

Effect of zinc application methods on yield attributes, yield and nutrient uptake in wheat (*Triticum aestivum*) varieties under sodic soil

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season 2008–10 at Chandesar, Azamgarh, on a zinc (Zn)-deficient and salt affected soil, to elucidate the most effective and economical method of Zn application for wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] yield improvement in partially reclaimed sodic soils of eastern Uttar Pradesh. Eighteen treatments comprised 6 methods of Zn application, viz. control (no Zn), seed soaking with 0.5% ZnSO₄·7H₂O aqueous, seed soaking with 1.0% ZnSO₄·7H₂O (ZnSHH) aqueous, 20 and 30 kg/ha ZnSHH (basal) and foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days after sowing (2 sprays), and 3 wheat varieties, viz. 'NW 1012', 'PBW 343' and 'Malviya 468' were tested in factorial randomized block design with 3 replication. All the Zn application methods, increased the plant height, tillers/plant, grains/spike, spike length, test weight, grain yield, straw yield and nutrient uptake over the control (no Zn). Foliar spray of Zn sulphate (5 kg/ha hepta hydrate) resulted in 26% higher grain yield than the control. Overall performance of 'NW 1012' variety of wheat showed superiority to 'Malviya 468' and 'PBW 343'. Variety 'NW 1012' gave 6.0 and 3.8% higher grain yield over 'Malviya 468' and 'PBW 343', respectively. Foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days after sowing was most economical. These foliar zinc application on wheat crop recorded ₹21.54 ×10³/ha net returns along with 1.33 benefit: cost ratio.

Key words : Seed soaking, Soil sodicity, Urea, Varieties, Wheat, Zinc

Wheat is grown predominately in rice–wheat cropping system, and this system is considered backbone of food security in India, which is followed in 10.5 million ha area (Yadav and Kumar, 2009), which occupies 65 to 70% of the total cultivated area in eastern Uttar Pradesh owing to higher and assured productivity. This system exhausts the soil nutrients limiting crop production, especially for the high-yielding varieties. Intensive cropping also renders deficiency of micro-nutrients in addition to major nutrients in the soil. The farmer's perception of nutrient management until now has mostly been the use of major nutrients like N, P and K. The imbalance use of inorganic fertilizer, in the absence of organic sources of nutrients, has led to the micronutrient deficiency especially in rice and wheat restricting upward growth of productivity. During recent years, Zn deficiency has become up as one of the major problem in cultivation of cereals reducing crop yield and

at times leads to the virtual failure of the crops. This problem is more serious especially in salt-affected soils, which either of deficient in nutrients or nutrients gets fixed, thus become unavailable to plant. Salt-affected soils are spread over 13 million ha in India of which about 1.3 million ha exists in Uttar Pradesh alone. Correction of Zn deficiency through addition of Zn fertilizer is common practice. However, Zn application should be done cautiously to avoid soil and environmental pollution. High level of phosphorus and calcium in soil had adverse effect on the availability of Zn to plants. Among wheat species, durum wheat is more sensitive to Zn deficiency than the bread wheat possible due to higher root growth at the expense of shoot growth (Rengel and Graham, 1995). Enriching seeds with Zn at the time of maturity by foliar Zn feeding had better response on seed germination, growth and yield of succeeding wheat crop grown in calcareous soil. Zinc deficiency is a common feature in plant and human nutrition in developing country, especially with cereal based food habits. Zinc deficiency in human results in a number of health problems. Considering these points, the present study was under taken to elucidate the most effective and economical method of Zn application for wheat yield im-

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provement in partially reclaimed sodic soils of eastern Uttar Pradesh.

