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## Introduction

This, the third issue of *IITA Research*, reflects IITA's continuing and active commitment to two goals that are vitally important to Africa: ensuring that adequate food is produced and sustaining the fragile natural resource base, depleted by intensified production.

Important in sustaining and improving food production is an analytical framework for assessing the suitability of different systems of crop and resource management, within either present or potential reach of farmers in the region. An interdisciplinary study that assesses the soil erosion effects of various land-use systems is included herein, as is another study that discusses soil physical properties as affected by alley cropping. Studies such as these incrementally provide the knowledge base that is needed for improvements to be effective in each agroecological zone.

Yet another priority is improving the quality traits of crops within our mandate, for their adaptation to different cropping systems and to varied uses. The article on developing dual-purpose cowpea lines exemplifies this aspect.

Nature always manages to stay at least one step ahead of Man. Constant in all crop improvement efforts is the continuing need to understand the constraints imposed on crop production by diseases, weeds, and insect pests, so that reliable control methods can be developed to arrest the losses in food production caused by such pests. IITA's documentation of the role played by lepidopterous maize borers in Nigeria exemplies such efforts, and the information is now being used to evolve a holistic approach to control damage to maize production by borers and other pests.

Also covered in this issue are news and views relating to IITA's role in research efforts to help Africa feed itself adequately into the future. Reported here are meetings, workshops, training, publications, and other professional activities, all of which improve communication among scientists committed to Africa's well-being.

Your feedback continues to be welcome, especially if you are located in an African institution. Let us share our research experience for common benefit.

**L. Brader**
Director General

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# Economic analysis of soil erosion effects in alley cropping, no-till, and bush fallow systems in southwestern Nigeria*

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**The plight of Africa, with its increasing population, declining per capita food production, and a relatively fragile resource base, has added an urgency to the worldwide concern for sustainable agriculture. Alternative soil and crop management systems are being evaluated to determine their suitability. The interdisciplinary study reported here used a capital budgeting approach to pinpoint the options available for some farming situations in tropical Africa.**

## Introduction

Shifting cultivation is typical of traditional agricultural systems in tropical Africa. Farmers fell and burn the fallow vegetation, cultivate the cleared land (typically 1 to 3 years) and then abandon the site (from 4 to 20 years), to forest or bush cover (Sanchez 1976; Kang et al. 1985). Until recently, enough arable land was available to use land in this way. Today, however, due to increasing population, fallow periods have decreased, leading to more intensive cultivation of marginal land and the clearing of forest lands for agriculture (Lal et al. 1986; El-Ashry and Ram 1987). A major consequence has been increased soil erosion from cropland, resulting in declining soil fertility and lower crop yields (Kang et al. 1985) from the loss of soil organic matter and nutrients contained in the eroded sediments. Soil productivity also declines further as the erosion reduces both the depth of the root zone and the soil's moisture-holding capacity (Lal and Kang 1982; Lal 1985).

The International Institute of Tropical Agriculture (IITA) has concentrated its research efforts over the past two decades on developing sustainable soil management technologies, which enhance food production and preserve the natural resource base. The most promising land-use systems are alley cropping and no-till farming (Verinumbe et al. 1984; Lal 1986). Alley cropping is an agroforesty system in which food crops are grown in alleys formed by hedgerows of trees or shrubs. The trees or shrubs are periodically pruned during the cropping season to prevent shading and reduce competition with food crops in the use of natural resources (Kang et al. 1985). In no-till systems, disturbance of the soil is kept to a minimum and crops are seeded through the residue of a previous crop or through sod without plowing. Herbicides are used to control weeds. Both systems control soil erosion and maintain soil fertility (Kang and Ghuman 1989).

Although some economic analyses are available on the viability of improved land-use systems in sub-Saharan Africa (Raintree and Turray 1980; Hoekstra 1982; Verinumbe et al. 1984; Ngambeki 1985; Sumberg et al. 1987), none of them accounts for the erosion process with its resultant long-term impact on costs and returns.

Based on a simulation model, this paper uses a capital budgeting approach to determine how those land-management technologies compare with each other and with traditional bush fallow systems in southwestern Nigeria, taking into account both the short-term and long-run impact of soil erosion on agricultural productivity and profitability.

The analysis is also conducted under two population density scenarios (high and low), which permits us to verify Boserup's (1981) hypothesis that there exists a positive correlation between population density and agricultural intensification. This study thus differs from previous economic analyses in that the productivity effects of soil erosion and population growth rate are assessed.

## Methods

Five land-management technologies in maize production are evaluated in the study. They are (1–2) continuous alley cropping systems with leucaena (*Leucaena leucocephala*) hedgerows planted at 2-m and 4-m intervals, (3) continuous no-till system, and (4-5) two traditional bush fallow systems with 25% and 50% farming intensities. The 25% land-use intensity system is represented by a 3-year cropping, 9-year fallow system, and the 50% farming intensity system by a 3-year cropping, 3-year fallow system. Maize is chosen because (i) it is commonly grown in southwestern Nigeria, and (ii) although numerous variations in land-use systems are possible, most results from agronomic trials so far have been obtained with maize as a food crop (Lal 1986; Kang and Ghuman 1989).

### Capital budgeting model

The model proposed here estimates the net present value at the end of the current crop year of the private costs and benefits accruing during a relevant time horizon from choosing an improved soil-conserving system (e.g., alley cropping) over the erosive traditional practice of shifting cultivation. Virtually all economists agree (at least in theory) that farmers' erosion control practices are based on their estimates of the net present value of their investment (Seitz and Swanson 1980; Ervin and Ervin 1982). The argument contends that any soil erosion that lowers productivity lowers future returns to the land. Therefore, farmers will adopt a conservation practice if the rate of return to capital invested exceeds the opportunity cost of capital. This requires at a minimum that the costs of the practice now be less than the present value of the benefits. The present value of incremental net returns *(PVINR)* from investing in the improved practice over a *T*-year planning horizon can be written as:

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$$PVINR = \sum_{t=0}^{T-1} (R_t - R'_t)\,\beta^t + \rho \Delta SV_T \beta^{T-1} \qquad (1)$$

where $R_t$ and $R'_t$ are the net returns per hectare in year $t$ for the with and without new technology scenarios, respectively; β denotes the discount factor and is equal to $(1+r)^{-1}$ where $r$ is the discount rate; $\rho$ is the expected percentage of change in salvage value (i.e, terminal net worth) to be received by the farmer at the end of the planning horizon. If $\rho < 1$, the farmer will not receive the full benefits of the salvage value. This is expected because of the imperfect land market which prevails (Ega 1985). The assumption that $\rho = 1$ would be naive, indicating a perfectly functioning land and capital market with buyers of farmland having sufficient information about the land they purchase (Ervin and Mill 1985). Thus, $\Delta SV_T$ is the change in the salvage value brought about by the new technology and is calculated as:

$$\Delta SV_T = \sum_{t=T}^{\infty} (R_t - R'_t)\,\beta^{t-T} \qquad (2)$$

Assuming that $R_t$ and $R'_t$ stay constant after $t = T$ (the sector being thus forced into steady state), the infinite horizon model can be converted into a finite horizon equivalent by giving a weight of $\beta^T/(1-\beta)$ to the change in the salvage value. When $PVINR > 0$, the farmer would gain from choosing the soil-conserving system. However, when $PVINR < 0$, the farmer would have the incentive to continue mining the soil by using the traditional erosive practice. In this case, a subsidy at least equal to the $PVINR$ may be necessary to override the private advantage of using the erosive practice (Walker and Young 1986).

The central feature of equation (1) is the specification of the net return function, $R_t$ and $R'_t$. Both are defined as price times yield less the variable costs of production:

$$R_t = P_t Y(Z_t) - C_t \qquad (3)$$

$$R'_t = P_t Y(Z'_t) - C'_t \qquad (4)$$

In equations (3) and (4), $Y(Z_t)$ is the crop yield function with a soil conserving system, and $Y(Z'_t)$ the same without it. They are assumed to depend upon cumulative soil loss

$$Z_t = \sum_{\tau=0}^{t-1} d_\tau \quad \text{and} \quad Z'_t = \sum_{\tau=0}^{t-1} d'_\tau$$

where $d_\tau$ and $d'_\tau$ denote the amount of topsoil lost in year $t$, for the conservation and erosive practices, respectively. Cumulative soil loss $Z_t$ and $Z'_t$ are explicit arguments in yield functions because crop yield in any year is affected by the depth of the soil remaining and the available technology (Lal 1981; Walker 1982). We assume yields decline with increases in cumulative erosion. This is attributable to nutrient losses and decreasing levels of organic matter through erosion (Young 1986; Lal 1986). Because productivity loss increases with cumulative soil loss, the economic incentive for using an erosive practice decreases as erosion proceeds. $P'_t$ is the price of crop in year $t$; $C_t$ and $C'_t$ denote the variable costs of crop production with and without the soil management technology in year $t$, respectively.

Substituting for $R_t$ and $R'_t$ in equation (1) gives (after rearranging terms):

$$PVINR = \sum_{t=0}^{T-1} \{P_t[Y(Z_t) - Y(Z'_t)] + [C'_t - C_t]\}\beta^t + \rho\{\beta^T/1-\beta\} + \{P_T[Y(Z_T) - Y(Z'_T)] + [C'_T - C_T]\} \qquad (5)$$

The right-hand side of equation (5) is composed of three parts. The first bracketed term, $P_t\{Y(Z_t)-Y(Z'_t)\}\beta^t$ is the present value of the yield differential between the improved (soil-conserving) and erosive systems. This expression will be positive (negative) if the soil-conserving system gives higher (lower) yields. The second component $\beta^t\{C'_t - C_t\}$ measures the net cost of adopting the conservation practice. It thus reflects any increase (saving) in operating inputs (e.g., labor, chemical or material costs) from the new technology. The last term, $\rho\,\beta^T/1-\beta\,\{P_T\{Y(Z_T) - Y(Z'_T)\} + \{C'_T - C_T\}\}$ is a terminal value, which reflects the discounted value of all incremental returns to be realized beyond $T-1$.

**Data sources and construction**

To determine the effects of soil erosion on net returns over time and under different fallow management systems, data on the relevant variables were collected and simulated (where appropriate) for conditions prevailing in southwestern Nigeria.

**Soil loss.** Rates of soil erosion under the different fallow-management systems were calculated over a 20-year planning horizon using the SCUAF (Soil Changes Under Agro-Forestry) simulation model (Young et al. 1987), in combination with soil erosion rates measured in field trials at IITA, Ibadan (southwestern Nigeria).

Cumulative annual soil loss was plotted over time for the five fallow-management systems described (Fig. 1). The soil is a moderately sloped sandy Oxic paleustalf type, with a mean slope gradient of 7%. Initial soil loss rates used in the simulation model were collected from the field trials just mentioned. They are estimated at 0.43 t ha$^{-1}$ for no-till farming, 0.17 t ha$^{-1}$ for alley farming with 2-m interhedgerow spacing, and 0.82 t ha$^{-1}$ for that with 4-m spacing (Kang and Ghuman 1989). An initial soil

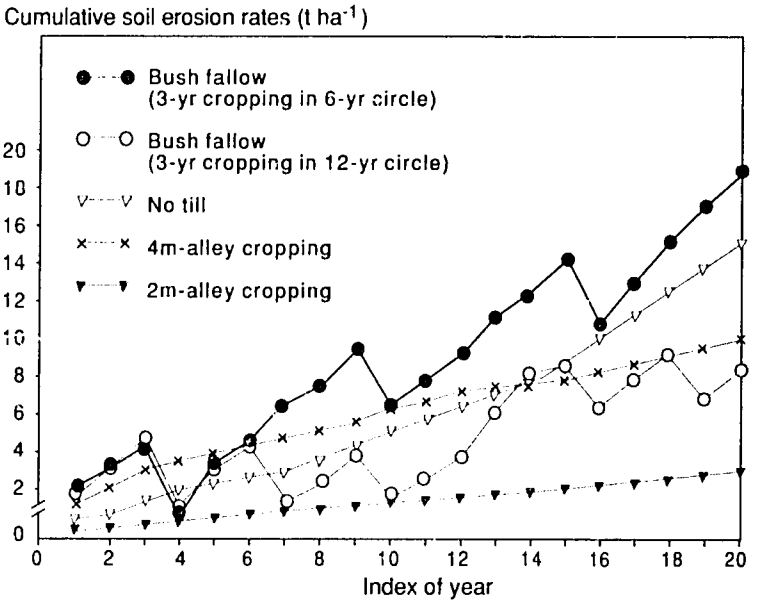


**Figure 1. Predicted cumulative soil loss under five land-use systems for an Oxic Paleustalf in southwestern Nigeria.**

loss rate of 1.53 t ha$^{-1}$ was used under the bush fallow systems, based on experimental data reported in IITA (1985).

**Crop yields.** Maize yield over the 20-year planning horizon was determined, based on the predicted cumulative soil erosion loss described above. The appropriate function relating maize yield to cumulative soil loss (i.e., for a sandy Oxic paleustalf with a 7% slope under southwestern Nigerian conditions) was obtained from Lal (1981):

$$Y_t = 6.70 \exp(-0.003\, Z_t) \quad R^2 = 0.89 \quad (6)$$

where $Z_t$ denotes cumulative soil loss rates in year $t$.

Using equation (6), maize yield levels under the five land-use systems were calculated for the base case, with yields expressed over the land occupied by the maize crop only (Fig. 2). Initial yield levels (t ha$^{-1}$) collected from field trials in Ibadan were 2.40 for no-till, 3.45 for alley cropping with 2-m spacing, and 3.17 for that with 4-m spacing. For the traditional bush fallow systems, an initial yield level of 2.27 t ha$^{-1}$ was chosen, based on results of tilled controlled plots without alley cropping (Kang and Ghuman 1989). This is a reasonable approximation as maize yields under traditional conditions range between 1.0 and 2.0 t ha$^{-1}$ (Mutsaers et al. 1987; Oyo North ADP 1989).

**Crop price and production costs.** The crop price was set at 0.59 Naira (N) per kg (in 1988, US $1 = N 5.00 on average). This was the average farm-gate maize price observed during the 1988 peak harvest period (June, July, and August) in Ibadan, Nigeria. Estimates of total variable costs per hectare for each fallow management system were as reported in Table 1.

Annual labor requirements for maize production under the alternative fallow management systems were based on Ngambeki (1985). With 50% farming intensity, 82 man-days are required for the traditional fallow management system with 3 years of fallow. In the 4-m alley cropping system, annual labor use is increased by 53% by the requirement for hedgerow pruning. In no-till, total labor use is reduced by 35% because of lower weeding requirements due to the herbicides applied. In the 2-m alley cropping system, total labor required is assumed to increase by 87% because of the pruning required by the increased number of leucaena hedgerows. We estimated that in the 2-m alley cropping system, 33% of the land is occupied by trees, compared to 20% in the 4-m alley cropping system. In the traditional fallow systems with 9 years of fallow, total labor required was assumed to decrease by 30% because of the low incidence of weed infestation. Labor costs per hectare for all land-use systems were calculated using a wage rate of N 7.5 per man-day, based on the prevailing minimum wage.

Because bush fallow and shifting agriculture require more frequent land clearing than the continuous alley cropping and no-till systems, it is important for comparison to account for the cost of clearing land. The latter was calculated based on an estimated 100 man-days of required labor to clear one hectare of high bush fallow (Oyo North ADP 1989). Assuming that all cropped lands were equally forested initially, land clearing cost in each system was imputed annually by allocating the required total labor cost linearly over 20 years.

