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IITA Annual Report 1988/89

COVER

International Institute of Tropical Agriculture

IITA Annual Report 1988/89

Toward Sustainable Agriculture for Africa

The design of the cover is based on a Nigerian textile in the collection of the Staatliches Museum für Völkerkunde, Munich, that of the first page a striped cotton fabric woven in the Republic of Niger.

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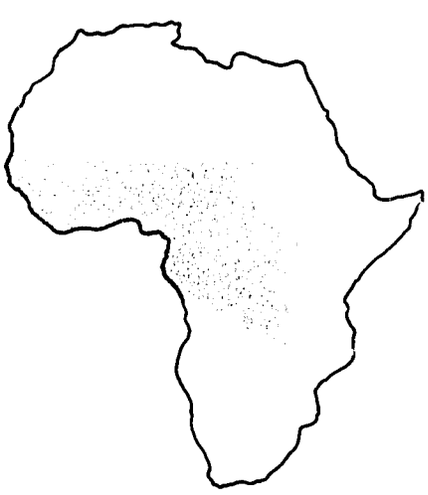

Humid Forest

Forest-Savanna Mosaic (Transition Zone)

Moist (Guinea) Savanna

Dry (Sudan) Savanna

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Director General's Review

Transforming Traditional Agriculture 6

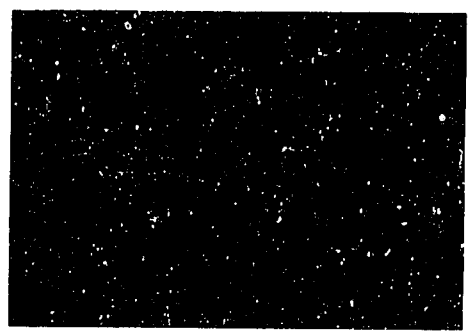
Perhaps it is the vast scale of the African continent itself that inspired in the past such grand-scale prescriptions for its development — prescriptions whose inefficacy figures so prominently and unhappily in today's development literature.

Tragically for the long run, African leaderships adopted the western model for growth at the expense of the most successful sector of their own economies: agriculture. In the 1960s agriculture was the key sector of most sub-Saharan countries, producing the major share of gross domestic product and an even larger share of exports.

The neglect of agriculture was detrimental to the vast majority of Africa's people — the more than 70 percent who worked the land, not only feeding themselves and their urban fellows, but producing agricultural surpluses for export. Decades of relative neglect of the rural sector — of low domestic farm prices, of cheap food from abroad — drained the countryside of labor as men and women sought higher wages in the cities. When as a consequence agricultural production declined, even as urban-centered, western-style development failed to materialize, Africa changed: a net exporter of agricultural products became increasingly dependent on imported grains and cereals.

Small wonder that today the old concept of development, as the process of transferring to one country what has worked in another, is derided as an idea whose time has passed.

What is taking its place is a new conviction, less grandiose, less simplistic, less dramatic. It is the conviction



that for the forseeable future the prosperity of sub-Saharan Africa is inextricably linked to agriculture; and that the prosperity of the agricultural sector consists of the prosperity of the millions of small-scale farmers — the men who control most of the benefits and the women who do much of the work.

The great strength of traditional agriculture has been that it does not exhaust the land. The farmer's own labor, amplified by simple technology, has sufficed in the past to produce enough food — year after year, for centuries — to sustain highly developed societies, even empires. Slash-and-burn agriculture, or shifting cultivation, traditional in West and Central Africa, has worked because it restores the fertility of the land by allowing natural vegetation, bushes and trees, to replace crops during fallow periods lasting from five to twenty years.

These successful traditional systems survive even today in West and Central Africa, but they are threatened by rapidly expanding populations. In many areas, increasing density of population and intensity of land use have reduced fallow periods. Shorter fallows result in sharp declines in productivity. In many villages of eastern Nigeria, historically stable farming systems have become unstable: as declining soil fertility and new disease problems result in lower yields, farmers shift from yam to the more resilient but less nutritious cassava. But even cassava, tropical Africa's most basic crop, is suffering: yields have fallen from about four to less than one ton per acre as fallows have shrunk from five to one-and-a-half years.

Contrary to a common notion, bringing surplus land into cultivation is not the solution for declining agricultural productivity in West and Central Africa. In most areas, soils are fragile and poor; the economic potential for large-scale irrigation is not promising; and much of sub-Saharan Africa is already densely populated in relation to the carrying capacity of the land.

Despite population growth, labor for farming is scarce in some rural areas because of urban migration. Frequent droughts and epidemics of pests and pathogens make even meager production impossible to sustain. The inescapable consequences of such conditions are economic stagnation, rural poverty, malnutrition, and environmental degradation: deforestation, soil erosion, and desertification.

Because this is not an acceptable future, Africa's leaders have begun to move their countries into the mainstream of one of the most remarkable changes of the twentieth century: the transformation of traditional agriculture into science-based agriculture, which permits more intensive cultivation of land already in use.

The future of Africa lies in this transformation. During the remainder of

this century and the first decade of the next, it will be this agricultural transformation — developing new technologies to improve existing farming practices, sometimes to replace them — that offers Africans the hope of producing more food while conserving and enhancing the productive capacity of their land for the future.

The crucial preconditions for the transformation are that these new technologies be appropriate for Africa, that they come primarily from research conducted in Africa, and that they ultimately meet the test on African farms. They cannot be imported from other continents and environments. We have learned that African problems require African solutions.

Of these three preconditions the key, I believe, is research conducted in Africa for the benefit of the small-scale farmer.

At IITA we believe that the strategy for feeding hungry people today while developing sustainable systems for the future must begin with the small-scale farmer.

Fortunately, in this instance economic rationality is not at odds with social imperatives: there is much evidence that in sub-Saharan Africa small-scale farmers are more productive per unit of land than large-scale farmers. The vast majority of farmers in West and Central Africa cultivate small farms, using traditional manual techniques to grow often complex mixtures of crops in well-proven farming systems. Men and women, these farmers are shrewd, hard-working, willing to experiment and responsive to incentives. With the right kind of support from their governments, including effective market, sales, and distribution services, they will adopt new technologies and produce the food surpluses needed to feed the cities.

These farmers are poor not because they are small, but because their farming systems have low and declining productivity. Raising farmers' productivity is the fastest and cheapest means to increase food production and to increase farmers' incomes; which in turn will stimulate employment and raise incomes throughout the economy.

There may be a limited place for mechanized food production in the most favored parts of West Africa. We know much more about mechanization in the lowland tropics now than we did twenty years ago. The next twenty years are likely to see significant advances in this area, and in our understanding of soil and land management. Given general economic development, in some places with favorable conditions and good management, a limited amount of large-scale agriculture can succeed, and is highly desirable. Nevertheless, as far ahead as we can see, most of West and Central Africa's home-produced food will come from smallholders. It is to them that policymakers and research scientists must address themselves.

A development strategy that emphasizes the leading role of agriculture and focuses on the small farmer leads not only to economic growth, but to growth with equity. We know that food surpluses and rural poverty can exist side by side; it is therefore important to empower the poor to gain access to food.

Raising the productivity of the small-scale farmer directly benefits a large portion of the poor and malnourished, reduces inequality by minimizing the attraction of urban migration, and increases employment of the landless. Increasing productivity particularly benefits rural women, who are believed to produce at least half the food in sub-Saharan Africa. Malnutrition appears to be most severe among pregnant and lactating women and among preschool children. According to a recent UNICEF report, 50 percent of Nigerian children suffer from malnutrition and undernutrition, and these rank after malaria as major causes of death. Rising farm prosperity based on improving technologies will thus contribute to better rural nutrition, improved social services, and a more equitable society.

Bold measures have been taken by a number of West and Central African governments to restore the agricultural foundations for national prosperity. Macroeconomic reforms in many countries have improved agricultural policies; determined efforts are underway to improve the infrastructure of markets, roads, and rural services. In

this progressive context, the availability of appropriate and productive technology developed through research becomes the limiting factor for agricultural growth.

A lively controversy has flourished as to whether or not the necessary technologies already exist, waiting on the shelf to be extended to the African farmer. The colonial premise was that the farmer was culture-bound, lazy, and ignorant. He needed to be educated by the extension agent. There is growing recognition, however, that extension is premature and wasteful unless it can offer technologies that are appropriate for small-scale farmers.

The Gender Perspective in IITA Research

African farm women work and live under difficult conditions: while they run their homes and raise their children, they also do much of the farm work, producing most of Africa's food. Despite their leading role in agriculture, however, in most African farming systems women are accorded inferior status. Certain tasks are reserved to men; others are assigned exclusively to women. In each village, certain fields — usually not the most favored ones — are women's fields; certain crops are women's crops.

The same distinction appears in the design and transmission of improved agricultural technology. Men's crops and men's tasks get most of the research and development. Extension workers, typically men, transfer technology most easily to men farmers; potential effects on women farmers are seldom weighed when innovations are considered. Women farmers in Africa begin with inferior education to men's, and inferior access to land, credit, and other resources. The introduction of technologies that are irrelevant or detrimental to their distinct needs can only make the situation of women farmers more difficult.

IITA is committed to improving the condition of rural women in Africa for two reasons: to increase food production, and to promote social equity. If tropical Africa is to develop a more productive, sustainable small-farm agriculture, it cannot afford to neglect half of its farming population. If improved agricultural technologies are biased against women, inhibiting their potential productivity, the entire society will suffer.

Equity considerations are equally compelling. Women and children represent a disproportionate share of Africa's poor and malnourished; malnutrition, for example, is most severe among pregnant and lactating women and among pre-school children. Raising the productivity of female farmers will reduce income inequality, improve rural health, and contribute to a more equitable society.

In IITA's research programs, questions relevant to women farmers are raised primarily in the multidisciplinary working groups that coordinate work on maize-, cassava-, and rice-based cropping systems. These groups are responsible for making sure that new technologies fit the needs of their intended beneficiaries.

In the maize-based systems group, for example, scientists have established that women farmers tend to plant later in the season than men farmers, to weed less, and to cultivate shadier farms. Investigation of these differences may suggest modifications to make technologies more useful to women. Resource management researchers have established that women farmers use bush fallows mainly as sources of firewood, for instance, and this insight will influence the design of new systems for fallow management. Economists in the maize-based systems group are comparing the value of women's farm work and off-farm activities, such as trading, processing farm products, or caring for children.

The inferior status of women farmers in Africa is mirrored by the representation of women among African agricultural professionals.

According to an FAO study, only 3.4 percent of national agricultural personnel in Africa are women. IITA seeks to increase the numbers of women in the national agricultural research and development agencies with which it collaborates.

IITA recently adopted an affirmative action policy to increase the number of women participants in IITA training at all levels. Women now represent only 16 percent of the graduate students conducting research at IITA; a Ford Foundation grant to support women scientists is helping us to correct this imbalance. Women represented 13 percent of the participants in the 13 group training courses conducted in 1988. We are not satisfied with this record, and we are committed to vigorous recruitment to increase the number of trained women in African agriculture.

Through our active efforts worldwide, IITA has had some moderate success over the last several years in recruiting outstanding women scientists to its research staff. Women among the staff scientists at IITA include three agricultural economists, a grain legume pathologist, and a number of post-doctoral researchers.

The rapid spread of improved rice and wheat in Asia — heralded by journalists as the Green Revolution — created the false expectation that agricultural technology could be easily transferred from one region to another. But conditions in Asia in the 1960s were very different from those we now find in Africa. Long before agricultural scientists developed improved varieties of rice and wheat, Asia had vast areas of irrigated land and a long tradition of efficient water management and control. This irrigated agriculture was already sufficiently developed to be receptive to simple new technology — rice and wheat varieties that were highly responsive to good management and the use of nitrogen fertilizer.

An example illustrates the difficulty of importing technology into Africa. Over ten years, one of the international agricultural research centers tested more than 2000 varieties of high-yielding Asian rice in West Africa. Only two of the Asian rices performed as well as the traditional African varieties; the rest were defeated by the diseases, pests, and soil conditions of the African environment.

In contrast to Asia, Africa is characterized by the diversity of its agricultural environments. Even within environments, few African farmers enjoy the stable and uniform conditions that characterize irrigated agriculture in Asia — conditions that were essential to the success of the Green Revolution in Asia. For African farmers, technologies must be tailored to the many specific climates, soils, pests, and farming systems of the continent's major ecological zones. Hence the importance of research.

A Continuum of Research

Among the smallholders whom IITA recognizes as the beneficiaries of its research, there is a range of abilities to provide even the low levels of external inputs, such as fertilizer, that are necessary for sustained production without long natural fallows. At one extreme, resource-poor farmers cannot afford to purchase any inputs; and they are largely ignored by conventional research. At the other extreme, smallholders already buy inputs to produce a marketable surplus; with further increases in their productivity, they can become driving forces for change in Africa.

IITA sees the African smallholder or family farmer as having the potential to drive change by progressing through three continuous phases.

In the first phase, the life of the resource-poor subsistence farmer is transformed by technologies that stabilize yields, reducing unpredictable variations. Reasonably confident of predictable returns, the farmer is encouraged to invest in scarce inputs, including labor, fertilizer, and improved seed, in the expectation of increasing production. Stable yields depend on crop varieties resistant to diseases and insect pests, and tolerant of adverse environmental factors such as drought. Stable yields also require effective approaches to weed, pest, and disease management that reduce dependence on chemicals and that work with nature to solve farmers' problems.

In the second phase, continued progress requires management practices that optimize the productivity of the small farmer's inputs, increasing yields while sustaining the natural resource base. The search for practical ways for resource-poor farmers to increase productivity substantially without degrading their land is a central theme of IITA's mission, and it is crucial to the future of food production in Africa.

The third phase of technology development for smallholders will allow farmers to avail themselves of an increasing volume of external inputs, continuing to increase output while sustaining the resource base.

Our objective at IITA is to create technologies that serve small-scale farmers in all three phases of this continuum. We work in partnership with the national research organizations of West and Central African nations, which test and adapt technologies to the agroecological zones and farming systems in their countries before extending them to farmers. Our shared goals are to develop sustainable agricultural systems that can replace shifting cultivation, and to increase the production of key food crops in these systems.

To illustrate the role of research in African agriculture, I would like to describe four cases that involve appropriate research and effective partner-

ship between IITA and national research organizations.

Maize Growing Increases Progress

As maize cultivation expanded into the moist savanna of West Africa, it encountered a virulent disease, streak virus, that devastated crops in recurrent epidemics. In 1975, IITA launched a ten-year research program to identify sources of genetic resistance to streak virus in the maize gene pool, and to breed this resistance into

African maize varieties. Through sustained, multidisciplinary research, IITA scientists achieved both of these goals, and we now share streak-resistant materials with national program scientists, who are incorporating streak resistance into their own local maize varieties. In Nigeria alone, two million hectares will be seeded to streak-resistant maize by 1990.

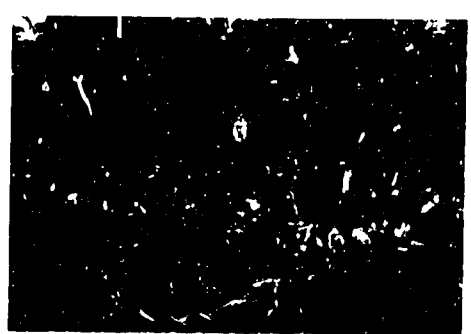
More recently, with the vigorous support of the Nigerian government, IITA has developed streak-resistant hybrid maize varieties adapted to West African environments. This development in turn has inspired the establishment of commercial seed companies that began with maize, then expanded to other crops, such as cowpea, soybean, and sorghum.

The Promise of Alley Farming

Alley farming, the most promising new farming system to emerge from IITA's research, is a form of agroforestry that offers a sustainable alternative to traditional shifting cultivation.

In shifting cultivation, one or more seasons of cropping rotate with several years of bush or tree fallow. The system is land-extensive and, during land-clearing, labor-intensive. In alley farming, food crops and bushes or trees grow simultaneously. In the most successful alley farming pattern, food crops are grown between hedgerows of leguminous bushes or trees, whose roots are colonized by bacteria that can fix atmospheric nitrogen. The nitrogen is available to the crops planted in the alleys, relieving the need for purchased fertilizers.

Under many conditions, alley farming permits sustained, continuous cultivation of food crops, while providing other benefits. The trees are pruned before and during the cropping period to keep them from shading and competing with the food crops. The prunings are used as mulch to improve soil structure, increase soil fertility, conserve water, and suppress weeds. Prunings from leguminous species provide additional nitrogen. Hedgerows also provide fodder for cattle and small ruminants, stakes for other crops, and fuel wood. Planted on the contours of sloping land, hedgerows help prevent erosion.



With the participation of scientists from many nations, the Alley Farming Network for Tropical Africa (AFNETA) has been established to introduce, test, and adapt this new technology in diverse environments. We believe that the term alley farming will become increasingly familiar during the coming decades.

Saving the Cassava Crop

The third example of appropriate research leading to useful innovation concerns cassava, the single greatest source of food energy in the humid regions of Africa. A few years ago it was reported that "a small bug is eating the heart out of Africa and its long-term impact could be far worse than the much publicized droughts causing starvation in many countries." The small bug was the cassava mealybug.

Competition evolves in natural systems to keep species in sustainable equilibrium. Cassava was brought to Africa from South America about 300 years ago without one of its competitors, the mealybug. When the cassava mealybug was accidentally introduced into Africa about 15 years ago, it too arrived from South America without natural enemies to keep its population in check, below levels that cause economic damage. Unopposed, the mealybug rapidly extended its range across tropical Africa, devastating cassava production.

The cassava mealybug could conceivably have been controlled by frequent applications of highly toxic pesticides over the pest's entire range in Africa. That approach, however, would have been both ecologically and socially unsound, and too expensive for the African farmer.

Instead, IITA launched a search for the natural enemies of the mealybug in Latin America in 1980. Explorations over thousands of square kilometers led to the identification of a tiny parasitic wasp that lays its eggs in the mealybug, and whose larvae kill the pest. We have since mounted a major program to mass-produce these natural enemies and, in collaboration with scientists in national research institutions, to release them in mealybug-infested areas, both from the ground and from aircraft over remote sites. The wasps multiply rapidly, destroying the mealybugs in vast numbers. Villages step back from hunger, without even understanding why the destructive mealybugs have disappeared.

