Effect of Zinc Oxide in Neem-Oil Emulsion Coated Urea on Productivity and Zinc Uptake of Aromatic Rice-Wheat Cropping System

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INTRODUCTION

Zinc deficiency is prevalent worldwide in temperate and tropical climates (Fageria et al. 2003, Slaton et al. 2005). It is especially widespread in calcareous soils with high pHs. An analysis of 2,33,003 soil samples taken from different states showed that 47% of Indian soils are deficient in Zn (Takkar 1996). In India, Zn deficiency is widespread in the rice-wheat cropping system belt of North India which has high pH, calcareous soils (Prasad 2005). The increase in soil pH is associated with increased sorption of Zn to soil hydroxides, carbonates and organic matter and decreased absorption by plant roots. Several workers in India have reported response of rice-wheat systems to Zn. The general recommendation for rice-wheat in India is a soil application of 10-25 kg $ZnSO_4$ heptahydrate ($ZnSO_4.7H_2O$) (Takkar 1996), which is quite costly, and small farm holders skip it resulting in reduced rice yields. Another factor that discourages the farmers from applying Zn is the adulteration of $ZnSO_4$ heptahydrate in market chains. Therefore, an attempt currently made by the fertilizer industry in India is to produce Zn-coated urea (also referred to as zincated urea), that would force the farmers to apply Zn to rice-wheat system along with N that they always use. For coating urea, ZnO, which contains 80% Zn, is being investigated. For effective coating of prilled urea with fine powder of 300-350 mesh ZnO can be homogenized in neem-oil with a suitable dispersant. Therefore, this investigation was undertaken to study the efficiency of ZnO in neem oil-emulsion coated urea in aromatic rice-wheat cropping system.

METHODS

A field experiment was conducted at the Indian Agricultural Research Institute, New Delhi during 2004 and 2005 in a rice-wheat cropping system. The soil of the experimental field was a sandy clay loam with a pH of 8.2, 0.54 % of organic C and medium fertility in respect to P and K. The DTPA extractable Zn (Lindsay and Norvell, 1978) in the soil was 0.68 mg kg^{-1} soil. The critical level of DTPA extractable Zn for rice grown on alluvial soils in the rice-wheat belt of North India varies from 0.38-0.90 mg kg^{-1} soil. Eight treatments comprising 0.5, 1, 1.5, 2, 2.5, 3 and 3.5% ZnO in neem oil-emulsion coated urea (ZnONOECU) and prilled urea alone, were allocated in a randomized block design with 3 replications. Nitrogen at 120 kg N ha^{-1} as prilled urea or ZnO in neem oil-emulsion coated urea was applied in two equal splits, half 10 days after transplanting (DAT) and the other half at panicle initiation (40 DAT). When applied at the site ZnONOECU supplied 1.3, 2.6, 3.9, 5.2, 6.5, 7.5 and 9.1 kg Zn ha^{-1} for the 0.5, 1, 1.5, 2, 2.5, 3 and 3.5% coating, respectively. The residual effect of the above treatments imposed in rice was evaluated in succeeding wheat. The results are presented by adding the data (yields and Zn uptake) of both rice and wheat crops grown in a sequence.

RESULTS AND DISCUSSION

A significant increase in combined grain yield of rice and wheat over prilled urea was obtained with 1 to 3.5% ZnONOECU (Table 1). Thus, an advantage of Zn coating with ZnO was observed up to the highest level of coating, i.e. 3.5%. However, the significant effect of coating treatments over prilled urea on the straw yield was recorded only at 3.5%. Removal of Zn was more in straw than in grain for all treatments. The total Zn uptake by rice and wheat crops was highest with 3.5% ZnONOECU and significantly more than 2.0% ZnONOECU. Agronomic efficiency (AE) of applied Zn varied from 197.3 to 534.8 kg grain kg^{-1} Zn and was highest at 0.5% ZnONOECU at all levels of application. The AE of Zn declined as the level of Zn application increased. Apparent recovery (AR) of applied Zn varied from 8.3% to 16.4% and was highest at 0.5% ZnONOECU at all levels of application. The AR of Zn decreased with increasing levels of Zn application. The increased uptake and recovery of Zn in ZnONOECU treatments resulted mainly from increased Zn availability in the soil. The solid phase equilibria studies by Lindsay (1991) showed that ZnO is too soluble to persist in soil and even in calcareous soils of pH 8.0, it will maintain a Zn concentration of approximately 10^{-4}M Zn^{2+} or higher; higher than that maintained by soil Zn (10^{-11}M).

Table 1. Effect of ZnO in neem-oil emulsion coated urea on grain yield, straw yield, Zn uptake, agronomic efficiency and apparent recovery of Zn in rice-wheat cropping system

Treatment	Zinc applied (kg ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Zinc uptake (g Zn ha^{-1})			AE (kg grain increase kg^{-1} Zn)	AR (%)
				Grain	Straw	Total		
Prilled urea alone	-	6.75	16.08	202.7	688.0	890.7	-	-
0.5% ZnONOECU	1.3	7.44	17.47	234.5	870.0	1104.5	534.8	16.4
1.0% ZnONOECU	2.6	7.80	17.86	260.7	948.6	1209.3	438.3	12.2
1.5% ZnONOECU	3.9	7.96	18.36	283.3	1021.5	1304.8	311.7	10.6
2.0% ZnONOECU	5.2	8.15	18.95	305.9	1124.5	1430.4	269.9	10.3
2.5% ZnONOECU	6.5	8.38	19.05	328.3	1167.3	1495.6	250.6	9.2
3.0% ZnONOECU	7.8	8.45	19.37	340.7	1236.1	1576.8	217.6	8.8
3.5% ZnONOECU	9.1	8.55	19.70	352.9	1298.4	1649.3	197.3	8.3
LSD (P=0.05)	-	0.93	3.41	42.5	194.6	211.1	79.0	4.98

ZnONOECU - Zinc Oxide in Neem Oil-Emulsion Coated Urea; AE - Agronomic Efficiency; AR - Apparent Recovery

CONCLUSIONS

It is concluded that the coating of prilled urea with 1.0% ZnO in neem oil-emulsion may be sufficient to get higher productivity and increased Zn efficiency compared to prilled urea alone in aromatic rice-wheat system.

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