Annals of Plant and Soil Research 18(1): 79-82 (2016)

ENHANCING NITROGEN USE EFFICIENCY AND YIELD OF RICE WITH ZINC AND BORON APPLICATION IN *INCEPTISOL* OF ODISHA

BANDITA JENA[1]* AND R.K. NAYAK

[1]Micronutrient Laboratory, Department of Soil Science and Agricultral Chemistry, Orissa University of Agriculture and Technology, Bhubaneswar (Odisha)-751003

Received: October, 2015; Revised accepted: January, 2016

ABSTRACT

A field experiment was conducted at central research station of OUAT, Bhubaneswar to study the effect of zinc and boron in enhancing nitrogen use efficiency and yield of rice grown in Inceptisols. The experiment was laid out in sandy loam Inceptisols with split plot design and total 18 treatments formed by three levels of N (0, 40 and 80 kgha^{-1}) in main plot and three levels of Zn (0, 2.5 and 5 kgha^{-1}), two levels of boron (0 and 1 kg ha^{-1}) in subplots. The results of the field experiment revealed that at 40 kg N +5 kg Zn + 1 kg B ha^{-1}level highest grain yield of 39.48qha^{-1} was recorded, which was 83% higher over no micronutrient control ($N_{40}Zn_0B_0$). Nitrogen uptake had positive and significant correlation with Zn and B uptake in grain. Highest agronomic nitrogen efficiency and physiological efficiency of 44.85 and 1.02kg/kg, respectively was observed with 5.0 kg Zn + 1.0 kg B + 40 kg N ha^{-1}. Highest nitrogen recovery efficiency (1.13kg/kg) was observed in combined application of 5.0 kg Zn + 1.0 kg B + 40 kg N kgha^{-1} treatment.

Keywords: Nitrogen use efficiency, Inceptisols, zinc, boron, yield, Rice.

INTRODUCTION

Most of agricultural soils of India are deficient in nitrogen. Nitrogen is normally a key factor in achieving optimum lowland rice grain yields (Fageria *et al.,* 1997)**.** Nitrogen is comparatively cheaper and its effects are quickly visible therefore farmers give priorities to nitrogen application. But nitrogen is subjected to different types of losses resulting in very low N-use efficiency. The low N-use efficiency is attributed mainly due to ammonia volatilization, denitrification, leaching, and runoff losses**.** Nitrogen use efficiency (NUE) is very low (20-30% only) under rice cultivation. So there is a potential to increase in nitrogen use efficiency by application of micronutrients. Although micronutrients are needed in much smaller quantities as compared to primary nutrients, they have major role in terms of their impact on crop growth and productivity. Among micronutrients, zinc and boron are known to be required for all higher plants as essential crop nutrients and are well documented to be involved in photosynthesis, N-fixation, respiration and other biochemical pathways (Cakmak and Marschner., 1988**).** Since, soils of Odisha are deficient in micronutrient like zinc and boron along with low nitrogen use efficiency in the rice grown soils, the present investigation was taken up with the objective of response of combined application of nitrogen, zinc and boron on grain and straw yield of rice, nutrient uptake and NUE in rice.

MATERIALS AND METHODS

The experiment was conducted during *kharif* of 2011 at central research station, O.U.A.T, Bhubaneswar, which is situated at 20 ^{0} 15$''$N latitude and 85^{0} 52 $''$ E longitude, elevation of 25.9 m above MSL (Mean sea level). It is situated at about 64 km away from the Bay of Bengal within the East and South Eastern Coastal plain agro-climatic zone of Odisha and falls under the East Coastal Plains and Hills zone of the humid tropics of India. Bhubaneswar experiences a warm and moist climate with hot and humid summer and a mild winter. The soil of the site was *Inceptisols*. The experimental site was sandy loam in texture, pH 6.1, nonsaline, organic carbon 4.0 g kg^{-1}, low in nitrogen(165 kgha^{-1}), Zn(0.4 mgkg^{-1}) and B(0.42 mgkg^{-1}). Eighteen different treatments were selected by taking 3 levels of N (N_0,N_{40} and N_{80} as main plot) and 3 levels of Zn (0, 2.5 and 5 kg/ha) with 2 levels of B(0 and 1 kgha^{-1}) in subplot. Treatments were replicated thrice in split plot design. The crop received recommended dose of P and K. Full dose of zinc as $ZnSO_4.7H_2O$,boron as borax with P and half dose of N and K were applied at transplanting. Rice seedlings (cv. Lalat) of 21 days old were transplanted on 15.7.12. Rest N and K were applied in two splits at tillering and PI stage .Crop was harvested at maturity. Soil and plant samples were collected for nutrient analysis. Nitrogen in plant samples was estimated by Kjeldahl method and soil

