Asian J. of Bio Sci. (2006) Vol. **1** No. 2 : 89-91

The effect of micronutrients on yield attributes, yield and nutrient uptake of hybrid rice (*Oryza sativa* L.)

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(Accepted : April, 2006)

A field experiment was conducted during the rainy seasons of 2003 and 2004 at Agricultural Farm Bilaspur, Chhattisgarh to observe the effect of micronutrients (Zn, B and Mn) alone or in combination on the yield, some yield attributes and nutrient uptake of hybrid rice (*Oryza sativa* L.). The experiment was laid-out in randomized complete block design (RCBD) with eight fertilizer treatments. The highest value of yield, different yield attributes and uptake of nutrients were recorded in the plots receiving boron in combination with Mn and Zn. Application of Mn+B+Zn significantly increased no of grains/ear and 1000 grain weight by 29.39 and 16.60% respectively over control. Application of Mn+B+Zn to rice crop improved its seed and straw yield (47.59 and 47.43%) and N, P and K uptake (83.33, 92.68 and 95.27%) thus emphasizing the need for micronutrient application to rice and other crops.

Key words : Boron toxicity, Micronutrient, Rice, Zinc

INTRODUCTION

RICE (*Oryza sativa* L.) is the main cereal crop in India but its productivity is very low compared with that in other advanced countries like China, USA and Japan. The crop is generally fertilized by farmers with nitrogen, phosphorus and potassium only, though micronutrients are also equally important. Micronutrients are elements which are essential for plant growth, but are required in much smaller amounts than those of the primary nutrients, nitrogen, phosphorus and potassium. Micronutrients are as important as the primary and secondary nutrients in plant nutrition. Rice like other commonly grown field crops requires 16 essential elements to complete the metabolic processes necessary for growth and reproduction.

Boron deficiency in crops is more widespread than the deficiency of any other micronutrient in the world (Gupta, 1993). Adequate B nutrition is critical not only for high yields but also for high quality crops (Brown and Shelp, 1997). B deficiency causes many anatomical, physiological and biochemical changes in plants (Blevins and Lukaszewski, 1998). The availability of B to plants decreases with increasing soil pH, particularly in calcareous soils and in soils with high clay content. Availability also decreases sharply under drought conditions probably because of both a decrease in B mobility by mass flow to the roots and the polymerization of boric acid (Marchner, 1995). Zinc deficiencies are widely spread throughout the world, especially in the rice lands of Asia and deficiencies occur in neutral and calcareous soils (Tisdale *et al*., 1997). Zinc uptake by plants decreases with increased soil pH. Uptake of zinc also is adversely affected by high levels of available phosphorus and iron in soils. Manganese deficiencies have been reported in different crops grown on organic soils.

Need for micronutrient fertilization in soil is increasing, yet the proportion of different fertilizer used in the country is not quite balanced. Higher crop yields naturally have higher requirement of nutrients due to more pressure on the land for available forms of nutrients. Thus, in this study, an attempt was made to find out the effect of several microelements (Zn, B and Mn) alone or in combination on yield attributes, yield and nutrient uptake of hybrid rice for increased sustainable yield.

MATERIALS AND METHODS

The field experiment was conducted at Agricultural Farm Bilaspur, Chhattisgarh during 2003 and 2004. Physico-chemical properties of the soil were measured by the standard methods of soil chemical analysis. The analysis for respective years of experimentation revealed that the soil had 0.52% organic carbon, 224.4 kg/ ha available nitrogen, 20.9 kg/ ha available phosphorus, 240.2 kg /ha available potassium with *p*H 7.98. The experiment was laid out in randomized complete block design (RCBD) with three replications. Treatment details were as follows:

T_1 NPK = Control (no micronutrient)
T_2 NPK+ Mn = Manganese sulphate @15 kg/ha
T_3 NPK+ Zn = Zinc sulphate @10 kg/ha
T_4 NPK+B = Boric acid @ 10 kg/ha
T_5 NPK+ Mn + Zn = Manganese sulphate @15 kg/ ha + Zinc sulphate @10 kg/ha
T_6 NPK+ Mn +B = Manganese sulphate @15 kg/ha + Boric acid @ 10kg/ha
T_7 NPK+ Zn +B = Zinc sulphate @10 kg/ha+ Boric acid @10 kg/ha
T_8 NPK+Mn+B+Zn = Manganese sulphate @15 kg/ha + Boric acid @ 10kg/ha + Zinc sulphate @10 kg/ha

A uniform application of 125 kg/ha N as urea, 75 kg/ha P2O5 as triple super phosphate (TSP) and 100 kg/ha K as K_2SO_4 were given to all the plots. Crop was raised following the recommended package of practices. Rice hybrid 'Proagro 6207' was transplanted at row spacing of 20 cm × 10 cm.