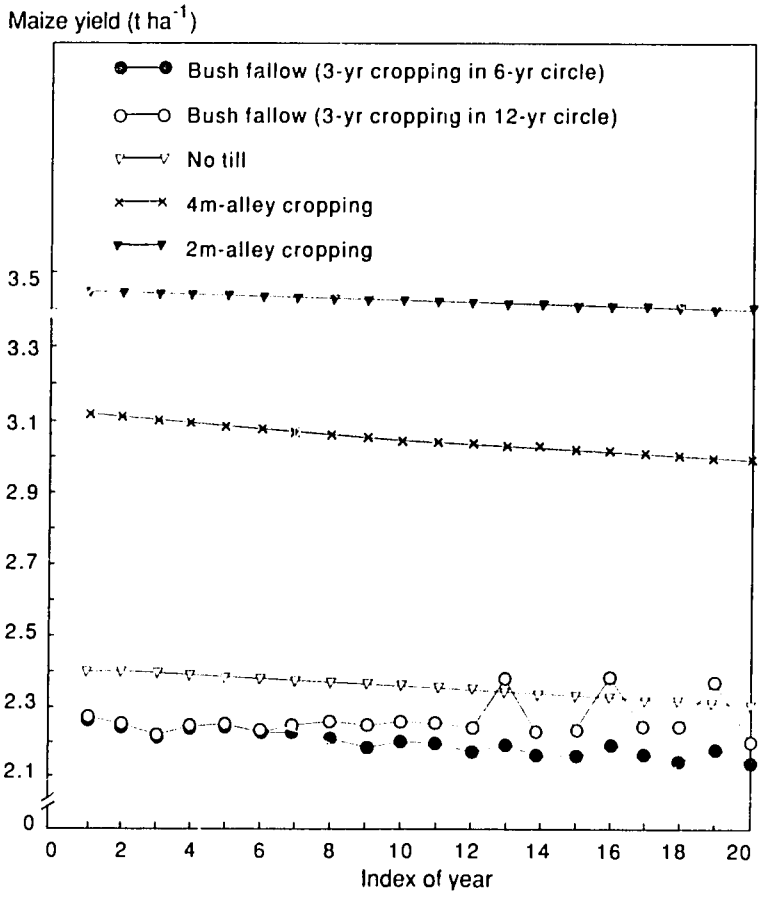


**Figure 2. Projected maize yields as a function of cumulative soil losses for five land-use systems over 20 years for an Oxic Paleustalf in southwestern Nigeria.**

## Results and Discussion

Assuming the farmer has been using the traditional shifting cultivation system with a 50% farming intensity, the income effects of soil erosion under alternative fallow management systems were assessed by computing the present value of incremental net returns (*PVINR*, see equation 1) over a 20-year planning horizon (see Fig. 3, where the values reported are for the base case [scenario 1]). A discount rate of 10% was used, based on the World Bank's estimate of the opportunity cost of capital for Nigeria (IBRD 1987). The opportunity cost of land is assumed to be limited, reflecting the case of a low population density. Assuming the farmer does not receive anything from the change in salvage value (i.e., $\rho = 0$), the traditional bush fallow system with a 25% farming intensity is found to be the most profitable, with a *PVINR* of N 2547 ha$^{-1}$, followed by the 4-m alley cropping (N 1755), the no-till system (N 1712), and the 2-m alley cropping (N 1373 ha$^{-1}$). We estimate that an-

**Table 1. Estimated annual average costs (Naira $ha^{-1}$ $a^{-1}$) of maize production under alternative land-use systems, southwestern Nigeria, 1988.**

| | Continuous cultivation | | | Bush fallow | |
|---|---|---|---|---|---|
| Inputs | 2m-alley | 4m-alley | No-till | 3-yr cropping in 6-year cycle | 3-yr cropping in 12-year cycle |
| Maize | 14.8 | 14.8 | 14.8 | 14.8 | 14.8 |
| Herbicides | - | - | 150.0 | - | - |
| User costs[a] (equipment & tools) | 73.7 | 73.7 | 139.3 | 73.7 | 73.7 |
| Labor costs | 1096.6 | 906.4 | 398.8 | 615.0 | 430.5 |
| Imputed land clearing cost | 37.5 | 37.5 | 37.5 | 150.0 | 75.0 |
| Capital costs (imputed at 10%) | 112.3 | 103.2 | 74.0 | 85.4 | 59.4 |
| Total | 1341.9 | 1135.6 | 814.4 | 938.9 | 653.4 |

(a) The user costs of the farm tools and equipment are computed based on the capital recovery factor formula :

$$A = PV\,[r/(1-(1+r)^{-t})]$$

where $A$ is the annualized cost of capital item; $PV$ is the present value of the capital item defined as the purchase price or less the present worth of its future salvage value; $t$ is the estimated lifespan of the capital item; and $r$ is the discount rate. A 10% discount is used for the base case, which is based on the opportunity cost of capital for Nigeria (IBRD 1987).

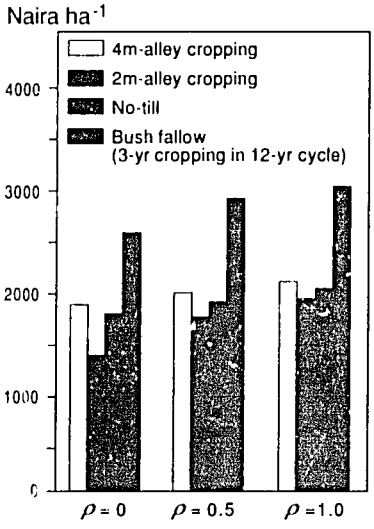


**Figure 3. Per hectare present value (discount rate = 10%) of incremental net returns from four alternative land-use systems, as compared to a bush fallow system using 3-year cropping in a 6-year cycle. No yield penalties are imposed, reflecting the conditions of low population density. $\rho$ denotes the expected percent change in terminal net worth to be received by the farmer.**

nual labor costs must decrease by at least 10% for the 4-m and 12% for the 2-m alley cropping for them to be competitive with the 12-year cycle bush-fallow system, if other factors remain equal. Therefore, where land is abundant and access to new forest land is 'costless', the attractiveness of soil-conserving technologies, such as alley cropping or no-till, is limited compared to bush fallow systems with long fallow periods (e.g., 9 years). This reinforces the argument that in land-abundant countries, strategies based on area expansion are the lowest-cost sources of growth (Pingali and Binswanger 1988).

Note from Figure 3 that the *PVINR* from switching to any of the fallow management systems increases as the amount of the salvage value the farmer expects to receive increases.

A second scenario takes into account the effect of land scarcity (Fig. 4). Under high population density, the opportunity cost of land is expected to rise, reflecting increasing shortages of arable land. To account for this, maize yields in shifting cultivation systems were discounted in proportion to the total land that is out of production (i.e., fallowed land). As expected, these yield penalties reduce the current profit advantage of the 12-year cycle bush fallow system. Despite its relatively low cost of production, the long-run yield gains from topsoil conservation with the 12-year cycle bush fallow are now insufficient to offset the handicap of direct yield penalty. The 4-m alley cropping system now yields the highest incremental return, with a *PVINR* of N 7377 $ha^{-1}$. The no-till and the 2-m alley cropping systems follow closely, with a *PVINR* of N 7334 and N 6995 $ha^{-1}$. As expected, the 12-year cycle bush fallow system yields the lowest incremental return, with a *PVINR* of N–351 $ha^{-1}$. Thus, as land value rises, the returns to investment in soil-conserving systems (especially the 4-m alley cropping and the no-till systems) increase. Therefore, we expect the 4-m alley system or the no-till cropping to be most attractive in areas with relatively high population density.

To evaluate the effects of different valuations of future income by farmers on the profitability of alternative fallow management systems, sensitivity analysis with respect to a higher discount rate (35%) was conducted. The impact of this on *PVNIR* was noticeably different for the low and high population density scenarios (Fig. 5). As expected, the higher discount rate tends to reduce the profitability of soil-conserving fallow management systems, compared to the more erosive 6-year cycle bush fallow system. That the no-till becomes more profitable than the 4-m alley cropping under a high discount rate scenario can be attributed to the establishment cost of the alley cropping system. It takes up to 2

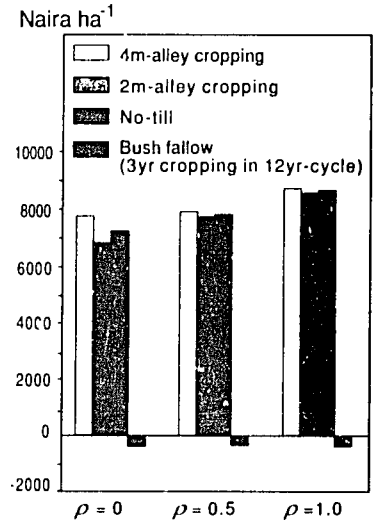


**Figure 4. Per hectare present value (discount rate = 10%) of incremental net returns from four alternative land-use systems, as compared to a bush fallow system using 3-year cropping in a 6-year cycle. Penalties are imposed on yields in the bush fallow system in proportion to land occupied by the bush fallow, reflecting the conditions of high population density. $\rho$ denotes the expected percent change in terminal net worth to be received by the farmer.**

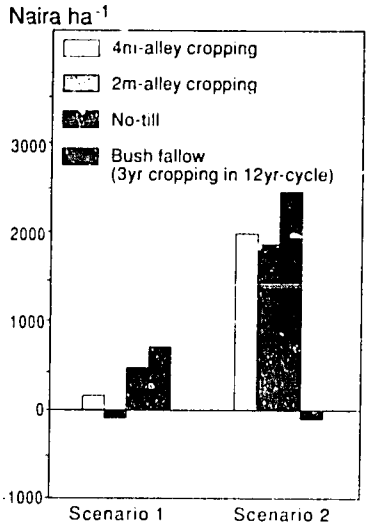


**Figure 5. Impacts of a higher discount rate (35%) on the per hectare present value of incremental net returns from four alternative land-use systems, as compared to a bush fallow system using 3-year cropping in a 6-year cycle. In Scenario 1, yields are expressed over the area occupied by the maize crop only. Scenario 2 represents the conditions of high population density; penalties are imposed on yields in the bush fallow systems, in proportion to the land in fallow.**

years before any benefit can be expected from the shrubs (Kang et al. 1985; Mutsaers and Spencer 1988).

These results confirm Boserup's (1981) hypothesis that there exists a positive correlation between intensity of land use and population density. The argument is that for given agroclimatic conditions, increases in population density will gradually move the agricultural system from forest fallow to annual cultivation. Thus intensive cultivation of permanent fields in the frontier, using labor-demanding technologies (such as the 4-m alley cropping) or external input demanding technologies (such as the no-till system), becomes the norm only when arable land is exhausted (Pingali and Binswanger 1988). It can, therefore, be concluded that where land value rises due to land shortages, farmers with lower discount rates are likely candidates for the adoption of the 4-m alley cropping system compared to the no-till. For those farmers exhibiting high discount rates under high population density conditions, research should focus on reducing the establishment cost of the 4-m alley cropping system to make it competitive with the no-till system.

## Limitations

It is useful to qualify the conclusions outlined here by reviewing the limitations of the study. Although it yields some insight about the productivity impacts of soil erosion, this study does not provide us with sufficient information regarding the potential for integration of alternative fallow management systems within the existing farming systems. To test if the technologies fit into the farmers' production plan, economic analysis based on a whole-farm modeling approach is necessary. Whole-farm models reflect the basic production processes involved in agriculture (e.g., nitrogen-fixing capabilities of leguminous trees) as well as many of the resource characteristics and constraints with which farmers must work (e.g., labor, land, and credit, to name a few). This further research should now be a priority.

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XN-ABK-206-A

# Evaluation of elite cowpea lines for dual purpose (leaf/fodder plus grain)*

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**Cowpea, which fits well into the cropping systems of several parts of Africa, is also a nutritionally important crop. Its grains, eaten by humans, have considerable protein; its tender leaves are cooked as a vegetable with cereal diets; and its haulms are used as livestock feed. Past research has focused on assessing and improving cowpea for these multiple traits. This article, based on genetic analysis, points to the need for a more specific strategy of dual targets, such as leaf plus grain or grain plus fodder, to suit regional consumption needs.**

## Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important grain legume of the lowland humid tropics and the semi-arid areas (Rachie and Roberts 1974). In Africa, it is widely distributed in cultivated and wild forms (Ng and Marechal 1984). In the West African savannas and the Sahel, cowpea is grown because it yields both grain for human consumption and haulms for animals (Foster and Mundy 1961). In eastern Africa, the tender leaves are periodically plucked and cooked as a side dish to the staple maize meal (Imbamba 1973). Thus, not only the grain but cowpea vegetative parts also make an important nutritional contribution (Lush 1978).

Cowpea morphology exhibits large variation, including both determinate and indeterminate types (Fery 1984). These range from climbing and spreading to dwarf and/or erect forms. Significant progress has been made in breeding determinate erect varieties with high grain yield and early maturity (Rachie 1984). Such types do not produce many leaves over an extended period. A concern has been raised that with such a thrust, the tendency may be toward the creation of cowpea types unsuitable for dual-purpose utilization, because cowpea types developed solely for grain may not provide the needed high fodder or vegetable leaf yields and ground cover.

A systematic effort was initiated at the International Institute of Tropical Agriculture (IITA) to identify potential dual-purpose varieties, and parents for use in a hybridization program devoted to the development of dual-purpose germplasm.

## Materials and Methods

Experiments were conducted at IITA, Ibadan, Nigeria, in 1985 and 1986. Ibadan is located at 7°30' N and 3°54' E. The site lies in the tropical rainforest zone and it is characterized by bimodal rainfall, with a monthly mean of about 160 mm in the first growing season (April–June), and 150 mm in the second (September–October). The experiments were conducted on a tropical Alfisol: 32 advanced breeding lines, pedigree selected over seven generations, were evaluated during the first season of 1985; 24 lines from these were selected and evaluated in the second season in the same year. The most promising 16 lines were again selected from the 24 and evaluated in the first season of 1986 (weather data for these seasons are given in Table 1).

The study was planted in a split-plot design, replicated three times. A plot consisted of four rows, each with 20 hills hand-planted 20 cm apart within the row and 60 cm between rows. Three seeds per hill were later thinned to two 15 days after planting. Three sprays of deltamethrin (as Decis®) were applied at 25 cc a.i. ha$^{-1}$, the first just before flowering and subsequently at 10-day intervals, for full protection. Plots were hand-weeded to control weeds. Leaves were picked following the practice normally adopted by farmers in East Africa. The third and fourth leaves from the apical bud from all the plants in the two middle rows were picked. With branches, however, the entire apical buds, including the third and fourth leaves, were picked. Leaves were picked at weekly intervals starting at 28 days after planting (DAP). Leaf picking comprised the main plots,

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**Table 1. Weather data for the 1985 and 1986 growing seasons at IITA, Ibadan.**

| Season/Month | Year | Rainfall (mm) | Relative humidity (%) | Temperature (°C) Min. | Max. | Mean |
|---|---|---|---|---|---|---|
| First season | | | | | | |
| Apr | 1985 | 142.1 | 73.0 | 23.6 | 32.2 | 27.5 |
| | 1986 | 70.8 | 74.8 | 20.9 | 31.9 | 26.4 |
| May | 1985 | 163.0 | 79.0 | 23.0 | 30.6 | 26.9 |
| | 1986 | 135.8 | 78.3 | 20.9 | 31.9 | 26.4 |
| Jun | 1985 | 230.0 | 80.0 | 22.6 | 29.1 | 25.9 |
| | 1986 | 136.0 | 79.0 | 28.6 | 30.2 | 29.4 |
| Second season (1985 only) | | | | | | |
| Sep | | 302.6 | 81.0 | 21.4 | 27.8 | 24.7 |
| Oct | | 162.4 | 77.0 | 22.1 | 29.9 | 26.0 |
| Nov | | 37.1 | 73.0 | 23.2 | 31.2 | 27.3 |

with varieties as subplots. Yield components, including number of pods plant$^{-1}$, seeds pod$^{-1}$, and 100-seed weight were recorded on five plants randomly taken from each plot. At the last seed harvest, all plants in the central two rows were cut at soil level and both fresh and dry forage yields determined. Data were analyzed using standard ANOVA techniques (Steel and Torrie 1980).

## Results

### Fresh leaf yield

Significant differences ($P = 0.05$) in fresh leaf yields were detected among the 16 entries. Total fresh leaf (TFL) yields ranged from 1.7–6.0 t ha$^{-1}$. An IITA medium-to-late maturity entry, VITA-3, developed in the 1970s ('old line') was the highest yielding. Two others, next in yield—an old line Tvx 1948-01F and a new (1983 selected) aphid-resistant entry—gave the next highest yields, but they fluctuated seasonally in the order of 50% between their highest and lowest TFL weights (Table 2). The remaining entries, mostly photoperiod-insensitive and early-to-medium in maturity (i.e., < 35 days to flower) gave low TFL and only 2-3 pickings before flowering.

Days to flower were positively correlated with days to maturity ($r = 0.66$, $P = 0.05$), which in turn correlated with TFL ($r = 0.42$). However, TFL yields were significantly ($P = 0.05$) but negatively correlated with total pods ($r = -0.29$), total grain ($r = -0.38$) and 100-seed weight ($r = -0.48$). Generally, lower TFL yields were associated with entries flowering within 40 days. Yields were high with late-flowering genotypes, but they fluctuated widely with season (Table 3).

Generally, TFL yield was highest in the 1985 first season, and less in 1986. Also in 1985, most lines were delayed in flowering by about 5 days compared with the subsequent seasons. Leaf-picking (before flowering) had no significant effect on the number of days taken to flower.

### Grain and fodder yield

Leaf-picking (before flowering) had no significant effect on grain and fodder yield. Total grain yield was significantly but negatively correlated with the maturity of entries, whether or not their leaves had been picked. Grain yield was, however, significantly and positively correlated with total pod weight ($r = 0.81$, $P = 0.05$). Entries differed significantly in number of pods plant$^{-1}$, seeds pod$^{-1}$, and 100-seed weight.

A median value was used to divide entries into four groups: (a) high grain + high leaf/fodder, (b) high grain + low leaf/fodder, (c) low grain + high leaf/fodder, and (d) low grain + low leaf/fodder (Figs. 1 and 2).