Thus we are using insects to kill insects in the world's largest biological control program. International economists have variously estimated the benefit of this program to Africa beyond the year 2000 at roughly $3 billion. If IITA were selling this product of its research, we would already have covered our operating budget for the next 150 years.

The Endangered Plantain

My fourth and final case for the need for productive research concerns plantain, a staple food for millions of Africans that is endangered by a devastating disease, black Sigatoka.

Plantain is ideal for small farmers in the very humid tropics: it fits easily into existing farming systems, its cultivation does not degrade the environment, and it produces high yields.

Black Sigatoka disease is the most important constraint on plantain production worldwide. Its fungal spores, dispersed by wind and water, are thus beyond the control of plant quarantine measures. Black Sigatoka causes plantain leaves to wither, resulting in sharply reduced yields. Losses are sometimes so high that the crop is uneconomical to grow.

The disease, first reported in Fiji, was accidentally introduced into Africa only recently; from Gabon it has spread rapidly northward, first to Cameroon, and then within a year to Nigeria. The disease can be controlled by fungicides, but only at a high cost, beyond the means of small farmers who grow plantain. There are no resistant plantain varieties in Africa.

IITA has been encouraged by several African governments to launch an urgent research campaign to control black Sigatoka. Our agricultural scientists are impelled by the need to save plantains for the millions of smallholders who depend on them for subsistence and livelihood. Using advanced laboratory techniques to cross and multiply both bananas and plantains, we are racing to develop resistant varieties before black Sigatoka

completely eliminates plantain in tropical Africa.

We are aware, however, that the development of resistance to streak virus in maize, which is a much simpler plant to cross, took ten years. Against the possibility that time may run out for plantain before resistant varieties are available, researchers at IITA's Onne substation are screening for Sigatoka-resistant African cooking bananas as a possible substitute crop.

These four examples stand for many that illustrate the vital role of agricultural research in developing new technologies for small-scale farmers. They demonstrate that technologies must be generated specifically for African farming systems; and that their value depends on IITA's national partners to test and adapt them for specific local conditions. We work together to redeem Africa's promise to improve the well-being of its people and to meet the challenges of the twenty-first century.

Laurence D. Stifel

Ibadan, August 1980

Introduction to IITA

The International Institute of Tropical Agriculture (IITA) was established in 1967 to increase the productivity of key food crops and to develop sustainable agricultural systems that could replace bush fallow, or slash-and-burn, cultivation in the humid and subhumid tropics. IITA was the first major African link in a world-wide network of international agricultural research centers known as the Consultative Group on International Agricultural Research (CGIAR). The Federal Republic of Nigeria provided 1,000 hectares of land for the Institute's headquarters and experimental farm at Ibadan, Nigeria, while the Ford and Rockefeller foundations provided the initial financial support.

IITA has four objectives:

1. To develop systems for the management and conservation of natural resources for sustainable agriculture in the humid and subhumid tropical zones.

There is global concern that Africa's growing population is placing increasing pressure on basic natural resources and threatening the viability of traditional farming systems.

2. To improve the performance of selected food crops that can be integrated into improved and sustainable production systems.

This is the shared goal of all the international institutes in the CGIAR system. IITA conducts varietal improvement research on seven crops: cassava, maize, rice, cowpea, yam, plantain, and soybean. Rice research is being scaled down at IITA and transferred to a sister research center.

3. To strengthen national agricultural-research capabilities in order to accelerate the generation and utilization of improved technologies by means of training, information, and other outreach activities.

The objective is to enable the Institute's partners in national research systems increasingly to meet their own technology requirements.

4. To improve food quality and food storage, processing, and marketing, in order to encourage more efficient use of available food supplies.

For a number of IITA commodities, particularly roots and tubers, the lack of efficient technology for storage, processing, and conversion to commercial products is a serious barrier to their increased use for both food and feed.

Research and training are conducted at IITA headquarters and in other areas of Africa in cooperation with regional and national programs. Although the geographical mandate of IITA includes the humid and subhumid tropical regions of the world, the Institute now places primary emphasis on improving the farming systems in the lowland humid and subhumid zones of West and Central Africa. Four of the Institute's principal research programs focus on crops: Grain Legumes, which focuses on cowpea and soybean; Maize; Rice; and Roots, Tubers, and Plantain, which includes cassava and yam. A fifth program, Resource and Crop Management, is concerned with soil resources and farming systems. Other programs concentrate on Biological Control, International Cooperation, and Information Services.

Research at IITA's headquarters and substations, and in agro-ecological zones throughout tropical Africa, is relevant to tropical zones on other continents. IITA shares its findings through germplasm exchange, publication, and training.

The Institute maintains vital links with national agricultural research programs. By testing IITA's innovations, adapting them to local conditions, and carrying them to farmers, national programs translate research into increased food production.

Principal funding for IITA is arranged through the CGIAR. Sources of financial support for IITA during 1988 are listed in the table on page 16.

The Institute employs over 180 scientists and professional staff members from more than 40 countries, and about 1100 support staff, most of whom are from Nigeria. The majority of the Institute's scientists are located at headquarters, while others are assigned to IITA substations at Onne, in Nigeria, and Cotonou, in the People's Republic of Benin, as well as to projects in collaboration with regional and national programs in Africa.

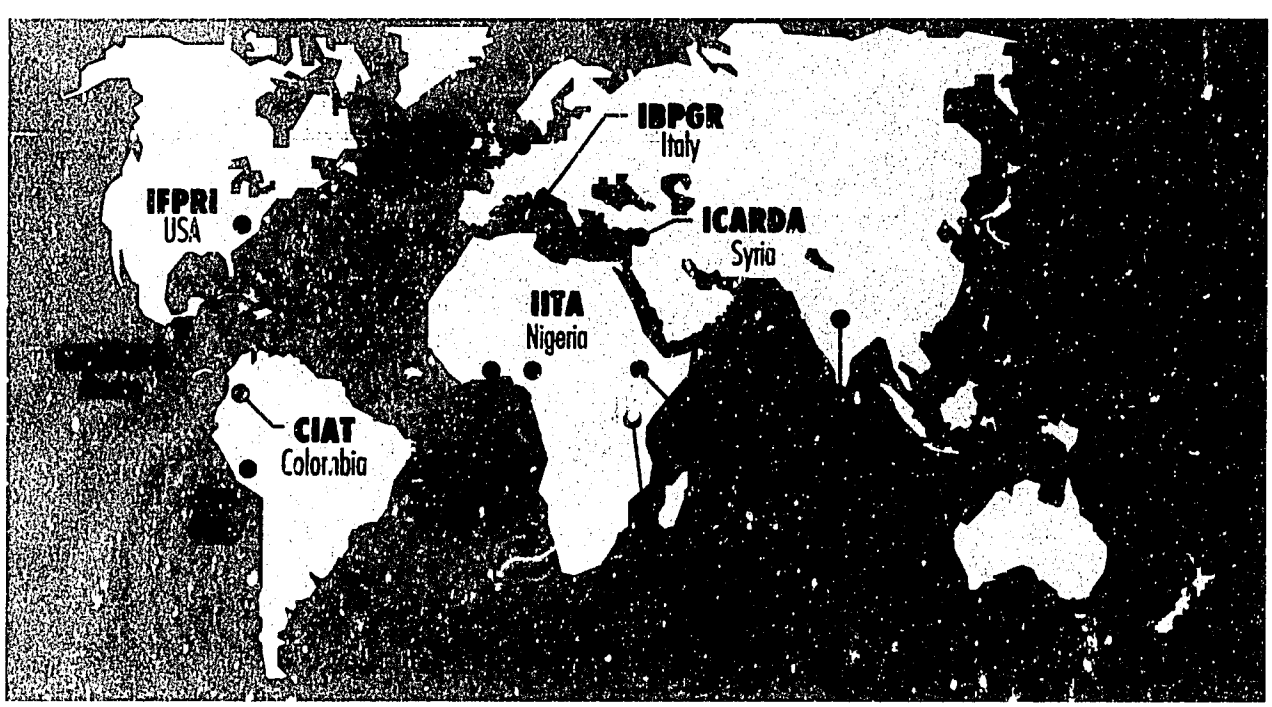
The Consultative Group on International Agricultural Research (CGIAR) is an informal association of countries, international organizations, and private institutions, formed in 1971 to provide sustained support for a well-defined and closely monitored program of international research on food commodities of vital importance to the developing countries of the world.

Cosponsored by the World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Development Programme (UNDP), the CGIAR operates without a formal charter, relying on a consensus deriving from a sense of common purpose. The CGIAR started with a nucleus of four existing international agricultural research centers, including IITA. The number of centers has now increased to 13, supported by 39 donor members and other contributors, who provided between US $240-250 million in funding in 1987.

Each CGIAR-affiliated center is independent and autonomous, with its own structure, mandate, and objectives, and overseen by its own board of trustees. Some centers focus on one or two commodities for which they have global mandates, while others have regional or ecological mandates for one or more commodities. Still others perform specialized functions in the fields of food policy research, genetic resources conservation, and the strengthening of national agricultural research in developing countries.

The CGIAR is serviced by an executive secretariat, located in Washington and provided by the World Bank. A Technical Advisory Committee (TAC), comprising a chairman and fourteen scientists, is drawn equally from developed and developing countries. The TAC makes recommendations on research programs and priorities, and monitors performance through annual program and budget reviews and periodic external reviews by independent scientists invited to serve on specially constituted panels. The TAC is supported by a secretariat provided by the three co-sponsors of CGIAR and located at FAO headquarters in Rome.

The CGIAR meets twice a year, once in Washington in October/November and once elsewhere in May. The meetings hear and discuss recommendations about overall strategy, budgetary needs, and management issues. Reports from individual centers, as well as independent external evaluations, are presented periodically at these meetings.



CIAT (Centro Internacional de Agricultura Tropical);
CIP (Centro Internacional de la Papa);
CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo);
IBPGR (International Board for Plant Genetic Resources);
ICARDA (International Center for Agricultural Research in the Dry Areas);
ICRISAT (International Crops Research Institute for the Semi-Arid
IFPRI (International Food Policy Research Institute);
IITA (International Institute of Tropical Agriculture);
ILRAD (International Laboratory for Research on Animal Diseases);
ILCA (International Livestock Center for Africa);
IRRI (International Rice Research Institute);
ISNAR (International Service for National Agricultural Research);
WARDA (West Africa Rice Development Association).

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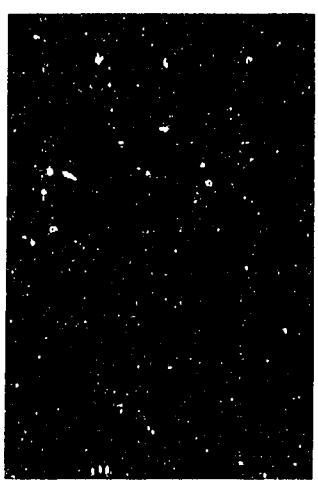


Since 1979, when as Head of State of the Federal Republic of Nigeria he turned over the reins of government to his successor, Olusegun Obasanjo has devoted himself to two great causes: the advancement of Africa's — indeed of all humanity's — political and social aspirations, and personal demonstrations that agriculture is the key to prosperity for Africa. He has been remarkably successful in both endeavors.

In global forums, General Obasanjo has a strong profile as a statesman who addresses the critical issues of his time. A staunch supporter of the United Nations, he serves on its Panel of Eminent Personalities in the Field of Disarmament and Development, where he boldly advocates a concept of security based on cooperation and reciprocity. He also served as co-chairman of the Commonwealth Eminent Persons Group on Southern Africa.

In the field of private voluntary action, General Obasanjo is the founder of the African Leadership Forum, a foundation whose seminars and communications programs give form and substance to his ideals for the next generation of political, industrial, and cultural leaders. He is also a member of the InterAction Council of Former Heads of Government, and a trustee of the Ford Foundation. Agriculture has always been uppermost in General Obasanjo's thinking. He put his belief into action upon his retirement from political and military life in 1979. He established Obasanjo Farms at Ota, in tropical southern Nigeria, to increase public awareness of the potential of farming and to encourage progressive farmers in food production. Poultry and livestock raising and processing are the farms' chief business, together with production of staple food crops and seed, livestock feed and freshwater fish, and the recycling of farm wastes. The farms have a small-farmer improvement scheme, and offer advice on land preparation and management, infrastructure development, and storage and processing problems.

General Obasanjo is setting a highly visible example that farming can be a respectable and dignified occupation — at a time when many African countries are turning back to the land with the failure of so many urbanization/industrialization projects. In a recent visit to IITA, General Obasanjo praised the Institute's efforts to harness "international scientists and African scientists and farmers to work together to bring about a new dawn of self-reliance in agriculture."

Donors

Donors for the year 1988 in US$1000

Donor	Core Funding	Special Projects Funding	Total
African Development Bank		200	200
Australia	38		38
Austria	90		90
Belgium	635	520	1,155
Canada	1,703	944	2,647
Canadian International Development Agency		130	130
China	15		15
Denmark	97	280	377
Ford Foundation	100	146	246
France	238		238
Gatsby Charitable Foundation		146	146
Germany, Federal Republic of	1,317	601	1,918
India	25		25
International Development Research Centre		458	458
International Fund for Agricultural Development		275	275
Italy	577	322	899
Japan	2,516		2,516
Netherlands	749	592	1,341
Nigeria	67	22	89
Norway	559	533	1,092
Rockefeller Foundation		197	197
Sweden	177	270	447
Switzerland		1,019	1,019
United Kingdom	790		790
United Nations Development Programme	141	80	221
United Nations University		60	60
United States Agency for International Development	5,435	4,841	10,276
University of Hohenheim		136	136
World Bank	5,800	119	5,919
Others (including training programs contributions)		617	617
TOTAL CONTRIBUTIONS	21,069	12,508	33,577

Calendar of Events

1988

January 4 – Feb. 5	Soil and plant analysis training course
January 11 – 15	Cowpea and soybean training course for agricultural development projects in Nigeria
January 21 – 22	Meeting of senior officials responsible for agricultural research in West and Central Africa
February 1 – 19	Improved weed management training course
February 15 – 26	Gene bank management training course
February 22 – Mar. 4	Soil and site characterization training course (with IBSRAM)
February 29 – Mar. 18	Seed technology training course
March 14 – 25	Alley farming training course
April 14 – 19	Interregional expert group meeting on exchange of technology for cassava processing and food products (with UNICEF)
April 26 – 29	Second meeting of root crop research collaborators in Africa
May 1	First Young African Scientist awards ceremony: A.O. Latunde-Dada (Nigeria), natural sciences (first prize); N. Sanginga (Zaire), natural sciences (second prize); Samuel Asuming-Brempong (Ghana), social sciences (first prize)
May 2 – 6	IITA Board of Trustees meeting
May 2 – June 3	Biological control of cassava pests, training course I
May 9 – 10	Planning meeting on collaborative programs in virus disease identification (with International Development Research Centre [IDRC] and national program virologists)
May 9 – July 15	Tropical root crops research and production training course
June 6 – 7	Meeting of directors of Nigerian agricultural research institutes with IITA
June 6 – July 1	Food crops utilization and nutrition training course
July 18 – August 5	Rapid multiplication of root crops training course
July 29	Donor's Day at IITA (visit to research facilities and experimental farm by heads of donor missions in Nigeria and the region)
August 1	IITA Day (ceremonies honoring staff having served ten and twenty years)
August 2 – 5	Internal review of the Root, Tuber and Plantain Improvement Program
August 8 – 9	Meeting on use of biotechnology for the improvement of cassava, yams and plantain in Africa
August 8 – 9	Biological control of cassava pests, training course II
August 22 – 24	Workshop on combating *Striga* in Africa: opportunities for research collaboration (with International Crop Research Institute for the Semi-Arid Tropics and IDRC)
August 26 – 31	Internal review of the Grain Legume Improvement Program
August 29 – Sept. 23	Rice research and production training course

September 5 – 9	Third planning meeting of the Collaborative Study on Cassava in Africa (with Centro Internacional de Agricultura Tropical)
September 12 – 13	Meeting of the CG Task Force on Sub-Saharan Africa on research needs for maize and cassava in eleven coastal countries of West and Central Africa
September 26 – 28	Founding meeting of Alley Farming Network for Tropical Africa (with IDRC, Canadian International Development Agency, International Council for Research in Agroforestry and International Livestock Center for Africa)
September 26 – 30	Workshop on plant genetic resources in African development (with IBPGR, United Nations Environment Programme [UNEP] and the Italian Government)
October 3 – Nov. 4	Biological control of cassava pests, training course III
October 17 – 21	Workshop on genetic resources of selected crops in Africa (with IBPGR, UNEP and the Italian Government)
October 17 – Dec. 9	Cowpea and soybean research and production training course
November 7 – 10	Meeting of the collaborative group in cassava-based systems research
November 14 – 18	Workshop on potential of cassava as a livestock feed (with ILCA and IDRC)
November 14 – 25	Training workshop for scientists of the cowpea network for West and Central Africa
November 28 – Dec. 2	IITA Board of Trustees meeting
December 5 – 9	Inauguration of biological control program center at IITA, Benin Station, Cotonou (held with a conference on the search for sustainable solutions to crop pest problems in Africa, and a workshop on the application of biological control in Africa)

1989

February 8 – 9	Seminar on Italian contributions to cowpea germplasm collection and evaluation (with the Italian government)
February 9 – 10	Workshop on the use of biotechnology for the improvement of cowpea
February 27 – Mar. 3	Workshop on the design and analysis of on-farm trials (with Ford Foundation)
March 20 – 23	International rice testing program for Africa workshop
April 24 – 27	IITA Board of Trustees meeting
April 30 – May 1	Special Program for African Agricultural Research (SPAAR) visit to IITA research programs, Cotonou and Ibadan

Research Programs in Action

Alley Farming

For millennia, farmers in the tropics have rotated primary crops with bush fallows of trees and shrubs in shifting cultivation systems. Oil palm, African pear, African breadfruit, and other trees and shrubs are widely appreciated by farmers as secondary sources of human food and livestock feed. Some trees and shrubs, such as locust bean, restore soil fertility as well as provide food and fodder.

