Resource and Crop Management Research Monograph No. 15

RESOURCE AND CROP MANAGEMENT DIVISION

ANNUAL REPORT 1992

Highlights of Scientific Findings

Resource and Crop Management Division
International Institute of Tropical Agriculture

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Annual Report 1992:

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Preface

The Resource and Crop Management Research Monograph series is designed for the wide dissemination of results of research about the resource and crop management problems of smallholder farmers in sub-Saharan Africa, including socioeconomic and policy-related issues. The range of subject matter is intended to contribute to existing knowledge on improved agricultural principles and policies and the effect they have on the sustainability of small-scale food production systems. These monographs summarize results of studies by IITA researchers and their collaborators; they are generally more substantial in content than journal articles.

The monographs are aimed at scientists and researchers within the national agricultural research systems of Africa, the international research community, policy makers, donors, and international development agencies.

Individuals and institutions in Africa may receive single copies free of charge by writing to:

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Abbreviations and acronyms

CGIAR	Consultative Group on International Agricultural Research
COMBS	Collaborative Group on Maize-Based Systems Research
CORTIS	Collaborative Group for Root and Tuber Crop Improvement and Systems Research
COSCA	Collaborative Study of Cassava in Africa
DMT	daily mean temperature
DSS	decision support system
FSP	farming systems perspective
GIS	geographical information systems
IARCS	international agricultural research centers
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
LGP	length of growing period
NARS	national agricultural research systems
RCMD	Resource and Crop Management Division
VAM	vesicular arbuscular mycorrhiza

I. Introduction

Goal of Resource and Crop Management Division

> ***The goal of the Resource and Crop Management Division (RCMD) is to develop economically and ecologically viable farming systems for increased and sustainable production by small-scale family farmers while conserving the natural resource base.***

The resources with which we are most concerned are soil, water, interception of solar radiation, labor and other energy resources, crop and fallow vegetation, and material inputs (fertilizers, pesticides, etc.).

Conceptual framework

In writing a dual mandate for IITA—one that embraced the genetic improvement of major commodities as well as a search for viable alternatives to shifting cultivation—the Institute's founders showed a clear realization that the long-term success of any effort to raise the productivity of food crops in Africa would depend on the ability of agricultural research to find new ways to maintain the productivity of the land under continuous cultivation. Thus, long before "sustainability" and "ecoregional" considerations became the by-words of agricultural development and were incorporated into the goals of the CGIAR system, they were recognized as a critical precondition if food production in sub-Saharan Africa was to be placed on the path towards steady improvement. The approach to these two concepts has therefore evolved over the 25 years of IITA's history. This evolution is traced in the volume published to commemorate the Institute's 25th anniversary: Sustainable Food Production in sub-Saharan Africa: 1. IITA's contributions (IITA, Ibadan, 1992).

IITA's evolving paradigm of ecoregional research uses a holistic approach for a focus on particular agroecological zones or agroecosystems in sub-Saharan Africa. This incorporates the farming systems perspective with a sustainability (long-term) research perspective.

The incorporation of the farming systems perspective has led to the development of three interlinked multidisciplinary research activities:

- collection, collation, and analysis of data on factors characterizing the environment and farming systems of a region or agroecosystem, and the identification and quantification of constraints facing farmers;

- technology development (mainly on-station) research aimed at the development of components for improving existing farming systems and their incorporation into new systems; and

- on-farm studies involving the evaluation of existing systems, on-farm experimentation, studies of technology adoption, and assessment of the impact of the new technologies.

In order to operationalize the complex concept of sustainability and to make it amenable to scientific investigation and measurement, IITA has adopted a working definition at the cropping systems level, namely, "a cropping system is sustainable, if it has an acceptable level of production of harvestable yield which shows a nondeclining trend from cropping cycle to cropping cycle and is resistant in terms of yield stability to normal fluctuations of stress and disturbance over the long term."

Use of the above definition allows the concept to be incorporated in the farming systems perspective and implies a focus on the processes, both biophysical and economic, which determine resource-use efficiency in cropping systems. The buildup of pests, diseases and weeds is incorporated as a destabilizing element. It also calls for detailed examination of important cropping and fallow systems. Sustainability not only requires conservation of biodiversity and resources within the cropping system, but also minimization of negative impact on the entire environment. This necessitates moving up to scales beyond that of the cropping system, to those of the farming system, the catchment area, and the region, etc.

Characterization research is conducted in close collaboration with national agricultural research systems (NARS). It aims to classify not only climatic, hydrologic, and edaphic factors, but also demographic factors, systems of land and labor organization, market infrastructure, health risks, and other factors influencing cropping systems in use by farmers in a given setting or those that may be adopted in future. It is conducted at the macro-level where differences at the regional level are important, through the macro-level to the micro- or cropping systems level.

On-station technology development research is conducted in close collaboration with international research centers (IARCs). Its focus is on land management, process studies, modeling, component technology design, and cropping systems research.

Any technology developed by intensive research at a relatively small number of test locations within an agroecological zone requires assessment of adaptability to various environments and subecological zones before it can be adopted and tested for transferability. Such on-farm testing and assessment are carried out in close collaboration with NARS. National institutes are broadly defined to include universities, non-governmental organizations, and the research divisions of private institutions.

IITA's ecoregional research model as operated in RCMD has collaboration with national scientists as one of its major operating principles. For this collaborative partnership to be effective, there must be mechanisms in place to ensure full understanding by IITA of the strengths and needs of national institutes in order to share relevant tasks with them, and to continue to strengthen their capacity through information exchange and skill-specific training. As an ecoregional center, IITA expects to provide a focal point where national and regional agricultural research programs can join in activities that could involve other international research institutes as well. Thus RCMD is actively engaged in Networks, Consortia and Task Forces with other international and national institutions as well as in training activities.

II. Agroecological Focus

The focus on specific agroecosystems or agroecological zones has been strengthened at IITA. Based on historical precedents and comparative advantage, the Medium Term Plan of IITA calls for the conduct of a full range of ecoregional research activities in the lowland moist savanna of tropical Africa, the humid forest zone, and the inland valley agroecosystem.

Humid forest zone

The agroclimatic limits for the humid forest zone, which includes both evergreen and deciduous rainforest formations, are set at a length of growing period (LGP) of 271–365 days, with a daily mean temperature above 20°C during the growing season. The dominant soils of the zone are ultisols and oxisols, which are characterized by the dominance of low activity kaolinitic clays.

The present forest is a mosaic of different types of land use; patches of secondary forest and fallow vegetation, and small remnants of primary vegetation. The traditional farming systems of the zone are those of shifting cultivation and fallow rotation. There are a great many variations of practice within these systems, but fundamentally they are typified by the alternation of short periods of cropping (1–4 years) followed by fallow periods characterized by successional components of the natural vegetation. The fallow period serves to suppress weeds.

The zone is varied, embracing areas differing significantly in climate, vegetation, and soil resources. The demographic structure of the population heralds continuing rapid population growth over the next two decades. Population densities vary considerably, with southeastern Nigeria recording the highest density in sub-Saharan Africa, and the Zaire Basin among the lowest. There are areas with large urban populations, and other areas that have a poorly developed infrastructure, with inadequate roads and a very uneven distribution of market outlets. In parts of the region, the rural economy is largely dependent on plantation crops, such as cocoa, rubber, oil palm, and kola nut. There is currently a low demand, both in Africa and internationally, for some of these products and world prices for all of them have declined. Cocoa and other smallholder plantation holdings have degenerated in many places without being replaced by any economically viable alternative. In other areas, rice, cassava flour, and gari have provided opportunities for a substantial expansion of cash cropping. Some parts of the humid forest zone have experienced a decline in per capita food production or even a decline in yield per unit area, while others have responded vigorously to market opportunities.

