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CULTURED TREES, THEIR ENVIRONMENT AND OUR LEGACIES

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Professor of Geography

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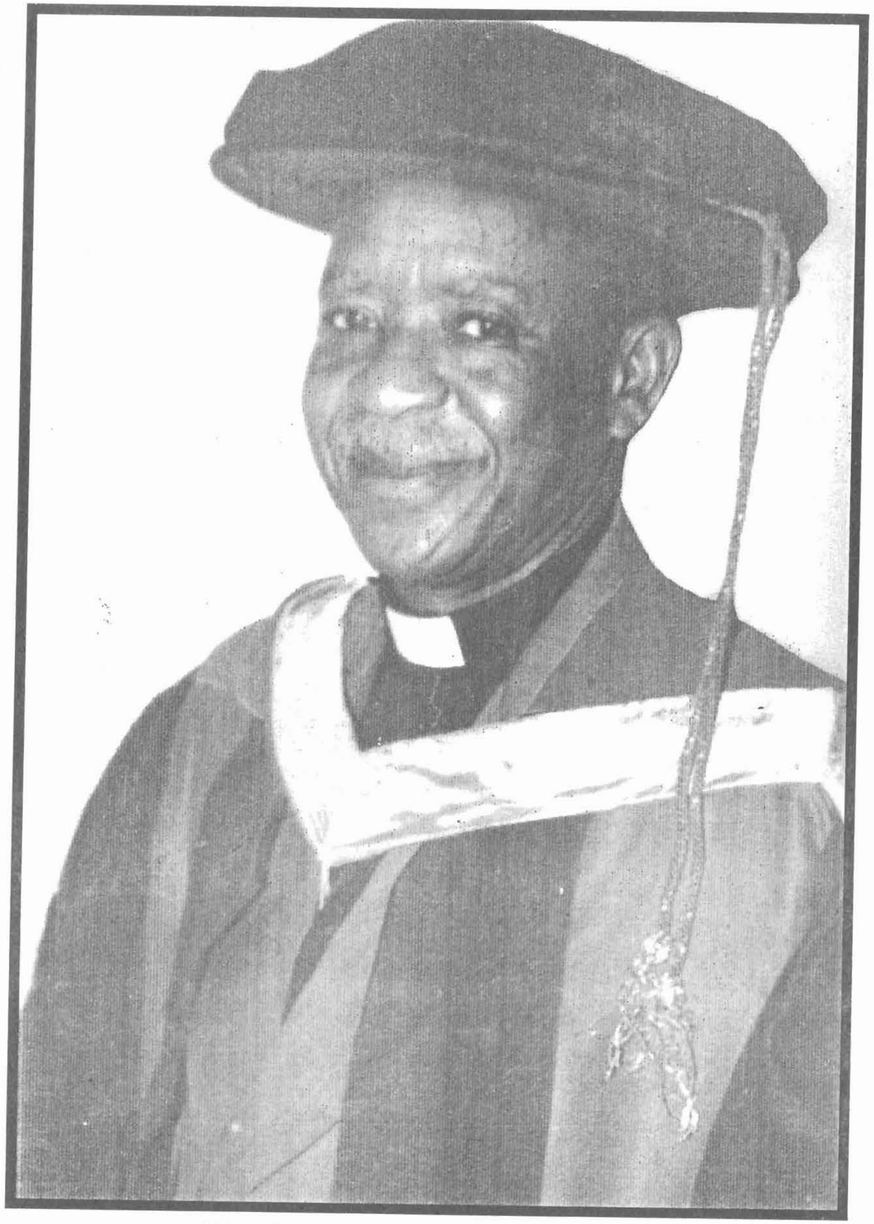

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An Inaugural Lecture Delivered on Tuesday, January 23, 2007 at Oduduwa Hall, Obafemi Awolowo University, Ile-Ife

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Introduction

Mr. Vice-Chancellor, distinguished ladies and gentlemen, it is my pleasure to stand before you today to present my academic report sheet. The report is significant in some respects. The father of Geography in Ife, Professor G.J.A. Ojo gave his inaugural lecture on culture, Professor S.A. Agboola talked on agricultural dimension, the Late Professor O. Adejuyigbe on boundary, Professor L.K. Jeje on landscape evolution and Professor (Mrs.) J.O. Abiodun on regional planning while Professor J.O. Adejuwon discussed hydrology. All these able teachers of mine delved into their major areas of research except the latter who gave a lucid report of his on-going research effort at that time. Professor J.O. Adejuwon is the foremost biogeographer in Nigeria and he gained world-wide recognition for his research on savanna and other environmental systems in Nigeria. However, he did not write on Biogeography for his inaugural lecture probably leaving this to be done by his first fruit in the discipline. Another information about all these teachers is that all of them are "aliens" in the Department of Geography of the University of Ife (now Obafemi Awolowo University) as none has a degree of the Department. Today, I stand before you as the first home-grown alumnus of the Department to give an inaugural lecture, and also the first in Biogeography in this University.

It is, therefore, my pleasure to give a summary of my research efforts and of my own modest contribution to knowledge in the field of Biogeography, in particular, and Geography, in general.

Geography and Its Branches

Geography is a spatial science studying human ecology, that is, the interrelationships between man and his environment over space and time. Geography has two main branches: Human and Physical. Each of them has many areas of specialization such as Social, Economic, Regional and

Population Geography; Biogeography, Climatology, Geomorphology and Hydrology. In my area of specialization i.e. Biogeography, we examine the relationships of man and his environment within the framework of the ecosystem concept. According to Areola (1990), this ecological approach sees every resource process as a set of interactions between the biotic and the abiotic components of the ecosystem which man manipulates to achieve his own ends. The consequences of this ecosystem manipulation in all its ramifications are of central concern to the biogeographer.

It is pertinent to point out that gone are the days when Geography was mainly associated with maps and diagrams. Gone are the days when it was just concerned with describing the spatial distribution of phenomena and data generated by other researchers in various disciplines. Geographers now generate their own data in the most appropriate scientific ways of data generation.

Plant-Soil Model

When God created the earth and all that is in it, He commanded;

> the earth to produce all kinds of plants including fruit trees and grain... and the earth produced all kinds of vegetation... and there was no one to work the land... The Lord God took a handful of soil and made a man... the Lord made a garden in a place called Eden... and he put the man there... The Lord God placed all kinds of beautiful trees and fruit trees in the garden... The Lord God put the man in the Garden of Eden to take care of it and to look after it.
>
> Genesis 1:11-12; 2:5-15 (C.E.V.)

This act of God started what we can refer to as environmental management. He put man in the Garden of Eden to tend the trees, pluck the fruits and make sure that their production never ceases. To achieve the latter, God expects man to manage the soils through which the plants receive their major nourishment.

Under the high forest of the Tropical Rain Forest, it is known that vegetation and soil are in equilibrium involving an almost closed cycling of nutrients associated with a characteristic pattern of water use (Jenny, 1941, Richards, 1957; Moss, 1969). This forest plant-soil equilibrium is attained by the creation of a very distinct micro-climate from the surrounding macro-climate. It is also due to the high rate of energy use as expressed by a very high rate of litter production, rapid mineralization rates and a rapid attainment of equilibrium with respect to organic matter relationships. These characteristics are largely dependent on the vegetation biomass of the Tropical Rain Forest.

The effect of the forest cover in intercepting rainfall and in modifying the temperature and humidity at the ground surface is considerable. Hence, it is not surprising that there is an almost closed nutrient cycle with little loss to groundwater and negligible losses in surface and near-surface lateral water movements. In the nutrient cycling process, the role of rainwash from the leaves is also significant in conveying nutrients to the soil (Nye and Greenland, 1960; Moss, 1969). Furthermore, the role of soil flora and fauna in the Tropical Rain Forest is important. They help in the decomposition of wood, bark and dead leaves into humus and the eventual breakdown of humus so formed into carbon dioxide, water and nutrient matter. Therefore, under the tropical rainforest, the plant-soil system is an extremely complex, resilient and stable ecological entity, strongly buffered against change induced by environmental effects, notably the seasonal and diurnal climatic changes (Moss, 1969).

