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Efficacy of zinc on yield, economics and soil properties of wheat (*Triticum aestivum*) in black soil of central Gujarat

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ABSTRACT

A field trial was conducted during winter (*rabi*) season 2011 to 13 in vertisol to study the influence of zinc on yield, nutrient uptake, economics and soil properties of wheat. The recommended doses of N, P and K were applied @ 120 N: 60 P_2O_5: 40 K_2O kg/ha in combination with Zn @ 0, 1.25, 2.5, 5 and 10 kg/ha were applied at time of sowing in all the treatments. Results of study revealed that the yield, harvest index and nutrient uptake (N, K and Zn). Zinc increased significantly with the application of recommended N P K + Zn @ 10 kg/ha as compared to NPK alone and other doses of zinc. In general, yield, harvest index and total nutrient uptake, increased to the highest level of Zn, except total P uptake. The maximum yield (grain-44.37 and straw-50.74 kg/ha) and total nutrient uptake (N-117.23 kg/ha, K-85.90 kg/ha and Zn 286.41 g/ha), was recorded by the application of 10 kg Zn/ha along with recommended dose of NPK as compared to control. The total P uptake declined with increasing levels of Zn. There was no appraisal change in soil pH, EC, organic carbon and $CaCO_3$, but the status of DTPA-extractable Zn of soil was improved remarkably owing to Zn application with combination of recommended NPK. The economics the yield revealed that the FLD recorded higher gross returns (₹55625) and net return (₹32925) with higher benefit cost ratio (2.45) when compared to control. The impact of FLDs was analyzed and remarkable improvement of knowledge and satisfaction of farmers in terms of yield and revenue by dint of technological intervention.

Key words: Nutrient uptake, Soil properties, Vertisol, Wheat, Yield, Zinc

Wheat (*Triticum aestivum* L.) is an important cereal crop, source of staple food and thus it is 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 ha) and production (77.6 million tonnes) of wheat during the year. 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 one of the world's importers of wheat. Considering its tremendous significance, the average yield of wheat is far below than the developed countries (FAO 2010). However the genetic potential of improved varieties developed in our country is less than other major wheat producing countries. Nutrient deficiency is one of the limiting factors which includes delayed sowing, high weeds infestations, water shortage at critical growth stages, intensive cultivation and imbalance and non-judicious fertilizers use. The deficiency of nitrogen and phosphorus is followed by Zn deficiency. Almost 50% of soils used for cereal production are Zn deficient in the world (Gibbson 2006).

Zinc 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 (Aref 2012). The main factors which show the deficiency of Zn is soil pH, carbonate content, organic matter, soil texture and other microelements (Keram *et al*. 2012 and Khan *et al*. 2008). Zinc is important for membrane integrity and phytochrome activities (Efe and Yarpuz 2011 and Mehdi *et al.* 2012). 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 (Dadarwal *et al.* 2009). Zinc fertilizers are used to avoid Zn deficiency and in the biofortification of cereal grains (Alloway 2009). Keeping above facts in view, the present investigation was conducted to evaluate the response of zinc in wheat.

MATERIALS AND METHODS

To study the efficacy of zinc sulphate on soil properties, yield and economics of wheat in black cotton soil of central Gujarat was conducted during 2011-13. A total of 75 farmers' field of kalol taluka, Panchmahal district of Gujarat was scheduled under irrigated conditions. Throughout the experimentation, alone the mean annual rainfall was 658.8 mm and 810.8 mm during 2011-12 and 2012-13 first and second year, respectively. The soil of

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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)	Yield (q/ha)		Harvest index (%)	Total uptake (kg/ha)			Total Zn uptake (g/ha)
	Grain	Straw		N	P	K	
0.0	35.47	40.49	46.6	89.61	19.43	63.66	204.49
1.25	38.11	41.46	47.15	98.82	18.84	67.11	221.83
2.50	39.43	46.84	46.81	99.57	18.64	72.13	236.44
5.00	41.21	48.65	45.90	106.36	19.22	78.41	264.91
10.00	44.37	50.74	46.58	117.23	19.12	85.90	286.41
Mean	39.72	45.34	46.61	102.28	19.05	77.44	242.81
CD (P=0.05)	0.231	2.76	1.62	1.51	0.70	0.85	1.20

