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EFFECT OF NITROGEN AND ZINC NUTRITION ON YIELD, QUALITY AND UPTAKE OF NUTRIENTS BY WHEAT

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ABSTRACT

A field experiment was conducted to investigate the response of wheat to nitrogen and zinc at Bichpuri, Agra (U.P.) during rabi season of 2008-09 and 2009-10 on an alluvial soil. Treatments consisted of four levels of N (0, 50, 100 and 150 kg ha^{-1}) and four levels of Zn (0, 2.5, 5.0 and 10 kg ha^{-1}). Application of 150 kg N ha^{-1} produced the highest grain (5.04 t ha^{-1}) and straw (6.82 t ha^{-1}) yield of wheat. Application of Zn up to 5 kg ha^{-1} also increased the wheat grain and straw significantly over control. The interaction effect between N and Zn significantly and synergistically influenced the yields which were observed the highest at 150 kg N in conjunction with 5 kg Zn ha^{-1}. Economic analysis indicated that the highest net return (Rs.49062 ha^{-1}) and B: C ratio (2.66) was recorded under 150 kg N ha^{-1}. Among zinc levels, relatively higher net return and B:C ratio were recorded with 5 kg Zn ha^{-1}. Protein content and yield in grain increased significantly with the addition of N up to 150 kg ha^{-1} and Zn up to 5 kg Zn ha^{-1}. Nitrogen uptake by wheat grain and straw progressively increased from 68.0 to 111.7 and 25.5 to 44.6 kg ha^{-1} with the increase in N levels. The uptake of Zn by grain and straw increased with zinc application up to 10 kg Zn ha^{-1}. The uptake of P by wheat increased with graded level of N up to 180 kg ha^{-1} and decreased with Zn levels.

Keywords: Nitrogen, zinc, yield, quality, nutrient uptake, wheat

INTRODUCTION

Intensive cultivation has resulted in depletion of soil nutrients to a great extent, thus nutrients requirement of the crops has increased considerably during the last few years. Nitrogen plays a key role in increasing the food grain production in India. The soils of Agra region are inherently low in soil organic matter and nitrogen is the major limiting plant nutrient. Cereals constitute the staple food in India and about 61% of the protein requirement of Indian population is met through cereals. The favorable response of applied nitrogen might be due to the vital role of nitrogen in the growth and metabolism of the plant. Nitrogen in the form of protein is major constituent of protoplasm, accelerate the cell division and hence the growth and development of root and shoot. Zinc is also an important micronutrient reported deficient in Indian soils and plays a significant role in various enzymatic and physiological activities of plant bodies. It helps in formation of chlorophyll and auxins. Losses of yield of 40% or more in many Zn deficient soils have a major economic impact on the farmers due to the reduced income as a result of lost yield. Although wheat is relatively tolerant to Zn deficiency but, the soils in which wheat is grown have very low concentrations of plant available Zn and cause wide spread Zn deficiency in grain and straw (Singh, 2010). The application of N and Zn, therefore, has shown significant effects on yield, uptake of nutrients and quality of crop. In the present study attempts have been made to evaluate the effect of nitrogen and zinc on yield, quality and nutrient uptake of wheat crop.

MATERIALS AND METHODS

A field experiments was carried on a sandy loam soil at R.B.S. College, research farm, Bichpuri (Agra) during rabi season in 2008-09 and 2009-10 with wheat Bichpuri (Agra) is situated at a latitude of $27^0$22" N, longitude of $77^0$9" E and altitude of 168 meters above the mean sea level. The mean annual rainfall of Agra is 650 mm and more than 80% generally occurs during south west monsoon season (July – Sept). The soil of the experimental site was sandy loam in texture with pH 8.1, organic carbon 3.4 g kg^{-1}, available N 145 kg ha^{-1}, P 8.9 kg ha^{-1} and Zn 0.53 mg kg^{-1}. There were sixteen treatment combinations having four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and four levels of zinc (0, 2.5, 5 and 10 kg Zn ha^{-1}) in randomized block design with three replications. Nitrogen and zinc were applied through urea and zinc sulphate, respectively at the time of sowing as per treatments. The basal doses of P (60 kg P_2O_5 ha^{-1}) and K (40 kg K_2O ha^{-1}) were applied through triple superphosphate and muriate of potash, respectively. Wheat crop (PBW 343) was sown in first week of November in both the years. Wheat crop was harvested in the first week of April in each year. The grain and straw yields were recorded after harvest of crop. The grain and straw samples were digested in HNO_3 and $HClO_4$ di-acid mixture. In

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the digest P was determined by vanadomolybate yellow colour method (Jackson 1973) and zinc by atomic absorption spectrophotometer. Nitrogen in grain and straw was determined by modified Kjeldahl method. The uptake of nutrients was calculated from the data on concentration of the given nutrient multiplied by grain and straw yield. Economics of wheat crop was calculated based on the prevailing prices of inputs and outputs during crop season.

