Annals of Plant and Soil Research 19(3): 315-318 (2017)

Zinc requirement of rice (*Oryza sativa*) crop in alluvial soil

S.V.S.CHAUHAN[1], BHOOPENDRA SINGH RAGHAV AND DHARVENDRA SINGH

RVSKVV-Krishi Vigyan Kendra, Morena (M.P.0-476001

Received: May, 2017; Revised accepted: August, 2017

ABSTRACT

A field experiment was conducted during kharif seasons of 2014 and 2015 at Baghel village of Morena district (M.P.) to assess the effect of different levels of applid Zn on growth, yield attributes, yield and quality of rice (Oryza sativa L.) crop. The experiment was laid out in randomized block design with five levels of zinc (0, 2, 4, 6 and 8 kg Zn ha^{-1}) with four replications. Results revealed that the application of 6 kg Zn ha^{-1} in rice recorded significantly highest plant height (98.6 cm), dry matter/hill (60g), panicles/m^2 (355), grains/panicle (138.1) and test weight (25.55) Rice crop responded significantly up to 6 kg Zn ha^{-1} by producing 6.15t ha^{-1} grain and 8.75t straw ha^{-1}. The content and yield of protein in rice crop increased significantly with increasing levels of zinc and maximum values were recorded with 8 kg Zn ha^{-1}. The uptake of zinc by grain and straw increased significantly from 94.8g ha^{-1} at control to 184.5g ha^{-1} and from 221.4 to 315.0g ha^{-1} with 6 kg Zn ha^{-1}. A phenomenal increase in N uptake was recorded in rice grain and straw due to increasing levels of zinc up to 6 kg Zn ha^{-1}. The values of efficiency indices decreased with the increase in levels of zinc. The apparent zinc recovery was highest at lower level (1.88%) of zinc application (2 kg Zn ha^{-1}) and decreased with increase in zinc dose. Better zinc use efficiency in rice (162.5 kg produce/kg Zn) was obtained with 4 kg Zn ha^{-1}.

Keywords: Alluvial soil, nutrient uptake, quality, yield, rice, zinc

INTRODUCTION

Rice (*Oryza sativa* L.), the most important cereal crop in India, occupies nearly 35% of the total area under food grains and 15-20% of the cropped area of rice comes under kharif acreage. Cultivation of high yielding dwarf varieties is responsive to fertilizer. Continuous and imbalanced use of selected fertilizer nutrients have resulted in deterioration of soil health and as a consequences, deficiencies of zinc and other micronutrients are increasing (Singh and Singh 2017). Zinc is one of the essential plant micronutrient and its importance for crop production is similar to that of major nutrients. Zinc has specific and essential physiological functions in plant metabolism. It plays major role in synthesis of tryptophan, which is precursor of indole acetic acid, Zinc is also important in protein synthesis. At several places normal yield of crops could not be achieved despite judicious use of NPK fertilizer due to zinc deficiency. Zinc deficiency is wide spread throughout the country. Nearly 50% of the cultivated soils in India are low in plant available zinc and these soils are under intensive cultivation with no or little application of zinc fertilizers. The low soil Zn status is an important limiting factor responsible for poor yields of the crops (Kamini Kumara, 2017). It is imperative to evaluate the response of Zn nutrition on rice productivity. Therefore, zinc management needs greater attention in crop production to combat with wide spread zinc deficiency in many rice growing areas. Since, not much work has been done to assess the response of rice to zinc application in Morena district of Madhya Pradesh. Therefore, present study was undertaken to study the effect of levels of zinc on yield and quality of rice.

MATERIALS AND METHODS

Field experiment was conducted during rainy seasons of 2014 and 2015 at farmer's field at Baghel village of Morena district of Madhya Pradesh. The soil of the experimental field had 155 kg N ha^{-1}, 15 kg P ha^{-1}, 195 kg K ha^{-1} and 3.5g kg^{-1}organic carbon. The pH of the soil was 7.5 (1:2.5 soil water ratio) and DTPA-extractable Zn in soil was 0.57 mg kg^{-1}. The experiment was laid out in randomized block design with four replications. The treatments, comprised of five levels of Zn (0, 2, 4, 6 and 8 kg Zn ha^{-1}) supplied through zinc sulphate at the time of transplanting. Twenty five days old seedlings of rice variety Pusa Basmati 1509 were transplanted with three plants per hill at a spacing of 20x20 cm distance. Recommended dose of 150 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1}

Corresponding author email: chauhansukhvirsingh@gmail.com

were applied through urea, diammonium phosphate and muriate of potash, respectively. Nitrogen was applied at three splits viz. at basal, maximum tillering and panicle initiation stage. Plant growth and yield attributes were recorded at harvest. The crop was harvested at maturity and grain and straw yields were recorded. The grain and straw samples were analyzed for nitrogen by modified Kjeldahl method (Jackson, 1973). These samples were digested in di acid mixture (HNO_3:$HClO_4$) and zinc concentration was determined on atomic absorption spectrophotometer. The uptake of nutrients in grain and straw was calculated by multiplying the grain and straw yield with respective zinc concentration. The protein content was computed from the nitrogen content multiplied by a factor 6.25. The following formulae were used to calculate zinc use efficiency and apparent Zn recovery:

Zinc use efficiency (kg produce/kg Zn applied) = Yield (F) – Yield (C)/Fertilizer Zn applied

Apparent Zn Recovery (%) = [Uptake of Zn in treated plot – Uptake of Zn in control plot/applied Zn dose] x 100

Where F and C are fertilizer treated and control plot, respectively.