Moist savanna zone

The moist savanna zone of sub-Saharan Africa, as described by IITA, extends in a band across West and Central Africa (the Guinea savanna) and includes coastal lowlands in eastern and southern Africa. It has an LGP of 151–270 days, a daily mean temperature during the growing period greater than 20°C, and altitudes less than 800 m above sea level.

The moist savanna zone can be subdivided into four zones, based on their *climate, vegetation, and agricultural potential. The northern Guinea savanna* of West and Central Africa, which has an LGP of 151–180 days and a total annual precipitation of approximately 900–1200 mm; the southern Guinea savanna of West and Central Africa, with an LGP of 180–210 days and an annual precipitation of approximately 1200–1500 mm; the derived savanna, with an LGP of 210–270 days and an annual precipitation mostly above 1300 mm; and the coastal savanna in parts of West, East, and Southern Africa, with an LGP and precipitation similar to those of the derived savanna but with a lower insolation and different soils. The rainfall pattern is monomodal in the northern and most of the southern Guinea savannas, but is bimodal in the derived and coastal savannas.

The uplands in the moist savanna zone are dominated by alfisols and associated entisols and inceptisols. Their inherent fertility is low, and they are susceptible to soil compaction and erosion. Ultisols and oxisols are less frequent, but they form the major soils in the moist savanna zone of Central Africa. Vertisols are distributed in patches across the zone.

The natural vegetation changes from forest in the derived savanna through savanna woodlands to open savanna in the drier part of the northern Guinea savanna. Most areas have been modified through agricultural use, especially in the derived savanna, which has lost its forest vegetation in many areas and is dominated by annual or perennial grasses and shrubs.

Potential biomass production increases with LGP from the northern Guinea savanna to the derived savanna. Thus, short–medium cycle annual crops (such as maize, cowpea, sorghum, millet, and cotton) are predominant in the northern Guinea savanna. Photosensitive, long-cycled millets, sorghum, and maize extend to the southern Guinea savanna, where long-cycled annuals (yam) or semiperennials (cassava) become increasingly important. Cropping systems in the derived savanna are complicated by the fact that long-cycled annuals and semiperennials are intercropped with short–medium cycled annuals, such as maize or cowpea. Perennial crops, such as kola and oil palm, are important tree crops in the more humid parts of the moist savanna. Within each subzone, nutrient-demanding crops, such as maize and yam, predominate in the more fertile soils, whereas millet, cassava, and oil palm tend to be grown in less fertile or degraded soils. Bush fallow is still the usual means of restoring soil fertility. Fallow periods are declining, however, and they are non-existent in some areas, especially in the northern Guinea savanna and the coastal savanna.

Current population densities in the southern Guinea savanna are some of the lowest in the moist savanna zone. The northern Guinea savanna and derived savanna are more heavily populated, but not to the extent of the coastal humid forest, which generally includes the urban population centers. Transport systems vary widely across the region, but they are generally worst in the southern Guinea savanna.

Food crops that maximize land productivity even on degraded soils dominate in areas of population-driven intensification. These are millet, sorghum, cassava, but also cowpea and groundnut. Cash crops (e.g., maize and cotton), which respond well to high levels of purchased inputs and produce high marketable surpluses, dominate in areas of market-driven intensification.

Traditional pastoralism is still the predominant mode of livestock production, especially in the drier areas of the moist savanna zone. Cattle production is shifting into the more humid areas of the zone. With increasing land-use intensification the woodlands, breeding sites of the tsetse fly, decline and thus the major vector of the *Trypanosomiasis* disease of cattle is eliminated. Animal traction is expanding, especially in the northern Guinea savanna, although manual labor is still the main source of farm energy.

Inland valleys

Inland valleys form one particular category of wetlands. They are the relatively shallow and narrow valleys that occur in the upper reaches of watersheds (major and minor) throughout sub-Saharan Africa. An inland valley can extend up to 25 km in length and its width varies from around 10 m in the upper levels to about 800 m in the lower stretches. These valleys provide potentially highly productive environments relative to uplands because of their hydrological characteristics and their soils. We define systems where farmers cultivate both inland valleys and upland fields as inland valley ecosystems. Systems where farmers cultivate only inland valley fields are extremely rare.

Three hydrological processes converge in the inland valleys: seepage, runoff, and vertical fluctuations in the water table. Topsoil lost due to erosion from uplands is also likely to be found in the valleys. These processes and the topography of inland valleys have resulted in the formation of soils that are generally more fertile than upland soils.

A large number of crops are grown in these valleys, such as rice (rainy season), sugarcane, cassava, yam, sweet potato, maize, legumes, vegetables, banana and plantain. Indeed, these valleys are the only areas in many countries where cropping takes place during the dry season. The potential yields of these crops in inland valley fields are significantly higher than on upland fields.

Inland valleys are distributed in all the agroecological zones of sub-Saharan Africa. Their ecosystems are thus significant in terms of both the total land area they occupy and their potential to become productive growing environments. This potential is particularly important in view of the declining per capita food production and increasing food imports in sub-Saharan Africa. The recurring and severe drought problems in Africa also point to the importance of utilizing the inland valleys more efficiently to increase food production.

The physical variability of inland valleys is high, as is also the variability of the farming systems concerned. For example, rice is the principal crop grown in inland valleys in the humid forest zone of Sierra Leone, but maize is dominant in similar areas of Cameroon. The components of inland valleys systems (e.g., water management, cropping systems, soil fertility management) thus vary in accordance with ecological factors (topography, rainfall, soils, pest occurrence, etc.) and socioeconomic factors (ethnic groups, degree of market integration, population pressure on uplands, etc.). The relative neglect of inland valley agroecosystems may be partly caused by this complexity and heterogeneity.

Past research on inland valleys in Africa has focused almost exclusively on rice cropping. Often, the implicit assumption was that the irrigated rice paddies of Asia could (or should) be reproduced in African inland valleys to bring about a green revolution. But the attempt to transfer Asian systems to Africa has served to highlight the striking ecological and socioeconomic differences between African inland valley systems and Asian irrigated rice systems. It is clear that the technologies developed in Asia are not directly transferable to sub-Saharan Africa.

Given the geographical spread and ensuing variability of inland valley ecosystems throughout sub-Saharan Africa, a variety of different categories of valleys exists in terms of ecological and socioeconomic factors. Different kinds of improved technologies will be needed for these different categories. Some categories may be better suited for resource and biodiversity conservation. Strategic information is needed, concerning (a) which classes of inland valleys should be preserved in their natural state; and (b) which technology improvements are required in the different categories of inland valleys to augment agricultural production.

Organization of Resource and Crop Management Division

The present organization of the division is a result of the evolution or a series of changes in the organizational system in the institute over time, particularly in the last six years.

As a multi-commodity research institute with a farming systems mandate, IITA initially had a farming systems research program and individual commodity improvement programs for roots and tubers, maize, rice, and grain legumes. These programs developed, as in much of the CGIAR, to become vertically segmented thematic research programs which made the institutionalization of the farming systems perspective difficult across programs within the institute. In 1987, cropping systems research groups were set up in the Resource and Crop Management Program to provide crop management expertise (agronomy and economics) across programs in the institute, focusing on particular crops (maize-based systems, cassava-based systems, and rice-based systems). Three years later, these cropping systems groups were transformed into agroecosystems research groups, but still only with crop management capacity.

