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SHORT COMMUNICATION

ALLEVIATING ADVERSE EFFECT OF SOIL SALINITY IN WHEAT (*TRITICUM AESTIVUM* L.) THROUGH APPLICATION OF ZINC FERTILIZER

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An experiment was conducted to study the alleviating adverse effect of soil salinity on three wheat varieties through application of zinc fertilizer. Wheat varieties KRL 19, NW 1012 (salt-tolerant) and HD 2285 (salt-susceptible) were grown in pots under non-saline (0, 20 kg Zn) and saline (8.0 dSm^{-1}, 20 kg Zn +8.0 dSm^{-1}) conditions during the rabi seasons. Study revealed that soil salinity adversely affected germination, plant height, number of tiller, number of leaves and leaf area per plant in all the three varieties at the tillering stage. Yield parameters viz., number of ear per plant, number of grain per ear, test weight, economic and biological yields declined significantly. Maximum reduction in these parameters was recorded in the susceptible variety (HD 2285) and minimum reduction in the tolerant varieties (KRL 19 and NW 1012). Zn application @ 20 kg ha^{-1} partially alleviated the adverse effects of salinity on economic yield with higher response (22.3% increment) in the susceptible variety HD 2285 compared to no application.

Key words: **Soil salinity, wheat genotypes, zinc sulphate**

Soil salinity is a major problem that threatens agriculture and soil productivity in arid and semi-arid regions (Mohammed *et al.* 1998). Presence of excessive salts in the root zone of soil system adversely affects vegetative and reproductive growth of plants through osmotic as well as specific ion effects. Wheat crop has been reported to be more sensitive to sodium chloride during young seedling and vegetative growth stages in comparison to germination and tillering stage (Hampson and Simpson 1990).

Micronutrient plays many important roles in plant nutrition and crop production. Zinc is one of the eight essential trace elements or micronutrients for the normal healthy growth and reproduction of crop plants. It is required in relatively small concentrations in the plant tissues (5-100 mg kg^{-1}) Parker *et al*. (1992). Organic matter, water saturation, texture and sorption capacity of the soils also affect zinc nutrition of plants. Zinc and manganese function in many plant enzyme systems as bridges to connect the enzyme with the substrate upon which it is meant to act. Zn is necessary for cell membrane integrity in plants (Welch *et al.* 1982). Root cell membrane permeability is increased under Zn deficiency which might be related to the functions of Zn in cell membranes (Marschner and Cakmak 1986 and Parker *et al*. 1992). Soil salinity may reduce Zn uptake due to stronger competition by salt cations at the root surface (Tinker and Lauchli 1984). External Zn concentrations could mitigate the adverse effect of NaCl by inhibiting Na and/or Cl uptake or translocation. In the salt affected areas, zinc application could alleviate

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possible Na and Cl injury in plants (Alpaslan *et al*. 1999). The present study was conducted to find out the alleviating adverse effect of soil salinity on plant growth and yield in sensitive and tolerant varieties of wheat through application of zinc fertilizer.

The experiments were conducted in a completely randomized design with three replications. Surface soil (0-30 cm) was collected from Research Farm, N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.). Two levels of soil salinity viz., 0 (control) and 8.0 dSm^{-1} were developed by using NaCl salt on soil weight basis as prescribed by Richards (1954). NaCl solution was applied enough to saturate the soil and after one month of incubation of the soil, two zinc levels viz., 0 (control) and 20 kg were applied by mixing as @ 20 kg $ZnSO_4.7H_2O$ ha^{-1} on soil weight basis before sowing. Earthen pots (10 inch diameter) lined with polythene sheet were filled with 8 kg of well-pulverized sandy loam soils of known salinity level. The calculated amount of recommended doses of inorganic fertilizers (i.e.120 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} on soil weight basis) were applied in pots through urea, single super phosphate and muriate of potash. All the P and K were applied at time of sowing, while N was applied in three equal splits doses. Wheat varieties KRL 19, NW 1012 (salt-tolerant) and HD 2285 (salt-susceptible) were grown in pots under non-saline (0, 20 kg Zn) and saline (8.0 dSm^{-1}, 20 kg Zn +8.0 dSm^{-1}) conditions during the rabi seasons of 2001- 03. In each treatment ten uniformly bold and healthy seeds were sown per pot and the germination was counted. Germination percentage was calculated by using the formula: Germination percentage = (Number of seeds germinated / Total number of seeds sown) x 100. Germination rate was calculated using the following formula:

