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Effect of nitrogen, zinc and boron on growth, yield attributes and yield of wheat under mid hill conditions of Himachal Pradesh

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Abstract

A field investigation was carried out at experimental farm of Department of Soil Science, College of Agriculture, CSK HPKV, Palampur with sixteen treatments 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. Nitrogen application @ 50, 100 and 150 per cent of recommended dose increased plant height, dry matter accumulation, total and effective tillers and grains per ear significantly. Similarly, application of Zn (10 kg ha^{-1}) and B (1 kg ha^{-1}) improved these growth parameters and yield attributes of wheat significantly. 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. Boron application @ 1 kg ha^{-1}increased grain yield by 8.1 per cent.

Key words: Nitrogen, zinc, boron, growth, yield attributes, yield, wheat.

Fertilizers have played a prominent role in increasing food grain production of the country in the past and were the kingpins of the green revolution. 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. Nitrogen is one of the major plant nutrients and is an essential constituent of all living cells. 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 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. Single nutrient approach has often caused reduced fertilizer use efficiency and consequent problems of multiple nutrients deficiencies in cereal-based cropping systems. Accelerated depletion of micronutrients from soil reserve due to enhanced food grain production has accentuated the micronutrient deficiencies in many parts of India, which has brought sharp reduction in the macronutrient (NPK) use efficiencies (Shukla *et al*. 2009). 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. The high rainfall conditions prevalent in the mid hills of Himachal Pradesh may favour the losses of these micronutrients. Their application in soil is expected to improve the crop productivity and may influence the use efficiency of macronutrients, particularly of nitrogen. Keeping these facts in view, the present investigation has been carried out under mid hill conditions of Himachal Pradesh.

Materials and Methods

A 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 varied 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 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, low in available N and medium in available P and K. The contents of DTPA extractable Fe, Mn and Cu were adequate whereas DTPA Zn was marginally adequate and hot water soluble B was insufficient. Sixteen treatment combinations comprised 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 replicated thrice in factorial RBD.

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 was applied at sowing. 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 29^{th} November 2010 and harvested on 25^{th} May 2011. The crop was grown with recommended package of practices under irrigated conditions. Plant height was measured at 60,105 and 150 DAS. Crop dry matter accumulation was recorded at flowering and at harvest. The yield attributes and yield were recorded at harvest.

Results and Discussion

Crop growth

Plant height increased at a slowest rate between 0-60 DAS, fastest rate between 60-105 DAS and then again at slower rate between 105-150 DAS (Table 1). Plant height increased with increasing dose of N. However, N_{150} could not significantly increase plant height over N_{100} at 105 and 150 DAS. The increased levels of N might have resulted in easy and greater availability of N to the crop plants, which consequently increased the meristematic activity of the plant and improved the plant height. These findings are in close conformity with those of Mattas *et al*. (2011). At all the three stages, plant height

Table 1. Effect of nitrogen, zinc and boron on plant height (cm) and dry matter accumulation (q ha^{-1})

Treatment	Plant height (cm)			Dry matter accumulation (q ha^{-1})	
	60 DAS	105 DAS	150 DAS	Maximum tillering	Harvesting
Nitrogen (% of recommended dose)					
0 (N_0)	12.5	51.0	74.1	33.8	69.3
50 (N_{50})	14.1	57.5	79.0	39.3	88.0
100 (N_{100})	15.5	61.7	82.8	44.3	98.5
150 (N_{150})	16.4	63.5	84.8	47.4	106.4
LSD (P=0.05)	0.9	3.0	2.4	3.5	4.6
Zinc (kg ha^{-1})					
0 (Zn_0)	14.0	56.8	78.8	39.3	87.3
10 (Zn_{10})	15.0	60.1	81.5	43.1	93.8
LSD (P=0.05)	0.6	2.1	1.7	2.5	3.3
Boron (kg ha^{-1})					
0 (B_0)	14.2	57.1	79.3	39.6	87.7
1 (B_1)	14.8	59.8	81.0	42.8	93.4
LSD (P=0.05)	0.6	2.1	1.7	2.5	3.3

was significantly more in Zn treated plots over plots receiving no Zn application. The increase in plant height might be attributed to the fact that zinc plays a vital role in growth and development of plants because of its stimulatory and catalytic effect in various physiological and metabolic processes of plants. Similarly, at all the three stages, plant height was statistically higher with boron application over plots receiving no B application. The increased plant height might be due to the reason that B is involved in the transportation of photo assimilates from leaves to other plant parts which ultimately increased the plant height. Similar results were obtained by Khan *et al.* (1996).

At maximum tillering dry matter accumulation increased significantly upto recommended dose of nitrogen where as at harvest significant effect was observed upto super optimal dose of N @ 150 kg ha^{-1}(Table 1). The increase in dry matter accumulation by nitrogen application might be due to enhanced vegetative growth, more synthesis of carbohydrates and their translocation. Similar results were also obtained by Mattas *et al.* (2011). Application of zinc (10 kg ha^{-1}) resulted in significantly more dry matter production. It may be due to the involvement of zinc in auxin metabolism which results in improvement in overall biomass. Likewise, application of 1 kg B ha^{-1} resulted in significantly more dry matter production. It may be due to the significant role of boron in translocation of sugar and starch, synthesis of amino acids and proteins (Das 2011). Similar results were obtained by Adiloglu and Adiloglu (2006).