RESULTS AND DISCUSSION

Yield

Data indicated (Table 1) that the grain and straw yield of wheat increased significantly with nitrogen application. The mean yield of wheat grain increased by 15.9, 34.7 and 46.4% over control due to 50, 100 and 150 kg N ha^{-1}, respectively. The corresponding increases in straw yield were 16.1, 34.7 and 45.6 percent. Increase in the level of nitrogen was responsible for the increased number of leaves and leaf area index causing higher photosynthesis and assimilation rates, metabolic activity and cell division which were responsible for significant increase in the growth and grain and straw yield of wheat. Responses to N application in wheat crop have also been reported by Singh *et al.* (2007), Yadav *et al*. (2012) and Singh *et al.* 2013. The mean grain yield increased from 4.08 t ha^{-1} at control to 4.46 t ha^{-1} with 5 kg Zn ha^{-1}. The corresponding increase in straw yield was from 5.55 to 6.08 t ha^{-1}. The yield of wheat grain and straw decreased at higher level (10 kg ha^{-1}) of zinc over 5 kg Zn ha^{-1}. This increase in yield might be due to its function as catalyst or stimulant in most of the physiological and metabolic processes and metal activator of enzymes, resulting in increased growth and development, which ultimately gave higher grain and straw yields of wheat. However, the response was better at lower rate of zinc application rather than at higher rate. Increase in yield due to application of Zn is quite obvious, as the soil under study was deficient in available zinc (0.52 mg Kg^{-1}). Goswami (2007) and Varshney *et al*. (2008), Khare and Dixit (2011) also noted a significant response of wheat to zinc applied to deficient soils. Based on mean of 2 years data, the interaction effect of N and Zn was significant for grain and straw yield (Table 2). All the levels of zinc increased the grain yield of wheat significantly at each level of N and vice versa. Maximum grain and straw yields were recorded at 150 kg N + 5 kg Zn ha^{-1} treatment. This favourable effect of N and Zn combination may be because addition of Zn with N might have maintained a favourable balance between N and Zn in the wheat plants for optimum growth. Sahay *et al*. (2009) also reported response of wheat to N and Zn applied in deficient soil.

Table 1: Effect of Nitrogen and Zinc levels on grain and straw yields of wheat crop (mean of 2 years)

Treatments	Yield (tha^{-1})		Protein in grain (%)	Protein yield (kg ha^{-1})	Net return (Rs ha^{-1})	B:C Ratio
	Grain	Straw				
Nitrogen (kg ha^{-1})						
0	3.44	4.64	12.50	457.2	29761	1.81
50	3.99	5.45	12.95	516.8	36431	2.12
100	4.64	6.35	13.45	623.7	44408	2.50
150	5.04	6.82	13.85	698.1	49062	2.66
CD (P=0.05)	0.17	0.14	0.21	17.66		
Zinc (kg ha^{-1})						
0	4.08	5.55	13.00	530.0	37302	2.14
2.5	4.25	5.80	13.10	556.6	39608	2.26
5.0	4.46	6.08	13.25	590.4	42110	2.40
10.0	4.33	5.88	13.35	578.1	40642	2.30
CD (P=0.05)	0.17	0.14	0.21	17.66		

Economics

Maximum net returns of ₹ 42110.0 ha^{-1} were recorded with 5 kg Zn ha^{-1}, which was higher by ₹ 4808 and ₹ 2502 compared with 0 and 2.5 kg Zn ha^{-1}. Application of 150 kg N ha^{-1} recorded the maximum net returns of Rs.49062, followed by ₹.44408 with 100 kg N ha^{-1} (Table 1). The benefit: cost ratio was highest (2.40) at 5 kg Zn ha^{-1} application. Increasing levels of Zn beyond 5 kg Zn ha^{-1} reduced the benefit: cost ratio in wheat due to increased cost of these inputs. Likewise, the benefit: cost was increased from 1.81 in control to 2.66 in 150 kg N ha^{-1}. The increase in net returns by the application of zinc and N fertilizer might be due to positive effect of these nutrients on grain yield.

Table 2: Interactive effect of zinc and nitrogen on yield of wheat

Zinc (kg ha^{-1})	Nitrogen (kg ha^{-1})			
	0	50	100	150
Grain yield (t ha^{-1})				
0	3.15	3.85	4.52	4.78
2.5	3.37	3.98	4.64	5.00
5.0	3.68	4.11	4.81	5.21
10.0	3.57	3.99	4.64	5.04
CD (P=0.05)			0.34	
Straw yield (t ha^{-1})				
0	4.21	5.27	6.16	6.55
2.5	4.58	5.45	6.34	6.85
5.0	4.95	5.63	6.57	7.14
10.0	4.81	5.48	6.36	6.90
CD (P=0.05)			0.28	