[1]* *Corresponding author's e-mail:mnsouat@gmail.com*

available N by alkaline $KMnO_4$ method. Available Cu, Fe and Zn in post harvest soil extracted with DTPA (Lendsay and Norvell 1978) and were determined on atomic absorption spectrophotometer. Boron in hot water expact was determined by azomethine – H colorimetric method. Nitrogen uptake was calculated by multiplying N concentration in plant tissue with yield. The data recorded were analysed statistically as per split plot design (Gomez and Gomez 1984). Efficiency parameters like NUE was calculated as: NUE (kg/kg) = (yield in treatment plot-Yield in control)/Nutrient applied (kg/ha)

RESULTS AND DISCUSSION

Crop Yield

The application of graded doses of nitrogen and micronutrients (Zn, B) significantly enhanced the rice grain and straw yield over control (Table 1). Mean rice grain yield increased significantly upto 40 Kg Nha^{-1} level thereafter yield decreased at higher N level which may be due to high N dose favouring vegetative growth .Similarly, application of micronutrients gave significant yield increase producing highest mean yield of 34.79 qha^{-1} at a dose of 5 kg Zn + 1 kg B ha^{-1}. However, better improvement in yield was observed when nitrogen was applied in combination with Zn and B. Highest grain yield of 39.48 qha^{-1} was produced at a combined application of 40kg N + 5 kg Zn +1 kg B ha^{-1} which may be attributed to synergistic effect of Zn and B on flowering and fruit setting. An increase in yield by 4.7 to 25.4 % in rice was observed by B application. Similar findings were also observed by Nagula *et al.* (2015). Unlike rice grain yield, rice straw yield increased with increase in N dose up to 80 kg level. The results are in agreement with Singh *et al.* (1993). Higher levels of nitrogen application increased tallness and make the crop more succulent and prone to lodge that decreased number of grains/panicle resulting lower grain yield.

Table 1: Effect of treatments on grain and straw yield of rice

Treatments	Grain Yield(q/ha)			Mean	Straw Yield(q/ha)			Mean
	N0	N1	N2		N0	N1	N2	
M1- Zn0B0	21.54	32.27	30.56	28.12	22.67	36.67	39.33	32.89
M2- Zn0B1	22.56	35.31	33.70	30.52	23.17	39.57	40.0	34.27
M3- Zn1B0	23.61	36.84	34.45	31.63	24.17	41.0	44.33	36.5
M4- Zn1B1	24.15	37.17	35.74	32.63	26.0	45.67	48.0	39.89
M5- Zn2B0	24.82	37.69	34.46	32.32	26.33	46.67	48.67	40.56
M6- Zn2B1	31.14	39.48	33.74	34.79	29.35	48.67	50.0	42.67
Mean	24.64	36.46	33.78		25.28	43.04	45.6	
C.D.(0.05)	N 4.03, M 5.03, NxM 8.71				N 5.25, M 6.28, NxM 10.87			

Economics

Since micronutrients (Zn and B) are costly inputs and involve in increasing nitrogen use efficiency, hence cost was calculated to test the effectiveness of cultivation. It was found (Table 2) that there was a net positive return of Rs. 4787 /- ha^{-1} after meeting the expenses towards Zn and B at 40kg N ha^{-1}. Extra yields produced by inclusion of Zn and B was sufficient to meet the expenditure of micronutrients with some surplus money.

Table 2: Effect of Zn and B on economics of rice over optimum nitrogen

Treatments	Net Return (Rs.)/ha Over N @40	B:C ratio
N40Zn0B0	-	-
N40Zn0B1.0	2283.2	2.07
N40Zn2.5B0	3935.6	3.9
N40Zn2.5B1.0	3292	1.57
N40Zn 5B0	3853.6	1.92
N40Zn 5B1.0	4786.8	1.54

Nutrient Uptake

The effect of micronutrients (Zn and B) alone or in combination with nitrogen significantly influenced nitrogen uptake by rice grain (Table 3). The results showed that mean nitrogen uptake increased significantly up to 40 kg Nha^{-1} application. Similarly zinc and boron application increased nitrogen uptake significantly over no Zn and B treatment. But better improvement in N uptake was observed by combined application of 2.5 kg Zn ha^{-1} with 40 kg N ha^{-1}. It indicated that application of zinc is more effective with nitrogen than boron which may be due to synergistic effect of N and Zn.. Zinc has appositive role in protein synthesis which may be the cause of enhancing nitrogen utilisation in presence of Zn (Das 2007). The N uptake in grain with higher dose of 80 kgN ha^{-1}) along with Zn and B was almost at par with 40 kgNha^{-1} level which varied from 45.0 to 53.4 kg ha^{-1}.

