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DIFFERENTIAL RESPONSE OF WHEAT CULTIVARS TO ZINC APPLICATION IN ALLUVIAL SOIL

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ABSTRACT

In a field experiment on an alluvial soil the effect of zinc was studied on wheat cultivars during rabi season of 2008-10 at Bichpuri (Agra). Zinc was applied at the rate of 0, 2.5, 5.0 and 10 kg ha^{-1}. Application of Zn up to 5 kg ha^{-1} significantly increased the grain and straw production whereas at 10 kg Zn ha^{-1} level the yields tended to decrease. The magnitude of response differed from cultivar to cultivar. Wheat cultivar UP2425 recorded average higher grain (51.50 q ha^{-1}) and straw yield (61.68 qha^{-1}) and lowest in HD 2009 (47.10 and 56.40 q ha^{-1}). Significantly higher protein content (13.34%) and protein yield (687.5 kg ha^{-1}) were recorded in wheat cultivar UP2425. Protein content (13.09%) and yield (593.6 kg ha^{-1}) at control increased to 13.4% and protein yield (676.7 kg ha^{-1}) at 10 kg Zn ha^{-1}. Zinc application progressively increased the uptake of N and P up to 5 kg and Zn uptake upto 10 kg Zn ha^{-1}. The maximum N, P and Zn removal was recorded in wheat cultivar UP2425.Application of 5 kg Zn ha^{-1} recorded the highest net return (Rs. 50880 ha-1) and B:C ratio (2.80). Wheat cultivar UP 2425 produced the highest net return (RS. 50937 ha^{-1}) and B:C ratio (2.81).

Keywords: Response, cultivars, zinc, yield, quality, net return, wheat, alluvial Soil.

INTRODUCTION

Wheat (*Triticum aestivum*) is an important cereal crop in Indian and occupies a prominent position on account of its manifold uses in daily life. The production and productivity of wheat are not sufficient, which can be improved through micro nutrient fertilization. Zinc is considered as the most important nutrient for the crops in Indian soils. It deficiency is wide spread in the soils of high pH, low organic matter, calcareous, sand, ill drained and sodic in nature. Cereal crops have relatively higher zinc requirement. Genotypic differences exist in sensitivity to zinc deficiency. Response to Zn application has been observed on many field crops grown on Zn deficient soils (Sinha *et al.* 1997, Singh *et al.* 2010) and the magnitude of response to Zn differs widely among the genotypes of the same crop. Zinc catalyzes the processes of oxidation in plant cells and is vital for the transformation of carbohydrates, regulates the consumption of sugar, increases the source of energy for the production of chlorophyll, aids in formation of auxins, the growth promoting compounds; promotes the absorption of water and in doing so prevents stunting. It acts as a component of the enzyme carbonic anhydrase, which is a catalyst that serves to decompose carbonic acid to CO_2 and H_2O and is necessary for the formation of the amino acid tryptophan, itself involved in the elaboration of indole acetic acid (IAA) hormone. Zinc deficient soils have a major economic impact on the farmers due to the reduced income as a result of lower yield. As there was no information available on the response of wheat genotypes to Zn application in light textured soils, an investigation was initiated to study the response of wheat cultivars to zinc application.

MATERIALS AND METHODS

The experiment was conducted under field condition during rabi season of 2008-09 and 2009-10 at the research farm, R.B.S. College, Bichpuri, Agra. There were sixteen treatment combinations having four wheat varieties (Raj 3765, UP.-2338, UP.2425, HD.2009) and four levels of zinc (0, 2.5, 5.0 and 10.0 kg Zn ha^{-1}) in randomized block design with three replications. The soil of the experimental plot 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}, Zn 0.53 mg kg^{-1}. Zinc was applied through zinc sulphate at the time of sowing. Recommended dose of NPK (150, 60, 40 kg ha^{-1}) were applied through urea, diammonium phosphate and muriate of potash, respectively. Full dose of phosphorus and potassium and half dose of nitrogen was applied as basal i.e. before sowing and remaining half dose of N was topdressed in two splits at first and second irrigation. The seeds of wheat genotypes were sown in lines at 20 cm apart using a uniform seed rate of 125 kg ha^{-1} in the first week of November during both the years. The cultivars were harvested and yield was recorded. Nitrogen content in grain and straw was determined by modified Kjeldahl method (Jackson, 1973). The grain and straw samples were digested in di acid mixture (HNO_3: $HClO_4$) for P and Zn estimation. Phosphorus was determined by molybdovanadate yellow colour method and zinc by atomic absorption spectrophotometer. Nutrient uptake in grain and straw was worked out by multiplying the yield with nutrients content. The economics was computed using the prices of inputs and outputs as per prevailing market rates.