The central pillars of ecoregional research at the institute are presently the three agroecosystems research programs within the Resource and Crop Management Division (humid forest, moist savanna, and inland valleys). They were created in 1992 by adding resource management capacity (soil science, weed science, etc.) to the crop management capacity (agronomy, economics) in the agroecosystems research groups. Characterization, on-station, and on-farm research are conducted within each of these programs.

III. Humid Forest Program

The objectives of the humid forest program are:

- *To characterize the current agricultural systems and environments of the humid forest zone.*
- To develop, as alternatives to the present system of shifting agriculture, cropping systems that are sustainable, economically viable, and acceptable to the farming communities being targeted.
- To ensure the adoptability of results by strong interaction between researchers and client farmers at all stages of technology development.

Characterization and diagnosis

Collaborative Study of Cassava in Africa

A major characterization activity, begun in 1989, is the Collaborative Study of Cassava in Africa (COSCA), which is being conducted in four phases. Phase I is a broad characterization of the biophysical, biological, and socioeconomic environment of cassava-producing zones and was completed in 1990. Phase II is a detailed production survey at the field level, data collection for which was completed in 1991. Field work for Phase III, a detailed study in six countries of postharvest issues, such as processing, marketing, and consumption, has reached an advanced stage. Phase IV consists of a detailed postharvest survey at the household level in urban centers.

Some results from Phase II were reported last year. Additional analysis in 1992 shows that the intensification pathways from "long" fallow (more than 9 years) through "short" fallow (up to 9 years) to continuous cropping can all exist in a single village depending on land type, crops produced, demographic pressure, and level of commercialization, among other factors. Approximately 5% of arable fields was under long fallow, 75% under short fallow, and 20% under continuous cropping. The relative number of cassava fields under continuous cropping is just below the average of 20%, but it is higher than that of yam and lower than those of sweet potato, rice, peas/beans, and maize. Cassava and yam are long-cycle crops; farmers seem to prefer short-cycle crops for continuous cropping. The relative number of cassava fields under long fallow is surpassed only by that of yam, and is about the same as that of maize. Of the 75% of the fields under short fallow, 40% consists of one set of crops alternated with fallow all the time; the balance (35%) involves rotation of different sets of crops and fallow.

Where cassava is involved as the main crop, it is grown as the last crop before fallow more frequently than any other major arable crop. Cassava is also the first crop to be cultivated after a long fallow, more often than maize, rice, and sweet potato; as often as peas/beans, but less often than yam. It is grown as the last crop before the long fallow more often than yam, rice, and sweet potato, but less often than maize and peas/beans.

Organic manure was applied to 5% of all arable crops; only 2% of cassava receives manure, well below this low average. Banana, maize, and yam are above average. Livestock grazing was done in 10% of all arable crop fields; but only in 3% of cassava fields, again well below the average. In the case of purchased inputs, inorganic fertilizer was used in 8% of all arable crop fields; at 3%, cassava is again well below the average, while yam, maize, and rice are above the average. Hired labor was used in 44% of all arable crop fields; at 43%, cassava is barely average and only yam and maize are above average in terms of the relative number of fields in which hired labor was used.

All the major arable crops are grown under intercrop conditions although at varying frequencies. Cassava is grown as a sole or major intercrop in approximately 75% of all the fields in which it appears and a minor crop in 25% of them. As a sole or major crop, it is surpassed by yam (sole or major in 95% of the fields in which it appears) and rice (sole or major in 90%). As a minor crop, cassava is surpassed by peas/beans and sweet potato (minor in 75% of the fields in which they appear), by banana (minor in 65%) and by maize (minor in 45%).

Information is provided for diverse conditions of market infrastructure, demographic pressure, climate, and agricultural intensification. It is integrated with information collected in the broad characterization survey of Phase I conducted in 1989. The Phase I data showed the need of farmers in areas of dense population and with a relatively good market access infrastructure for early-maturing, high-yielding, pest- and disease-resistant cassava varieties with good processing qualities. Farmers who produce predominantly sweet cassava types are also seeking cassava varieties which are suitable for in-ground "storability" and have good cooking qualities. Farmers who practice intercropping are additionally seeking certain growth habits which are suitable for intercropping, such as high-branching types. But they would delay planting until later in the season in order to use low-branching types which give a high root yield.

As much as 45% of total cassava production is marketed. Before harvest, this is sold in the field or after harvest, in the rural markets, in the urban markets, or at the farmers' homes. The sales are made through middlemen, traders, and processors, as well as directly to consumers. Sale in the field before harvest is population-driven. Field sales tend to occur in villages of high population where there is limited commercialization of production and where labor is relatively not scarce. In such areas, people who buy cassava in the field are able to afford harvesting labor; cassava harvesting is labor-intensive. The relative number of villages where cassava is sold through middlemen is highest in areas of high population density and good market access infrastructure. These are areas of commercial production where the relative number of villages which sell cassava in the field is low. This means that farmers are not able to take advantage of the services of middlemen when they sell cassava in the field because of the high labor requirement in cassava harvesting.

The proportion of total production marketed is higher in poor than in good market access areas, because the higher the concentration on cassava production, the higher the proportion that is marketed. The level of concentration on cassava production is higher in poor than in good market access areas, except where cassava is sold through the middlemen. Under the same conditions of market access, the proportion marketed is higher where farmers sell through middlemen than where they sell directly to consumers.

The relative number of villages where cassava production is increasing is significantly higher where farmers sell through middlemen than where they sell directly to consumers. Following this, concentration on cassava production is higher where farmers sell cassava through middlemen than where they sell directly to consumers under the same market access conditions.

The effect of the participation of middlemen in cassava marketing is, therefore, to increase the proportion marketed and the relative importance of cassava in commercial areas, where farmers would otherwise diversify production away from cassava. In areas of poor market access, the higher the relative importance of cassava, the higher the proportion marketed. In areas of good market access, this trend is reversed—the higher the proportion marketed, because of the participation of middlemen, the higher the relative importance of cassava.

Survey of resources and resource management in Cameroon

A second major diagnostic exercise has been the survey of 20 villages in the humid forest zone of Cameroon to characterize the resource base and resource management in current farming systems. The survey used a geographic grid coded for native vegetation and soils as sampling frames. Through village-level interviews, important tree species and bush plants were identified, such as indicator trees, trees and bush used for firewood, staking, and plant associations, planting schedules, and fallow times for the different field types. Data on market access, fertilizer use, and animal husbandry practices were also collected. On this basis, types of fields and fallow management practices can be correlated with population density, market access, and socioeconomic variables. This study was implemented to ask the following questions:

- What is the spectrum of resource availability for small-scale farmers in the humid forest zone?

- In what ways do farmers manage the resources available to them?

- What are the factors determining changes in resource availability?

- In what ways do farmers respond to changes in resource availability?

- What are the factors facilitating adoption of new technology by small-scale farmers?

The results of the survey are currently being analyzed and will provide a baseline for guiding resource management research at the Humid Forest Station. The survey will later be extended to other parts of the humid forest zone.

