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TECHNOLOGICAL INNOVATION FOR A SUSTAINABLE TROPICAL AGRICULTURE

PROCEEDINGS

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PROCEEDINGS

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MAIZE AND BRACHIARIA INTERCROPPING SYSTEM EFFICIENCY IN THE USE OF SOIL PHOSPHORUS RESERVES[1]

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Introduction

During the early stages of agricultural development in the Cerrado Region of Brazil, it was recognized that the major limiting factors to crop production were soil acidity and the very low P status of the soils (GOEDERT and LOBATO, 1984). This led to a major research effort to find cost-effective ways of correcting soil acidity and P deficiency (GOEDERT, 1983). This research included investigation of the extent to which acidity had to be corrected and evaluation of the most appropriate form of P fertilizer, its rate and frequency of application, as well as the method of placement, and residual effects of the added P fertilizer (SOUZA and LOBATO, 2004). Thus, in this region of P-deficient soils, since the 1970s, farmers have been applied P fertilizer in excess of crop requirements to build soil P concentration. It is now obvious that the soil P levels have been rising generally in commercial farming areas in the Brazil, mainly in the Cerrado Region as a result of accumulated fertilizer residues. In this condition, yield responses to applied P have become quite infrequent, indicating that these accumulated reserves are supplying P to the crops. In this context, the objective of this study is to contribute to a more systematic assessment of the residual effect of soil phosphorus. If the recovery of added P is of interest not only in the year of application but in subsequent years as well, this raises the following questions: (a) over what time scale should recovery be measured?, (b) can the residual P produce yields that are economically viable for the farmer?, and (c) what is the effect of the crop system, braquiaria intercropping with corn, in to optimize the use of residual phosphorus?

Material and methods

The experiments were conducted at the Embrapa-Maize and Sorghum Research Center in Sete Lagoas, MG, Brazil (19° 28' S, 44° 15' W and 732 m above sea level) in a P phenotyping site.
The soil is clayey red oxisol under savanna vegetation (cerrado). Soil analyses of samples taking from 0 to 0.20 m and 0.20 to 0.40 m depth in 2003, presented the following results: pH- water 5.98 and 5.52, OM 33.5 and 27.5 g dm^{-3}, P (Melich1) 5.3 and 3.2 mg dm^{-3}, K 46.6 and 21.1 mg dm^{-3}, respectively. In 2003, three levels of soil P were established by broadcasting 0, 218 and 436 kg P ha^{-1}, corresponding to 500 and 1,000 kg.ha^{-1} of P_2O_5 (triple superphosphate 45 % P_2O_5), and incorporating it into the top 0.10-0.15 m of soil, with a rototiller (COELHO et al., 2004). After that, the experiments started its residual phase with no further applications of P fertilizers and under zero tillage soil management.

The experiments were conducted in autumn/winter seasons of 2008 and 2009 in the system corn after soybean (2ª corn crop, also called "later season"). The treatments consisted of three level of P, two crops systems and four corn hybrids. The experiments were in random blocks, using a split-split plot design consisting of three treatment factors, with four replications. The main plots were levels of P (0, 218 and 436 kg P ha^{-1}) applied in 2003, and classified as low, medium and high; the split-plot factor consisted of the crop system (corn and corn intercropping with brachiaria) and the split-split plot factor consisted of the corn hybrids, three single hybrids, BRS1010, DKB 390 (DKB350 in 2009), P30F35, and one double hybrid BRS 3060. Maize hybrids were sowed at 0.70 m between rows with 4 seeds per meter (plant density 55,000 ha^{-1}). The brachiaria brizantha, cv. Xaraes, was sowed intra and inter-row of maize at a rate of 10 kg of seeds ha^{-1}, and it was used as cover crop. In 2008, fertilizers at planting time consisted of 100 kg.ha^{-1} of gypsum (13% S) plus 100 kg.ha^{-1} of KCl (60 % K_2O) plus 100 kg.ha^{-1} of urea (45% N) and no N fertilizer was applied side-dress. In 2009 no fertilizers were applied at sowing time. Thirty days after planting, 67.5 kg.ha^{-1} of N was applied as urea. In both years, irrigation was provided as needed to complete a total of 400 mm of water during the crop development and growth, simulating the precipitations conditions that occur in the center west region of Brazil.

Corn biomass and grain yields were determined by hand harvesting four adjacent 4-m long rows (appropriately bordered). Grain yield was adjusted to standard 130 g.kg^{-1} grain moisture. Samples of stover and grain were dried to a constant weight in a forced-air oven at 65°C and (grain and stover) dry matter contend was determined. The dry samples of grain and stover were ground in a Willey mill to pass a 1-mm screen. The dry and ground samples were analyzed for total nutrients (NPK) concentrations at the Embrapa Maize and Sorghum Foliar Analysis Laboratory.

The top 0.20 m of soil was sampled each year (2003, 2008 and 2009) after corn crops establishment. Soil samples were taken between the planted rows collecting single 20 cores (2.25 cm diameter) from each subplot of the cropping system corn and corn intercropping with brachiaria. Composted soil samples from 20 single cores, were mixed, air dried and crushed to pass a 2-mm sieve and analyzed for soil fertility indicators.

