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Effect of Zinc Application on Rice Yield under Wheat Rice System

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Abstract: A field experiment was conducted during 2004-05 on wheat and rice to study the response of Zinc application in wheat-rice system. Two levels of zinc 5 and 10 kg ha^{-1} with control were studied with the basal dose of N, P_2O_5, K_2O as 120-90-60 kg ha^{-1} in the form of urea, TSP, SOP and zinc sulphate during both the crops. Wheat variety Naseer 2000 and rice variety IRRI 6, both were planted in R.C.B design with three replications. Zn application, significantly affected wheat grain yield, ranged from 2.7 to 3.5 t ha^{-1}, giving highest increase of 31.6% over control from 5 kg Zn ha^{-1}. The number of tillers, spike m^{-2}, spike length, plant height and 1000 grain weight of wheat were also significantly affected over control with the same treatment. Paddy yield was also significantly affected by Zn levels ranged from 3.9 to 5.9 t ha^{-1}. The highest yield was obtained from 10 kg Zn ha^{-1} each applied to both crops. Similarly Zn application also affected significantly to the yield parameters of rice like the number of spike m^{-2}, number of spike/plant, spike length, plant height and 1000 grain weight over control from the above said treatment of 10 kg Zn ha^{-1}. The concentration of zinc in soil and leaves was significantly affected by the application of zinc in wheat and rice, ranged from 0.47-1.37, 22.6-367.37 mg kg^{-1} in wheat and 0.45-1.18; 29.32-40.67 mg kg^{-1} in rice, respectively (soil and leaves). The highest concentration in soil and leaves was recorded by the cumulative application of 10 kg Zn ha^{-1} while lowest from control. The direct application of 5 and 10 kg Zn ha^{-1} gave an increase of 39 and 45% while residual effect 30.0 and 43.0%, cumulative effect of 38 and 50% over control, respectively. The residual application of 10 kg Zn ha^{-1} can be recommended for economical production in wheat rice system.

Key words: Zinc, rice, direct, residual, cumulative, yield, wheat-rice system

INTRODUCTION

Zinc is one of the most important micro nutrient essential for plant growth. Zinc fertilization is widely recommended for rice and wheat as its deficiency occurs in NWFP. Zinc deficiency is the third most serious crop nutrition problem in the country ranking after N and P deficiency (Rashid and Rafique, 1996). Experiments conducted in pots using soil deficient in zinc showed the reduction in dry matter yield of wheat and rice (Alam *et al.*, 1997), who concluded from their experiments that application of zinc and copper significantly, increased the paddy yield over control. Nawaz *et al.* (2004) conducted research work on rice and concluded that comparative effects of Zn and Cu on paddy yield indicated more response to Zn as compared to Cu and further suggested that 10 kg Zn ha^{-1} was the optimum dose for rice under prevailing soil conditions of D.I. Khan. Zinc and Copper contents in soil and leaves of rice were directly related to the increased application of these elements. Nutrients survey conducted by Zia *et al.* (2000) has revealed widespread deficiencies of macro and micro nutrients in major rice producing districts of the Punjab. The deficiency of Zn was a major problem and its deficiency was registered in 93% soils. Nathan *et al.* (2005a) evaluated the immediate and residual effects with four commercial Zn fertilizers on paddy rice and noticed that Zn concentration and grain yield was increased from application of 13.5 kg Zn ha^{-1}.

They also found that during the second year, tissue Zn concentration and yield increased linearly, as Zn rates increased and were not affected by Zn source. Nathan *et al.* (2005b) further noticed that Zn fertilization increased the yield by 12 to 180% compared with the unfertilized (control) in flood irrigated rice. Charati and Malakouti (2006) concluded from their research that Zn application increased the concentration of this nutrient in the grain of paddy rice. The average concentration of Zn in the unhusked rice grain increased significantly from 61.8 kg g^{-1} in the control samples to 64.3 and 64.6 kg g^{-1} in the samples that were treated with 5 and 10 kg Zn gm^{-1} of soil, respectively.