$$Ó\ GT_1/T_1+ \ldots\ldots+GT_n / T_n$$

Where, GT is seed germinated each day and T refers to the day during the trail. After 15 days the seedlings were thinned to three seedlings per pot. Pots were irrigated as per requirement. Growth observations on plant height, tiller number, leaf number and leaf area were recorded at tillering stage. Leaf area was measured by automatic area meter (LICOR, USA). Data on wheat yield and yield components were recorded at harvesting stage. Dried samples were digested in digestion mixture (Nitric acid-perchloric acid) according to method of Tandon (1993) and estimation of Zn was done by using Atomic Absorption Spectrophotometer (Shimadzu 6200AA, Japan). Data were statistically analyzed by AGRES statistical software version 3.01. Pool data of the results has been discussed and summarized below.

An increase in the rate and percent germination was recorded with time (Fig. 1). NaCl stress reduced the rate and per cent germination in all the treatments as compared to the non-saline control. Under salinity, 100 per cent germination could not be achieved until 8th day after sowing. Application of zinc sulphate @ 20 kg ha^{-1} to NaCl stressed and control treatments enhanced the rate and per cent germination in all the wheat varieties, whereas application of zinc sulphate to the unstressed control treatment resulted in to 100 per cent germination on the 7th day of sowing. The decrease in rate of germination per cent under saline condition in wheat may be due to reduced rate of water imbibitions and mobilization of reserve food material from embryo to embryo axis (Mansour and Mutawas 1998, Das and Panda 2000). Zinc sulphate helps in enhancement of germination because it may increase the activity of hydrolytic enzymes (Marschner 1995, Hemantaranjan 2000).

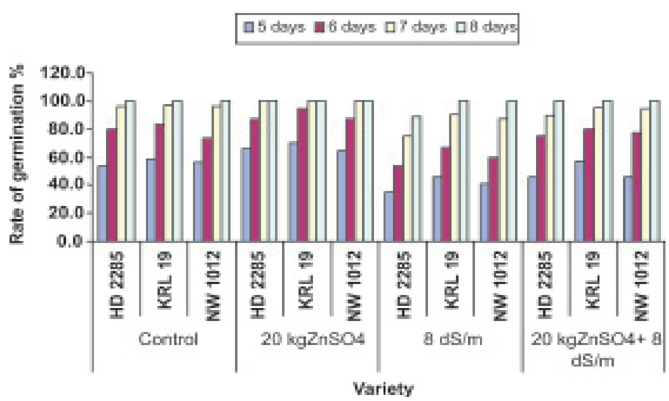

Fig. 1. Effect of zinc application on germination% of three wheat varieties under salinity

Under saline soils, Zn and P deficiencies are more or less universally present (Quijano-Guerta *et al.,* 2002).

Zinc is not available in such soils, because Zn and sorbs or precipitates in unavailable forms (Khoshgoftar *et al.* 2004). Zinc performs various important roles in protecting cells from the damaging reactions caused by ROS. Zinc is required for maintenance of integrity of biomembrances (Marschner 1995).Under Zn- deficient conditions there is a typical increase in plasma membrane permeability in Zn-deficient plants, particularly in soils affected by salinity. Thus, under these conditions plant growth and yield may decrease (Marschner 1995). In this study salinity decreased plant height in all the wheat varieties. The salt tolerant varieties KRL 19 and NW 1012 showed higher (18.3 and 18.2 cm) respectively mean value of plant height than salt susceptible HD 2285 (13.7 cm) at the tillering stage (Fig. 2). However, the magnitude of reduction in plant height under salt stress was more 25.1% in susceptible variety HD 2285 than 18.1% in tolerant variety KRL 19. Salinity caused a significant reduction in leaf area, number of tillers and leaves in all the wheat varieties (Fig. 2). The minimum reduction in leaf area (5.8 and 10.6%), number of tillers (22.2 and 33.3%) and leaf number (11.1 and 19.4%) was recorded in the tolerant varieties KRL 19 and NW 1012 respectively than in salt susceptible variety HD 2285 at tillering stage.

