Lime Requirements and Downward Movement of Ca and Mg

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Previous studies on a Typic Acrorthox at Manaus, Brazil have shown that soil acidity becomes a limitation to annual crop production at approximately 18 months after burning the forest vegetation. Increases in Al saturation over time of cultivation and profile depth were partially related to decreases in exchangeable bases, since absolute levels of exchangeable acidity have seldom exceeded 1.5 meq/100 ml. Under such conditions, liming could be expected to help correct topsoil acidity and promote the downward movement of Ca and Mg, improving root penetration into the subsoil. Increased root growth into the subsoil could increase soil water availability and reduce the risks of crop failures due to the occasional dry spells that occur in the Manaus region.

Research performed on the acid savannas of Brazil has indicated that the Ca from gypsum supplied by ordinary super-phosphate moved rapidly into the subsoil and alleviated acidity problems. Although this P source would be more expensive than triple superphosphate in the Manaus region, the additional cost might be justified if a similar phenomenon were observed in these soils.

The objectives of this study were 1) to determine the lime requirements of this Typic Acrorthox for annual crop production, and 2) to determine which combination of calcium sources and rates of application most effectively promoted the downward movement of Ca and Mg into the subsoil.

The study was initiated in 1983 on an area containing 51, 55, and 53% Al saturation at sampling depths of 0-20, 20-40, and 40-60 cm, respectively. Treatments were established in a randomized, complete block design with four replications. The locally derived calcitic lime source, from Maues County, Amazonas, was the same as that used in the nutrient-dynamics study. Particle-size characteristics of the lime were 63% finer than 60-mesh and 36% in 20- to 60-mesh. Mean chemical analyses of these fractions was 33% Ca, .8% Mg and 83% $CaCO_3$ equivalency. Rates of lime were 0, 0.5, 1, 2, and 4 t/ha, calculated by the Brazilian methodology, which adjusts for both $CaCO_3$ content and particle size. In terms of $CaCO_3$ equivalency, these rates would be equal to 0.6, 1.1, 2.3, and 4.6 t/ha. Three additional treatments contained 1 t/ha of gypsum in combination with 0, 1, and 2 t/ha of lime. All other nutrients were supplied under nonlimiting conditions. Part of the N applied to corn was supplied as ammonium sulfate to diminish the S variable among treatments. Four crops, in the succession of corn, cowpeas, and soybeans, have been harvested in the study.

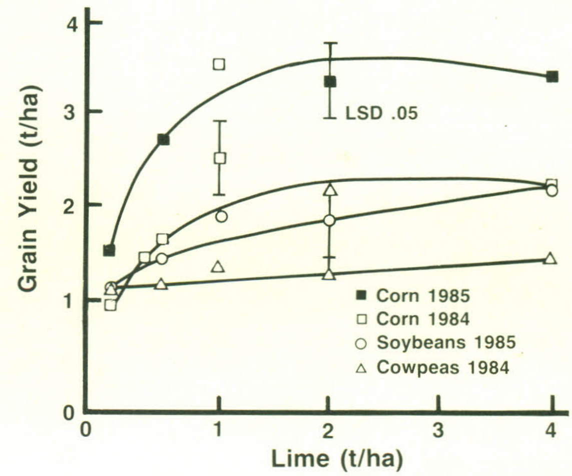

Figure 1. Yields of four consecutive crops as a function of lime rates applied before planting corn in 1984.

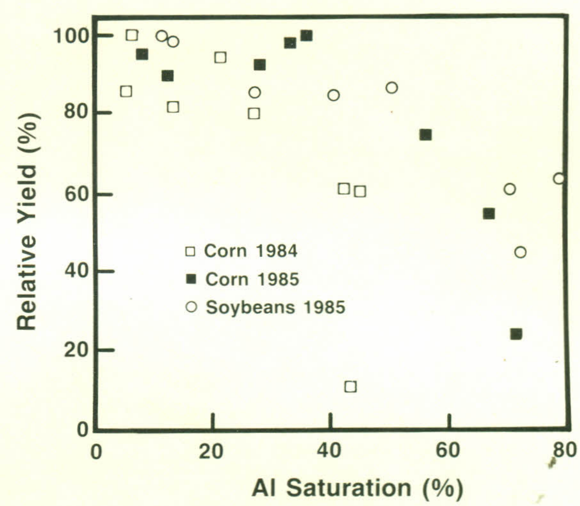

Figure 2. Relationships between relative yield and Al saturation for lime and gypsum treatments.