## Discussion

Late flowering and/or indeterminate growth appeared to be traits characteristic of the three best leaf-producing genotypes. Although flowering and indeterminacy are

**Table 2. Total cowpea leaf yield (t ha$^{-1}$) of the best yielding lines of the 16 selections.**

| Entry | Total fresh leaf yield 1985 1st season | 1985 2nd season | 1986 1st season |
|---|---|---|---|
| VITA-3 | 9.3 | 4.9 | 3.9 |
| IT83S-755-1 | 8.2 | 2.3 | 4.7 |
| Tvx 1948-01 | 7.7 | 4.2 | 2.9 |
| SE± | .73 | .37 | .22 |
| LSD ($P = 0.05$) | 1.2 | .63 | .36 |
| CV(%) | 26.6 | 25.1 | 16.5 |

**Table 3. Comparisons in selected lines for initiation of flowering in relation to total yields (t ha$^{-1}$) of leaf (TFL), grain, and fodder on leaf-picked plants.**

| Lines | 1985, 1st season TFL | Grain | Dry wt fodder | 1985, 2nd season TFL | Grain | Dry wt fodder | 1986, 1st season TFL | Grain | Dry wt fodder |
|---|---|---|---|---|---|---|---|---|---|
| Early (30-35 DFF[1]) | | | | | | | | | |
| IT81D-789 | 2.9 | 1.8 | 1.3 | - | - | - | 2.0 | 1.1 | 1.0 |
| IT82E-18 | 4.4 | 1.5 | 1.2 | 3.7 | 0.5 | 1.6 | 2.9 | 1.3 | 1.3 |
| Medium (35-40 DFF) | | | | | | | | | |
| IT83S-672-10 | 4.1 | 1.1 | 1.7 | 2.6 | 0.5 | 5.3 | 2.1 | 1.4 | 1.7 |
| IT83S-841 | 4.2 | 1.0 | 2.0 | 3.0 | 0.5 | 2.6 | 2.0 | 1.2 | 1.3 |
| Late (> 40 DFF) | | | | | | | | | |
| Tvx 1948-01F | 7.7 | 1.5 | 2.0 | 4.2 | 1.1 | 4.3 | 3.0 | 1.1 | 1.5 |
| VITA-3 | 9.3 | 0.05 | 1.4 | 4.9 | 0.6 | 7.2 | 4.0 | 0.6 | 2.3 |
| IT83S-755-1 | 8.2 | 0.07 | 1.4 | 2.3 | 0.5 | 4.5 | 4.7 | 0.7 | 2.3 |

1. Days to first flower.

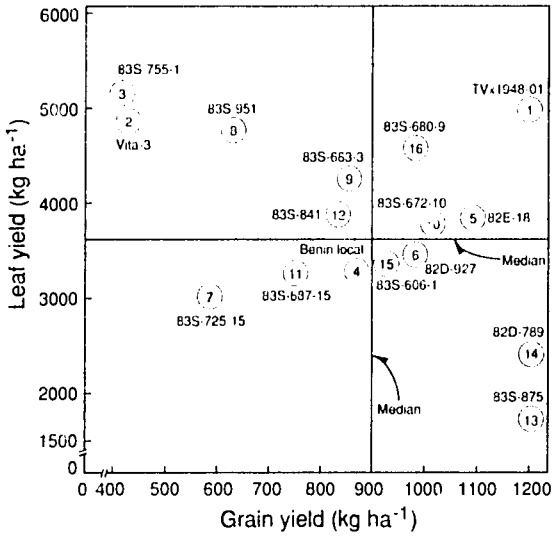


**Figure 1. Grain versus leaf yields of 16 dual-purpose cowpea varieties.**

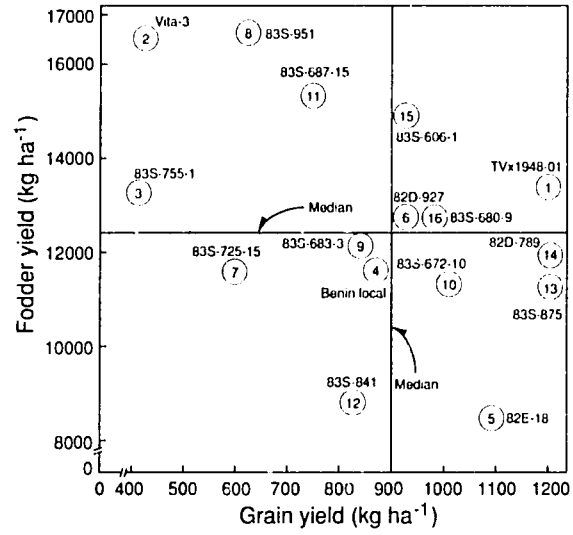


**Figure 2. Grain versus fresh fodder yields of 16 dual-purpose cowpea varieties.**

moderately to highly heritable, they are under separate genetic control (Fery 1984). The apparent moisture effect in the delay of flowering during the first season of 1985 appears to have been environmental in nature, and not necessarily from photoperiodic sensitivity. In VITA-3, Tvx 1948-01F, and IT83S-755-1, which have indeterminate growth habit, TFL yields appeared highly responsive to prolonged precipitation in the 1985 first season. In that year, these varieties formed dense stands and remained lush until late flowering (during the long rains) of the first but not the second season. It is known that many crops mature faster when water is reduced toward the end of a growing season (Major 1980). Therefore, the most obvious sustained vegetative growth under the abundant moisture supply in 1985 was a response to environment, possibly attributable to some large genotype x environment interaction. In improvement efforts, the latter could limit progress in selection for dual-purpose traits.

Upper yield limits could be set arbitrarily at > 5 t ha$^{-1}$ for fresh leaf and ≥ 12 t ha$^{-1}$ for fodder. Only one or two entries attained these limits (Figs. 1 and 2). However, a multitrait such as high grain plus fodder yield is likely to be difficult to incorporate into a single genotype of a short-to-medium growing season. From Figures 1 and 2 it can be observed that Tvx 1948-01F was in the high grain plus high leaf ranking category, but not strictly the highest fodder producer as well. It had, on the other hand, the best combination of both high grain and high leaf/fodder. When planning a breeding program, it might be easy to assume that good leaf-producing genotypes would also produce an acceptable amount of fodder. This may not necessarily be so, but the relationship between the two attributes is definitely not negative. There is a likelihood also that in superior leaf-yielding genotypes, high grain yield might be negatively correlated with high leaf yield. Since late-maturing types are likely to be good leaf yielders, to expect any positive association with grain yield means that a given genotype must be able sufficiently to partition its photosynthate to both the sink (the grain) and the source (i.e., the vegetative component) in equal measure.

Such a genotype is possible, particularly if the two traits are under manipulable genetic control(s) or the traits are not adversely correlated. Some traditional dual-purpose cowpeas are known to yield adequate grain as well as leaf (Akundabweni, unpublished data), when fully protected from insect pests. It could be assumed, therefore, that high grain yields and abundant foliage are not incompatible merits in a single genotype. In some past yield trials involving VITA-3, Tvx 1948-01F, and IT83S-755-1, for instance, grain yields have appeared promising.

The negative correlations between grain yield and leaf production observed in this study could have been due partly to the decumbent habit of some of the indeterminate top leaf-yielding entries. They might have been unable to carry all their pods above the leaves because of their poor skeletal (woody) tissue. Consequently, most pods, when produced underneath the canopy, might have succumbed to disease damage. *Choanephora cucurbitrum* (Singh and Allen 1979) adversely affected the pods of IT83S-755-1 and VITA-3 during the first season in 1985 when seed yields were observed to be low.

High grain plus high leaf/fodder yield potential is a complex trait, and progress can be expected only if the heritable components of the multitrait are well understood. This requires a quantitative study of the magnitude of the genotype x environment interaction and how it could be minimized in genotype assessment and selection for dual-purpose types. Following this, an attempt could be made to transfer factors responsible for high yield expression from the high grain but low leaf/fodder genotypes (e.g., IT83S-875) into the high leaf/fodder but low grain producers (e.g., IT83S-951) by crossing (see Figs. 1 and 2). Finally, a suitable dual-purpose and multitrait selection index might be necessary for effective culling of poor combinations and segregations in early generation crosses.

The results of this study have revealed potential grain, leaf, and fodder yields and their interaction in a range of cowpea varieties. This information can be used in guiding an ongoing breeding program to develop dual-purpose varieties. In view of the fact that dual purpose varieties in East Africa are primarily for 'leaf and grain' whereas dual-purpose varieties in West

Africa are primarily for 'grain and fodder', the current breeding strategy is to develop two sets of dual-purpose varieties to suit these regional preferences. This will also eliminate the need for simultaneous selection for leaf + grain + fodder yield, which is less efficient than selection for leaf + grain or grain + fodder.

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# Distribution and species composition of lepidopterous maize borers in southern Nigeria*


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**Maize is an important source of food and feed in many parts of Africa. It is the primary staple and a major source of calories for half the population of sub-Saharan Africa. Past research—such as the study reported here—has shown lepidopterous stem borers to be important insect pests on the crop, causing major yield losses, especially on late-planted or 'second-season' maize. Based on the data gathered, a control strategy is being developed that will integrate host plant resistance with biological control agents and improved agronomic practices.**


## Introduction

Stem borers are among the economically most important pests of maize in Africa. Four borers cause significant yield loss: the maize stalk borer, *Busseola fusca* Fuller (Lepidoptera: Noctuidae); the pink stalk borer, *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae); the African sugar cane borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae); and the spotted stalk borer, *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) (Bowden 1954; Harris 1962; Appert 1970; Brenière 1971; Girling 1978). Feeding by borer larvae on maize plants usually results in crop losses, as a consequence of death of the growing point (deadhearts), early leaf senescence, reduced translocation, lodging, and direct damage to the ears (Appert 1970; Brenière 1971). Estimated yield losses caused by maize borers in Nigeria range from 10 to 100 % (Usua 1968*a*).

A large proportion of maize in West Africa is grown in the forest zone. The rainy season in this zone lasts 6 – 9 months (March to November); in some regions the rains are bimodal, interrupted by a short, unreliable 'August break'. The August break divides the rainy season into 'first' and 'second' seasons. Maize planted at the beginning of the rains is called first season maize, and maize planted after the August break is referred to as second season maize. Maize stem borers are far more abundant in the second than in the first season, and the second crop is sometimes a complete loss (Adeyemi et al. 1966; Girling 1980). Consequently, many farmers in the bimodal rainfall zone of West Africa do not plant second season maize (Tams and Bowden 1953; IITA 1976).

The objectives of this study were to monitor natural infestations of maize borers during the second planting season, and to determine the distribution and relative importance of the different borer species in several locations in southern Nigeria. This information is a prerequisite for the development of an integrated pest management program for these insects.

## Materials and Methods

Experiments were conducted during the second planting season at four locations in southeastern Nigeria in 1985, and at two locations in southwestern Nigeria in 1986. In 1985, trials were planted the first week of August at the following locations: the


* Slightly adapted from an article originally published in *Bulletin of Entomological Research* 80: 363-368 (1990). Reproduced by permission of C·A·B International.

high rainfall station of the International Institute of Tropical Agriculture (IITA) at Onne near Port Harcourt, Rivers state; the National Cereals Research Institute Station at Amakama near Umuahia, Imo state; a farmers' field in Sapele, Bendel state; and the Diocesan and Development Services Research Farm at Idah, Benue state (Fig. 1). These locations were chosen to represent a wide area within southeastern Nigeria, including forest zone locations and a forest-savanna transitional zone location (Idah). Two maize hybrids, 8341-6 and 8338-1, were planted in fifty 5-m rows each at all four locations. The former hybrid matures earlier than the latter. In 1986, trials were planted the second week of August in a farmers' field at Alabata and at the IITA main station, Ibadan, both in Oyo state. Twenty-five 5-m rows of the early-maturing, open-pollinated variety TZESR-W were planted at each location. An early-maturing variety was chosen for the 1986 trial because these two locations have a shorter growing season than the 1985 sites. All plantings had a spacing of 75 cm between rows and 25 cm between plants. Two seeds per hill were planted, and the stand was thinned to one plant per hill 2 weeks after emergence. Fertilizer was applied: 300 kg $ha^{-1}$ of NPK (15-15-15) at planting, and 170 kg $ha^{-1}$ of calcium ammonium nitrate 4 weeks after planting. Twenty-five plants per variety per location were randomly sampled every 2 weeks. Plants were brought into the laboratory, dissected, and the number of borer larvae and pupae per plant determined. The borer species were identified by the senior author, following the keys by Tams and Bowden (1952), Brenière (1976), and Staeubli (1977). The number of damaged plants was recorded and when ears were present, the number of damaged ears and the number of larvae per ear were also recorded. In 1986, the number of *Mussidia nigrivenella* Ragonot (Lepidoptera: Pyralidae) eggs was also counted. The extent of borer damage on each sampling date in 1986 was assessed by examining the dissected plants for presence of borer damage (as done in 1985) and by additionally counting in the entire field the plants that showed external signs of damage.

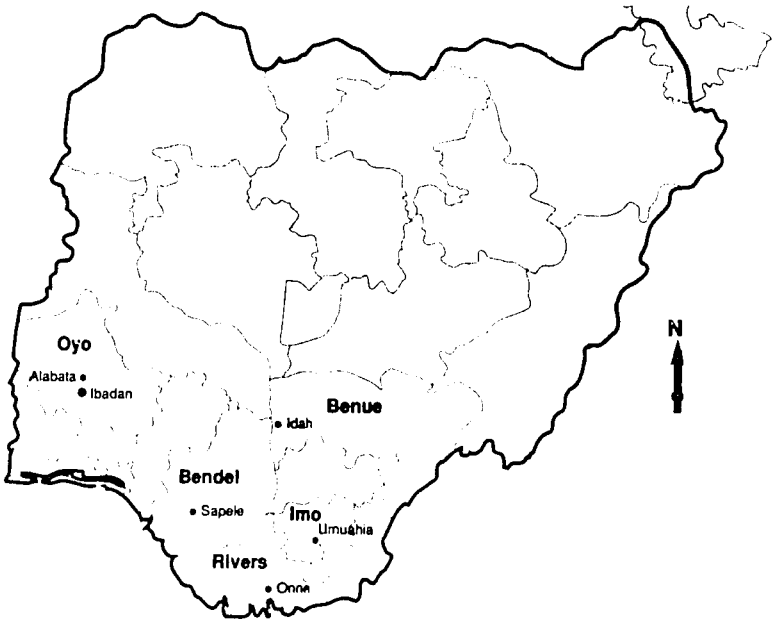


**Figure 1. Locations in Nigeria where trials were carried out.**

## Results

### 1985 Trials

There were marked differences in the incidence and severity of stem borer attack among locations in 1985 (Figs. 2 and 3). The peak of oviposition by *S. calamistis* occurred slightly earlier in Umuahia than in Onne. Four weeks after planting, the percentage of plants with borer damage (Fig. 2) and the number of larvae per 25 plants were higher at Umuahia. Infestations at Sapele and Idah started later, and 4 weeks after planting the percentage of plants with borer damage here was lower than at the other two locations. Infestation increased sharply at Onne, with over 80% of the plants showing borer damage 6 weeks after planting, compared to 50% at Umuahia, 22% at Sapele, and 11% at Idah (Fig. 2). *S. calamistis* was the dominant species in all locations up to 8 weeks after planting. *E. saccharina* was first found at Onne at this time, and by the end of the season it was the most abundant species at all locations except Umuahia, where *S. calamistis* comprised over 50% of the larvae found (Fig. 3).

By harvest time, almost 100% of the plants sampled at all locations had some borer damage (Fig. 2). Numbers of larvae were higher at Sapele and Onne (up to five larvae per plant) than at Idah or Umuahia (up to two larvae per plant). The mean number of larvae per plant was greatest on hybrid 8341-6 (Fig. 3). The distribution of *E. saccharina* larvae within the plants was similar at all locations, with the majority of larvae found in the stems (Table 1). At Sapele and Umuahia, the majority of *S. calamistis* occurred in the stem; at Idah, however, most of the larvae were found in the ears. *B. fusca* was found only at Idah, where it constituted 2% of the population 11 weeks after planting. *Cryptophlebia* sp. (Lepidoptera: Olethreutidae) was found at Onne, Idah, and Umuahia, while *Coniesta* (=*Acigona*) *ignefusalis* (Hampson) (Lepidoptera: Pyralidae) was found at all locations. These two species constituted a relatively minor proportion of the borer population (Fig. 3).

At Sapele and Onne, all the ears showed damage. The mean number of larvae per ear was highest at Sapele (up to four larvae per ear) and lowest at Idah and Umuahia (up to one per ear); *E. saccharina* was the predominant borer in the ears at all locations except Umuahia (Table 2). *M. nigrivenella*, a preharvest pest of maize, which infests the ears and continues developing in storage (Moyal 1988), was found at all locations. It was especially abundant in Sapele, but at this location it was present only in hybrid 8341-6 (Fig. 3).