Data showed that application of zinc sulphate resulted in increased plant height and tiller number in all the wheat varieties irrespective of growth stage and salinity. Observed increase in plant height and number of leaves as a result of application of zinc sulphate was more in salt susceptible variety, but the increase in per cent germination, tiller number and leaf area was higher in the salt tolerant varieties KRL 19 and NW 1012 respectively. El-Sherif *et al.* (1990) showed that zinc application to the soil ameliorated the tomato tolerability to salinity stress. Reduction in plant height on account of soil salinity and its reversal by Zn sulphate indicates its possible role in stem elongation. Salinity induced retardation of growth might have also been mediated through of zinc availability under salt stress, which in turn might have caused reduction in auxins which are important hormones for stem growth and elongation (Datta *et al*. 1998). Reduction in tiller number caused by salinity may be due to hindrance in proper development of tiller primordial, their early mortality or lack of their initiation (Venkateshwarlu *et al.* 1972).

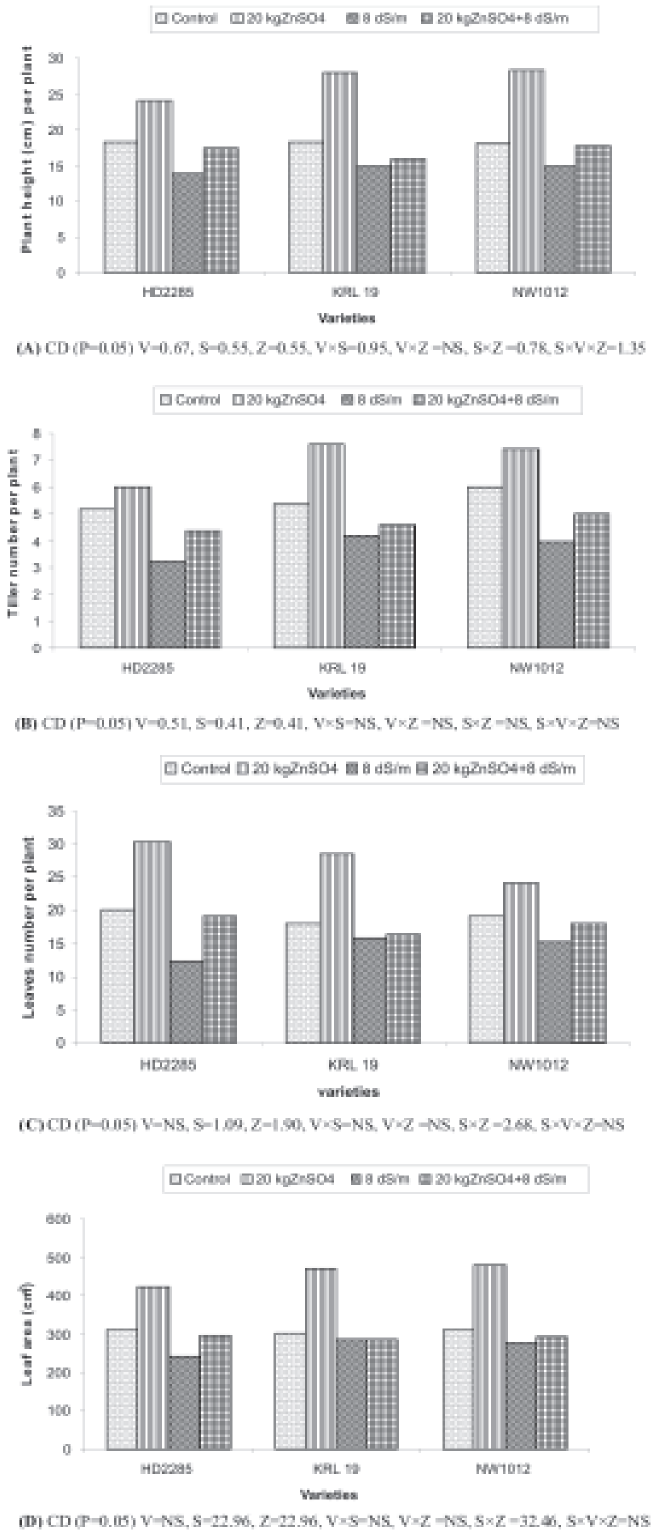

Fig. 2. Effect of zinc application on (A) plant height, (B) tiller number, (C) leaf number and (D) leaf area of three wheat varieties at the tillering stage under salinity

The data on grain yield and its components given in Table 1 reveals that number of ears per plant in variety KRL 19 were higher than varieties NW1012 and HD 2285. The maximum reduction (27%) due to salinity was observed in susceptible variety HD 2285 whereas the salt tolerant varieties NW 1012 und KRL 19 recorded 17.8 and 10% reduction as compared to their respective