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Zinc deficiency in rice is widespread not only due to native Zn in soil, since Zn under flooded rice is rendered unavailable by forming insoluble Zn compound, such as Zinc sulfide, zinc carbonate and zinc phosphate. The application of Zn at the rate of 10-14 mg kg^{-1} soil to rice had a significant residual effect up to three crops in cropping sequence. Hussain and Yasin (2004) conducted research work on response of Zn and B on the yield of wheat and rice at two different sites in Punjab. They concluded that the application of 5 kg Zn ha^{-1} increased the wheat grain yield by 16 and 13% over check, respectively.

Rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) is the most important cropping system in Punjab. It is practiced on 2.2 mh in Pakistan. Despite crucial position of rice and wheat as staple crops of the country, productivity of the system is poor, with average yield of rice 2.0 and wheat 2.2 t ha^{-1}. The major factors responsible for low yield is less use of organic manure, crop residues and unbalanced use of fertilizer in this system. Further less wheat yield is due to deteriorated soil structure by puddling which destroys soil aggregates and creates hard pan that can restrict the rooting depth of both rice and wheat. An intensive cultivation removes a great amount of macro and micro nutrients from soil and may lead to severe deficiencies if nutrients are not replenished properly. An unbalanced fertilizer application may disturb nutrients availability to crops, leading to reduction in yield.

In Zn and B management experiments, maximum mean wheat grain yield with 5 kg Zn ha^{-1} was 3.85 t ha^{-1} against 3.45 t ha^{-1} from check. The paddy yield increase over control due to residual application of Zn was 6.1%, whereas paddy yield increase due to cumulative effect of Zn was 17%. Application of Zn improved their uptake in rice and wheat (Hussain and Yasin, 2004).

By keeping in view these problems experiments were conducted to determine direct, residual and cumulative effect of Zn on rice after wheat. In D.I. Khan this type of study has not been conducted so far.

MATERIALS AND METHODS

A field experiment was conducted during 2004-05 on wheat to study the response of applied zinc and its residual/cumulative effect on rice crop. The experiment was laid out at Arid Zone Research Farm D.I. Khan in Randomized Complete Block Design with seven treatments replicated three times. The treatments comprised of check (T1), 5 kg Zn ha^{-1} to wheat and nil to rice (T2), nil to wheat and 5 kg Zn ha^{-1} to rice (T3), 10 kg Zn ha^{-1} to wheat and nil to rice (T4), nil to wheat 10 kg Zn ha^{-1} to rice (T5), 5 kg Zn ha^{-1} each to wheat and rice (T6), 10 kg Zn ha^{-1} to wheat and rice (T7). The basal dose of 120-90-60 kg ha^{-1} of N, P_2O_5 and K_2O was applied in the form of Urea, TSP, SOP and Zinc Sulphate. All P, K, Zn and half N was applied at sowing to both crops while remaining half N was applied at 2nd irrigation in wheat and at panicle initiation to rice crop. The wheat variety Naseer 2000 and IRRI 6 of were planted during the study. The wheat was sown during second week of November 2004 while rice during first week of June. The treatment plot size of 2.40 x 6.00 m was kept for both the crops as rice was planted in same layout of wheat. All the other cultural practices were followed uniformly throughout the growing period of each crop. A composite soil sample was taken before the commencement of the study. The soil was analyzed for various physico-chemical characteristics (Table 1). Electrical conductivity and pH of the soil was determined according to method by Black (1965), soil texture was determined by the hydrometer method (Moodie *et al*., 1954), whereas lime was estimated by acid neutralization method (Richard, 1954). Organic matter was determined by the modified method of Walkly and Black (Nelson and Sommers, 1982). Olsen P and K were determined according to Black 1965. The soil and leaf samples were collected at panicle initiation stage. The soil was analyzed for available zinc according to the method given by (Lindsay and Norvell, 1978). The leaf samples were dried, ground and analyzed by wet digestion method according to method given by (Walsh and Beaton (1973). The post harvest data i.e., number of tillers^{-2}, spike m^{-2}, spike length and plant height in wheat and rice were recorded at proper time. The net plot of 0.60×5.00 m was harvested manually for 1000 grain weight and grain yield of both wheat and rice. All the relevant data was statistically analyzed using MSTATC computer program.