As long as traditional farmers have enough land to support the slow alternation of trees and crops, and enough labor to clear the land after the fallow periods, the bush fallow system can sustain a modest productivity. In many parts of Africa and elsewhere in the tropics, however, increasing demand for land to support burgeoning populations has shortened fallow periods. Without adequate rest periods of slow tree and shrub growth to recover from the exhaustion of crop cultivation, soil fertility declines. Declining soil fertility translates into declining crop yields. Caught in this unhappy chain of cause and effect, tropical African farmers need more productive, land-efficient, and sustainable agricultural systems.

Alley cropping, the most promising product of IITA's continuing research in resource management, is a sustainable alternative to traditional bush fallow systems. Instead of alternating brief periods of crop production with long periods of bush fallow, the alley-cropping farmer grows plants and trees simultaneously in alternating rows. Alley cropping became alley farming when the International Livestock Center for Africa (ILCA), with which IITA has collaborated on alley-cropping research since 1981, added livestock to the system. The animals — small ruminants, such as goats and sheep — make use of supplemental browse produced in the hedgerows.

[illegible] Tropical Africa [illegible] IITA.

As far back as the early 1920s, Nalaad farmers in the Philippines were already practicing a basic form of alley cropping, using the leguminous tree *Leucaena leucocephala* to terrace steep slopes and provide green manure for crops. In the 1930s the Dutch colonial government introduced the same technology on contour terraces on the island of Timor in eastern Indonesia, planting *Leucaena* hedgerows three meters apart to control erosion and improve soil fertility. The first published research on alley cropping, by Hernandez in 1961, reported on four years of continuous intercropping of maize with *Leucaena* in the Philippines. The trees were planted on sloping land in hedgerows one meter apart and pruned bimonthly. Hernandez reported that erosion was reduced and maize yields substantially increased.

At IITA, alley-system research and development grew out of research in the early 1970s on sustained intercropping of tree species with food crops, as a potential replacement for shifting cultivation in the humid and subhumid tropics of Africa. Alley-system research has been conducted mainly on the Institute's headquarters farm at Ibadan, Nigeria, in the subhumid/humid transition zone, with a total annual rainfall of about 1100 millimeters in two rainy seasons. Research on a smaller scale is conducted on acid soils at the Onne substation, which has an annual rainfall of about 2400 millimeters in a single rainy season.

In some 135 experiments, involving more than 30 hedgerow species, IITA scientists have focused mainly on two issues: the enhancement of soil fertility, and the establishment and management of hedgerow species. Which hedgerow species grow best with which intercrops or cropping systems? Should hedgerows be planted as seeds or as seedlings? How deeply and how far apart should plants be set, and what are the most favorable agronomic practices? What kinds of care work best to establish hedgerows with different companion crops? How should plants be weeded and pruned and fertilized? Are prunings best used for green manure or for livestock feed?

Alley Farming: Trial Results

IITA's research shows that the success of the entire alley farming system

hinges on the hedgerow species. The most important hedgerow characteristics are ease of establishment, deep roots, rapid growth, tolerance of pruning, vigorous regrowth after pruning, and high foliage production.

To maintain soil fertility, the hedgerow species should have the ability to fix atmospheric nitrogen. In addition, it should have high nitrogen content in the leaves, combined with a rapid rate of leaf decomposition. On the other hand, slow decomposition of foliage is advantageous when soil conservation and weed control are major considerations. In systems that include livestock, hedgerows should produce year-round fodder.

In IITA's prototype alley farming system, hedgerows are pruned both before and during the cropping period to reduce shading and competition with food crops growing in the alleys. As in earlier experiments in the Philippines and Indonesia, prunings are used as a mulch to increase soil fertility, conserve moisture, and suppress weeds. Prunings can also yield fodder for animals, stakes for crop plants, or firewood. Planted along the contours of sloping land, hedgerows

For the soils of the moist savanna and the transition zones of West and Central Africa, IITA scientists have identified the most suitable hedgerow species: *Leucaena leucocephala*, *Gliricidia sepium*, *Calliandra callathyrsus*, and *Cassia siamea*. Of these, *Leucaena*, the most promising, has been the most extensively studied.

Inoculated with appropriate strains of nitrogen-fixing bacteria, *Leucaena* fixes 70 to 135 kilograms of nitrogen per hectare in six months. *Leucaena* prunings have the same effect on maize crops as 30 to 50 kilograms per hectare of fertilizer. With the application of *Leucaena* prunings in lieu of nitrogen fertilizer, maize yields of 2 tons per hectare were obtained by continuous cropping in a long-term trial on sandy-loamy soil at IITA. Continuous application of *Leucaena* prunings also maintains the levels of organic matter and nutrients in the soil. With *Leucaena* leaves and prunings providing large amounts of biomass and nutrients for the crops between the hedgerows, food-crop yields can be maintained over a long period even as the nutritional status of the soil is improved.

Other Institute research shows the advantages of establishing hedgerows from seeds, which are easier and cheaper to handle than seedlings. Direct seeding, however, requires strict attention to planting depth and seed treatment, and to the species and the stage of growth of the crop plants growing between the hedgerows. In non-acid soils, cereal crops profit from two to four meters of growing room between the hedgerows, and from low hedgerows, maintained by frequent pruning, to reduce shading.

Technology Transfer to Farmers

IITA's purpose is to develop improved technologies that can be transferred to small farmers in Africa by their national programs. Alley farming can be successfully and profitably adopted by both resource-poor farmers who have been largely ignored by past research, and small farmers with enough resources to produce modest surpluses for the market. IITA scientists have been working with farmers since 1980 to test the potential of alley farming under actual farm conditions.

During the past two crop years, 1987-1989, collaborating farmers have planted more than 80 alley experiments on their farms in the subhumid and transitional zones of Nigeria. IITA collaborating researchers in other countries in West and Central Africa have established similar trials on farmers' fields. IITA's on-farm trials have emphasized the development and evaluation of techniques suitable for use by small alley farmers in these subhumid zones of West Africa. Other on-farm experiments are adapting and evaluating alley farming for other farm environments typical of tropical Africa.

While the emphasis of their research has been on alley farming, IITA scientists also assess the traditional methods that alley farming is designed to supplant. In many traditional-farming areas, fallow species provide important materials for farm and domestic use: timber for construction; fuel; animal feed; fruits and vegetables; medicinals; mulch and stakes for crops. Recognition of the true productivity of bush fallows is essential for a realistic

assessment of alley farming as an alternative.

In almost four years of extensive on-farm trials, IITA has collected information on farmers' behavior during the establishment phase of alley farming. African small farmers have often proved to be sufficiently intrigued by the idea of using shrubs to improve soil fertility and yields to try the alley system. Their initial interest, however, has not always translated into the extended effort needed to protect and maintain the young hedgerows. Nor are the farmers always motivated to abandon familiar cropping patterns. Some busy farmers, for example, put off establishing hedgerows until they have planted their crop. Late planting increases the probability that young hedgerow plants will be damaged during weeding.

Properly managed in trials by trained personnel, IITA's model alley-cropping system of maize followed by cowpeas between the hedgerows begins to improve yields significantly in the second year. Under less favorable conditions on actual farms, however, the improvement usually doesn't show until the third year after the hedgerows have been planted.

To keep farmers from getting discouraged, IITA researchers have devised alley systems in which the hedgerows provide early, direct, and significant economic benefits; and in which future economic benefits are large and certain enough to justify the farmers' patience. For example, agronomists are testing systems in which perennial cash and food crops, such as oil palm and plantain, are planted in the same

Assurance of an early yield of perennial crops has encouraged farmers to plant annual crops in their alleys and to maintain the alleys during the first two to four years, until the system effects a visible improvement in yields of annual crops.

The Collaborative Research Network

Disparities in climates, soils, and cropping practices within and between tropical African countries require alley farming systems tailor-made for each region or subregion. To launch this effort, more than 100 representatives from 19 countries attended a 1986 workshop at IITA. The workshop culminated in the establishment of the Alley Farming Network for Tropical Africa (AFNETA) to promote discussion and research on alley farming, to test technologies, and to encourage cooperation among regions and countries interested in alley farming. The network is sponsored by IITA, ILCA, and the International Council for Research on Agroforestry (ICRAF); with financial support from the Canadian International Development Agency (CIDA), the Danish International Development Authority (DANIDA), the International Fund for Agricultural Development (IFAD),

and the United States Agency for International Development (USAID).

A full-time network coordinator, headquartered at IITA, began work in February 1989. The steering committee, including the representatives of the international centers, the coordinator, and eight scientists from participating national programs, is chaired by Dr. E.O. Asare of the Institute of Renewable Natural Resources at the University of Science and Technology, Kumasi, Ghana. The committee has already received more than 40 research proposals for alley farming trials in various countries of East, West, and Central Africa. Most of the adaptive experiments sponsored by the AFNETA will be carried out by scientists in African national agricultural research systems.

The sponsors expect the network to build a solid research foundation for sustainable alley farming systems that include the important crops and cropping systems, livestock, and tree products of tropical Africa. By the mid-1990s, according to this schedule, the network will be engaged in on-farm research in all the diverse agroclimatic regimes of this vast region.

Biotechnology — the array of advanced laboratory techniques for manipulating the genetic characteristics of crops and animals — offers agricultural researchers powerful new tools for addressing the food problems of Africa. IITA, like the other international agricultural research centers, is adapting the new techniques to current research, while planning new research to take advantage of biotechnology's unique possibilities.

With financial support from the government of Italy, IITA has established a biotechnology unit to consolidate and strengthen its increasing work in this area. The new unit, which went into full operation at Ibadan in mid-1989, will apply biotechnology to all crop improvement programs at the Institute, and will collaborate with laboratories and institutions specializing in advanced and basic biotechnology research elsewhere in the world. In biotechnology, as in all its research activities, IITA adapts new approaches and methods for transfer to its partner programs in tropical African countries.

Among the research efforts in which biotechnology promises to figure significantly, even decisively, are some of special relevance to developing-country agriculture:

[illegible]

The ability to regenerate complete, viable plants from plant fragments, even from single cells, is basic to biotechnology.

IITA scientists have developed and adapted media in which they can culture meristem tissue — new, uninfected tissue from the very tips of growing shoots — into virus-free plants. Using meristem culture, the biotechnology unit has regenerated some 100 clones of cassava and related species, 500 clones of sweet potatoes, 600 clones of yams, and 100 clones of cocoyams.

Callus tissue — a mass of undifferentiated cells — can also be regenerated into viable plants. Callus culture promises to be instrumental in the improvement of yam, which is a polyploid and does not flower under natural conditions. These characteristics do not trouble the farmer, who propagates yam vegetatively; but they frustrate scientists attempting to improve the crop. Regeneration of plants from small fractions of tuber or from callus tissue may result in the expression of useful variability in the clones.

In the case of cassava, however, scientists have been unable to regenerate more than roots from ordinary callus cultures. By culturing young cassava leaf tissue in a special liquid medium, scientists have been able to get somatic embryos directly. Somatic embryogenesis on the cultured leaf tissues occurred six weeks after incubation. Somatic embryos at different stages of development were then separated from the leaf tissue and transferred to the medium.

The ability to regenerate plants from single protoplasts, cells that have been stripped of their cellulose walls, is essential to realizing biotechnology's potential. Research on protoplast regeneration of plantains and bananas has not so far involved African species, but in collaboration with the Catholic University of Leuven, in Belgium, IITA scientists are attempting to regenerate African bananas and plantains by somatic embryogenesis. Work on cell-suspension and protoplast-culture techniques are next on their agenda. This line of research will eventually lead to practical, reliable methods for regenerating plantain plants from somatic cells.

Multiplying and Distributing Germplasm

Cultured germplasm is ideal for distribution to national programs: it is considerably lighter and less bulky than conventionally propagated plants. Also, tissue-culture techniques can be

IITA [illegible]

used for rapid multiplication of planting materials. A test-tube technique for propagating plantain and cooking banana by culturing shoot tips, developed in the 1980s, is now routinely used to obtain large numbers of plants in a fraction of the time required for conventional multiplication in the field. Shoot tip culture has been used successfully to propagate more than 200 *Musa* germplasm accessions.

Most important, cultured germplasm is certifiably free of pathogens. Tests of

meristem-cultured sweet potatoes confirm that the two pathogens of the sweet-potato virus complex have been eliminated from IITA's germplasm collection. Heating the mother plant prior to meristem culture, scientists have discovered, improves the elimination of mosaic viruses from regenerated cassava plants and white yams. For white yam, which does not tolerate heat well, scientists are investigating the effectiveness of treating meristem cultures with a chemical that reduces viral infections. Virus-free plantlets, sealed in sterile containers, meet plant quarantine standards for international distribution.

Insect and Disease Resistance

The development of crop species with inherent resistance to insect pests and disease pathogens may require transfers of genes from wild relatives, even from unrelated species or genera, into cultivated plants. In cowpea and cassava, and to a lesser extent in maize, natural fertility barriers between cultivated varieties and wild relatives have so far frustrated attempts to transfer genes. Such gene transfers from wild species to cultivars, almost impossible by conventional plant breeding, can be achieved through biotechnology.

Among the most destructive insect pests of cowpea are the *Maruca* pod borer and three pod-sucking bugs. After screening over 8000 cowpea genotypes, IITA researchers have been unable to identify resistance to these pests in the cultivated species. They have found excellent sources in wild species, but attempts to transfer the wild genes into the cultivars by conventional crossing have failed because crosses do not produce progeny. IITA scientists, with university collaborators in Nigeria as well as in Italy and the United States, are developing and assessing a variety of advanced methods for securing viable progeny from wide crosses between pest-resistant wild species and their cultivated cowpea cousins.

In rices of African origin in IITA's rice germplasm collection, scientists have found genes that confer immunity to

Microwell and wheelin tubes in manipulation, [illegible] and improved crops.

the rice yellow mottle virus and resistance to the *Diopsis* stem borer. Yet attempts to transfer these important traits from the native species to high-yielding improved rices have been frustrated by the reluctance of the crucial genes to recombine in conventional crossing. In collaboration with advanced laboratories, IITA scientists will assess biotechnical alternatives for overcoming this obstacle to rice improvement.

Black Sigatoka, a fungal disease, has recently emerged as the major threat to plantain and banana production in Africa. Attempts at conventional breeding for resistance to this disease have been hindered by lack of genetic variability and inherent barriers to cross-fertilization, but tissue culture and embryo culture techniques may enable researchers to surmount these obstacles.

With laboratories in the United States and Europe, IITA's biotechnology unit is assessing the value of advanced techniques for the improvement of maize for tropical Africa. Of particular interest to IITA is the potential for using viral-coat-protein gene-transfer techniques to incorporate resistance to important African maize viruses into improved maize varieties.

Diagnosing Viruses

Using monoclonal antibodies and complementary DNA, advanced testing methods can detect and identify plant viruses in less than one day of routine lab work, instead of the months of skilled effort required by conventional methods. With these methods, IITA scientists have identified the various viral strains prevalent among the Institute's mandated crops in Nigeria.

In collaboration with the United States Department of Agriculture laboratory at Beltsville, Maryland, IITA's virology unit is producing monoclonal antibodies and complementary DNA of the prevalent viruses infecting root and tuber crops in tropical Africa. These materials will be available to national systems, many of which are unable to use the difficult conventional methods for diagnosing the viral diseases afflicting their countries' crops.

The International Development Research Center (IDRC) of Canada is supporting an IITA project to help national programs use monoclonal antibodies in their own laboratories if

locally prevalent viral strains. With the Canada Agriculture research station at Vancouver, IITA is planning a special workshop to train African researchers in this technique.

With monoclonal antibody methods available in African national programs, rapid, accurate diagnosis of viral diseases will no longer be hampered by quarantine regulations, which prohibit shipment of infected plants or plant parts across international borders for analysis at IITA. Timely reports from countries throughout tropical Africa about the distribution and virulence of crop viruses will be instrumental to scientists in national systems and at IITA in devising prompt, appropriate responses.

Conserving Germplasm

Well-preserved germplasm collections — seed banks — hold the genetic capital for all crop improvement efforts. In seed banks, the unique genetic traits of nearly extinct wild

species and ancient races await identification and use by plant breeders. With low-temperature preservation and tissue culture techniques, IITA scientists can conserve, multiply, and transfer disease-free germplasm from

asexually and cannot readily be maintained in seed form. Low-temperature storage will enable researchers to preserve rare genotypes, control genetic erosion over generations, and increase the genetic variability available to breeders.

A method for reducing plant growth allows IITA to maintain extensive test-tube collections of root crop and plantain germplasm. The collections currently include 1000 clones of sweet potatoes, 900 clones of yams, 100 clones of cassava and related species, 150 clones of cocoyams, and 150 clones of plantain and banana. Lowering the incubation temperature, researchers have found, produces diminutive but otherwise unaffected cassava, yam, cocoyam, and sweet potato plants that can live in vitro on an ordinary culture medium for more than a year. Increasing the sucrose concentration in tuber culture media can produce hardy miniature tubers that tolerate long storage much better than normal tubers, and also sprout readily.

Increasing Genetic Variability

Somaclonal variation — genetic variation appearing among supposedly identical clones regenerated from tissue cultures — is a problem for gene banks, which strive for perfect conservation of genotypes. But in plants like plantain and banana that do not readily cross sexually to create new genotypes, somaclonal variation is an invaluable source — sometimes the only practical source — of new characteristics for crop improvement.

In an experiment at IITA, more than 4000 clones of seven plantain cultivars, representing the major plantain types,

were multiplied in the laboratory and transplanted to the field, where they displayed somaclonal variations at a rate similar to rates of natural genetic variability in other genera.

Biotechnology will also accelerate the improvement of such vegetatively propagated crops as plantain, cooking banana, and yam, which do not cross during sexual reproduction. Even among cultivated cassava species, reluctant flowering limits the choice of parents for breeding. Investigation of the chromosomes of cassava and its wild relatives, and culturing of their hybrid embryos and ovules, may lead to significant advances for cassava breeding and improvement.

New methods for efficient plant breeding

Electrophoresis — a method of sorting DNA fragments by using an electric field to move them through a medium at rates that vary according to their molecular weights and electric charges, permits rapid, positive identification of plant tissue. The technique enables researchers to match unknown plant materials with documented plants in the collections and to differentiate or classify regenerated plants in vitro. These capabilities will contribute to the efficient selection of promising germplasm for crop improvement.