Anthropological village-level studies

A more intensive anthropological study of four villages in the Mbalmayo area of Cameroon was conducted in 1992 to obtain information on the interaction of culture, society, and history in shaping resource management systems. This work has allowed a better understanding of changes that have occurred following the collapse of a relatively stable agroforestry system based on cocoa. This has resulting in a shift towards food crop production without technical support to alleviate constraints of decreasing soil fertility and weed infestation. Information has also been collected on the principal food crop patterns, the labor requirements and role of women in these systems, and the complicated land tenure issues. The results will be published during 1993.

Biophysical characterization

The chemical analysis of soils collected from over 120 locations during a reconnaissance survey of the zone has been the first stage in the biophysical characterization of the humid forest area of southern Cameroon. The soils have been analyzed for a range of routine and more fundamental properties to quantify the intensity of soil acidification and plant nutrient depletion, and facilitate deduction of the most appropriate methods of soil amelioration. Results are currently being collected and interpreted.

Since a good deal of research will be conducted at the Mbalmayo farm site, a complete biophysical characterization of this 1000 ha property is a necessary prerequisite to the assessment of its representativeness. A topographic survey was completed in 1991, and during 1992 the survey points were digitized, thus allowing the production of contour maps at any desired scale. Areas representing two types of land clearing, as well as a forested area, were sampled on a 20 m x 20 m grid pattern to a depth of 1 meter, to obtain estimates of microvariability in soil chemical properties.

Technology development

Crop and fallow management

Studies continued on a number of aspects of the alley cropping system. In the screening of five hedgerow species on a coastal ultisol in southeastern Nigeria, four species (*Flemingia macrophylla, Senna siamea, Gmelina arborea,* and *Acacia mangium*) all proved to have undesirable attributes. Only *Dactyladenia barteri* could be recommended for alley cropping on that acid soil. These results emphasize the importance of screening and selection of species based on relevant criteria for a given system before species are included in long-term trials.

Senna siamea and *Gmelina arborea,* on the other hand, could be suitable fallow species for soil fertility regeneration. They show a potential for increasing soil organic matter, basic cations, and cation exchange capacity.

Studies are continuing on crop management practices for sustainable and perennial plantain production. In a study of mulch sources for plantain, *Pennisetum purpureum,* closely followed by *Dactyladenia barteri*, produced the best yields, but the level of management required to produce the *P. purpureum* mulch makes it less attractive. Further studies are needed on more efficient mulching techniques and also on the use of agroforestry, including multispecies hedgerows to produce mulch in situ. On-farm trials were conducted to test the compatibility of *L. leucocephala* and *S. siamea* associated with oilpalm or plantain and foodcrops as a permanent perennial alley cropping system. Plantain/banana interplanted in hedgerows failed because of heavy competition from the generally unpruned hedges. Oilpalm did quite well because farmers trim the hedges on both sides of the trees.

An on-station trial for the introduction of pigeonpea into cassava/maize showed that when planted at 10 000 stands/ha with one stand of pigeonpea to each of cassava, the pigeonpea significantly reduced cassava yield. This did not happen if pigeonpea was planted at that density in alternate rows. In a groundnut + cassava trial, highest groundnut yields were obtained when groundnut was planted three weeks before the cassava.

Process studies

A study on the effect of heaped burning on soil properties and plant growth has commenced on an ultisol soil which represents a large area of southern Cameroon. The aim of the exercise is to determine the cause of observed poor growth on ash patches following forest burning. Known amounts of wood at two rates were used. After the burning, samples of ash and soil (to 50 cm depth) were taken and sampling is being repeated at 2–3 monthly intervals for determination of chemical, physical, and biological properties.

Process-level studies on soil organic matter dynamics, nutrient cycling, and soil faunal activity in alley cropping and cover crop systems, are being conducted on a coastal utisol in southeastern Nigeria. The aim of the study is to gain a better understanding of the chemical and biological determinants of soil organic matter accumulation and breakdown, to allow optimum management of this all-important soil component. Data are being collected on soil faunal activity and populations, nutrient leaching, plant residue decomposition, the effect of soil fauna on decomposition, N-mineralization, and soil microbial biomass on established alley cropping trials. It is anticipated that some of these activities will be extended to Mbalmayo, Cameroon, in 1993.

Modeling and decision support

Modeling of plant interaction and cropping system dynamics is continuing, to quantify plant interaction in cassava/maize mixtures, and to identify key plant parameters for intercrop optimization. A canopy model, based on a spheroid as a general analagon for any canopy, is near completion. The model will allow direct calculation of potential canopy synthesis from a single light measurement below a canopy, using a LICOR leaf area index meter.

A decision-support system for the introduction of legumes into cassava-based systems is being developed, and a preliminary version was tested at the Crops Research Institute in Kumasi, Ghana, and with scientists at the National Cereals Research and Extension Project in Cameroon. A list of priority legumes for multiplication is being selected, based on these trials.

Technology transfer

Farmer-managed alley cropping trials were established between 1986 and 1989 in three locations in southern Nigeria (Alabata, Ayepe, and Ohosu), in most cases with oilpalm or plantain as 'carrier crops', planted inside the hedgerows. Plantain turned out to be *unsuitable but oilpalm grew well in the hedgerows.* Most of the plots have been left to go to fallow while a small number were uprooted or intentionally burnt down by their owners. Several farmers, however, maintain the oil palm inside the hedgerows. In Alabata, farmers were assisted to prune their overgrown hedgerows to make a new start. This will allow them to judge the effect on the maize + cassava crop.

For Ayepe and Ohosu, it is hypothesized that alley cropping may only be adoptable if it allows farmers to grow a high value crop which could otherwise not be grown. Experiments will, therefore, be started in Ayepe in 1993 by the University of Ibadan on the use of alley cropping for plantain production.

The Collaborative Group for Root and Tuber Crop Improvement and Systems Research (CORTIS) held its annual meeting at Institute of Agricultural Research and Training, Moor Plantation, Ibadan. The theme of the meeting was "Choice and on-farm testing of improved crop varieties, with special reference to root and tuber crops." Participants developed an outline of a methodology for on-farm varietal testing, to bring methodological consistency to this work region-wide. The major elements were:

- involving cropping systems scientists in all phases of the breeding work;

- subjecting promising clones to intercropping conditions, only in the final breeding phase;

- establishing maximum level of farmer-management of on-farm variety trials. Researchers should abstain from interference but maximize their observations to explain differences among farmers.

CORTIS will now focus on the integration of legumes in cropping systems, using the approach developed by Collaborative Group on Maize-Based Systems Research (COMBS).

Progress was made with the revision of the "Field Guide for On-Farm Experimentation." This book incorporates past experiences with on-farm research in West and Central Africa, including the CORTIS methodology for on-farm variety testing.

IV. Moist Savanna Program

The goal of the moist savanna program is the development of technologies that will be adoptable by smallholder farmers in the moist savannas of sub-Saharan Africa. The program has structured its plan of work to provide a balance between research on resource management and crop management. While we carry out research to understand the fundamental processes governing resource availability and use as well as ways in which these affect technology development, our scientists have proposed a hypothesis on a pressure-response development mechanism for technology adoption. This is being field-tested to assess its reliability as the driving force for technology development and adoption. We are aware, however, that there is a confounding effect of agroecology and development intensification, irrespective of whether this intensification is market- or population-driven.

Characterization and diagnosis

Current research is focusing on completing the systematic characterization of resources and constraints in the moist savanna zone, and on the development of decision support systems for targeting technologies to appropriate subzone environments.

One of the objectives of agricultural economics research in 1992 was to develop a methodology which could be used by national agricultural research systems and IITA for the agroecological/socioeconomic characterization of savanna systems. Specific activities focused on development and partial application of a framework for the characterization of savanna systems, data collection for validating the framework, and data collection and partial analysis for characterization at the macro level.

