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Soil

It has been estimated recently that half of the uncultivated land in the world which is potentially arable is in the tropics. This amounts to about 2,000,000,000 acres, which is substantially more than is now under cultivation in tropical areas. Most of the potential for bringing new land under cultivation is in Africa and South America, where only about 22 and 11% respectively of the potentially arable soil is now being cultivated. Soil surveys and expanding research efforts are providing information for the development of new lands and for improved soil management practices for the intensification of productivity on soils now being cultivated.

Soil surveys. Substantial progress is being made in many tropical countries in taking inventories of their soil resources. Reconnaissance soil maps at scales ranging from 1:50,000 to 1:250,000 have been completed for a number of countries and territories including British Honduras, Chad, Cuba, Dahomey, the Dominican Republic, El Salvador, Guatemala, Ivory Coast, New Caledonia, Peru, the Philippines, Samoa, Sarawak, Sierra Leone, and many islands of the West Indies. The UN Food and Agricultural Organization and UNESCO have recently published a soil map of South America at a scale of 1:5,000,000 with an accompanying text. This is volume 4 in the 10-volume series *Soil Map of the World.* The other volumes are being processed for publication. Soil surveys are under way in certain regions of many countries including Brazil, Burma, Colombia, Ghana, Indonesia, Kenya, Madagascar, Thailand, Cambodia, Laos, Vietnam, Nicaragua, Panama, Rhodesia, Rwanda, Senegal, Tanzania, Togo, and Venezuela. Many large-scale soil maps have been made of specific areas of many of the countries for special purposes such as irrigation projects, colonization, and agrarian reform.

Nitrogen. In order to obtain maximum benefits from the use of high-yielding crop varieties, it is necessary to apply nitrogen fertilizers to most soils of the humid tropics. As rice is one of the most important food crops in the tropics, considerable work has been done to increase the effectiveness of nitrogen fertilizers in rice production. Much of this work has been done in recent years by the Tennessee Valley Authority with the financial support of the Agency for International Development and in cooperation with a number of tropical countries. The findings indicate that (1) losses of applied nitrogen are often severe from flooded rice paddies, particularly when flooding is either delayed or intermittent; (2) among conventional nitrogen sources, ammonium sulfate is often superior to urea for rice grown on acid soils; (3) nitrification inhibitors have little potential for reducing losses of fertilizer nitrogen from flooded soils; and (4) coated (soluble) nitrogen fertilizers such as sulfur-coated urea have a real potential for increasing the effectiveness of applied nitrogen when flooding is delayed.

For sustained high production of corn in the humid tropics of Africa and Latin America, nitrogen fertilization is essential. Recent studies in several countries have shown that more than 100 bu/acre can be obtained with nitrogen applications of from 60 to 120 lb/acre. In experiments with corn in Puerto Rico on soils representative of extensive areas in the humid tropics, it was found that (1) postplant applications of nitrogen as urea were much more effective than preplant applications in increasing grain yield and nitrogen uptake; (2) near-maximum grain yields were generally obtained with only 60 lb/acre of applied nitrogen; and (3) nitrogen fertility can be built up in some soils that are continuously cropped and fertilized to such an extent that yields of close to 100 bu/acre and plant uptake of 125 lb/acre of nitrogen were observed on plots which had received no additional nitrogen.

In greenhouse studies in Puerto Rico an evaluation of the nitrogen-supplying power of representative soils of the humid tropics was made by continual cropping of corn and sorghum. Various chemical extraction procedures were used, and the relationship between the amount of nitrogen extracted by these procedures and that removed by continual cropping was measured. The results showed that many of these soils can supply substantial quantities of nitrogen upon continual cropping. The data also demonstrated that simple chemical methods can provide a reliable means for evaluating the ability of these soils to supply nitrogen during the cropping period.

Phosphorus. Where phosphate fertilizers have been used on cultivated crops for a number of years, it has been found that there are substantial residual benefits to succeeding crops which cannot be measured by simple chemical tests currently in use. Recent research has indicated that the mineralization of organic matter may supply a substantial part of the phosphorus required during the cropping season. Studies are now under way to develop simple chemical procedures for soil phosphorus analysis which will provide a better correlation between crop response and applied phosphorus fertilizers on soils of the humid tropics.

Studies during the past 4 years by the Tennes-

Proportion of rice-growing areas in selected Southeast Asian countries that may be suitable for rock-phosphate application*

	Area in flooded rice, 10^3 hectares	Area of acid alluvial soils, 10^3 ha (>pH 4.0)	Area of acid alluvial soils, 10^3 ha (<pH 4.0)	Area of acid terrace soils, 10^3 ha (>pH 4.0)	% of rice area†
Malaysia	480	250	25	50	62
Thailand	6800	2000	685	3300	78
South Vietnam	2500	800	618	–	32

*From Tennessee Valley Authority, *Tailoring of Fertilizers for Rice*, 1972.
†Only the acid alluvial and acid terrace soils are included. The very acid alluvial soils (acid sulfate soils for the most part) are excluded.

see Valley Authority have shown that there are substantial differences in agronomic effectiveness among rock phosphates of different geographic and geologic origin. Good correlations have been found between the citrate solubility of the phosphorus in rock phosphates and agronomic effectiveness. The rock phosphates of relatively high citrate-soluble phosphorus content approach the commonly used triple superphosphate in effectiveness, especially on the acid soils in the humid tropics, and the cost is much less per unit of phosphorus. There are substantial areas of acid soils in the rice-growing regions of Southeast Asia on which rock phosphate can be used effectively (see table).

Soil acidity and liming. Crop species vary in their tolerance of exchangeable aluminum in acid soils. Cotton is rather sensitive, and root growth may be restricted if the percentage of saturation of aluminum on the exchange sites is more than 10%. Corn, on the other hand, will tolerate up to 40% or more of aluminum saturation. Not only crop species but also the variety of a species may vary widely in tolerance for aluminum. There are extensive areas of acid soils in the humid tropics which have the problem of aluminum toxicity. The problem in surface soils can be eliminated by liming. However, since it is not feasible at present to lime the subsoils, the use of aluminum-tolerant varieties would permit the roots to exploit the subsoil moisture and nutrients. Recent research has demonstrated the potential use of aluminum-tolerant varieties of important crops in the tropics.

Recent laboratory and greenhouse tests in Puerto Rico have shown that the calcium in the soil solution plays an important role in minimizing aluminum toxicity. In field experiments with corn, sorghum, and green beans on representative acid soils of the humid tropics, it was found that the addition of lime had little or no beneficial effect if the aluminum concentration was low and sufficient calcium was present, regardless of the level of soil acidity. About 11,000 lb/acre of green beans was produced on check plots with a pH of 4.5 in the surface soil and 4.8 in the subsoil.

For background information *see* FERTILIZER; SOIL in the McGraw-Hill Encyclopedia of Science and Technology. [MATTHEW DROSDOFF]

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