However, whenever the forest is opened up for cultivation, the plant-soil equilibrium is disrupted. At the time the crops are growing, there is a gradual deterioration in soil fertility (Kowal and Tinker, 1959, Nye and Greenland, 1960; Jeje, 1980) resulting from the withdrawal of nutrients by crops and the exposure of the soil to agents of erosion such as rain and surface wash. Erosion can lead to loss of organic matter and mineral nutrients, an increase in acidity, a loss of clay particles and a deterioration in structure as the soil becomes more compacted (Jeje et al, 1982).

Studies on secondary succession (i.e. fallow period) have afforded wider knowledge on the plant-soil relationships (Jenny, 1941; Pereira, 1955; Aweto, 1978). During the fallow period, the vegetation that colonises it helps to rebuild soil fertility by protecting the soil from the elements of tropical weather, reducing surface wash of the finer particles of soil and the nutrients associated with them; providing soil building materials in form of organic matter which is the main source of soil nutrients, creating a micro-climate under which the rate of organic matter mineralization is reduced and an increase in available nutrients is achieved and finally, creating favourable conditions for earthworms and other soil macro - and micro-organisms which help to give the soil a good structure. Tansley (1941) further noted that the sequential changes in vegetation structure and floristic composition during the course of fallowing depended, in turn, on improvements in soil nutrients status and water-holding capacity. Thus, the vegetation and the soil beneath it, according to Langdale-Brown (1968), are inter-related and exert reciprocal effects on one another.

The cultivation of tree crops in the Tropical Rain Forest region has brought a different dimension to agricultural practice and environmental conditions in this region. Such tree crops include cocoa, kola, coffee, oil-palm and citrus. These tree crops seem to simulate the features of a fallow ecosystem

by creating similar plant-soil interactions during the course of their growth except that they (the tree crops) are managed by man mainly as mono-cultural ecosystems. Furthermore, the tree crop vegetation does not appear to persist indefinitely. In the case of cocoa trees, for example, they may persist for over 40 years. Therefore, it can be assumed that as these tree crops advance in age, they also create a plant-soil system of their own (Wessel, 1969).

However, the complex interrelations between the elements of soil and those of the vegetation in an ecosystem suggest that probably a more meaningful and realistic approach to the study of the impact of tree crops cultivation on soil characteristics has to be within the framework of an integrated plant-soil system model (Fig. 1).

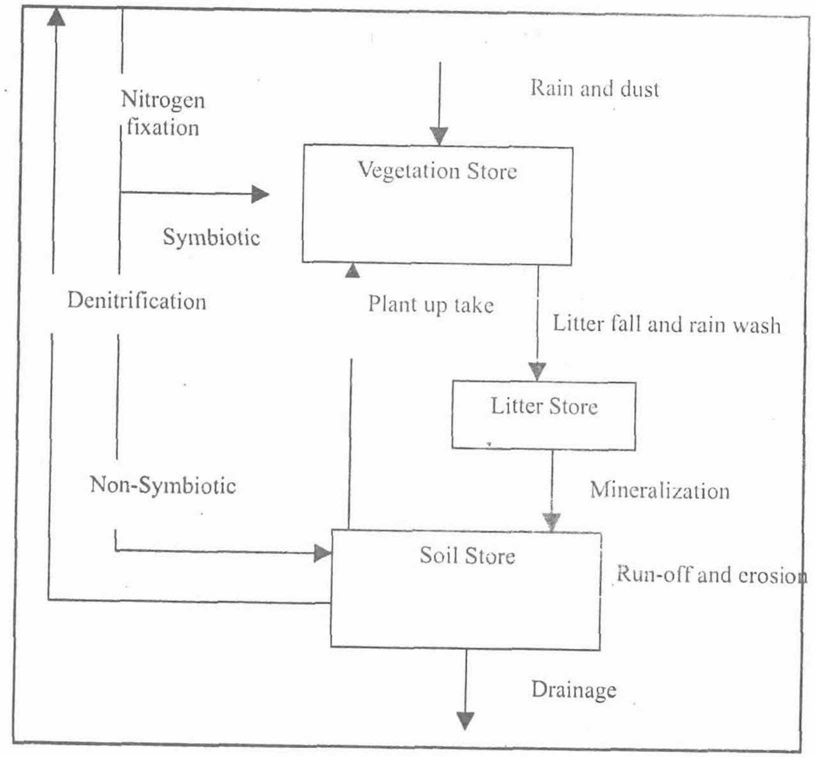

Fig. 1: The Plant Soil Model

Indeed, Moss (1969) has warned against the practice of examining soil and vegetation as separate entities. This is because they operate as two separate but strongly dependent open systems. To neglect soil is to eliminate the part of the plant-soil system which will remain when the vegetation has been removed for cultivation; to neglect the vegetation is to make it impossible to evaluate, or even recognize, those soil properties which influence and are influenced by it. In other words, neither the changes which take place in the soil under tree crops nor the changes that take place in their physiognomy during the course of their life span can fully be understood if the vegetation and soil components are studied separately. Hence, in my research in the ecosystems of cultured trees, a plant-soil system model has been adopted to analyze the interrelationships between the soil characteristics and vegetation parameters in the tree crops communities over space and time.

Cocoa Environmental Systems

Ecology of Cocoa: Cocoa (*Theobroma cacao* L.) is a native of the lowland tropical forest of the upper Amazon Basin of South America. Cocoa thrives very well on undulating and well-drained land with deep, clayey, non-acid and nutrient rich soils. A typical soil profile of *Egbeda* series described as a very suitable soil type for cocoa cultivation is given by Smyth and Montgomery (1962) as:

0-7cm	Dark brown, sandy loam; weak, medium sub-angular blocky; friable; very few iron concretions; frequent quartz gravels; merging to
7-27cm	Dark reddish brown; sandy loam; weak, medium sub-angular blocky; firm; frequent small iron concretions; frequent quartz gravels; merging to
27-50cm	Dark reddish brown; sandy clay loan; moderate, medium sub-angular blocky; firm; few of frequent concretions; few medium irregular iron concretions; frequent angular quartz gravels; merging to
50-75cm	Dark reddish brown; sandy clay; strong medium angular blocky; very firm; few small irregular iron concretions; few angular quartz gravels and stones; clear smooth boundary;
75-120cm	Dark red with distinct yellowish brown orange and grey mottles; clay; strong medium angular blocky; very firm; few stones.

The climatic requirements of cocoa is quite variable. While temperatures range from 25°C to 31°C, annual rainfall should range from 1200mm to 2000mm. The latter, however, must be well distributed throughout the year as cocoa performs best when there is no marked dry season. Especially in its young state, cocoa needs protection from strong winds and very bright sunshine. Hence, cocoa farmers usually cultivate shade trees and plants (especially plantain and banana) and when cocoa has substantial foliage, the shade trees and plants are removed. This practice is aptly expressed in a Yoruba adage:

Ogede to wo koko ye
O to di igi buruku.

Literally translated:

The plantain/banana that nurtures cocoa to maturity
Has become a useless tree.

Cocoa starts fruiting at about the fourth year and reaches maximum production between 15 and 30 years after planting, after which production declines (*Galleti* et. al, 1956).

Cocoa is believed to have been introduced into Nigeria in about 1854 by Chief Squiss Ibannigo (Are and Gwynne Jones, 1974). It was from Ibannigos plantation that cocoa cultivation spread inland and it was first exported from Nigeria in 1890 (Berry, 1974). Although the government gave some support to the cocoa farmers, the cocoa industry in Nigeria owes its development to peasant small-holder farmers who were responsible for the original production and still remain the backbone of the industry. Another important characteristic of cocoa worthy of note in south-western Nigeria is its nature of shifting. Indeed, Ekanade (1985b) described it as a moving crop because cocoa usually has a core area of production at a point in time. At present the centre of high production of cocoa has moved to the Ondo/Edo States axis. (Fig. 2).

