AMELIORATION OF SOIL BY TREES - THE WAY FORWARD

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A soil of high productivity offers plant roots:

(1) deep rooting because of many large pores and good movement of soil particles against each other;

(2) a sufficient water supply due to a high available water capacity;

(3) optimal gas circulation with the atmosphere because of a high content of stable coarse pores;

(4) high nutrient reserves, together with a high exchange capacity;

(5) intensive soil flora and fauna, which regenerate the nutrient pool by mineralising organic matter (Blume, 1985).

Tropical soils vary greatly in type and productivity. Geologically recent soils of volcanic or sedimentary origin are often very fertile. Those derived from older igneous rock and are heavily leached, are acidic and have a low moisture and nutrient-holding capacity.

In general, however, the sudden and heavy rainstorms of the tropics cause leaching of soluble plant nutrients to below the root zone. Many soils, therefore, have a low level of natural potential fertility and are particularly low in N and P. Much of the nutrient content in the crop zone is contained in the vegetation. The level of organic matter in tropical soils is also usually low, most of it breaking down quickly in the warm moist conditions. Many tropical soils also have poor structure, thus reducing their stability under intensive cultivation. In areas of alternating wet and dry seasons, a rapid but short-term release of nutrients is produced, often at the onset of the rains. Heavy rainstorms are also responsible for widespread erosion in the tropics. Additionally, soils with specific 'problems' are common in the tropics, eg saline soils and sandy soils (see 'Amelioration of Soil by Trees' 1986 for descriptions of problem soils).

As described by Anderson in Chapter 2, there is a great contrast between (1) the natural ecosystem where some of the lowest fertility soils support rainforests of massive structure and productivity as a consequence of tight nutrient cycling between vegetation and soil and (2) farming, where nutrient-bearing plant materials are removed for human use, inevitably leading to a reduction in soil fertility.

Farmers in the tropics clearly recognize the importance of soil fertility and conservation. However, in replacing the balanced natural ecosystem with a farm-productive system, either soil fertility is consumed or much labour and high material inputs are required if both high production and soil fertility are to be maintained. Tropical farmers, therefore, face a fertility management choice under current scientific and technical knowledge.

The soil may be 'mined' by continuous cropping and no replenishment of nutrients. Food can then be produced cheaply requiring the use of only very

little expensive support energy. The subsequent decline in fertility results in a reduction of yield leading to an unproductive 'low level equilibrium' which is inefficient in terms of solar energy but very efficient in relation to support energy (Rutherberg, 1971).

Alternatively, the farmer requires high support energies to maintain and increase soil fertility. This results in much more efficient use of solar energy but is expensive in economic terms. This alternative is therefore usually unavailable to the poor farmer in the tropics (Rutherberg, 1971).

The farmer, therefore, searches for a compromise between a solar energy efficient, support energy inefficient highly productive system and a solar energy inefficient, support energy efficient low productive system. One of the major modes of farming used to achieve such a compromise is shifting cultivation where there is a tree/bush fallow. The deep tree roots bring up nutrients that had previously been leached down, and the fallen leaves from these trees enrich the nutrient-depleted, overcropped soil surface, and leached nutrients are thus recycled. Other beneficial effects of trees to the soil fertility are outlined in Chapter 2. However, with increased rates of population growth, increased demand for land has limited those areas where shifting cultivation can be practised. There is not enough land to leave much of it resting and unproductive for long periods of time.

Agroforestry options, however, can combine the characteristics of productive herbaceous cropping systems with the ameliorating effects of tree cover and a perennial root network. This combination provides a multiple cropping system for fuel, food fodder and fertilizer. It also has a stabilizing effect on catchment hydrology and soil erosion. Although the practice of agroforestry is very old, it is a very new science. There is very little available knowledge of soil management techniques in agroforestry as practised until now. There is also little understanding of the mechanisms by which trees improve soil fertility. Both of these are required for the formulation of effective management methods in agroforestry. Methods determined on a predictive mechanistic basis rather than on an empirical basis will facilitate technology transfer to needful farmers and will also reduce the time, space and costs required for conventional plot trials.

Young, in Chapter 5, explains that management practices which control the quantity, quality and timing of decomposition of plant residues are required to maintain soil fertility. These processes of decomposition are discussed further by Swift in Chapter 2. As Young (Chapter 5) points out, different management practices can have different effects on soil processes. The complexity of the effects management practices can have on this poorly understood system can be seen in Figure 1.

Clearly, in order for the farmer to know which management method to use when and in which situation, much scientific research is required to further understand the mechanisms by which trees improve soil fertility and interact with soil biological processes, physical factors and nutrient cycling. This will form the basis of Commonwealth Science Council's project which aims to develop a predictive understanding of how to use trees to reclaim problem soils in agroforestry systems.