Breeders generate genetic variation by crossing unlike types and then attempt to isolate individuals with particular, desirable combinations of the parental genes. This process can now be made more efficient by employing "genetic markers" as tags for genes of interest and thereby directing the selection

process. Advanced laboratories, using new techniques, are building detailed genetic maps of a wide variety of crops. IITA scientists plan to map particular traits of interest, permitting breeders to make accurate selections of useful genes for incorporation into improved varieties.

IITA's new biotechnology unit links advanced biotechnology laboratories in Europe and the United States with national agricultural institutions in Africa. With direct access to the latest developments in biotechnology, IITA functions as a training center for African scientists and for master's and doctoral degree students. Since 1981, the Institute has held training courses for scientists from African national programs on the efficient use of tissue culture techniques.

To strengthen and broaden its contacts with the national programs, and to identify the most likely areas for biotechnology research, IITA hosted a meeting in August 1988 of African scientists working on cassava, yam, plantain, and cooking banana. The 25 participants, representing 14 institutions in seven African countries, agreed on recommendations for the future of IITA's biotechnology research. A similar meeting, devoted to applications of biotechnology to cowpea research, was held in February 1989.

Post-harvest Technology

Improving the nutrition of hundreds of millions of people in tropical Africa is not only a matter of developing high-yielding crop varieties and farming systems. Under the rubric of post-harvest technology, scientists and technologists in IITA's crop-improvement and crop-management programs encourage people to eat better by making good foods more available, easier to process and prepare, and more attractive and nutritious.

ITEM: Throughout tropical Africa, a single species of *Callosobruchus*, the cowpea weevil, eats as much as 50 to 90 percent of the harvested grain while it is in storage, before it ever gets to market. Another weevil, *Sitophilus*, attacks maize in the field and in storage. The larger grain borer, *Prostephanus truncatus*, accidently introduced into Africa from Central America, attacks many stored food grains and products, including cassava chips and maize. It can destroy 30 percent or more of stored maize in six months.

IITA scientists, in collaboration with universities and research institutions in Nigeria and other countries, have so far identified three cowpea varieties with enough inherent resistance to weevils to survive six months of storage with only 15 percent grain damage. The resistance genes, incorporated into improved cowpea varieties for a wide range of growing conditions, are now available through national programs to farmers in many countries of tropical Africa. Meanwhile, scientists continue to screen more than 15,000 cowpea accessions in the Institute's germplasm bank for genes that will confer stronger resistance.

With collaborators from Purdue University in the United States and a bilateral program in Cameroon, IITA scientists are continuing a search that began in 1972 for useful genetic traits among the cultivated cowpea's wild relatives. Using a new screening technique developed at Purdue, the researchers have found evidence of strong resistance to cowpea weevil in some wild cowpeas. The advanced techniques available in IITA's biotechnology unit (see article, p.23) may succeed in overcoming the natural barriers to transferring genes from wild cowpeas to cultivars. A similar search is getting under way in the maize germplasm collection for sources of resistance to the *Sitophilus* weevil.

The larger grain borer is traditionally controlled by fumigating or dusting the stored maize with chemical insecticides, which are dangerous, expensive, and often unavailable when and where they are needed in tropical Africa. Scientists in the Biological Control Program (see article, p.50) are looking for a safer, more appropriate alternative: a natural enemy of the borer that can be introduced into Africa from Central America, the borer's home ground. One predatory insect with a rapacious appetite for borers is already known; the search is on for other likely candidates in Central America and Mexico.

ITEM: While cassava is the most important food in many areas of tropical Africa, providing a staple for some 200 million people, from one place to another it is produced in different shapes, sizes, and textures; it is processed into different forms; and it is prepared in different ways. The prospects for crop and farming-system innovations depend on their responsiveness to the diverse local preferences of farmers, processers, and consumers. For making smooth fufu, a popular casssava product in Ghana, only cassava that becomes mealy after boiling and pounding will do. In West Africa, consumers judge gari, a flour made from fermented and dry-roasted cassava, on the basis of how much it swells in water. In some areas of West Africa, consumers prefer yellow gari, made by adding palm oil to white gari at the roasting stage.

Madame Gillies Agyeman and preparation of gari, a popular food made from the cassava tuber

With support from the Rockefeller Foundation, IITA is collaborating with the Centro International de Agricultura Tropical (CIAT) in the Cooperative Study of Cassava in Africa (COSCA). The study involves gathering detailed information on the myriad

local cassava preferences, as a guide for future crop improvement and crop utilization programs. IITA researchers have already developed cassava varieties that are rich in carotene, a yellow pigment that is the chemical precursor of vitamin A. The yellow tubers of these varieties produce yellow gari without expensive palm oil, and with a nutritional bonus.

ITEM: The tubers of some West African cassava varieties contain dangerous concentrations of hydrocyanic glucosides, which must be removed by a laborious three-day fermentation process. IITA's crop management researchers (with colleagues from the Nigerian National Root Crops Research Institute at Umudike, and the Agricultural Development Program at Owerri) are screening various cassava varieties and processing methods for the best combination for producing gari with hydrocyanic glucoside levels below the 10 parts per million specified by the Nigerian Food and Drug Administration.

Among IITA-improved cassava types with low hydrocyanic glucoside concentrations in the raw tubers, the researchers have identified a variety that produces acceptable gari after only one day of fermentation. The search has also turned up a local low-hydrocyanic-glucoside cultivar that produces acceptable gari with no fermentation at all. Another indigenous variety, okoiyawo, has proved to be the most acceptable low-hydrocyanic-glucoside cassava for milling into flour to make bread and other baked goods.

IITA food technologists are also investigating alternative methods of cassava processing for making gari. The traditional African process, which is done by women, is tedious and inefficient. The tubers must be peeled by hand, even in commercial, semi-mechanized gari mills. Grated into chips or finer particles, the cassava is fermented, dried, broken, sifted, and finally roasted in a hot pan without oil. The researchers are testing simple hand implements that can peel tubers of varying sizes and shapes without

Maize harvests are often reduced in storage by insects, leading to IITA research on resistant varieties.

wasting edible flesh or pulp, which makes up at least 40 percent of peels removed with knives. For roasting cassava, the researchers are also investigating fuel-efficient stoves that burn corn stalks or other agricultural wastes instead of scarce firewood; and that produce an even heat, resulting in uniform gari particles.

ITEM: Consumers are increasingly rejecting cheap, home-grown cassava products in favor of costlier imported wheat products. At a local market in Ibadan, IITA researchers found the prices of baked goods made with cassava flour 30 percent lower than the prices of the same products made with wheat. In taste-tests, however, consumers rated the products equally acceptable, and some couldn't even tell the difference.

To encourage cassava consumption, food technologists are developing and modifying recipes based on suitable varieties selected from the Institute's cassava germplasm collection. In 1988, a joint IITA-UNICEF program on household food security and nutrition developed and tested 44 cassava-based recipes during a training course for 1,778 research and extension personnel in 12 Nigerian states.

ITEM: Cassava is seriously deficient in protein. The protein content of gari, which is breakfast, lunch, and supper for many people in the region, is 1 percent or less. Soybean, rich in high-quality protein, is an ideal fortifier for cassava and other protein-deficient foods; but soybean has yet to gain widespread recognition, much less acceptance, among producers, processors, or consumers.

Some processors and consumers resist soybeans because they are difficult and time-consuming to prepare. With funding from the International Development Research Centre (IDRC) in Canada, researchers from IITA and the Institute for Agricultural Research and Training (IAR&T) at Obafemi Awolowo University, Nigeria, are developing simpler, less tedious methods for preparing soybeans to enhance the nutritional quality of traditional recipes.

In a small-scale test, an IITA food technologist has confirmed the feasibility of using commercial screw presses to extract part of the oil from soybeans. Without further processing, the

extracted oil can be used in a variety of foods. Consumers surveyed in three villages in Oyo State, Nigeria, judged foods developed by an IAR&T home economist using partially defatted soybean cake to be "very acceptable."

Other tests show dramatic improvements in nutritional quality resulting from partial substitution of soybean for conventional ingredients in a variety of recipes. Wheat bread with a 30 percent admixture of partially defatted soybean flour is more than twice as rich in protein as bread made with pure wheat flour. Soybean flour produced and processed in Africa is also much cheaper than wheat, which must be imported. A large commercial bakery in Lagos, Nigeria, is now making bread with 25 percent soybean flour.

Demonstration of soybean product cooking classes to prepare nutritionally enriched meals.

Gari, less than 1 percent protein when made with pure cassava, becomes 11 percent protein when fortified with whole soybean flour before it is roasted; and 9 percent protein when fortified with residue from soybean milk. In taste-tests, consumers were unable to distinguish traditional 100 percent cassava gari from the soybean-fortified version.

These tests are the basis for a variety of initiatives by the IITA-IAR&T joint project to increase consumer awareness of soybean's nutritional value and good cooking characteristics. The project's home economists have taught classes of women to make soy milk; soy moi-moi, a steamed patty made from soybean paste; soy akara, a deep-fried food made from a paste of cowpeas and soybeans; and the most popular dish, egusi stew with soybeans substituting for egusi melon seeds in a mixture with pounded yam or eba, a porridge made from gari. Of the women who attended the classes, fewer than 10 percent failed subseqently to introduce soybeans into their own food preparation. Conversely, of 229 women who adopted soybeans, only 4 had not attended the program's classes.

From the beginning to the end of 1988, the number of stores carrying soybeans in Ibadan, in Oyo State, Nigeria, increased from only 10 to 201. In a survey at the beginning of the joint project, none of the households in two sites in Oyo State knew anything about soybeans. A year later, in the same sites, more than half the respondents had served soybeans to their families, and 35 percent of local farmers were producing soybeans to meet the new demand. By 1988, fewer than 5 percent of respondents did *not* know about soybeans.

In its research, IITA thus clearly recognizes the importance of post-harvest issues to the African smallholder or family farmer, ranging from processing methods and losses to product quality, nutritional value, and market demand.

The Institute has just concluded a strategic study on post-harvest technology research. It plans to adopt a food systems approach to post-harvest research, so that research priorities are more clearly based on factors that would provide African consumers better access to nutritionally improved food products.

Sweet Potato Research

Sweet potato, originally transplanted from its native South America, is now grown — often for its leaves as well as its root — in most farming areas of Africa. It is a staple food in Rwanda, Uganda, and Burundi; and it ranks second or third among the most important crops in several other countries. On IITA's original research agenda, drafted some 20 years ago, sweet potato was prominent among the crops slated for scientific attention. In two decades of research, IITA scientists and their colleagues in national programs have made substantial progress toward unlocking the potential of this crop as a staple food for Africa. Their achievements include improved varieties; tissue-culture techniques for crossing sweet potatoes; tests for diagnosing viral infections in germplasm; and improvements in storing, documenting, analyzing, and multiplying germplasm.

Beginning in 1988, responsibility for sweet potato improvement in the international agricultural research system was transferred to the International Potato Center (CIP), headquartered in Lima, Peru: the change is consonant with the conclusions of IITA's recent strategic planning exercise that the Institute was working on too many commodities and should adopt a narrower focus. In carrying forward IITA's research on the African sweet potato, CIP will have the advantages of its strategic location at the center of origin and of primary genetic diversity of the genus; and of its mandated single focus on tuber crops. CIP's future progress will build on the foundations laid in Africa.

Beginning work in 1971, IITA scientists found a dearth of previous research on sweet porato production in the tropics, particularly in Africa. They also found no central collection of tropical sweet potato germplasm anywhere on the continent. Their first task, before they could even begin to decide what research to concentrate on, was to identify existing sweet potato cropping practices and to understand the constraints faced by smallholders or family farmers with limited resources.

The constraints, it was quickly apparent, were many: low soil fertility and a chronic lack of fertilizers; lack of improved varieties and of planting materials; poor cultural practices; low yields; crop damage from pests and diseases; storage losses; and a product that was too sweet for the taste of many consumers, especially in West Africa.

[illegible]

IITA's scientists set their goals accordingly, aiming to meet the needs of the small-scale, poor, family farmer who applies limited management inputs to one to ten hectares; a description that fits more than three quarters of the farmers in Africa and most tropical and subtropical regions.

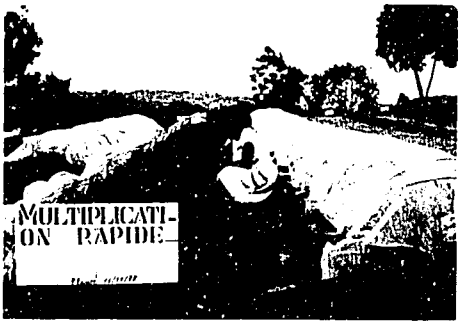
The research goals included identifying genetic sources of resistance to the important pests and diseases of sweet potato; incorporating these genes into high-yielding sweet potato varieties; adapting the improved varieties to the different ecological zones of tropical and subtropical Africa; and maintaining nutritional quality and consumer appeal. To complement the improved cultivar, the scientists also aimed to develop improved cultural practices that would rely as little as possible on purchased inputs; as well as methods for reducing postharvest losses. Finally, the objectives included training scientists and technicians in national programs and institutions, and disseminating research findings.

Building a Gene Bank

IITA plant breeders began close to home, collecting the few local sweet potato varieties they could find in Nigeria. Because of Nigerian regulations against importing plant materials, intended to exclude exotic pests and diseases, the first foreign accessions from the Americas and Asia arrived as seeds. For the same reasons, improved breeding materials distributed by IITA to collaborating national programs were also in seed form. The need to use seed hindered the work, since some sweet potato varieties do not naturally flower or produce adequate seed. The difficulties of growing plants from seeds made international sweet potato improvement a tedious, frustrating proposition.

In their efforts to produce vegetative material that was completely free of diseases, especially viruses, IITA scientists discovered that the sweet-potato-virus disease is actually caused by two distinct viruses, one transmit-

ted by aphids, the other by whiteflies. Either virus may remain latent and undetectable in the plant until it is joined by the second, when the disease is expressed. This discovery made it necessary for the scientists to develop a new test for infection, using susceptible clones to confirm the presence of the virus.



Production of disease-free materials became possible in 1977 with the establishment of IITA's tissue culture laboratory. Now experimental sweet potato lines could be cloned in test tubes from living plant tissue. IITA clones were readily passed by Nigeria's Federal Quarantine Office and distributed to scientists in national programs and other institutions throughout Africa.

In 1981, the tissue culture laboratory responded to requests from 17 African countries and several others in Asia, South America, and the Pacific region for disease-free sweet potato lines from IITA's collection of clones, which then numbered some 400. By 1988, the Institute's sweet potato germplasm collection had grown to include some 1500 clones in test tubes. Tissue cultures were distributed to 37 countries in Africa and 26 other countries around the world, while 44 countries received germplasm in seed form.

Improved High-Yielding Varieties

Unimproved sweet potato varieties in Africa produce average yields of only 4 to 14 tons per hectare when harvested 180 to 240 days after planting. IITA's improved lines, even without fertilizers, yield 21 to 41 tons per hectare in just 140 days. The best varieties achieve high yields without sacrificing the baking, roasting or boiling qualities, or the combination of dryness and reduced sweetness, that make them attractive to consumers.

Many of IITA's new lines are resistant to sweet-potato-virus disease; some are also moderately resistant to weevils, the most destructive field and storage pests of sweet potatoes in Africa. The most effective weevil control depends on a combination of inherent resistance in the plant, early planting and harvesting, and re-ridging the soil 30 days after planting. IITA has tested a variety of postharvest measures that help prevent weevil damage during storage.

Root-knot nematodes — which attack the sweet potato's feeder roots and the storage root, leaving the plant vulnerable to other infections — are common problems where farmers practice continuous cropping. IITA scientists, screening 414 sweet potato lines in the germplasm collection, were able to identify 55 with high resistance to nematodes. The use of these cultivars in rotation with other crops has proved effective in controlling nematode populations.

Fostering National Programs

When IITA began sweet potato research in 1971 there were no national sweet potato research programs in Africa. With the Institute's encouragement and support, by 1988 Africa had 27 national root-crop programs, several of which included sweet potato. At first, the national programs relied on IITA seed hand-carried by trainees returning from Ibadan, but the advent of tissue culture technology increased the flow of improved materials from IITA to plant-breeders in national programs, for selection under local conditions.

In time, many national programs were able to go beyond screening and selection of IITA-improved germplasm to establish their own varietal improvement programs. With support from IITA, national programs became centers for plant breeding, selection, on-farm testing, multiplication, and dissemination of locally adapted, improved varieties to farmers.

Cameroon initiated its National Root Crops Improvement Program, its first national food-crop program, in the Institute of Agricultural Research in 1978. IITA provided research and training support, posting scientists to the new program to work with Cameroon scientists on improving cassava, yam, and cocoyam, as well as sweet potato.

From hundreds of trials on farmers' fields, the program's researchers identified several sweet potato cultivars that enjoyed widespread acceptance by Cameroon growers. An improved variety, originally selected at IITA, yielded two to four times as much as

the best local varieties in three different agroecological zones. It also showed superior resistance to pests and diseases, and was highly rated by consumers.

With the availability of improved varieties that were attractive to both farmers and consumers, sweet potato production in the Adamaous Western Highland and Coastal Lowland regions of Cameroon increased rapidly, raising farmers' incomes. Encouraged by the success of the new sweet potatoes — their first experience with improved food-crop technology — local farmers became more receptive to subsequent innovations.

In **Rwanda**, one of Africa's smallest and most densely populated countries with one of the continent's most intensive agricultures, local varieties of sweet potato have been widely cultivated since the crop was introduced in the eighteenth century. Rwanda's small farmers — the average farm size is less than one hectare — were impatient for early-maturing new varieties that would respond to low levels of purchased inputs. "Late-maturing varieties are for the rich," farmers commonly complained, "because only they can afford to wait."

Working with Rwandan scientists, IITA scientists identified and incorporated genes for early maturity into sweet potato lines with higher yields, better disease and insect resistance, and appealing taste. The best of the high-yielding, early lines, selected and multiplied in Rwanda for distribution to farmers, were ready for harvesting three to four months after planting, compared with five to eight months for

Scientists in **Burundi** adapted many features of Rwanda's sweet potato program to their country's needs. The improved lines developed and introduced in Burundi, using germplasm from the IITA collection, have approximately doubled the yields of local varieties.