Table 3: Effect of Zn and B on nitrogen uptake (kgha^{-1}) by rice grain

Micronutrients (kg ha^{-1})	Nitrogen(kg ha^{-1}) 0	40	80	Mean
M1- Zn0B0	14.22	40.91	45.04	33.39
M2- Zn0B1	25.99	46.68	45.26	39.31
M3- Zn1B0	31.42	50.30	47.38	43.03
M4- Zn1B1	25.35	47.44	49.86	40.88
M5- Zn2B0	26.4	50.11	53.45	43.32
M6- Zn2B1	33.44	41.85	44.56	39.95
Mean	26.14	46.21	47.59	
C.D.(0.05)	N 4.36 , M 7.57 ,NxM 13.11			

Efficiency Indices

It was observed that agronomic nitrogen use efficiency varied from 11.28 to 44.85 kg ha^{-1} with different treatments (Table 4). Highest value (44.85 kg ha^{-1}) was recorded with 40 kg N+ 5.0 kg Zn+ 1.0kg B ha^{-1} agronomic nitrogen use efficiency was 26.83kg/kg with out Zn and B, but with inclusion of 1kg B and 2.5 kg Zn ha^{-1} the efficiency were 34.44 and 38.25 kg/kg of N added, respectively. Combined application of 2.5 kg Zn +1kg B ha^{-1} further increased the NUE to 39.09 kgkg^{-1} N added. Highest efficiency was 44.85 kg/kg N added in treatment receiving higher dose of Zn @5and B @1 kg/ha (Fig.1). It indicates that with increased dose of Zn and B along with 40 kg Nha^{-1} efficiency gradually increased. However, at higher N dose (80 kg N) the ANUE was decreased. Other efficiency parameters like apparent N recovery and physiological efficiency were increased at optimum N application alongwith micronutrients (Zn and B).

Table 4: Effect of zinc and boron on agronomic nitrogen use efficiency (Kg Kg^{-1}) in rice

Treatments	Zn_0 B_0	Zn_0 $B_{1.0}$	$Zn_{2.5}$ B_0	$Zn_{2.5}$ $B_{1.0}$	$Zn_{5.0}$ B_0	$Zn_{5.0}$ $B_{1.0}$	Mean
N_{40}	26.83	34.44	38.25	39.09	40.38	44.85	37.31
N_{80}	11.28	15.20	16.14	17.76	16.16	15.26	15.30
Mean	12.71	16.55	18.13	18.95	18.85	20.04	

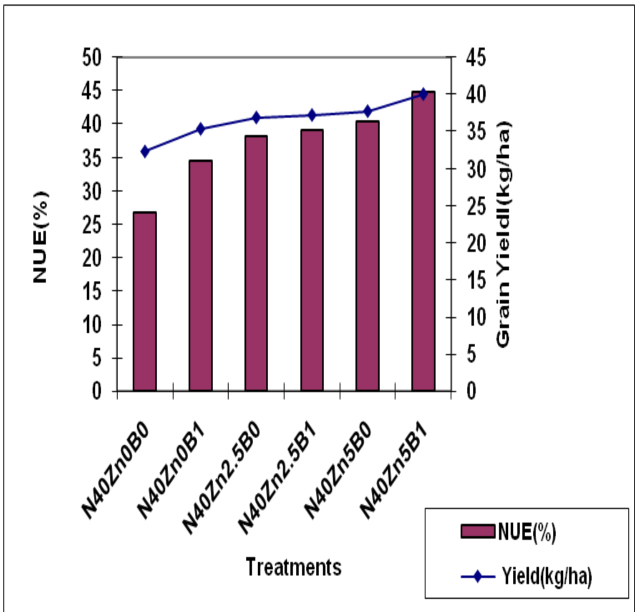

Fig. 1: Effect of micronutrients with RDN on grain yield and NUE of rice

Soil Fertility

After harvest the rice crop, the soil nutrients in post harvest soil were presented in Table 5. The nitrogen status of initial soil was low (165.2kg ha^{-1}). Post harvest soil status showed that average available N content at 0, 40 and 80 kg N ha^{-1} were in order of 119.3, 130.7 and 133.7 kgha^{-1}, respectively, which clearly indicated a declined status from initial value due to better utilisation from applied source as well as from native source. Similarly initial DTPA Zn content was 0.4 mg kg^{-1}, but after harvest average Zn content in treatments receiving 0, 2.5 and 5 kg Zn ha^{-1} were in order of 0.38, 1.08 and 1.33 mg kg^{-1}, respectively. It indicated that Zn status declined in plots not receiving any Zn fertilizer where as considerable build up of Zn was noted in Zn treated plots (Kandali *et al.* 2015). Initial soils had 0.42 mgkg^{-1} of Boron, but after harvest the boron status in soil at 0 and 1kg