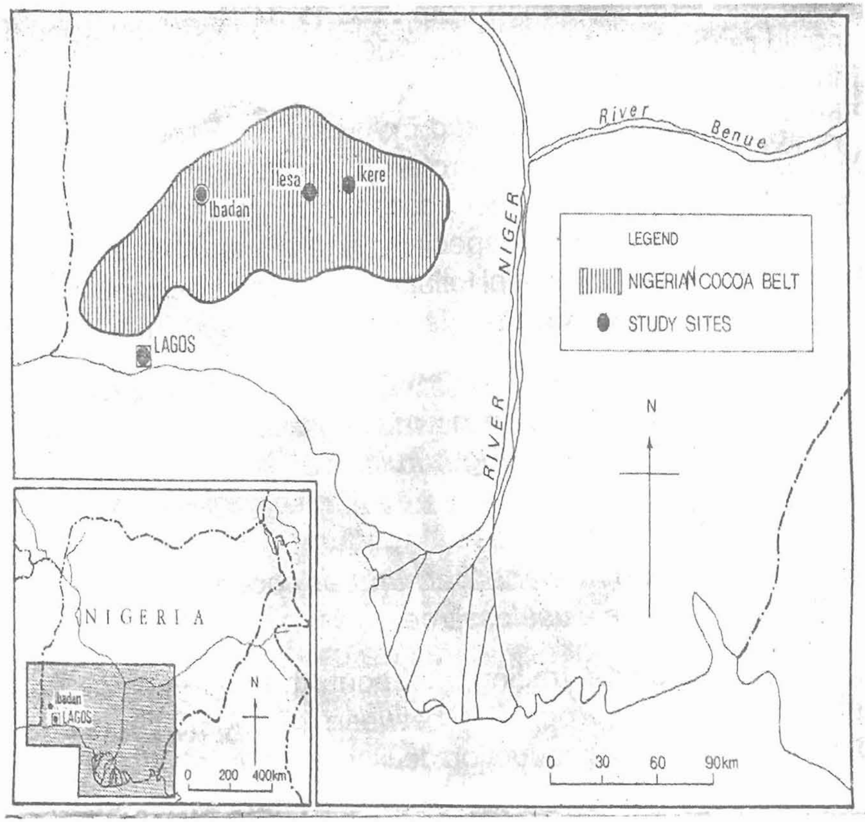

Fig. 2: The Nigerian Cocoa Belt

Processes of Land Occupation in the Nigerian Cocoa Belt

This section is based on two studies conducted in the Ife Region on land occupation of the Nigerian Cocoa Belt, which could be applied to other cocoa growing areas of south-western Nigeria. Adejuwon (1971) was able to show how the Ife Division was colonized by peasant farmers in the first six decades of the twentieth century to pursue the cultivation of cocoa. He described the systematic colonization of the areas, which implies the destruction of the original Tropical Rain Forest. Adejuwon (1971) explained that the pattern has resulted from the effects of economic factors connected with the change from purely subsistence economy to an export crop production oriented economy. If a growing community has to feed itself and add the production of a new crop, planted to meet additional need (e.g. the purchase of imported goods), then the corresponding rate of increase in the area of cultivated land would tend to be high.

Aloba (1983) also shows how the pattern of rural roads in Ife Division evolved between 1911 and 1970. The study clearly indicates the impact of road construction on the vegetal life of the area. However, Aloba (1983) has attributed the increasing road network density in Ife Division mainly to the concomitant change in land use pattern following the introduction of cocoa as important economic crop. The main point to note about these works is that they focus on the importance of peasant cocoa cultivation in causing changes to the landscape of the Nigerian Cocoa Belt.

Edaphic Elements of Cocoa Plant Community

My researches in the cocoa plant communities were conducted in the Cocoa Belt of southwestern Nigeria. One of the significant contributions relates to the status of the soil physical properties under cocoa (Ekanade, 1985a; 1985b). Hitherto, soil texture has been described as the most permanent and most fundamental soil property that is hardly changed by man through soil management practices (Faniran and Areola, 1978; Paton, 1978). Soil texture has considerable influence on soil structure. However, studies under cocoa show that textural elements, especially sand particles and clay fractions of soil differed significantly from those under forest. Sand particles and clay fractions have been shown to be of great importance when soil structure is being considered (Kohnke, 1968; Brady, 1974; Paton, 1978) and my research has shown a significant degradation of these vital soil physical properties under cocoa plantations. It shows that % sand content increases while that of clay decreases under cocoa both in the topsoil and subsoil. The increase in sand aggregates and a decrease in clay fractions in the topsoil are an indication of mechanical eluviation. Erosion by surface runoff could also have occurred when, during the first few years the plots used to cultivate cocoa were also used simultaneously to cultivate arable crops, so that when the land was later covered by cocoa, it could have failed to completely recover from the earlier erosional processes.

The substantial degradation of clay fractions possibly poses a more serious threat to soil fertility under cocoa as the colloidal composition of clay in the soil complex is of great importance in maintaining soil fertility (e.g. Kohnke, 1968; Cruickshank, 1972; Sanchez, 1976). It is well known that when the clay content is adversely affected, it may be difficult for other soil elements to regenerate since the structure and the soil moisture holding capacity will degenerate.

The importance of soil texture cannot be overemphasized. It has considerable influence on soil structure, consistence, degree of compaction and stability, soil drainage, soil aeration and root penetration. It determines the ability of the soil to hold and exchange nutrients and it is a crucial factor in determining soil response to liming and fertilizer applications on agricultural lands.

The research also indicates that soil structural properties of bulk density and total porosity under cocoa differed significantly from those under forest. These highly significant differences have grave implications for the structural development of soils under cocoa. This essentially means that once the Tropical Rain Forest is opened up to cocoa, soil compaction will take place over the years, and this can have important consequences. Nicou (1972), for example, observed that relatively small changes in bulk density have a marked effect on root development while Trouse and Humbert (1961) showed that small changes in bulk density cause roots to become flattened while substantial changes in bulk density cause root restriction. It is also known that total porosity determines the degree of soil aeration and is positively correlated with nutrient absorption by plants. Therefore, the situation whereby the soil total porosity under cocoa degenerates compared with that under forest has serious implications for the nutrient absorption in aging cocoa plantations.

The nature of nutrient properties of soil under cocoa was also investigated (Ekanade, 1985b; 1988; 1991b). These studies show that soil properties of pH, organic matter content, nitrate-nitrogen, available phosphorus, calcium, magnesium, potassium, sodium, cation exchange capacity and base saturation are all significantly lower under cocoa than under forest.

The temporal changes of soil properties under cocoa were also considered (Table 1 and Fig. 3). Twelve age groups of cocoa were considered for chemical and nutrient properties of soil. In general, the patterns of change overtime for each property show an initial small rise followed by a drop in the level of each property; this is followed by a rise to a peak at about 25 years, before a continuing decline occurred. For example, soil organic matter was 2.8% under one year old cocoa, 4.0% at 25 years and 2.6% at 55 years. Similarly, exchangeable magnesium is 1.9, 4.3, and 2.0 me/100g at one, 25 and 55 years respectively.

In order to further quantify the extent of soil degradation under cocoa in the Nigerian Cocoa Belt resulting from the opening up of the Tropical Rain Forest, an index of deterioration was formulated. The index of deterioration was calculated as the difference between the mean values of soil properties in the forest on the one hand and the cocoa plant communities on the other. The computed difference was then expressed as a percentage of the mean value of such a forest soil property.