Characterization at the macro level was carried out in six countries. Data for this characterization were obtained through literature reviews, and interviews with agricultural scientists, development agents, and policy makers in each country. These data were analyzed using Geographical Information Systems. Preliminary results of this characterization in the Republic of Benin are presented below. As a result of this analysis, which has taken into consideration the predominant activity of the rural residents, those parts of the country that fall within IITA's mandate area have been broadly classified into five farming systems. These farming systems are:

1. Oilpalm-based (Mono, Atlantique, Oueme, and Southern Zou provinces);

2 a. Maize/cassava-based (old settlement, Northern Zou province);

b. Maize/yam-based (new settlement, Northern Zou province);

3. Yam-based (Southern Borgou and Atacora provinces);

4. Cotton-based (Northern Borgou and Atacora provinces); and

5. Sorghum-based (Northeast Atacora province).

The characterization framework distinguishes four categories of systems: population-driven systems in the land-expansion phase, population-driven systems in the land-intensification phase, market-driven systems in the land-expansion phase, and market-driven systems in the land-intensification phase.

Categorization of the farming systems in the Republic of Benin is based on the application of our minimum data set for each of the systems. Examples of components of the minimum data set are population density (whether low or high), availability of good quality uncultivated land (yes or no), transport and market infrastructure (poor or good), type of government policy, labor market, tools, lead crop (cash or food crop), types of crops cultivated, and use of family labor.

Examples of how the minimum data set is applied are given below:

1. If good quality uncultivated land was available, the system was considered to be in the land-expansion phase (either population- or market-driven). Otherwise, the system was assumed to be in the land-intensification phase (either population- or market-driven).

2. If transport infrastructure was good (road density > 15 km/100 km^2, roads usable throughout the year), the system was considered to meet the necessary, but not sufficient, condition for being market-driven. If transport infrastructure was poor, the system was considered to be population-driven, with the land-expansion/land-intensification categorization determined by example 1 above.

3. If sales from one of the two most important crops were used to finance purchased inputs, such as hired labor and/or fertilizer, the system was considered to have a highly profitable major cash crop.

In the northern Guinea savanna of Nigeria, we distinguished between systems that are driven by population alone, and those driven by both market opportunities and population. Within each of these evolutionary pathways, we distinguished between a land expansion stage (when new uncultivated land is still available) and a later land intensification stage, when fallow periods are reduced on land already under cultivation. While these are the primary driving forces, agroecological factors, such as soils and government policy, are recognized as important modifiers affecting the characteristics of systems. We analyzed the changes in farmer objectives, cropping systems, resource endowments, and management practices as systems move along these evolutionary pathways or change from one to the other, and identified the factors that cause these changes.

We used this dynamic framework to capture the heterogeneity of agricultural systems in the mandate area and concluded that systems in the mandate area vary because they are following different evolutionary pathways or are at different stages of the same pathway. In addition, differences in government policy and biophysical factors can cause differences among systems at the same stage on the same evolutionary path.

We also characterized constraints according to the primary driving forces and modifying factors, which can be either characteristics of the resource base, such as soil characteristics, or characteristics of agricultural systems, such as cropping intensity. Characteristics of agricultural systems in turn depend upon the type of evolutionary pathway the system is following and the stage in that pathway. Soil acidity is an example of a constraint where the primary driving force (soil type) is a characteristic of the resource base, while *Pratylenchus* nematodes and *Striga hermonthica* are constraints that are primarily driven by characteristics of agricultural systems such as land-use intensity and cropping systems. Application of this approach to the three constraints mentioned above identified the systems where the constraints were likely to be most serious. An example was the use of cassava as a mechanism for controlling *Striga* in population-driven intensification, where sorghum is a dominant food crop and soil fertility is low. In areas of market-driven expansion, adoption of a highly profitable cash crop will be desirable. This is because profitable cash crop cultivation is the primary driving force of this system.

In order to understand constraints to the expansion of cowpea in market-driven intensification areas within the northern Guinea savanna of Nigeria, we surveyed farmers in 50 households from five villages in the Zaria–Kaduna area. While cereals (mainly maize and sorghum) occupy 74% of the cultivated area, legumes, mainly cowpea, occupy only 11%. Farmers appeared unwilling to expand cowpea production because the opportunity cost of growing cowpea is very high in land-scarce environments due to its low yield compared with the yields of other crops, such as maize, which are available to farmers in market-driven areas. Unless cowpea yields can be increased dramatically by a factor of about five or six, it is unlikely that there will be a substantial increase in cowpea production in areas of market-driven intensification.

Resource management research and technology development

Further studies were carried out in 1992 in the derived savanna subzone to improve our understanding of the resource profile and technology development in alley cropping systems, mycorrhiza, and nitrogen cycling. Various workers have demonstrated the role of vesicular arbuscular mycorrhizal (VAM) fungi in nutrient uptake, especially of P in low fertility soils, thereby enhancing the yield of plants. Most of these studies have been carried out under greenhouse conditions. Studies were carried out this year to assess the effect of the VAM fungus (*Glomus aggregatum*) and indigenous mycorrhiza on growth, and on the P and N uptake of cowpea, and to quantify the contribution of VAM to the cassava yield in alley cropping systems. Results show that indigenous and introduced fungi can obtain an increase in cowpea growth and P uptake more than can be obtained by P fertilizer. However, *G. aggregatum* was not as effective in increasing cowpea growth and P uptake as indigenous fungi obtained from a cowpea-growing area. Inoculation with VAM increased cassava yield by 18–100%. Studies on biological nitrogen fixation were continued this year. Results show that *Albizia lebbeck*, a tree legume that grows well in both acidic and nonacidic soils, has the same potentials in alley cropping as either *Leucaena leucocephala* or *Gliricidia sepium*.

Work on the effect of *Leuceana* pruning frequency in maize/cassava intercropping systems showed that delay in hedgerow pruning affected the yield of cassava more than that of maize. This may be the result of more light competition on cassava, particularly during early growth. Studies to quantify root competition between woody hedgerows and associated crops in alley cropping systems and to determine nutrient contribution from roots show that alley cropping with *Leucaena* increased maize and cowpea yields. A shading effect was noticed on crop rows grown adjacent to hedgerows. A high degree of root turnover was observed during maize cropping.

Long-term studies continued to assess crop performance at low external chemical (fertilizer) input systems and to evaluate long-term performance of exotic and indigenous woody species. In plots both with and without alley cropping, results showed that tillage (mainly by reducing soil compaction) had pronounced effects on maize yield. The effects were greater in plots without alley cropping. Tillage effect was less pronounced in plots alley cropped with *Leucaena* and *Gliricidia*. Without N application or with the application of 45 kg N ha^{-1}, maize yield was highest in plots alley cropped with *Leucaena* and *Gliricidia*, compared with nonlegume trees such as *Dactyladenia barteri* and *Alchornia cordifolia*.

Weed/crop interactions in alley cropping systems have been investigated using *L. leucocephala* as the hedgerow plant. Alley cropping with *Leucaena* resulted in a shift in weed flora away from fast-growing annual weeds that are characteristic of frequently cultivated fields to shade-tolerant, less competitive weeds. Weed density was higher over time in arable fields without alley cropping than in fields where alley cropping was practiced. This beneficial effect of *Leucaena* alley cropping could be reduced by a buildup of *Leucaena* volunteers where the *Leucaena* hedgerows are allowed to seed during a fallow period. Weed suppression was more in *Leucaena* plots that were cropped every other year than in continuously cropped *Leucaena* plots. One weeding within three weeks after planting maize was enough to minimize weed-related yield loss in *Leucaena* alley cropping systems, while plots without *Leucaena* hedgerows had to be weeded twice to minimize yield loss in maize by weeds.