Yield attributes

Total number of tillers and effective tillers increased significantly with increasing N level upto 100 per cent (Table 2). The increased levels of N have resulted in easy and greater availability of N to the crop plants. As N is an integral constituent of chlorophyll and imparts green colour to plants, thus increased N supply might have resulted in higher photosynthetic activity which led to profuse vegetative growth. Thus, the increased N supply brought forth a significant increase in number of tillers and effective tillers per metre row length. These results also corroborate findings of Mattas *et al.* (2011). However, super optimal dose could not significantly increase the number of tillers over the recommended dose of N. Data given in Table 2 further revealed that total and effective tillers were significantly increased with zinc application. The increase in total and effective tillers with Zn application could be due to the fact that Zn plays an important role in formation of growth hormones and auxin metabolism. These findings are in accordance with Dahiya *et al.* (2008).

Table 2. Effect of nitrogen, zinc and boron on yield attributes and grain yield of wheat

Treatment	Tillers/m^2	Effective tillers/m^2	Grains/ear	1000-grain weight (g)	Grain yield (kg ha^{-1})
Nitrogen (% of recommended dose)					
0 (N_0)	285.3	263.6	36.6	47.0	2479
50 (N_{50})	328.0	306.2	43.5	52.2	3659
100 (N_{100})	379.6	352.4	46.2	55.5	4114
150 (N_{150})	389.3	363.1	48.1	56.3	4583
LSD (P=0.05)	11.1	12.0	2.4	1.6	219
Zinc (kg ha^{-1})					
0 (Zn_0)	340.0	315.6	42.7	52.4	3537
10 (Zn_{10})	351.1	327.1	44.5	53.1	3881
LSD (P=0.05)	8.0	8.4	1.7	NS	155
Boron (kg ha^{-1})					
0 (B_0)	340.9	317.8	42.5	52.5	3563
1 (B_1)	350.2	324.9	44.6	53.0	3854
LSD (P=0.05)	8.0	NS	1.7	NS	155

Boron influenced total number of tillers significantly but failed to exhibit any significant effect on effective tillers. The beneficial effect of B on plant growth may be ascribed to involvement of B in development of new cells in meristematic tissue and it also regulates carbohydrates metabolism. Similar results were reported by Dewal and Pareek (2004).

Number of grains per ear was significantly affected due to N application. Nitrogen application significantly increased grains per ear but the response was upto 100 per cent recommended N dose (N_{100}) only. Increase in number of grains per ear could be attributed to increased accumulation of photosynthates from source to sink with increased levels of fertilizer nitrogen. These results are in conformity with the earlier findings of Mattas *et al*. (2011). Grains per ear were significantly increased from 42.7 under no application of zinc to 44.5 under10 kg Zn ha^{-1}. It might be due to the reason that zinc plays important role in regulating the auxin concentration in plants and is an essential component of enzymes which promotes the growth and development of plants. Zinc also helps in initiation of primordia for reproductive parts. Patel *et al*. (2008) have also reported similar results. Grains per ear were significantly increased with B application. Boron might have brought increased translocation of photosynthates, increased pollination and seed setting which in turn might have brought increased number of grains per ear. Similar findings were obtained by Ahmed and Irshad (2011).

Nitrogen application brought about significant influence on test weight (Table 2). Optimal dose of nitrogen (N_{100}) was better than N_0 and N_{50}. However, super optimal dose of nitrogen did not increase the test weight over optimal dose of nitrogen. Higher availability of N might have enhanced accumulation of assimilates in the grain and thus resulting in heavier grains of wheat. Zinc and boron application could not bring about significant increase in test weight of wheat.

Grain yield

The data pertaining to wheat grain yield (Table 2) revealed that application of nitrogen consistently and significantly increased the grain yield of wheat upto 150 kg N ha^{-1}. Wheat grain yield varied from 2479 kg ha^{-1} under N_0 (no application of N, control) to 45.83 kg ha^{-1} under highest level of N application, N_{150} (150% of recommended dose of N). 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 Mattas *et al*. (2011) and Roshan *et al*. (2011) at different locations. Significantly higher grain yield was recorded with the application of Zn over no zinc. The per cent increase in grain yield with Zn application was 9.7 over no zinc. The increase in grain yield on zinc addition might be due to enhanced formation of growth hormones such as auxin. Further, it also promotes starch formation and seed maturation. Such a response to application of zinc in deficient soil was quite obvious. Similar findings were reported by Keram *et al*. (2012). Application of boron @ 1 kg ha^{-1} also increased the grain yield of wheat (Table 2). The grain yield increased from 3563 under B_0 to 3854 kg ha^{-1} under B_1 level of boron. The per cent increase in grain yield with B application was 8.1 over no B application. The increase in grain yield of wheat on boron application might be due to positive role of B in reproductive physiology essential for grain formation and development in the boron deficient soil. 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).

The present investigation conclusively inferred the indispensability of Zn and B application along with NPK fertilization in wheat. The wheat crop even responded to additional application of 50% more than the recommended dose in an acid alfisol under mid hill conditions of Himachal Pradesh.

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