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SHORT COMMUNICATION

Soil organic matter and phosphorus relationships under tropical forests

Summary

A positive correlation was detected between soil organic matter and acid-extractable P in the superficial soil horizons, but not in the subsoil, of secondary forests in the humid tropics. Clearing diminished the original level of organic matter concomitantly with concentration of acid-extractable P.

An important correlation between soil organic matter and acid-extractable P (Bray P_1) * in the superficial soil layers of tropical secondary forests in Sierra Leone, W. Africa was detected as shown in Figure 1. This relationship might explain documented observations that the major reserves of available P under natural and undisturbed forest and savanna ecosystems are found in the surface soil layers. Acid-extractable P, which also includes exchangeable P, ranged from 1 to 20 kg/ha in the surface (0–15 cm) layers of diverse forested sites, while substantially less P, about 1/5 of the surface concentrations were contained in the subsoil (32-60 cm). No significant correlations between organic matter and P were detected in subsoil zones as shown in Figure 2. It is important to note, however, that P from these depths provides a significant source of available P for the natural savanna and forested ecosystems. In the latter, the deep-rooted forest species pump considerable quantities of P into the canopy which eventually becomes mixed in the superficial soil layers. Nye [4] estimates from radioactive P measurements, that the subsoil in forested sites contributes 10-25% of the total P concentrations in forest canopy.

The stability of a natural forest or savanna ecosystem depends in large measure on P recycled in the organic materials. Generally, the concentration of the soil P in the upper solum under savanna is 4 to 5 times *less* than in the similar zones under forest. Crops respond to P fertilization of cleared burned savanna, but rarely in forested sites that have been cut, burned, and sown to crops in the same year [6].

* Bray extractant 0.03*N* NH_4F and 0.025 *N* HCl.) was used and P determined spectrometically by molybdenum blue method. Soil organic matter was determined by the wet oxidation method.

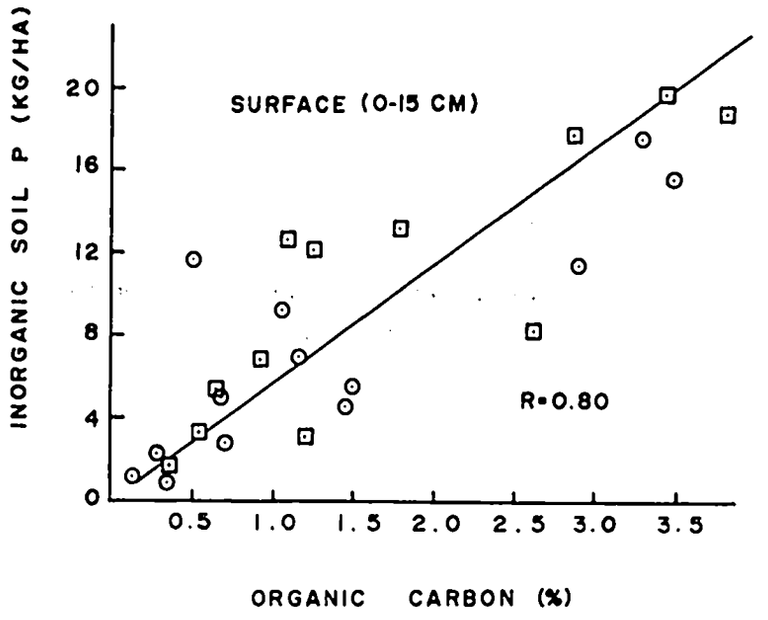

Fig. 1. Relationship between organic carbon and inorganic phosphorus in soils of the humid tropics under secondary forest in Sierra Leone W. Africa. Values indicated with circles were taken from forest sites adjacent to experimental plots. Values in squares taken from upland soils under secondary forest in coastal plain of Sierra Leone. All samples taken from surface soils between 0 and 15 cm depth.