the different farmers field was black, having pH 6.92 to 8.20, electrical conductivity (EC) 0.29 to 0.38 dS/m, low in organic carbon content (0.98 to 1.6 %), low in available nitrogen (165 to 220 kg/ha), phosphorus (12.6 to 18.5 kg/ha), potassium (325 to 355 kg/ha), $CaCO_3$ (21.5 to 23.10 g/kg) and in DTPA extractable Zn (0.69 to 0.96 mg/kg) for 2010-11 and 2011-12, respectively. Wheat cv GW-496 was sown during *rabi* season by seed drill using seed rate 120 kg/ha. A basal dose of 60:60:40 N, P_2O_5, and K_2O was applied before sowing of wheat, in the form of urea, DAP and muriate of potash fertilizers. Remaining doses of N (60 kg) was applied to wheat crop in two split doses during crop growth. The doses of Zn @ 0, 1.25, 2.5, 5.0 and 10 kg/ha were given through zinc sulphate (agricultural grade) before sowing of wheat along with basal dose of N, P_2O_5, and K_2O. All cultural practices and protection measures were followed uniformly. Weeds were controlled through hoeing along with weedicides. The crop was harvested at maturity after 120 days of 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.

Technology gap = Potential yield – Demonstration yield

$$\text{Technology index} = \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100$$

Knowledge level of the farmers was measured and compared before and after implementation of FLD by applying dependent't' test. Further, the satisfaction level of respondent farmers about extension services provided was also measured for overall impact of FLDs.

The selected respondents were interviewed personally with the help of a pre-tested and well structured interview schedule. Client Satisfaction Index was calculated as developed by Kumaran and Vijayaragavan (2005). Harvest index was calculated by using the following formula:

$$\text{Client satisfaction index} = \frac{\text{The individual obtained score}}{\text{Maximum score possible}}$$

$$\text{H.I.} = \frac{\text{Grain yield (q/ha)}}{\text{Biological yield (q/ha)}} \times 100$$

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The two year pooled data were tabulated and statistically analyzed to interpret the results.

RESULTS AND DISCUSSION

Soil properties

A perusal values depicted in Table 2 indicate that the effect of different doses of Zn fertilizers applied @ 1.25, 2.50, 5 and 10 kg/ha could not exist significant difference most of the soil properties. However the higher DTPA-Zn status (0.95 mg/kg) of soil was recorded significantly with the application of 10 kg Zn/kg along with RDF. The treatment four Zn @ 5 kg/ha was at par with 10 kg Zn/kg along with RDF. The minimal DTPA-Zn (0.84 mg/kg) was found in control and showed parity with the application of Zn 1.25 and 2.50 kg/ha along with RDF. These findings are in close conformity with the results reported by of Rathod *et al*. (2012) and Prasad *et al*. (2010).

Yield and harvest index

The pooled mean of two consecutive year prepared in Table 1 revealed that the grain (44.37 q/ha), straw (50.47 q/ha) yield and harvest index (46.58 %) was observed in treatment consisting of NPK+10 kg Zn/ha, which was significantly

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)	Soil properties parameters							
	N (kg/ha)	P (kg/ha)	K (kg/ha)	pH	EC (dS/m)	OC (%)	$CaCO_3$ (%)	DTPA-Zn (mg/kg)
0.0	208.25	18.40	519.50	6.92	0.22	0.67	2.00	0.84
1.25	211.25	20.50	518.75	6.92	0.19	0.70	1.73	0.86
2.50	215.75	19.12	522.75	6.92	0.19	0.71	1.82	0.85
5.00	220.50	19.42	531.25	6.92	0.23	0.69	1.74	0.89
10.00	217.75	21.75	519.25	6.92	0.22	0.65	1.91	0.95
Mean	214.70	19.84	522.30	6.93	0.21	0.68	1.84	0.88
CD (5%)	3.65	0.57	2.32	0.18	0.012	0.021	0.099	0.029

higher than the control. The application of 5 kg Zn/ha was statistically at par to 10 kg Zn/ha in grain (41.21 q/ha) and straw (48.65 q/ha) yield and harvest index (45.90 per cent). The lowest grain (35.47 q/ha) and straw (40.49 q/ha) yield as well as harvest index (46.60 per cent) was recorded in control. The treatments consisting 1.25 and 2.50 kg Zn/ha could not reach the level of significance with to control in grain and straw yield, respectively, whereas the harvest index was could not rich the level of significance amongst all the treatments. Generally, it was observed that the importance of Zn application with recommended NPK in terms of yield (grain and straw) and harvest index profile assorted as.

