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Agroforestry systems and soil surface management of a tropical alfisol

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Introduction to the series

Most uplands of the humid and sub-humid regions of Sub-saharan Africa comprise Alfisols, Ultisols, Oxisols and some Inceptisols. These soils have low nutrient and water reserves available to plants and are of low inherent fertility. Alfisols are relatively more fertile than Ultisols and Oxisols, but they have poorer soil physical properties. Alfisols have a coarse-textured surface horizon overlying a clayey subsurface layer. These soils have a weak structure and are highly susceptible to crusting, compaction and accelerated soil erosion [Lal, 1976; Lal, 1985]. In addition to being susceptible to erosion, these soils are also prone to mid-season drought stress.

Most uplands have traditionally been used for extensive subsistence systems requiring long forest fallow for fertility restoration and for erosion control [Nye and Greenland, 1962]. Traditional systems are based on low inputs, are complex and diverse, and have built-in good security and stability. Bush fallowing, in humid and sub-humid regions, is viable as long as there is enough land to enable lengthy rotation and that yield expectations are not too high. If not, soil degradation and productivity decline set in rapidly and stability of the system is lost. Nonetheless, attempts at introducing some form of permanent cultivation in the humid tropics have persistently met some of the most troublesome ecological problems. Viable and intensive farming systems must be based on the following [Lal, 1987a; b].

1. Reducing the fallow period to the minimum necessary and replacement of bushfallowing by orderly and efficient planted fallowing,
2. Improving the nutrient capital through inorganic and organic fertilizer amendments, addition of biomass and crop residue mulch, biological nitrogen fixation, and efficient nutrient recycling mechanism,

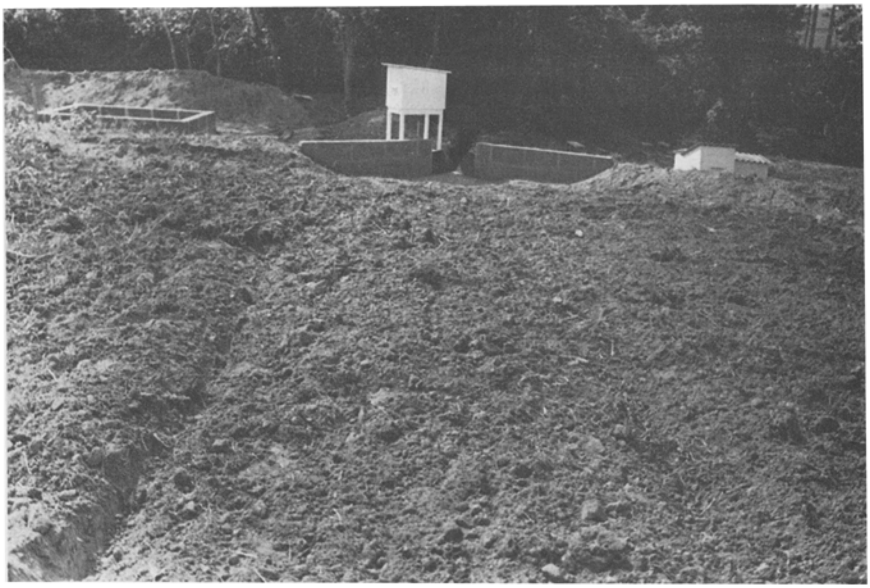

Fig. 1. Runoff and erosion collection system with 1′H-Flume installed within the cement-block retaining walls. Water level recorder is fixed in the white box above the Flume. Sampling tank is housed in the sump on the right.

3. Maintaining a high level of soil organic matter content through adoption of suitable soil surface management and cropping systems,
4. Increasing farm production to raise the economic status from subsistence to partly/fully commercialized farm and minimizing the need for clearing new land, and
5. Integrating trees and animals with food crop production systems.

Sustainable agricultural systems that preserve the resource base for continuous use must, by necessity, be based on evolutionary change through improvement of the traditional system. The improved agricultural system should be more efficient while retaining the favorable traits of the traditional system. For the improved system to succeed it must have the following characteristics:

i. Higher energy flux through judicious purchased input: Both overall energy flux and energy use efficiency must be increased. In addition, the system must endeavor to reduce nutrient losses by effectively containing runoff and erosion.
ii. Restoration of life-supporting bio-physical processes: The soil quality and its productive capacity must be preserved and improved by preventing soil erosion, promoting high biological activity of soil fauna, improving soil organic matter content, and by continuously replacing the

Fig. 2. A close up of the collection system looking upstream.