International Cooperation

During the past 17 years, many countries in Africa and beyond have collaborated with IITA in sweet potato improvement. Some 80 percent of **Sierra Leone**'s sweet potato hectarage is now planted to improved varieties, and the demand for new planting materials strains the capacity of the government's extensive new multiplication and distribution network. The Government of **Ethiopia**, convinced of the sweet potato's potential as an emergency food reserve, is establishing a root-crops research station. IITA-improved varieties have been made available to farmers in drought areas.

In **Uganda**, where sweet potato ranks second to cassava among root crops as a staple food, the government's breeding program draws on an extensive germplasm bank that includes several IITA introductions. Scientists in **Mozambique** lose no time multiplying and disseminating improved cultivars received from IITA. Of the ten varieties released to farmers so far, three are the country's highest-yielding sweet potatoes. **Kenya**'s researchers have tested several IITA-improved lines. The best, released to farmers in the country's main sweet potato-producing region, has yielded up to 30 tons per hectare in on-farm trials.

After three years of government-

new varieties have been adopted and are being grown by more than 1500 farmers. Higher sweet potato yields and improved consumer acceptance — the fruits of joint breeding and selection efforts by scientists from IITA and collaborating countries — are reported from countries as diverse and far-flung as **Ghana, Gabon, Liberia, Madagascar, Sudan,** the **Seychelles, Kiribati, Puerto Rico, Jamaica, Fiji, Samoa, Thailand,** and the **Solomon Islands.**

The transfer of responsibility for sweet potato in the international agricultural research system from IITA to CIP does

Improved cuttings harvested at IITA are made available to national programs by in vitro distribution.

not spell the end of sweet potato research and improvement in Africa. A significant portion of IITA's unique and comprehensive collection of sweet potato germplasm will remain in Africa, under CIP's aegis. As IITA works with CIP in outreach activities, the results of past and future sweet potato research will continue to flow to African national programs through the networks established during almost two decades of fruitful collaboration.

The IITA Research Program

Resource & Crop Management Program

The double challenge for agriculture in the humid and subhumid tropics of Africa is to grow enough crops to feed a rapidly growing population without degrading the region's resources, principally the soil. IITA's Resource and Crop Management Program is concerned with both factors in the food-production equation — crops and resources — in developing improved farming systems that are economically and ecologically viable, sustainable, and productive for smallholders and family farmers.

The program's crop-management scientists, organized into multidisciplinary working groups with colleagues from IITA's crop improvement programs and other relevant specialties, evaluate traditional and innovative cropping systems based on the Institute's principal mandated crops: cassava, maize, and rice.

Resource-management research focuses on soil, a major limiting factor in many agricultural systems of tropical Africa, as well as on other significant resources: water; solar radiation; labor and mechanical energy sources; soil fauna; and fertilizers and other chemicals.

Because crop production rapidly exhausts their soil's fertility, African farmers have traditionally allowed farmland to revert to natural vegetation after only a few years of cultivation. The duration of the fallow resting period, typically five to twenty or more years, has depended mainly on the time required for natural processes to restore soil fertility.

In recent years, however, increasing demand for food and other agricultural products, and increasing competition for land, have forced farmers to cut short or eliminate the fallow periods. If soil fertility is to be maintained under the pressure of more intensive cultivation, researchers must develop sustainable cropping systems to improve or supplant traditional African systems, such as bush fallow, that are based on shifting cultivation.

From their point of view, meanwhile, the program's resource-management scientists investigate the relationships between soil management and productivity. What are the physical, chemical, and biological characteristics of the soils used by farmers in tropical Africa? How do these characteristics regulate the transport and storage of water and plant nutrients in the soil? How do they affect erosion?

How do the various characteristics interact to produce and maintain soil fertility? And what are the mechanisms of soil degradation? What are the individual roles and the interactions of these soil characteristics in producing plants? What are the social and economic contexts of farming in these environments?

And, finally, the scientists ask, what new farming techniques, or modifications of existing techniques, will permit sustained crop production at stable or increased levels without degrading the soil's fertility?

The program's resource management unit includes specialists in agroclimatology, soil fertility and soil microbiology, weeds, soil physics and soil chemistry, and resource economics. Their research focuses on the soils and soil-related problems typical of the major agricultural ecosystems of the African humid and subhumid tropics.

In measuring the relative advantages and disadvantages of various farming systems, and designing appropriate improvements for tropical African conditions, the programs's research begins on experiment stations: on the Ibadan campus and on the IITA farms, located in the major ecological zones in which the Institute's mandated crops are grown; and on many other sites operated by collaborating national institutions and agencies throughout West and Central Africa.

[illegible] IITA's cropping [illegible]

Potentially useful innovations evolve through a three-stage process that begins with testing on the experiment stations. Researchers transfer promising technologies to actual fields in their intended areas of tropical Africa, to be adjusted and adapted under realistic agronomic, ecological, and social conditions. Information from these farm trials returns to scientists at the experiment stations, to become the basis for further rounds of improvement and testing before the technology is ready for release to farmers through national agricultural research systems.

On the basis of almost two decades of research on African soils and the ecological and social contexts in which African farmers cultivate their crops,

IITA scientists and their collaborators in national systems have established general principles for economic and sustainable agriculture. Their research has affirmed the value of fundamental soil-conserving and soil-enhancing practices: maintaining soil cover, limiting the use of heavy equipment, loosening compacted soils, avoiding monocultures in favor of mixtures of shallow- and deep-rooted crops; and using fertilizers, but avoiding overuse.

These general principles are embodied in improved farming systems and methods developed through research by program scientists with their collaborators in national systems. Some examples follow.

Alley cropping, a form of agroforestry in which crops are grown between hedgerows of woody shrubs and trees, is the most promising new system developed at IITA. The use of leguminous hedgerow species, which harbor nitrogen-fixing bacteria in their roots, can make the system virtually self-fertilizing. With periodic pruning to keep them from shading the companion crop, the hedgerows also furnish mulch and feed for livestock. (See article, p.20)

In 1988, the eighth year of trials on IITA's Ibadan farm, yields of alley-farmed maize were 100 percent higher when planted between hedgerows of one species, and 69 percent higher when planted between hedgerows of another, than were the yields of conventionally planted maize. In other 1988 alley-farming trials on sloping fields, hedgerows demonstrated their superiority to conventional plantings in controlling soil erosion and water runoff.

Experiments with collaborating national systems in the subhumid zone of Zaire and in the People's Republic of Benin have confirmed the effectiveness of leguminous hedgerows in maintaining soil fertility: maize yields in alley-farmed plots were significantly higher than yields in conventionally planted plots.

The resource management program has evaluated **mulches and cover crops** — including fast-growing, leguminous

species that can be planted as live mulches — for various ecological conditions in tropical Africa. Used before, during, and after cropping, mulches prevent or retard soil degradation and suppress weeds. IITA researchers have improved some simple, hand-operated equipment for planting crop seeds through mulch cover.

For extensive **land clearing and development**, IITA's research suggests specialized equipment that causes a minimum of soil disturbance and subsequent erosion. The shear blade, for example, cuts trees at ground level, making it unnecessary to pull the stumps out of the ground. In the humid-forest zone of Nigeria, studies in 1988 by IITA and the United Nations University found that even after five years, the soil was less able to absorb water in fields that had been compacted by heavy machines than in fields that had been cleared by hand.

IITA resource management researchers have evaluated a variety of **minimum-tillage farming systems**, in which crops are planted through a permanent ground cover with little or no soil preparation. These systems have proved effective in conserving soil moisture and organic content, preventing erosion, and maintaining cooler soil temperatures. IITA's experiments have demonstrated the utility of minimum-tillage or no-tillage systems in alley farming, and the importance of mulches and herbicides for suppressing weeds on untilled soils.

The program's crop-management working groups, emphasizing interdisciplinary collaboration under actual farm conditions, synthesize resource-management and crop-improvement research into sustainable, productive cropping systems that are appropriate for smallholders. During 1988, the three working groups continued the development of improved mixed-crop farming systems, based on maize, cassava, and rice, for the major ecological zones of tropical Africa.

In the Shaba province of Zaire, a new streak-resistant maize variety, selected by researchers in the national program from IITA breeding materials, yielded up to two and one half times as much as the local variety. In trials under actual farm conditions, resistant maize populations from IITA outyielded other varieties by 600 to 700 kilograms per hectare.

On farms in Mono province in Benin, another IITA variety, renamed Sekou

in the national system, outperformed the best local varieties in its first season. In a maize-based cropping system in the forest/savanna transition zone, an IITA-improved cassava cultivar, interplanted with the maize, yielded half again as well as the local variety.

[illegible]

In five villages in Nigeria, by 1988 farmers had adopted improved cassava varieties from IITA and the National Root Crops Research Institute of Nigeria on more than 30 percent of their fields. The improved varieties yielded approximately 50 percent better than local cassava.

Local farmers and IITA researchers tested cassava-based intercropping systems in 1988 in Nigeria's forest zone. Economic analysis by the crop-management working group revealed that intercrops of maize or soybean with cassava were highly profitable for local farmers, while added costs for insecticides made cowpea a marginal proposition. After three years of trials to compare the effects of various cropping systems on soils, the researchers identified a significant improvement in important soil characteristics associated with increasingly complex

Fallow and Fertility

Recent studies by researchers from the Resource and Crop Management Program illustrate vividly the vicious circle that traps traditional agriculture in much of tropical Africa. Farmers, under pressure to increase food production for growing populations, shorten their fallow periods. Reduced fallows result in reduced soil fertility, which translates in turn into less food production, not more, increasing the pressure on the farmer to cultivate ever-more-marginal lands or to shorten his fallows even more drastically.

In collaboration with the Imo State Agricultural Development Project, IITA researchers in 1988 surveyed farmers in villages in the humid forest zone of southeastern Nigeria, which includes some of the most densely populated areas in sub-Saharan Africa. Historically, traditional farmers cropped their soil for a single season, then allowed it to revert to forest for four to seven years to regain its fertility. With this long rest period, the fragile soil was able to sustain a modest production almost indefinitely.

Asked to compare their current practices with those of twenty years ago, farmers in all villages reported reducing their fallow periods by an average of about 40 percent, from an average of 4.5 years to only 2.5. In general, the most densely populated regions reported the shortest fallow periods and the greatest average reduction.

Farmers now report fallow periods of two years or less in about 25 percent of the surveyed villages, compared with 4 percent of the villages twenty years ago. Fallows of four years or more are reported in only 30 percent of the villages today, compared with 40 percent previously. Agronomists consider the abbreviated fallows now common in the more densely populated areas to be marginal for this ecological regime — too short to assure sustained agricultural production.

In virtually all of the villages, farmers were able to identify shorter fallow periods as the primary cause of their reduced yields. In one survey region, farmers' estimates of the decline in fallow period over twenty years averaged 22 percent; while their estimates of yield decline averaged 75 percent. In another region, according to farmers' current estimates, a 62 percent decline in fallow period was associated with a decline in yields of more than 90 percent.

In addition to diminished yields, the IITA researchers found, abbreviated fallows also coincided with diminished crop diversity. Farmers also recognized that shorter fallow periods were the reason for the declining quality and quantity of various products — fuelwood, planting stakes, construction materials, wild foods, and others — that they traditionally harvest from the bushes and trees that alternate with cultivated crops.

In Center Province, Cameroon, less densely populated than southeastern Nigeria, another survey revealed even more drastic curtailment of fallows. In humid-forest villages generally, the survey found 64 percent of households using fallows of three years or less. In those villages connected to cities by road, 11 percent of households reported fallows of one year or less. Only 6 percent of surveyed households — a somewhat higher percentage of them in roadside villages — reported using fertilizers in place of fallows to restore soil fertility. In villages of the transition zone, where farmers crop their fields for more years between fallows than they do in the forest zone, 96 percent of households reported fallows of three years or less.

Root, Tuber, and Plantain Improvement Program

Cassava, plantain, and yam, widely grown by subsistence farmers, are the staple foods of hundreds of millions of people in the humid and subhumid regions of tropical Africa. Of the three crops, cassava, a tuber, is by far the most important, providing more than half the calories consumed by more than 200 million people.

Cassava

Cassava is uniquely important in Africa as a reserve against famine. In the nutrient-poor, often acid soils of the lowland humid forest zone of Central and West Africa, where it is traditionally grown, cassava produces more food for less labor than any other crop. In recent years, cassava's tolerance for drought has encouraged its rapid adoption by farmers in areas with unreliable rainfall.

Because of its special value as insurance against hunger in these famine-prone areas, cassava is accorded the highest priority in IITA's Root, Tuber, and Plantain Improvement Program. The recent extension of cassava culture into areas of low and unreliable rainfall adds urgency to the IITA scientists' search for varieties suited to semi-arid conditions. At the same time, the importance of cassava in the highlands of eastern and southern Africa is the impetus for IITA's work with the Eastern and Southern African Root Crops Research Network (ESARRN) on varieties for mid-altitude conditions.

In general, the major constraints on increased cassava production include diseases, insect pests, nematodes, and weeds. For each major agro-ecological zone, IITA's cassava program aims to develop and disseminate improved cassava cultivars that combine high yield, resistance to major diseases and insect pests, and adaptation to a wide range of ecological conditions and farming systems. To appeal to consumers, the improved varieties must also have appealing taste and other qualities suitable for making popular dishes. Additional research will lead to reduction of post-harvest losses and improvements in the labor-intensive processing that cassava requires.

IITA's high-yielding cassava varieties are multiplied for release to thousands of Central Africa's farmers.

By 1989, many national programs in Africa had adopted improved, high-yielding cassava varieties developed at IITA, and locally named varieties selected from the Institute's breeding material. These improved varieties had been multiplied and distributed widely to thousands of farmers in countries throughout Africa, including Cameroon, Gabon, Liberia, Nigeria, Rwanda, Seychelles, Sierra Leone, Tanzania, and Zaire.

Early research succeeded in developing lines with resistance to the two most destructive cassava pathogens in Africa, cassava mosaic virus and cassava bacterial blight; as well as reduced cyanide content and more appealing skin texture, flesh color, and other characteristics. Dissemination of the improved lines was initially delayed, however, by the slow process of multiplying cassava planting material; and delayed further by national plant quarantine regulations.

Both obstacles were at least partially overcome by the introduction of tissue culture techniques, which eliminate viral and other diseases. Clones in tissue culture form have now been shipped to more than 30 countries. More recently, the development of techniques for multiplying plants rapidly, and for distributing small cassava stem cuttings in sealed polyethelene bags, has further eased the process of cassava improvement.

In 1988, screening cassava hybrids and clones in the germplasm collection, IITA scientists for the first time identified naturally occurring, partly fertile tetraploids and triploids. Subsequent screening revealed that a substantial proportion of hybrids produced "giant", or diploid, pollen cells. To cassava breeders, these discoveries offer increased genetic variability and novel gene combinations, suggesting new breeding strategies for cassava improvement.

Also in 1988, IITA cassava breeders developed improved varieties with yellow root flesh, for use in the preparation of the traditional West and Central African roasted cassava dish, yellow gari. Normally white, gari turns yellow if palm oil is added to the cassava during roasting. The palm oil, rich in carotene, a plant pigment that converts to vitamin A in animals, makes yellow gari more nutritious than

white gari, and as much as one third more expensive. The yellow-flesh cassava developed at IITA combines high carotene content with good agronomic characteristics, resistance to pests and diseases, and high yield; and its tubers make yellow gari without palm oil.

Biological control of the cassava mealybug, a major pest of cassava, by the tiny wasp *Epidinocarsis lopezi* has been successful since the earliest releases of this natural parasite in 1981-1982 in Nigeria by IITA's Root, Tuber, and Plantain Improvement Program. The Institute's Biological Control Program has since released the parasite, by air and on the ground, in 18 countries across Africa's cassava belt, substantially reducing mealybug damage. Biological control of cassava pests has recently been augmented by IITA's cassava breeders, who have developed two varieties with demonstrable levels of genetic resistance both to mealybug and to green mite.

As the Institute's collection of genotypes has continued to grow, increasing the variety of genetic characteristics available to breeding programs, researchers have been able to identify suitable improved varieties for the major African intercropping systems. Other lines of research have led IITA scientists to the genes controlling varietal differences in drought tolerance, and to the identity of the microorganism that causes root and tuber rot in cassava. On a more mundane level, tests in IITA's laboratories have demonstrated that flour made from certain varieties of cassava and yam can be used as a partial substitute for

growing African demand for bread.

Plantain

Plantain is a particularly useful crop for small farmers in the humid forest zone. As a backyard crop, it coexists easily with established farming systems; it reduces degradation of the ecosystem; and it provides a reliable source of food for the "hungry season" before other crops are harvested. The most important threat to plantain production is black Sigatoka, an especially virulent fungal disease that attacks plantain and cooking banana in many parts of Africa. Many areas where black Sigatoka is not prevalent are also experiencing rapid, mysterious declines in yields of plantain and cooking banana, probably due to a combination of stresses. The Institute's scientists press the search for both the causes and the cures of these yield declines.

IITA scientists trying to breed plantain varieties with genetic resistance to black Sigatoka disease face three challenges: first, to find fertile, seed-producing female plants; second, to find diploid male plants with inherent resistance to Sigatoka; third, to mate the two successfully. Screening plantain cultivars in the IITA collection,

the researchers found four females that produced seeds, and several males with significant degrees of disease resistance. Seeds from the initial crosses, grown at IITA's substation at Onne, Nigeria, were cultured by the Institute's biotechnology unit [see article, p. 23] to overcome their natural reluctance to germinate.

In another approach to black Sigatoka disease, Institute breeders in 1988 crossed susceptible plantains with resistant diploid bananas. Some of the hybrids yielded as many as 169 seeds per bunch, producing almost 100 plants. Using new biotechnological techniques, IITA is now multiplying four resistant cooking banana hybrids from these crosses for distribution.

Yam

West and Central Africa produce and consume over 90 percent of the world's yams, a primary staple for tens of millions of people. The importance of the crop, and the promise of significant improvements in yield, more than justify continuing yam research. The goals of IITA's yam breeders are to produce plants that require less laborious staking; to improve the yam tuber's shape; to build in genetic resistance to major diseases and nematodes; and to make yams look and taste better to consumers.

