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IMPACT OF Zn APPLICATION ON YIELD, QUALITY, NUTRIENTS UPTAKE AND SOIL FERTILITY IN A MEDIUM DEEP BLACK SOIL (VERTISOL)

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Abstract: A field investigation was conducted during winter (*rabi*) season 2010-11 and 2011-12 in Vertisol to study the response of wheat yield, nutrient uptake, protein content and effect on soil properties to zinc application. The recommended doses of N, P and K were applied @ 120 N: 60 P_2O_5: 40 K_2O kg ha^{-1} in combination with Zn @ 0, 1.25, 2.50, 5, 10 and 20 kg ha^{-1} as zinc sulphate at the time of sowing in all the treatments. Pooled analysis of data revealed that yield, harvest index, nutrient (N, K and Zn) uptake and quality increased significantly with the application of recommended NPK+Zn @ 20 kg ha^{-1} by wheat as compare to NPK alone. In general, yield, harvest index, total nutrient uptake and quality increased up to highest level of Zn, except total P uptake. The maximum yield (grain-4.66 and straw-5.44 kg ha^{-1}), harvest index (46.07), total nutrient uptake (N-123.19 kg ha^{-1}, K-90.86 kg ha^{-1} and Zn-327.74 g ha^{-1}), total carbohydrate (70.37 per cent) and gluten (12.37 per cent) content was achieved by the application of 20 kg Zn ha^{-1} with recommended NPK as compare to control and other treatments, while the total P uptake was decline with increasing levels Zn. There is no appraisal change in soil pH, EC, organic carbon and $CaCO_3$, but the status of DTPA-extractable Zn of soil was improved remarkably due to rational Zn fertilization combined with recommended NPK.
Key words: Zinc, yield, nutrient uptake, quality, wheat, soil properties, Vertisol.

Introduction

Wheat (*Triticum aestivum L.)* is an important cereal crop, source of staple food and thus the most important crop in food security prospective. India occupies second position next to China in the world with regard to area (27.7 million hectares) and production (77.6 million tonnes) of wheat. It is the second most important food grain crop in India ranking next to rice (*Oryza sativa L.*) contributing about 35% of the food grain production. India is now one of the major world's importers of wheat. Besides its tremendous significance, average yield is far below than developed countries (FAO, 2010), although the genetic potential of local varieties is not less than any country in the region. Nutrient deficiency is one of the important yield limiting factors includes delayed sowing, high weeds infestations, water shortage at critical growth stages,

intensive cultivation and imbalance and non-judicious fertilizers use. The universal deficiency of nitrogen and phosphorus is followed by Zn deficiency. Almost 50% of the world soils used for cereal production is Zn deficient (Gibbson, 2006).

Zn is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory co-factor of a large number of enzymes (Grotz and Guerinot, 2006). The main factors which affect the amount of zinc in soil are pH, carbonate content, organic matter, soil texture and interaction between zinc and other microelements, such as iron (Bukvic et al., 2003). Zinc is important to membrane integrity and phytochrome activities (Shkoinik, 1984), Zinc is essential for the normal healthy growth and reproduction of plants and plays a key role as a structural constituent or regulatory co-factor of a wide range of enzymes in many important biochemical pathways (Kabata and Pendias, 2001). Zinc fertilizers are used in the prevention of Zn deficiency and in the biofortification of cereal grains (Alloway, 2009). Keeping this in view, the present investigation was therefore conducted to evaluate the response of wheat to Zn fertilization.

Materials and methods

This research work was carried out on a *Typic Haplustert* at the Research Farm of Department of Soil Science and Agricultural Chemistry, J.N. Krishi Vishwa Vidyalaya, Jabalpur (M.P.) which lies between 23°10" N latitude and 79°57" E longitude, during the successive year. The experiment was laid out in randomized complete block design with four replications. The experimental soil (0-15 cm depth) was analyzed for initial soil physicochemical properties. Soil texture was clayey having the following characteristics: sand-25.3%, silt-17.90%, clay-56.8%, pH-7.2, O.C.-4.5 g kg^{-1}, $CaCO_3$-20.5 g kg^{-1}, EC-0.22 dS m^{-1}, available N 223.0-kg ha^{-1}, available P 18.9-kg ha^{-1}, available K-314.3 kg ha^{-1}, DTPA extractable Zn-0.66 mg kg^{-1}. Wheat GW-273 was sown during Rabi season, 2010-2011 and 2011-2012 on 15 and 20 December, respectively, with hand drill using seed rate 120 kg ha^{-1}. A basal dose of 60:60:40 N, P_2O_5, and K_2O was applied before sowing of wheat, through urea, super phosphate and muriate of potash fertilizers. Remaining 60 kg N was applied to wheat crop in two split doses during crop growth. The doses of Zn @ 0, 1.25, 2.50, 5, 10 and 20 kg ha^{-1} were given through zinc sulphate fertilizer before sowing of wheat alongwith basal dose of N, P_2O_5, and K_2O. All crop management and protection measures were followed. Weed control