AGE OF COCOA IN YEARS	BULK DENSITY (G/CM³)	TOTAL POROSITY (%)	pH (CACL₂)	ORGANIC MATTER (%)	NITRATE NITROGEN (PPM)	AVAILABILE PHOSPHORUS (PPM)	CALCIUM ME/100G	MAGNESIUM ME/100G	POTASSIUM ME/100G	SODIUM ME/100G	C.E.C ME/100G	BASE SATURATION (5)
1	1.39	48.5	5.2	2.8	29.1	7.5	5.9	1.9	0.3	0.2	9.3	89.2
5	1.37	48.3	5.9	3.0	38.4	10.2	6.6	2.8	0.5	0.2	11.0	91.8
10	1.36	48.7	5.7	2.8	30.3	7.8	5.1	2.1	0.2	0.1	8.3	90.4
15	1.33	49.8	6.0	3.1	31.4	8.4	6.0	2.5	0.4	0.2	9.6	94.8
20	1.24	53.2	6.0	3.4	36.9	12.8	8.6	2.7	0.3	0.2	12.7	92.9
25	1.15	56.6	6.1	4.0	48.9	14.6	11.4	4.3	0.7	0.3	17.2	97.1
30	1.20	54.7	5.9	3.6	34.4	11.0	8.5	2.1	0.5	0.3	12.1	94.2
35	1.28	51.7	5.4	2.9	34.1	9.6	5.7	2.1	0.3	0.2	8.8	94.2
40	1.32	50.2	5.6	2.7	27.3	8.9	5.0	1.8	0.2	0.1	7.9	89.9
45	1.45	45.3	5.3	2.5	30.5	9.0	5.2	2.1	0.3	0.2	8.6	87.6
50	1.43	46.0	5.2	2.4	26.5	8.2	4.3	1.8	0.2	0.1	7.2	88.8
55	1.40	47.2	5.2	2.6	25.7	7.9	4.2	2.0	0.2	0.1	7.5	86.7

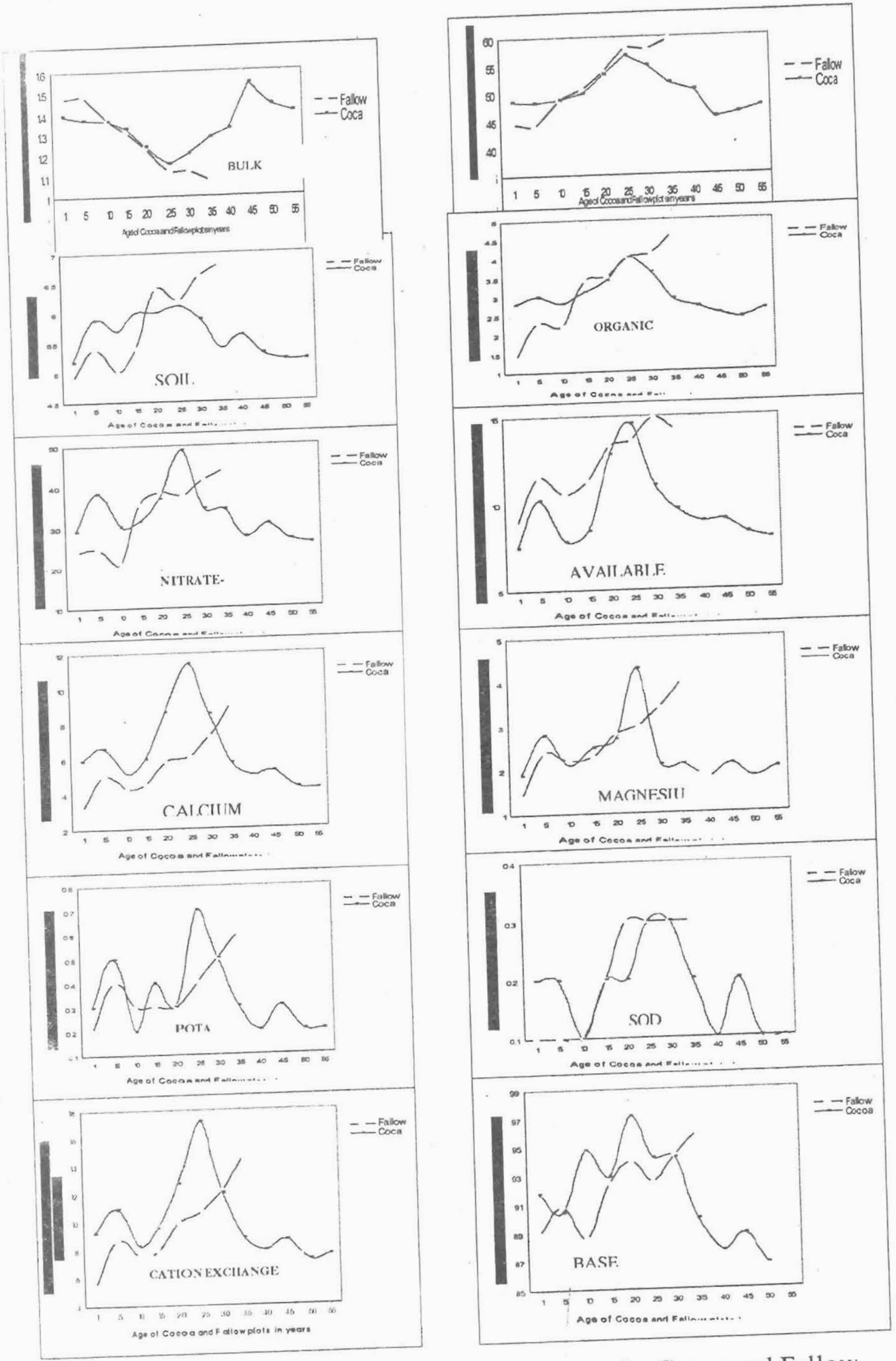

Fig. 3. Temporal Variations of Soil Properties under Cocoa and Fallow

The computation of the index of deterioration is premised on the assumption that the status of any soil property in a cultivated plant community was once the same as that in the forest before the commencement of cultivation. In effect, the mean level of a soil property in the forest is regarded as the optimal level.

Table 2 shows the deterioration indices of soil properties under cocoa. It is evident from Table 2 that the chemical and nutrient properties in the topsoil are mostly affected. These soil elements include organic matter, nitrate-nitrogen, available phosphorus, calcium, potassium, magnesium and cation exchange capacity. The deterioration of soil bulk density under cocoa is also substantial. Furthermore, the table indicates that the pattern of soil deterioration in the subsoil under cocoa appears to be the same as that in the topsoil, except that the indices are lower in most cases. All these results imply that soil physical, chemical and all the nutrient properties, in particular, deteriorate under cocoa communities with time, once the Tropical Rain Forest is removed.

Table 2: Deterioration indices of soil properties under cocoa+

SOIL PROPERTY	TOPSOIL	SUBSOIL
Bulk Density	-31.0	-
Total Porosity	18.3	-
Sand	-8.6	-4.1
Silt	21.3	-9.9
Clay	13.6	11.9
pH ($CaCl_2$)	13.2	-6.4
Organic Matter	26.7	13.0
Nitrate-Nitrogen	27.2	36.2
Available Phosphorus	19.4	28.1
Calcium	37.8	36.2
Sodium	50.0	0.0
Potassium	42.9	40.0
Magnesium	42.1	31.0
C.E.C.	34.0	31.5
Base Saturation	8.4	3.2

+The negative indices for bulk density and sand fractions show a degradation of these physical properties of soil under cocoa.

Biotic Elements of Cocoa Plant Community

Some vegetation properties of the forest and cocoa plant communities were analysed and given in Table 3. The table indicates that most of the mean values of the vegetation properties are generally lower in the cocoa plant community than in the forest. It also shows that the mean values of tree density and accumulated litter are higher in the cocoa than in the forest plant community. The Student's t-test analysis reveals that tree density, foliage cover, tree height, tree girth, tree basal area and volume of wood are highly significantly different between the two plant communities.

To show the extent of the environmental degradation resulting from the opening up of the Tropical Rain Forest to cocoa cultivation, the deteriorating indices of the vegetation properties were calculated for cocoa plant units as indicated above. The assumption is that the status of any vegetation property under cocoa plant community was once the same as that under forest before cultivation. In effect the mean level of a vegetation parameter under forest is regarded as the optimal level. Table 3 shows that the replacement of the Tropical Rain Forest with cocoa has resulted in deterioration indices, ranging from about 7 to 95%. In fact, the sum total of the biological production of any vegetation unit could be subsumed under volume of wood. It is found in this research that the latter has deteriorated to a level of 95% when compared with original forest before cultivation. Therefore, the results show that the opening up of the Tropical Rain Forest culminates in an almost total removal of the vegetation cover.

However, the study shows that tree density and accumulated litter are higher in the cocoa than in the forest. Hence, their deterioration indices are negative relative to the forest (Table 3).

Table 3: Mean values of vegetation properties of forest and cocoa and deterioration indices of vegetation in the cocoa plant community

VEGETATION PROPERTY	FOREST	COCOA	DETERIORATION INDEX (%)
Tree Density (ha)	441.0 (±1.173)	785.0*(±3.155)	-78.0
Foliage Cover (%)	95.5 (±0.608)	89.9*(±1.565)	6.9
Tree Height (m)	16.2 (±0.220)	6.7*(±0.153)	58.6
Tree Girth (m)	1.57(±0.048)	0.52*(±0.026)	66.9
Tree Basal Area (m^2)	0.21(±0.011)	0.025*(±0.003)	88.1
Volume of Wood (m^3)	3.40(±0.133)	0.17*(±0.025)	95.0
Accumulated Litter (Kg)	2583.0(±71.870)	2651.0(±125.680)	-2.6

Significant at 1% level.