Table 1: Physico-Chemical properties of Soil

Soil properties	Value
pH (1:2)	8.00
E.C dS m^{-1} (1:2)	0.600
$CaCO_3$ Eq. (%)	11.00
Organic matter (%)	0.69
Nitrogen %	0.039
Sod Bicarbonate Ext. P (mg kg^{-1})	4.50
Amm. Acetate Ext. K (mg kg^{-1})	90.00
DTPA Ext. Zn mg kg^{-1}	0.80
Sand (%)	20.00
Silt (%)	48.00
Clay (%)	32.00
Textural class	Silty clay

RESULTS AND DISCUSSION

Zinc concentration in soil: The application of zinc in wheat significantly affected the concentration of zinc in soil over check (Table 2) that ranged from 0.47 to 1.37 mg kg^{-1}. The highest concentration 1.37 and

1.08 mg kg^{-1} were recorded by the application of 10 kg Zn ha^{-1}. The lower concentration 0.81 and 0.78 mg kg^{-1} were obtained from 5 kg Zn ha^{-1} while the lowest concentrations of (0.47, 0.46 and 0.45 mg kg^{-1}) were recorded from check plots. The application of zinc in rice significantly affected the concentration of zinc in soil over check that ranged from 0.45 to 1.18 mg kg^{-1}. The highest concentration was recorded by the cumulative application of 10 kg Zn ha^{-1}, followed by 1.02 mg kg^{-1} achieved with direct application of 10 kg Zn ha^{-1} and lowest concentration was recorded from control. These results are in agreement with Nawaz *et al.* (2004), who reported that Zn significantly enhanced yield of rice and available soil and plant Zn contents. Hussain and Yasin (2004) also concluded that in rice crop uptake of Zn was also increased with Zn application.

Zinc concentration in leaves: The zinc concentration in leaves of wheat was significantly affected by the application of zinc (Table 2) that ranged from 22.67 to 36.37 mg kg^{-1}. The highest concentration was recorded by the application of 10 kg ha^{-1} and lowest from control plots. The second highest concentration was achieved with 5 kg Zn ha^{-1}. The concentration of zinc in leaves of rice was significantly affected by the application of zinc that ranged from 29.32-40.67 kg^{-1}. The highest concentration was recorded by the cumulative application of 10 kg Zn ha^{-1} followed by the residual application of 10 kg Zn ha^{-1} and cumulative application of 5 kg Zn ha^{-1} and they were statistically non-significant and also at par with direct application of 5 kg Zn ha^{-1}. The lowest concentration was recorded from check but was statistically at par with residual application of 5 kg Zn ha^{-1}. These results revealed that uptake of Zn in plants increased with the addition of zinc in soil especially at higher level of Zn. The results are in agreement with Nawaz *et al.* (2004), Hussain and Yasin (2004), Nathan *et al.* (2005a) and Charati and Malakouti (2006).

Table 2: Zinc concentration (mg kg^{-1}) in soil and leaves

Treatments	Zinc kg ha^{-1} to crop: Wheat	Rice	Wheat: Soil	Leaves	Rice: Soil	Leaves
1	0	0	0.47c	22.67c	0.45f	29.32d
2	5	5	0.78bc	30.33b	0.58e	32.33cd
3	0	0	0.45c	23.00c	0.83cd	36.33b
4	10	10	1.08ab	34.00ab	0.77d	35.67bc
5	0	0	0.46bc	23.33c	1.02b	38.00ab
6	5	5	0.81bc	30.67a	0.91b	37.33ab
7	10	10	1.37a	36.37a	1.18a	40.67a
LSD 0.05			0.506	4.49	0.125	3.44