controls (Table 1). Regardless of salt treatment, growing plants in Zn deficient soil without Zn treatment greatly reduced ear per plant. Reduction in number of ears per plant becomes more severe as a result of salt stress. Addition of zinc sulphate to NaCl stressed and unstressed control resulted into increased number of ears per plant. Application of zinc sulphate to NaCl stressed plants enhanced the number of ears per plant in all the wheat varieties. However, maximum increase (31.6%) was observed in the salt susceptible variety as compared to NW 1012 and KRL 19, which showed an increase of 21.5 and 17.2%, respectively.

Salinity decreased the number of grains per ear in all the three wheat varieties but the decrease in HD 2285 was higher than NW 1012 and KRL 19 (Table 1). The percent increase in number of grains per ear was maximum in HD 2285 (24.6%) as compared to NW 1012 (11.7%) and KRL (9.2%) by the $ZnSO_4$ application under salt stressed conditions. Application of $ZnSO_4$ resulted in significant increase in number of grains per ear. The $ZnSO_4$ treated plant achieved maximum number of grains per ear than untreated control at salt stress. Zn deficiency often results in decrease in plant growth and smaller leaves are presumably related to disturbances in the metabolism of auxin, indole acetic acid (IAA) and finally yield (Marschner 1995, Yilmaz *et al.* 1997, Ranjbar and Bahmaniar 2007).

The test weight of all the varieties decreased under slat stress. The salt susceptible variety HD 2285 showed 20% reduction as compared to 8.7% in NW 1012 and

Table 1. Effect of zinc application on number of ear plant^{-1}, number of grain ear^{-1} and test weight (g) of three wheat varieties under salinity.