The higher tree density in the cocoa plant community could be ascribed to the fact that cocoa is usually cultivated to certain specifications and density for good establishment. With its characteristically high tree density and, possibly, its high foliage cover in its first 5-15 years, a high production of leaf litter is encouraged, and this litter is known to accumulate. Two main reasons had been adduced for this litter accumulation. First, the activities of micro- and macro-organisms under cocoa plantations are usually limited as a result of the management techniques, especially those dealing with the application of chemicals. Secondly, cocoa leaves are highly lignified making them less susceptible to decomposition. (Ekanade, 1985b; 1988; 1989b; 1990; 1998).

Plant-Soil System in Cocoa Farms

In line with the concept of plant-soil model, an attempt was made to look more closely at the interaction between cocoa plant and the soil under it. The Pearson's product-moment correlation was employed to elucidate the nature of relationships among and between soil and vegetation properties (Table 4). In view of some obvious expected relationships, it is the most striking aspects of these relationships that will be considered (Ekanade, 1989). These have to do with the inverse significant correlations between soil and vegetation properties in the cocoa plant community with respect to tree height, tree girth, tree basal area and volume of wood and the number of weed species. These results could be explained by the fact that tree height, tree girth, tree basal area and volume of wood are biomass variables that develop structurally over time. Hence, in the process of development cocoa trees immobilize substantial nutrients in their structure besides the removal of pods (Lockard and Burridge, 1965; Ogutuga, 1975). Other researchers have, however, reported highly significant positive correlations between soil and vegetation biomass properties in the forest and savanna fallows of southwestern Nigeria. For example, Aweto (1981) reported high positive correlations between tree diameter and tree height on the one hand and soil properties on the other in the forest fallows of varying ages.

Table 4: Correlation coefficients between soil and vegetation properties in the cocoa plant community

SOIL PROPERTIES	TREE DENSITY	FOLIAGE COVER	TREE HEIGHT	TREE GIRTH	TREE BASAL AREA	VOLUME OF WOOD	NO. OF COCOA PODS	NO. OF WEED SPECIES	ACCUMU-LATED LITTER
Sand (T)	-0.32^{1}	-0.35^{2}	-0.41^{2}	-0.80^{2}	-0.76^{2}	-0.59^{2}	-0.47^{2}	0.69^{2}	-0.68^{2}
Silt (T)	0.30^{1}	0.37^{2}	-0.44^{2}	-0.80^{2}	-0.76^{2}	-0.60^{2}	0.48^{2}	-0.70^{2}	0.69^{2}
Clay (T)	0.21	0.05	-0.17^{2}	-0.09	-0.11	-0.07	0.08	-0.11	0.02
Bulk Density (T)	-0.36^{2}	-0.46^{2}	0.48^{2}	0.78^{2}	0.75^{2}	0.62^{2}	-0.53^{2}	0.72^{2}	-0.74^{2}
Total Porosity (T)	0.38^{2}	0.54^{2}	-0.46^{2}	-0.60^{2}	-0.58^{2}	-0.52^{2}	0.47^{2}	-0.56^{2}	0.66^{2}
PH (T)	0.37^{2}	0.38^{2}	-0.42^{2}	-0.72^{2}	-0.68^{2}	-0.55^{2}	0.45^{2}	-0.65^{2}	0.68^{2}
Organic Matter (T)	0.68^{2}	0.84^{2}	0.60^{2}	0.79^{2}	0.70^{2}	0.71^{2}	0.39^{2}	-0.62^{2}	0.88^{2}
Nitrate-Nitrogen (T)	0.30^{1}	0.46^{2}	-0.49^{2}	-0.77^{2}	-0.75^{2}	-0.64^{2}	0.45^{2}	-0.66^{2}	0.67^{2}
Available Phosphorus (T)	0.47^{2}	0.42^{2}	-0.39^{2}	-0.76^{2}	-0.72^{2}	-0.56^{2}	0.49^{2}	-0.69^{2}	0.71^{2}
Calcium (T)	0.40^{2}	0.40^{2}	-0.40^{2}	-0.77^{2}	0.73^{2}	-0.58^{2}	0.48^{2}	-0.70^{2}	0.72^{2}
Magnesium (T)	0.36^{2}	0.35^{2}	-0.43^{2}	-0.78^{2}	-0.74^{2}	-0.59^{2}	0.46^{2}	-0.68^{2}	0.65^{2}
Potassium (T)	0.28^{1}	0.44^{2}	-0.46^{2}	-0.78^{2}	-0.75^{2}	-0.62^{2}	0.50^{2}	-0.70^{2}	0.71^{2}
Sodium (T)	0.32^{1}	0.40^{2}	-0.39^{2}	-0.76^{2}	-0.72^{2}	-0.58^{2}	0.49^{2}	-0.68^{2}	0.71^{2}
C.E.C. (T)	0.51^{2}	0.39^{2}	-0.40^{2}	-0.72^{2}	-0.69^{2}	-0.55^{2}	0.46^{2}	-0.66^{2}	0.68^{2}
Base Saturation (T)	0.40^{2}	0.39^{2}	-0.42^{2}	-0.80^{2}	-0.77^{2}	-0.61^{2}	0.48^{2}	-0.70^{2}	0.70^{2}
Sand (S)	-0.29^{1}	0.41^{2}	-0.29^{1}	-0.40^{2}	-0.45^{2}	-0.46^{2}	-0.41^{2}	-0.20^{2}	0.31^{1}
Silt (S)	0.21	0.34^{2}	-0.31^{1}	-0.63^{2}	-0.39^{2}	-0.41^{2}	0.40^{2}	-0.22^{2}	0.46^{2}
Clay (S)	0.38^{2}	0.44^{2}	0.45^{2}	0.94^{2}	0.89^{2}	0.40^{2}	0.55^{2}	-0.18	0.38^{2}
PH (S)	0.33^{2}	-0.02	0.13	0.12	0.12	0.12	-0.09	0.05	-0.24
Organic Matter	0.55^{2}	0.12	-0.01	-0.06	-0.06	0.06	-0.02	-0.13	-0.08
Nitrate-Nitrogen (S)	0.76^{2}	0.08	0.38^{2}	0.58^{2}	0.45^{2}	0.44^{2}	-0.23	0.06	-0.12

Available Phosphorus (S)	0.44[2]	0.42[2]	-0.40[2]	-0.39[2]	-0.50[2]	-0.40[2]	0.31[1]	-0.22	-0.47[2]
Calcium (S)	0.33[2]	0.37[2]	-0.34[2]	-0.38[2]	-0.48[2]	-0.49[2]	0.40[2]	-0.23	0.34[2]
Magnesium (S)	0.30[1]	0.12	0.04	-0.13	-0.10	-0.02	-0.13	-0.24	-0.07
Potassium (S)	0.20	0.28[1]	-0.16	-0.50[2]	-0.46[2]	-0.31[1]	0.32[1]	-0.21	0.32[1]
Sodium (S)	0.22	0.12	-0.02	-0.24	-0.21	-0.20	0.11	-0.18	0.09
C.E.C. (S)	0.40[2]	0.33[2]	-0.23	-0.66[2]	0.59[2]	-0.38[2]	0.40[2]	-0.21	0.37[2]
Base Saturation (S)	0.30[1]	0.26[1]	-0.39[2]	-0.60[2]	-0.62[2]	-0.32[1]	0.31[1]	-0.23	0.33[2]

T - Topsoil, S Subsoil [1]Significant at 5% level [2]Significant at 1% level

Similarly, Adesina (1984) recorded high and positive correlations between soil and vegetation properties in both forest and savanna fallows of varying ages. The observed discrepancy between the results of this study and those of other researchers should not be surprising. The mere fact that cocoa is essentially a monoculture managed by man makes it different from fallows that are less disturbed by man. This means that the ecological setting of cocoa plots is constantly being disturbed whereas this is not so with the fallows. Besides, fallow plots consist of varied species that return to the soil various types of elements such as nitrogen fixed by leguminous plant species in the process of nutrient cycling (Nye and Greenland, 1960; Nye, 1961). Furthermore, cocoa, as a perennial crop is known to make long-term demands on soil nutrients. All these indicate that as cocoa biomass variables remove and immobilize soil nutrients over time, the soil-plant relationships become negative whereas under fallows, nutrients are known to accumulate overtime, hence the positive soil-plant relationships.