practices were included physical method i.e., hoeing along with weedicides. The crop was harvested at maturity (120 days after sowing). Grain and straw yield were recorded and analysed for N, P, K and Zn content by adopting standard procedure for calculating the total nutrient uptake by wheat. Total carbohydrate and wet gluten content (%)of wheat grain were determined by A.O.A.C. (1965). The entire data was analysed statistically by using ANOVA.

Results and Discussion

Yield and harvest index

The pooled mean of two consecutive year in table 1 revealed that the grain (3.88 t ha^{-1}) and straw (4.76 t ha^{-1}) yield as well as harvest index (46.19 per cent) was observed in treatment consisting NPK+20 kg Zn ha^{-1}, which was significantly higher than the control at maturity stage. The treatment with 10 kg Zn ha^{-1} was statistically at par to 20 kg Zn ha^{-1} in grain (4.62 t ha^{-1}) and straw (5.42 t ha^{-1}) yield and harvest index (46.07 per cent). The lowest grain (3.88 t ha^{-1}) and straw (4.76 t ha^{-1}) yield as well as harvest index (44.97 per cent) was recorded in control. The treatments consisting 1.25, 2.50 and 5 kg Zn ha^{-1} which was at par with to control in grain and straw, respectively, whereas the harvest index was inferior insignificant with all the treatments. Generally, it was observed that the importance of Zn fertilization with recommended NPK in terms of yield (grain and straw) and harvest index profile assorted as:

Grain yield (t ha^{-1}): 3.88 > 3.93 > 4.04 > 4.429 > 4.62 > 4.66

Straw yield (t ha^{-1}): 4.76 > 4.81 > 4.88 > 5.09 > 5.42 > 5.44

Harvest index (%): 44.97 > 44.98 > 45.15 > 45.37 > 46.07 > 46.19

The increase in grain and straw yield as well as harvest index due to Zn fertilization might be the fact that Zn plays an important role in biosynthesis of the IAA and intiation of primodia for reproductive parts and a result of favourable effect of zinc on the metabolic reactions within the plants. The results are in close conformity with findings of Goswami (2007) and Singh et al. (2012) also reported that increasing levels of zinc increased wheat yield.

Total nutrient (N, P, K and Zn) uptake

The perusal of pooled mean data of two consecutive years (Table 1) showed that the increasing levels Zn application combined with recommended dose fertilizer (RDF) increase total N, K and Zn uptake by wheat over RDF alone, except total P uptake. The maximum

and significant total N (123.19 kg ha^{-1}), K (90.96 kg ha^{-1}) and Zn (327.74 g ha^{-1}) uptake, was recorded with treatment comprising application of 20 kg Zn ha^{-1} alongwith recommended dose of NPK, which was significantly higher than the control, except total P uptake. The treatment with application of 5 and 10 kg Zn ha^{-1} was at par to 20 kg Zn ha^{-1} on total N, K and Zn uptake, whereas the highest total P uptake (19.27 kg ha^{-1}) was recorded in control. The increase in total N, K and Zn uptake could be attributed to synergistic effect between N and Zn and due to the positive interaction of K and Zn, respectively. The present findings support the results of Ashoka et al. (2008), Morshedi and Farahbakhsh (2010). A linear decrease and non-significant result in total P uptake was noted with increasing levels of Zn application as compare to control. It might be due to antagonistic effect of P with Zn. Zn was found to inhabit the translocation of P from roots to the tops. Such types of finding were also reported by Alam et al. (2000). The minimal total N (88.68 kg ha^{-1}), K (64.75 kg ha^{-1}) and Zn (214.39 g ha^{-1}) uptake by wheat was recorded in control, which was statistically at par to the treatments with the application of 1.25 and 2.50 kg Zn ha^{-1} on total N, K and Zn uptake by wheat, while lowest total P uptake (18.71 kg ha^{-1}) was recorded in treatment with application of 1.25 kg ha^{-1} with recommended NPK.

