Continuous Cropping Experiment in Manaus: M-901

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In fields undergoing mechanized continuous cultivation, crop rotation and site-specific soil properties can influence the quantity, frequency, and timing of fertilizer and lime inputs.

Objective

The objective of this study was to determine the extent to which lime and fertilizer recommendations for the Yurimaguas Ultisols should be changed to sustain continuous cultivation in the clayey Oxisols, which are predominate in the Central Amazon.

Procedures

A long-term experiment was initiated at Manaus in 1981. The experiment involves 35 treatments with four replications in a randomized complete-block design. In addition to an absolute check, crop responses to N, P, K, S, Mg, Cu, B, Zn, Mn, and lime are evaluated individually by increasing rates in three or four treatments for each nutrient. Treatments for each nutrient were not initiated until the soil and plant analyses from preceding crops and the yields suggested that a particular nutrient deficiency was likely to occur. Once a yield response was obtained using a given nutrient, the nutrient was added to all subsequent treatments (except the absolute check) to avoid confounding yield responses to the other nutrients. Rates of individual nutrients included in the blanket applications were adjusted for each crop, based on previous crop performance on treatments designated to evaluate yield responses to each nutrient.

The sequence of crops, varieties, and fertilizer treatments initiated during the nine years since clearing the primary forest by slash-and-burn are shown in Table 1. Three treatments each for N and P were initiated with the first crop, because N needs are difficult to assess without local crop response data and because initial laboratory measurements of P sorption suggested that this element would be an immediate constraint for any crop in this Oxisol. Phosphorus was applied uniformly to all remaining plots before planting the subsequent soybean crop. Similarly, K and calcitic lime have been applied uniformly to all treatments after obtaining significant responses in the second and third crops, respectively. Responses to Cu were sporadic and not associated with any specific crop in the rotation. Nevertheless, Cu was included in the blanket applications for the first corn crop to avoid potential interaction with other nutrients under investigation. Potential Mo constraints were avoided with applications of 20 g/ha to the first soybean crop and the fifth cowpea crop.

Potential S losses during initial clearing (by burning) and the avoidance of S-carrying fertilizers for N, P, and K

Table 1. Cropping sequence and time after burning when lime and fertilizer treatments were initiated.

Crop	Variety	Time from planting to harvest	Treatments initiated
Rice	IAC 47	3.0 – 7.4	N & P
Soybean	Tropical	8.9 – 12.6	K
Soybean	Tropical	18.5 – 22.3	Lime & Cu
Cowpea	Manaus	22.9 – 25.2	
Corn	BR 5102	27.6 – 31.3	S
Cowpea	VITA 3	32.7 – 34.9	
Corn	BR 5102	37.2 – 41.8	B & Zn
Soybean	Tropical	42.3 – 46.2	
Cowpea	IPEAN V-69	46.9 – 48.9	Mn
Corn	BR 5102	52.1 – 56.2	
Cowpea	IPEAN V-69	58.1 – 61.0	
Corn	BR 5102	63.1 – 67.3	Mg
Cowpea	IPEAN V-69	69.2 – 71.5	
Corn	BR 5102	76.1 – 80.1	
Cowpea	IPEAN V-69	82.2 – 84.4	
Corn	BR 5110	87.0 – 91.2	
Cowpea	IPEAN V-69	93.9 – 96.2	

applications suggested a possible early depletion of soil reserves for this nutrient. Although treatments to evaluate responses to S and all remaining nutrients were initiated after the second year of cultivation, no significant responses have been obtained during any particular crop. During the last two cowpea crops, responses to Mg have been associated with imbalances caused by a buildup of soil K. Likewise, Mn deficiencies in legumes have only occurred with overliming at the highest lime rate.

In Figure 1, cumulative yield responses to variable rates of P, K, and lime during 17 consecutive crops are compared to yields obtained without lime and fertilizers (absolute check). Additional nutrients applied at constant rates to all fertilized treatments were 634 kg N/ha and 1 kg Cu/ha. Without lime and fertilizer inputs, total yield for 17 crops was 1.7 t/ha. The importance of lime to continuous cropping is exemplified by yield comparisons among 0, 2, and 4 t lime/ha at fixed levels of P and K. Across these lime rates, cumulative yield was increased from 8.5 to 32.5 t/ha.

