

Effect of Nitrogen, Zinc and Boron on Nutrient Concentration at Maximum Tillering of Wheat

Rana SS^{*1}, Sanjay K Sharma² and Sapna Kapoor²

¹Department of Agronomy, CSK HP Agricultural University, Palampur, India

²Department of Soil Science, CSK HP Agricultural University, Palampur, India

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*Corresponding author: SS Rana, Department of Agronomy, Forages and Grassland Management, CSK HP Agricultural University, Krishi Vishwavidyalaya, Palampur 176 062, HP India; Email: ranassdee@gmail.com

Abstract

A field investigation was carried out at Palampur with sixteen treatment combinations consisting of four levels of N (0, 50, 100 and 150 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. 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. In general, application of nitrogen increased the concentrations of N, P, K, Mn, Fe, Cu, Zn and B in plants at maximum tillering of wheat. N, K, Mn, Cu and B concentration of wheat at maximum tillering increased with increasing level of nitrogen upto 150% recommended dose of nitrogen. P concentration increased upto 100% dose of nitrogen while Zn and Fe concentration increased upto 50% recommended dose of nitrogen. Application of Zn @ 10 kg ha⁻¹ resulted in increased N, K, Zn and B concentrations and decreased Fe, Mn and Cu concentrations. P concentration in plants of wheat at maximum tillering was not affected significantly due to Zn application over no Zn application. Boron @ 1 kg ha⁻¹ significantly increased N, P, K, Zn and B concentrations at maximum tillering of wheat.

Key words: Nitrogen; Zinc; Boron; Nutrient Concentration; Maximum Tillering; Wheat

Introduction

A crop absorbing enough of plant nutrients is expected to yield higher than a crop accumulates lower nutrients. Thus estimating nutrient concentrations is essentially an important task to have strategies for sustained higher yields. 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 as it is a constituent of proteins, enzymes and chlorophyll, and takes part in metabolic processes involved in the synthesis and transfer of energy. 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. 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. Accelerated depletion of micronutrients from soil reserve due to enhanced food grain production has accentuated the micronutrients deficiencies in many parts of India,

which has brought sharp reduction in the macronutrient (NPK) use efficiencies Shukla [1-3].

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. 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 zone-II 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 study was planned to reveal the influence of nutrients application in soil on nutrient concentrations on plants and subsequent effect of yield of wheat 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° 6' N latitude 76° 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°C in January to around 30°C during May-June. The average annual rainfall ranges between 1500 to 3000mm, 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 were replicated thrice in factorial RBD and comprised 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).

Recommended dose of N, P₂O₅, K₂O for wheat is 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 wheat plant samples were collected at maximum tillering stage. Grain and straw samples were collected during threshing. The wheat plant samples collected at tillering stage and grain and straw samples collected after the harvest were brought to laboratory fresh. Then washed immediately in order to make them free from dust or any other adhering substances. Samples were first washed under running tap water. Subsequently, these samples were washed with acidified distilled water (1ml concentrated HCl per liter) followed by thorough rinsing twice with distilled water. The samples were then dried in an oven at 60°C. The dried samples were then ground in a grinder fitted with stainless steel parts to pass through 1 mm sieve. These are then kept in paper bags for subsequent analysis. The detail of methods employed for chemical analysis is given below in (Table 1).

Table 1: The methods used for determination of nutrient concentration in plant samples.

Parameter	Method employed
Nitrogen	Digestion with concentrated H ₂ SO ₄ in the presence of digestion mixture (K ₂ SO ₄ , CuSO ₄ and Selenium powder in
Phosphorus	Digestion in diacid mixture (HNO ₃ and HClO ₄ in 9:4 ratio) and further determination following vanadomolybdate acid yellow colour method (Jackson 1973).
Potassium	Digestion in diacid mixture and further estimation by flame photometric method Black [2].
Boron	Digestion by dry ashing in muffle furnace at 550°C for 2 hrs followed by digestion with 6.0 N HCl and further determination using carmine method Hatcher and Wilcox [3]
Fe, Mn, Zn and Cu	Digestion in di-acid mixture and further estimation using atomic absorption spectrophotometer (AAS) Jackson [1]