Research continued in 1992 on the use of herbaceous legumes in live mulch systems with *Pseudovigna argentea*. Results confirm that herbaceous legumes in a live mulch system have beneficial effects on weed control and on soil fertility maintenance. Maize yield (1.8 t ha^{-1}) in the unweeded no-tillage plot that received 90 kg N ha^{-1} did not differ significantly from maize yield in the unweeded live mulch plot without N-fertilizer (1.4 t ha^{-1}).

Studies with *Crotalaria verrucosa*, another herbaceous legume, to assess long-term weed management on maize/cassava intercrop, show that *C. verrucosa* improved weed management in a maize/cassava system. This was shown by the fact that one weeding in a maize/cassava system with *C. verrucosa* was as good as two weedings in plots without the legume. The presence of *Crotalaria* did not have an adverse effect on maize or cassava yield. Cassava yield in a weed-free maize/cassava intercrop (28.1 t ha^{-1})

was identical to cassava yield in a *Crotalaria*/maize/cassava intercrop (28.4 t ha^{-1}) that was also kept free of weeds.

The objectives of studies on the biology and control of *Imperata cylindrica* (speargrass) are to develop methods for controlling this weed and to recover land, abandoned because of speargrass infestation, for productive and sustainable crop production. In 1992, studies in the derived savanna were on the biology of speargrass and the introduction of an improved cultural control that could be within reach of smallholder farmers. The objective of the biological studies was to characterize phenological developments in speargrass and to determine the effects on these developments of types of burning at various periods of the dry season. Flowering occurred in speargrass during the dry season in response to slashing, burning, or a combination of these treatments. Intact speargrass fields hardly produced any flowers. Burning alone appears to cause more flowering than slashing or a combination of slashing and burning. Farmers at Ijayi, Nyena, in the derived savanna, generally use tractor hiring services to plow their speargrass fields once, before planting maize, and weed it twice. Our study shows that their maize yield is 50% lower than the yield they could get if they were to hoe-till their burnt fields before planting maize, and also weed them twice. The highest maize yield was obtained when speargrass was weeded five times. This is done by some farmers in the northern parts of Oyo state.

Technology testing and evaluation

The areas of research focus in 1992 included farm-level testing of improved technologies and familiarizing NARS with technology targeting and implementation. We tested selected legumes as components of cereal-based cropping systems in the northern Guinea savanna. The objective of the research was to analyze the constraints and opportunities of legumes to contribute to the sustainability and increased productivity of cropping systems in the savannas. Plots where maize/sorghum, *Aeschynomene histrix*, and soybean had been cropped in 1991 were planted to maize/sorghum in 1992. Field observations showed increased vigor of maize and sorghum in *A. histrix* and soybean plots, reduced *Striga* infestation on maize and reduced weed infestation in the *A. histrix* plots. Nematode damage was also reduced after legume rotations.

The impact of maize expansion into zones that traditionally produce sorghum and the implication of maize expansion on *Striga* infestation and control were investigated further this year. Varieties of maize and sorghum resistant to *Striga* were tested in farmers' fields in Bauchi state in collaboration with the Institute for Agricultural Research, Samaru, IITA's Maize Improvement Program, and International Crops Research Institute for the Semi-Arid Tropics. Results show that maize varieties resistant to *Striga* from the Maize Improvement Program confirmed their superior performance under *Striga* infestation, although the yield advantage was small under very high *Striga* infestation. Sorghum varieties resistant to *Striga* performed very well initially, especially the variety "Framida", but none of the varieties is adapted in its phenology to the northern Guinea savanna. Early planting causes complete yield losses due to grain mold and bird attack; late planting causes yield losses due to shoot-flies.

Efforts to strengthen collaborative work with national scientists continued in 1992 through the Collaborative Group on Maize-Based Systems Research (COMBS). The objective was to strengthen the focus of technology research and transfer by improving on-farm research methodologies with national institutions. Results of this year's activities include progress in the development of a legume data base in collaboration with national scientists in Nigeria, Benin, and Ghana; and development of a computer-based information retrieval system through interactive field work with country members of COMBS and CORTIS (Collaborative Group for Root and Tuber Crops Improvement and Systems Research). The first version of this computer software was tested at several field sites in Nigeria, Ghana, and Cameroon in collaboration with members of COMBS and CORTIS. A user-friendly version, which can be sent out to members of COMBS and CORTIS for field testing, will be ready in early 1993.

V. Inland Valley Program

The inland valley program inherited and has continued to implement the medium-term research plan developed by the inland valley systems research group in 1990. This calls for characterization of the inland valley agroecosystem, and development and testing of improved technology adapted to different categories of inland valleys.

Characterization and diagnosis

As reported last year, Level I characterization of inland valleys was initiated and completed in 1991. It consisted of the mapping of broad agroecological and economic zones throughout West and Central Africa at a scale of 1:5,000,000. The map produced enabled 11 large agroecological and economic zones to be identified cutting across West and Central Africa. Each zone covers more than 10 million ha.

In 1992 sample areas were chosen within two of these zones for more detailed (Level II) characterization using remote sensing techniques. These are the Kabala and Moyamba areas of Sierra Leone with a growing period greater than 7 months, relatively high population density (more than 30 people/km^2) low income (per capita income less than $365/year). Soils are ferralsols. This zone comprises 17.6 million ha in West and Central Africa. The second area is the Kaduna/Minna area of Nigeria, with a growing period 5–6 months, high population density, and low per capita income. Soils are luvisols. This zone comprises 11 million ha in West and Central Africa.

The advantage of using remote sensing in Level II characterization is that all data obtained are quantified and digitized over the area covered on the ground by satellite images (i.e., 60 km x 60 km for SPOT, with a 20 m x 20 m resolution; and 185 km x 170 km for LANDSAT TM4, with a 28.5 m x 28.5 m resolution). The satellite images were chosen on the basis of pragmatic criteria within each Level I zone. The images were to be recent, taken at the end of the dry and wet seasons, be cloud-free (less than 10% cloud cover), and cover areas accessible for ground truthing, including, where possible, experimental sites of IITA and its collaborators.

The satellite images were first analyzed using unsupervised interpretation techniques. The preliminary maps obtained were utilized to identify observation sites where ground truthing activities were to take place. The information recorded at these observation sites was used to produce a supervised interpretation of the satellite scene. The second ground truthing validates the supervised interpretation and final maps are produced at a scale of 1:20,000.

Level II classification provides data on the proportion of land within a satellite scene which is in inland valley bottoms, fringe as well as uplands, the intensity of land cultivation in the inland valleys as well as uplands, the accessibility of inland valleys as determined by the proximity to roads, cities, etc., stream frequency and drainage density, as well as the shape of inland valleys.

The LANDSAT TM scene analyzed for Kaduna covered 3.13 million ha or 28% of the Level I area it represents. The two SPOT HRV scenes analyzed in Sierra Leone each comprised a total area of 0.36 million ha or 4% of the area represented.

