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Interaction Effect of Zinc and Nitrogen on Growth and Yield of Barley (*Hordeum vulgare* L.) on Typic Ustipsamments

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Abstract: In a field experiment on loamy sand soil (Typic Ustipsamments), application of zinc and nitrogen enhanced the grain and straw yield of barley (*Hordeum vulgare* L.). Grain and straw yield increased significantly with the application of Zn and N at the rate of 5.0 kg Zn ha^{-1} and 60 kg N ha^{-1}, respectively. Yield components like effective tillers, ear length, number of grains per ear and test weight increased significantly with the application of 5.0 kg Zn and 60 kg N ha^{-1} as compared to lower levels. Higher doses of Zn and N increased yield and yield components non-significantly. The interaction effect of ZnxN on grain yield was found to be significant. The combined application of 7.5 kg Zn along with 90 kg N ha^{-1} registered the maximum grain yield of 49.20 q ha^{-1} and straw yield of 72.6 q ha^{-1} which was 21.17 and 28.58 q ha^{-1} additional over control.

Key words: Barley, nitrogen, zinc, interaction, yield

INTRODUCTION

Barley (*Hordeum vulgare* L.) has the widest ecological range amongst cereals and is widely grown in Rajasthan and other temperate and tropical regions of India. Its lower cost of cultivation and low input demand helps in its preference by farmers in the area[1]. Barley grain is considered as an important raw material for many industries and as food grain consumed in the form of unleavened bread. Besides, straw is a good quality fodder for cattle. Barley is comparatively more tolerant to salinity, alkalinity, frost and drought conditions than other rabi season crops. Farmers of arid and semi-arid regions of the country prefer this crop as it requires less water and does well even with saline water. In Rajasthan it is grown both as irrigated and unirrigated crop on coarse textured soils. The major constraint limiting barley production in this state is poor fertility status of coarse textured sandy soils coupled with imbalanced nutrition. The easiest way to boost the productivity if through balanced fertilization to the undernourished crop[2].

During the past three and half decades, micronutrients have occupied an important position in Indian Agriculture and have become indispensable to the productivity of crops. Micronutrients have been known to increase the yield and improve the quality of different cereals including barley. Zinc, an essential micronutrient now stands third in requirement and importance next to N and P[3]. About sixty per cent soils of India are deficient to low in zinc. The deficiency of zinc is more widespread in coarse textured soils low in organic matter. Use of high analysis fertilizers, little or no use of organic material, intensive cropping and traditional negative attitude of farmers towards micronutrients resulted in depletion of zinc reserves. Deficiency of zinc in field crops is one of the major soil fertility problems in many areas of the country[4]. Its application has been found to increase the yield of number of crops including cereals.

Nitrogen, a vital plant nutrient, is universally deficient plant nutrient in soils of India, particularly in coarse textured soils of arid and semi-arid regions. Its application has resulted in significant increase in yield and yield components of all the crops. However little is known about the relative Zn and N requirement of barley in these soils. Out of the major contributing factors, the main factor for increasing barley production has been enhanced productivity, which can be achieved by adopting better management practices and judicious use of nutrients. Also, high price index of zinc and nitrogenous fertilizers coupled with their limited production made it imperative to develop optimum doses of Zn and N for enhancing barley yields[5]. Thus, the present investigation was carried out to study the comparative pattern of Zn and N in relation to growth and yield of barley.

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MATERIALS AND METHODS

A field experiment was conducted during rabi with barley crop (cv.RD-2052) at Agronomy research farm, S.K.N College of Agriculture, Jobner, Jaipur (Rajasthan, India). The Entisol (Ustipsamment) soil of the experimental site was loamy sand in texture, having pH (1:2) 8.2, EC 1.62 dSm^{-1}, CEC 5.32 C mol (p+) kg^{-1} and organic carbon 2.2 g kg^{-1}. The soil contained 135.7, 19.65 and 151.2 kg ha^{-1} of available N, P_2O_5 and K_2O, respectively. Soil was low in available zinc (0.42 mg kg^{-1}). The treatment consisted of combination of four levels of zinc (0, 2.5, 5.0 and 7.5 kg ha^{-1}) through zinc sulphate and four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) through urea in two splits. All plots received a uniform basal recommended dose of phosphorus @ 30 kg P_2O_5 ha^{-1} and potassium @ 30 kg K_2O ha^{-1} in the form of SSP and KCl, respectively.

The sixteen treatment combinations were replicated thrice in factorial randomized block design (RBD). There were total of 16x3=48 plots measuring 3.75x2.25 m^2 each net plot size. Number of total and effective tillers was recorded selecting randomly 10 plants from each plot. Yield parameters like ear length, number of grains per ear and test weight were also recorded at harvest. After threshing, the weight of sun dried harvested produce of each net plot was recorded separately. Grain and straw yield was recorded after threshing and winnowing.

RESULTS AND DISCUSSION

Yield parameters: Total number of tillers at tillering per meter row length increased with increasing levels of zinc but the difference were significant only under 5.0 and 7.5 kg Zn ha^{-1} as compared to control (Table 1). However, all the levels of zinc were statistically at par to each other. It can be attributed to higher availability of zinc to meet the demand of growing plants as the experimental soil was deficient in available zinc content (0.42 mg kg^{-1}). The results are in coronation with those obtained by Modiash *et al.*[6]. Application of 90 kg N ha^{-1} increased the total number of tillers at tillering stage significantly over control and 30 kg N ha^{-1}. However, it was at par with 60 kg N ha^{-1}. The application of 30 and 60 kg N ha^{-1} though at par to each other were also significantly better over control.