The inverse relationships between the number of weed species and most soil properties could not be explained in terms of nutrient absorption. Rather these relationships relate to the openness of cocoa plots and the consequent impoverishment of the soil (Ekanade, 1989).

Cocoa and Kola Environmental Systems

It has been pointed out that cocoa is usually cultivated as monocrops in the Nigerian Cocoa Belt. However, it has also been observed that some peasant cocoa farmers interplant their cocoa farms with kola. The focus of research in this case is to investigate what effect the intercropping of cocoa and kola has on the soil both spatially and temporally. Actually, the major objectives of peasant farmers in intercropping their cocoa farms with other tree crops especially kola (*Cola nitida* (Vent) Schott and Endl.) are two fold. First, it is primarily to provide shade for cocoa trees and secondly to maximize their returns. Although observations show that most farmers do not cultivate their farms to any formal defined spatial arrangement with respect to the interplanted tree crops, some do.

Two suitable cocoa plantations of different ages interplanted with kola of similar ages respectively were selected at Ipetumodu. The first plantation consisted of 15-year-old cocoa trees interplanted with kola of the same age, while the second was 40-year-old cocoa trees interplanted with kola of the same age. The spacing arrangements of the plantations show that one row of kola is planted between each three rows of cocoa. While the mean interspatial distance between cocoa trees is 2.5m that of kola is 5.3m. Furthermore, the spacing between cocoa and kola averages about 4.0m.

From this research, it was concluded that during early period of interplanting cocoa and kola no spatial variations were evident to soil properties. However, as these tree crops advance in age spatial variations of soil properties take place under them. The results further pinpoint the fact that certain important soil elements are significantly differentiated under the 40-year-old cocoa/kola plantation. The general trend is that under kola and between kola and cocoa most of the soil macronutrients are significantly higher in values than under cocoa. It is, therefore, concluded that these spatial and temporal variations in soil properties could be attributed to the land surface exposure under cocoa and possible higher extraction of nutrients by cocoa than kola. Thus, the interplantation of cocoa and kola does not effect significant changes in soil initially until physiognomic differences occur in them. Hence, the disparities in soil elements under cocoa and kola in southwestern Nigeria could be attributed to differences in growth habit and nutrient extraction rather than management practices over time.

Hitherto, my research on what happens to soil under

cocoa, and later under cocoa/kola environmental systems had been limited to the peasant farmers' holdings in the Nigerian Cocoa Belt. The field laboratory for the research now reported shifted to the Gambari Experimental Station (GES) of the Cocoa Research Institute of Nigeria (C.R.I.N), Ibadan located in the Nigerian Cocoa Belt. It has been pointed out earlier that it is a common practice among most of the cocoa farmers in the Nigerian Cocoa Belt to interplant their cocoa with other trees but in a haphazard manner. It was felt that attention should shift to considering well-ordered interplantation in various arrangements at CRIN. Although CRIN possesses many monocultural plantations of cocoa in different randomized arrangements, it also has interplanted ones with such tree crops as kola, oil palm, coffee, cashew, plantain/banana and even exotics such as *Tectona grandis* and *Gmelina arborea*.

The plantation considered was that of cocoa/kola interplantation with four randomized planting arrangements capable of having different impacts on soil properties unoer them. These arrangements include:

A: row of kola between two rows of cocoa;
B: single row of cocoa between two rows of kola;
C: two rows of cocoa; and
D: a kola stand close and adjacent to two cocoa stands in a row.

The results show that soil nutrients are differentiated among different planting arrangements of a combination of cocoa and kola. It is indicated that the planting arrangement in which a kola stand is close and adjacent to two cocoa stands in a row (D) is the most beneficial to soil nutrients. This was attributed mainly to the higher level of organic matter content maintained under the planting arrangement than any other treatment. (Ekanade, 1990; Ekanade and Egbe 1990).

It is generally known that when there is an accumulation of soil organic matter, the latter being a store and source of important plant nutrients, there is usually a build-up of nutrients in the topsoil (Aweto, 1981; Areola et al, 1982). Similarly, Areola (1984) has also shown that highly significant correlations exist between organic matter content and other soil chemical properties under old cocoa farms. Therefore, the role of organic matter content in the build-up of nutrients appears critical in all vegetal ecosystems. However, the higher level of organic matter content together with the subsequent higher levels of other nutrients under D planting arrangement demanded some explanation as the planting arrangements were contiguous although randomized. It was argued that the phenomenon was related to the nature of organic materials found under the planting arrangement. It seemed that organic materials, especially leaves emanating from kola do decompose faster than those emanating from cocoa because cocoa leaves are lignified (Ekanade, 1985b) making cocoa leaves decompose very slowly. Therefore, under a monocropping of cocoa, as in C, the rate of nutrient returns to the soil through litter would be slower than under that of kola. In that case, it could be reasoned that the planting arrangement in which kola alone (A) is found should be expected to have greater beneficial effects upon soil nutrients than D since cocoa leaves would probably decompose slowly under the latter planting arrangement. What actually happened under D is a sort of synergistic relationship in which the rapid decomposition of kola leaves brings about a higher rate of decomposition of cocoa leaves as well (Ekanade, 1990). This being the case, more nutrients would be released to the topsoil under D than under those arrangements containing either kola or cocoa alone.

Cocoa and Oil Palm Environmental Systems

I further stretched the tentacles of my research to the consideration of cocoa in combination with oil palm (*Elaeis guineensis*). In the Nigerian Cocoa Belt peasant farmers do not intercrop their cocoa farms with oil palm in any definite pattern. In fact, oil palm has been known to grow wildly on their

farms. Hence, this research was carried out at CRIN. The plantation studied was 8.9 hectares. The experimental design used is a randomized block design with three spacing arrangements replicated six times. The treatments are as follows:

Control: Pure stands of oil palm and cocoa side by side and with a spacing of 9.1m triangular for oil palm and 1.6m^2 for cocoa (control). The densities for oil palm and cocoa were 83 and 1595 trees/hectare respectively.

Avenue Planting: One line in three of palms was omitted and cocoa planted in the ensuing wide interlines. There were 83 oil palms and 1688 cocoa trees per hectare respectively.

Hollow Square: Palms were planted in a 9.1m^2 with alternate palms in alternate rows omitted. Cocoa was planted in the squares so formed (hollow square planting). There were 100 and 1600 oil palms and cocoa trees per hectare respectively.

From these spacing arrangements four treatments were considered under which soil samples were collected. They included:

A: Pure stands of cocoa
B: Pure stands of oil palm
C: Avenue planting arrangement
D: Hollow square planting arrangement

Results indicate that soil properties are of higher values under hollow square planting followed by those in the avenue planting arrangement. Student's t-test also indicates that most of the soil properties are significantly lower under other planting arrangements than under the hollow square planting arrangement.

The fact that the hollow square planting arrangement has the highest values for moisture content and organic matter content makes way for other soil elements to be well favoured. As pointed out earlier soil organic matter content is repository of most of the other soil properties such as nitrogen and available phosphorus.

Cocoa and Fallow Environmental Systems

So far studies have been reported on the impact of cocoa on soil properties and also on the nature of soils when kola and oil palm are grown in combination with cocoa under different planting arrangements. Efforts were also made to compare the effects of cocoa and fallow systems on soil over time. Two major studies were carried out. First, plots of cocoa and fallow of between 10 and 15 years were considered in Ikirun area while cocoa plots of between one and 55 years, and fallow plots of between one and 35 years were considered in Ilesa Division as the second study. The deterioration indices of soil properties under cocoa and fallow plots when compared with forest were calculated. While deterioration indices under cocoa range from -4.1% to 66.2%, those under fallow range from -1.6% to 57.5% (Adejuwon and Ekanade, 1988). The studies clearly indicate that cocoa plots suffered higher level of deterioration than fallow plots.