MATERIALS AND METHODS

A field experiment was conducted in winter season of 2008–09 and 2009–10 at the experimental farm of Shri Durga Ji Post-Graduate College Chandesar, Azamgarh, Uttar Pradesh, which is located in the Gangetic alluvium of eastern Uttar Pradesh at 26.04°N and 83.11°E at an elevation of 77.36 m above mean sea-level. The soil was sandy loam, alkaline (pH 8.8) with electrical conductivity EC 0.45 dS/m, low in initial available N (132.5 kg/ha), medium in available phosphorus (18.3 kg P/ha), high in available potassium (241 kg K/ha), low in organic carbon (0.38%) and low available Zn 0.11 mg/kg soil. The treatments consisting of 3 wheat varieties ('NW 1012', 'PBW 343' and 'Malviya 468') were sown in main plots and 6 methods of Zn application [control (no Zn), seed soaking with 0.5% ZnSHH aqueous, seed soaking with 1.0% ZnSHH aqueous, 20 kg/ha ZnSHH (basal), 30 kg/ha ZnSHH (basal) and foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days after sowing (2 sprays), were applied in sub-plots of factorial randomized block design with 3 replications. Wheat was sown after the harvesting of rice in the third week of December during both the years at the spacing of 21 cm apart at the depth of 3–4 cm with the seed rate of 100 kg/ha. A uniform application of N, P₂O₅ and K₂O was applied @ 120:60:60 kg/ha through urea, diammonium phosphate and muriate of potash, respectively. Half dose of N and full dose of P₂O₅ and K₂O were drilled basally at the time of sowing and remaining dose of N was applied in 2 equal splits as top-dressing 25 and 50 days after sowing. Full dose of ZnSHH those applying in soil as per treatments (i.e. 20 and 30 kg/ha) was applied at the time of first ploughing as broadcasting. Seed soaking treatment with respective aqueous ZnSHH solutions was done for 6 hours after which the treated seeds were dried in shade for 24 hours at room temperature before sowing. Seed for control treatment were soaked with distilled water also for 6 hours. Crop was raised using recommended cultural practices during both the years. Economics was computed using prevailing costs of inputs and labour and returns were computed by grain price as 6,450/tonnes and straw price as 1,500/tonnes. After harvest, treatment-wise grain and straw samples were collected for N, P, K and Zn nutrient analysis and for nutrient uptake. Nitrogen was determined by micro Kjeldahl method, P was estimated in aliquot calorimetrically using vanadomolybdate yellow colour method, K was determined with flame photometer and Zn by atomic absorption spectrophotometer method. Total nutrient uptake (grain + straw) in wheat was determined

by multiplying the N, P, K and Zn concentration with corresponding grain and straw yields, respectively and expressed in kg/ha or g/ha.

RESULTS AND DISCUSSION

Yield attributes

Yield-attributing characters viz. plant height, tillers/plant, spike length, grains/spike and 1,000-grain weight, were positively affected by Zn application methods in all the varieties. All the varieties showed statistically almost similar in plant heights, whereas 'Malviya 468' produced taller than 'PBW 343' which was at par with 'NW 1012' during both the years. All the Zn-treated plots were significantly superior to untreated control plot (no Zn). Foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days after sowing gave the best response in terms of plant height (Table 1). However, 30 kg/ha ZnSHH (basal) produced tallest plant, which was significantly superior to all the Zn application methods and doses except foliar spray of 5 kg/ha ZnSHH (zinc sulphate) with 2% urea in 1,000 litres water at 25 and 50 days and seed soaking with 1.0% ZnSHH aqueous. 'Malviya 468' produced significantly greater number of effective tillers, and was significantly superior to variety 'NW 1012' and at par with 'PBW 343'. Zn application also influences the varietal performance for effective tillers/plant (Table 1). The lowest number of tillers was recorded from the untreated Zn plots, which was at par with seed soaking with 1.0% ZnSHH aqueous and foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days and highest recorded from basal soil application of 30 kg/ha ZnSHH. 'Malviya 468' produced the maximum spike length, being significantly superior to rest of the wheat varieties during both the years. All methods of Zn application treatments resulted in significantly higher spike length compared to the control (no Zn) (Table 1). Among the Zn application methods, 30 kg/ha ZnSHH (basal) was produced longest spike which was significantly longer over the rest Zn application methods. Wheat variety 'Malviya 468' produced significantly higher grains/spike than 'NW 1012' and 'PBW 343' (Table 1). Application of ZnSHH irrespective of the methods of application resulted in higher grains/spike relative to untreated control. Foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days resulted in significantly higher grains/spike than other method of Zn application except 30 kg/ha and seed soaking 1.0% ZnSHH solution. Highest 1,000-grain weight was recorded with 'PBW 343', which was statistically at par with 'NW 1012'. Zn application methods and doses also showed variability in 1,000-grains weight (Table 1). All the Zn treatments resulted in significantly higher 1,000-grains weight over the

control. The highest test weight was recorded under with soaking of seed in 1.0% ZnSHH during both the years, which was significantly superior to all the Zn-treated plots. Our findings confirm the findings of Singh *et al.* (2011) and Chaudhary *et al.* (2014).