Application of 7.5 kg Zn ha^{-1} produced the maximum number of effective tillers which were significantly higher over control and 2.5 kg Zn ha^{-1} but at par with 5.0 kg Zn ha^{-1}. Significant increase in effective tillers/m in wheat with the application of 5 kg Zn ha^{-1} was also observed by Vyas and Choudhary[7]. It is evident from the data (Table 1) that application of 60 and 90 kg N ha^{-1} differ non-significantly from each other but significantly superior to control and 30 kg N ha^{-1} with regard to effective tillers at harvest (m^{-1} row length). The percent increase in ear length and number of grains per ear with the application of 7.5 kg ha^{-1} was observed to be 18.85 and 11.41 over control. Increase in the ear length with application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} was found to be significant over control, while significant increase in number of grains per ear and test weight was observed at 5.0 and 7.5 kg Zn ha^{-1} over control. This increase could be due to the fact that Zn plays an important role in regulating the auxin concentration in plants and is an essential component of enzymes which promotes the growth and development of plants. It may also be pointed out that growth and development of plants depend upon physiological and metabolic activity of plants influenced by application of zinc. These results are in line with the findings of Shukla[8].

The maximum ear length (6.64 cm), number of grains per ear (46.45) and test weight (48.52 g) were obtained with the application of 90 kg N ha^{-1} which was found to be at par with 60 kg N ha^{-1} but significantly superior over control and 30 kg N ha^{-1}. The reason for better growth and development of crop could be attributed to increased availability of nitrogen to plants. Further, nitrogen is an integral constituent of chlorophyll and imparts green colour to plants which captures more sunlight resulting in acceleration of photosynthetic rate. Thus, application of N was indirectly associated with higher manufacture of carbohydrates which might have led to enhance vegetative growth. Thus, the increased N supply brought forth a significant increase in number of tillers at tillering stage, effective tillers at harvest, number of grains per ear, ear length and test weight (Table 1). Similar results were obtained by Verma and Singh[9]. Combined application of Zn and N showed non significant increase in respect to yield attributes.

Grain and straw yield: Significant increase in grain and straw yield was observed with increasing levels of zinc upto 5.0 kg Zn ha^{-1}. Application of 7.5 kg Zn ha^{-1} produced the maximum grain and straw yield of 45.82 and 66.38 q ha^{-1}, representing significant increase of 31.63 and 28.57% over control, respectively (Table 2). However, 5.0 kg and 7.5 kg Zn ha^{-1} were at par with each other. These results are in close conformity with those obtained by Gupta *et al.*[10] and Vyas and Choudhary[7]. Grain and straw yield influenced significantly with 90 kg N ha^{-1} as compared to control and 30 kg N ha^{-1}. Application of 60 and 90 kg ha^{-1} were found to be at par with each other. Vyas and Choudhary[7] also observed similar results in wheat crop.

Table 1: Effect of Zinc and Nitrogen application on yield components of barley

Treatments	Tillers at tillering stage	Effective tiller at harvest	Ear lengths (cm)	Number of of grains per ear	Test weight* (g)
Zinc (kg ha^{-1})					
0	48.64	66.38	5.04	40.57	42.55
2.5	52.15	72.40	5.57	42.55	45.06
5.0	54.01	78.15	5.84	44.14	47.37
7.5	54.98	82.13	5.99	45.20	47.16
CD (P=0.05)	4.20	5.10	0.45	3.08	3.61
Nitrogen (kg ha^{-1})					
0	44.80	65.50	4.05	38.26	40.82
30	51.16	73.30	5.49	42.23	44.95
60	55.20	78.85	6.28	45.54	47.86
90	58.79	81.41	6.64	46.45	48.52
CD (P=0.05)	4.20	5.10	0.45	3.08	3.61

* weight of 1000 grains

Table 2: Effect of Zinc and Nitrogen application on grain and straw yield of barley

	Nitrogen (kg ha^{-1})				
Zinc (kg ha^{-1})	0	30	60	90	Mean
Grain yield (q ha^{-1})					
0	28.03	29.72	38.23	43.25	34.81
2.5	35.53	35.69	44.58	45.21	40.25
5.0	37.75	44.30	45.12	47.60	43.69
7.5	38.51	47.63	47.94	49.20	45.82
Mean	34.95	39.33	43.97	46.31	
Straw yield (q ha^{-1})					
0	44.02	49.45	55.28	57.76	51.63
2.5	49.18	54.81	61.79	64.82	57.65
5.0	54.62	60.73	67.78	71.44	63.64
7.5	58.19	64.20	70.54	72.60	66.38
Mean	51.50	57.30	63.84	66.65	
CD (P=0.05)	Zn	N	ZnxN		
Grain	2.45	2.45	4.90		
Straw	5.10	5.10	NS		

NS = non-significant

Application of zinc significantly influenced the grain and straw yield of barley since zinc had beneficial effect on the yield contributing characteristics. Also, increase in Zn absorption and availability of N provide balanced nutritional environment to the plants.

The combined application of Zn and N significantly increased the grain yield only (Table 2). Maximum grain yield of 49.2 q ha^{-1} was obtained with 7.5 kg Zn plus 90 kg N ha^{-1} which was 21.17 q ha^{-1} additional over control. This might be ascribed to beneficial effect of Zn application on N availability, possibly as a result of activation of physiological process because zinc acts as a co-enzyme and /or catalyst. Similar results were obtained by Mathur and Lal[11].

The study concludes that judicious use of zinc and nitrogen in barley grown on coarse textured soils can result in better crop production in a economic and sustainable way.

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