Quality

The protein content in wheat grain increased significantly with nitrogen application and maximum value was recorded with 150 kg N ha^{-1}. This may be due to the fact that the plants accumulated more nitrogen with increasing levels of nitrogen and ultimately showing more protein content. Since, N is an important constituent of plant protein which plays an important role in protein synthesis, higher protein content could be expected at increased doses of nitrogen. Similar results were reported by Singh *et al*. (2007). The levels of Zn had significant beneficial effect on protein content in wheat grain. The maximum values of protein content in grain were noted under 10 kg Zn ha^{-1}. Indispensable role of Zn in nitrogen metabolism particularly in the biochemical processes involving nitrate reduction and protein synthesis by its activating or catalytic influence on numerous enzyme systems might account for higher nitrogen content in crop. Khare and Dixit (2011). There was a consistent and significant increase in protein yield of wheat grain with increasing levels of nitrogen and maximum value (698.1 kg ha^{-1}) was recorded at 150 kg N ha^{-1}. This increase in protein yield due to nitrogen levels may be attributed to increased yield and protein content in wheat grain. Singh *et al*. (2004) also reported an increase in protein production with N application. There was a gradual increase in protein yield with increasing levels of Zn up to 5 kg ha^{-1}. Thereafter, a reduction in protein yield was noted at higher level of Zn (10 kg ha^{-1}).

Table 3: Effect of nitrogen and zinc levels on nutrients uptake and by wheat grain and straw

Treatments	Nitrogen (Kg ha^{-1})		Phosphorus (Kg h^{-1})		Zinc (g ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
Nitrogen (kg ha^{-1})						
0	68.0	25.5	7.3	4.6	123.1	109.9
50	82.8	32.2	8.9	6.0	139.5	126.5
100	100.0	39.4	11.9	8.2	146.1	144.2
150	111.7	44.6	11.1	9.6	146.6	150.3
CD (P=0.05)	3.75	1.75	0.58	0.34	6.81	5.33
Zinc (Kg ha^{-1})						
0	85.3	32.7	10.4	7.8	123.2	107.6
2.5	89.7	34.8	10.9	7.5	130.4	125.9
5.0	94.6	37.1	10.8	7.3	148.9	146.7
10.0	92.5	36.5	10.0	6.4	162.8	154.7
CD (P=0.05)	3.75	1.75	0.58	0.34	6.81	5.33

Uptake studies

The results indicate that the mean nitrogen removal by the wheat grain and straw increased from 68.0 to 111.7 and from 25.5 to 44.6 kg N ha^{-1}, respectively as the dose of nitrogen was increased from 0 to 150 Kg N ha^{-1}. This increase can invariably be attributed to increased grain and straw yield and higher nutrient demand for plant growth. Similar results were reported by Sahay *et al*. (2009). Application of lower levels of zinc increased the N uptake by wheat grain and straw over control. Nitrogen uptake by wheat crop decreased at higher levels of zinc in both crop seasons. The improvement in N uptake with Zn was mainly due to higher production of grain and straw. The maximum values of N uptake by wheat crop recorded with 5 kg Zn ha^{-1}. The uptake of phosphorus by wheat crop was enhanced to about two times at 150 kg N ha^{-1} as compared to control. The effect of nitrogen application in increasing phosphorus uptake may be associated with physiological stimulation of plant rather than increased ramification of root system. These results are in agreement with those reported by Chaudhary *et al*. (1997), Sahay *et al*. (2009) and Khare and Dixit (2011). The increase in phosphorus uptake with increasing levels of nitrogen seems to be

associated with increased P availability from applied N with a concomitant increased uptake of P by wheat crop. The phosphorus uptake by wheat grain and straw tended to decrease significantly with higher level of Zn over control. The mean phosphorus uptake by wheat grain decreased from 10.4 to 10.0 kg ha^{-1} due to 10 kg Zn ha^{-1}. The corresponding reductions in P uptake by straw were from 7.8 to 6.4 kg ha^{-1}. Thus, lower values of P uptake by wheat grain and straw were recorded with 10 kg Zn ha^{-1}. The results suggest on antagonism between zinc and phosphorus. Singh *et al*. (2004) also reported a decrease in P uptake with zinc application. The results indicated (Table 3) that the uptake of zinc by wheat grain and straw increased from 123.1 to 146.6 and 109.9 to 150.3 g ha^{-1} with 150 kg N ha^{-1} application due to increase in grain and straw yields. Similar results were also reported by Nayak *et al*. (1997) in wheat. Application of zinc significantly increased the average zinc uptake by wheat grain and straw from 123.2 to 162.8 and 107.6 to 154.7 kg ha^{-1}, respectively. This increase in Zn uptake with its addition may be ascribed to greater grain and straw production. It is also evident that Zn uptake at its lower level was more pronounced that at higher levels. Similar results were reported by Dwivedi *et al*. (2002) and Singh *et al*. (2010).

On the basis of the experimental findings, it is concluded that application of N and Zn, besides augmenting the crop yield, also improves the quality and uptake of nutrients in wheat. Application of 150 Kg N and 5 Kg Zn ha^{-1} can be recommended for wheat in alluvial soils of Agra region.

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