Quality parameters

The quality of wheat viz. total carbohydrate and wet gluten depends on their inherent chemical compositions, which have a response function in various enzymatic activities in grain. The pooled mean of two consecutive years (Table 1) revealed that total carbohydrate and wet gluten content on wheat grain (70.37 and 12.37 per cent, respectively) was recorded with treatment comprising 20 kg Zn ha^{-1}, which was significantly higher than the control. The treatment with application of 2.50, 5 and 10 kg Zn ha^{-1} was at par to 20 kg Zn ha^{-1} on both total carbohydrate and wet gluten content on wheat grain. The minimal total carbohydrate and wet gluten content on wheat grain (60.01 and 10.05 per cent, respectively) was recorded in control, which was statistically at par to the treatments with the application of 1.25 kg Zn ha^{-1} on total carbohydrate and wet gluten content on wheat grain. This indicates that there is value to increase Zn level more than 1.25 kg ha^{-1} for obtaining high total carbohydrate and wet gluten, of grains. This might be due to Zn contributed in photosynthesis, chlorophyll, metabolism of starch formation and

enzyme carbonic anhydrase accelerating carbohydrate formation, the maximum requirements Zn were enough to accumulate suitable carbohydrate contents. It also activate glutamic dehydrogenase enzyme, synthesis of RNA and DNA enhancing gliadin and glutenin content, which are main protein components of gluten accumulated in the later stages of grain filling. The results are in conformity with the findings of Singh et al. (2002), Seadh et al. (2009) and Soleymani et al. (2012)

Soil properties

The two years pooled values pertaining to soil properties of Vertisol after harvesting of wheat viz. pH, EC OC $CaCO_3$ and DTPA-Zn status are present in table-2. A perusal values indicate that the effect of different increasing Zn fertilizers treatments @ 1.25, 2.50, 5, 10 and 20 kg ha^{-1} on soil chemical parameters, which was neutral and non-saline condition. Soil was medium in organic carbon content and non-calcareous in respect to $CaCO_3$ content. The significant and highest DTPA-Zn status (0.97 mg kg^{-1}) of soil was recorded with the application of 20 kg Zn kg^{-1} alongwith RDF. The treatment comprising Zn fertilization @ 10 kg ha^{-1} was at par with 20 kg Zn kg^{-1} alongwith RDF. The minimal DTPA-Zn (0.82 mg kg^{-1}) was found in control i.e. application of NPK alone, which was at par with the application of Zn fertilizer @ 1.25, 2.50 and 5 kg ha^{-1} alongwith RDF. These findings are in close conformity with the findings of Rathod et al. (2012) and Prasad et al., (2010)

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Table 1 Effect of Zn application on yield, harvest index, total nutrient (N, P, K and Zn) uptake by wheat in Vertisol (Pooled data of two year)

Levels of Zn (kg ha^{-1})	**Yield** (kg ha^{-1})		**Harvest index** (%)	**Total uptake** (kg ha^{-1})			**Total Zn uptake** (g ha^{-1})	**Total Carbohydrate** (%)	**Wet gluten** (%)
	Grain	**Straw**		**N**	**P**	**K**			
0	3.88	4.76	44.97	88.68	19.27	64.75	214.39	60.01	10.05
1.25	3.93	4.81	44.98	90.88	18.71	66.17	222.70	61.15	10.30
2.50	4.04	4.88	45.15	97.55	18.86	71.22	246.19	64.37	10.93
5.00	4.24	5.09	45.37	106.39	19.15	77.45	271.56	65.60	11.89
10.00	4.62	5.42	46.19	115.22	19.25	84.64	295.93	69.20	12.19
20.00	4.66	5.44	46.07	123.19	19.18	90.96	327.74	70.37	12.37
Mean	4.23	5.06	45.45	103.65	19.07	75.86	263.08	65.12	11.28
C.D. (5%)	0.45	0.56	1.70	12.52	NS	9.14	35.33	4.35	0.86

Table 2 Effect of Zn application on soil properties of Vertisol after harvesting of wheat (Pooled data of two year)

Levels of Zn (kg ha^{-1})	**Soil properties parameters**				
	pH	**EC** (dSm^{-1})	**OC** (%)	**$CaCO_3$** (%)	**DTPA-Zn** (mg kg^{-1})
0	6.98	0.23	0.63	2.00	0.82
1.25	6.90	0.19	0.68	1.63	0.83
2.50	7.03	0.21	0.69	1.75	0.84
5.00	7.03	0.23	0.67	1.63	0.87
10.00	6.90	0.22	0.65	1.88	0.93
20.00	7.05	0.23	0.70	1.88	0.97
Mean	6.98	0.21	0.67	1.79	0.88
C.D. (5%)	NS	NS	NS	NS	0.06

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