In the Kaduna area, valley bottoms and fringes comprise 3.78 and 8.62%, respectively, giving together 12.4% of the total area. The Kaduna area is mainly in the transition between the northern and southern Guinea savannas. As much as 67% of the valley bottoms is either intensely or moderately cultivated (more than 50% of the valley cultivated in any given year), while the corresponding figure for the valley fringes is 54%. Intensity of cultivation in the valleys is affected by the presence of dense wood, shrubs and grasses, which make land clearing difficult, the population density in the area, accessibility as determined by nearness to major roads and settlements, and the presence of reserved forest areas in the uplands, which farmers are prohibited from exploiting.

A significant relationship exists between upland and inland valley land-use patterns. The higher the land-use intensity on the upland, the higher the land-use intensity in the inland valleys. Geology also has an effect on inland valley structure and use. For example, in the part of the Kaduna/Minna area, which is predominantly underlaid by older granite basement complex, drainage densities are low (0.54–0.59) and stream frequency is very coarse (0.44–0.40). The valleys have a higher bottom width and lower fringe width compared with other areas falling predominantly in undifferentiated gneiss–migmatite area, or the area underlaid basically by undifferentiated meta-sediments, which have a medium drainage density (0.75–0.82) and a coarse stream frequency (0.86–0.92).

It is noteworthy that the distribution pattern of inland valleys in Moyamba and Kabala is different. The two areas fall within different agroecological zones (Kabala in the southern Guinea savanna and Moyamba in the humid forest zone), and are also in areas with different geological formations. It is known that the composition and morphological features of parent materials are factors that determine drainage patterns within a given land area and thereby the distribution and shape of inland valleys. In Kabala, inland valleys are located on the granite basement complex in a plateau region that is slightly (but locally steeply) dissected. Slopes vary between 2 and 20%. The inland valleys are narrow and their lengths limited. Analysis of the SPOT image showed that they occupy 5.4% of the total land area. In Moyamba, the kasila group granulites prevail as parent material in a gently undulating interior plain of very low relief. Inland valleys are wider and longer and they cover 15.7% of the total land area.

Because the definition of inland valleys and the methodology used for analyzing the SPOT images for Sierra Leone and the LANDSAT TM image for Kaduna were significantly different, it is not possible to strictly compare the data. All future analysis of Level II images will use the definitions and methods used in the Kaduna study.

Limited comparison between the data from Sierra Leone and Nigeria shows that the drier Kabala and Kaduna areas have a significantly lower percentage of their total area occupied by inland valleys (5.4% and 3.8%, respectively) compared with the wetter forest zones of Moyamba (15.7%). The lowest percentage total area occupied by inland valleys is in the northern Guinea savanna area of Kaduna. The percentage of all inland valleys which is cultivated does not differ much in the two southern locations. It is 24% in Kabala and 29% in Moyamba. However, 67% of all valley bottoms are moderately or intensively cultivated in the Kaduna area. Since there are more inland valleys in Moyamba than Kabala, cultivated inland valleys occupy 1.3% of the total area in Kabala versus 4.7% in Moyamba and 1.4% (valley bottoms only) in Kaduna. A slightly higher percentage of total land area (inland valleys + uplands) is cultivated in Kabala (19.1%) than in Moyamba (12%). This percentage is yet greater in Kaduna (34%).

Our preliminary results, therefore, indicate that Kaduna inland valley agroecosystems are indeed substantially different from those in Kabala and Moyamba with regard to the factors determining the percentage of cultivated inland valleys in dry areas versus wetter areas, and with regard to the role of agricultural intensification in the uplands on inland valley cultivation. There are noticeable but less significant differences between inland valley systems in Kabala and Moyamba. This suggests that the agroecological and economic zones delineated in Level I provide the relevant partitioning of the West and Central Africa landscape, albeit one that can be further refined when Level II characterization is completed. Because of variations within a given Level I zone, each Level II map is likely to produce a typology of one or more categories of inland valleys according to valley shape, inland valley land use in conjunction with upland land uses, population density, and transport networks.

At the final level of characterization of inland valleys (Level III) a large set of economic and ecological parameters is monitored in a sample of inland valleys selected from Level II sites, through field observations and measurements and surveys of individual farmers and fields. The purpose is to develop a detailed and analytical characterization of inland valley agroecosystems. Observations and surveys are conducted over an entire year to capture wet and dry season cropping. A detailed classification of inland valleys is obtained using cluster analysis to obtain an analytical typology which will enable researchers to identify the characteristics of inland valleys best suited for cultivation and those best suited for resource conservation or protection, and to identify and quantify constraints to different landuses in terms of ecology and economic sustainability and farmers' welfare, for principal categories of inland valleys.

Level III characterization was initiated in the Kabala area in 1991. The methods used have previously been tested at other locations (Bida in Nigeria and Makeni in Sierra Leone) where the inland valleys program had experimental sites. Level I characterization established that Bida in Nigeria is representative of less than 1 million ha in West and Central Africa. The site was therefore closed in 1992 as it was deemed to be too small an extrapolation domain for an international agricultural research center.

During the year, analysis of soil samples taken in 1990 at the experimental site in Bida as well as the Makeni area of Sierra Leone showed no difference in organic carbon and clay content as well as P availability between valleys at each location, but a high variation within valleys. A reanalysis of soil samples taken in 1985 at Bida in the course of the Wetland Utilization Research Project showed that there is a higher content of organic carbon and clay in top soils of valley bottoms compared with soils in the fringes and uplands. Consequently it is important to demarcate the topographic position when analyzing soils in inland valleys.

For Level III characterization, a random sample of 60 farmers with inland valley fields was chosen from four villages near Kabala. The same number of farmers were selected in three villages in an area of southcentral Benin Republic, where about 80% of all the farmers are female. Level II characterization is to be undertaken in this zone in the Benin Republic in 1993. Diagnostic trials have been undertaken on weed loss and fertility management similar to those conducted in Bida and Makeni, which were reported last year. The objectives are to quantify yield losses due to weed infestation, and to understand farmers' weed management practices, farmers' decision-making procedures, the interactions between farmers' water management, soil fertility management, and weed management practices.

Results so far obtained show *Fimbristylis littoralis, Cyperus difformis, Kyllinga* sp., *Paspalum* sp., *Panicum* sp., *Echinochloa* sp., *Alternanthera sessiles, Ipomoea acquatica, Hydrolea glabra, Ludwigia* sp. *Sphenoclea zeylanica* as most abundant in the Lema Tre region of Benin, and *Cyperus rotundus, Mariscus* sp. *Fimbristylis littoralis, Brochiaria deflexa, B. alata, Cynodon dactylon, Digitaria ciliaris, Phyllantus amarus, Croton lobatus*, and *Physalis angulata* as more common in the valleys in the Agbagoule region of Benin.

Technology development

After detailed characterization of inland valley agroecosystems, which will result in a typology of different valleys, the IITA research strategy calls for the design and testing of technology for increased production in these valleys.

The integration of legumes in the cropping systems of inland valleys has been identified as a possible way of minimizing weed competition and increasing fertility under conditions of minimal or zero water control. A start has been made in identifying legumes that are adaptable to the diverse water regimes in these valleys. Twelve legume species were acquired and are being screened at an inland valley in the IITA experiment station for their suitability to inland valley conditions. *Calopogonium mucunoides, Mucuna pruriens, Crotalaria retusa*, and *Stylosanthes gracilis* were obtained from various farmers' fields in southern Cameroon. *Vigna radiana, V. luteola*, and *Cajanus cajan* were obtained from IITA's Genetic Resources Unit. *Sesbania rostrata, Crotalaria caricia, Pueraria phaseoloides, Clitoria ternata*, and *Cassia occidentalis* were collected from various farmers' fields within Oyo state.

