ILLUSTRATED CONCEPTS IN TROPICAL AGRICULTURE

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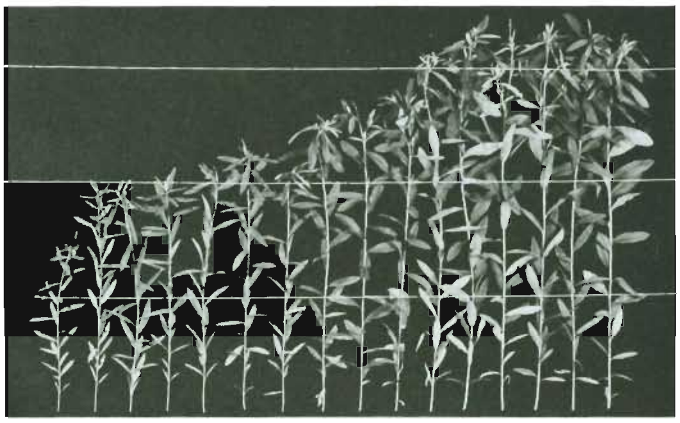
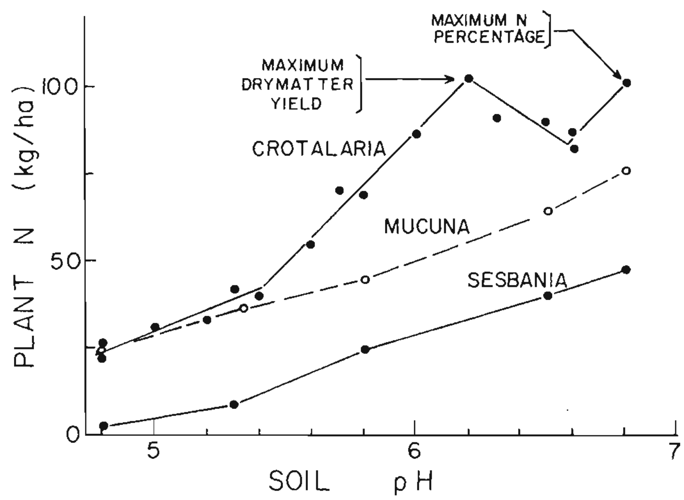
GREEN MANURING—RENEWED INTEREST IN AN OLD CONCEPT





". . . there are many plants which, when cut down and left on the land, improve the soil. Thus lupines, for instance, are plowed into a poor soil in lieu of manure." So wrote Varro more than 2000 years ago. In 1910, C. Hopkins, in his book *Soil Fertility and Permanent Agriculture* wrote: "there are three general methods of supplying organic matter to the soil: (1) By green manure and crop residues. (2) By accumulation in pasturing. (3) By applications of farm manure. The most important and least appreciated method of maintaining or increasing the supply of organic matter in the soil is by the use of *green manure and crop residues.*"

The most important output from green manure legumes is N. We no longer emphasize the value of green manure crops for increasing soil organic matter, but as escalating energy costs increase the price of N fertilizer, the green manure approach gains new appeal for the N it supplies. The concept has special relevance for areas where agricultural production must be sustained without dependence on N fertilizer. Until the present time, much of the research on growing legumes for the primary purpose of fixing N has been fragmented. It is clear, however, that a successful program should begin with genetically adapted legumes and associated rhizobia; that the environment should supply all requirements of the legume-rhizobia symbionts in good measure; and that all should be done for optimum production of beneficiary crops.

A critical factor for legume-rhizobia symbioses is a soil pH that will minimize Al and Mn toxicities and will enhance the availability of nutrients often required in greater quantities by the host plant-*Rhizobium* combination than by the host plant growing independently. One means of soil pH control is by liming—a practice that supplies Ca and usually Mg.

The pictorial graphs are of three green manure legumes important in the Tropics. They grew across a uniform pH gradient from 4.7 to 7.1 that had been established by applying $CaCO_3$ from zero to 22 tonnes per hectare. The soil, an Oxisol, is manganiferous. Variable-charge colloids dominate the exchange complex.

The growth pattern of *Sesbania cannabina* (upper left) suggests that this legume is sensitive to Mn toxicity. Growth increased substantially in the interval between plants No. 3 and Noi. 8. In the field this corresponds to soil pH 5.2 to 5.7. Within this pH interval, in this soil, Mn solubility decreased to low values with increasing soil pH. Growth also increased substantially above pH 6.5. This is the pH of greatly increased Ca solubility and, although not determined here, probably of Mo solubility also.

Growth of *Crotalaria juncea* (lower left) increased most dramatically from plant No. 7 to plant No. 12, which represented soil pH 5.6 to 6.3. In this range Al and Mn solubilities were low, P solubility was maximum, and Ca in solution was positively related to soil pH.

The growth pattern of velvet bean (*Mucuna* sp.), as illustrated by the size of fully expanded leaves (upper right), demonstrates that increased growth associated with liming was not altogether a matter of decreased toxicity of Al and/or Mn because the most impressive improvement in leaf size and color (N percentage) was attained in the pH interval 6.5 to 7.1.

Plant N, graphed as a function of soil pH (lower right), is an appropriate way to evaluate green manure crops. The nitrogen contents of these legumes varied from 2 kg/ha to 100 kg/ha when they were incorporated into the soil at age 70 days. Not all of the N in legumes is fixed by rhizobia. Note that the curves for Crotalaria and Mucuna diverge from a single value, about 23 kg/ha, suggesting that in this condition both species were dependent on a single N source, namely, the soil. Maize accumulated 21 kg N/ha during the same time.

Three points come through clearly: (1) legumes differ in their N-fixing capabilities, (2) nitrogen fixation by a particular legume is influenced greatly by the soil environment, and (3) on strongly acid maganiferous soils some legumes are no more effective than nonlegumes as N accumulators.

R. S. Yost, D. O. Evans, N. A. Saidy, R. L. Fox, No. 25, 1981.