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Response of Zinc Fertilization to Wheat on Yield, Quality, Nutrients Uptake and Soil Fertility Grown In a Zinc Deficient Soil

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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, 5.00, 10.00 and 20.00 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 @ 20.00 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 t 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%) and gluten (12.37%) content was achieved by the application of 20.00 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.

Keywords: Zinc deficiency, Wheat, Nutrient uptake, Soil properties**.**

1. 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 [1], 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 [2].

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 in many important biochemical pathways and essential for the normal healthy growth [3]. 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 [4]. Zinc is important to membrane integrity and phytochrome activities [5]. Zinc fertilizers are used in the prevention of Zn deficiency and in the biofortification of cereal grains [6]. Keeping this in view, the present investigation was therefore conducted to evaluate the response of wheat to Zn fertilization.

2. Materials and methods

This research work was carried out on a *Typic Haplustert* at the Research Farm of Department of Soil Science and

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Agricultural Chemistry, J. N. Krishi Vishwa Vidyalaya, Jabalpur (M.P.) which lies between 23^{o}10" N latitude and 79^{o}57" E longitude, during the successive years 2011 and 2012. 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 physico-chemical properties by adopting standard laboratory procedure. The soil of the experimental site falls under Vertisol and belongs to Kheri-series of fine montmorillonite, Hyperthermic family of *Typic Haplusterts* popularly known as "medium black soil". The textural class of soil is clayey, neutral in reaction (pH-7.1), non-saline (EC-0.27 dS m^{-1}), non-calcareous (2.70%), medium in organic carbon content (0.63%), low in available nitrogen (217.5 kg ha^{-1}), medium in available P (18.5 kg ha^{-1}) and K (330.1 kg ha^{-1}) and deficient in DTPA-extractable Zn (0.54 mg kg^{-1}). Wheat (Var. GW-273) was sown during *rabi* season, 2010-11 and 2011-12 on 15th and 20th December, respectively, with hand drill using seed rate 120 kg ha^{-1}. A basal dose of 60 N: 60 P_2O_5: 40 K_2O kg ha^{-1} 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, 5.00, 10.00 and 20.00 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 analyzed for N, P, K and Zn content by adopting standard procedure for calculating the total nutrient uptake by wheat. Estimation of gluten content in grain was obtained by hand washing method [7]. Total carbohydrate content in grain was determined by Phenol sulphuric acid method [8]. The data generated from the present study were analyzed statistically and to draw suitable inference as per standard ANOVA technique [9].

3. Results and discussion

The results obtained from the present investigations as well as relevant discussion have been presented under following heads.

3.1. Yield and harvest index

The pooled mean of two consecutive years in Table 1 revealed that the maximum grain (4.66 t ha^{-1}) and straw (5.44 t ha^{-1}) yield as well as harvest index (46.19 per cent) were observed in treatment consisting NPK+20 kg Zn ha^{-1}, which was significantly higher than the control at maturity stage. The treatment with 10.00 kg Zn ha^{-}1 was statistically at par to 20.00 kg Zn ha^{-1} in grain (4.62 t ha^{-1}) and straw (5.42 t ha^{-1}) yield and harvest index (46.07). The lowest grain (3.88 t ha^{-1}) and straw (4.76 t ha^{-1}) yield as well as harvest index (44.97) were recorded in control. The treatments consisting 1.25, 2.50 and 5.00 kg Zn ha^{-1} which were 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 > 4.42 > 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 [10].

3.2. 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 were recorded with treatment comprising application of 20.00 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 5.00 and 10.00 kg Zn ha^{-1} was at par to 20.00 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 [11]. 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 [12]. 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.

3.3. 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 %, respectively) were recorded with treatment comprising 20.00 kg Zn ha^{-1}, which was significantly higher than the control. The treatment with application of 2.50, 5.00 and 10.00 kg Zn ha^{-1} were at par to 20.00 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 %, respectively) were 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 [13].

3.4. Post-harvest soil properties of experimental site

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, 5.00, 10.00 and 20.00 kg ha^{-1} on soil chemical parameters, which was neutral and non-saline condition. Soil was found to be 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 20.00 kg Zn kg^{-1} alongwith RDF. The treatment comprising Zn fertilization @ 10.00 kg ha^{-1} was at par with 20.00 kg Zn kg^{-1} alongwith RDF. Post-harvest soil properties of experimental site remain unchanged due to buffering capacity of soil. 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 5.00 kg ha^{-1} alongwith RDF [14].

4. Conclusion

The present studies indicated that the application of 10.00 and 20.00 kg Zn ha^{-1} alongwith recommended dose of NPK on wheat crop enhanced both grain and straw yields, total nutrients uptake (N, P, K and Zn) and quality like total carbohydrate and wet gluten of produce as well as maintained its chemical composition and restored soil fertility in terms of pH, EC, OC, $CaCO_3$ and DTPA-Zn status in a Zn-deficient soil.

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}) Grain*	*Straw*	*Harvest index*	*Total uptake (kg ha^{-1}) N*	*P*	*K*	*Total Zn uptake (g ha^{-1})*	*Total Carbohydrate (%)*	*Wet gluten (%)*
0 (Control)	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 (dS m^{-1})*	*OC (%)*	*$CaCO_3$ (%)*	*DTPA-Zn (mg kg^{-1})*
0 (Control)	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

List of Abbreviations

S. No.	*Abbreviations*	*Expansion*
1	N	Nitrogen
2	P	Phosphorus
3	K	Potassium
4	Zn	Zinc
5	kg ha^{-1}	Kilogram per hactare
6	g ha^{-1}	Gram per hactare
7	mg kg^{-1}	Miligram per kilogram
8	pH	Soil acidity
9	EC	Electrical conductivity
10	OC	Organic carbon
11	$CaCO_3$	Calcium carbonate
12	DTPA-Zn	Available Zinc

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Author Profile

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