B ha^{-1}, on an average was 0.36 and 0.72 mg kg^{-1}, respectively. It indicated that plant had taken a small portion of B for its requirement (Nagula *et al.* 2015).

Table 5: Nutrients status in post harvest soil

Treatment		N (kg ha^{-1})	Zn (mg kg^{-1})	B (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})
N_0	Zn_0B_0	96.53	0.30	0.32	1.13	48.96
	Zn_0B_1	91.87	0.29	0.67	0.93	41.26
	$Zn_{2.5}B_0$	88.28	0.75	0.32	0.87	64.86
	$Zn_{2.5}B_1$	90.89	0.80	0.26	0.90	58.90
	Zn_5B_1	88	0.92	0.32	1.00	56.92
	Zn_5B_1	85.88	0.98	0.45	1.13	69.01
N_{40}	Zn_0B_0	101.22	0.50	0.44	1.20	68.00
	Zn_0B_1	90.6	0.48	0.32	1.00	53.08
	$Zn_{2.5}B_0$	88.47	1.12	0.32	1.13	86.23
	$Zn_{2.5}B_1$	87.56	1.55	0.62	1.50	64.54
	Zn_5B_1	90.01	1.65	0.35	1.10	45.29
	Zn_5B_1	92	0.99	0.37	1.17	64.01
N_{80}	Zn_0B_0	128.58	0.32	0.36	1.07	38.43
	Zn_0B_1	127.07	0.35	0.77	1.33	73.10
	$Zn_{2.5}B_0$	122.09	0.91	0.61	0.87	47.25
	$Zn_{2.5}B_1$	125.83	1.10	1.16	1.07	94.15
	Zn_5B_1	114.8	1.19	0.18	1.43	55.75
	Zn_5B_1	123.72	1.81	1.02	1.10	80.55

It may be concluded that application of Zn and B alongwith nitrogen had significant effect in increasing grain yield. Efficiency parameters like apparent N recovery and physiological efficiency increased at optimum N application alongwith micronutrients. Hence, to get maximum utilisation of nitrogen in terms of yield, Zn and B may be applied with recommended dose of N.

Acknowledgement

Authors are thankful to ICAR for funding the Project

REFERENCES

Abdul Salam, M and Balasubramanian S. (1988) Influence of N, Zn and their interaction on yield & nutrient uptake of IR 20 rice(Oriza Sativa) in different seasons. *Indian Journal of Agricultural Sciences* **58**(3): 190-193.

Cakmak, I. and H. Marschner. (1988) Increase in membrane permeability and exudation in roots of zinc deficient plants. *Journal of Plant Physilogy* 132: 356-361.

Das, D.K.(2007) *Micronutrients:Their Behaviour in Soils and Plants*, 2nd Edition, Kalyani Publishers, PP-54-150

Fageria, N.K., Baligar, V.C., Jones, C.A. (1997) *Growth and Mineral Nutrition of Field Crops;* 2nd Ed; Marcel Dekker: New York.

Gomez, K.A and Gomez, A.A. (1984) Statistical procedures for agricultural research.Wiley Interscience, New York.

Kandali, G.G., Basumatary, A. Barua, N.G. Medhi, B.K. and Hazarika, S. (2015) response of rice to zinc application in acidic soil of Assam. Annals of Plant and Soil Research 17(1): 74-76.

Nagula, N., Biju Joseph and Gladies, R. (2015) Effect of silicon and boron on nutrient status and yield of rice in lateite soils. *Annals of Plant and soil Research* 17(3) : 299-302.

Sharma, R. (2015) Response of rice genotypes to nitrogen management. *Annals of Plant and Soil Research* **17**(4): 423-424.

Singh, G and Singh, O.P. (1993) Effect of method of seeding and levels of nitrogen on yield and yield attributes of rice under flood affected condition. *Indian Journal of Agronomy* 38(4): 551-554.