Means followed by same letter(s) do not differ significantly at $p<0.05$

Wheat and rice grain and yield components as affected by zinc: The results revealed that grain yield of wheat were significantly affected by Zinc application. The maximum tillers m^{-2} (553) were recorded from the treatment receiving 5 kg Zn ha^{-1}. The number of spike m^{-2} and spike length were also influenced significantly with zinc application. There was overlapping among the treatments anyhow the maximum number of spike m^{-2} and spike length were observed in plots receiving 5 kg Zn ha^{-1} followed by 10 kg Zn ha^{-1} whereas maximum spike m^{-2} (374) and spike length (10.7 cm) were observed in plots receiving 5 kg Zn ha^{-1} followed by 10 kg Zn ha^{-1}. The minimum spike m^{-2} (270) and spike length (10.1 cm) was recorded from check. The highest grain yield of 3564 kg ha^{-1} was achieved against 2708 kg ha^{-1} from check (no zinc), giving an increase of 31.6% over control. The highest wheat yield was obtained from 5 kg Zn ha^{-1} which differed significantly from all other treatments (Table 3), it was followed by 3207 kg ha^{-1} by the application of 10 kg Zn ha^{-1}. Zinc application also affected significantly 1000-grain weight ranged from 33.3 to 35.9 gm. The highest weight was obtained from 5 kg Zn ha^{-1} while 10 kg Zn ha^{-1} also enhanced plant height, which differed significantly from check plot but was at par with 5 kg Zn ha^{-1}. These results were supported by Hussain and Yasin (2004) who concluded that 5 kg Zn ha^{-1} application gave the highest wheat yield over NPK, having an increase of 12% over check.

The rice crop was planted in the same layout of wheat. The results on rice revealed that plant height affected significantly by zinc application as maximum height 111.3 cm was attained with 5 and 10 kg Zn ha^{-1} applied both to wheat and rice crop. The number of spike m^{-2} and spike length were also influenced significantly over control with zinc application. The maximum number of spike m^{-2} (376), No. of spike per plant (25) and spike length 24.6 cm) were also recorded from the treatment receiving 10 kg Zn ha^{-1} each applied both to wheat and rice, whereas 24.5 and 24.3 cm spike length were obtained from 5 kg Zn ha^{-1} applied to the wheat crop only and 5 kg Zn ha^{-1} each applied both to rice and wheat crop. The grain yield of rice was also significantly affected by zinc application.

The highest grain yield of 5903 kg ha^{-1} was obtained from the treatment receiving 10 kg Zn ha^{-1} applied both to rice and wheat crop having an increase of 49.6% over control (3944 kg ha^{-1}) as depicted in Table 4. It was followed by direct application of 10 kg Zn ha^{-1} giving an increase of 45% over control, while 5 kg Zn ha^{-1} application gave an increase of 39%. There was also

Table 3: Wheat response to zinc application under wheat-rice system

Treatments	Zinc kg ha^{-1} to crop Wheat	Rice	No. of tillersm^{-2}	No. of spike m^{-2}	Spike length (cm)	Plant height (cm)	1000 grain weight (g)	Grain yield (kg ha^{-1})
1	0	0	363d	270d	10.1d	95.9d	33.3c	2708c
2	5	0	553a	374a	10.7a	103.0a	35.2ab	356a
3	0	5	384d	305cd	10.3bcd	99.9bc	34.0bc	3000b
4	10	0	478bc	352ab	10.4abcd	102.3ab	34.3abc	3207b
5	0	10	449c	286bcd	10.2cd	99.6c	34.3abc	2974bc
6	5	5	518ab	351ab	10.6ab	103.1a	35.9a	320b
7	10	10	491bc	322bc	10.5abc	100.8abc	34.6abc	305b
LSD 0.05			41.78	40.80	0.3513	2.503	1.831	276.8

Means followed by same letter(s) do not differ significantly at $p<0.05$

Table 4: Rice response to zinc application under wheat/rice system

Treatments	Zinc kg ha^{-1} to crop Wheat	Rice	No. of spikesm^{-2}	No. of spike/plant	Spike length (cm)	Plant height (cm)	1000 grain weight (g)	Grain yield (kg ha^{-1})	Percent increase over control%
1	0	0	327d	18.5e	21.3c	100.1c	21.53e	3944f	-
2	5	0	349c	19.4d	23.3b	104.8bc	21.80de	5131e	30.0
3	0	5	367ab	24.1b	24.5a	112.7a	22.26bc	5484d	39.0
4	10	0	357bc	19.0de	21.7c	104.0c	22.05cd	5646c	43.1
5	0	10	369ab	22.5c	23.0b	110.1ab	22.45b	5727b	45.1
6	5	5	371ab	24.1b	24.3a	111.3a	22.73a	5451d	38.2
7	10	10	376a	24.9a	24.6a	111.3a	22.30bc	5903a	49.6
LSD 0.05			17.55	0.757	0.675	5.399	0.27	69.16	

Means followed by same letter(s) do not differ significantly at $p\leq0.05$

residual effect of zinc. 43 and 30% increase over control was obtained by the residual application of zinc applied to the previous crop of 10 and 5 kg Zn ha^{-1}, respectively. 5 kg Zn ha^{-1} applied to both crops gave an increase of 38% over control, which was equivalent to 5 kg Zn ha^{-1} applied only to rice crop.