### 1986 Trials

The percentage of plants with borer damage was higher at Alabata than at IITA, Ibadan, at 3 and 5 weeks after planting but from 7 weeks after planting onward the percentage of maize plants with borer damage was lower at Alabata (Fig. 4). By harvest time, borer damage was observed on 80% of the plants sampled at Alabata, and on 92% at Ibadan (Fig. 4). The infestation with *S. calamistis* began earlier and

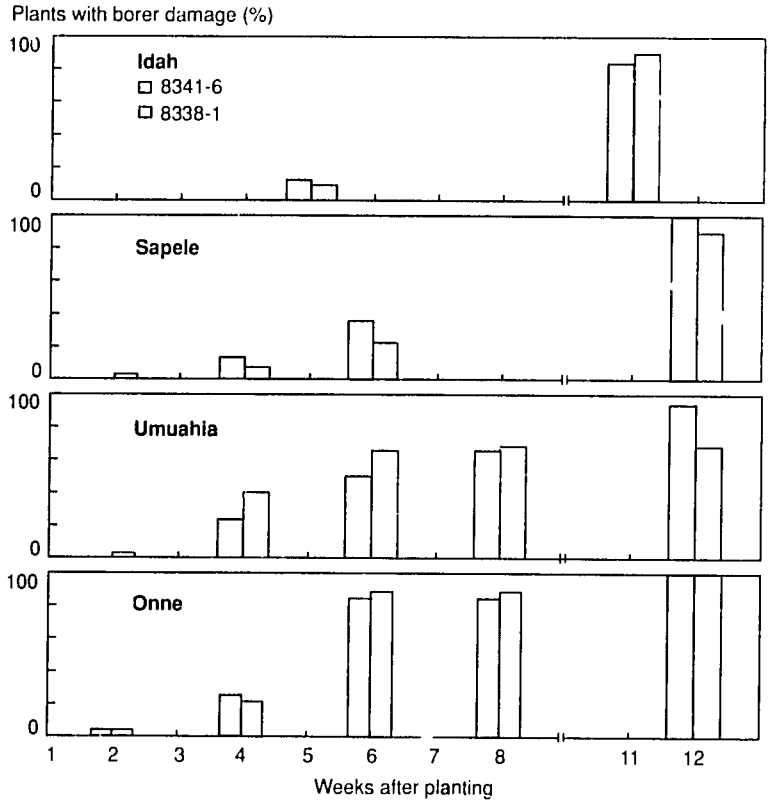


**Figure 2. Percentage of plants of two maize hybrids with borer damage at four locations in southeastern Nigeria, 1985.**

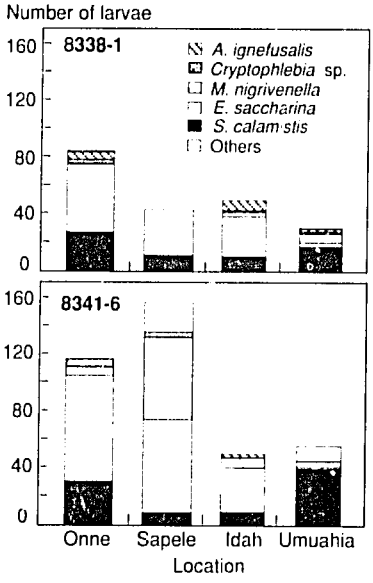


**Figure 3. Species and number of lepidopterous larvae per 25 plants in two maize hybrids sampled 12 weeks after planting, southeastern Nigeria, 1985.**

was higher at Alabata than at IITA, Ibadan, but later in the season the incidence of this insect was similar at both locations (Fig. 5). From 9 weeks after planting onward, the mean number of borer larvae per plant was higher at IITA, Ibadan than at Alabata.

*E. saccharina* was first detected in both locations 9 weeks after planting, but the incidence of this pest was always higher at IITA, Ibadan. As in 1985, the majority of *E. saccharina* larvae were found in the stems (Table 3). Up to six *E. saccharina* larvae per plant were found 11 weeks after planting at IITA, Ibadan, the highest number found at any location in 1985 or 1986. *E. saccharina* was the predominant ear borer at Alabata from 11 weeks after planting onward, while *M. nigrivenella* was most abundant at IITA, Ibadan (Table 4). At IITA, Ibadan, 44% of the ears were found to be infested with *M. nigrivenella* eggs or larvae 15 weeks after planting; 84% of the eggs were found attached to the silks.

## Discussion

Kaufmann (IITA 1981) described *S. calamistis* as 'a moist-area oriented species' dominant in southeastern Nigeria, in contrast to *E. saccharina* referred to as 'a dry area oriented species' dominant in the western part of the country, and observed that this was a "definite pattern in the distribution of stem borers of maize". Our findings did not confirm this alleged distribution pattern. Kauffman's report was based on samplings in only one location in eastern Nigeria (Umuahia or Umudike). A more detailed sampling regime, which included several locations in southeastern Nigeria, demonstrated the importance of *E. saccharina*; this species was the dominant maize borer at the time of harvest at all sites we sampled in 1985 except Umuahia (Table 2). The reasons for the virtual absence of *E. saccharina* from Umuahia (IITA

**Table 1. Distribution of *Sesamia calamistis* and *Eldana saccharina* larvae in the plant and percentage of ears with larvae in two maize hybrids in southeastern Nigeria, 1985.**

| Location[1] and hybrid | Percentage of larvae in stem | | Percentage of larvae in ears | | Percentage of ears with larvae | |
|---|---|---|---|---|---|---|
| | *S. calam.* | *E. sacch.* | *S. calam.* | *E. sacch.* | *S. calam.* | *E. sacch.* |
| Sapele | | | | | | |
| 8338-1 | 80 | 77 | 20 | 23 | 10 | 20 |
| 8341-6 | 40 | 50 | 60 | 50 | 16 | 52 |
| Onne | | | | | | |
| 8338-1 | 40 | 64 | 60 | 36 | 60 | 90 |
| 8341-6 | 72 | 84 | 28 | 16 | 67 | 89 |
| Idah | | | | | | |
| 8338-1 | 14 | 76 | 86 | 24 | 22 | 30 |
| 8341-6 | 43 | 57 | 57 | 43 | 19 | 41 |
| Umuahia | | | | | | |
| 8338-1 | 61 | 80 | 39 | 20 | 22 | 2 |
| 8431-6 | 69 | 100 | 31 | 0 | 44 | 0 |

1. Sampling 12 weeks after planting, except at Idah (11 weeks).

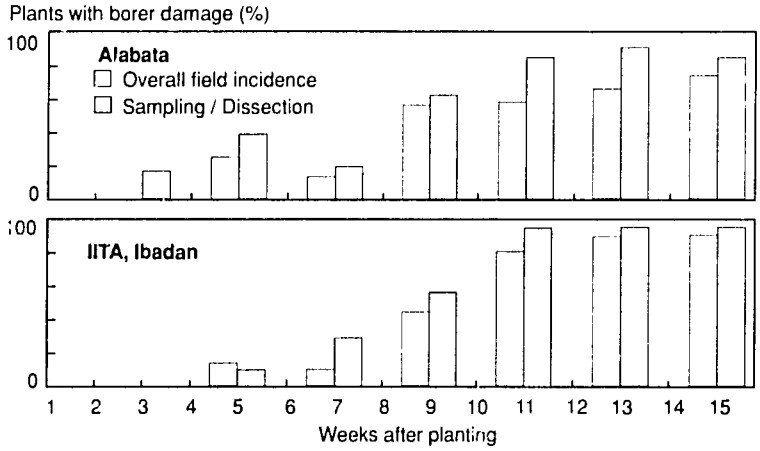


**Figure 4. Percentage of maize plants with borer damage at two locations in southwestern Nigeria, 1986.**

**Table 2. Mean number of larvae per ear and borer species composition in two maize hybrids in southeastern Nigeria, 1985.**

| Location and hybrid[1] | Mean no. larvae/ear | Species composition (%) | | | | |
|---|---|---|---|---|---|---|
| | | *E. sacch.* | *S. calam.* | *M. nigrivenella* | *Cryptophlebia* sp. | Others[2] |
| Sapele | | | | | | |
| 8338-1 | 0.5 | 70 | 30 | 0 | 0 | 0 |
| 8341-6 | 3.9 | 27 | 8 | 64 | 0 | 1 |
| Onne | | | | | | |
| 8338-1 | 3.1 | 48 | 39 | 0 | 7 | 6 |
| 8341-6 | 2.8 | 40 | 28 | 16 | 16 | 0 |
| Idah | | | | | | |
| 8338-1 | 0.9 | 46 | 25 | 21 | 8 | 0 |
| 8341-6 | 1.2 | 55 | 24 | 18 | 0 | 3 |
| Umuahia | | | | | | |
| 8338-1 | 0.8 | 4 | 44 | 37 | 15 | 0 |
| 8341-6 | 1.0 | 0 | 53 | 3 | 10 | 34[3] |

1. Sampling 12 weeks after planting, except at Idah (11 weeks).
2. Includes *Acigona ignefusalis* and *Busseola fusca*.
3. Some larvae dead at time of examination, identification not certain.

**Table 3. Distribution of *E. saccharina* and *S. calamistis* larvae in maize plants, and percentage of ears with larvae in two locations in southwestern Nigeria, 1986.**

| Location[1] and hybrid | Percentage of larvae in stem | | Percentage of larvae in ears | | Percentage of ears with larvae | |
|---|---|---|---|---|---|---|
| | *S. calam.* | *E. sacch.* | *S. calam.* | *E. sacch.* | *S.calam.* | *E. sacch.* |
| 9 WAP[1] | | | | | | |
| IITA, Ibadan | 66 | 94 | 33 | 6 | 8 | 12 |
| Alabata | 50 | 50 | 50 | 50 | 10 | 10 |
| 11 WAP | | | | | | |
| IITA, Ibadan | 14 | 79 | 86 | 21 | 20 | 52 |
| Alabata | 50 | 77 | 50 | 23 | 8 | 16 |
| 13 WAP | | | | | | |
| IITA, Ibadan | 80 | 74 | 20 | 26 | 8 | 24 |
| Alabata | 50 | 38 | 50 | 62 | 4 | 32 |
| 15 WAP | | | | | | |
| IITA, Ibadan | 0 | 97 | 100 | 3 | 4 | 4 |
| Alabata | 100 | 70 | 0 | 30 | 0 | 16 |

1. WAP = Weeks after planting.

1985) are not clear (Table 2). Absence of alternate hosts and/or microclimatic differences might be responsible; this aspect deserves further investigation.

At IITA, Whitney (1970) found larvae of *B. fusca* to comprise 45% of the larval population in the stems of maize plants at the end of the first planting season, while *E. saccharina* comprised 14% and *Sesamia* spp. 8%. Usua (1968b) carried out samplings in November-December 1964 and found *B. fusca* to be the predominant pest of maize in the rainforest of southwestern Nigeria. At Ibadan, he found *B. fusca* to be the most abundant borer of maize from September to November 1964 and in September of 1965 (Usua 1968*b*). This is in marked contrast with our findings since we observed *S. calamistis* and *E. saccharina* to be the predominant maize borers at both Ibadan (in September) and Alabata (in November). In our samplings, *E. saccharina* was especially abundant at IITA, Ibadan with up to six larvae per plant at the end of the growing season. The use of minimum tillage and growing three crops of maize per year might help explain the high incidence of this insect at IITA, Ibadan. *E. saccharina* is known to survive well in maize stubble (Adeyemi 1969). The abundance of E. *saccharina* at IITA had previously been reported (IITA 1980). We did not find *B. fusca* at IITA, Ibadan, while at

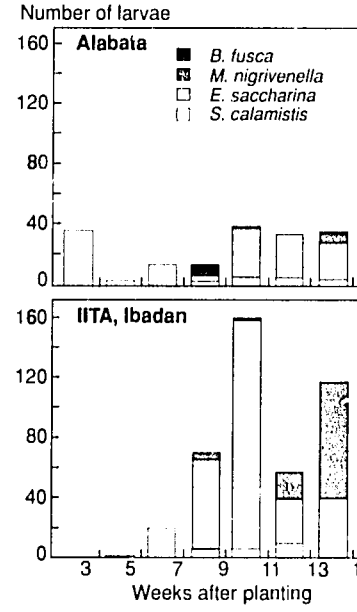


**Figure 5. Species and number of lepidopterous larvae per 25 maize plants at two locations in southwestern Nigeria, 1986.**

**Table 4. Mean number of borers per ear and species composition in maize planted in two locations in southwestern Nigeria, 1986.**

| Sampling date and location | Mean no. larvae/ear | Species composition (%) | | |
|---|---|---|---|---|
| | | *E. saccharina* | *S. calamistis* | *M. nigrivenella* |
| 9 WAP[1] | | | | |
| IITA, Ibadan | 0.5 | 25 | 17 | 58 |
| Alabata[2] | 0.3 | 28.6 | 28.6 | 28.6 |
| 11 WAP | | | | |
| IITA, Ibadan[3] | 1.6 | 78 | 15 | 5 |
| Alabata | 0.4 | 56 | 33 | 11 |
| 13 WAP | | | | |
| IITA, Ibadan | 1.0 | 32 | 8 | 60 |
| Alabata | 0.8 | 85 | 15 | 0 |
| 15 WAP | | | | |
| IITA, Ibadan | 3.0 | 1 | 1 | 98 |
| Alabata | 0.5 | 62 | 0 | 38 |

1. WAP = Weeks after planting.
2. *Busseola fusca* constituted 14% of larvae found.
3. *Cryptophlebia* sp. constituted 2% of larvae found.

Alabata this insect was found only at 9 and 11 weeks after planting and even then it constituted only 29 and 3% of the borer population, respectively. Harris (1962) reported *S. calamistis* to be abundant at Ibadan and indicated *E. saccharina* might occasionally be the most common stem borer of maize at the end of the growing season. In Ghana, Leyenaar and Hunter (1977) reported *Sesamia* spp. and *E. saccharina* as the most damaging pests of maize in the forest zone, and *B. fusca* as the most abundant borer in the savanna zone. Similar distribution of borers has been reported by Cochereau (1985) in Côte d' Ivoire.

The two methods used to assess the percentage of maize plants with borer damage in 1986 were compared. In general, plant dissection permitted the detection of stem borer damage in a larger number of samples than counting the number of plants with external signs of damage (Fig. 4). At Ibadan, the difference in the number of damaged plants detected by each method was more marked early in the season (Fig. 4). This is probably because stem borers like *S. calamistis* (the predominant species early in the season in our studies) might be damaging plants without leaving external signs of damage. Later in the season, the percentage of plants with borer damage detected is very similar using either method. This is probably because at that time *E. saccharina* is the most abundant stem borer and its presence is easy to detect by the frass hanging from the adult exit holes in the stem. The results obtained with either method would be affected by, among other factors, the time of assessment during the growing season and the predominant stem borer at the time. Sampling entire plants has the disadvantage of being a destructive and more labor intensive method.

In 1985, *M. nigrivenella* was most abundant at Sapele, particularly on hybrid 8341-6. The female moths of this pest lay eggs on the silks of the maize ear (Moyal 1988). The large number of *M. nigrivenella* on hybrid 8341-6 might have been due to preference for this hybrid or to a sharp and short-duration oviposition peak of this insect, coinciding with the silking period of the hybrid. This hybrid is earlier than 8338-1. The infestation of *M. nigrivenella* at Ibadan in 1986 (44% of the ears) was similar to a 40% infestation observed at Sapele the previous year. Whitney (1970) found this insect to comprise 51% of the insect population in maize ears at the end of the first planting season at IITA, Ibadan. The large difference in the number of *M. nigrivenella* eggs we found at Ibadan 9 weeks after planting (1.8/ear) and the number of larvae found 11 weeks after planting (0.1/ear) suggests heavy mortality or migration. Similar observations have been made by Moyal (1988). Eggs and young larvae on the silks are exposed to predators and rainfall. *M. nigrivenella* was found at all locations, and it was observed to cause extensive damage to the ears of maize. Little is known about the bionomics of *M. nigrivenella* in Nigeria; this aspect deserves further attention. Recently, Moyal (1988) has completed a thorough study of this pest in Côte d' Ivoire.

The studies reported here confirmed the importance of stem borers in southern Nigeria and prompted further investigations on the impact of some of these insects on the yield of maize. The results of these latter investigations are reported elsewhere (Bosque Pérez and Mareck, in press). There is a need to develop control practices for the major maize stem borers in West Africa. IITA has been involved in developing sources of resistance to *S. calamistis* and *E. saccharina* (Bosque-Pérez et al. 1989); we believe resistance could be combined with other control practices to reduce the economic losses experienced by maize farmers.