Even before 1988, despite the frustrating complexity of yam's reproductive biology, IITA breeders were able to make as many as 10,000 crosses annually to select for promising characteristics. During the past five years, scientists have made significant improvements in methods for producing high-quality, low-cost, and

abundant yam planting material, relieving farmers of their traditional

Gloria Duah

Transferring an improved technology from the experiment station to farmers' fields is often a frustratingly slow and problematic business. But Gloria Duah, an enterprising Ghanaian farmer, saw the chance for fast results from a new method for producing seed yams that she observed during a visit to IITA in 1984. Duah's use of an improved method to increase production of this African staple has won her a national award in Ghana as "Most Scientific Farmer" and the title "Best Overall Farmer" in the Volta River region.

The new method, developed by IITA scientists with colleagues from the Nigerian research system, addresses two perennial problems in growing the small tubers, weighing from 100 to 1000 grams, that are planted as seeds for commercial-size yams. One problem is the shortness of the optimum period for transplanting seed yams into the field. The farmer has about two months, from March to May, from the start of the rainy season to just before its peak, to

[illegible]

get the seed yams into the ground. Late planting results in poor establishment and low yields.

The second problem for seed-yam farmers is [illegible] need to set aside one quarter of each crop to use as seed for the next.

harvesting, especially in heavy, dry soils that are difficult to dig. Because they rot quickly, broken tubers cannot be stored from the harvest period, which ends in March, until the next traditional planting season, which begins in May.

At IITA, researchers tried extending the planting season by a full three months, planting yam minisetts — pieces of tuber weighing 25 to 30 grams — directly in nursery beds as early as February, the hottest, driest part of the year in tropical Africa. With heavy mulching to lower soil temperatures and conserve moisture, the early planting yielded as well as traditional plantings, while obviating the need to transplant. The result was an early harvest of seed tubers for commercial yam production. The flexible planting time means that seed tubers broken during harvest can be replanted as minisetts immediately, before they rot, to produce another crop of seed yams.

A glimpse of the new cropping system at Ibadan in 1984 was enough to persuade Gloria Duah to sign up for an IITA training course. After producing 6000 minisetts of seed yams that first year, Duah leased 10 hectares in Nigeria to produce 500,000 seed tubers in 1985. By 1988, back home at her Cristly Farms in Ghana, she was gearing up for large-scale production, harvesting 15,000 yams for local markets as well as 100,000 seed yams, to be multiplied into 1.5 million in 1989 and 2.5 million per year thereafter. The government of Ghana has given Cristly Farms a three-year contract for a total of 5 million seed yams for distribution to farmers, who will produce yams for market [illegible]

In 1988, yam breeders brought to fruition their five-year effort to produce varieties with resistance to foliar necrosis, a disease that causes yam plants under African conditions to lose all their leaves before flowering.

[illegible]

Hybrid seeds, produced from necrosis-resistant cultivars in IITA's germplasm collection, were planted in isolation in 1983; the resulting seedlings were raised in 1984 and cloned in 1986. The best selections from these clones, advancing in 1988 to uniform trials at four ecologically diverse locations in Nigeria, yielded dramatically better than the best local cultivars.

Sweet Potato

Primary responsibility for sweet potato in the international agricultural research system was transferred in 1988 to CIP, the International Potato Center in Peru. [See article, p. 30]. During 17 years of work on the crop, IITA scientists had made significant improvements, developing clones resistant to weevils, sweet-potato virus complex, and root-knot nematodes; selecting more than 50 non-sweet varieties, preferred by consumers in West and Central Africa, from IITA's extensive germplasm collection; and

distributing improved varieties to more than 50 countries. Tissue culture methods, developed in the Institute's biotechnology unit [see article, p. 23], produced disease-free elite planting materials that could cross international borders without quarantine. Tissue culture was also instrumental in achieving rapid and sure multiplication of scarce breeding materials and secure conservation of germplasm.

Biotechnology

Biotechnology played a key role in root, tuber, and plantain improvement at IITA in 1988, enabling breeders to overcome previously intractable problems in reproductive biology. The Institute thus was able to produce and multiply disease-free planting materials that it can freely share across national borders with its research partners throughout Africa and beyond.

For the first time, five white yam varieties, obtained by meristem culture, were certified disease-free by Nigeria's Plant Quarantine Authority, in effect giving them passports to travel anywhere. IITA is now multiplying these potentially valuable materials for international distribution.

Plantlets of 12 selected varieties of cassava, regenerated by meristem culture, were transplanted for testing to detect virus infection. The Institute sent almost 2000 plantlets from other meristem-cultured cassava materials to 25 countries in Africa; and more than 1600 plantlets from meristem-cultured sweet potatoes to 23 countries around the world. IITA's collection of germplasm, the raw material for biotechnology, continued to grow. The yam germplasm collection was converted in 1988 from the field to in vitro form and augmented by 600 new accessions. IITA's in vitro collections now include 1000 clones of sweet potatoes, 900 of yams, 100 of cassava and related species, and 150 of cocoyams.

Grain Legume Improvement Program

Protein-rich grain legumes — principally cowpea and, in recent years, soybean — are especially important in many parts of Africa where diets are otherwise protein-poor.

Cowpea

Because of its tolerance of drought and heat, cowpea is a major component of typical farming systems in the dry savanna zone of the northern tropics. In the moist savanna to the south, cowpea is a relatively less important component of more complex and diverse farming systems. Even beyond its growing range, in the humid forest zone farther south, cowpea is marketed very successfully as a high-protein food, returning a cash income to farmers in the savannas. Cowpea haulms, or pods, are widely used as an animal feed.

In West Africa, where cowpea is second only to groundnut among legumes in the diet, at least 80 percent of cowpea is grown in mixed cropping systems, interplanted with pearl millet in the Sahelian desert zone, and with sorghum or pearl millet in the dry savanna. The cowpea is usually interplanted randomly with the cereal in a style of association to which both have evidently adapted through centuries of co-evolution. More recently, cowpea has also been grown in association with maize in the moist savanna; and with cassava and yam in forest/savanna transition zones.

The cropping systems in which cowpea is cultivated vary mainly with latitude, which determines the duration of the growing season: from two to three months in the north, to five months or more in the southern savanna. IITA's cowpea breeders have shifted their attention from varieties suitable for grain production as a sole crop to varieties adapted to the cereal-intercropping systems of the West African savanna.

The major goal for IITA's scientists in the savanna is developing cowpeas that combine adaptation to the region's millet-, sorghum-, and maize-based mixed-cropping systems with resistance to major pests and diseases. Cowpeas in the savanna are challenged by such pests as parasitic weeds, aphids, bruchids, and thrips; and a catalogue of diseases, including bacterial blight, ashy stem blight, *Septoria*, scab, and brown blotch.

In collaboration with the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and the Institute for Agricultural Research at Ahmadu Bello University, in northern Nigeria, IITA is basing a cowpea research team — plant breeder, pathologist, and physiologist/agronomist — in the savanna. The new substation is at Kano, in northern Nigeria, in the major cowpea-growing zone that extends across several countries of West and Central Africa. ICRISAT's existing sorghum-research facility at Kano will afford IITA's team the opportunity for collaborative research on cowpea in sorghum-based cropping systems.

For the Sahel zone, a prime objective of IITA breeders is to develop dual-purpose cowpeas, equally useful as food or as fodder. These types will be well adapted to the low levels of fertilizers and other inputs typical of the millet-based cropping system that predominates in the region. They will be tolerant of the region's characteristic drought and heat, and they will be resistant to the region's endemic parasites, diseases, and pests. An IITA cowpea scientist is presently stationed at ICRISAT's Sahelian Center in Niger.

IITA's cowpea, a protein-rich component of African farming systems, show many improved characteristics.

For the transition/forest zone, IITA's research team — a breeder, an entomologist, and a pathologist — is developing cowpeas with resistance to the zone's important insect pests: pod borers, pod bugs, thrips, and bruchids. The search for genetic resistance reaches beyond cultivated cowpeas to their wild relatives. Together with other IITA programs, the Grain Legume Improvement Program is adapting improved cowpea varieties specifically for the cassava-, yam-, and rice-based cropping systems characteristic of transition/forest agriculture.

The Institute's cowpea breeders, past and future, draw their genetic capital from the world germplasm collection, maintained by IITA's Genetic Resources Unit. In this pool of genetic diversity, now exceeding 15,000 accessions, the grain legume program's scientists have found significant levels of resistance to the storage weevil,

leafhoppers, and aphids; and partial resistance to other pests and diseases. The genes for resistance have been incorporated into elite varieties, conferring multiple resistance.

Using techniques developed in the Biotechnology Unit and advanced laboratories elsewhere, IITA's cowpea breeders are preparing to breed interspecific hybrids, pyramiding genes from diverse parents, including wild cowpeas, to create cultivars with multiple resistance to important pests and diseases.

In collaboration with the University of Naples, in Italy, and Purdue University, in the United States, the Institute has initiated an interspecific-crossing program that will draw on the diverse genetic capital in the world cowpea collection. Also with the University of Naples, and with other Italian institutions, IITA is pursuing basic research in cowpeas under a special grant from the Italian government.

The focus of the breeding program until recently has been on developing erect or semi-erect cowpeas that mature early and are insensitive to variations in day length. The most successful of IITA's erect varieties, which mature as early as 60 days after planting, are being used in rice-based mixed cropping systems in the Philippines, other parts of Southeast Asia, and a few areas in Nigeria. Farmers sow these cowpeas in their rice fields immediately after they have harvested their rice, when the fields would normally lie fallow. Using only the residual moisture in the soil, the legumes mature quickly, yielding a valuable harvest where nothing grew before. IITA's rice-based systems working group is evaluating the potential of this rice-cowpea farming system for Africa's inland valley ecosystem. Farmers in northern Nigeria, meanwhile, have adopted some of IITA's semi-erect breeding lines.

In 1988, pest and disease resistance were the major themes of IITA's cowpea research. With colleagues at Purdue University, IITA researchers continued their studies on improved methods for screening cowpeas for bruchid resistance, developing a technique for identifying resistance in less than one day, instead of the 45 days required by the conventional screening method.

The search for additional sources of genetic resistance led in 1988 to two wild cowpea species that have shown significant resistance to three major pests. IITA scientists have successfully crossed these wild cowpeas with cultivated species. The resulting fertile hybrids are currently being screened to determine if resistance has been inherited from the wild parent.

IITA researchers also developed a screening technique for pod bugs that uses dry seed in the laboratory and is both faster and easier to use than the earlier method. Techniques for screening for resistance to *Maruca* pod borer were also improved, enabling researchers to identify significantly different levels of resistance among various lines of *Vigna vexillata*, a wild species. Collaborating with researchers at the International Center for Insect Physiology and Ecology (ICIPE) and Wye College of London University, the IITA group then went on to investigate the mechanism involved in the wild cowpea's resistance to pod borer and pod bugs.

IITA breeders made extensive use in 1988 of a cowpea line from Botswana that showed resistance to the different strains of the parasitic weed *Striga*. Several lines combining resistance to *Striga* with superior agronomic characteristics are now being evaluated for the Sahel and savanna zones. An IITA breeder, working in Ghana with the national program in cowpea and soybean improvement, has identified a bruchid-resistant line with white seed color and high-yield potential as superior for on-farm testing. IITA breeders have incorporated resistance to aphids and bruchids, as well as multiple resistances to several diseases and viruses, into a large number of cowpea lines, including local farmer's varieties.

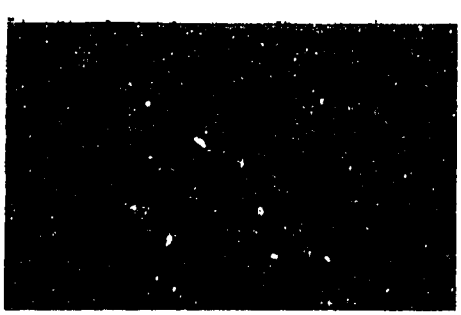
During 1988 IITA responded to requests for improved cowpea lines from 55 countries. Four IITA-improved varieties progressed from international trials through extensive testing by national programs to official release in Ghana, Tanzania, Democratic Yemen, and Bolivia.

Soybean

Despite its agronomic and nutritional virtues, soybean has not yet become widely popular in Africa, because high-yielding soybeans from the United States and elsewhere have not been able to be grown successfully. The major obstacle has been the inability of native rhizobia — the same nitrogen-fixing bacteria that readily colonize the roots of cowpeas, groundnuts, and other African legumes — to form symbiotic

relationships with exotic soybeans. The alternative, innoculation of African soils with imported rhizobia, was too expensive and complex for most African smallholders. Recently, in collaboration with scientists from Nigeria, Cameroon, Ghana, and Zaire, IITA scientists transferred the ability to nodulate with African rhizobia from an unimproved Nigerian soybean to high-yielding, imported varieties.

IITA's breeding program has also overcome the second major obstacle to soybean cultivation in Africa: the tendency of soybean seeds in warm, humid climates to lose viability soon after they are harvested, long before they can be planted. After years of effort, researchers were able to transfer genes for seed longevity into elite soybean lines that are readily symbiotic with indigenous rhizobia. As a result, African smallholders can now grow this high-protein crop without purchased fertilizer.



Soybeans, [illegible] make [illegible] and [illegible] in [illegible] dishes.

By 1986, a single improved variety, relatively high-yielding and resistant to *Cercospora* leaf spot, had become popular in the savanna and mid-altitude zones of Nigeria. In 1987, when this variety proved susceptible to another strain of leaf spot, aggressive screening by IITA scientists quickly identified a few varieties with multiple resistance. The best of these also proved to have higher yield, greater resistance to shattering, and better seed color than the previously popular variety.

Since research by IITA scientists and their colleagues has overcome the main barriers to cultivation in tropical climates, soybean production has attracted significant interest in many areas of West and Central Africa. In the moist savanna and transition zones, improved soybean cultivars have proved less susceptible than cowpeas and other food legumes to pests and diseases.

Against the day when soybean achieves its deserved popularity as a source of high-protein food and oil for tropical Africa, IITA maintains a soybean germplasm collection, continues an active breeding program, and investigates postharvest and utilization issues.

With Nigerian colleagues from the Institute for Agricultural Research and Training at Obafemi Awolowo University, the Institute's scientists experimented in 1988 with different bread recipes, mixing in various percentages of soybean flour as a high-protein, cheaper substitute for wheat flour. Acceptable bread, with almost twice the protein value of bread made solely from wheat, resulted from a mixture of 25 percent partially-defatted soybean flour. In another collaborative project, IITA and IAR&T scientists in 1988 fortified gari — a West African staple made from fermented cassava — with whole soybeans or the residue from soybean milk production. The resulting gari had ten times the protein content of traditional gari.

Maize Research Program

The popularity of maize in West and Central Africa continues to rise, as population growth and increasing urbanization create demand for a crop that repays the farmer's labor with generous yields of food and feed, and that produces nutritious grain that can be easily transported and stored.

Most African maize farmers, however, lack the resources to respond to the growing demand. Relying on traditional farming systems, cultivating their small fields with few, if any, purchased inputs, they face formidable problems: endemic pests and diseases, and a variety of unfavorable agronomic and ecological conditions. As a result, African maize yields are commonly about 1 ton per hectare, well below their potential.

The main objective of IITA's Maize Research Program is to give the small farmer, with limited resources, varieties that diminish the risks of production. These varieties must have the potential for high yields, they must be resistant to the major pests and pathogens, and they must be better adapted than present cultivars to the farmer's environmental and agronomic circumstances. With the perception of reduced risk will come the farmer's increased investment in other improvements to increase maize production.

The Maize Research Program tailors its research to four principal ecological zones in West and Central Africa. The lowland moist savanna has the greatest potential for maize production in West Africa: already, during the past decade, maize has increasingly replaced sorghum in this region. Without modest applications of fertilizer, or nitrogen-fixing intercrops, however, low soil fertility constrains continuous maize cultivation.

The lowland humid forest zone, characterized by high rainfall and humidity at elevations up to 800 meters above sea level, presents the maize farmer with one discouragement after another: disease and insect attacks, low light intensity during the growing season, acid soils, low soil fertility, and high humidity that makes grain drying and storage difficult. Rapid urbanization in some coastal areas of this zone has nevertheless stimulated the demand for fresh maize as well as for dried grain.

Maize is a major potential crop, which produces [illegible] a nutritious staple food in the African diet.

In many tropical regions, the mid-altitude zone — from 800 to 1500 meters above sea level — is ideally suited to maize. With good management, farmers can achieve and sustain high yields. In Africa, however, maize at these altitudes is subject to periodic epidemics of maize streak virus, maize mottle virus, blight, and rust.

In the lowland dry savanna, or Sudan savanna, zone, low rainfall — 500 to 800 millimeters per year — makes rainfed maize production risky without appropriate soil- and water-management practices and early-maturing varieties. With irrigation, however, maize has great potential in the lowland dry savanna. Especially on good soils in the wetter parts of the zone, maize production is already expanding into traditional sorghum/millet systems.

At IITA headquarters in Ibadan, the program's scientists are responsible for research in maize agronomy, plant pathology, entomology, and breeding and genetics. These scientists also develop and test improved germplasm and distribute it to researchers in national systems and others for further testing and adaptation. The effort also enlists scientists from other IITA programs. As part of the Institute's international cooperation effort, for example, scientists are posted to collaborating national research systems to assist in developing appropriate germplasm. An agronomist and an economist in the Resource and Crop Management Program concentrate on maize-based farming systems, and scientists in the virology unit investigate maize viruses.

In 1988 IITA's most active maize partnerships were with Cameroon and Zaire. IITA also participates with other national maize programs in the Semi-Arid Food Grains Research and Development (SAFGRAD) maize network, and posts a coordinator to SAFGRAD project headquarters in Burkina Faso. Within the international research system, IITA's maize research program shares research findings and genetic materials with the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and other institutions. In 1988, IITA

distributed 242 international maize yield trials in response to requests from collaborating research institutions in 26 countries throughout Africa and beyond.

IITA's high-yielding, streak-resistant maize varieties have found international acceptance.

The major insect enemies of maize in Africa are maize stem borers, which attack the growing maize plant itself; leafhoppers, which are vectors of major maize viruses; and the various stored-maize pests, including *Sitophilus* and *Prostephanus* species, which attack the grain after harvest. To defeat these pests, the scientists work at understanding their biology, their population dynamics, and their complex interactions with the plant. In the search for maize plants with built-in pest resistance, the researchers devise methods for multiplying and raising the pests, for infesting maize plots under controlled conditions, and for selecting superior plants.

