Annals of Plant and Soil Research 17 (1): 74-76 (2015)

RESPONSE OF RICE TO ZINC APPLICATION IN ACIDIC SOILS OF ASSAM

G.G. KANDALI, A. BASUMATARY, N.G. BARUA, B.K. MEDHI AND S. HAZARIKA

Department of Soil Science, Assam Agricultural University, Jorhat-785013

Received: September, 2014; Revised accepted: November, 2014

ABSTRACT

Field experiments were carried out in 2011 and 2012 at the Instructional Cum Research Farm of Assam Agricultural University, Jorhat, Assam, to find out the effect of different levels of zinc (0, 5, 10, 15, 20, 25 and 30 kg Zn SO_4 ha^{-1}) on yield, economics and Zn uptake by rice. The results revealed that the rice responded significantly to graded doses of zinc application. The highest grain (4.59 t ha^{-1}) and straw yield (6.64 t ha^{-1}) was recorded at 25 kg $ZnSO_4$ ha^{-1} which was 73.8 % and 20.5% greater than control, respectively. The highest mean zinc concentration (21.7 mg kg^{-1}, 45.6 mg kg^{-1}) and uptake (97.5 g ha^{-1}, 311.7 g ha^{-1}) in grain and straw were recorded at 25 kg $ZnSO_4$ ha^{-1}. The apparent zinc recovery was highest at lower level of zinc application and decreased with increase in zinc doses. Available Zn increased with increasing levels of Zn and maximum value of Zn in post harvest soil was noted at 30 kg Zn SO_4 ha^{-1}. All growth parameters performed better under 25 kg Zn SO_4 ha^{-1}. Net returns (₹. 23198.7 ha^{-1}) and B: C ratios (2.43) were recorded highest with 25 kg Zn SO_4 ha^{-1} and lowest with control.

Key words: Zinc response, yield, zinc uptake, zinc use efficiency, residual zinc, rice.

INTRODUCTION

Out of the seventeen essential elements required for plant growth, Zn is ranked as the fourth most deficient element in Indian soils after N, P and K. Shukla and Behera (2011) reported that 49% of the Indian soils are deficient in Zn. Singh (2009) reported that 34% of the acidic soils of Assam are deficient in Zn. However, recently Shukla (2011) reported about 25% of Zn deficiency in the state of Assam. Zn deficiency continues to be one of the key factors in determining rice production in several parts of the country (Chaudhary *et al*., 2007). Rice is the stable food for more than half of the world population and it provides 21% and 15% per capita of dietary energy and protein, respectively (Maclean *et al*., 2002). At present, lowland rice occupies about 39% of the total cropped area of Assam (Adhya *et al*., 2008). Being the single major source of Agricultural GDP, rice plays a significant role in the state economy. Considering the intensive cultivation of high yielding rice varieties and acidic soil reactions in the rice growing areas of Assam, the response of rice to applied Zn is the subject deserving investigation. In Assam, most of the cultivable land especially rice growing soils are showing Zn deficiency and information in relation to Zn fertilizer management is inadequate. However, though response to zinc application was observed in deficient and marginally zinc deficient areas, but an optimum level of zinc had not been determined and data available are not sufficient to assess an optimum level of zinc in relation to agro climatic conditions of Assam. Therefore, this study was conducted with an objective to find out a suitable level of zinc fertilizer to supply the zinc requirement to increase the yield and productivity of rice in acidic low lying rice growing areas.