Yield Response to Lime and Gypsum

Yields for the corn and soybean crops increased significantly in response to the application of 1 t/ha lime (Figure 1). Although nonsignificant, cowpea yields were increased by 0.5 t/ha with the same lime rate. The largest yield responses to gypsum occurred with corn in the absence of lime (Table 1). Yields for soybeans and for both corn crops declined with increases in Al saturation above 30% (Figure 2). Differences in corn yield trends in 1984 and 1985 may have been related to several factors: 1) omission of blanket applications of B and Zn in 1984; 2) increases in Al saturation levels with time for the low lime rates; and 3) increased Ca movement into the subsoil with time of cultivation.

Soil Chemical Properties

Changes in topsoil chemical properties as a function of time after liming are shown in Figures 3-5. Liming increased the levels of Ca and Mg and decreased exchangeable Al levels. In the absence of lime or gypsum, Ca and Mg declined with cultivation, while Al levels remained relatively constant. Consequently, Al saturation levels approached 80% at the final sampling date. Aluminum saturation was maintained at tolerant levels during the first year of cultivation with 1 t/ha of lime. However, results indicated that more lime would be required to avoid acidity constraints during subsequent cultivation.

Table 1. Crop yields as a function of rates of lime with and without supplementary application of 1 t/ha of gypsum (G).

Applied Lime	Grain Yield			
	Corn '84	Cowpea '84	Corn '85	Soybean '85
	t/ha			
0	0.3	1.1	0.9	1.0
0+G	1.6	1.2	2.0	1.4
1	2.5	1.4	3.5	1.9
1+G	2.1	1.4	3.6	1.8
2	2.2	1.3	3.3	1.8
2+G	2.6	1.5	3.2	2.1
LSD .05	0.8	ns	0.8	0.8

The application of 1 t/ha of gypsum provided a moderate increase in topsoil Ca. This increase in Ca was more pronounced when gypsum was combined with lime. Profile samples were collected at three and 12 months after liming. Data shown in Figures 6 and 7 are for the latter sampling date. Liming increased Ca levels in the subsoil to the maximum depth sampled and reduced Al levels at depths of 20-40 cm. Improvements in the subsoil chemical environment by applications of gypsum were more pronounced when

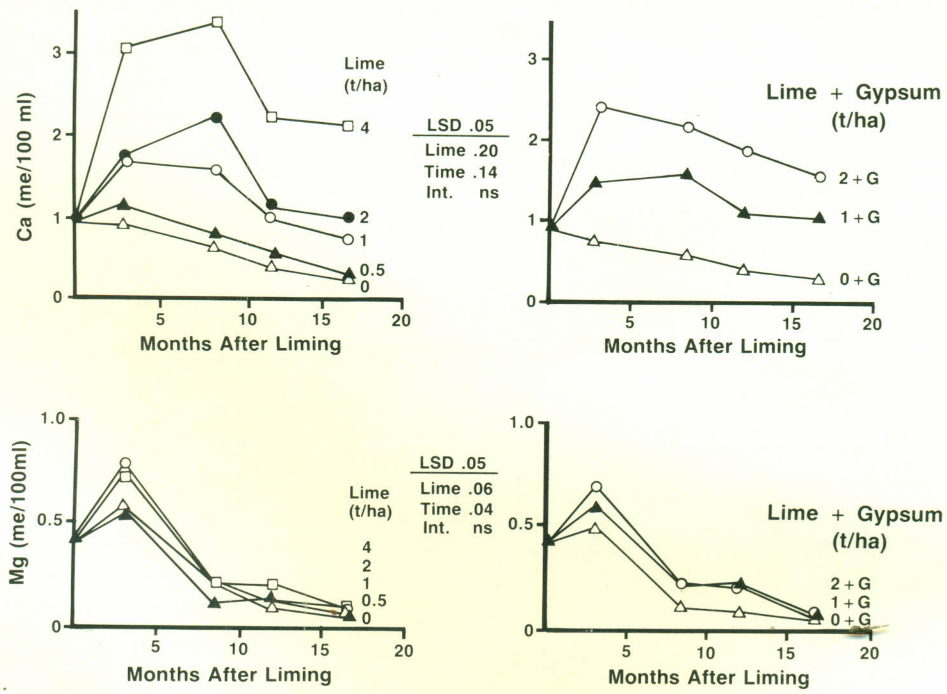

Figure 3. Topsoil exchangeable Ca and Mg levels as a function of time after applying lime and gypsum.