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# Effect of hedgerow species in alley cropping systems on surface soil physical properties of an Oxic Paleustalf in southwestern Nigeria*

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**Sustaining the production base of farming, as well as increasing its productivity, involves a study of soil properties in relation to cropping practices/systems. Alley cropping, or the growing of tree crops in hedgerows with annual or seasonal food crops, has shown multiple benefits. This article, which reports the long-term effects of growing four tree species (two leguminous and two nonleguminous) on physical properties of the surrounding soil, finds those effects related to the quantity and quality of mulch specific to each tree species. It forms part of IITA's many studies on the role of alley cropping in improving agriculture in tropical Africa.**

## Introduction

Shifting cultivation and related bush fallow and slash-and-burn cultivation systems (1–3 years cropping alternating with 4–10 years of fallow) continue to be widely practiced by smallholder farmers in the humid tropics of Africa (Lagemann 1977; FAO 1978). Rapid population growth has, however, resulted in shortening of the fallow period in many areas, with a consequent increase in soil degradation and decline in crop yield (Lagemann 1977; FAO 1978). Alley cropping has been proposed as an alternative to shifting cultivation, to sustain crop production and reduce soil degradation (Kang et al. 1984, 1990). Alley cropping is the growing of food crops in alleys formed by hedgerows of trees or shrubs, preferably N-fixing leguminous species, that are pruned during the crop growing season to minimize shading of the food crops. The prunings are used as mulch or incorporated as green manure (Kang et al. 1981, 1984, 1985, 1990).

Alley cropping results in improvements in soil chemical properties and nutrient cycling, erosion control, and weed suppression, in addition to providing fodder, stakes, and firewood (Kang et al. 1981, 1984, 1985, 1990; Kang and Ghuman 1989; Mwenye 1984; Yamoah et al. 1986; Young 1986, 1987; Lal 1988). Information is sparse on the effects of alley cropping on soil physical properties, particularly with respect to the effects of hedgerow species. Results from a few studies conducted in

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southern Nigeria suggest that improvements in soil physical properties were greater with *Leucaena leucocephala* hedgerows than with *Gliricidia sepium* hedgerows (Kang and Ghuman 1989), and that *Cassia siamea* hedgerows were better than *Gliricidia sepium* and *Flemingia congesta* hedgerows (Yamoah et al. 1986). Compared with other treatments, alley cropping resulted in better soil physical properties (Yamoah et al. 1986; Kang and Ghuman 1989). The effects of other hedgerow species on soil physical properties are, however, unknown. This study quantified the long-term effects of alley cropping with two N-fixing leguminous species and two nonleguminous indigenous species on the surface soil physical properties of an Oxic Paleustalf in southwestern Nigeria. Observations were made in an ongoing trial established since 1981.

## Materials and Methods

The experiment was conducted at the International Institute of Tropical Agriculture (IITA) site in Ibadan (7° 30'N, 3° 54'E) in the forest-savanna mosaic zone of southwestern Nigeria. Mean annual rainfall is 1250 mm, with a bimodal pattern. The rains usually commence in late March and continue until early November, with a short break during the July-August period. The dry season lasts from November to March.

The soil at the experimental site is a clayey, kaolinitic, isohyperthermic Oxic Paleustalf of the Egbeda series with a sandy loam topsoil and a sandy clay subsoil. A layer of angular and subangular quartz (gravel layer) occurs at a depth of 0.20-0.30 m (Moormann et al. 1975).

A randomized complete block design was used, with three replications. There were five treatments, consisting of four hedgerow species (*Leucaena leucocephala, Gliricidia sepium, Alchornea cordifolia*, and *Acioa barteri*) with interhedgerow spacings of 4 m and a control with no hedgerows. Within hedgerows, the plants were spaced at 0.25 m intervals. Plot size was 6 x 24 m. All plots received fertilizer at a rate of 45 kg N, 20 kg P, and 20 kg K per hectare. Fertilizer was applied only to the main season (April-July) crop, maize *(Zea mays)*. No fertilizer was applied to the minor season (August-October) crop, cowpea *(Vigna unguiculata* Walp.). A minimum tillage system was used (Lal 1987). Preplanting land preparation was done by spraying 0.5 kg ha$^{-1}$ a.i. paraquat, followed by hand pruning of the hedgerows and application of the prunings as mulch in the interhedgerow spaces. Crops were planted at a population of 40,000 plants ha$^{-1}$. Hedgerows were pruned at 6-8 week intervals during the growing season.

Soil physical measurements were carried out before and during the maize cropping season of 1989. Five soil cores (50 mm high and 51 mm in diameter) were randomly collected from the 0-0.05 m depth in all plots on 31 January and 6 June. They were taken to the laboratory and saturated by capillarity for 48 h. Soil water retention at saturation, and at potentials of −10 kPa, −100 kPa, and −1500 kPa were determined using pressure plate apparatus (Klute 1986). Penetrometer resistance in the 0-0.02 m depth was determined on the same cores after they had equilibrated at these moisture potentials, as described by Hulugalle and Rodriguez (1988). Bulk density of the cores was determined after oven drying at 105°C. Apparent pore-size distribution was inferred from the soil water retention characteristics using the capillary rise equation $\psi = -2\sigma/r\rho_w$, where $\psi$ is soil water potential, $r$ is the radius of the curvature of the interface (i.e., pore radius), $\sigma$ is the surface tension, and $\rho_w$ is the density of water (Campbell 1985). Composite soil samples taken from the 0–0.05 m depth of all plots on 31 January 1989 were air dried, ground, and passed through a 2-mm sieve; particle size distribution was determined with the hydrometer method (Klute 1986). Diurnal variation in soil temperature at a depth of 0.05 m was monitored with mercury-in-glass bent stem-soil thermometers on 3 February, 2 March, 4 April, 27 April, 25 May, and 4 July 1989. Soil water content in the 0.02-0.07 m depth adjacent to the thermometer was concurrently measured by gravimetric sampling at 1400 hours on the same days. Water infiltration was measured over a 2 h period in February with a double-ring infiltrometer. Water infiltration results were analyzed following Philip's equation, $i = S/(2\sqrt{t}) + A$, where $S$ is sorptivity, $A$ is transmissivity, $t$ is time, and $i$ is infiltration rate (Philip 1957). All data were analyzed by analysis of variance for a randomized complete block design (Little and Hills 1978).

## Results and Discussion

**Particle size distribution.** Particle size distribution was not significantly affected by any of the experimental treatments (Table 1). This result is in contrast to other studies, which indicate that soil erosion rates and, hence, losses of the fine soil component (silt + clay) are lower with alley cropping (Lal 1988; Kang and Ghuman 1989). Exposure of the clay-rich subsoil with the higher erosion rates in the control, however, may have resulted in similar values of sand, silt, and clay contents (Lal 1976).

**Table 1. Effect of hedgerow species on particle size distribution (%) in the 0-0.05 m depth of an Oxic Paleustalf in Ibadan, Nigeria, on 31 January 1989.**

| | Particle size distribution | | |
|---|---|---|---|
| Hedgerow species | Sand | Clay | Silt |
| *Gliricidia sepium* | 72.7 | 14.7 | 12.6 |
| *Alchornea cordifolia* | 76.0 | 12.0 | 12.0 |
| *Leucaena leucocephala* | 76.0 | 12.7 | 11.3 |
| *Acioa barteri* | 76.0 | 12.7 | 11.3 |
| Control | 74.7 | 12.7 | 12.6 |
| ± SE | 1.84 | 0.74 | 0.92 |

**Soil bulk density.** Bulk density in the 0-0.05 m depth was not significantly affected by date of sampling (Table 2). Bulk density averaged over both dates of sampling was lowest with *L. leucocephala*, and highest in the control ($P < 0.05$). This may have been due to addition of large amounts of *L. leucocephala* prunings as mulch and the absence of such additions in the control (Table 3). Mulching is known to improve soil physical properties (Lal 1987). Bulk density did not differ significantly between alley-cropped plots.

**Table 2. Effect of hedgerow species on soil bulk density (Mg m$^{-3}$) in the 0-0.05 m depth of an Oxic Paleustalf in Ibadan, Nigeria, in 1989.**

| | Bulk density | | |
|---|---|---|---|
| Hedgerow species | 31 Jan | 6 Jun | Mean |
| *Gliricidia sepium* | 1.31 | 1.34 | 1.33 |
| *Alchornea cordifolia* | 1.36 | 1.43 | 1.40 |
| *Leucaena leucocephala* | 1.26 | 1.35 | 1.31 |
| *Acioa barteri* | 1.31 | 1.36 | 1.34 |
| Control | 1.36 | 1.46 | 1.41 |
| Mean | 1.31 | 1.39 | |

± SE: Between dates = 0.024; between hedgerow species = 0.031; between hedgerow species for same date = 0.044; between hedgerow species for different dates = 0.046.

**Table 3. Biomass dry weight (t ha$^{-1}$) of prunings[1] of hedgerows during the main season in 1989 in Ibadan, Nigeria.**

| Hedgerow species | Pruning date 10 Apr | 22 May | 27 Jun | Total |
|---|---|---|---|---|
| *Gliricidia sepium* | 1.08 | 2.03 | 0.42 | 3.53 |
| *Alchornea cordifolia* | 2.48 | 0.99 | - | 3.47 |
| *Leucaena leucocephala* | 2.43 | 1.33 | 0.63 | 4.39 |
| *Acioa barteri* | 2.76 | - | - | 2.76 |
| ± SE | 0.31 | 0.16 | 0.07 | 0.37 |

1. Includes leaves and young green parts of the stem.

**Soil water retention, apparent pore-size distribution, and penetrometer resistance.** Soil water content at saturation in the 0-0.05 m depth on 31 January was in the order *L. leucocephala* > *A. barteri* = *G. sepium* = *A. cordifolia* > control ($P < 0.01$) (Fig. 1). On 6 June it was in the order *L. leucocephala* = *G. sepium* > *A. barteri* = *A. cordifolia* = control ($P < 0.05$). The water content values at saturation in the various treatments appear to reflect the quantities of prunings returned as mulch (Table 3). Lal (1987) also reported that water content at saturation increased in proportion to the weight of mulch applied. Soil water content at −10 kPa did not differ significantly between treatments on 31 January, but was significantly greater ($P < 0.05$) in *A. cordifolia* plots on 6 June than in other treatments. This was primarily due to a higher increase in the proportion of micropores (pore radius, $r < 1.4$ µm) in *A. cordifolia* plots, as will be discussed later.

Pore-size distribution in the 0-0.05 m depth differed significantly ($P < 0.01$) with date of sampling. Measurements on 31 January and 6 June showed that the proportions of macropores and micropores decreased and increased, respectively, with time (Table 4). Proportions of mesopores ($r$ = 1.4-14.4 µm) were, however, not significantly affected (Table 4). The decrease in proportions of macropores and increase in micropores was largest with *A. cordifolia* hedgerows.

Penetrometer resistance in the 0-0.02 m depth at −10 kPa did not differ significantly between treatments on either 31 January or 6 June (Fig. 2). At −100 kPa and −1500 kPa, the largest values of penetrometer resistance were observed on both sampling dates in the control and *A. cordifolia* plots. At the same potentials on 31 January, penetrometer resistance was significantly lower ($P < 0.05$) in *L. leucocephala* plots than in all other treatments. Decreases in penetrometer resistances at potentials of −100 kPa and −1500 kPa were observed in *L. leucocephala*, *G. sepium*, and *A. barteri* plots over the period 31 January to 6 June. The higher penetrometer resistances in the control and *A. cordifolia* plots suggest that surface crusting was greatest with these treatments.

The above changes in soil water retention, pore-size distribution, and penetrometer resistance indicate the degree of soil compaction and crust formation that occurred between 31 January and 6 June.

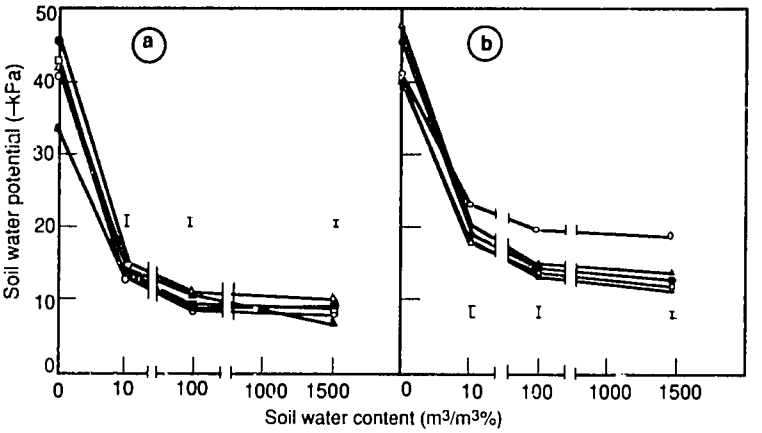


**Figure 1. Effect of hedgerow species on soil water retention in the 0-0.05 m depth of an Oxic Paleustalf in Ibadan, Nigeria on (a) 31 January and (b) 6 June 1989. (Δ) *Gliricidia sepium*; (o) *Alchornea cordifolia*; (●) *Leucaena leucocephala*, (□) *Acioa barteri* (▲) control; I = SE of mean.**

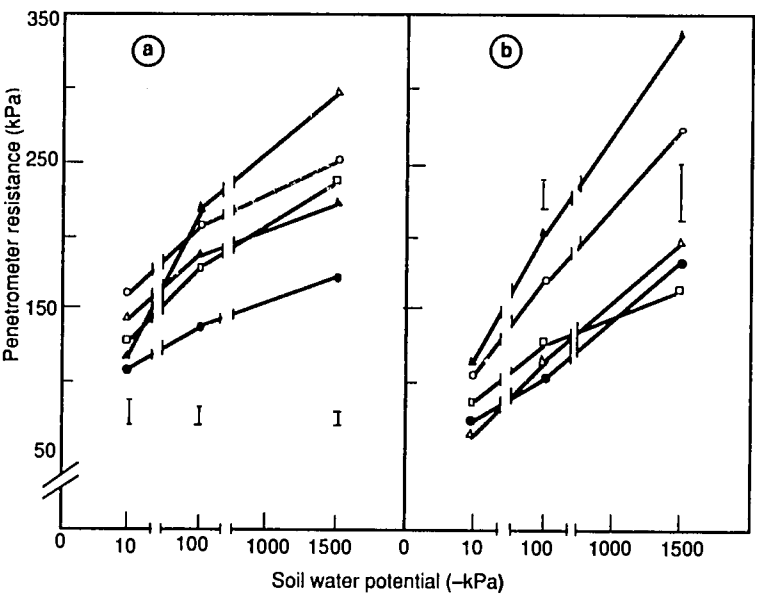


**Figure 2. Effect of hedgerow species on penetrometer resistance in the 0-0.02 m depth of an Oxic Paleustalf in Ibadan, Nigeria, on (a) 31 January and (b) 6 June 1989.(Δ) *Gliricidia sepium*; (o) *Alchornea cordifolia*; (●) *Leucaena leucocephala* (□), *Acioa barteri* (▲) control; I = SE of mean.**

**Table 4. Effect of hedgerow species on the percentage of macropores, mesopores, and micropores in the 0-0.05 m depth of an Oxic Paleustalf in Ibadan, Nigeria, in 1989.**

| Hedgerow species | 31 Jan | 6 Jun | Mean |
|---|---|---|---|
| Macropores (pore radius > 14.4 μm) | | | |
| *Gliricidia sepium* | 69.2 | 62.2 | 65.7 |
| *Alchornea cordifolia* | 73.8 | 54.2 | 64.0 |
| *Leucaena leucocephala* | 72.5 | 63.0 | 67.8 |
| *Acioa barteri* | 71.9 | 65.5 | 68.7 |
| Control | 71.6 | 62.8 | 67.2 |
| Mean | 71.8 | 61.5 | |
| ± SE: | Between dates = 0.55; between hedgerow species = 2.04; between hedgerow species for same date = 2.89; between hedgerow species for different dates = 2.64. | | |
| Mesopores (pore radius 1.4-14.4 μm) | | | |
| *Gliricidia sepium* | 12.1 | 9.7 | 10.9 |
| *Alchornea cordifolia* | 10.3 | 8.3 | 9.3 |
| *Leucaena leucocephala* | 12.0 | 8.5 | 10.2 |
| *Acioa barteri* | 11.1 | 8.0 | 9.6 |
| Control | 11.3 | 11.2 | 11.2 |
| Mean | 11.4 | 9.1 | |
| ± SE: | Between dates = 0.53; between hedgerow species = 0.76; between hedgerow species for same date = 1.07; between hedgerow species for different dates = 1.09. | | |
| Micropores (pore radius < 1.4 μm) | | | |
| *Gliricidia sepium* | 18.7 | 28.1 | 23.4 |
| *Alchornea cordifolia* | 15.8 | 37.5 | 26.7 |
| *Leucaena leucocephala* | 15.5 | 28.5 | 22.0 |
| *Acioa barteri* | 17.3 | 26.5 | 21.9 |
| Control | 17.1 | 26.1 | 21.6 |
| Mean | 16.9 | 29.3 | |
| ± SE: | Between dates = 0.17; between hedgerow species = 1.60; between hedgerow species for same date = 2.26, between hedgerow species for different dates = 2.03 | | |

**Table 5. Effect of hedgerow species on water infiltration characteristics, measured in February 1989, of an Oxic Paleustalf in Ibadan, Nigeria.**

| | Infiltration characteristics | | |
|---|---|---|---|
| Hedgerow species | Sorptivity[1] (mm min$^{-0.5}$) | Transmissivity[2] (mm min$^{-1}$) | Infiltration rate[1] at 2 h (mm min$^{-1}$) |
| *Gliricidia sepium* | 28.22 (3.34) | 1.49 (2.44) | 2.53 (0.93) |
| *Alchornea cordifolia* | 12.81 (2.55) | 1.46 (0.43) | 1.96 (0.67) |
| *Leucaena leucocephala* | 31.50 (3.45) | 0.10 (2.31) | 1.59 (0.46) |
| *Acioa barteri* | 24.78 (3.21) | 2.08 (2.49) | 2.87 (1.05) |
| Control | 38.86 (3.66) | -1.03 (2.19) | 0.79 (-0.23) |
| ±SE | (0.300) | (0.066) | (0.20) |

1. Values in parentheses are log-transformed values of $(x)$ where $(x)$ is the untransformed value.
2. Values in parentheses are log-transformed values of $(10+x)$ where $(x)$ is the untransformed value.