Grain and straw yield

Grain and straw yields of wheat was significantly affected by various Zn application methods with respect to wheat varieties. Grain yield showed significant variation among the varieties during both the years. Wheat variety 'NW 1012' produced significantly higher grain yield than 'Malviya 468' and 'PBW 343' (Table 1). 'NW 1012' produced 6.0 and 4.0% higher grain yield than 'PBW 343' and 'Malviya 468', respectively. The differences between 'PBW 343' and 'Malviya 468' were statistically significant. With regards to Zn application methods and doses, foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days resulted in the maximum grain yield, which was significantly higher over rest of other Zn treatments and 26% higher grain yield over the control. The differences between 20 and 30 kg/ha ZnSHH application in soil as basal was statistically non-significant, indicating no beneficial effect of increasing level of ZnSHH. Pre-sowing seed soaking with ZnSHH treatments were also better than control but inferior to soil and foliar application of ZnSHH. The favourable influence of Zn application on the grain yield may be attributed to its role in various enzymic reactions, growth processes, hormone

production and protein synthesis and also the translocation of photosynthates to reproductive parts thereby leading to higher yield of the crop. Singh and Singh (2007), Singh *et al.* (2011) and Chaudhary *et al.* (2014) also reported similar results.

Among the varieties, 'Malviya 468' gave significantly higher straw yield, which was at par with 'NW 1012' and 2.9% higher over 'PBW 343'. Straw yield of 'NW 1012' was also significantly higher than 'PBW 343'. Application of ZnSHH from different methods significantly increased straw yield over the control. Best response was noted from seed soaking with 1.0% ZnSHH solution, which was significantly higher straw yield over rest of other Zn application method. All methods of Zn application were almost at par to each other except seed soaking with 1.0% ZnSHH aqueous.

'NW 1012' recorded the highest (39.7%) harvest index, which was significantly higher over the other two wheat varieties. All the Zn application methods and doses improved the harvest index. The highest harvest index was recorded with the 5 kg/ha foliar spray of ZnSHH with 2% urea at 25 and 50 days, which was significantly higher over all the Zn treatments and lowest from without Zn (Table 1).

Nutrient uptake

Total nutrient uptake by wheat (grain and straw) was influenced by ZnSHH application through different methods and doses. Total N, P, K and Zn uptake did not show

Table 1. Effect of Zn application methods and doses on yield attributes and yields of wheat varieties grown under sodic soil (pooled data of 2 years)

Treatment	Plant height (cm)	Tillers/plant	Spike length (cm)	Grains/spike	1,000-grain weight (g)	Grain yield (tonnes/ha)	Straw yield (t/ha)	Harvest index (%)
<i>Wheat varieties</i>								
'NW 1012'	70.4	4.7	8.8	45.3	38.1	4.15	6.31	39.7
'PBW 343'	67.6	4.8	9.3	44.1	38.2	3.93	6.16	38.9
'Malviya 468'	71.1	5.0	10.6	48.6	37.4	3.99	6.34	38.6
SEm±	0.23	0.07	0.05	0.31	0.17	0.02	0.04	0.2
CD (P=0.05)	0.7	0.2	0.15	0.91	0.49	0.05	0.12	0.6
<i>Zn application methods</i>								
Control (no Zn)	67.5	4.6	9.2	43.0	36.4	3.50	6.12	36.4
Seed soaking with 0.5% ZnSO ₄ .7H ₂ O aqueous	69.3	5.0	9.5	44.6	38.3	3.74 (6.9)	6.28	37.3
Seed soaking with 1.0% ZnSO ₄ .7H ₂ O aqueous	69.9	4.8	9.4	47.0	39.1	3.99 (14.0)	6.52	38.0
20 kg/ha ZnSO ₄ .7H ₂ O	69.3	4.9	9.6	46.3	38.2	4.26 (21.7)	6.27	40.5
30 kg/ha ZnSO ₄ .7H ₂ O	70.4	5.1	10.0	46.9	37.9	4.27 (22.0)	6.24	40.6
Foliar spray of 5 kg/ha ZnSO ₄ .7H ₂ O with 2% urea in 1,000 litres water at 25 and 50 DAS (2 sprays)	71.0	4.8	9.7	48.2	37.7	4.41 (26.0)	6.20	41.6
SEm±	0.33	0.1	0.07	0.45	0.24	0.03	0.07	0.28
CD (P=0.05)	1.0	0.3	0.21	1.3	0.68	0.09	0.21	0.8