Data obtained from consecutive two years were statistically analyzed as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth parameters

Effect of Zn application of plant height, tillers/m^2, dry matter accumulation/hill at harvest was significant over no zinc application. These parameters increased significantly up to 6 kg Zn ha^{-1} over the control. These growth attributes tended to decrease with higher level (8 kg ha^{-1}) of zinc over 6 kg Zn ha^{-1}. Zinc nutrition is known to increase the tillering in rice, which might have caused a significant increase in dry matter accumulation Jat *et al.* (2011) have also observed an increase in dry matter accumulation of rice by application of zinc.

Yield attributes and yield

Number of effective tillers/m^2, panicles/m^2, panicle length, panicle weight, grains/panicle and test weight were positively influenced with zinc application. The maximum values of these yield attributes were recorded with 6 kg Zn ha^{-1}. Adequate Zn levels in soil increased tillering and consequently the number of panicles/m^2. The increase in Zn availability might be responsible for increased number of leaves, resulting in higher photosynthesis, metabolic and cell division which consequently increased growth and hence yield attributes (Jat *et al.* 2011). Application of graded doses of zinc to rice significantly enhanced the grain and straw yield over control (Table 1). The maximum grain (6.15 t ha^{-1}) and straw (8.75 t ha^{-1}) yields were recorded with 6 kg Zn ha^{-1} over rest of the treatments, but was on a par with 8 kg Zn ha^{-1}. Application of 6 kg Zn ha^{-1} increased the grain and straw yield of rice to the tune of 16.7 and 17.8 % over the control, respectively. The favourable influence of Zn application on the yield of rice 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 crop. Increase in yield owing to application of zinc is quite obvious, as the soil under study was deficient in available zinc (0.57 mg kg^{-1}). Yadav *et al.* (2013) and Kulhare *et al.* (2014) reported similar results in rice.

Table 1: Effect of zinc levels on growth and yield attributes and yield of rice (mean of 2 years)

Zn (kg ha^{-1})	Plant height (cm)	Dry matter /hill (g)	Panicles / m^2	Panicle length (cm)	Panicle weight (g)	Grains /panicle	Test weight (g)	Yield (t ha^{-1})	
								Grain	Stover
0	94.6	49.5	306	24.1	2.13	135.4	24.18	5.27	7.43
2	95.9	53.0	317	25.3	2.16	136.1	24.76	5.52	7.78
4	96.9	56.0	335	26.1	2.34	137.0	25.25	5.92	8.13
6	98.6	60.0	355	26.2	2.48	138.1	25.55	6.15	8.75
8	98.1	58.6	347	25.8	2.37	137.8	24.66	6.11	8.53
SEm±	0.97	1.41	3.97	0.91	0.05	0.6	0.08	0.09	0.73
CD (P=0.05)	2.10	3.03	8.65	1.96	0.11	1.3	0.17	0.19	1.56

Quality

The protein content in grain and straw of rice increased from 9.6 to 10.8 % and 2.6 to 3.2 %, respectively with 8 kg Zn ha^{-1} (Table 2). This increased in protein content with Zn addition may be attributed to its involuement in nitrogen metabolism. Singh and Singh (2017) reported an increase in protein content with zinc addition in maize. The protein yield increased significantly with each increment of zinc dose. The highest protein yield was obtained with kg Zn ha^{-1} which was significantly higher than the control and lower levels of zinc. This was mainly owing to higher grain yield and protein content in rice grain. Since, variation in protein content has genetic and biochemical limitation, the protein yield is more influenced by grain yield and thus followed almost trend similar to grain yield Singh *et al.* (2008) reported similar results.