Magnitude of the yield response to lime depended on both the crop and the time after lime was applied (Figure 2). Without lime, soybean yield declined markedly between 1983 and 1985. During the four initial corn crops, yields were not increased significantly beyond the rate of 2 t lime/ha. In the two final corn crops, yields were almost doubled between 2 and 4 t lime/ha. Therefore, the residual effect of 2 t lime/ha, for corn-based cropping systems on this Oxisol, would be about five years. In contrast to corn, cowpea yield response to lime was considerably lower, never exceeding the rate of 2 t/ha. Relationships between relative yield and soil acidity levels for corn and soybean differed from those observed for cowpea (Figure 3). Corn and soybean yields remained within 80% of the maximum, with Al saturation levels of less the 20%, as opposed to 58% with cowpea. Previous annual reports on comparisons between lime and gypsum treatments in this soil indicated that the cowpea response to lime was due primarily to a Ca effect rather than a reduction in Al toxicity.

Treatments in Figure 1 with 3 t lime/ha received an initial lime application of 2 t/ha in the first corn crop, followed by 1 t/ha in the fifth corn crop, when residual effects from the first application began to decline. Reductions in P inputs from an average of 16 to 8 kg/ha/crop decreased total yields by 10.5 t/ha. Similarly, reductions in K inputs from an average of 35 to 21 kg/ha/crop

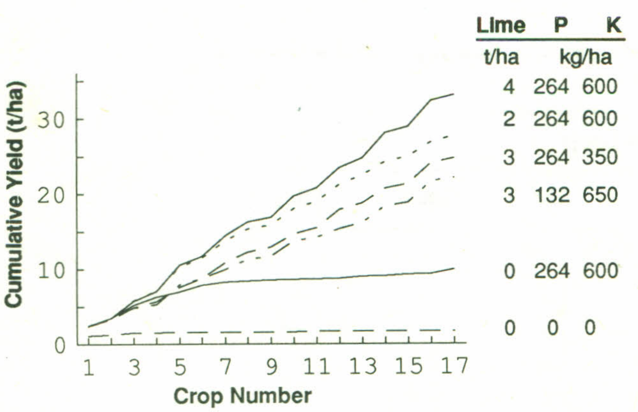

Figure 1. Cumulative yields of 17 consecutive crops of rice (1), soybean (3), corn (6), and cowpea (7), as a function of lime, P, and K inputs during nine years of cultivation in a clayey Oxisol of the Central Amazon.

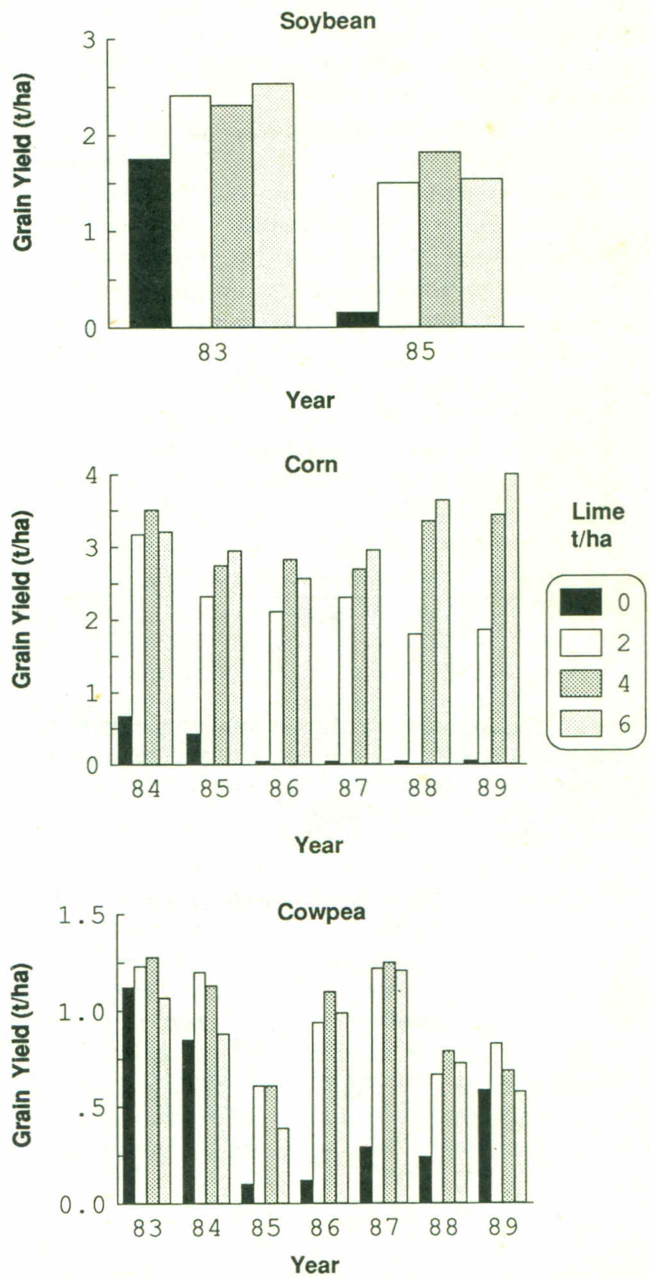

Figure 2. Grain yields for individual soybean, corn, and cowpea crops to lime rates applied to a clayey Oxisol before planting soybeans in 1983.