Figures in parentheses are percent increase in grain yield relative to control (without zinc application)

Table 2. Effect of Zn application methods and doses on nutrient uptake and economics of wheat varieties grown under sodic soil (pooled data of 2 years)

Treatment	Nutrient uptake (kg/ha)				Total cost of cultivation ($\times 10^3$ ₹/ha)	Gross income ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
	N	P	K	Zn uptake (g/ha)				
<i>Wheat varieties</i>								
'NW 1012'	111.5	30.05	81.1	231	15.72	36.23	20.51	1.30
'PBW 343'	112.2	28.95	78.7	225	15.72	34.59	18.87	1.20
'Malviya 468'	111.2	29.30	81.1	230	15.72	35.25	19.53	1.24
SEm \pm	1.09	0.29	0.41	1.14	0.10	0.26	0.17	0.02
CD (P=0.05)	NS	0.85	1.19	3.3	NS	0.75	0.48	0.05
<i>Zn application methods</i>								
Control (no Zn)	89.6	24.5	72.3	193	15.72	31.76	16.04	1.02
Seed soaking with 0.5% ZnSO ₄ .7H ₂ O aqueous	104.0	26.6	77.0	207	15.74	33.54	17.80	1.13
Seed soaking with 1.0% ZnSO ₄ .7H ₂ O aqueous	115.2	29.8	81.5	221	15.74	35.52	19.78	1.26
20 kg/ha ZnSO ₄ .7H ₂ O	117.6	31.7	82.6	239	16.17	36.88	20.71	1.28
30 kg/ha ZnSO ₄ .7H ₂ O	120.5	31.8	83.6	251	16.39	36.90	20.51	1.25
Foliar spray of 5 kg/ha ZnSO ₄ .7H ₂ O with 2% urea in 1,000 litres water at 25 and 50 DAS (2 sprays)	122.9	32.5	84.9	259	16.21	37.75	21.54	1.33
SEm \pm	1.54	0.41	0.58	1.6	0.07	0.28	0.22	0.02
CD (P=0.05)	4.44	1.19	1.69	4.6	0.19	0.80	0.65	0.07

much variability among the varieties except some little variations but Zn application definitely had a positive effect on these elements. Foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days followed by soil application of 30 kg/ha ZnSHH were the most efficient treatments. The magnitude of increased in N, P, K and Zn uptake with foliar spray of 5 kg/ha ZnSHH along with 2% urea in 1,000 litres water at 25 and 50 days was 37.2, 32.7, 14.4 and 34.2% in wheat (grain and straw) respectively, over the control. It is clear from the findings that Zn influenced the growth and grain yields of crop possibly through accelerated uptake and transport of beneficial nutrients like N, P, K and Zn in plants (Table 2). These results are in accordance with the finding of Chaudhary *et al.* (2014). Zinc has special role to play especially in sodic soils where its solubility and uptake is greatly reduced due to high pH. Nutrients being the constituents of various metabolites like chlorophyll, enzymes, hormones and other secondary metabolites influence various physiological processes which in turn affect growth and productivity of plants and also protect them against biotic and abiotic stresses. Increasing Zn levels progressively increased Zn concentration and its uptake by crops (Singh and Singh, 2007). These results corroborated with the findings of Savaghebi *et al.* (2003) and Majidi and Malakouti (2007).

Economics

Among the wheat varieties, maximum gross income, net return and benefit: cost ratio were recorded with 'NW

1012', which was significantly higher over the rest of the varieties. The higher net return with 'NW 1012' was owing to significantly higher grain yield than the other varieties. The maximum net returns and benefit: cost ratio were recorded with foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 DAS, which was at par with over all the Zn application methods and doses. This could be attributed to higher grain yield with treatment. These results are in conformity with the finding of Chaudhary *et al.* (2014).

Thus the foliar spray of 5 kg/ha ZnSHH with 2% urea in 1,000 litres water at 25 and 50 days is most economical. Soil application of 20 and 30 kg/ha zinc sulphate (heptahydrate) and pre-sowing seed soaking with 0.5 and 1.0% ZnSHH aqueous were also beneficial but had variable response in all the 3 varieties. This is because of the low input cost of ZnSHH and also efficient utilization by wheat crops. There was no possibility of soil fixation or immobilization of Zn in foliar spray. In addition, Zn was easily available to plants at the time of active tillering as well as grain-filling period since the foliar spray treatment was done at tillering and beginning of reproductive stage of wheat.

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