Enhancing phosphorus use efficiency in crop plants grown on Brazilian oxisols

Fageria, N.K.[1]; Baligar, V.C.[2]; Li, Y.[3]

[1]Embrapa Arroz e Feijão, Santo Antônio de Goiás, GO, CEP 75375-000, Brazil; [2]Sustainable Perennial Crops Research Laboratory, Beltsville Agriculture Research Center, USDA-ARS, Beltsville, Maryland 20705, USA; [3]Tropical Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, Homestead, Florida 33031, USA.

Introduction

Brazilian Cerrado region which is about 205 million ha, Oxisols are dominating soil group. These soils are commonly deep, well drained, and well structured, but they are acidic and very low native fertility, especially phosphorus. The main reasons for P deficiency in these soils are low natural P level and high P immobilization capacity. Average chemical properties of Oxisols of cerrado region are: pH in water 5.2, Mehlich 1 extractable P 1.2 mg kg^{-1}, Ca 0.64 cmol kg^{-1}, Mg 0.58 cmol kg^{-1}, Al 0.64 cmol kg^{-1}, K 47.2 mg kg^{-1}, Cu 1.3 mg kg^{-1}, Zn 1.0 mg kg^{-1}, Fe 116 mg kg^{-1}, Mn 14 mg kg^{-1}, organic matter 15 g kg^{-1} and base saturation 17%. Recovery efficiency of applied P by principal crops grown on Oxisols is less than 20% and therefore, higher rate of P application is required to achieve maximum yields, reduce cost of production, and to maintain environmental quality. To improve P use efficiency in agriculture, integrated P management strategies that take into consideration improved fertilization along with soil and crop management practices are necessary.

Phosphorus Uptake and Use Efficiency by Annual Crops

Nutrient uptake is influenced by soil, climate and plant factors. Furthermore, crop yield level is an important factor associated with nutrient accumulation. Data related to the quantity of nutrients accumulated by a crop species give an idea of fertility depletion and help in managing soil fertility. The best time to determine nutrient accumulation in plant is at flowering or at harvest, when accumulation is expected to be maximum. Yield and P uptake and use efficiency of principal annual crops grown on Brazilian Oxisols are presented in Table 1. Phosphorus uptake was higher in grain compared to straw in four crop species. Phosphorus use efficiency was higher in cereals compared to legumes. The higher P use efficiency in cereal is associated with higher yield of cereals compared to legume species.

Management Practices to Improve Phosphorus Use Efficiency

Modern agriculture requires the implementation of efficient, sustainable, and environmentally sound management practices. In this context, appropriate fertilization is an important practice required to achieve optimum yields of crops. Fertilizer is, however, one of the most expensive crop production inputs and, if used improperly, can lead to environmental degradation and decreased production efficiency. Integrated nutrient management systems should be used to improve the overall nutrient availability and use efficiency by crops. Management practices to improve P use efficiency of crops include management of pH, correct source, method and rate of fertilizer application, water management, pest management, and the use of high yielding or nutrient efficient cultivars. In acid soils, use of adequate rate of lime is most important factors in improving nutrient use efficiency. Liming not only supplies Ca, and Mg and neutralizes Al but also improves soil pH and base saturation. Hence, improve soil chemical and biological environment and improve crop yields. Figure 1 shows increase in yield of soybean with liming of a Brazilian Oxisol.

Table 1. Straw and grain yield and P uptake and use efficiency by crops grown on Brazilian Oxisol

Crop species	Yield (kg ha^{-1})	P uptake (kg)	PUE (kg kg^{-1})[1]
Upland rice			
Straw	6104	2.9	2105
Grain	4413	9.5	465
Corn			
Straw	11006	4.5	2446
Grain	8221	16.7	492
Common bean			
Straw	1807	2.3	786
Grain	3182	13.9	229
Soybean			
Straw	3518	1.8	1954
Grain	4003	14.3	280

[1]PUE = Phosphorus use efficiency.

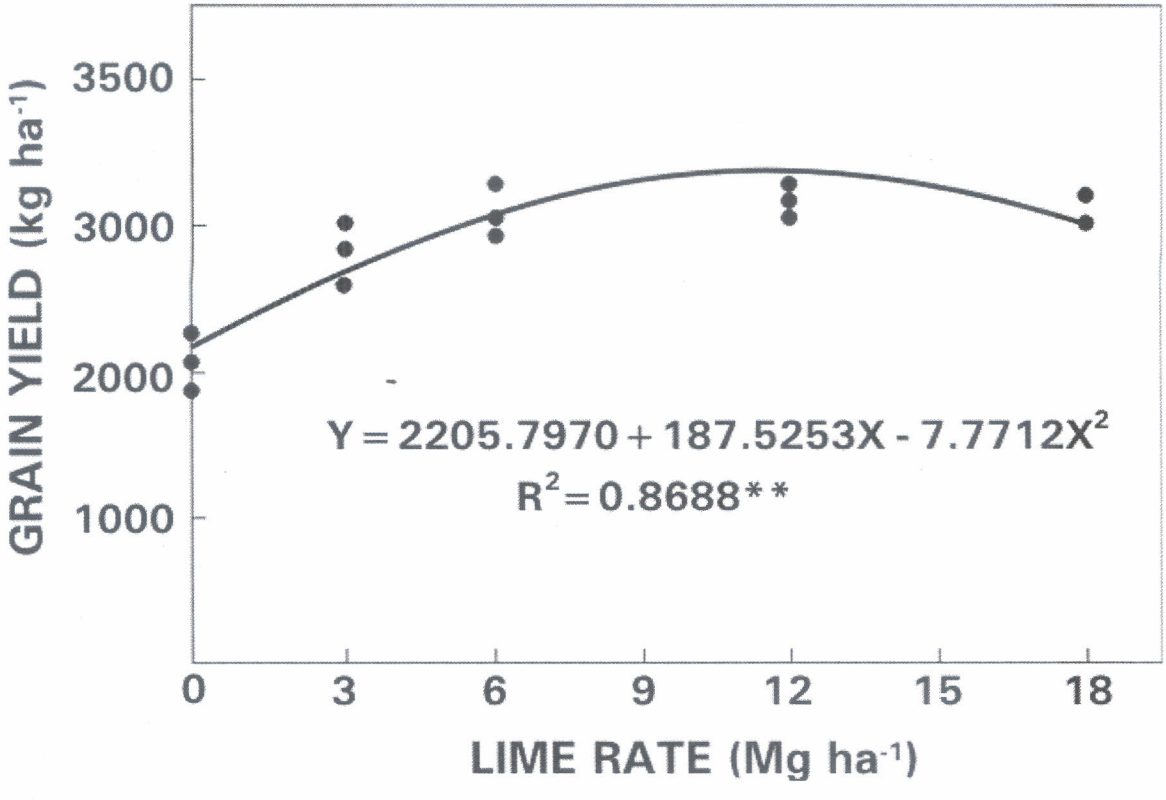

Fig. 1. Relationship between lime rate and soybean grain yield grown on Brazilian Oxisol.