Zn level kg ha^{-1}	Varieties	Number of ear plant^{-1} Salinity (dSm^{-1})			Number of grain plant^{-1} Salinity (dSm^{-1})			Test weight (g) Salinity (dSm^{-1})		
		1.2	8.0	Mean	1.2	8.0	Mean	1.2	8.0	Mean
0	HD 2285	7.4	5.4	6.4	66.4	44.6	55.5	38.0	30.2	34.1
	KRL 19	8.0	7.4	7.7	69.8	55.2	62.5	41.4	39.4	40.4
	NW 1012	8.4	6.9	7.7	72.0	54.0	63.0	43.2	39.4	41.3
	Sub mean	7.9	6.6	7.3	69.4	51.3	60.3	40.9	36.3	38.6
20	HD 2285	9.4	7.9	8.7	70.8	59.2	65.0	44.8	40.0	42.4
	KRL 19	10.2	9.7	10.0	86.0	60.8	73.4	46.2	45.0	45.6
	NW 1012	11.2	8.8	10.0	87.0	61.2	74.1	47.8	46.0	46.9
	Sub mean	10.3	8.8	9.5	81.3	60.4	70.8	46.3	43.7	45.0
Average Mean of Varieties	Mean	9.1	7.7	8.4	75.3	55.8	65.6	43.6	40.0	41.8
	HD 2285	8.4	6.7	7.5	68.6	51.9	60.3	41.4	35.1	38.3
	KRL 19	9.1	8.6	8.8	77.9	58.0	68.0	43.8	42.2	43.0
	NW 1012	9.8	7.9	8.8	9.5	57.6	68.6	45.5	42.7	44.1
CD at 0.05	V		0.52			0.63			4.65	
	S		0.42			0.52			3.80	
	Z		0.43			0.52			3.80	
	V×S		0.74			0.90			NS	
	V×Z		0.74			0.90			NS	
	SxZ		NS			0.73			NS	
	S×V×Z		NS			NS			NS	

4.8% in KRL 19 (Table 1). The significant decrease in test weight under salt stress may be attributed to enhanced osmotic pressure of soil solution owing to high salt concentration. It seems that higher osmotic pressure of soil solution resulted in reduction in cell expansion, elongation, starch-sugar imbalance, low availability of water and thus translocation of photosynthates to developing seed (Gill 1979 and Munns 2006).

Application of zinc sulphate enhanced test weight as compared to control under salt stress conditions. Zn application led to significantly higher test weight of 15.2% in the salt susceptible variety HD 2285 as compared to lower increment of 9.6% in NW 1012 (Table 1) indicating that application of $ZnSO_4$ counter acted the adverse effect of soil salinity. Studies by Yilmaz *et al.* (1997) also emphasized that Zn nutrition had more role in seed setting than vegetative growth. In cereal crops, Zn deficient plants tend to be shorter with tiller number lesser that adversely affected starch sugar balance which was met by applying $ZnSO_4$ (Gill 1979 and Brown *et al.* 1993).

Salinity significantly decreased economic and biological yield per plant in all the wheat varieties as compared to control (Table 2). Per cent reduction in economic yield (g) per plant due to salinity was significantly more in the susceptible variety HD 2285 (25.6%) than the salt tolerant varieties (15.6 and 9.8% in NW 1012 and KRL 19 respectively) (Table 2). The enhancement in economic yield per plant due to application of zinc sulphate under salinity was significantly more in the susceptible variety HD 2285 (22.3%) than the tolerant varieties NW 1012 and KRL 19 (15.2 and 9.8%), respectively. This might probably be due to the important role of Zn for activation of various types of enzymes, such as those required for the CO_2 assimilation pathway (Marschner (1995) and synthesis of indole acetic acid (Marschner 2002).

Table 2. Effect of zinc application on economic yield, biological yield and harvest index (HI) of three wheat varieties under salinity.