The uptake of nutrients (N, P, K) was calculated as nutrient uptake = concentration (%) of the given nutrient × yield on dry weight basis. The crop was harvested and data on yield attributes and yields were recorded. The data were analysed statistically on pooled basis for both years, as per procedure suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Pooled data for 2003 and 2004 show that addition of micronutrients alone or in combinations significantly increased the yield attributes viz grains/ear and 1000 seed weight compared with the control (Table 1).

Every micronutrient treatment like B, Mn, Zn and their combinations gave significantly higher per cent of filled grain as compared to control. The highest grains/ear (100.5) was recorded in T_8 treatment and statistically at par with that of treatments T_7, T_6 and T_4 where B was applied alone or in combination with Mn or Zn. So it is clear that the effect of B was more pronounced than any other micronutrients. This result indicated that the addition of B had a vital role on the grain set in rice.

Like other yield components, 1000 grains weight also showed significant influence of different treatments (Table 1). The 1000-g rain weight varied from 16.14 g to 18.82 g. The highest 1000-grain weight (18.82) was recorded in T_8 treatment which was statistically not different with that recorded with T_7 treatment. The lowest 1000-grain weight (16.14) was obtained in control treatment. The increase in yield attributes with micronutrients could be attributed to the well developed root-system, improvement in vegetative growth and better availability of nutrients at vital growth period. These results are in close conformity with the findings of Martens et al. (1994).

The yield data (Table 2) reveal a positive response to micronutrient treatment. Micronutrients either individually or in combinations significantly enhanced the seed and straw yields of rice over control. The mean seed and straw yield given by T_4 (B) was 5.697 and 7.990 tonnes/ha respectively. Further more, it was observed that the yield demonstrated by B alone was statistically identical to that recorded in T_5 and T_6. Soil application of Mn+Zn, Mn+B, Zn+B, and Mn+B+Zn significantly increased seed yield by 36.05, 37.82, 41.37, and 47.59% and straw yield

Table 1 : Effect of micronutrients on yield attributes and nutrient uptake of hybrid rice.

	Treatment	Seed yield (tonnes/ha)			Increase (%)	Straw yield (tonnes/ha)			Increase (%)	Benefit:cost ratio		
		2002	2003	Pooled		2002	2003	Pooled		2002	2003	Pooled
T_1	NPK (control)	4.199	4.189	4.194		6.047	6.097	6.072		1.45	1.37	1.41
T_2	NPK+Mn	5.105	5.199	5.152	22.84	7.681	7.678	7.679	26.47	1.49	1.61	1.55
T_3	NPK+Zn	5.208	5.204	5.206	24.13	7.887	7.883	7.885	29.86	1.69	1.92	1.80
T_4	NPK+B	5.695	5.699	5.697	35.84	7.991	7.989	7.990	31.59	1.72	1.95	1.83
T_5	NPK+Mn+Zn	5.661	5.751	5.706	36.05	8.011	8.091	8.051	32.59	1.99	1.92	1.95
T_6	NPK+Mn+B	5.782	5.778	5.780	37.82	8.235	8.317	8.276	36.30	2.05	2.05	2.05
T_7	NPK+Zn+B	5.937	5.921	5.929	41.37	8.479	8.416	8.447	39.11	1.98	2.51	2.24
T_8	NPK+Mn+B+Zn	6.196	6.185	6.190	47.59	8.951	8.953	8.952	47.43	2.11	2.51	2.31
	LSD (P = 0.05%)	0.27	0.24	0.26		0.61	0.67	0.71		0.37	0.34	0.36

LSD : minimum significant difference.

Table 2 : Effect of micronutrients on seed yield, straw yield and benefit : cost ratio of hybrid rice.