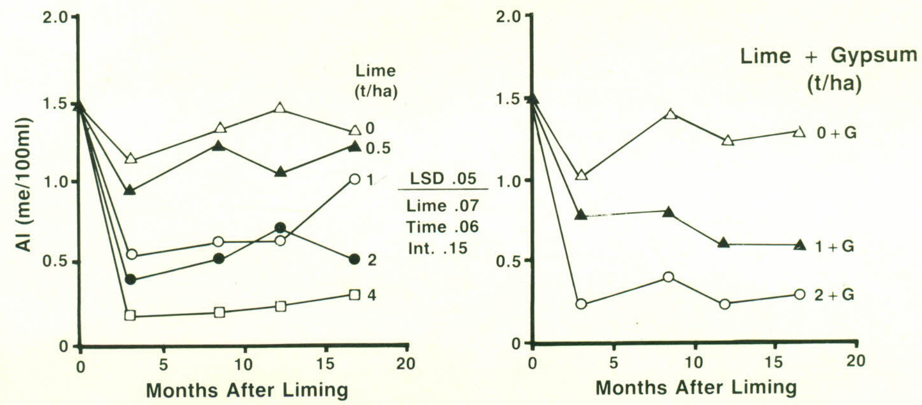

Figure 4. Topsoil exchangeable Al as a function of time after applying lime and gypsum.

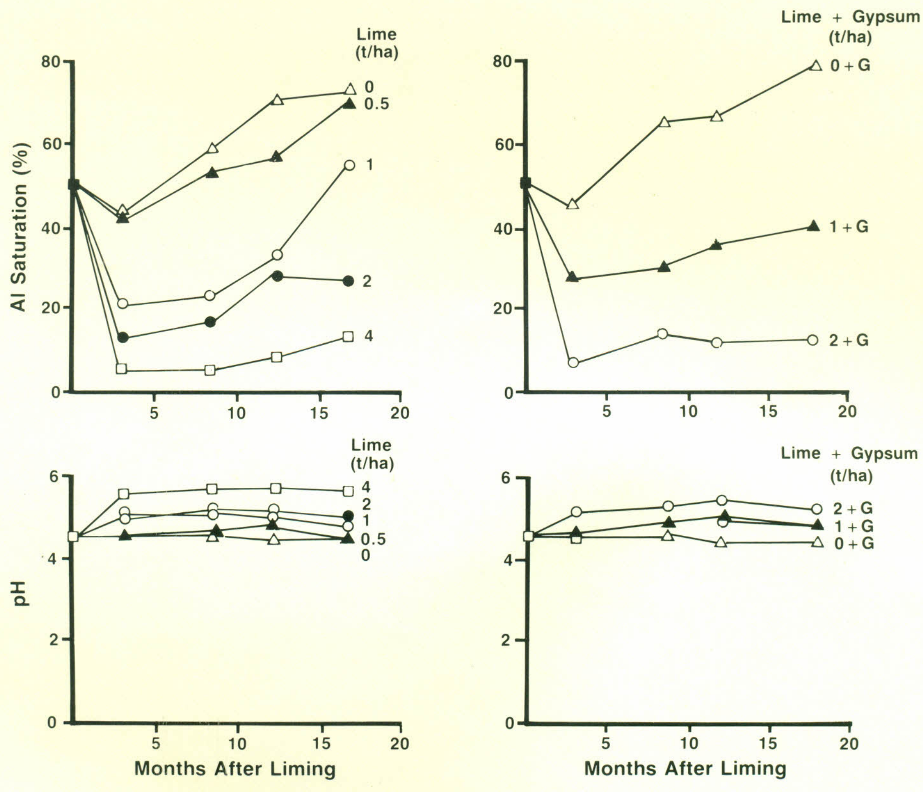

Figure 5. Topsoil Al saturation and pH as a function of time after applying lime and gypsum.

this material was combined with lime than when applied alone. Differences in subsoil chemical properties among lime treatments at three months after liming were negligible. The observed increases in subsoil Ca between three and 12 months after liming coincided with the time at which Ca declined in the topsoil (Figure 3).

Conclusions

1) Moderate applications of lime (1 or 2 t/ha) reduced acidity in the topsoil to non-limiting levels, promoted Ca movement into the subsoil, and significantly increased crop yields from corn and soybean, but not from cowpea, in the first four-crop succession.

2) Gypsum had a more pronounced effect on soil chemical properties when combined with lime than when applied alone.