Results and Discussion

Nutrient Concentration at Maximum Tillering

Application of nitrogen significantly affected its per cent concentration in plants of wheat at maximum tillering (Table 2). The variation in concentration of nitrogen was 1.63 per cent under no nitrogen application (N₀) to 2.35 per cent under the treatment receiving super optimal dose of nitrogen (N₁₅₀). This substantial increase can be due to increased N availability enabling plants to take up more nitrogen. Secondly, N application might have increased the root growth which favoured more removal of nitrogen

by wheat plants. Zinc application @ 10kg ha⁻¹ resulted in significant increase in nitrogen concentration of wheat tillers. It increased from 1.91 per cent under no Zn application to 2.01 per cent under Zn₁₀. This increase in nitrogen concentration might be attributed to better plant growth as zinc helps in nitrogen absorption due to synergistic relationship between nitrogen and zinc. Similar findings were obtained by AbdEl-Hady [4]. Application of boron @ 1kg ha⁻¹ significantly influenced nitrogen concentration over no B application. Nitrogen concentration increased from 1.94 per cent under B₀ to 1.98 per cent under B₁, respectively. It might be due to the role of boron in the absorption of nitrogen Das [5].

Table 2: Effect of nitrogen, zinc and boron on macro (%) and micronutrient concentration (mg kg⁻¹) at maximum tillering and grain yield of wheat.

Treatment	N	P	K	Zn	Mn	Fe	Cu	B	Grain
Nitrogen (% of recommended dose)									
0 (N ₀)	1.63	0.32	1.25	22.08	63.16	103.63	25.83	13.07	24.79
50 (N ₅₀)	1.73	0.34	1.33	25.25	68.19	116.13	30.17	14.17	36.59
100 (N ₁₀₀)	2.13	0.36	1.39	26.75	75.46	121.50	33.75	16.92	41.14
150 (N ₁₅₀)	2.35	0.36	1.44	26.75	81.68	124.88	35.67	18.04	45.83

LSD (P=0.05)	0.04	0.01	0.04	2.09	3.80	10.33	1.26	0.44	2.19
Zinc (kg ha ⁻¹)									
0 (Zn ₀)	1.91	0.34	1.34	23.17	73.47	123.31	31.88	15.00	35.37
10 (Zn ₁₀)	2.01	0.35	1.37	27.25	70.77	109.75	30.83	16.00	38.81
LSD (P=0.05)	0.03	NS	0.03	1.48	2.68	7.30	0.89	0.31	1.55
Boron (kg ha ⁻¹)									
0 (B ₀)	1.94	0.33	1.34	24.42	71.27	113.88	30.96	14.91	35.63
1 (B ₁)	1.98	0.36	1.37	26.00	72.97	119.19	31.75	16.19	38.54
LSD (P=0.05)	0.03	0.01	0.03	1.48	NS	NS	NS	0.31	1.55

The phosphorus concentration of wheat at maximum tillering increased with increasing level of nitrogen upto 100 per cent recommended dose of nitrogen. Further increase in N level (N₁₅₀) did not increase the P concentration of wheat tillers over its preceding level. Similar results were reported by Yadav [6]. However, application of Zn (Zn₁₀) could not increase phosphorus concentration of wheat at maximum tillering over no Zn application (Zn₀). Boron application @ 1kg ha⁻¹ resulted in significant increase in phosphorus concentration. The increased P concentration might be due to the favourable effect of B which alters the permeability of plasma lemma at the root surface in such a way that P absorption increases Patel and Golakiya [7]. Nitrogen application resulted in higher K concentration. The maximum concentration (1.44 per cent) was recorded at highest rate of nitrogen application (N₁₅₀) which was significantly better over rest of the N levels (N₀, N₅₀ and N₁₀₀). The results are in accordance with those reported by Yadav [6]. K concentration also significantly increased with application of zinc @ 10 kg Zn ha⁻¹. Similar results with application of zinc on K concentration in plants were reported by AbdEl-Hady. Similarly, application of boron @ 1kg ha⁻¹ increased potassium concentration at maximum tillering (1.37 per cent) over no boron application (1.34 per cent). Slight increase in K content with boron application may be due to the fact that it depresses the uptake of Ca which otherwise has antagonistic effect on K as reported by Reeve and Shive [8].

Zn concentration increased from 22.08mg kg⁻¹ under N₀ to 26.75mg kg⁻¹ under N₁₀₀. Further increase in N level to 150 per cent of recommended nitrogen did not increase the concentration of Zn any more. The increase in Zn concentration might be due to synergistic effect between nitrogen and zinc as adequate supply of N enhanced the translocation of Zn from roots to other parts of plants. Further better root and shoot growth with the application of N might have led to better utilization of the zinc and other cations from the soil solution. Similar results were reported by and Lin et al. [9]. Zinc concentration increased with the increase of zinc in nutrient solution. Application of zinc @ 10kg ha⁻¹ (Zn₁₀) resulted in significantly higher zinc concentration (27.25mg kg⁻¹) over no zinc application (23.17mg kg⁻¹). The increase in Zn concentration with the application of Zn may be attributed to its enhanced supply through ZnO added externally. Ai-Qing et al. [10] also reported an increase in zinc concentration with its addition. B increased the zinc concentration by 18 per cent over no application of B. Similar results were reported by Kaur [11]. Manganese concentration

increased consistently from 63.16mg kg⁻¹ under N₀ to 81.68mg kg⁻¹ under N₁₅₀.