Maize scientists and virologists at IITA have conquered maize streak virus, once the foremost pest of maize in Africa. Beginning in 1975, IITA researchers have devised improved screening techniques to identify streak-resistant germplasm, and organized an

incorporate the resistance genes into improved varieties. By 1985, high-yielding, streak-resistant varieties — both open-pollinated and hybrid — with different maturities and grain types, had been developed for farmers in all the maize-producing zones of Africa, in active collaboration with scientists from CIMMYT and African national programs. The value of this ten-year effort was recognized by the 1986 King Baudouin Award for International Agricultural Research.

In 1988, as a stimulus to emerging government and private seed-production programs in Africa, IITA produced 14 tons of streak-resistant maize seed for multiplication by national programs in seven West African countries: Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Niger, and Togo. A streak-resistant IITA variety that has proved popular in Nigeria is being multiplied by the Nigerian Seed Service for use in the savanna, where it has demonstrated its superiority to other varieties.

Research continues on maize mottle and other viruses, and on the pathogens that cause downy mildew, ear and stalk rot, and blight. The parasitic *Striga*, or witchweed, has emerged as a major threat, as maize production has expanded into the savanna, where witchweed is at home and rampant. IITA scientists are investigating *Striga*'s biology and ecology, its economic importance, and its reactions to agronomic factors, looking for a strategy to defeat the parasite by producing a *Striga*-resistant or -tolerant plant.

With the creation of the maize-based

commitment to on-farm research in maize agronomy has increased. From 1979 to 1987, IITA scientists collaborated on agronomic research with national programs through participation in the SAFGRAD maize network in Burkina Faso. Similar joint efforts continue in the Institute's bilateral maize programs in Cameroon and Zaire. A maize agronomist, as well as a breeder, will be based at IITA's planned savanna substation in Cote d'Ivoire for research on that increasingly important maize environment.

IITA's maize breeders develop improved cultivars — both open-pollinated populations and varieties, and stable inbreds and hybrids — for the three major maize-producing ecological zones: lowland forest, lowland savanna, and mid-altitude tropics. The major concern in developing improved cultivars is the incorporation of resistance to the insects, diseases, and plant parasites peculiar to each zone. The breeders are also aware of the importance of maintaining and improving consumer appeal — taste, texture, and other characteristics — as maize becomes an increasingly popular staple.

The focus of the program's early breeding efforts was on combining the potential for high yield with significant resistance to rust and blight, the two most important maize diseases in lowland Africa. IITA breeders promptly developed two open-pollinated varieties that were not only resistant to these foliar diseases, but that also grew vigorously and responded well to intensified management in African environments. As the

acceptance throughout Nigeria and in several other African countries, in 1977 the maize breeders added a third fungal disease, downy mildew, to their agenda, beginning anew the patient process of identifying resistance genes for incorporation into improved genotypes. After more than a decade of progress, the effort continues.

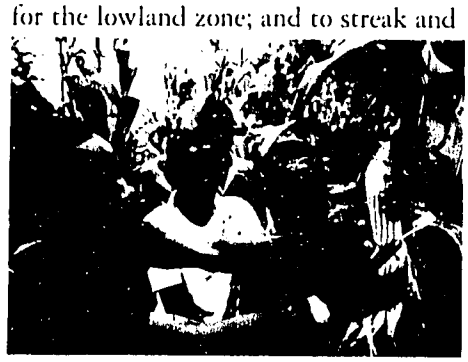
Also in 1977, the program undertook to tailor varieties for the mid-altitude zone, the most promising environment for maize production in Africa. Research began on the Jos Plateau in Nigeria, later extending through collaborative projects to Cameroon and Zaire, with the specific objectives of combining resistances to streak and to the blight and rust fungi that are major factors in the mid-altitude zone. In 1988, in Nigeria, Cameroon, and Zaire maize lines were identified with superior yield and disease resistance for mid-altitude conditions. These lines, derived from a single variety developed at IITA, are the only streak-resistant, open-pollinated varieties adapted to this ecological zone. National agencies in all three countries are now releasing these varieties to farmers.

At the same time, the maize program's hybrid project developed disease-resistant inbred lines for combining with other materials adapted to the mid-altitude zone. In 1988, hybrids were selected in the mid-altitude zones which combine good disease resistance with high yield potential. These research achievements led to the first international hybrid trials for the mid-altitude zones, conducted in 1989.

The maize program's initial focus on lines for use by national programs. Inbreds provide plant breeders with uniform, homozygous sources of disease resistance and other characteristics for combination in improved varieties. Drawing on promising selections from all over the world, as well as from African national programs and private companies, the Institute's scientists have been able to develop inbred lines that grow vigorously in African environments; resist the major African diseases; and combine readily with other breeding materials. These lines are now available to national programs and other institutions interested in breeding locally adapted, improved maize varieties and hybrids.

The success of the inbred-line project encouraged the Nigerian Government in 1982 to support IITA in an expanded project to develop hybrids for commercial seed production and distribution in the country's private sector. By 1984, hybrids produced by IITA had helped to establish two successful Nigerian private seed companies.

IITA scientists continue to press the development of hybrids with combined resistance to streak and downy mildew, for the lowland zone; and to streak and



ear and stalk rots, for the mid-altitude zones. In 1988, three new hybrids performed very well in Nigeria; several advanced hybrids were selected for specific adaptation to the second growing season in the forest zone; and researchers measured genetic variation in the efficiency with which hybrids use nitrogen at five ecologically diverse sites in Nigeria.

In 1988, the program's entomologists concentrated on screening for resistance to stem borers. New sources of stem-borer resistance, unadapted to African environments, were crossed with adapted lines that include resistance to streak and the major fungal diseases.

With a scientist from the People's Republic of Benin, IITA scientists continued to investigate methods of screening for resistance to *Sitophilus* weevil and mechanisms of resistance to maize storage pests. Recognizing the preference of some West African consumers, in 1988 IITA breeders purified some streak-resistant maize lines for soft (floury) grain. The resulting lines were tested, in cooperation with national maize programs, during 1989.

Measuring the damage *Striga* does to maize, IITA researchers in 1988 found that *Striga* infestation caused a 60 percent yield loss in a susceptible variety. Using a simple and reliable field-infestation technique to screen germplasm, scientists identified previously unknown sources of *Striga* tolerance, while confirming the susceptibility of most maize varieties. Using resistance genes from temperate-zone varieties, the scientists initiated the development of *Striga*-tolerant maizes

Rice Research Program

Rice in Africa is not generally grown on leveled fields with controlled irrigation, like the paddy rice of Asia. Without controlled flooding, African rice plants must compete with weeds for available soil nutrients. Weakened by nutrient deficiency, rice plants become increasingly vulnerable to a variety of diseases.

The rice plants may be damaged by too little water, which encourages certain diseases, or by too much water. Groundwater often carries toxic concentrations of iron. Grassy weeds around the typical African rice field are hosts to important insect pests. In the African environment, therefore, increased rice production depends on improvements both to the rice plant itself, to incorporate resistance to major pests and diseases, and to rice agronomy, including water management.

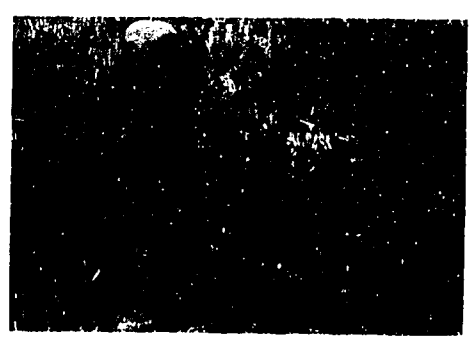
At IITA, a working group for rice-based systems enlists both crop-management specialists from the Resource and Crop Management Program and breeders from the Rice Research Program. Through this coordinated effort, IITA scientists have developed more than fifty elite varieties specifically adapted to appropriate farming systems for most of the diverse rice environments in tropical and subtropical Africa. Improved varieties, developed at IITA in collaboration with national research programs and other institutions, have been adopted in nearly every rice-growing country on the continent.

The Rice Program's achievements form a solid basis for continued progress at the West African Rice Development Association (WARDA), which will assume full responsibility for West African rice improvement in the CGIAR system by the end of 1991. IITA scientists are making every effort to assure the smooth transfer of responsibility to their WARDA colleagues, including making IITA's facilities, especially its research support services and irrigated rice fields, available for their use. The two international centers will collaborate on resource and crop management research in the inland valley ecosystem. For the time being, IITA will pursue pre-breeding research on African rice, it will continue to collect and conserve the genotypes of African rice, and it will duplicate the collections maintained by the International Rice Research Institute.

The focus of IITA's rice improvement research, which will be maintained by WARDA, has been on three agro-ecological regimes in which rice is grown in Africa. **Upland** rice is planted on well-drained soils in the humid-forest zone. Far from the major urban markets where rice is imported to feed burgeoning populations, upland rice farmers practice traditional shifting cultivation to produce subsistence crops. Local upland rice cultivars have evolved independently from lowland types in response to stresses from acid, infertile soils, and from a variety of weeds and diseases.

For the upland-rice farmers, IITA breeders have concentrated on increasing the yield potential of the tall traditional lines, which have a tendency to lodge, or fall down. At the same time, the breeders want to retain the excellent tolerance of stress and resistance to disease that these cultivars have evolved. The breeding effort has produced higher yields by incorporating genes for shorter straw and increased tillering into existing upland varieties. The most successful IITA innovations in upland rice have been several early-maturing varieties, resistant to blast disease and tolerant of drought. These varieties have been widely adopted in drought-prone inland valleys in the savanna, and in upland areas with moderate rainfall in Nigeria and Cameroon.

Since 1987, in accordance with the Institute's strategic review, the greatest part of IITA's rice-improvement effort has been aimed at the more fecund floodplain and inland-valley swamp ecosystems. Described as **rainfed lowlands** in conformity with the terminology adopted for Asian rice, in fact these soils are mainly watered not by direct rainfall, but by drainage and



Young, new Nerica rice plants [illegible] to adverse [illegible] during the [illegible]

seepage from the surrounding upland regions. More fertile and less drought-prone than the uplands, the rainfed lowlands represent a vast potential for rice production in Africa. For these areas the program has produced varieties that have been widely accepted by Nigerian farmers.

Irrigated paddy, the common rice-growing system in Asia, is the most favorable environment for rice cultivation. With appropriate management, irrigated paddy produces the highest yields from well-adapted varieties; and, with sufficient water and warm weather, it permits two or more crops each year. With all its advantages, however, paddy rice's potential in Africa is limited mainly by the high cost of irrigation.

Several of IITA's paddy-rice varieties combine high-yield potential and moderate blast resistance with good grain quality. These varieties are becoming increasingly popular among farmers in Cameroon, where paddy culture is already established, as well as in parts of Nigeria. In ten years of work to overcome genetic obstacles to interspecific crossing, plant breeders have also made substantial progress toward transferring important disease resistance from upland rice into semi-dwarf paddy varieties.

With scientists from IITA, breeders in Cameroon's national rice program have concentrated on screening international nurseries for well-adapted paddy varieties. The search has so far identified a moderately cold-tolerant, high-yielding variety for the Ndop plain; a blast-resistant variety for the Mbo region; and two early-maturing lines for the Mbo and Babungo areas. The program's agronomists, meanwhile, have designed and tested appropriate rice-production systems to overcome the most important constraints to paddy culture in Cameroon. The systems include prescriptions for optimum fertilizer doses and methods, and suggestions for well-adapted green manures that can rotate with rice to reduce farmers' need for purchased fertilizer.

The Cameroon program is only one example of the connections between IITA and national research programs and other institutions in most of the rice-producing countries of sub-Saharan Africa. In 1988, for example, the IITA rice program produced and distributed a record 11.2 tons of improved seed for multiplication and further testing and improvement by collaborating national programs and agencies, most of them in Nigeria. IITA also submitted seed for 165 entries in the International Rice Testing Program for Africa, a joint effort with the International Rice Research Institute to test and distribute improved varieties and breeding materials to national programs throughout the continent.

[illegible]

A screening program to identify genetic sources of tolerance to iron links IITA to the Central Agricultural Research Institute, in Liberia, and to Nigeria's National Cereals Research Institute. In an effort to breed resistance to the rice yellow mottle virus, the Institute collaborates with the national research program of Niger, where the disease is endemic.

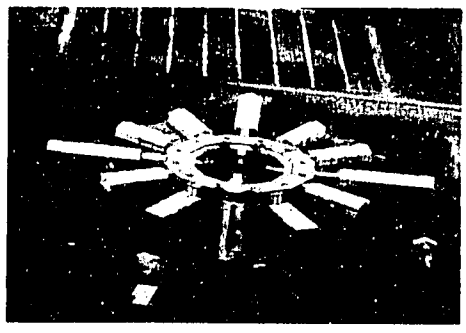
Biological Control Program

The Biological Control Program originated at IITA in 1979 as an urgent experiment to combat the cassava mealybug and the cassava green mite, two recent and decidedly unwelcome immigrants from South America. Uncontrolled, the two pests were spreading rapidly in Africa's cassava belt — an area larger than the United States — threatening yield losses as high as 80 percent to the sub-Saharan region's most important crop, the staple food for some 200 million people.

The conventional, chemical response — frequent dosings with potent insecticides — would have been ecologically brutal, socially unacceptable, economically expensive, and practically impossible. A biological alternative, enlisting nature's own agents and mechanisms to keep pest populations in tolerable balance, was indicated. IITA's scientists already knew that, on their home ground in South America, mealybug and mite populations are naturally controlled by biological antagonists, including parasitic wasps and ladybugs. Arduous field research in South America, all the more difficult because the pest is virtually invisible to the naked eye, had identified the cassava mealybug's primary natural antagonist: *Epidinocarsis lopezi*, a predacious wasp. The successful establishment of this wasp in Africa, therefore, promised prompt, self-perpetuating, and self-regulating mealybug control.

The biological strategy was also recommended by its logistical efficiency. To succeed, *E. lopezi* required no effort from thousands of extension agents, preaching the gospel of biological control to millions of individual farmers. All IITA's biological controllers needed was tens of millions of laboratory-bred wasps to broadcast from airplanes or release on the ground.

Biological control has worked from the start: the introduced wasps, multiplied at IITA and released in cassava-growing regions, readily established themselves in the African environment and promptly set about reducing mealybug depredation by half or better, in many areas to virtually subeconomic levels. The early success of this textbook application quickly established biological control as a key element in IITA's integrated pest-management strategy, a varied arsenal of techniques to combat pests that threaten food supplies in tropical Africa (See article, p. 52).



[illegible]

By 1988, the Biological Control Program had 13 professional staff members. To the original pair of enemy targets the program has added the complex of cowpea pests, the banana weevil, the larger grain borer, the mango mealybug, and grasshoppers. The potential for biological control of the parasitic *Striga, Imperata*, and other weeds is being [illegible]

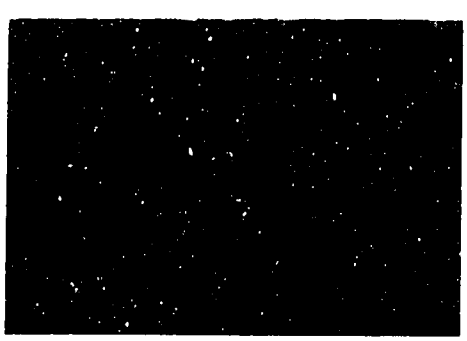
Recently, the program has begun to transfer its activities from IITA headquarters in Ibadan to new offices and laboratories at the Institute's research station in Cotonou, People's Republic of Benin. The first phase of the facility, occupied in 1988, contains laboratories and offices for scientists, their students and technicians, and visiting scientists; six air-conditioned greenhouses with a total area of 1200 square meters; an insectary that meets international quarantine requirements; and a wing devoted to the mechanized mass-rearing of insects.

A unique feature of the insect-rearing wing is the artificial cassava tree, an armature on which cassava plants grow in a nutrient water solution. The device was developed by the program's scientists to simulate ideal natural conditions for the mass-production of mealybug and mite antagonists. Its inventors refined the system in 1988 by eliminating all mechanical and electrical components, substituting a drip-irrigation system that increases plant growth while reducing the need for labor and the chance for error. The program distributed several such "cassava trees" to national programs in 1988, enabling cassava-growing countries to begin arming themselves for biological control of the mealybug, the cassava green mite, and other pests.

Against each pest, the program organizes a group of appropriate specialists for a three-pronged attack that includes research, training, and support of national biological-control programs. Researchers study the plant's physiology and growth patterns, the better to understand the plant's vulnerability to the pest. They

study the biology and ecology of the pest, both in the field and in the laboratory; and of the pest's natural enemies, both exotic and indigenous. Developing appropriate sampling methods and computer simulation models, the researchers analyze the agricultural and ecological contexts in which plant and pest coexist, and assess the economic costs attributable to the pests and the net benefits to be derived from biological control.

The program also trains biological control professionals at three levels of competence. At the most basic level, laboratory and field technicians are taught the basic methods of biological control, entomology, and general crop-protection. Their training emphasizes techniques for surveying pest damage, and for sampling pest populations before and after release of their natural enemies. Promising candidates for



Hiscanus [illegible] in western Kenya's international control efforts.

Master's degrees in biological control or pest management, recruited from the technical training courses or directly, are sent to appropriate universities in Africa or overseas. And finally, doctoral candidates, including top-ranking students from the Master's program and other well-qualified applicants, cap their university studies with thesis research in Africa.

By 1988, more than 250 biological-control specialists from 35 African countries had received IITA training. In 1988, a total of 108 trainees took courses at IITA and also in Zaire, Tanzania, and Mozambique; 38 fellows pursued MSc or PhD programs.

IITA's Biological Control Program participates in a network of 35 national programs in the African cassava belt. An objective of IITA's program is to help establish an appropriate national biological control program in each African country requesting assistance.

Since its initial success, the program has maintained its biological offensive against the cassava mealybug. By early 1988, the mealybug's waspish antagonist, *E. lopezi*, had been released at more than a hundred sites in 21 countries of western, central, eastern, and southern Africa, and has made itself at home on more than 1.8 million square kilometers of the continent's cassava belt. IITA scientists have identified other natural enemies of the mealybug in South America, and have successfully introduced some of them to the African environment.