Fig. 3 shows the trend of temporal variations of the various soil properties under cocoa and fallow plots. The pattern of change over time for bulk density under cocoa shows a decrease in value up to the twenty-fifth year before its values continue to rise and by the forty-fifth year its value has reached 1.45g/cm^3. Under fallow there is a rather consistent decrease in the values of bulk density except for an initial rise at about the fifth year. The implication of any rise in the bulk density values is that the soil is getting more compacted whereas a fall indicates a less compact soil. The pattern of changes, over

time, for other soil properties under cocoa show an initial small rise followed by a drop in the level of each property. This is followed by a rise to a peak at about 25 years, before a continuing decline occurs. For example, available phosphorus was 7.5ppm at one year, 14.6ppm at 25 years and 7.9ppm at 55 years. In general, the levels of other soil properties were characterized by increases as the fallow advances in age. In actual terms, for example, base saturation was 88.9%, 93.9% and 95.9% under fallows of one year, 20 years and 35 years respectively.

To further show the temporal changes of soil properties under these systems, the Pearson's product moment correlation coefficients between the ages of cocoa and fallow plots and the soil properties were calculated. The most significant observation concerning these correlation coefficients is the inverse relationship between the ages of cocoa and the value of each soil property except bulk density. It is, however, instructive to point out that the positive relationship between the age of cocoa and bulk density has the same implication as the negative relationships recorded in other soil properties. A reverse situation is observed under fallow where positive relationships are recorded between the age of fallow and the value of each soil property, except bulk density. That is, while the levels of soil properties under fallow improve over time through accumulation, they are depleted under cocoa. Hence it was indicated that cocoa and fallow ecological units have their own unique effects on soil properties after the removal of the Tropical Rain Forest (Ekanade, 1989a).

Fruiting and Non-fruiting Tree Crops

It has been indicated that soils under cocoa, kola and oil palm deteriorate over time in various degrees when compared with soils under forest. It has also been shown that cocoa has higher deteriorating impact on soils than either kola or oil palm.

Furthermore, it has been established that when these crops are intercropped, the impact on soil is less deteriorating. One major explanation that has been put forward in this research effort is the fact that soil nutrients are immobilized in the fruits which are later harvested thereby truncating nutrient cycling processes. In order to establish this claim some research efforts were directed to looking at the impact of fruiting and non-fruiting tree crops on soil properties.

A study was carried out at CRIN using W8/1 plot which covered about 2 hectares and planted to cocoa and kola. The plot was cleared in 1964 and planted to F3 Amazon cocoa with the aim of interplanting it later with kola. In 1966, kola (*Cola nitida*) was planted. While kola was spaced 7.62m apart, cocoa was spaced 3.05m between kola interlines. In 1987, 21 years after planting, the yield records for kola were collected. It was realized that 26 of the kola trees had never produced any fruit i.e. they were sterile. Out of these non-productive kola trees 10 were randomly selected and identified on the ground. Then the adjacent productive kola tree to each of the non-productive kola trees was also selected. Soil samples were collected from under the selected kola trees at one-metre distance from the tree trunk. Results of analysis indicate that the values of structural properties of pH, organic matter, available phosphorus, nitrate-nitrogen, sodium, potassium, magnesium and calcium are lower under productive than under non-productive kola trees. The paired comparison technique as described by Snedecor and Cochran (1967) was used to compare values between the two systems. The results of paired comparisons indicate that structural properties significantly deteriorated under productive kola. The main reason for this was related to the process of harvesting kola pods. In this process, harvesters trample on soil under productive kola tree more than under non-productive kola tree. This was believed, therefore, to be responsible for the more compact nature of the soil and hence its lower porosity value under productive kola.

The paired comparison test shows that most of the soil chemical properties are not significantly different between productive and non-productive kola except topsoil pH, and nitrate-nitrogen, and subsoil potassium, magnesium and calcium. Among these soil properties only nitrate-nitrogen is significantly higher under productive than under the non-productive kola. This latter phenomenon appears quite revealing. It indicates the reality of the situation when the foliage of a kola grove is carefully observed. In kola plantations the tendency is for sterile kola trees to "leave" plentifully. In that regard, their demand on soil nitrates may necessarily be higher than the productive kola (Ekanade, 1989b).

The most outstanding results of this study are the significant differences noted with respect to subsoil potassium, magnesium and calcium under these treatments. As stated earlier, these exchangeable cations are significantly higher under non-productive kola. The implication of these results is that while the cations are withdrawn in the subsoil under productive kola for fruiting purposes they are somehow accumulated under the non-productive kola leading to higher levels in the subsoil than in the topsoil. In essence, there appears to be annual withdrawal of these nutrients by productive kola, and once the fruits are harvested they are equally withdrawn from the nutrient cycling process. The outcome of this study confirms the notion of Ekanade (1985a, 1985b, 1987, 1988, *inter alia*) that one of the major and potent factors responsible for soil deterioration under cocoa and other tree crops as compared with those under forest is the immobilization of nutrients in pods and fruits which are removed from the nutrient cycling process in their environmental systems.

A similar study was also carried out in Iwo using the then plantations of the Investments Corporation of Oyo State planted to cashew (*Anacardium occidentae*), guava (*Psidium guajava*) which are fruit trees whose fruits are harvested twice annually, and teak (*Tectona grandis*) and gmelina (*Gmelina arborea*). The latter two are exotic timber trees harvested at maturity.

Table 5 gives the summary of findings. It could be observed that soil properties under forest are superior to those under either fruit trees or exotic timber trees. Textural, structural, chemical and nutrient properties of soil, especially in the topsoil, are more significantly differentiated under the fruit trees than under the exotic timber trees. It is clear that guava does not have as much deteriorating impact on subsoil properties as either cashew or exotic trees. Similarly, teak does not negatively affect subsoil properties as much as gmelina.

All these point to the fact that tree crops whether fruit or exotic trees, have differential effects on soil properties consequent on the removal of forest vegetation. These differential effects, according to Ekanade (1991b), could be due to the nature of the trees themselves, the mode of immobilization of nutrients in the vegetation biomass and fruits, the nutrient cycling process, the burning of the ecosystems (as done for the exotic trees) and the method of harvesting (as using tractor-wagons for fruiting trees).

The levels of nitrate-nitrogen under gmelina deserve some comments. It appears gmelina absorbs more of nitrate-nitrogen from the subsoil than from the topsoil. Indeed, in the topsoil the level of nitrate-nitrogen is close to that under forest. It is, therefore, concluded that the leaf litter of gmelina contains higher level of nitrate-nitrogen than other tree crops in this study. As a matter of fact, field observation shows that its leaves are different from those of others, being succulent and not brittle. The findings here agree with an earlier conclusion of Adejuwon and Ekanade (1988) in respect of nitrate-nitrogen levels under gmelina in Ikere Forest Reserve.

Table 5: Comparison of means of soil properties between forest and the various tree crops using Student's t-test

Soil Properties	Anacardium occidentae		Psidium Guajava		Gmelina Arborea		Tectona Grandis	
	T	S	T	S	T	S	T	S
Sand	1.52	1.25	1.82	1.71	1.33	1.71	1.21	1.23
Silt	3.65**	0.62	0.51	1.27	0.53	0.50	0.86	1.23
Clay	2.12*	3.87**	2.81*	1.43	1.93	2.09	1.07	1.22
Bulk Density	6.26**	4.44**	6.22**	0.16	3.10**	0.85	5.29**	2.01
Total Porosity	5.31**	3.62**	3.14**	1.44	3.45**	2.00	2.92**	1.07
Organic Matter	4.56**	1.68	2.85**	0.21	2.32*	1.80	2.19*	0.43
Nitrate-Nitrogen	3.26**	1.75	4.58**	0.63	2.06	6.38**	2.59*	1.84
Available	3.88**	4.25**	4.05**	2.06	1.32	2.71*	0.00	2.24*
Calcium	6.28*	1.45*	3.02**	1.72	3.98**	2.20*	4.87**	2.65*
Potassium	3.34**	1.48	2.97**	2.04	2.54*	5.39**	2.34*	2.48*
Sodium	2.62*	0.73	2.07	3.01**	1.06	2.28*	1.89	0.85
pH ($CaCl_2$)	3.34**	2.02	3.00**	2.08	1.98	1.31	0.93	1.83