It can be concluded from the above results that for getting economical grain yield of paddy, 10 kg Zn ha^{-1} applied to wheat will sufficient for rice crop. Zinc application also affected 1000-grain weight ranged from 21.53 to 22.73 g and highest weight has been recorded from 10 kg Zn ha^{-1}. These findings are supported by Zia *et al.* (2000) who concluded a significant residual Zn application response up to three crops in sequence while the increase as paddy yield of 6.1 and 17.0% was noticed with the residual and cumulative application of 5 kg Zn ha^{-1} as noticed by Hussain and Yasin (2004). Nathan *et al.* (2005b) also concluded that Zn fertilization increased the yield by 12 to 180%.

CONCLUSION

10 kg Zn ha^{-1} applied to wheat can prove economical for rice production in wheat-rice system.

REFERENCES

Alam, S.M., A. Latif and Zafar Iqbal, 1997. Response of rice to nitrogen and zinc fertilization with or without copper. Pak. J. Soil. Sci., 13: 41-45.

Black, C.A., 1965. Methods of Soil Analysis. Part Ii. Amer. Soc. Agron., Madison, Wisconsin, USA.

Charati, A. and M.J. Malakouti, 2006. Effect of Zinc and Cadmium Concentrations on the Rates of Their Absorption by Rice and on Some Growth Characteristics of the Plant (*Oriza sativa* L.) Part 2: Yield and composition. 18th World Congress of Soil Science, Philadelphia, Pennsylvania, July 9-15, 2006, USA., pp: 155-173.

Hussain, F. and M. Yasin, 2004. Soil fertility monitoring and management in rice-wheat system. Annual Report LRRP, NARC, Islamabad, pp: 1-33.

Lindsay, W.L. and W.A. Norvell, 1978. Development of DTPA Soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Am. Proc., 42: 421-428.

Moodie, D., H.W. Smith and R.A. McCreary, 1954. Laboratory Manual for Soil Fertility. Washington State College, Monograph, pp: 31-39.

Nathan, A.S., E.E. Gbur, Jr., C.E. Wilson, Jr. and Richard J. Norman, 2005a. Rice response to granular zinc sources varying in water-soluble zinc. Soil Sci. Soc. Am. J., 69: 443-452.

Nathan, A.S., R.J. Norman and C.E. Wilson, 2005b. Effect of zinc source and application time on zinc uptake and grain yield of flood-irrigated rice. Agron. J., 97: 272-278.

Nawaz, M. Shahid, M. Qasim, A. Bakhsh and A.H. Gurmani, 2004. Effect of zinc and copper fertilization on rice yield and soil/plant concentration. Pak. J. Soil Sci., 20: 13-18.

Nelson, D.W. and L.E. Sommer, 1982. Total Carbon, Organic Carbon and Organic Matter. In: Methods of Soil Analysis. Page, A.L., M.H. Miller and D.R. Keeny (Eds.) Part 2. 2nd Edn., Am. Soc. Agron. Madison. WI., pp: 539-577.

Rashid, A. and E. Rafique, 1996. Micronutrient in Pakistan Agriculture, Significance and Use. Technical Brochure. Pak. Agric. Res. Council. Islamabad.

Richards, L.A., 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA. HB 60.

Walsh, L.M. and J.D. Beaton, 1973. In: Soil Testing and Plant Analysis Soil Sci. Soc. Am. Madison, USA., pp: 185.

Zia, M.S., M. Aslam, M. Yousaf, N.A. Khan and A. Ali, 2000. Techniques to control zinc deficiency problem in wetland rice soils. In Proceeding of National Seminar on Micronutrient in Soils and Crops in Pakistan. NWFP Agriculture University, Peshawar. pp: 181-190.