Zn level kg ha^{-1}	Varieties	Economic yield (g plant^{-1}) Salinity dSm^{-1}			Biological yield (g plant^{-1}) Salinity dSm^{-1}			Harvest index plant^{-1} Salinity dSm^{-1}		
		1.2	8.0	Mean	1.2	8.0	Mean	1.2	8.0	Mean
0	HD 2285	11.7	8.7	10.2	28.0	15.3	21.6	41.7	56.9	49.3
	KRL 19	13.3	12.0	12.6	31.0	21.3	26.1	42.7	56.3	49.5
	NW 1012	14.7	12.4	13.5	34.1	19.9	27.0	43.0	62.2	52.6
	Sub mean	13.2	11.0	12.1	31.0	18.8	24.9	42.5	58.5	50.5
20	HD 2285	14.7	11.2	13.0	36.0	26.0	31.0	39.8	43.1	41.4
	KRL 19	16.7	13.3	15.0	42.0	23.2	32.6	39.7	57.3	48.5
	NW 1012	19.8	14.6	17.2	47.5	31.6	39.5	41.6	46.6	44.1
	Sub mean	17.1	13.0	15.1	41.8	26.9	34.4	40.4	49.0	44.7
Average Mean	Mean	15.1	12.0	13.6	36.4	22.9	29.7	41.4	53.7	47.6
of Varieties	HD 2285	13.2	10.0	11.6	32.0	20.6	26.3	40.7	50.0	45.4
	KRL 19	15.0	12.6	13.8	36.5	22.2	29.4	41.2	56.8	49.0
	NW 1012	17.2	13.5	15.4	40.8	25.7	33.3	42.3	54.4	48.3
CD at 0.05	V		0.72			1.77			NS	
	S		0.59			1.44			NS	
	Z		0.59			1.44			1.84	
	V×S		1.02			NS			NS	
	V×Z		NS			2.50			2.60	
	SxZ		0.84			2.04			NS	
	S×V×Z		NS			1.24			NS	

Zn content in shoot and grain was decreased significantly under salt stress (Fig. 3) due to reduced cell division and differentiations leading to poor sink development, photosynthesis and translocation of metabolites to the reproductive sink. The Zn content in shoot and grain increased significantly with application of $ZnSO_4$ as compared to untreated control. It also had a positive effect on plant growth and yield component regardless of salinity and increased the zinc content in wheat shoot. Could be some of the possible reasons for lower yield (Sharma 1991, Annick *et al.* 2004 and Munns 2006).

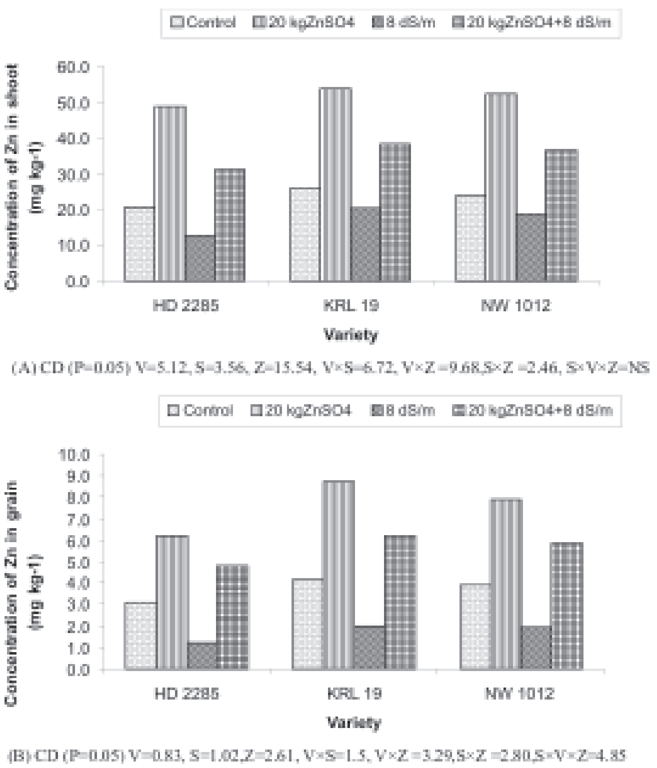

Fig. 3. Effect of zinc application on zinc content in (A) shoot and (B) grain (mg kg^{-1}) of three wheat varieties under salinity stress

It is concluded from the present study that the application of $ZnSO_4$ @ 20 kg ha^{-1} helped in partial alleviation of the adverse effects of salinity on plant growth and economic yield, with more benefits occurring in the salt susceptible variety HD 2285. Salinity led to relatively higher values of harvest index as compared to the non-saline control. This is caused by relatively greater reduction in biological yields than economic yield caused by salinity. Application of zinc sulphate led to significant increase in the economic yield per plant and yield components of wheat plants.

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