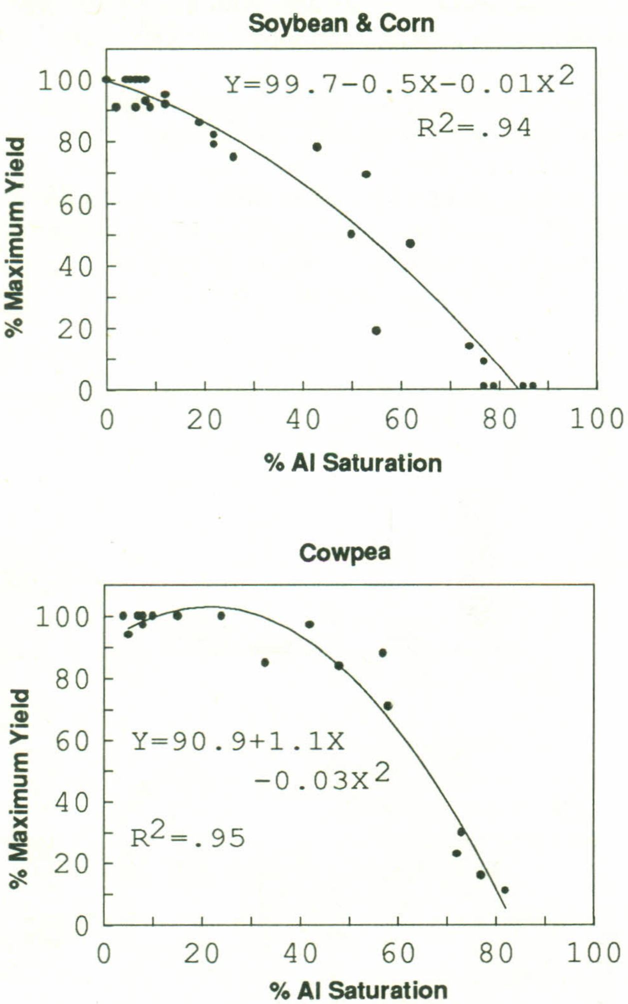

Figure 3. Relationships between relative yields of 15 consecutive crops of soybean, corn, and cowpea and Al-saturation levels of four lime rates in a clayey Oxisol of the Central Amazon

reduced yields by 9.2 t/ha. Individual response to applications of 25, 50, and 100 kg K/ha/crop are shown in Figure 4. Potassium was applied to all crops, except numbers 4 and 16. There was no yield advantage in any crop to rates greater than 50 kg K/ha. In general, the optimum rate for corn and soybean was 50 kg K/ha; the optimum rate for cowpea was 25 kg K/ha. Soil analysis data indicated that yield depressions with the highest K rate were associated with reductions in the Mg saturation to less than 5% of the effective CEC. The absence of a buildup in soil K levels during the 17 crops suggested that the frequency of K inputs should be based on individual crops.

Fertilizer N requirements for corn have been continually evaluated on treatments with three urea-N rates (Table 2). Within the range of 40 to 120 kg N/ha, there was no increase in yield for the two initial crops. With a subsequent reduction in N rates, yields for the third and fourth crops were increased with the application of 80 kg N/ha. In the two final crops, the fertilizer N requirement increased from 80 to 120 kg N/ha. Collectively, corn-yield response to variable rates of N suggested that N inputs should be increased progressively from 40 to 120 kg N/ha during six years of continuous cropping.

These data confirm that mechanized continuous cultivation is possible in clayey Oxisols, which represent one extreme in the range of well-drained acid soils of the humid tropics—the Ultisols of Yurimaguas representing the other. As in the Ultisols, judicious management of lime and fertilizer inputs guided by routine soil analysis plays a key role. The sequence of nutrient constraints, their remedies, and the residual effects of inputs during continuous cultivation differed between Manaus and Yurimaguas. There is no single fertilization recipe capable of replacing the requirement for soil-management expertise at the site-specific or regional level.

Table 2. Corn-yield response to N during six consecutive years of continuous cropping.

Applied N	Corn Crop 1984	1985	1986	1987	1988	1989
kg/ha	t/ha					
20	—	—	1.5	1.5	—	—
40	2.7	2.2	1.7	1.7	—	—
80	2.5	1.8	2.7	2.2	2.0	2.8
120	2.9	2.3	—	—	2.2	3.1
160	—	—	—	—	2.0	3.2