T= Topsoil
S = Subsoil
**Significant at 5% level*
***Significant at 1% level.*

Other Areas of Interest

There are other areas of interest which have attracted my attention in the study of environmental systems. For example, variations in soils of a common class were examined for *Okemesi* series (Jeje and Ekanade, 1988) while soil patterns in large-scale agricultural projects were considered under the plots of Oyo State Agricultural Development Project (OYSADEP) in Saki area and the Rivers State Oil Palm Project in Ubima (Ekanade, 1993; 2003). Hill-slope agro-ecosystems and their implications on environmental systems were also considered (Ekanade, 1996). In all these studies, variations and effects of common arable crops such as yam, maize, cassava and rice soil elements were established. Innovation diffusion of farm management and impacts of adoption of modern farming techniques in rural southwestern Nigeria were researched among peasant farmers found in OYSADEP operational area (Ekanade and Salami, 1996; Ekanade et al, 1998). In these studies it was discovered that peasant farmers were adopting modern techniques such as fertilizing their arable crops, thereby spreading innovation brought by OYSADEP. For now, I am involved in climate change studies with respect to weather decision-making processes of peasant farmers and prediction of climate change and land-use scenario in Nigeria (Ekanade, 2005a, 2005b).

I do hope to do more work on climate change. However, I earnestly desire that my own up-coming academic fruits will work more on such areas of environmental systems as human impact on disappearance of plant species, the nature of biodiversity with respect to exotic plantations and surviving forest reserves and nature parks; and, of course, foliar analysis of tree crops considered in my research efforts.

Sustaining Our Legacies

Mr. Vice Chancellor, Sir, I have briefly recounted my efforts at looking at the environment of our cultured trees that are found all around us. Through these research efforts, directed mainly to the peasant farmers, it is apparent that cocoa and other tree crops could still resurface as the sources of wealth of Nigeria as they used to be. In the then Western Nigeria, for example, the legacies bequeathed to us through cocoa production are still visible till today and are still being managed by Ekiti, Ogun, Ondo, Osun and Oyo States. Besides, most of us here are beneficiaries of the cocoa boom and therefore are physical and visible legacies.

In order to sustain these legacies both for us and the coming generations, some of the implications of my research of the environment of cultured trees, with particular reference to cocoa, need be indicated. The first has to do with formulating sustainable land use planning and management practices for cocoa growers, at least in southwestern Nigeria.

This relates to the period after the high cocoa production and the nature of clay minerals in cocoa soils. In the latter case, there is the need to advise farmers to be cautious in the selection of sites for cultivating cocoa especially now that the hitherto suitable virgin land for cocoa in Southwestern Nigeria has become marginalized (Ekanade, 1989a). In the Nigerian Cocoa Belt, the best cocoa soil types that are clayey down the soil profile are *Itagunmodi, Ondo and Egbeda* Soil Associations (Smyth and Montgomery, 1962). In this regard, agricultural extension officers are needed here to advise farmers on this aspect as the mortality of cocoa trees depends greatly on the capability of soil to retain moisture during the dry season.

With regard to the period after high cocoa production, cocoa farmers should be encouraged to maintain the high organic components of the cocoa plant community after the peak period so that the status of soil nutrients and the soil textural and structural properties could be maintained optimally over a long period of time. This will help to prolong the productive life of cocoa trees. Jolly (1942), for example, assessed the effect of organic manuring on cocoa yields in Grenada and found that the productive period and the life span of cocoa trees were prolonged.

The maintenance of such organic components could be achieved once the tree density and percentage foliage cover are high since an efficient nutrient cycling process in the cocoa ecosystem will continue. Besides, the use of organic mulches could also constitute a means of replenishing the soil by preventing runoff and accelerated soil erosion (resulting from land exposure) and releasing nutrients into the soil as they decompose. These organic mulches could be collected in the form of green manures from the farmers' fallow plots which are usually found at short distances from their cocoa farms, or by frequently weeding their cocoa plots, at least, four times a year. However, the weeds slashed down have to be spread almost evenly over the plots rather than depositing them in heaps. Indeed, the use of organic mulches may be a more preferable soil management technique to peasant farmers because of some attendant problems in the application of chemical fertilizers.

It has been indicated that the use of chemical fertilizers is not a component of agricultural and management practices of cocoa farmers in southwestern Nigeria. However, as observed at CRIN, the application of chemical fertilizers, using correct dressings, especially following the twenty-fifth year of planting cocoa could be recommended. This would maintain the mineral nutrient status, which in turn will facilitate better nutrient cycling process. There may, however, be some attendant problems in the application of chemical fertilizers by the peasant farmers. These problems relate mainly to application using correct dressings, exhorbitant cost and transportation. In this case, there is need for many agricultural extension workers to assist farmers while governments at all levels need to subsidise the cost of chemical fertilizers substantially in order to reduce cost to the farmers and also open up rural areas for easy accessibility.

Lastly, it has been shown that the life span of cocoa plants could be elongated and soil degradation minimized under tree crops by interplanting cocoa, kola, oil palm and other tree crops in particular patterns in such a way that a mixture of their litter materials culminates in the release of crucial nutrients to the soil. The advantage of mixed cropping apparently derives from the benefits of intra - and inter-specific relationships, which are achieved with a suitable species diversity. Clearly, suitable crop combinations would tend to approximate to the primeval habitat of the individual crop under which they thrived optimally prior to domestication and would enhance the productivity of the crops (Ekanade et al, 1991). Therefore, peasant farmers, who hitherto have not been interplanting their tree crop plots in any definite manner, are

advised to start doing so in a way that soil productivity could be enhanced as reported from CRIN's planting arrangements. All these boil down to the adoption of appropriate tree crop agroforesty which could result in substantial agronomic and economic gains (Onwubuya et al, 1983; Afolami and Ajobo, 1983) as the tree crops would provide the farmers with money, often interchangeably. As earlier stated, the assistance of agricultural extension officers would be required to actualize this proposal.

CONCLUSION

It is worthy of note that the Federal Government of Nigeria is aware that the most enduring resources are found in the agricultural sector of the economy. Hence, its recent interest in revamping this sector in order to bring back the old glory. There are now Development Committees for our major agricultural produce such as cocoa, oil palm, cassava and groundnut, all in an effort to increase production.

The commodity for concern here is cocoa. Nigeria used to be the second highest producer of cocoa in the world, but today it ranks fourth. Earlier, I have indicated that a lot of legacies, still visible till today, have emanated from cocoa. Last year, the Minister of Agriculture stated that one of the strategies put in place by the present government to stem the tide of rapid decline of cocoa production was the setting up of the National Cocoa Development Committee (NCDC) charged with the responsibility of preparing a National Rehabilitation Programme Blueprint. The government targets a production of 600,000 metric tonnes by 2008.

The operation of the NCDC hangs on the setting up of sub-committees to address issues of input procurement, input distribution, farmer sensitization and training, regeneration and rehabilitation, alternative uses, organization and mobilization of farmers and funding of NCDC. There is no doubt that this committee has started impacting positively on cocoa production. My fear, however, is that the increase in production may be temporary. NCDC, for now, is not really concerned about cocoa environment. No sub-committee takes care of the soil. Let the NCDC know that this is not the first attempt to rehabilitate moribund cocoa plots. Previous efforts have failed because the environment of cocoa was neglected. My research has shown that one of the most important factors responsible for this failure is the non-consideration of the variations and deterioration that occur in soil properties over time (Ekanade, 1985b). It is hoped that the NCDC will listen, hear and act by setting up a sub-committee on soil improvement strategies under cocoa. This will make its efforts to revamp cocoa production, mainly through rehabilitation, to be successful and also restore the legacies of this "golden" and "money" tree.

Mr. Vice Chancellor, Sir, I want to sincerely thank God for making it possible for me to make my own modest contribution to advance knowledge in my chosen area. I am grateful to the University Research Committee for giving me research grants that eased my academic pursuit. I appreciate all my teachers, my colleagues, students, the technical and administrative staff of the Department of Geography for their support and my family for their patience and understanding, and all of you for listening.

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