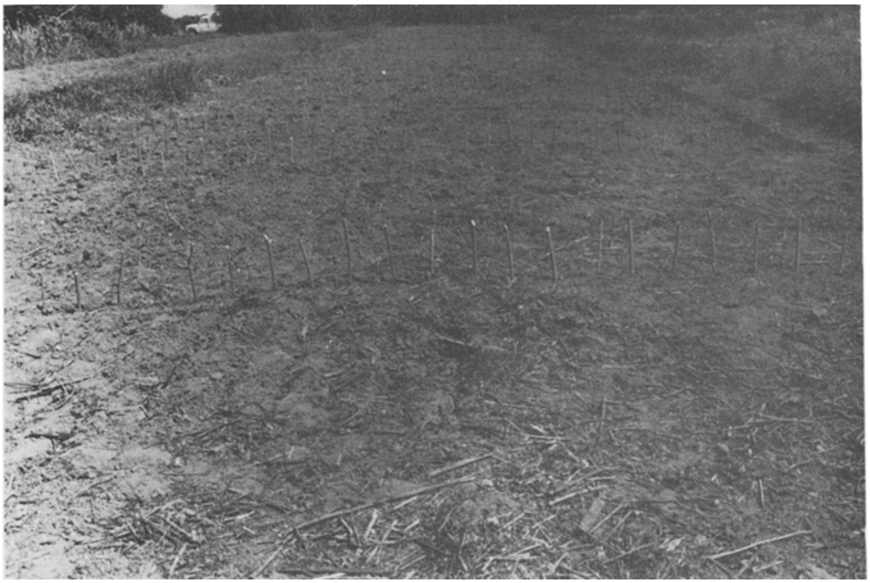

Fig. 3. Planting cuttings of *Gliricidia sepium* on the contour.

nutrients removed in the harvested produce through judicious applica
tion of chemicals and effective recycling mechanisms.

iii. Ecological compatability: Simplified agro-ecosystems, such as monocu ture, are usually less stable than diversified systems. The problems c accelerated soil erosion, rapid nutrient depletion, and shift in floral an faunal population are the results of over-simplification of an ecosystem

Agroforestry systems

The concept of mixtures to create diversity is appropriately extended by growing woody and herbaceous perennials in association with seasonal annuals. Suitable combinations of species of perennials and annuals and cultural practices of their management are different for different soils and environments. While leguminous shrubs and trees may improve soils nitrogen capital, their deep and extensive root systems and tall canopy compete for water and nutrient reserves and solar radiation. While competing for the space, trees and shrubs can also provide additional products for the farm household such as fuel, fodder, mulch, staking material and other minor products.

Agroforestry has been defined as 'a system combining agricultural and tree crops of varying longevity (ranging from annual through biannual and perennial plants), arranged either temporally (crop rotation) or spatially (intercropping), to maximize and sustain agricultural yield' [Vergara, 1982]. Different types of agroforestry systems widely used in the humid tropics include rotational agroforestry and intercropping system of agroforestry. Traditional shifting cultivation is a rotational agroforestry in which woody species of natural regeneration are rotated (5–40 years) with the cultivation of annuals (1–3 years). In comparison, intercropping system of agroforestry implies the continuous presence of both annual and perennial groups of plants on the same site at the same time. Some of the examples of intercropping system of agroforestry include alley cropping, shelterbelts and windbreaks, boundary planting of trees and woody hedges, live fences, and the corridor system of land use.

Alley-cropping research at IITA

Alley cropping is an agroforestry system in which food crops are grown in alleys formed by contour hedgerows of trees or shrubs [Kang et al., 1981]. The hedgerows are preferably established from native trees or perennial shrubs. These trees are periodically pruned to prevent shading of the food crops. Agronomic and soil fertility aspects of alley cropping systems have been extensively studied at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria [Kang et al., 1984; Kang and Duguma, 1985; Kang et al., 1985]. However, the effects of alley cropping systems on runoff and soil erosion, soil structure and compaction, moisture retention and availability to plants, and the effects of soil fertility depletion on soil physical properties and crop growth and yields have not been studied.

Field runoff plots were, therefore, established at the research farm of IITA to evaluate conservation-effectiveness of alley cropping systems (Fig. 1 to Fig. 4). Plots were established in close proximity to those of Dr. Kang established for agronomic and soil fertility investigations. The following series of research reports are based on a 6-year study designed to quantitatively evaluate soil physical and hydrological aspects of such an agroforestry system. Initial discussions in establishing these plots and other help received from Drs. Kang, Wilson and Lawson of IITA is gratefully acknowledged.

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