MATERIALS AND METHODS

Field experiments were conducted during 2011 and 2012 in the Instructional Cum Research Farm of Assam Agricultural University, Jorhat situated at 26^0 43' 14.1" N and 94^0 11' 42.6" E. The physico-chemical characteristics of the soil were: sandy clay loam in texture, pH 5.2, EC 0.02 dSm^{-1}, organic carbon 8.2 g kg^{-1}, available N 286 $kgha^{-1}$, Bray's P 26 $kgha^{-1}$, K 284 $kgha^{-1}$ and DTPA Zn 0.55 $mgkg^{-1}$. The experiment consisted of six levels of $ZnSO_4$ (0, 5, 10, 15, 20 ,25 and 30 Kg ha^{-1}) which corresponds to 0, 1.05, 2.1, 3.15, 4.2, 5.25, and 6.3 Kg Zn ha^{-1} in a randomised block design with three replications. Twenty five days old seedlings of rice var Ranjit were transplanted with three plants per hill at a spacing of 20x20 cm surrounded by 30 cm wide bunds. Recommended dose of Urea, SSP, and MOP were applied @ 60kg N + 20 kg P_2O_5 + 40 kg K_2O ha^{-1} along with 2t ha^{-1} compost as broadcast and incorporated into the soil by puddling just before transplanting. Urea was applied in three splits viz. at basal, maximum tillering and panicle initiation stage. Plant growth was measured by taking plant height, total tillers, effective tillers, filled grain, saffy grain and thousand grain weight. Crops were harvested at maturity and grain and straw yields were recorded. Dried grain and straw samples were ground and digested in diacid mixture and zinc concentration was determined in Atomic Absorption spectrophotometer. Zinc uptake in grain and straw was calculated by multiplying the grain and straw yield with respective zinc concentration. Zinc use efficiency (kg grain kg^{-1} Zn) and apparent zinc recovery (%) of rice grains were calculated following the procedure of Baligar *et al*. (2001).

RESULTS AND DISCUSSION

Yield: Grain and straw yield of rice responded significantly to zinc application (Table 1). Grain and straw yield increased gradually with the increase in zinc levels. All the treatments produced significantly different grain and straw yield. The grain yield ranged from 2.64 t ha^{-1} to 4.59 t ha^{-1} and straw yield from 5.51 t ha^{-1} to 6.64 t ha^{-1} due to zinc application. The highest grain (4.59 t ha^{-1}) and straw yield (6.64 t ha^{-1}) was found in the treatment receiving 25 kg $ZnSO_4$ ha^{-1} which was significantly higher than all other treatments. The percent increase in grain yield due to zinc application among the treatments varied from 34.4% to 73.8% over control, while in straw yield, percent increase varied from 3.6 to 20.5 percent. Fageria *et al*. (2011) reported 97% increase in rice yield due to zinc fertilization. Similar increase due to Zn application in dry matter and grain yields in different crops have also been reported by Kumar *et al* (2011) and Nagarathna *et al* (2010). The increase in grain and straw yield with application of zinc may be attributed to adequate supply of zinc that might have increased the availability and uptake of other essential nutrients resulting in improvement in metabolic activities and also due to the effect of zinc on the proliferation of roots. Similar findings were also reported by Muthukumaraja *et al*. (2013).

Table 1: Yields of grain and straw and zinc content as affected by zinc (mean data of 2 years)

Treatments $ZnSO_4$ ($kgha^{-1}$)	Grain yield ($t\ ha^{-1}$)	% response	Straw yield ($t\ ha^{-1}$)	% response	Zinc in grain ($mg\ kg^{-1}$)	Zinc in straw ($mg\ kg^{-1}$)
0	26.41		55.08		17.4	32.5
5	35.51	34.45	57.13	3.72	20.4	33.8
10	35.68	35.1	58.68	6.53	18.2	40.7
15	41.60	57.51	63.06	14.48	18.3	42.2
20	42.61	61.34	65.24	18.44	20.1	39.3
25	45.92	73.87	66.40	20.55	21.7	45.6
30	43.74	65.61	63.07	14.51	20.8	45.4
S.Em	0.69		1.24		0.49	1.5
CD (0.05%)	1.50		2.70		1.06	3.27

Content and uptake of zinc: Zinc concentration (Table 1) and uptake (Table 2) in grain and straw increased gradually with the increase in zinc level up to 25 kg $ZnSO_4$ ha^{-1} and then decreased at 30 kg $ZnSO_4$ ha^{-1}. It was observed that maximum zinc uptake of 97.5 g ha^{-1} and 311.7 g ha^{-1} was recorded with 25 kg $ZnSO_4$ ha^{-1} in grain and straw, respectively which was statistically higher than the treatment receiving 30 kg $ZnSO_4$ ha^{-1}. Dwivedi and Tiwari (1992) also reported that zinc concentration and uptake in grain and straw increased with zinc rate particularly in zinc deficient soils.