The increase in grain and straw yield as well as harvest index due to Zn application might be the fact that the Zn plays an important role in biosynthesis of the IAA and initiation of primodia for reproductive parts and a result of favorable effect of zinc on the metabolic reactions within the plants. The results are in consonance 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) increased total N, K and Zn uptake by wheat over RDF alone, except total P uptake. The maximum total N (102.28 kg/ha), K (77.44 kg/ha) and Zn (242.81 g/ha) uptake was recorded 10 kg Zn/ha along with recommended dose of NPK, which was found to be significantly higher than the control, except total P uptake. The application of 2.5 and 5 kg Zn/ha was at par to 10 kg Zn/ha on total N, K and Zn uptake, whereas the highest total P uptake (19.43 kg/ha) was recorded in control. The increase in total N, K and Zn uptake could be attributed to synergistic effect between N and Zn and owing to the positive interaction of K and Zn, respectively. The present findings support the results of Ashoka *et al*. (2008), Morshedi and Farahbakhsh (2010) and Singh, M.K., *et al.* (2010). Whereas a linear decrease in total P uptake was noticed 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. Similar of finding were also reported by Aref, (2012), Keram, *et al.* (2012) and Dadarwal, *et al.* (2009). The minimum total N (89.61 kg/ha), K (63.66 kg/ha) and Zn (204.49 g/ha) uptake by wheat was recorded in control.

Economics

The economics of wheat production under front line demonstrations were estimated and the results have been presented in Table 3. Economic analysis of the yield performance revealed that front line demonstrations recorded higher gross returns (Rs. 55625.0/ha) and net return (Rs. 32925.0/ha) with higher benefit cost ratio (2.45) compared to control (44325, 23125 and 2.09) respectively. These results are in line with the findings of Hiremath *et al.* (2007), Hiremath and Nagaraju (2009) in potato and onion.

Table 3 Effect of Zinc on economics of wheat cultivation (Pooled data of two year).

Levels of Zn (kg/ha)	Cost of cultivation (₹/ha)	Yield (q/ha)	Gross income (₹/ha)	Net income (₹/ha)	B: C ratio
0.0	21200	35.47	44325.0	23125.0	2.09
1.25	22350	38.11	47650.0	25300.0	2.13
2.50	22425	39.43	49262.5	26837.5	2.19
5.00	22575	41.21	51487.5	28917.5	2.28
10.00	22700	44.37	55625.0	32925.0	2.45

Impact of intervention

Application of zinc @ 10 kg Zn/kg along with RDF recorded 2.00 q/ha higher yield in the demonstration as compression to control. The best potential yield comes from the demonstration field where all inputs are applied at optimum level. The technology gap may be attributed due to dissimilarities in soil fertility, salinity and erratic rainfall and other vagaries of weather conditions in the area. Hence, to narrow down the gap between the yields of different Zn level, location specific recommendation appears to be necessary. Technology index shows the feasibility of the zinc level at the farmer's field. The lower the value of technology index more is the feasibility. The data presented in Table-4 revealed the technology index values 4.3 %. The finding of the present study is in agreement with the findings of Hiremath and Nagaraju (2009) in case of onion.

Farmers' satisfaction

The extent of satisfaction level of respondent farmers over extension services and performance of demonstrated technology was measured by Client Satisfaction Index (CSI) and results presented in Table 5. It reveals from Table-5 that the majority of the respondent farmers expressed

Table 4 Yield, technology gap and technology index of demonstration

Variables	Yield (q/ha)	Increase (%) over the control	Technology gap (q/ha)	Technology index (%)
0.0	35.47			
1.25	38.11	7.50	8.38	18.02
2.50	39.43	11.13	7.09	15.24
5.00	41.21	16.15	5.31	11.49
10.00	44.37	25.49	2.0	4.30

Table 5 Extent of farmers satisfaction of extension services rendered (n=75)

Satisfaction	level Number	Per cent
Low	12	16
Medium	39	52
High	24	32

medium (52 %) and high (32%) level of satisfaction for extension services and performance of technology under demonstrations. Whereas, 16 per cent of respondents expressed lower level of satisfaction. The results are in conformity with the results of Khan *et al.* (2008) and Kumaran and Vijayaragavan (2005) in case of bajra crop. The medium to higher level of satisfaction with respect to services rendered, linkage with farmers and technologies demonstrated etc. indicate stronger conviction, physical and mental involvement in the demonstration which in turn would lead to higher adoption. This shows the relevance of demonstration of proven technology.