Soil compaction and crusting in nonmechanized farming systems result from human traffic during planting, pruning, weeding, and fertilizer application, and from high-intensity rainfall which occurs in humid tropical regions (Lal 1987). The differential soil compaction and crusting between treatments reflect the pruning frequency, and the quantity and quality of prunings retained as mulch. *L. leucocephala* and *G. sepium* hedgerows produce large quantities of easily decomposable prunings at frequent intervals, whereas *A. barteri* produces smaller quantities of slowly decomposable prunings less frequently (see earlier discussion and Mwenye 1984). The net effect is, however, similar, since the soil surface is effectively protected from the compactive effects of both rainfall and traffic for extended periods by the prunings of *L. leucocephala*, *G. sepium*, and *A. barteri*. *A. cordifolia*, which produces only moderate quantities of moderately decomposable prunings (Mwenye 1984) compared to *L. leucocephala*, *G. sepium*, and *A. barteri*, provides less protection to the soil surface. Soil compaction is, therefore, higher in *A. cordifolia* plots during the growing season.

**Water infiltration characteristics.** Sorptivity determined during the dry season in February 1989 did not differ significantly between treatments (Table 5). Transmissivity and infiltration rates at 2 h were, however, significantly larger ($P < 0.05$) in alley-cropped treatments. The increases in infiltration rate and transmissivity may have been due to an increase in the number of subsurface transmission pores ($r > 50$ μm) caused by decaying roots and high earthworm populations, both of which are features of alley cropping systems (Ball 1985; Kang et al. 1990).

**Diurnal variation in soil temperature.** Soil temperature at a depth of 0.05 m was significantly lower in *L. leucocephala* plots on 3 February ($P < 0.01$) and 4 April ($P < 0.05$), and in *A. barteri* plots on 27 April ($P < 0.01$) (Fig.3) than in the other treatments. On 25 May, soil temperatures in *A. barteri* and *L. leucocephala* plots were significantly lower ($P < 0.01$) than in the control. The differences in soil temperature on each day of measurement were related to differences in soil water content. Soil temperature was related to soil water content in the 0.02-0.07 m depth q (m$^3$ m$^{-3}$%) thus:

$$T_{max} = 40.20 \exp(1.60 \times 10^{-2}\,\theta),$$
$$r^2 = 0.70^{***}\ (P = .001),\ n = 90;$$

where $T_{max}$ is maximum diurnal soil temperature (°C) at a depth of 0.05 m. High soil water contents are known to have a 'damping' effect on soil temperature (Campbell 1985). Differences in soil water content in turn were attributable to differences in ground cover, either from better growth and shading effect of the shrubs (e.g., 2 February and 4 April) (Mwenye 1984) or from thicker mulch provided by prunings of the shrubs (27 April and 25 May), which created differen-

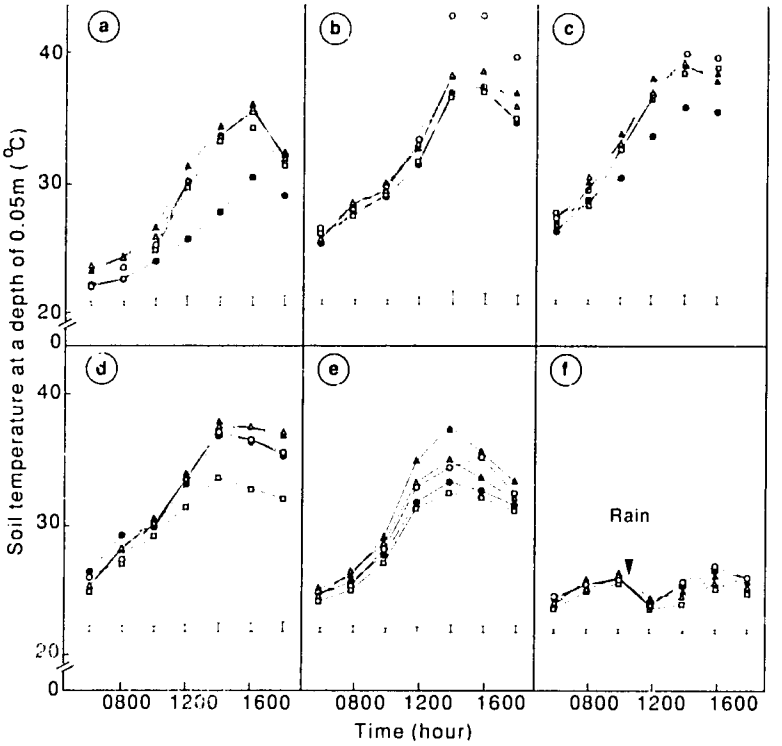


**Figure 3. Effect of hedgerow species on diurnal variation in soil temperature at a depth of 0.05 m in an Oxic Paleustalf in Ibadan, Nigeria on (a) 3 February, (b) 2 March, (c) 4 April, (d) 27 April, (e) 25 May, and (f) 4 July 1989. (Δ) *Gliricidia sepium*; (o) *Alchornea cordifolia*; (●) *Leucaena leucocephala* (□), *Acloa barteri* (▲) control; I = SE of mean.**

tial patterns of soil water evaporation. When soil water content was very low (2 March) or very high (4 July), ground cover did not result in differences in soil water content, and hence soil temperature.

## Conclusions

Soil compaction and maximum diurnal temperatures were lower and water infiltration greater with alley cropping than in the control. Among the hedgerow species studied, soil compaction was, in general, lower with *L. leucocephala* hedgerows, although *A. barteri* hedgerows had an ameliorative effect on soil temperature. It should be noted, however, that the differential effects of hedgerow species and the control on surface soil physical properties, in addition to being caused by direct short-term treatment effects as discussed, may in part also be due to long-term cumulative treatment effects. Some of the factors that affected surface soil physical properties were pruning frequency, and quantity and quality of the prunings produced by the hedgerows. Improvements in soil physical properties were more likely to occur when a shrub produced either large quantities of easily decomposable prunings frequently or smaller quantities of slowly decomposable prunings less freqaently. Hedgerow species that can frequently produce large quantities of prunings which decompose slowly may, therefore, be the most desirable for alley cropping systems.

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# Thesis abstracts

*results of research by IITA trainees*

**Adebitan, S.A. 1991. Factors influencing infection, spread, and severity of two *Colletotrichum* species on cowpea (*Vigna unguiculata* [L.] Walp.) under different cropping systems.** Ph.D. thesis, University of Ibadan, Ibadan, Nigeria.

Screenhouse and field experiments were conducted between 1987 and 1989 to investigate the factors affecting infection, severity, and spread of two diseases of cowpea: anthracnose, caused by *Colletotrichum lindemuthianum*, and brown blotch, caused by *Colletotrichum truncatum*. The following factors were studied: reaction of cowpea genotypes to infection; methods and time of inoculation in screening cowpea seedlings for resistance; plant spacing, genotype, and cropping pattern in sole cowpea and cowpea/maize intercrop; and time of cowpea introduction into the cowpea/maize association.

Cowpea varieties IT82E-60, IT81D-1137, and Vita-7 were most susceptible to anthracnose, whereas TVx 3236, IT81D-994, and IT81D-975 were most resistant. Varieties IT82E-60, IT82D-699, and Ife Brown were most susceptible to brown blotch, whereas TVx 3236, Vita-7, and IT81D-1137 were most resistant.

Wrapping of wounded seedlings with inoculum meal of *Colletrotrichum* at 21 days after seedling emergence enhanced optimal conditions for infection and disease development, with a clear distinction between susceptible and resistant varieties.

Significantly lower incidence and severity of the diseases occurred on intercropped cowpea than on the monocrop. Though incidence values of 25% on pods from intercropped cowpea and 43% on those from sole cowpea infected with *C. lindemuthianum* were recorded, the sole cowpea had a higher seed yield (678 kg $ha^{-1}$) than the intercropped (458 kg $ha^{-1}$).

Increasing cowpea spacing, between and within rows, reduced the infection and severity of both *Colletotrichum* species on cowpea in both the sole crop and the intercrop. Infection rates for the pathogens were lower on intercropped cowpea than on the sole crop, and infection rates increased as plant spacing decreased.

Disease infection, severity, and spread significantly increased with increase in age among all the tested varieties. Infection rates were highest on IT82E-16 (semierect type) and lowest on IT84S-2246-4 (erect type). Thus, the erect variety was more suitable than the spreading type in reducing the spread of both diseases.

Cropping pattern significantly affected the incidence and severity of the fungi on cowpea, decreasing generally in the order sole > strip > intrarow > doublerow > interrow.

Planting cowpea one week before maize and planting both crops simultaneously reduced the incidence and severity of the two fungi on cowpea more than when cowpea was introduced later into maize. Infection rates were lowest on cowpea planted simultaneously with maize.

**Orkwor, G.C.E. 1990. Studies on the critical period of weed interference in yam (*Dioscorea rotundata* Poir) intercropped with maize (*Zea mays* L.), okra (*Abelmoschus esculentus* L. Moench), sweet potato (*Ipomoea batatas* L. Lam) and the biology of the associated weeds.** Ph.D. thesis, University of Nigeria, Nsukka, Nigeria.

Studies on the management and biology of weeds associated with yam/maize/okra/sweet potato intercropping were carried out between 1983 and 1986 at the research farm of the National Root Crops Research Institute, Umudike (5° 29' N, 7° 32' E) and at the Institute's substation at Igbariam (6° 20' N, 6° 57' E). The biological efficiency of the crop mixture and the role of sweet potato as a weed suppressant were determined. Crop yield reduction due to wrong timing of weed removal and the critical period of weed interference in the mixture were also determined. The incidence and attack of insect pests on the crop mixture in relation to duration of weed infestation were also investigated. Weed seed distribution at various soil depths in the cropped field at Umudike and its implications in formulating long-term weed control measures in the area are discussed.

The critical period of weed interference in the crop mixture was 3 to 16 weeks after planting (WAP). Uncontrolled weeds reduced yields of yam tuber by 35%, maize by 60%, okra by 75%, and sweet potato by 80%. Intercropping extended the critical weed-free requirement period of the component crops, compared with their sole crops. There was no economic yield advantage in keeping the mixture weed-free throughout the growing season, provided weeds were kept below the economic threshold through the critical weed-free requirement period of the mixture.

Crop response to weeds varied from sole cropping to intercropping, but yam maintained the same upper limit of critical weed-free requirement period (16 weeks) in the sole croppings as in intercropping.

The mixture yielded a land equivalent ratio (LER) of 1.68, thus indicating 68% higher biological efficiency in intercropping than in sole cropping of the component crops. The middle canopy crop in the system (okra) and sweet potato at the ground level received 88.6% and 70.4%, respectively, of photosynthetically active radiation at 8 WAP. The high LER obtained in the intercrop as well as high levels of solar energy interception in the canopies indicated compatibility and good crop geometry of the component crops.

Sweet potato produced over 70% ground cover between 6 and 8 WAP, which suppressed weeds significantly. Significant positive correlations were observed between increased ground coverage by sweet potato and other crop yields, especially with yam.

**Tamò, M. 1991. The interactions between cowpea (*Vigna unguiculata* Walp.) and the bean flower thrips (*Megalurothrips sjostedti* Trybom) in the Republic of Benin.** Thesis for the degree of Doctor of Technical Sciences, Swiss Federal Institute of Technology, Zurich, Switzerland.

The system analysis approach was used to study the influence of the bean flower thrips, *Megalurothrips sjostedti* (Trybom) (Thysanoptera, Thripidae), on the yield formation of cowpea, *Vigna unguiculata* Walpers (Leguminosae, Fabaceae).

A demographic canopy model was developed for a photosensitive cowpea variety, whose growth and development is driven by temperature, solar radiation, soil phosphate, and water. The dynamics of age-structured populations of leaves, shoots, peduncles, roots, and reproductive organs having numbers and mass attributes was simulated by a time-varying distributed-delay model with attrition. A modified

functional response model from predation theory was used to estimate the daily photosynthate acquisition. The dry-matter allocation was simulated by the metabolic pool model. Growth and yield formation of the plant were driven by the computed ratio between supply and demand of carbohydrates.

Results of the simulation studies compared satisfactorily with four sets of field data used for the validation of the model. The model was also used to evaluate the influence of drought stress and different levels of available phosphate in the soil. The model, designed for research purposes, was then considered as a basic tool for further studies on the structure and function of the cowpea ecosystem.

Different sampling techniques were used to study the spatial and temporal distribution of the different life stages of *M. sjostedti*: emergence cages for eggs, heat extraction for larvae and adults, and both drop board and D-Vac for adults. Within-plant distribution was described by the maximum likelihood estimate of a preference index, whereas between-plant distribution was analyzed using Taylor's Power Law. Enumerative sampling plans for adults were constructed for both the drop board and the D-Vac methods.

The analysis of temporal distribution over 3 years showed a low population level during the first planting season, followed by a rapid and massive buildup during the second season. During the dry season, in the absence of cowpea, *M. sjostedti* was found to feed and reproduce on a wide range of wild leguminous plants.

The influence of temperature on cohort development and reproduction of *M. sjostedti* was studied in environmental cabinets at 5 different temperatures (15, 20, 25, 30, and 37°C). An analytic function was used to relate developmental rates to constant temperatures. Both temperature-dependent survival and fecundity of females were expressed by 4th order polynomials. For all life stages, optimum development was obtained around 30°C.

Eggs of *M. sjostedti* were attacked by a Phytoseiid mite, *Iphiseius* sp, and by two parasitic hymenoptera, *Megaphragma* sp and *Oligosita* sp, both Trichogrammatids. Among the larval predators, the Anthocorid bug *Orius* sp was the only one found to show an impact on the abundance of *M. sjostedti*, and that only during the first cropping season.

From over 5000 larvae reared individually, 6 were attacked by an entomopathogenous fungus, probably *Beauveria* sp, while, unlike for closely related thrips species in Southeast Asia, no one was parasitized by hymenoptera. In view of this fact, the hypothesis of a foreign origin of *M. sjostedti* was postulated, and recommendations for biological control were made.

The impact of different densities (0, 1, 2, 6, and 10) of 1st instar larvae of *M. sjostedti* was studied on isolated individual inflorescences of cowpea plants growing on artificial substrate in the greenhouse. The results indicated that 6 larvae of *M. sjostedti* feeding on an inflorescence during 5 days are sufficient to induce shedding of all flower buds.

The information gathered was then used to design a population model for *M. sjostedti*-cowpea interactions, based on three modules building the core of the cowpea growth model, i.e., the time-varying distributed delay, the functional response acquisition function, and the metabolic pool model. The thrips model was superimposed on the cowpea model to evaluate two-trophic interactions, and the way the interactions are affected by phosphate and water availability in the soil. The model also allowed a preliminary evaluation of the effect of possible biological control candidates on pest-plant interactions.

**Fagbola, O. 1990. Interactions between drought stress and vesicular-arbuscular mycorrhiza on the growth of *Gliricidia sepium* (Jacq.) Walp and *Leucaena leucocephala* (Lam.) de Wit in nonsterile topsoil and subsoil.** M.Sc. thesis, University of Ibadan, Ibadan, Nigeria.

The experiment was carried out in the greenhouse with nonsterile soil. It was a completely randomized block design, with three replicates and a factorial combination of two watering regimes (control and stressed), two mycorrhizal treatments (inoculated with *Glomus deserticolum* and not inoculated), and two different soils (topsoil and subsoil). The two tree species investigated were *Gliricidia sepium* (Jacq.) Walp. and *Leucaena leucocephala* (Lam.) de Wit.