All data were analyzed by conventional analysis of variance procedures for split-split plot design, using the Statistical Analysis System (SAS Inst., Cary, NC). Tukey's Studentized Range (HSD) test was used for mean separation within each treatment. Statistical significance was assessed at the 0.05 level.

Results and discussion

Soil Phosphorus "Availability"

Several soil test laboratories (Research Institutes, University and Private) within the Cerrado region have adopted the Mehlich-1 soil test based on correlations with previous soil test methods and with very limited field calibration research conducted on local soils, mainly under zero tillage soil management. Although cerrado soils are often high in total P many of them are characteristically low in plant available P. For example, data of analysis of a soil profile used for these experiments indicated: total phosphorus (0.10 %) 1,000 mg P dm^{-3}, horizon Aep (0 – 0.13 m) and (0.096 %) 960 mg dm^{-3}, horizon AB (0.13 – 0.28 m). The available P (Mehlich1) was 8.1 and 5.5 mg dm^{-3} respectively. Previous studies carried on this soil, show that, due to the higher soil capacity of P adsorption, the application of higher rates of P was necessary to reach 20 and 40 mg of P dm^{-3} of soil, extracted by Mehlich1 (Table 1). The original P status in this soil is 5 mg of P dm^{-3}. The application of 218 kg P ha^{-1} maintain the extractable P (Mehlich1) level above or at the critical level (8 to 10 mg P dm^{-3} soil) throughout five harvests of corn and two of soybean and resulted in 80 to 85% of maximum yield (Table 1). According to result of research conducted by Coelho & França (2004) in this soil, the critic level of P (Mehlich1) to achieve 90% maximum corn grain yield (7.03 t ha^{-1}) was between 8 and 10 mg dm^{-3} of soil.

Corn Grain Yields

In the Table 2, are presenting the average grain yield obtained in the seasons of 2008 to 2009 relative to corn cultivated in a soil with different level of P. The corn grain yield range from 4.41 to 7.25 t ha^{-1} with average of 6.23 t ha^{-1}. The residual value of P was determined by measuring the increase in crop yield in the years following the initial application of P, compared with the yield obtained on soil that had not received this nutrient (control). With the residual effect of P applied was possible to get gains in the corn grain yield in more than 30 % as compared to control (Table 2). The yields of corn were not affected by intercropping with brachiaria. In average, the yield dry matter of brachiaria (data not showed) was around of 3.30 t. ha^{-1} and it was not affected by the P levels.

Conclusions

For corn cultivated after soybean, as second crop, it is possible to obtain economic grain yields, using the effect residual of P accumulated in the soil. However, the "availability" of P in the soils has to be above the critic level (> 8 mg P-M1 dm^{-3} soil). Thus, the long-term recovery of P added in fertilizers should be considered as part of the efficiency of P use from these sources, and this has not been recognized adequately, mainly under zero tillage soil management. In this research there is no evidence that the use of brachiaria intercropping with corn can to optimize the use of residual phosphorus. The research still on going, using the crop system corn intercropping with brachiaria cultivated after soybean, under zero tillage soil management.

Keywords: Cerrado region, water-soluble P fertiliz-

ers, P residual, corn hybrids, zero tillage, crop-livestock integration.

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Table 1. Soil P analyzes (0.20 m depth)

P levels	Crop System	P- Mehlich1		
		2003*	2008	2009
------ *kg ha^{-1}* ------		---------- *mg dm^{-3}* ----------		
0 (Low)	Corn	5.33 ± 0.85	7.25 ± 2.22	6.97 ± 2.36
	Corn + brachiaria		6.25 ± 1.89	6.05 ± 1.03
218 (Medium)	Corn	20.50 ± 7.87	9.25 ± 4.50	10.10 ± 2.22
	Corn + brachiaria		12.00 ± 6.78	10.53 ± 4.07
436 (High)	Corn	39.70 ± 14.98	31.50 ± 14.48	23.86 ± 5.30
	Corn + brachiaria		24.25 ± 14.17	23.43 ± 7.37
Average		31.84	15.08	13.50
CV %		20	61	42

*P initial in 2003 determined in soil samples taken four months after triple superphosphate has been applied.

Table 2. Corn grain yield adjusted to standard moisture.

P levels	Crop system	Hybrids	Corn Grain yields			
			2008		2009	
kg ha^{-1}			*t ha^{-1}*	*%$^{(1)}$*	*t ha^{-1}*	*%$^{(1)}$*
0	Corn		6.21	100	4.87	100
(Low)	Corn + brachiaria		4.41	100	5.68	100
218	Corn		6.57	106	6.72	138
(Medium)	Corn + brachiaria		5.88	133	6.97	123
436	Corn		6.99	113	6.57	135
(High)	Corn + brachiaria		6.69	152	7.13	126
0 (low)			5.31a	100	5.28b	100
218 (medium)	Means P levels		6.23a	117	6.85a	130
436 (high)			6.84a	129	6.85a	130
Means	Corn		6.59a	100	6.06a	100
Crop System	Corn + brachiaria		5.66b	86	6.60a	109
		BRS1010	5.09b	83	5.81b	92
Means		P30F35	6.98a	114	7.25a	115
Hybrids		DKB390/350	6.90a	113	6.16b	97
		BRS3060	5.55b	91	6.07b	96
Average			6.13	100	6.33	100
CV %			23		18	

(1)Values in percent are related to the treatment control and for hybrids the average values.