	Treatment	No of grains/ear	Increase (%)	1000- grain weight (g)	Increase (%)	Nutrient uptake (kg/ha)					
						N	Increase %	P	Increase %	K	Increase %
T_1	NPK (control)	77.67		16.14		34.8		4.1		31.7	
T_2	NPK+Mn	86.75	11.69	17.91	10.97	47.9	37.64	5.4	31.71	45.5	43.53
T_3	NPK+Zn	87.12	12.17	18.12	12.27	50.7	45.69	5.5	34.15	49.7	56.78
T_4	NPK+B	94.51	21.68	18.31	13.44	51.1	46.84	5.6	36.59	50.4	58.99
T_5	NPK+Mn+Zn	92.02	18.48	18.35	13.69	60.1	72.70	6.9	68.29	59.8	88.64
T_6	NPK+Mn+B	94.71	21.94	18.34	13.63	62.3	79.02	7.1	73.17	60.9	92.11
T_7	NPK+Zn+B	96.01	23.61	18.71	15.92	62.8	80.45	7.6	85.36	61.3	93.37
T_8	NPK+Mn+B+Zn	100.5	29.39	18.82	16.60	63.8	83.33	7.9	92.68	61.9	95.27
	LSD (P = 0.05%)	4.21		2.97		6.5		0.9		5.9	

LSD : minimum significant difference.

by 32.59, 36.30, 39.11, and 47.43%, respectively over no application of micronutrients. The treatment containing B, Mn and Zn together produced the highest yield on the other hand, the Treatment T_1 (control) gave the lowest seed yield (4.194 tonnes/ ha) and straw yield (6.072 tonnes/ha) and these reductions were significant in all of the experiments. This increase in yield of rice might be due to the fact that micronutrients exerted a beneficial effect on chlorophyll content in the leaves and dry matter in plant which increased the productivity. Similar results were also reported by Keratkasikorn et al. (1991). The pronounced effect of B on grain yield of rice agrees well with the findings of Jahiruddin *et al.* (1992) and Abedin *et al.* (1994). All the levels were significantly higher than control in respect of benefit cost ratio (Table 2). The highest benefit: cost ratio (2.31) of the crop was recorded in treatment T_8 (Mn+B+Zn), however, it was statistically at par with that of treatment T_7 (Zn+B).

Total N, P and K uptake increased significantly in different treatments in comparison to control (Table 1). Treatments T_3 (Zn) and T_4 (B) produced similar effect on N, P and K uptake. Soil Application of Mn+Zn, Mn+B, Zn+B, and Mn+B+Zn significantly increased N and P uptake of rice by 72.70, 79.02, 80.45 and 83.33% and 68.29, 73.17, 85.37 and 92.68% and K uptake by 88.64, 92.11, 93.37 and 95.27% respectively over control. The increased uptake of the nutrients was due to added supply of nutrients caused well-developed root-system resulting in higher uptake of phosphorus and other nutrients. These findings are in close conformity with those of Martens et al. (1994) and Sharma et al. (1998), who reported significant improvement in uptake of nutrients due to micronutrient applications under different agroclimatic conditions.

Positive effects of B on the yield and yield components of rice were also reported earlier by other researchers (Agarwal *et al.*, 1997; Subedi et al., 1997a, 1997b; Rerkasem and Jamjod, 1997). B has many physiological functions in plants such as sugar transport, cell wall synthesis, reproduction, pollen tube growth, pollen germination, lignification, carbohydrate metabolism, RNA metabolism, respiration, indole acetic acid metabolism (IAA), phenol metabolism, membrane integrity, ascorbate metabolism and oxygen activation (Blevins and Lukaszewski, 1998; Cakmak and R.mheld, 1997). Manganese activates several important metabolic reactions, aids in chlorophyll synthesis, accelerates germination and maturity, and increases the availability of P and Ca. Zinc is involved in several enzyme systems, cell wall formation, electron transport and oxidation reactions and necessary for root cell membrane integrity (Marshner, 1986).

Based on the findings of the present investigations, it may be concluded that micronutrient, the B either individually or in combinations was found to be optimum for Rice hybrid 'Proagro 6207' production. The results of this study suggest that fertilization with micronutrients should be taken into consideration under different soil, genotype and environmental conditions.

ACKNOWLEDGEMENT

Author wishes to thank Department of Agriculture Bilaspur, (C.G.), Indira Gandhi Agriculture University, Bilaspur, (C.G.) and Prof. Dr. Y. N. Jha, Department of Zoology, S.B.R. Govt. P.G. College, Bilaspur for their kind cooperation and valuable guidance.

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