Table 2: Effect of zinc on zinc uptake in grain and straw

Treatment $ZnSO_4$ ($kgha^{-1}$)	Zinc uptake in grain (gha^{-1})			Zinc uptake in straw (gha^{-1})		
	2011	2012	mean of two years	2011	2012	mean of two years
0	39.8	51.6	45.8	164.6	194.0	179.3
5	56.3	88.6	72.5	182.3	204.1	193.2
10	59.7	69.8	64.8	236.1	240.9	238.5
15	72.1	79.8	75.9	260.7	272.3	266.5
20	79.6	94.7	87.1	239.6	274.1	256.8
25	97.4	99.6	97.5	302.1	321.3	311.7
30	87.8	89.5	88.6	271.0	301.9	286.5
S.Em	4.41	3.67	3.31	19.73	8.42	10.26
CD (0.5%)	9.6	7.99	7.21	42.99	18.35	22.36

Efficiency indices: Apparent Zn recovery decreased significantly with higher Zn levels (Table 3).This was due to inverse relationship often observed between utilization and rate of application. The maximum values of apparent Zn recovery was noted at 5 kg $ZnSO_4$ ha^{-1}. Thereafter, it tended to decrease with increasing levels of Zn and minimum values were recorded at 30 kg $ZnSO_4$ ha^{-1}.

Available Zn: The mean available Zn content of soil was depleted under control. The mean initial available Zn status of soil which was 0.55 mg $kg\text{-}^{1}$ decreased to 0.50mg kg^{-1} after harvest of rice crop. The zinc status of soil varied from 0.50 mg kg^{-1} at control to 1.30 mg kg^{-1} at 30 kg Zn SO_4 ha^{-1}. Depletion of soil available Zn in control without Zn supply and its build up in zinc fertilizer plots has also been reported by Singh (2009).

Economics

Economic analysis of different treatments revealed that the highest cost of cultivation (₹.16230.3 ha^{-1}) was recorded in 30 kg $ZnSO_4$ ha^{-1}. The gross return (₹.39420), net Return (₹.23198.7 ha^{-1}) and B: C ratio (2.43) were recorded highest with 25 kg $ZnSO_4$ ha^{-1}. This might be due to higher yield obtained in this

Table 3: Apparent Zn recovery and available Zn as affected Economic by different treatments

$ZnSO_4$ (kgha^{-1})	Gross Return (₹/ha)	Net Return (₹/ha)	B:C ratio	Apparent Zn recovery (%)	Avail. Zn (mg kg^{-1})
0	202201.5	7760.2	1.47	-	0.50
5	30917.25	14729.95	1.91	2.54	0.75
10	31161	14964.7	1.92	0.90	0.90
15	35929.5	19725.2	2.22	0.96	1.06
20	36850.5	20637.2	2.27	0.99	1.20
25	39420	23198.7	2.43	0.98	1.25
30	37535.25	21304.95	2.31	0.68	1.30
SEm ±	-	-	-	-	0.10
CD (P=0.05)	-	-	-	-	0.21

treatment compared to all other treatments. On the other hand, lowest net returns (₹. 7760.2 ha^{-1}) and B:C ratio (1.47) were recorded under control due to lower yields of grain and straw.

From the present study, it can be concluded that application of 25 kg $ZnSO_4$ ha^{-1} proved significantly beneficial in respect of yield and economics of rice grown in acidic soils of Assam.

REFERENCES

Adhya, T.K.; Singh, O.N.; Swain, P. and Ghosh, A. (2008) Rice in Eastern India: Causes of low productivity and available options.*Journal of Rice Research*, 2(1) :1-5.