RESULTS AND DISCUSSION

Wheat cultivar UP2425 recorded average higher grain (51.50 qha^{-1}) and straw yield (61.68qha^{-1}) as compared to other wheat varieties which was 9.3% and 9.4% higher over cultivar HD. 2009 (Table 1). Among four wheat cultivars, two cultivars namely UP2338 (48.62 q ha^{-1}) and Raj 3765 (48.0 q ha^{-1}) were found statistically at par in terms of grain yield. The wheat cultivar HD.2009 recorded minimum grain yield (47.10 q ha^{-1}) as compared to other cultivars. On the basis of grain yield response, the wheat cultivars may be arranged as UP2425> UP2338> Raj3765> HD 2009. The variable response to wheat genotypes may be related to their Zn absorption capacity and its translocation to tops and also due to differences in their root CEC. Efficient Zn utilizer genotypes have higher root CEC than in efficient ones as reported by Sinha *et al.* (1997) in pea cultivars.

Table 1: Effect of zinc levels on grain and straw yield of wheat cultivars (mean of 2 years)

Treatments	Yield (q ha^{-1})		Protein in grain (%)	Protein yield in grain (kg ha^{-1})	Net return (Rs ha^{-1})	(B:C) ratio
	Grain	Straw				
Cultivars						
Raj3765	48.00	57.47	13.15	631.0	46218	2.55
UP2338	48.62	58.24	13.28	644.2	47082	2.59
UP2425	51.50	61.68	13.34	687.5	50937	2.81
HD 2009	47.10	56.40	13.22	621.6	45028	2.48
CD (P=0.05)	1.90	2.08	0.12	15.33		
Zinc (kg ha^{-1})						
0	45.31	53.92	13.09	593.65	42705	2.38
2.5	48.01	57.61	13.18	631.30	46332	2.57
5.0	51.39	62.17	13.28	678.30	50880	2.80
10.0	50.50	60.09	13.40	676.75	49349	2.70
CD(P=0.05)	1.90	2.08	0.12	15.33		

The differential behavior of wheat genotypes in the present investigation is similar to the findings of Sinha *et al.* (1997) with respect to lentil varieties. Sharma and Singh (2012) and Mukherjee (2012) also reported similar results in wheat genotypes. The grain and straw yield of the wheat cultivars increased significantly over control with zinc application up to 5 kg Zn ha^{-1}, beyond which the declining trend was observed at 10 kg Zn ha^{-1} application (Table 2). Varshney et al (2008) and Khare and Dixit (2011) reported similar results. Highest average grain yield (51.39 q ha^{-1}) was recorded with 5 kg Zn ha^{-1}, while lowest grain yield (45.31 q ha^{-1}) in control treatment. The percent increases in grain yields of UP2338 and UP2425 due to 2.5, 5 and 10 kg Zn ha^{-1} over control were 5.8 and 6.0, 12.9 and 13.4 and 11.7 and 10.3%, respectively. Thus, zinc application brought about a significant improvement in grain yield of wheat cultivars but the magnitude of increase varied appreciably. Application of 2.5 kg Zn ha^{-1}, on an average, increased the grain yields by 5.7, 5.9, 6.0 and 6.0 percent in Raj 3765, UP2338, UP2425 and HD 2009, respectively. The corresponding increases with 5 and 10 kg Zn ha^{-1} were 14.3 and 12.6, 13.2 and 11.7, 13.9 and 10.5 and 12.0 and 10.9 percent. From these figures, it may be concluded that Raj 3765 showed the higher response under different levels (2.5, 5 and 10 kg ha^{-1}) of Zn addition followed by UP 2338, UP 2425 and HD 2009. Differential responses of various cultivars to added Zn have also been reported by Sharma *et al.* (1992) and Shivay and Prasad (2013). The interactive effect of cultivars and zinc levels on grain and straw yield was significant (Table 2) and maximum grain and straw yield were produced by UP 2425 with 5 kg Zn ha^{-1} application.

Protein yield

Data revealed that the maximum protein yields (687.5 kg ha^{-1}), were recorded in wheat cultivar UP 2425 followed by UP2338, Raj 3765 and HD 2009. On the other hand, wheat cultivar HD 2009 produced the lowest protein in its grain. The lower yield of protein may be attributed to lower grain yield and protein content in wheat cultivar HD 2009. Protein yield in grain of wheat cultivars was significantly affected due to zinc application. The protein yield increased from 593.6 kg ha^{-1} at control to 678.3 kg ha^{-1} with 5 kg Zn ha^{-1}. Protein yield reduced at 10 kg Zn ha^{-1} over 5 kg Zn ha^{-1}. Similar results were reported by Singh *et al.* (2010).