Implications

Results from this study indicate that acidity constraints for this Typic Acrorthox can be corrected with moderate applications of a locally available source of lime. Residual effects of the lime rates, and the effect of liming on root proliferation in the subsoil, will be quantified as this study continues.

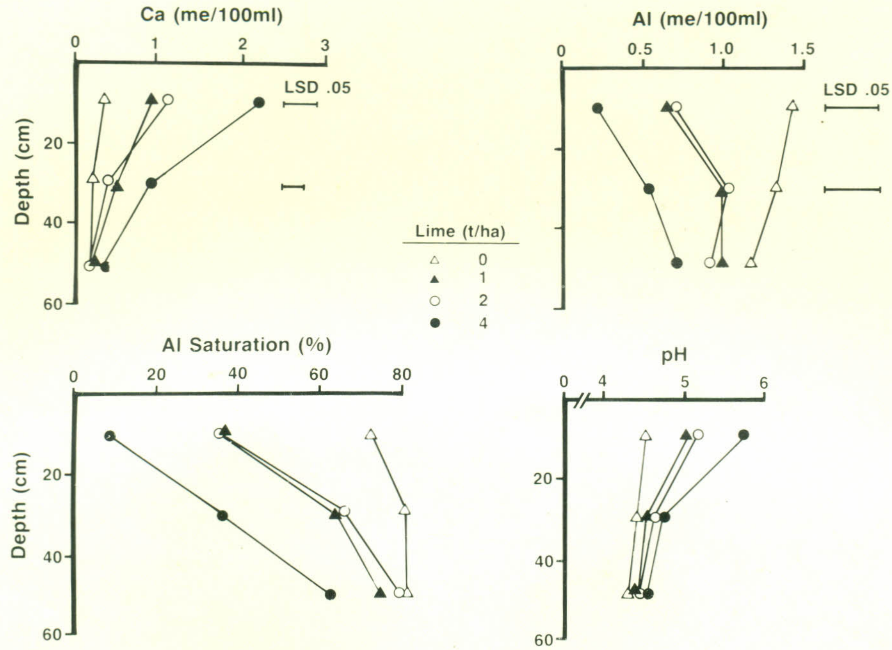

Figure 6. Profile soil acidity characteristics at 12 months after applying several rates of lime.

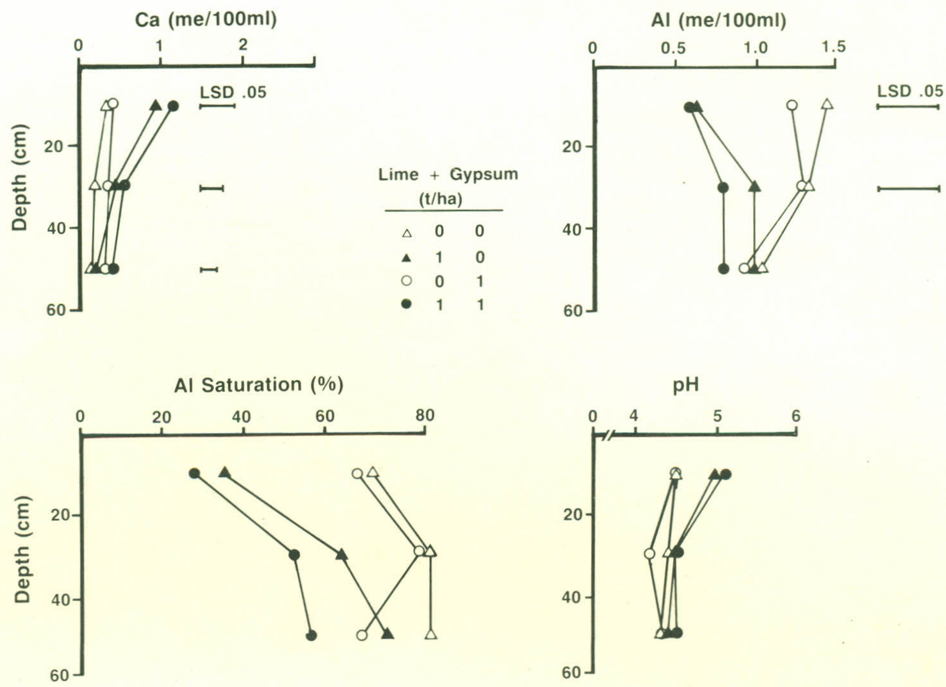

Figure 7. Profile soil acidity characteristics at 12 months after applying lime and gypsum.