When the natural systems are destroyed during the process of opening new farm sites, as for example in traditional shifting agriculture, the supply of available P in the recycled organic material as well as that inherent in the parent material, comprise the pool of P available to the agronomic crops[5]. The longer a soil remains under regenerative brush, grass, or in forest, the more nearly will it achieve the maximum levels of available P in part limited by the original supply and the characteristics of the soil. Because of the generic, shallow root systems of most food crops, the P associated with the soil organic matter in the upper solum exerts an important influence on the potential yields that can be attained during the 1st and 2nd year of production for any particular site under subsistance (shifting) agriculture. With the advent of clearing, the organic matter level drops sharply in the 1st year and by the 3rd year, under continuous cultivation, the original concentration of organic matter is diminished by 50 per cent and becomes more or less stabilized at this level provided regenerative cover and residues are annually incorporated into the surface soil [2].

Since a direct correlation between soil organic carbon and inorganic (acid-extractable) P has been established, as shown in Figure 1, the di-

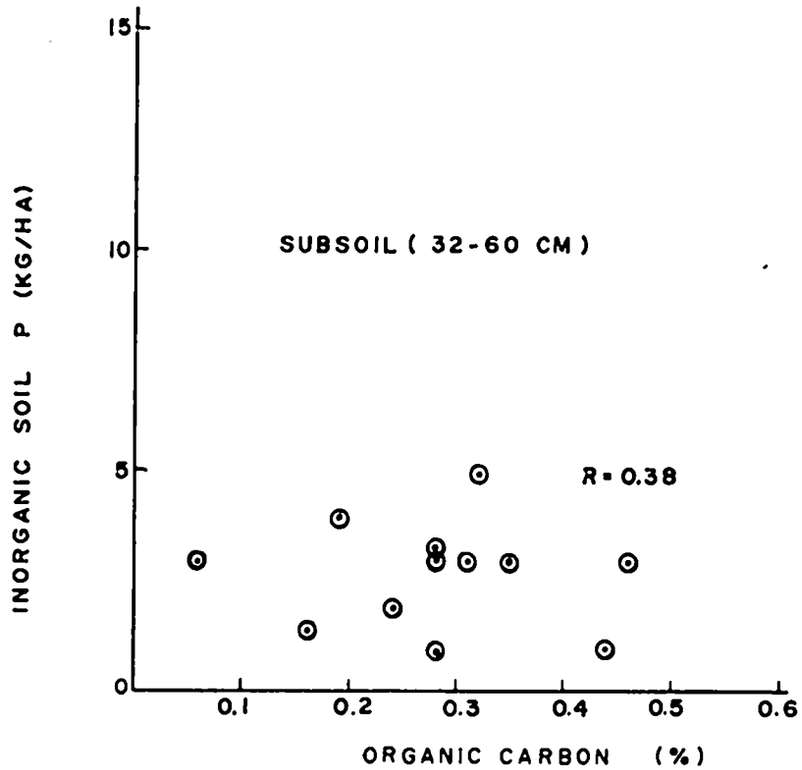

Fig. 2. Relationship between organic carbon and inorganic P in sub-soils from upland forested sites in Sierra Leone, West Africa.

minution of organic matter directly influences the concentration of P available to the crop. Nye [4] reported that mineralization of organic P is a concomitant reaction with the oxidation of organic matter which contributes, in some Ghanian soils 12 kg per ha of P to the surface layers, a substantial amount. Almost without exception however, on upland, well-drained soils, yields declined in the 2nd year following clearing. Apparently, there was sufficient P in the soil to supply the needs of the crop only during the 1st year. Declining reserves of organic matter during subsequent cropping periods however, could not restore concentration of inorganic P at levels high enough to maintain adequate yields. Therefore, dependence on supplies of P from organic matter under systems of *sustained* cultivation is not expedient without addition of inorganic P fertilizer. It has been shown that where minimal amounts of inorganic P are used in closely-supervised and carefully managed sites under sustained cultivation, the P associated with the organic matter (not necessarily the 'organic phosphorus') is relatively

inconsequential compared to the contribution of inorganic P from outside sources [1]. It should be carefully noted, however, that much of the positive residual effects of applied inorganic P under sustained cropping are also attributable to the beneficial properties of organic matter; for example, the high ion exchange capacities of this material as well as its chelating properties. These soil parameters are of singular importance to crop production in the leached soils of the humid tropics where exchange capacities are low and P fixation by Al and Fe sesquioxides can be serious yield-limiting factors in many instances [5 7]. The value of ley periods in cropping systems and the utilization of plant residues and cover must be seriously considered in the development of successful cropping systems for the humid tropics.

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