From preliminary observations in 1992, *Cajanus cajan* (an important grain legume in diets in some parts of West Africa), *Vigna radiata*, and *Sesbania rostrata* show the greatest promise for adaptation to the conditions of inland valleys.

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MSc/MPhil	*Topic*
Akaluhme Omozaphue (Nigeria) University of Ibadan, Nigeria	Socioeconomic study of plantain marketing in Nigeria
Chinwo, Kevin Chisom (Nigeria) University of Ibadan, Nigeria	Survey on impact of fertilizer use on ground and surface water quality in the northern Guinea savanna (NGS) region of Nigeria.

Ekpo, Mercy Obot (Nigeria) University of Ibadan, Nigeria	Interaction of rhizobiophage and indigenous Bradyrhizobium on nodulation, nitrogen fixation, and yield of IITA-bred cowpeas
Hamadina, Mohammed (Nigeria) RSUST, Port Harcourt, Nigeria	Cover crops in alley cropping system
Kroma, Margaret (Sierra Leone) Njala University College	Gender responsibility in postharvest practices and loss reduction technologies of small farmers
Nyobe, Tarcisius (Cameroon) University of Ibadan, Nigeria	Saturation and hydraulic conductivity using "slow evaporative method" application to fallow management systems
Ojedokun, Oluyemi (Nigeria) University of Ibadan, Nigeria	Mycorrhizal dependency of indigenous alley cropped woody species in different soil types
Oseni, F.O. (Nigeria) University of Ibadan, Nigeria	Comparison of two methods of 15N application to assess N contribution of tree prunings to maize in microplots
Quainoo, Albert K. (Ghana) University of Helsinki, Finland	On-farm research
Stessens, Johann (Belgium) Katholieke Universiteit, Leuven	Farmer perceptions of the constraints to the expansion of legume production in the northern Guinea savanna of West Africa
Thomas, Vinod George (India) University of Ibadan, Nigeria	Forms of phosphorus in soil under alley cropping with different woody species in southwest Nigeria
Van Langenhove G. (Belgium) Katholieke Universiteit, Leuven	Decomposition process of organic residues in the alley cropping systems
Welkie, Sylvia (Canada) University of British Columbia, Canada	The relationship between *Leucaena* hedgerow pruning intensity on performance of associated mixed cropped maize and cassava

PhD	***Topic***
Abolaji, Grace T. (Nigeria) Southern Illinois University, USA	An analysis of the impact of research-extension farming linkages on small farmers' adoption of improved cassava varieties in Nigeria
Ahmed, Benjamin (Nigeria) ABU, Zaria, Nigeria	Economic analysis of the potentials for sustained maize production in the northern Guinea savanna of Nigeria
Akinnifesi, Kehinde (Nigeria) University of Ibadan, Nigeria	Root activities of hedgerow and associated crop and their effects on nitrogen-use in *Leucaena*-alley cropping system
Akonde, Pierre T. (Benin) University of Hohenheim, Germany	Effects of long-term alley cropping systems on food crops productivity in southern Benin Republic
Ambassa-Kiki, L. R. (Cameroon) University of Ibadan, Nigeria	Rehabilitation of a degraded ultisol in central Cameroon, at Minkoameyos
Amissah-Arthur, A. (Ghana) University of Ibadan, Nigeria	Studying agricultural drought and its impacts on cowpea production in Nigeria using physical simulation models and remote sensing techniques
Anoka, Ugochinyere (Nigeria) University of Reading, UK	Phenology of speargrass (*Imperata cylindrica* L. Raeuschel) and the implications of bush fire and preplant management practices on its persistence in arable fields
Atayese, M. O. (Nigeria) University of Ibadan, Nigeria	Screening of leguminous woody seedlings for ectomycorrhizal benefits
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Boehringer, Andreas (Germany) University of Hohenheim, Germany	Simultaneous fallow systems in southern Benin

Bohlinger, Brigitte (Germany) University of Hohenheim, Germany	The aspects of fallow plant management during the cropping cycle
Chineke, Theodore (Nigeria) University of Ibadan, Nigeria	Agricultural climatology of the Nigerian environment
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Egbe, A. (Nigeria) University of Ibadan, Nigeria	Comparative development of two indigenous multipurpose trees for agroforestry
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Fagbola, Olajire (Nigeria) University of Ibadan, Nigeria	Decomposition rates of various leguminous woody foliages and their mixtures on late establishment of cassava as influenced by vesicular arbuscular mycorrhizas in alley farming
Freeman, Horatio A. (Sierra Leone) University of Minnesota, USA	A model of agricultural intensification in west African northern Guinea savanna
Hongo, Hamimu H. (Tanzania) University of Reading, UK	Microclimatology and mixed cropping
Huwer, Gerlinde Maria (Germany) University of Hohenheim, Germany	Soil fertility and water conservation
Kadiata, B. D. (Zaire) RSUST, Port-Harcourt, Nigeria	Biological nitrogen fixation and management of an alley cropping system
Kaleem, Fezrat Z. (Ghana) University of Science and Technology, Ghana	Nitrogen fixation in soybean under sole crop and maize intercrop and residual effect on a following maize crop
Kormawa, Patrick (Sierra Leone) University of Hohenheim, Germany	The potential for production and marketing of soybean in West Africa
Kunda, K. Ndolumingu (Zaire) Université Catholique de Louvain-la-Neuve, Belgium	Matière organique du sol et cinétique de minéralisation de la matière organique azotée du sol dans les jachères naturelles et dans les parcelles cultivées

Latt, Christopher (USA) University of Florida, USA	The interactions among reserve carbohydrates, pruning strategies, and biomass production of hedgerow tree species
Liya, S. (UK) University of Ibadan, Nigeria	Nitrogen fixation and release by leguminous trees used for alley cropping
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Ruhigwa, B. A. (Zaire) Rivers State University of Science and Technology, Nigeria	Root and nutrient distribution patterns in an acid soil under selected hedgerow tree species
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Annex 2

Publications by RCMD staff

Contributions by RCMD staff to scientific literature that became available during 1992, including research notes or disease reports, journal articles, papers in monographs or conference proceedings, and edited monographs.

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3. Indices for Measuring the Sustainability and Economic Viability of Farming Systems, Simeon K. Ehui and Dunstan S.C. Spencer, November 1990.

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The International Institute of Tropical Agriculture (IITA) is an autonomous non-profit institution, with headquarters on a 1,000-hectare experimental farm at Ibadan, Nigeria. It was established in 1967 as the first major African link in an integrated network of international agricultural research and training centers located in the major developing regions of the world.

Funding for IITA came initially from the Ford and Rockefeller foundations. Land for the experimental farm was allocated by the Government of the Federal Republic of Nigeria. Principal financing has been arranged since 1971 through the Consultative Group on International Agricultural Research (CGIAR).

The Resource and Crop Management Division (RCMD) is concerned with two of the three main thrusts of IITA research, namely: resource management research, which is the study of the natural resource base with a view to refining existing resource management technologies and devising new ones, and crop management research which aims at the synthesis of the products of resource management research and plant breeding into sustainable and productive cropping systems.

The goal of RCMD is to develop economically and ecologically viable farming systems for increased and sustainable production by the smallholder or family farmer of Africa, while conserving the natural resource base.