The dry-matter yield of the two tree species was greater in the topsoil than in the subsoil. This is likely related to the physical and chemical characteristics of the topsoil, as well as its abundance of soil fauna. Inoculation with *Glomus deserticolum* in the subsoil resulted in a 88% increase in the shoot dry weight of gliricidia and a 30% decrease in the shoot dry weight of leucaena under well watered conditions. The drought-stress treatment reduced the shoot dry weight of both tree species in both topsoil and subsoil. However, when grown in the subsoil and inoculated with *Glomus deserticolum*, drought-stressed gliricidia had a 13% increase in shoot dry weight, compared to the noninoculated control. Phosphorus content and percentage mycorrhizal infection were strongly correlated, with a correlation coefficient (r) of 0.73 for leucaena, and 0.79 for gliricidia.

**Idisi, P. O. 1990. The potential for hybrid maize production in the northern guinea savanna of Nigeria: a comparative study with open-pollinated maize varieties.** M.Sc. thesis, Ahmadu Bello University, Zaria, Nigeria.

Data from on-farm experiments and from a complementary farm survey, all within the northern guinea savanna (NGS) of Nigeria, were used to ascertain the potential for hybrid maize production in NGS.

Various statistical tools, costs and returns, and return to resources analyses were used to compare hybrid maize and open-pollinated varieties (OPV) of maize. Hybrid maize used more fertilizer and has a higher total cost of production than OPV maize. Fertilizer, seed, and other costs accounted for the differences in cost. Hybrid maize gave a higher economic return to inputs at existing market prices, but its variability of net revenue was also more. Advantage of hybrid maize over OPV increases as total cost and output prices increase.

Farmers sowed hybrid maize at 27,000 plants $ha^{-1}$ and OPV at 23,000 plants $ha^{-1}$. The cultural practices used by small-scale farmers in the NGS are highly varied, leading to high variability of yield (CV of 49% for hybrid and 50% for OPV maize).

In a farmer's adoption preference ranking, hybrid maize was rated better than OPV in terms of field performance, germination percent, output per unit area, and it was preferred by more than 60% of the farmers as their crop of the future. OPV had less than 10%; those who will grow both as the crop of the future constituted about 20%. Farmers recognized the high production cost associated with hybrid maize. They recognized also the cost and difficulty of getting seeds, and the lack of

extension information as some likely obstacles in adopting hybrid maize.

Finally, in position determination, maize was rated the most important crop in the NGS in terms of total area put to the crop, consumption now, cash crop importance, and output per unit area. Fertilizer shortages and increasing costs threaten its enviable position. Sorghum is the second most important crop in the NGS. It needs less fertilizer and could become the most important crop if fertilizer becomes costly and/or unavailable. Maize gained prominence in the NGS within the past two decades, aided by improved varieties, presence of grinding mills, roads, government programs, and presence of research and extension organizations.

**Mbahe, R.E. 1990. Germination of cassava *(Manihot esculenta* Crantz) pollen.** M.Sc. thesis, University of Ibadan, Ibadan, Nigeria.

Cassava pollen grain viability was investigated through germination, both in vitro and in vivo. Thirteen in vitro media of the 61 tested germinated, with percentages ranging from 0.4 to 5.7% and averaging 1.2%. The best medium (5.7% germination) was made of 150 ppm boric acid, 450 ppm calcium phosphate, 25% sucrose, and 0.6% bacto-agar.

Pollens of the IITA-improved clones used in the study were also tested in vivo. With hand crossing, up to 34.5% fruit set, with an average of 2.6 seeds/fruit, was observed. Comparison of in vitro pollen germination values, with seed set from artificial crosses using the same pollen sample, indicated that in vitro germination above 1% using agar medium may be regarded as an adequate level of pollen viability for a cassava crossing program.

Clone TMS 30555 showed the best stigma receptivity, while the pollen of clone TMS 4(2) 1425 had the best fertility and cross compatibility level across the females used.

**Nkwiine, C. 1990. Effect of soybean-maize cropping rotation on soybean rhizobial population and soybean nodulation.** M.Sc. thesis, Makerere University, Kampala, Uganda.

Experiments were conducted to determine the effects of soybean-maize cropping sequences on the infectivity of introduced *Bradyrhizobium japonicum* and the rhizobial population in the soil.

A streptomycin-resistant mutant of *B. japonicum* strain IRj 2114 was developed, tested for its ability to nodulate and fix nitrogen, and introduced on soybean seeds at the start of the field experiments. Soybean (*Glycine max* L.) and maize (*Zea mays* L.) were then grown in four cropping sequences: (i) soybean-soybean-soybean (SSS), (ii) soybean-soybean-maize (SSM), (iii) soybean-maize-soybean (SMS) and (iv) soybean-maize-maize (SSM). A greenhouse study was also carried out to determine the effects of soybean, maize, and fallowing on the survival and establishment of rhizobia under controlled conditions.

Percentage soybean nodulation by the introduced rhizobium, and seasonal changes in soybean rhizobial populations along (AR) and between (BR) crop rows were determined, using the antibiotic resistance and most probable number (MPN) methods, respectively.

The streptomycin-resistant *B. japonicum* nodulated effectively and fixed a large quantity of nitrogen (158 mg/plant) in symbiosis with soybean. Both the total number of nodules per plant and the proportion of nodules due to inoculum IRj 2114 varied significantly ($P \leq 0.01$) with cropping sequences. In the first season, nodule recovery due to the introduced rhizobium was low, being only 15%. In the subsequent season, the maize crop adversely affected soybean nodulation. In the third season, occupancy of the mutant rhizobium, which was 60% for the SSS sequence, was only 42% for SMS.

Population of soil rhizobia was similarly affected by the cropping sequences. Rhizobial numbers were significantly ($P \leq 0.05$) higher when the first two crops were soybean (SS) than when maize followed soybean (SM).

Throughout the sampling period, more rhizobia occurred in the AR zone than in the BR, indicating the positive effects of rhizosphere on the rhizobial population. A pot experiment confirmed observations in the field. Greater stimulation of rhizobia was obtained for soybean than for maize.

It was thus concluded that for the successful establishment of improved strains of *B. japonicum*, a second soybean crop should follow the first inoculated crop.

**Sama-Lang, P. 1991. Application of the model QLE (quantified land evaluation) in identifying "management factors" limiting maize yields in West and Central Africa.** M.Sc. thesis, Wageningen Agricultural University, the Netherlands.

The model QLE (quantified land evaluation) was applied to generate potential yields of maize from selected land units in a selected part of West Africa: Ayepe pilot area in Oyo state, Nigeria. Actual yields were compared with the potential yields in an attempt to identify factors that limit production.

In QLE, availability of solar irradiance, soil moisture, and nutrient availability are the main limiting land qualities. The main "Land Utilization Type" was listed as maize production, under the major land use "Rainfed Agriculture."

The Ayepe pilot area and surrounding hamlets were used as sites. Land units were identified and, for evaluation purposes, aggregated into 7 land evaluation units, relative to their suitability for the land use in view: rainfed maize production. The land evaluation units corresponded to soil mapping units identified in a survey exercise carried out to improve on existing soil data sets. Some farms on a certain site showed different land units as one of the first causes of yield variations. This was exploited in identifying other management-related factors and in subsequent stages of the evaluation procedure.

Compared to QLE-generated yields on runs carried out on data from the Ayepe site, the actual production yields for the selected site show differences exploited in the identification stage of this work. For estimating QLE production situations, only climatic data from comparable rainfall data sets from IITA central station in Ibadan and from Ayepe were used in the calculation of potential yields. Soil-related data as well as actual maize yield data were equally used where available.

As regards differences in maize yields between farms (regrouped here into land units), generated potential yields were appropriately used to explain differences and in identifying corresponding management measures where needed. Thus actual yield data on maize for respective farms were used, along with other management measures applied by the farmers.

Other landscape-related factors, such as erosion and deposition, may cause yield differences between farms. Shading from tree canopy lowered the impact of incident radiation. A quantitative evaluation of this was provided for in the QLE model. For management, weed competition and pest incidence were found important.

# Current literature

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***This list updates our previous issue (March 1991). Readers who need reprints of articles here may request them from the authors or from Publications Unit, IITA.***


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# *Recent IITA publications*

**Combating Striga in Africa.** Edited by S.K. Kim. 151 pp.

Based on a workshop held at IITA, Ibadan, from 22 to 24 August 1988, this volume contains 17 papers relating to basic and strategic research on the biology of striga, including biotechnology; physical and chemical control; breeding for resistance; and adaptive research, including integrated weed management. Recommendations on these aspects are included, with an emphasis on collaborative research, training, and information exchange.

**Crop Genetic Resources of Africa** (2 volumes). Vol. I, 305 pp.; Vol. II, 322 pp.

Volume I is the proceedings of a meeting held under joint auspices of several organizations (IBPGR/UNEP/IITA/CNR, Italy) but brought together by IITA, to discuss crop genetic resources in Africa (Nairobi, Sep 1988). Volume II covers a similar meeting on strategies and activities pertaining to the crops of special interest to IITA (Ibadan, Oct 1988): cassava, cowpea, maize, plantain, rice, soybean, yams, and bambara groundnut. Papers herein present research in plant genetic resources relating to collection, characterization, evaluation, conservation, taxonomy, cytogenetics, plant breeding, plant health, and biotechnology applications. Recommendations from each workshop are included.

**On-farm Research in Theory and Practice.** Edited by H.J.W. Mutsaers and P. Walker. 210 pp.

Scientists working in real farm conditions require reliable research methods and analytical techniques, which often differ from those of conventional on-station research. The 23 papers in this publication, from a workshop held at IITA between 27 February and 3 March 1989, attempt to capture the current status of on-farm research, with an emphasis on sub-Saharan Africa.

# IITA technologies and on-farm adoption: are we wasting our time?

D.S.C. Spencer

*In October 1989, IITA launched a new seminar series aimed primarily not at presentation of data, but at discussion of concepts, perspectives, and opinions. Dunstan Spencer, agricultural economist and Director of IITA's Resource and Crop Management Program, launched the series with an attempted typology of improved technologies and a clear perspective on what IITA's immediate focus should be. This is a condensed version of his presentation.*

## The setting

The target population for whom IITA is developing its improved technologies, as defined in the recently published (1988) strategic and medium-term plans, is the small-scale family farmer. This is a farmer who usually cultivates less than 3 hectares and whose own labor and management is the major input into the production system. Such farmers produce about 90% of the food in sub-Saharan Africa (SSA) in an activity that employs 50-80% of its people. They have very little cash or capital for purchased inputs.

IITA's stated focus is on the humid and subhumid tropics of West and Central Africa, and its mandate crops are cassava, maize, and cowpea, as well as plantain, yam, and soybeans.

Sub-Saharan Africa is the only region in the world where per capita food production has declined over the past two decades, exacting a high price in both human and economic terms. In most African countries, calorie intake is below the minimum recommended nutritional standard. The demand for food imports is increasing, while imported grain prices are rising. Many African governments face acute balance of payments and foreign exchange problems as the terms of trade have turned against the traditional African exports of primary commodities.

Growth in food production in the past has depended primarily on increases in cultivated area at the expense of restorative bush fallows. As we know, many tropical soils are fragile, losing organic matter and nutrients quickly if exposed or cultivated intensely. Thus, soil productivity is declining. Since most food production still occurs in subsistence farming, there is little use of commercial inputs that could improve yields. Most labor for cultivation is provided by people working with relatively simple hand tools. The scarcity of such labor limits the additional area that could be cultivated. Arduous weather, pest damage, and crop diseases aggravate difficulties in the production of food, using existing technologies.

There is thus an urgent need for new or improved technologies and systems of land development and management, which will permit increased productivity and prevent resource degradation. Since labor and capital are the most limiting factors generally, it is important to increase returns per person-day and per dollar invested rather than to increase yield per hectare. This holds true even in areas of relatively high population density, such as eastern Nigeria.

Second, for likely adoption by small farmers, a technology must be within their resource endowment and management capacity. For example, air freight is obviously the most effective way of getting vegetables from African producers to important markets in Europe. Riverine farmers in Africa may stand by their farm to watch planes go overhead. As far as they are concerned, such transportation technology does not exist. If the canoe did not exist for their use, they would have to walk wherever they went or swim across streams!

If a new technology does not meet both criteria (increase labor and capital productivity and be within the resource endowment and management capacity of small farmers), it is not of much use.

## Types of technology

Let me attempt a typology of improved technology, not necessarily restricted to IITA.

**Type 1: Doomsday technologies.** These are technologies which, when employed, give short-run increases in productivity, particularly of labor and land. However, within a short period of time, usually less than 5 years, the technology collapses because it destroys the production base, the soil, leaving the farmer worse off than he/she was at the start. Such technologies also usually require management and capital inputs well beyond the reach of small farmers. In the past they have been packaged by governments for use by such farmers. A classic example of such technology is the mechanical clearing of uplands for annual food crop production, using bulldozers and tree pushers, followed by plowing, harrowing, etc., with heavy equipment. The IITA modification of this technology, which involves mechanical land clearing using the shear blade, followed by zero tillage for annual crop production, or by a plantation crop, probably borders between this type of technology and the next.

**Type 2: Technologies that require massive structural changes.** Such technologies usually give short as well as long run increases in productivity of land and labor and sometimes even of capital. For them to be adopted by small farmers, however, massive structural and institutional changes are required, which include large investments in irrigation systems, setting up of new input delivery and marketing systems, changes in land tenure systems, etc. Many of IITA's leading technologies fall in this category. They include high-yielding grain cowpeas that need 3-5 sprayings to give reasonable yield, hybrid maize varieties that need new seed production and distribution industries and high fertilizer doses, rice varieties that perform very well only under irrigated conditions, minisett yam techniques that require plastic mulch, zero tillage systems that require expensive herbicides, protective clothing, and new equipment, among others.

**Type 3: Technologies that require little or no structural change.** These require little structural and institutional change, and usually result in short and long run increases in productivity of land, and sometimes of labor and capital also. IITA has produced a few such technologies. They include cassava varieties, such as TMS 30572, in the gari-producing zones of West and Central Africa, sweet potato varieties that have done very well in the west of West Africa, freely nodulating soybean varieties that seem to be moving out now, and of course, the classic biocontrol of the cassava mealybug.

Where do I place alley cropping? I believe the verdict is not in yet on whether it should be classified in Type 2 or Type 3. If we package it for continuous cultivation of, for example, pure crop maize followed by sprayed

cowpeas with high doses of fertilizer and zero tillage with herbicides, it will fall under Type 2. If we package it as an improved fallow management system, with maize + cassava intercropping and with little or no added fertilizer, it will fall in Type 3.

### Implications

Are we wasting our time in producing the different types of technologies here at IITA? If we focus on Type 1 or doomsday technologies, we would be definitely wasting our time and contributing to the eventual destruction of our environment.

What about Type 2 technologies that require much structural change? We should remember that most of our efforts in SSA to bring about such structural changes have failed. Effective irrigation schemes are still very few, and many set up in recent years are no longer functional. Improved input delivery and marketing systems are not in place, and there have been very few changes in land tenure systems. Even if they had the will, many of our governments and economies do not have the needed domestic capital resources for the massive investment in infrastructure that will be necessary. Benevolent funding from international sources is a fanciful option. Such funds are often biased and/or misused, and effective policing would lead to questions of sovereignty. I believe that the prospects for bringing about the needed structural changes within a decade or two are minimal. By continuing to produce Type 2 technologies, we might well be wasting our time.

What about Type 3 technologies? I believe they stand the best chance to get to farmers a little at a time, because they are within their means to adopt and manage and because of auto-diffusion. Nongovernmental organizations can make such technologies available to the farmers, even if government institutions do not. To generate Type 3 technologies efficiently and speedily, we still need an appropriate and well funded research system, which can use the latest in research technologies, such as biotechnology for the transfer of desirable genes into plants and animals. Also, an effective information dissemination system will be needed to make such available technologies known to farmers and help the auto-diffusion process.

Emphasis on developing Type 3 technologies would call for low external input systems, which exploit biological nitrogen fixation and mycorrhizal associations. It would mean varieties that fit easily into farmers' existing systems such as intercropping, are resistant to locally prevailing diseases, and have taste characteristics the farmers presently like.

By devoting our energies and resources to such technologies, we could succeed in producing a large number of them. What would be the results? For one, there will be no glamor for our scientists. There will be no Norman Borlaugs coming out of IITA! However, we will help to bring about needed growth by relatively small increases in productivity in the next decade or two. We will set the stage for future scientists and policy makers, who may in future be in a position to make the structural changes and exploit the available Type 2 technologies.

But what if I am wrong and somehow or the other our policy makers and politicians show the will and effort to bring about needed structural changes? Then our Type 3 technologies will still benefit the poorest of the poor, who will not be able to exploit the benefits of structural change. Type 2 technologies can then be developed fairly rapidly by future IITA scientists to be exploited by all.

But because the prospect is remote of bringing about the needed structural changes in SSA in the immediate future, I conclude that we will be wasting our time if we now continue to develop many Type 2 technologies.