Table 2: Effect of zinc levels on quality, nutrient uptake and efficiency indices in rice (mean of 2 years)

Zn (kg ha^{-1})	Protein content (%)		Protein yield (kg ha^{-1})	N uptake (kg ha^{-1})		Zn uptake (g ha^{-1})		Zn apparent recovery (%)	Zn use efficiency (kg produce/kg Zn)
	Grain	Stover		Grain	Stover	Grain	Stover		
0	9.6	2.6	505.8	81.6	30.5	94.8	221.4	-	-
2	9.8	2.7	541.0	87.2	33.4	132.5	241.2	1.88	125.0
4	10.1	2.9	597.9	95.9	37.4	156.3	277.2	1.53	162.5
6	10.4	3.1	639.6	115.0	42.8	184.5	315.0	1.49	146.3
8	10.8	3.2	349.0	104.5	43.5	183.9	308.8	1.13	92.5
SEm±	0.09	0.05	10.9	2.67	1.35	7.71	9.88	-	=
CD (P=0.05)	0.19	0.11	23.2	5.75	2.92	16.58	21.24	-	-

Nutrient uptake

Nitrogen uptake by grain and straw of rice increased significantly with increasing levels of zinc and the highest N uptake was observed with 6 kg Zn ha^{-1}, i.e. 115.0 and 42.8 kg ha^{-1} and lowest in the control i.e. 81.6 and 30.5 kg ha^{-1} (Table 2). Thus, the beneficial effect of Zn on photosynthesis and metabolic processes augments the production of photosynthates and their translocation to different plant parts including grain, which ultimately increased the uptake of N in grain and straw. These results are in accordance with the findings of Jena and Nayak (2016). Zinc uptake by rice grain and straw increased significantly with increasing levels of zinc application over control (Table 2). Highest zinc uptake was found with 6 kg Zn ha^{-1} and lowest in control. The increase in Zn uptake by grain and straw with 6 kg Zn ha^{-1} was from 94.8 to 184.5 g ha^{-1} and 221.4 to 315.0 g ha^{-1}, respectively over the control, respectively. The higher zinc removal due to Zn application could be attributed to the priming effect caused by higher crop growth and consequently higher removal due to balanced fertilization. The uptake of nutrient is a function of yield and its concentration in crop. As the application of Zn increases, the yield as well as Zn concentration increased and hence the Zn uptake also increased. Similar findings have also been reported by Yadav *et al.* (2013) in maize.

Efficiency indices

Zinc fertilization had a significant effect on agronomic efficiency of applied zinc for rice crop. The maximum value of zinc use efficiency for rice was at 4 kg Zn ha^{-1}. Agronomic efficiency decreased as the level of Zn fertilization increased (Table 2). Zinc use efficiency in rice declined from 162.5 to 92.5 kg grain/kg Zn when the level of zinc was increased from 4 to 8 kg Zn ha^{-1}. Similar results were reported by Yadav *et al.* (2013). Recovery efficiency of zinc in rice was the highest with application of 2 kg Zn ha^{-1} and lowest at 8 kg Zn ha^{-1}. Kandali *et al.* (2015) also reported a decrease in apparent zinc recovery at higher levels of zinc application.

From the present study, it can be concluded that application of 6 kg Zn ha^{-1} proved significantly beneficial in respect of yield, quality and uptake of nutrients in rice in soils of Morena district.

REFERENCES

Gomez, K.A. and Gomez, A.A. (1984) *Statistical procedures for Agricultural Research Second Edition*, John willey and Sons, New York.

Jackson M L. (1973) Soil *Chemical Analysis*, Prentice Hall of India Private Limited, New Delhi.

Jat, S.L., Shivay, Y.S, and Parchor, C.M. (2011) Dual purpose summer legumes and zinc fertilization for improving productivity and zinc utilization in aromatic hybrid rice (*Oryza sativa*). *Indian Journal of Agronomy* **56** (4): 328-333.

Jena, B. and Nayak, R.K. (2016) Enhancing nitrogen use efficiency and yield of rice with zinc and boron application in Inceptisol of Odisha. *Annals of Plant and Soil Research* **18** (1): 79-82.

Kamini Kumari (2017) Yield, quality and nutrient uptake of rabi fodder crops in response to zinc. . *Annals of Plant and Soil Research* **19**(2): 219-202.

Kandali, G.G., Basu matary, A., Barua, N.G., Bedhi, B.K. and Hazarika, S. (2015) Response of rice to zinc application in acidic soils of Assam. *Annals of Plant and Soil Research* **17**(1): 74-76.

Kulhare, P.S., Sharma, G.D., Sharma, B.L. and Khamparia, R.S. (2014) Direct and residual effect of Zn and organic manures on yield, Zn content and uptake in rice (*Oryza sativa*)-wheat (*Triticun aestivum*) sequence on a Vertisol. *Journal of the Indian Society of Soil Science* **62** (3): 274-279.

Singh, S. and Singh, V. (2017) Productivity, quality and nutrients uptake of maize (*Zea mays*) as influenced by sources and levels of zinc.*Annals of Plant and Soil Research* **19** (1): 85-99

Singh, V., Singh, S. and Singh, J.P. (2008) Direct and residual effect of zinc on yield and its uptake in rice-wheat cropping system. *Annals of Plant and Soil Research* **10** (1): 48-51.

Yadav, B., Khamparia, R.S. and Kumar, R. (2013) Effect of zinc and organic matter application on various zinc fractions under direct seeded rice in Vertisols. *Journal of the Indian Society of Soil Science* **61** (2): 128-134.