaivel *et al*. (2004). Boron application did not influence available Zn content significantly.

Table 3. Effect of nitrogen, zinc and boron on DTPA extractable Zn, Fe, Mn, Cu and hot water soluble B (mg kg^{-1}) after wheat harvest and grain yield (kg/ha)

Treatment	Zn	Fe	Mn	Cu	B	Grain
Nitrogen (% of recommended dose)						
0 (N_0)	0.59	25.37	19.82	0.64	0.43	2479
50 (N_{50})	0.63	26.42	21.49	0.66	0.43	3659
100 (N_{100})	0.67	26.59	21.90	0.68	0.45	4114
150 (N_{150})	0.70	26.96	22.18	0.68	0.47	4583

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LSD (P=0.05)	0.04	NS	NS	NS	NS	219
Zinc (kg ha^{-1})						
0 (Zn_0)	0.61	25.90	21.06	0.66	0.43	3537
10 (Zn_{10})	0.68	26.77	21.64	0.67	0.45	3881
LSD (P=0.05)	0.03	NS	NS	NS	NS	155
Boron (kg ha^{-1})						
0 (B_0)	0.64	26.16	21.14	0.66	0.42	3563
1 (B_1)	0.66	26.51	21.56	0.66	0.46	3854
LSD (P=0.05)	NS	NS	NS	NS	0.02	155

The application of N, Zn and B dose did not significantly influence the available Fe, Mn and Cu content of the soil after the harvest of the wheat crop. Application of nitrogen and zinc could not significantly influence available B content in the soil. Contrary to this, significant increase in the available B content was observed with application of B. The application of 1 kg B ha^{-1} (0.46 mg kg^{-1}) increased the available boron content by 0.04 mg kg^{-1} over no boron application (0.42 mg kg^{-1}). The increase in available boron status of soil might be due to considerable gain of boron content in soil with boron application. Increase in B availability as a result of B application has earlier been reported by Agarwal *et al*. (2007).

Grain yield

Application of nitrogen consistently and significantly increased the grain yield of wheat upto 150 kg N ha^{-1} (Table 3). Application of 50, 100 and 150 per cent of recommended dose of N increased the grain yield of wheat by 47.5, 65.9 and 84.8 per cent, respectively over the control. Increase in yield by N might be due to increased vegetative growth, more synthesis of carbohydrates and their translocation for the synthesis of organic nitrogen compounds which are constituents of protoplasm and chloroplasts. The results are substantiated by the findings of the studies conducted by Kachroo and Razdan (2006), Mattas *et al*. (2011) and Roshan *et al*. (2011) at different locations. Significantly higher grain yield was recorded with the application of Zn. The per cent increase in grain yield with Zn application was 9.7 over no zinc application. Such a response to application of zinc in deficient soil was quite obvious. Similar findings were reported

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Keram *et al*. (2012). Application of boron @ 1 kg ha^{-1} also increased the grain yield of wheat. The per cent increase in grain yield with B application was 8.1 over no B application. Beneficial effects of B on grain yield of wheat have also been reported by other workers (Debnath *et al*. 2011 and Nadim *et al*. 2011).

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