## *MEETING* IPM in Root and Tuber Crops

A workshop on Integrated Pest Management (IPM) in Root and Tuber Crops was held at IITA's Biological Control Center for Africa in Cotonou, Benin Republic, during 10–14 December 1990.

Its aim was to develop human resources for the generation and transfer of appropriate IPM technology, by stimulating interaction among researchers of IPM components, practitioners, and field specialists. Of the 56 participants, 17 represented national programs from 15 African countries, 4 were from international or other organizations working in several African countries, and 35 represented IITA (including scientists and Ph. D. students), of whom 28 were from the Biological Control Program.

Roots and tubers were the basic topic of the workshop, but other plants included in the farming systems were also discussed. Arthropod pests, diseases, nematodes, and weeds were discussed. A holistic approach was taken by elaborating on (a) soil/water-host plant interactions, (b) plant-plant competition concerning other crop plants, weeds, and natural vegetation, (c) plant-pest and pathogen interactions, (d) influence of higher trophic levels (parasitoids, predators, pathogens, parasitic weeds), all as influenced by (e) climate/weather, and (f) the farmer, the consumer, government, researcher, etc. Within this framework of ecosystems analysis, cultural control, resistant varieties, and biological control were discussed, including their broader application through the extension services.

Representatives of national programs explained how these concepts were being put into practice in their countries. While several (Congo, Gabon, Ghana, Nigeria, and Zambia) mentioned the success of biological control of cassava mealybug in their countries, Zaire expressed the need for more releases in new areas. Participants expressed their interest in biological control work against the cassava green mite. Weeds were considered a major constraint that was addressed too little. Control by all possible means of the variegated grasshopper, the African cassava mosaic virus, and the political and financial problems of implementing IPM were often mentioned.

During the last day, a total of 193 recommendations was listed under the following headings: government, research, training, implementation, information, administrative structures. Of these, about a dozen recommendations were distilled in an ordered procedure by the plenary session. They will be presented, with the abstracts of the presentations, in a forthcoming publication on this workshop.

The workshop was funded by the United Nations Development Programme, which had earlier funded a similar effort by the Centro Internacional de Agricultura Tropical (CIAT), Colombia.

# Obeng stresses health hazards in tropical agriculture

The well-being of agricultural workers is of paramount importance in the practice of agriculture because a healthy farming community is more likely to sustain productive agriculture than one weakened by infections and diseases and preoccupied with ill health, said Letitia E. Obeng, formerly director of the African Regional Office of the United Nations Environment Programme. She was delivering the third lecture in the annual Distinguished African Scientist Lecture Series at IITA, Ibadan, on 24 April 1991.

Obeng had chosen as her theme "The Right to Health in Tropical Agriculture," emphasizing people and the health hazards they face in practicing agriculture in parts of the tropics.

Lamenting that the health of the agricultural worker hardly gets half the attention lavished on the health of the crops he cultivates, Obeng said even the continued effectiveness of the practice of agriculture requires that farming communities be protected from avoidable infections to which they are exposed because of their occupation.

Water-intensive agriculture creates ecological conditions favorable to some pathogens and endemic diseases, while yet other health hazards are caused by situations where water for domestic and personal use is scarce. Among the debilitating diseases that prevail are river blindness, caused by the blackfly; filariasis; guinea worm; malaria; and a complex of crippling, sometimes fatal, diarrhoea and dysentry.

It need not be surprising, Obeng said, that the health of farming communities is a neglected subject, given the enormity of problems facing African agriculture. Insect pests, weeds, diseases, and uneven distribution of rainfall accentuate the problems of food production in an environment already prone to drought, resulting from an overall insufficiency of usable water. It is precisely in looking at these numerous risks to which food crops are prone that the risks farming communities are exposed to get overlooked.

What can be done to create conditions more conducive to the health of farming communities? The answers are not simple. We need, first, to look at disease-causing organisms and what makes them flourish. This would involve a look at freshwater ecosystems, domestic water supply, and human waste disposal systems, including an appreciation of the crucial balance between different types of organisms and the harmful role of parasites. We need then a systematic analysis of these relevant factors, so that a deliberate effort can be mounted to overcome them.

Obeng distinguished three major types of infections and diseases:

- pathogen-based infections and diseases, acquired by prolonged contact with infected surface waters;
- pathogen-based infections occurring where water for domestic and personal hygiene is inadequate; and
- nonpathogen-based diseases, caused by exposure to chemicals.

Offering a synoptic overview of numerous diseases, Obeng emphasized the key role of reliable and adequate water supply and a safe human waste disposal system in protecting the health of rural communities.

Unfortunately, the advance of irrigated agriculture in Africa has tended to help, rather than inhibit, the spread of diseases, emphasizing once again the distortions implicit in according water for the crops a higher priority than adequate fresh water for the human community.

Where safe domestic water is inadequate, farming communities end up using water contaminated by chemicals. In recent years, various chemicals, in the form of synthesized fertilizers, herbicides, and pesticides, have increasingly found their way into the environment. Excesses of chemical compounds, applied in agriculture and aquaculture or discharged through industrial wastes, eventually leach into the surface and ground waters. Nitrates, cyanamides, fluorides, and mercury have been known to contaminate the water supply, affecting aquatic and human life.

The situation can be remedied only when expertise and resources to manage all natural resources are pooled in an integrated way. Soils, water, plants, humans, and animals need to be managed integrally, as the component parts of a system.

Farmers everywhere are at least as necessary for agriculture as improved inputs, Obeng argued, and they deserve sustainable good health. Efforts at improved or sustainable agriculture must recognize this, she urged.

## *MEETING* African Soybean Network proposed

An African network has been proposed for soybean production and utilization, as part of a global initiative. The proposal was developed at a planning workshop at IITA, Ibadan, during 14–18 January 1991 on "Soybean Production and Utilization for Africa", which was cosponsored with IITA by the Food and Agriculture Organization (FAO) of the United Nations and Nigeria's National Cereals Research Institute.

The workshop brought together 212 participants from 14 countries. They included, in addition to scientists and researchers, policy makers, extension personnel, and representatives of industry, nongovernmental organizations, and women's groups active in the promotion of soybeans.

The participants divided themselves into vigorous working groups, which explored research needs in soybean production, small-scale and medium-scale processing, home-level utilization, extension, and macrolevel policy. After identifying researchable problems and listing them by priority, they spelt out how the issues and constraints identified would be dealt with by specific activities or outputs within a network.

The keynote speaker in the opening session, Nigeria's Minister of Agriculture and Natural Resources, S. Mustapha, reiterated the country's keen interest in soybean research, production, and utilization.

IITA Director General Lukas Brader, who gave the welcome and closing addresses, reaffirmed IITA's commitment to developing soybeans for the tropics, and to further research on soybean production and utilization.

Noting the key role that soybean can play in sustaining the productivity of the region's cropping systems and in balancing the nutritional composition of daily diets based on cereals and root crops, Brader welcomed the close cooperation offered to IITA in soybean improvement by national programs across the region.

# Use of monoclonal antibodies: training workshop held

A plant virology workshop, held at IITA, Ibadan, Nigeria, during 22–26 April 1991, offered 13 scientists attending from 10 African countries intensive training in virus detection techniques. There was special emphasis on the use of monoclonal antibodies, and on virus diseases of crops important to African countries.

Those taking part gained "hands-on" experience in identifying viruses and their strains, using serological techniques, such as the enzyme-linked immunosorbent assay (ELISA). The trainees took home with them detection kits, including antisera, both monoclonal and polyclonal. Other supplies needed by them in making serological tests effective have been supplied to them in a special project, funded by the International Development Research Centre (IDRC) of Canada.

The workshop itself was a part of that project, and the Vancouver Research Station of Agriculture Canada collaborated with IITA in this effort, emphasizing the bridging role that IITA has sought to play between advanced laboratories and African national systems, with a focus on key crops of Africa.

Prompt detection and proper identification of viruses are both difficult at present for national programs with limited equipment and resources. Yet they are crucial in developing measures for effective control of plant viruses. The workshop was another step in IITA's efforts to augment national and regional capability in Africa, in partnership with donor institutions and advanced laboratories.

## Nominations invited.....

**Researchers as trainers:** The Training Program at IITA welcomes nominations of experienced researchers who will have an opportunity to organize in-country training of fellow researrkers. National program leaders may nominate candidates who, while attending an IITA course, will plan their own in-country training course. Selected individuals will receive supplemental training and experience in communication and training skills. IITA staff will then collaborate in conducting in-country courses.

**Training internships:** National programs with staff who have principal responsibility for training researchers and extensionists may nominate candidates for a limited number of internships within the IITA Training Program. Selected interns learn to develop and manage training courses through on-the-job experience at IITA. They will also develop their own country training plans.

***Write to: Group Training Coordinator, Training Program, IITA.***

## *MEETING* Biocontrol of Locusts

IITA hosted a workshop on Biological Control of Locusts and Grasshoppers, also at its Biological Control Center for Africa in Cotonou, Benin Republic, from 29 April to 1 May 1991. The meeting was sponsored by the U.S. Agency for International Development (USAID), and the International Institute of Biological Control (IIBC) shared organizational responsibilities.

There were 97 participants, including 18 from countries directly affected by the pests, 35 researchers from other countries, 5 from international organizations working on locust control, and 15 from IITA, mostly from its Biological Control Program.

The main objectives were to (1) inform those concerned with locust and grasshopper control, especially national programs, of progress in biological control; (2) promote further research through exchange of views, especially receiving the viewpoints of those directly concerned with locust and grasshopper control; and (3) develop research methods and ideas on application of biocontrol.

David Greathead, director of IIBC, delivered the keynote address, in which he spoke of the existing natural enemies of locusts and their limitations. The joint IIBC/IITA/DFPV (Niger's department of training in plant protection) locust program, which seeks to develop mycoinsecticides for control of locusts and grasshoppers, presented some successful results against the desert locust and variegated grasshopper.

A diverse range of applications of pathogens was discussed. Training in biocontrol and in insect pathology was repeatedly stressed as an important need.

A proceedings volume is planned, and a summary report is available from C.J. Lomer, IITA Biological Control Center for Africa, Cotonou, Benin Republic.

## Group training courses scheduled for January – June 1992

| Dates | Course (duration) |
|---|---|
| 13–31 Jan | Seed Production Techniques, Organization & Management (3 weeks) |
| 17 Feb to 6 Mar | Research Farm Management (3 weeks) |
| 24 Feb to 20 Mar | Postharvest Technology (4 weeks) |
| 30 Mar to 10 Apr | Alley Farming in Tropical Africa (2 weeks) |
| 11 May to 3 Jul | Root Crops Research and Technology Transfer (8 weeks) |
| 1–19 Jun | Sustained Food Production Systems (3 weeks) |

# People

**Noel F. Beninati** joined as maize breeder in the USAID/IITA/Cameroon NCRE project in Cameroon in January 1991. Dr Beninati, who got his Ph.D. in plant breeding from the University of Minnesota, USA, was most recently a cereals breeder in Mali with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

**Dana K. Berner** joined IITA's Maize Research Program as striga biologist in June 1991. Dr Berner, who got his Ph.D. in plant pathology from Louisiana State University (LSU) in 1991, has worked in Sierra Leone, Mauritania, and Nigeria. Most recently, he was an instructor with LSU.

**Robert J. Carsky**, previously postdoctoral fellow in agronomy at IITA, joined the USAID/IITA/Cameroon NCRE project as an extension agronomist in May 1991. Dr Carsky will be based in Maroua, Cameroon.

**Jean Detongnon** joined in May 1991 as grain legume specialist in the USAID/IITA/Cameroon NCRE project in Maroua, Cameroon. He obtained his Ph.D. in plant breeding and genetics from Oregon State University, USA, and worked most recently as a cowpea breeder in the Republic of Benin.

**Diane A. Florini** joined IITA's Grain Legume Improvement Program as plant pathologist in February 1991. Dr Florini, who got her Ph.D. in plant pathology from Cornell University, worked most recently (1988-1990) as regional outreach coordinator with the USAID/IITA/Zaire RAV project.

**Friedhelm Gauhl and Cornelia Pasberg-Gauhl** joined IITA's Root Tuber and Plantain Improvement Program in January 1991. In an unusual appointment, the couple will share the position of plant pathologist at IITA's high rainfall station, Onne, near Port-Harcourt, Nigeria, to work on the black sigatoka disease of plantain. They both obtained their Ph.D. in plant pathology in 1989 from the Universität Gottingen, where Cornelia was also head of the tissue culture laboratory. Friedhelm was most recently a tropical ecologist with the Max Planck Institut, Germany.

**Clifford S. Gold** joined IITA's Biological Control Program in January 1991 as an associate scientist. He is based in Kampala, Uganda, and will work on the banana weevil. Dr Gold, who got his Ph.D. in biological control from the University of California at Berkeley, was previously an assistant entomologist with ICRISAT in India. He has also been a consultant with IITA.

**Leonidas S. Halos** joined IITA's Root, Tuber and Plantain Improvement Program in March 1991 as a research specialist in postharvest technology. She worked most recently with the Philippine Rice Research Institute, and earlier with the International Rice Research Institute (IRRI) in the Philippines.

**Birgit Kristensen** joined IITA's Biological Control Program in Cotonou, Republic of Benin, in June 1991 as an associate expert. Her professional interests are in environmental protection, and she will work on the ecology of phytoseiid predators of the cassava green mite.

**Neal W. Menzies** joined IITA's Resource and Crop Management Program in February 1991 as a postdoctoral fellow in soil chemistry. He is based at the IITA humid forest station, Mbalmayo, Cameroon.

**Samuel N.C. Okonkwo** joined IITA's Maize Research Program in January 1991 as a visiting scientist. A professor at the University of Nigeria, Nsukka, since 1976, Dr. Okonkwo will work on striga biology and its control to help maize production.

**Diane Russell**, an anthropologist, joined IITA's Resource and Crop Management Program in January 1991 as a Rockefeller Foundation Fellow. Dr Russell, who has worked previously in Zaire, will be based in Cameroon.

**Baij Nath Singh**, rice breeder with WARDA but stationed at IITA, Ibadan, arrived in April 1991. Dr Singh was previously a visiting scientist with IRRI in the Philippines, and chairman, plant breeding department, Rajendra University of Agriculture, Pusa, Bihar, India.

**Charles F. Yamoah** joined in March 1991 as a soil scientist/agroforester in the USAID/IITA/Cameroon NCRE project. Dr Yamoah, who has previously been a research scholar and research fellow at IITA, was most recently assistant professor of agronomy at the University of Arkansas, Fayetteville, USA.

# Awards

## Professional recognition for four IITA scientists

**I. Okezie Akobundu**, weed scientist with IITA, was chosen 'Honorary Member for 1991' by the Weed Science Society of America, in recognition of his "contributions to weed science in Nigeria and the world". He received the award at the annual meeting of the society in Louisville, Kentucky, USA, in February 1991.

**Hans R. Herren**, entomologist and director of IITA's Biological Control Program, was among the 1990 winners of the Rank Prize for Nutrition. The £25,000 award, from an endowment by the Rank Foundation, UK, seeks to recognize and foster significant advances in science. Dr. Herren, who is a pioneer in IITA's highly successful biocontrol efforts, received the award in London in February 1991.

**Stephen M. Lawani**, information scientist and director of IITA's Information Services, received two awards early in 1991, in recognition of his professional accomplishments. He was elected Fellow of the African Academy of Sciences for having "contributed significantly to the development of knowledge in Africa and the world at large." He also received the Nigerian Library Association's first Eminent Service Award at its annual convention in Ilorin, Kwara, in March 1991.

**Saiv Raj Singh**, entomologist and until recently (Mar 1991) director of IITA's Grain Legume Improvement Program, received the 1991 Distinguished Service Award of Kansas State University. He received the award in Manhattan, Kansas, USA, in May 1991.

## About IITA

The goal of the International Institute of Tropical Agriculture (IITA) is to increase the productivity of key food crops and to develop sustainable agricultural systems that can replace bush fallow, or slash-and-burn, cultivation in the humid and subhumid tropics. Crop improvement programs focus on cassava, maize, plantain, cowpea, soybean, and yam. Research findings are shared through international cooperation programs, which include training, information, and germplasm exchange activities.

IITA was founded in 1967. The Federal Government of Nigeria provided a land grant of 1,000 hectares at Ibadan, for a headquarters and experimental farm site, and the Rockefeller and Ford foundations provided financial support. IITA is governed by an international Board of Trustees. The staff includes around 180 scientists and professionals from about 40 countries, who work at the Ibadan campus and at selected locations in many countries of sub-Saharan Africa.

IITA is one of 16 nonprofit, international agricultural research centers currently supported by the Consultative Group on International Agricultural Research (CGIAR). Established in 1971, CGIAR is an association of about 50 countries, international and regional organizations, and private foundations. The World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Development Programme (UNDP) are cosponsors of this effort.

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