Baligar V.C, Fageria N.K, and Z.l. He (2001) Nutrient use efficiency in plants. *Communication in Soil Science and Plant Analysis*. 32: 921-950.

Choudhary, S.K., Thakur, S.K and pandey, A.K. (2007) Response of wet land rice to nitrogen and zinc. *Oryza*. **44** :31-34.

Deb, D.L. (1992) Development of soil and plant analytical methods for micronutrient and sulphur in Sri Lanka.GCPF/SRI/047/NET field document No.11 pp: 42-54

Dwived, B.S and Tiwari, K.N (1992) Effect of native and fertilizer zinc on drymatter yield and zinc uptake by wheat. (*Triticum aestivum* L.) in Udic Ustochrepts. *Tropical Agriculture* 69:357-361.

Fageria, N.K., Dos Santos, A.B. and Cobucci, T. (2011) Zinc nutrition of lowland rice. *Communication in Soil Sci and Plant Analysis*. 42: 1719-1727.

Fageria, N.K., Slaton, N.A. and Baligar, V.C. (2003).Nutrient management for improving lowland rice productivity and sustainability. *Advances in Agronomy* **80**: 63-65.

Gupta Shelley and Handore Kalpana (2009) Direct and residual effect of zinc and zinc amended organic manures on the zinc nutrition of field crops. *International Journal of Agriculture Sciences* 1:26-29

Kumar. V., Bhatia. B.K. and Shukla. U.C. (2011) Effect of different levels of zinc on growth and yield of amaranth. *Soil Sci* 131: 151-155.

Maclean, J.C., Dawe, D.C., Hardy B. and Hettal, G.P(2002) Rice almanac (3rdedition) CABI publishing willing ford , pp 253

Muamba J. Kabeya and Ambara G. Shankar (2013) Effect of different levels of zinc on growthand uptake ability in rice zinc contrast lines (*Oryza sativa* L.*) Asian Journal of Plant Science and Research* 3(3):112-116

Muthukumararaja, T.M. and M.V. Sriramachandrasekharan (2012) Effect of zinc on yield, zinc nutrition and zinc use efficiency of lowland rice. *Journal of Agricultural Technology* :8(2): 551-561

Muthukumararaja, T.M. and M.V. Sriramachandrasekharan (2013) Response of rice genotypes to zinc fertilization in Typic Haplustert soil. *Indian Journal of applied Research* 3(2): 27-29

Nagarathna, T.K., Shankar, A.G. and Udayakumar, M. (2010) Assessment of genetic variation in zinc acquisition and transport to seed in diversified germplasm lines of rice (*Oryza sativa*) *Journal of Agricultural Technology* 6 (1): 171-178.

Navarro, E.L. and Kirschey, K.G. (1980) ZnO application to soil and its residual effect on rice. *Journal of Crop Science*. **5**(3): 100-104.

Reza Yadi, Salman Dastan and Esmaeil Yasari (2012) Role of zinc fertlizer on grain yield and some qualities parameters in Iranian Rice genotype. *Annals of Biological Research* 3:4519-4527.

Shehu H.E., Jamala G.Y and Musa A.M (2011) Response of transplanted irrigated rice (faro, 44) to applied zinc by nursery enrichment of Fadama soil in AdamawaState, Nigeria. *World Journal of Agricultural Sciences* 7:143-148.

Shukla, A. K, (2011) Micronutrient research in India: Current status and future strategies. *Journal of the Indian Society Soil Science* **59**: S88-S98.

Shukla, A.K. and Behera, S.K. (2011) Zinc management in Indian Agriculture. *Indian Journal of fertilisers*. 7:14-33.

Singh, M.V. (2009) Micronutrient nutritional problems in soils of India and improvement for human and animal health. *Indian Journal of Fertilizer* **5**(4): 11-26.

Slaton, N. A., Normon, R.J and Wilson, Jr.C.E (2005) Effect of zinc source and application time on zinc uptake and grain yield of flood irrigated rice. *Agronomy Journal* **92**:272-278.