ILLUSTRATED CONCEPTS IN TROPICAL AGRICULTURE

A series prepared by the Department of Agronomy and Soil Science
College of Tropical Agriculture and Human Resources
University of Hawaii

LIMING IN THE TROPICS: VARIABLE-CHARGE SOILS MAY BE HIGHLY BUFFERED

Fig. 1. Growth of cowpea across a pH gradient produced in an Oxisol (Wahiawa series) by liming from pH 4.7 (extreme left) to pH 7.1 (extreme right).

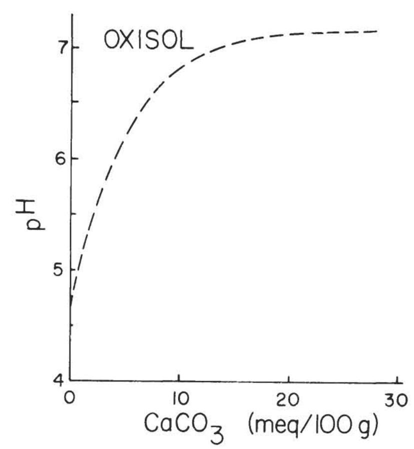

Fig. 2. Lime curve produced by adding increasing quantities of $CaCO_3$ to an Oxisol (Wahiawa series).

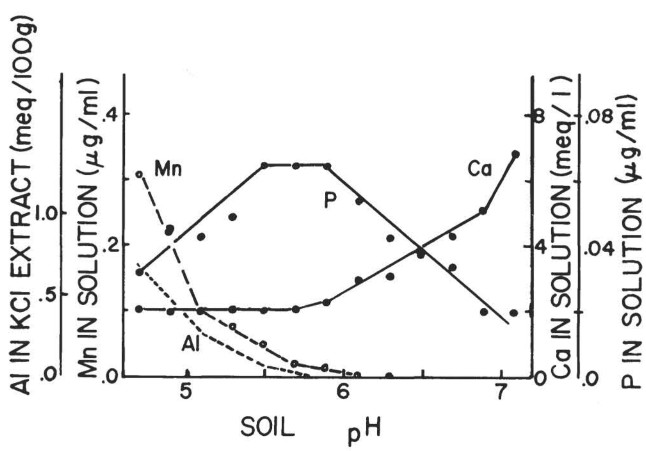

Fig. 3. Changes in the solubility or extractability of Al, Mn, P and Ca in relation to the pH to which an Oxisol (Wahiawa series) had been limed.

Some tropical legumes—cowpea for example—are generally believed to require less lime than temperate legumes require. Such comparisons may not be valid, although an important distinction may be made between the soils on which tropical legumes and temperate legumes most frequently grow. Small quantities of lime usually suffice to increase soil pH significantly in the acid range that is characteristic of highly weathered tropical soils.

For example, cowpea that grew on an Oxisol across a pH gradient produced by liming (Fig. 1) responded markedly to lime in the pH range 4.7 to 5.6. An examination of the lime curve of the Oxisol (Fig. 2) leads one to predict that small amounts of lime will significantly increase the pH of the Oxisol in the pH range near 5. When soil pH exceeds 6, however, large amounts of lime are required to increase soil pH by the same amount. Such soils are highly buffered against pH change in that range. The property of being poorly buffered at low pH and highly buffered at high pH is characteristic of variable-charge soils. Variable-charge soils, as the name implies, take on additional charge—the effective cation exchange capacity increases—with increasing soil pH. In such soils, calcium concentrations in solution change sluggishly as soil pH changes in the low range but change rapidly in the range of strong pH buffering between pH 6 and 7 (Fig. 3). High Ca concentrations depress P solubility.

Important soil management concepts come from these relationships: (1) At low soil pH, Oxisols require less lime to precipitate toxic aluminum (and perhaps manganese too) than do constant charge soils in the same pH range. (2) Tropical legumes that have high calcium requirements may not grow well on strongly acid, highly weathered soils unless such soils are heavily limed. If a choice is available, grow crops with low calcium requirements on Oxisols and Ultisols. (3) An appropriate pH for efficient P utilization is in the pH range where Al and Mn have ceased to be problems and before Ca in the soil solution sharply increases. In the Wahiawa soil shown here, the appropriate pH for P utilization was in the range 5.5 to 5.9. (4) Variable-charge soils may abruptly become very acid if cropping continues to remove basic cations after soil pH falls below the highly buffered zone. (5) Maintaining pH of variable-charge soils within acceptable limits requires a degree of control that may not be necessary for soils with constant-charge colloids. (6) Lime requirements for a desired pH can be based on a lime curve (titration curve), but the appropriate pH to which a soil should be limed will depend on the problem being corrected and the soil's mineralogical and chemical properties. If the only problem is Al toxicity, pH 5.3 to 5.5 should suffice; if Mn is excess, pH 5.8 should be high enough. If maximum P solubility is the only consideration, then pH 5.5 to 5.9 is a suitable range; but for significantly enhanced Ca solubility in soils with variable charge, soil pH 6 is required unless Ca is added as a neutral salt, such as gypsum.

R. L. Fox, N. A. Saidy, and R. S. Yost, No. 24, 1981.