Per cent increase in Mn concentration due to application of 50, 100 and 150 per cent of recommended N was 7.9, 19.4 and 29.3, respectively. Similar observations were reported by Lin et al. [9]. Mn concentration decreased with the application of zinc @ 10kg ha⁻¹ (Zn₁₀). It might be because of negative effect of zinc on translocation of Mn as reported by Narwal and Malik [12]. Boron application could not significantly influence Mn concentration at maximum tillering of wheat. Iron concentration at maximum tillering increased with the application of nitrogen. It ranged from 103.63 mg kg⁻¹ under control to 124.88 mg kg⁻¹ under N₁₅₀. However, the increase was not consistent above the application of 50 per cent of recommended N as the differences among N levels (50-150 per cent of recommended N) were not significant. Application of zinc @ 10kg ha⁻¹ decreased iron concentration at maximum tillering from 123.31mg kg⁻¹ under Zn₀ to 109.75mg kg⁻¹ under Zn₁₀. This indicated mutual antagonism between these two nutrients. The antagonistic relationship might be attributed to the competition of Fe²⁺ with Zn²⁺ at absorption sites of roots causing inhibition in absorption of each other and also resulting in ionic imbalance. The ferrous (Fe²⁺) iron competes with zinc (Zn²⁺) in the uptake process for formation of chelates or other reactions Sinha and Sakal [13]. Similar results were reported by Ai-Qing et al. [10] in wheat. Application of boron increased Fe concentration under B₁ (119.19mg kg⁻¹) over B₀ (113.88mg kg⁻¹) but the difference was not significant.

There was significant and consistent increase in Cu concentration in wheat tillers with increased levels of nitrogen from 25.83 mg kg⁻¹ under N₀ to 35.67 mg kg⁻¹ under N₁₅₀. Application of 50, 100 and 150 per cent of recommended dose of N increased Cu concentration in wheat tillers by 16.8, 30.6 and 38.0 per cent, respectively. This might be due to better root and shoot growth and healthy plants in presence of higher nitrogen levels. As a result the plants might have taken up higher amount of nutrients including copper. Similar observations were reported by Lin et al. [9]. However, application of zinc @ 10kg ha⁻¹ significantly reduced copper concentration in plant at maximum tillering. The decreased Cu concentration with Zn application might be attributed to antagonism of zinc (Zn²⁺) and copper (Cu²⁺) ions having same ionic radii and charge which compete with each other for the absorption sites in the plasma membrane of roots as both ions have been found to be absorbed by the same transport system Choudhary et al. [14]. Copper

concentration varied from 30.96 at B₀ and 31.75 at B₁, however the increase in Cu concentration was not significant.

Boron concentration at maximum tillering increased significantly and consistently with increase in nitrogen level from 0 to 150 per cent of the recommended dose and values ranged from 13.07 mg kg⁻¹ under control to 18.04 mg kg⁻¹ under N₁₅₀. Application of 50, 100 and 150 per cent of recommended dose of N increased B concentration in wheat tillers by 8.4, 29.4 and 38.0 per cent, respectively. This could be due to more vegetative growth and root growth, which release root exudates resulting in increased boron availability in soil and finally the uptake by plants. The results of the investigation are in consonance with the findings of Hellal et al. [15]. Application of zinc @ 10kg ha⁻¹ also enhanced the boron concentration at maximum tillering from 15.0mg kg⁻¹ under Zn₀ to 16.0mg kg⁻¹ under Zn₁₀. Similar results have been reported by Kaur [11]. Likewise, boron application increased boron concentration significantly from 14.91 mg kg⁻¹ under B₀ to 16.19 mg kg⁻¹ under B₁. The per cent increase in B concentration was worked out to 13.4 over no B application. The increase in boron concentration may be ascribed to increased availability of boron through the addition of borax.

Grain Yield

There was consistent increase in grain yield of wheat upto 150kg N ha⁻¹. 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. [16] and Roshan et al. [17] 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. 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. [18]. Application of boron @ 1kg 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. 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 Agarwal et al. [19]. Beneficial effects of B on grain yield of wheat have also been reported by other workers Debnath et al. and Nadim et al. [20,21].

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