Dry matter, grain yield and phosphorus use efficiency of lowland rice as influenced by phosphorus fertilization

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Introduction

Lowland rice is an important cereal crop for world population and in Brazil about 60% of the rice production comes from lowland rice ecosystem. Brazil has about 35 million hectares of lowland areas, locally known as "varzea". At present only about 1.8 million hectares of these areas are under cultivation and these soils present largest agricultural potential lands in the world. Phosphorus deficiency has been identified as one of the main nutrients limiting crop production on these soils. The objective of this research was to study the influence of phosphate fertilization on dry matter, grain yield, and P use efficiency in lowland rice.

Methodology

A field experiment involving flooded rice was conducted during two consecutive years in a farmer's field in the municipality of Dueré, State of Tocantins, Brazil. The soil of the experimental sites was an Inceptisol. The initial Mehlich 1 extractable soil P of the experimental site was 3.2 mg kg^{-1}. Treatments consisted of six P rates, i.e., 0, 131, 262, 393, 524, and 655 kg P ha^{-1} as termophosphate yoorin applied as broadcast and incorporated with disking in the first year of experimentation. Flooded rice cultivar Epagri 109 was planted at a spacing of 17 cm between rows by mechanical drilling with a seed rate of about 120 kg ha^{-1}. Regression analysis was used to evaluate treatment effects. Appropriate regression equations were selected on the basis of probability level significance and higher R^2 values.

Results and Discussion

Shoot dry weight and grain yield increased significantly in a quadratic fashion with increasing P rate from 0 to 655 kg P ha^{-1} (Table 1). Based on regression equation, maximum shoot dry matter was obtained with the application of 506 kg P ha^{-1}. Whereas, maximum grain yield was obtained with the application of 509 kg P ha^{-1}. Variations in shoot dry weight and grain yield were 89 and 87% with P fertilization, respectively. Response of lowland rice to P fertilization has been reported, when Mehlich-1 extractable P level in Brazilian Inceptisols is lower than 13 mg P kg^{-1} (Fageria et al., 2003).

Agronomic, physiological, recovery, and utilization efficiencies decreased with increasing P rates from 131 to 655 mg P kg^{-1} (Table 2). Across P rates, 10.3 kg rice grain yield was produced with the application of 1 kg P. Similarly, 509.2 kg dry matter (straw plus grain) was produced with the accumulation of 1 kg P in the grain plus straw. In the case of agrophysiological efficiency, across P rates, 324.4 kg grain yield was produced with the accumulation of one kg P in the grain plus straw. Average recovery efficiency was 4.3% and utilization efficiency was 22.4 kg grain yield with the utilization of one kg P. Sahrawat and Sika (2002) reported apparent recovery of applied P in the range of 4.8 to 11% by rice in an Ultisol.

Table 1. Dry matter of shoot and grain yield of lowland rice under different P rates.

P Rate (kg ha^{-1})	Shoot dry weight (kg ha^{-1})	Grain yield (kg ha^{-1})
0	3930.3	1126.9
131	7088.7	3160.9
262	7753.5	4396.7
393	7664.3	5144.4
524	8093.3	4719.5
655	7021.0	5148.3
Regression analysis		
P rate (X) vs, shoot dry weight (Y) = $1252.79 + 15.57X - 0.0153X^2$, $R^2 = 0.89^{**}$		
P rate (X) vs. grain yield (Y) = $1268.99 + 15.36X - 0.0151X^2$, $R^2 = 0.87^{**}$		

** Significant at the 1% probability level.

Table 2. Phosphorus use efficiency in lowland rice under different P rates.

P rate (kg ha^{-1})	AE (kg kg^{-1})	PE (kg kg^{-1})	APE (kg kg^{-1})	RE (%)	UE (kg kg^{-1})
131	15.5	604.4	300.9	6.3	39.6
262	12.7	536.8	269.5	5.1	27.1
393	10.5	521.8	477.4	3.8	19.7
524	6.8	443.6	277.8	3.4	14.8
655	6.2	439.3	296.6	2.7	10.9
Average	10.3	509.2	324.4	4.3	22.4
R^2	0.52^{**}	NS	NS	0.43^{**}	0.50^{**}

**, NS Significant at the 1% probability level and nonsignificant, respectively.

AE = Agronomical efficiency, PE = Physiological efficiency, APE = Agrophysiological efficiency, RE = Recovery efficiency, and UE = Utilization efficiency.

Conclusions

Lowland rice dry matter as well as grain yield significantly increased with P fertilization in Inceptsol, indicating importance of P fertilization in such soils for improving rice yield. Maximum dry matter of shoot was obtained with the application of 506 kg P ha^{-1} and grain yield with the application of 509 kg P ha^{-1}. Low recovery efficiency indicating higher P immobilization capacity of these soils due to presence of Al and Fe oxides.

References

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