REFERENCES

Alloway B J. 2009. Soil factors associated with zinc deficiency in crops and humans. Envi Geochem. and Health (DOI 10.1007/s10653-009-9255-4). 2002. Available from: <http://www.cropresearch.org>.Accessed: 12 May 2011.

Aref F. 2012. Effect of different zinc and boron application methods on leaf nitrogen, phosphorus and potassium concentrations in maize grown on zinc and boron deficient calcareous soils. *Journal of Soil and Nature* **6**(1): 1–10.

Ashoska, Mudalagiriyappa P and Desai B K. 2008. Effect of micronutrients with or without orgaic manures on yield of baby corn-chickpea sequence. *Karnataka Journal of Agricultural Science* **21**(4): 485–7.

FAO. 2010. Scaling soil nutrient balances: Enabling meso-level applications for African realities fertilizer and plant nutrition. Bulletin 15, Rome.

Dadarwal R S, Jain N K and Singh D. 2009. Integrated nutrient management in baby corn (*Zea mays*). *Indian Journal of Agricultural Sciences* **79**(12): 1023–5.

Efe L and Yarpuz E. 2011. The effect of zinc application methods on seed cotton yield, lint and seed quality of cotton (*Gossypium hirsutum* L.) in east Mediterranean region of Turkey. *African Journal of Biotechnology* **10:** 8782–9.

Gibbson R S. 2006. Zinc: the missing link in combating micronutrient malnutrition in developing countries. *Proceedings of the Nutrition Society*, University of East Anglia, Norwich, 28 June - 1 July, 2005.

Goswami. 2007 Response of wheat (*Triticum aestivum*) to nitrogen and zinc application. *Annals of Agricultural Research* New Series **28**(1): 90–1.

Hiremath S M and Nagaraju M V. 2009. Evaluation of front line demonstration trials on onion in Haveri district of Karnataka. *Karnataka Journal of Agricultural Science* **22**(5): 1092–3.

Hiremath S M, Nagaraju M V and Shashidhar K K. 2007. Impact of front line demonstrations on onion productivity in farmers field. Paper presented in Nation Sem Appropriate Extn Strat Manag Rural Resources, University of Agricultural Science, Dharwad, 18-20, December, p 100.

Keram K S, Sharma B L and Sawarkar S D 2012. Impact of Zn application on yield, quality, nutrients uptake and soil fertility in a medium deep black soil (vertisol). *International Journal of Science, Environment and Technology* **1(5):** 563–71.

Khan M A, Fuller M P and Baluch F S. 2008. Effect of soil Applied zinc sulphate on wheat (*Triticum aestivum* L.) grown on a calcareous soil in Pakistan. *Cereal Research Communication* **36:** 571–82.

Kumaran M and Vijayaragavan K. 2005. Farmers' satisfaction of agricultural extension services in an irrigation command area. *Indian Journal of Extension Education* **41**(3&4): 8–12.

Morshedi A and Farahbakhsh H. 2010. Effects of potassium and zinc on grain protein contents and yield of two wheat genotypes under soil and water salinity and alkalinity stresses. Plant Ecophysiology **2:** 67–72.

Mehdi S S, Husain B and Singh L. 2012. Influence of seed rate, nitrogen and zinc on fodder maize (*Zea mays*) in temperate conditions of western Himalayas. *Indian Journal of Agronomy* **57**(1): 85–8.

Prasad R K, Kumar V, Prasad B and Singh A P 2010. Long-term effect of crop residue and zinc fertilizer on crop yield, nutrient uptake and fertility built-up under rice-wheat cropping system in calciortents. *Journal of Indian Society of Soil Science* **58**(2): 205–11.

Rathod D D, Meena M C and Patel K P. 2012. Evaluation of different zinc-enriched organics as source of zinc under wheat-maize (Fodder) cropping sequence on zinc-deficient Typic Haplustepts. *Journal of Indian Society of Soil Science* **60**(1): 50–5.

Singh O, Kumar S and Awanish. 2012. Productivity and profitability of rice as influence by high fertility leves and their residual effect on wheat. *Indian Journal of Agronomy* **57**(2): 143–7.

Singh M K, Singh R N, Singh S P, Yadav M K and Singh V K. 2010. Integrated nutrient management for higher yield, quality and profitability of baby corn (*Zea mays*). *Indian Journal of Agronomy* **55**(2): 100–4.