Table 2: Interactive effect of Zn and cultivars on yield of wheat

Zn (Kg ha^{-1})	Wheat Cultivars Raj 3765	UP2338	UP2425	HD2009
	Grain yield (q ha^{-1})			
0	44.35	45.15	47.86	43.91
2.5	46.90	47.83	50.75	46.56
5.0	50.72	51.10	54.53	49.20
10.0	49.98	50.44	52.89	48.72
CD(P=0.05)	3.80			
	Straw yield (q ha^{-1})			
0	52.78	53.72	56.95	52.24
2.5	56.28	57.40	60.90	55.87
5.0	61.37	61.82	65.98	59.53
10.0	59.47	60.02	62.94	57.97
CD(P=0.05)	4.16			

Economics

An examination of the data presented in table 1 clearly indicated that maximum net returns of (Rs. 50937 ha^{-1}) were obtained in UP 2425. On the other hand, minimum net returns were obtained in HD 2009 (Rs 45028 ha^{-1}). The maximum and minimum B:C ratios were obtained in UP2425 and HD 2009, respectively. The highest net returns of Rs 50850 ha^{-1} was obtained from 5 kg Zn ha^{-1}. The 10 kg Zn ha^{-1} proved as second best fetching the net return of Rs.44349 ha^{-1}. In the light of this, it can be argued that more grain and straw yield with these treatments may be reason for the resultant profits. The income per rupee spent (B/C ratio) was highest (Rs. 2.80) with 5 kg Zn ha^{-1}. It is due to more net return (Rs ha^{-1}) than cost of cultivation involved with this treatment. The second best treatment assessed to be 2.5 kg Zn ha^{-1} followed by 10 kg Zn ha^{-1}. The B/C ratio was minimum due to no Zn fertilization Singh *et al.* (2010) reported similar results.

Table 3: Uptake of nutrients as affected by Zn levels and wheat cultivar

Treatments	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Zinc (g ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
Cultivars						
Raj3765	101.1	32.7	12.9	6.5	166.4	146.8
UP2338	103.3	33.9	13.7	7.4	166.2	147.4
UP2425	110.0	36.7	13.5	6.8	179.1	159.2
HD2009	99.6	31.7	12.8	6.4	161.7	144.6
CD(P=0.05)	2.28	0.77	0.49	0.57	0.77	0.52
Zinc (kg ha^{-1})						
0	95.1	30.0	12.9	6.7	136.7	119.0
2.5	101.4	32.7	13.2	6.9	157.4	137.6
5.0	109.4	36.3	13.6	6.5	182.8	167.2
10.0	108.1	35.8	13.2	6.4	196.5	174.4
CD(P=0.05)	2.28	0.77	0.49	0.57	0.77	0.52

Uptake Studies

The N uptake data (Table 3) indicate that the cultivar UP2425 removed significantly higher amount of nitrogen from the soil over other wheat cultivars. The minimum amount of nitrogen was utilized by cultivar HD2009. All the four cultivars differed in respect of nitrogen uptake by their grain and straw. On an average the N uptake in grain of cultivars Raj 3765, UP 2338, UP 2425 and HD 2009 was 101.1, 103.3, 110.0 and 99.6 kg ha^{-1}, respectively. The corresponding average values for straw were 32.7, 33.9, 36.7 and 31.7 kg N ha^{-1}. The differences in N uptake by various wheat cultivars may be due to variation in their production capacity of grain and straw. A consistent increase in N uptake by grain and straw of the cultivars was recorded up to 5 kg Zn ha^{-1} application. The nitrogen uptake by grain increased from 95.1 kg ha^{-1} at control to 109.4 kg ha^{-1} at 5 kg Zn ha^{-1}. Similar trend in nitrogen uptake was noted in wheat straw in both crop seasons. Higher values of N uptake with levels of zinc addition are apparently the result of higher yield and nitrogen absorption by wheat cultivars. Similar results were reported by Arya and Singh (2000) and Singh *et al.* (2010). The results reveal that the UP2425 and UP2338 utilized the higher amounts of phosphorus than those of other cultivars. This may be due to both higher yield and higher P concentration in wheat grain and straw of these two cultivars. The lower values of phosphorus uptake by Raj 3765 may be ascribed to lower grain and straw production. An increase in P uptake by grain and straw was noted with lower level of zinc. Application of 10 kg Zn ha^{-1} tended to reduce the P uptake by wheat grain and straw over 5 kg Zn ha^{-1}. The results indicate an antagonistic effect of zinc level (10 kg Zn ha^{-1}) on P utilization by the crop. Similar trend of reduction in P uptake was recorded in straw. The changes in P uptake brought about by higher levels of zinc were more pronounced and significant. These results are in agreement with the findings of Singh *et al.* (2004).

Wheat cultivar UP2425 removed relatively more amount of zinc in its grain and straw over other cultivars. On the other hand, the minimum amount of zinc was utilized by HD 2009 cultivar. The uptake of zinc by grain and straw of wheat cultivars increased with Zn application at different levels over control due to increase in grain and straw yields and zinc concentration in plants. The zinc uptake by grain increased from 136.7 to 196.5 g ha^{-1} with 10 kg Zn ha^{-1}. The corresponding increase in zinc uptake by straw was from 119.0 to 174.4 g ha^{-1}. Similar trend was reported by Dwivedi *et al.* (2002) in various cultivars. The magnitude of increase in zinc uptake was higher at higher levels of zinc as compared to lower levels. Similar results were reported by Singh *et al.* (2010).

On the basis of the above results, it may be inferred that to get maximum return (Rs ha^{-1}) and benefit: cost ratio from the cultivars under study, the cultivars should be grown with 5 kg Zn ha^{-1} by the farmers of Agra region under existing agro climatic conditions,.

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