In 1988, the program made large-scale releases of mealybug enemies from the air and the ground at numerous sites in the Central African Republic, Tanzania, and Mozambique. Small-scale releases continued in Sierra Leone, Togo, Burundi, Zaire, Malawi, and Zambia.

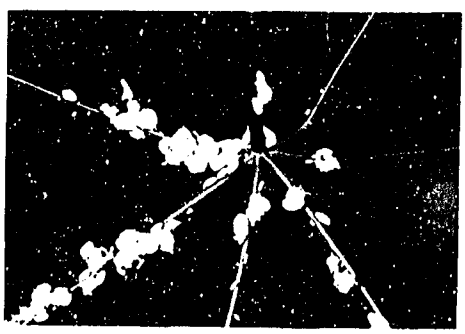
The success of *E. lopezi* against the cassava mealybug continues. Five years after the first limited releases of the well established in 70 percent of all fields, over an area of more than 200,000 square kilometers. Mealybug damage, which had affected 88 percent of cassava plants soon after the wasp was first released, was found on only 23 percent of cassava plants just one year later. Today, eight years after these first releases, less than 6 percent of plants have mealybug populations large enough to cause injury.

The program achieved similar early results in most locations. A 1988 study under controlled field conditions dramatically confirmed the efficiency of *E. lopezi* in controlling the mealybug in the rainforest zone of Ghana, and surveys during 1988 of mealybug populations in Nigeria, Benin, Zambia, and Malawi revealed an encouraging level of biological control achieved by the wasp in ecological zones beyond southwestern Nigeria.

In addition, an Indian parasite of another important pest, the mango mealybug, which damages plantains as well as mangoes, has been released at many sites in Ghana and Benin; the parasite very promptly made dramatic inroads on the mango mealybug population.

The program also continued its efforts in 1988 toward biological control of the cassava green mite, which has proved more resistant to biological control. Program technicians produced as many as 6 million mite eggs daily to feed as many as 50,000 larval predators per week for release in pest-infested Nigerian areas and smaller areas in Ghana, Benin, Zaire, Kenya, Uganda, and Burundi. Surveys during the 1989 dry season should reveal whether the

green mite's predators, seven predacious mites of a different family, have become permanently established in Africa.



— and can repay their costs many times over. Assuming the rapid spread of both the cassava mealybug and *E. lopezi* throughout the entire cassava belt, an independent review team recently estimated the annual gain in cassava yield from control of the mealybug at 10.2 million tons.

"Reasoning that the benefits will continue for years, decades, and even centuries, as seems likely," the reviewers concluded, "the benefit-cost ratio of the IITA project will become very large" — and is estimated to exceed US$3 billion over the next 25 years.

IITA's experience testifies that biological control strategies, well conceived, well planned, and well executed, can work against major pests of important crops in Africa's diverse environments

Integrated Pest Management

Classical biological control — fighting a pest by enlisting its natural enemies — is part of an overall strategy of integrated pest management that IITA is developing against the multitude of Africa's crop pests. Integrated pest management offers the farmer a choice of strategies and weapons that can reduce pest damage to tolerable levels without degrading the agricultural environment. Its arsenal includes several biological methods — for example, the use of improved cropping systems and crop plants that defeat pests — as well as the judicious use of chemicals.

Until quite recently, especially in developed economies, chemical insecticides and herbicides have held the attention of researchers and farmers. Growing awareness of the hidden ecological and agricultural costs of over-reliance on chemical control has sparked renewed worldwide interest in biological methods.

For Africa, where chemical poisons are often unavailable and always too expensive for small farmers, IITA's research has emphasized specific, effective biological strategies against economically important insect pests. IITA's plant breeders have scored notable successes in identifying genes that confer built-in resistance to attacks, and in transferring these genes to improved cultivars. A parallel breeding strategy arms crop plants with inherent defenses against such plant diseases as maize streak virus, cassava bacterial blight, rice blast, and cowpea mosaic virus. Crop-management researchers evaluate cropping practices and patterns, both traditional and innovative, for their effectiveness in deterring pests and

Available options for integrated pest management are assessed in IITA's several crop-based systems working groups. In the working groups, scientists from all relevant disciplines come together to coordinate their efforts toward the development of improved varieties and farming systems. The best experimental test of integrated pest management involves controlled field trials, in which scientists can measure the impacts of pests and their natural enemies on resistant and susceptible crop varieties, in various sole- and mixed-cropping systems, under various management regimes. In certain situations, the techniques of systems analysis and predictive modeling help researchers to identify likely interventions among the components of integrated pest management.

International Cooperation and Training

The special role of International Cooperation at IITA is to strengthen the capacities of African national research systems to select and adapt — and ultimately, to generate — improved technologies for their own agricultural and social environments. Even the best cultivars and technologies developed at IITA cannot be transplanted to farmers' fields throughout tropical Africa without the participation of national programs at every stage, from the early definition of problems to the fine-tuning of solutions for local use.

IITA's new Medium-Term Plan, in effect in from 1989 to 1993, reaffirms the crucial role of national systems in mediating and generating agricultural change in Africa. The Institute's International Cooperation effort conceives and carries out a variety of training programs and cooperative projects in which responsibilities are shared between international researchers and colleagues in national systems.

Since its first formally organized collaborations with Liberia and Tanzania in 1973, IITA has joined in research and training partnerships with 31 national programs in Africa. The early effort in Tanzania, the Maize and Food Legumes Research Project, trained 80 Tanzanians in a short-term, in-service program, and supported 33 more in studies toward degrees in agriculture. The project's researchers, both IITA staff and Tanzanian, developed a cowpea variety that matures in 60 days, and two high-yielding, disease-resistant varieties.

The High Yielding Varieties Technology Project, which began in 1981, ultimately linked IITA with no fewer than 24 national programs. The project trained researchers in national programs to test high-yielding varieties of maize, rice, cowpea, and soybean for adaptation to the various ecological zones of tropical Africa.

In Cameroon, IITA has a team of 17 scientists working with partners in the National Cereals Research and Extension Project to develop high-yielding types of maize, rice, sorghum, and millet. The project has provided graduate training at all levels for NCRE staff. In 1988, two IITA scientists continued working with the Cameroon Root Crops Improvement Program on testing, rapid multiplication, and distribution of cassava, sweet potato, and yam.

Collaborative research in the Hybrid Maize Project, beginning in 1982, has made vigorous, tropically adapted, inbred lines available to national maize-breeding programs. IITA specialists have cooperated with researchers from 26 African programs

Networks

Collaborative research networks connect IITA to national and regional agricultural institutions in Africa and beyond, to address specific issues of common interest. Networks plan, implement, and disseminate research; share information and technical innovations; and conduct training exercises. Not incidentally, networks also afford smaller countries, many of which are unable to mount comprehensive research and development programs, forums for participation in agricultural progress.

A technical working group of the Special Program on African Agricultural Research (SPAAR), a donor group that supports networking activities, recently identified the characteristics that a research network should have, including:

- *An important research objective.*
- *A source of improved technology or ideas.*
- *A harmonizing or coordinating institution.*
- *An information-exchange system.*
- *Free exchange of results and methods, including plant and animal materials.*
- *A steering committee of participating member countries.*
- *Education and training opportunities.*

IITA acts as a catalyst in promoting and managing appropriate networks for the tropical and subtropical regions of Africa. Because it is a major source of technological innovation and scientific research in the region, IITA often assumes the coordinating role during a network's early stages. It is IITA's objective, however, to cede the coordinating role to participating national institutions as soon as they are able and willing to assume it.

IITA is presently coordinating five collaborative research networks:

- *Eastern and Southern African Root Crops Research Network.*
- *Central and Western African Root Crops Research Network.*
- *Cowpea Research Network of the Semi-Arid Food Grains Research and Development (SAFGRAD) Project.*
- *Maize Research Network of the SAFGRAD Project.*
- *Alley Farming Network for Tropical Africa (AFNETA).*

since 1978 in the Semi-Arid Food Grains Research and Development project, headquartered in Burkina Faso. The project has developed improved varieties and agricultural practices for maize and cowpea cultivation in tropical Africa.

An IITA scientist worked with the Rwanda Farming Systems Research Project, which ended in 1988, to select crop varieties and develop farming systems suitable for the Bugesera-Gisaka-Migongo area. The project introduced improved fallow-management practices and an appropriate alley-farming system, and identified four varieties of cassava and two of sweet potato for multiplication and wide distribution.

IITA [illegible]

Since its inception, IITA's Biological Control Program has depended on close teamwork with national systems to manage precise releases of crop-pest antagonists and timely surveys of pest populations over large areas in participating countries. (See article, p.50.)

IITA's newest partnership with national systems, initiated in 1988, is the Collaborative Study of Cassava in Africa. Covering six tropical countries, tion for international research centers, national systems, and others interested in the region's most important food crop.

In all, during 1988 International Cooperation was active in 11 continuing special projects, linking 46 IITA scientists with national programs in ten African countries. For the future, the Institute plans to reduce its commitments of scientists in a few countries, in favor of assigning experienced teams of two or three appropriate specialists to national systems in more countries.

In 1988, International Cooperation appointed two research liaison scien-

[illegible] attention is given to [illegible] at all [illegible] and [illegible] projects.

tists to coordinate the increasingly complex collaborations between the Institute and the national programs of tropical Africa. Attentive to the national programs in his or her assigned region, the research liaison

Research Liaison Scientists

The function of the research liaison scientist is to be an honest broker between IITA and its partners, the national agricultural research systems of tropical Africa. The IITA Strategic Plan, which dedicates the Institute to strengthening national systems, recognizes "that it is essential to distinguish national system requirements at different stages of institutional development, from an early, 'embryonic', stage through medium strength to maturity."

Each research liaison scientist, a permanent member of IITA's scientific staff, is assigned to cover seven or eight countries related by geography, ecology, language, or other common factors. In each country, the scientist develops a thorough understanding of the institutions, the scientists and other personnel, the research agenda, and the requirements of the national agricultural research system. The scientist's insights help IITA to make its own research program more relevant, and to develop effective

The research liaison scientist's functions include identifying the research and development needs of the national research system in each country; assessing the system's capacities for collaborating in its own development; linking the system with appropriate IITA programs or other resources; coordinating IITA activities in each country; and helping other IITA scientists to focus their efforts on the most important problems.

The first research liaison scientist is assessing the needs of English-speaking countries in West Africa as a first step toward improving research linkages. Another scientist is working with Central African countries. Beginning in 1990, a third will cover the French-speaking West African countries. In addition, a liaison scientist has been assigned to IITA by the United States Agency for International Development (USAID) to connect its programs with the improved technologies developed at IITA and other international

scientist evaluates their needs for specific assistance, as well as their readiness for cooperative projects. The scientist is then in a position to link national programs with the appropriate resources at IITA or elsewhere. (See article, p. 55).

To conduct agricultural research and development, all national systems need capable and committed professional staffs and direction. When IITA began operating in 1967, the deficit of scientists and professionals trained in African agriculture — especially of African scientists and professionals — was enormous and growing. Training for African agricultural professionals at all levels, therefore, was part of the Institute's original mandate; and training remains an increasingly important aspect of IITA's mission today. No proposal to develop or transfer technology from IITA fails to consider the training requirements of the participating countries. In International Cooperation's varied partnerships with national systems, training is the constant theme.

To realize the potentials of their own programs, or to participate effectively in cooperative projects, virtually all national agricultural research systems in tropical Africa share a need for trained professionals. Since 1971, more than 6,000 trainees, most of them Africans, have come to IITA. IITA scientists and occasional guest instructors have taught a total of 74 courses devoted to a single crop, and 84 specialized courses in various research areas, including 9 in weed management and 11 in biological pest control. Fifteen group courses, totaling 56 weeks of training, were offered in 1988 at Ibadan by IITA's five major research programs. Most of the 315 trainees came from sub-Saharan Africa; 65 percent came from West and Central Africa.

As the growing capability of national systems permits, group training courses will be increasingly relocated from Ibadan to collaborating countries. In-country courses can reach more trainees, at lower cost, with instruction more appropriate to their conditions. IITA continues to support the in-country courses, assisting the national systems to plan curricula, prepare training materials, and train the trainers, turning their own professionals into effective teachers. In addition, IITA scientists often participate in in-country training as advisers and guest instructors.

To date, IITA scientists and International Cooperation's training officers have helped to establish and teach 44 in-country courses. In 1988, the program posted a training officer to the University of Nsukka, in Nigeria, to help organize a training course in the uses of food crops in nutrition. The course attracted 27 trainees, 20 of them women. For a course in on-farm research in rice-based cropping systems, held in Bida, Nigeria, an IITA senior scientist served as a resource person. Funds were provided by the International Development Research Center (IDRC).

More than 400 trainees have come to Ibadan for study, research, and field experience leading to the MSc and PhD degrees. In 1988 the Institute inaugurated the IITA Graduate Research Fellowship Program. The program is open to outstanding African men and women graduate students in agriculture and related sciences who are committed to thesis research in tropical Africa. Fellows work under the supervision of IITA scientists at Ibadan or elsewhere in Africa.

The program was announced in May; by the end of June, 60 applications had been returned to Ibadan, where an IITA committee selected the first five fellows: three from Nigeria, one from Ghana, and one from Sierra Leone. In future years the program will support up to twenty students.

Also in 1988, supported by external funding, 70 other graduate students — 25 MSc and 45 PhD candidates — worked with 22 IITA senior scientists in various research programs. The Biological Control Program, meanwhile, in addition to its group training course at Cotonou, sent four students — from Zaire, Burundi, and Cote d'Ivoire — for MSc studies at overseas universities. The Institute also responded to requests from governments,

IITA emphasizes in-country projects, as here in Rwanda, to reach more trainees with instruction

development agencies, and universities in Africa to provide non-degree-related training to 22 visitors on various missions.

Many graduates of IITA training have gone on to become leaders in African national research institutes, universities, and government programs. They have become directors of research, heads of departments, and program coordinators, as well as senior scientists and technicians.

Bilateral and Multilateral Collaborative Projects (1988)

Project Name	*Location*	*Staff*	*Total Life Budget ($ X 1000)*	*Donor*
National Cereals Research and Extension (NCRE)	*Cameroon*	*17*	*14,871.8*	*USAID*
Cameroon National Root Crops Improvement Program (CNRCIP)	*Cameroon*	*2*	*725.0*	*Gatsby Charitable Foundation*
Semi-Arid Food Grains Research and Development Project (SAFGRAD)	*Burkina Faso*	*5***	*3,472.0*	*USAID*
Food Legumes	*Burkina Faso*	*1**	*416.0*	*IDRC*
Zaire Applied Agricultural Research Project (RAV)	*Zaire*	*14*	*8,117.4*	*USAID*
Rwanda BGM II Farming Systems Research	*Rwanda*	*1*	*269.0*	*World Bank*
Ghana Grain Legumes Improvement	*Ghana*	*1*	*809.0*	*CIDA*
Ghana Smallholder Rehabilitation Program	*Ghana*	*1*	*837.9*	*IFAD*
East and Southern Africa Root Crops Research Network (ESARRN)	*Malawi*	*1*	*289.0* *943.0*	*IDRC/* *USAID*
Congo Kindamba Food Crops Development Project	*Congo*	—	*374.9*	*IFAD*
Collaborative Study of Cassava in Africa	*Nigeria/Tanzania/ Côte d'Ivoire*	*3*	*1,900.0*	*Rockefeller Foundation*

*Project terminated March 1988

**Resident research terminated March 1988, leaving 2 scientists for network coordination.

Research Fellows and Research Scholars

Research Fellows (PhD)

Biological Control Program (BCP)

G. Akpokodje (Nigeria), *University of Ibadan*
G. Goergen (Fed. Rep. of Germany), *University of Giessen*
H. Rogg (Fed. Rep. of Germany), *University of Giessen*
F. J. Senkondo (Tanzania), *University of London*

Grain Legume Improvement Program (GLIP)

S. A. Adebitan (Nigeria), *University of Ibadan*
H. Adu-Dapaah (Ghana), *University of Ibadan*
B. Asafo-Adjei (Ghana), *University of Minnesota*
S. Blade (Canada), *McGill University*
F. A. Myaka (Tanzania), *University of London*
R. A. Noameshi (Togo), *University of Ibadan*
C. P. Paul (Sri Lanka), *University of Ibadan*

Maize Research Program (MRP)

Y. A. Akintunde (Nigeria), *University of Ibadan*
M. Asanzi (Zaïre), *Ohio State University*
O. J. Osanyintola (Nigeria), *University of Ibadan*

Resource and Crop Management Program (RCMP)

A. I. Babalola (Nigeria), *University of Ibadan*
R. Ernst (Fed. Rep. of Germany), *University of Hohenheim*
T. Guanglong (China), *Institute of Soil Science, Chengdu*
S.M. Liya (U.K.), *University of Ibadan*
H. Lutzeryer (Fed. Rep. of Germany), *University of Hohenheim*
M. Mohammed (Bangladesh), *University of Ibadan*
M. A. Olagoke (Nigeria), *University of Nigeria, Nsukka*
O. Onafeko (Nigeria), *University of Ibadan*
G. O. Oyediran (Nigeria), *Obafemi Awolowo University, Ile-Ife*
B. A. Ruhigwa (Zaïre), *Institut Facultaire d'Agronomie, Yapambi*
D. E. Siaw (Ghana), *University of Ibadan*
M. K. Smith (Ghana), *University of Ibadan*

Rice Research Program (RRP)

M. Mgonja (Tanzania), *University of Ibadan*

Root, Tuber and Plantain Improvement Program (TRIPP)

A. Agueguia (Cameroon), *University of Ibadan*
M. H. Makame (Tanzania), *University of Ibadan*
R. Ndibaza (Tanzania), *University of Ibadan*
O. Salau (Nigeria), *University of Ibadan*

Research Scholars (MSc)

Biological Control Program (BCP)

A. M. Animashaun (Nigeria), *University of London*
H. Braimah (Ghana), *University of Reading*
K. Konan (Côte d'Ivoire), *Simon Frazer University, Vancouver*
S. J. Mugalu (Uganda), *University of London*
P. Ndairagije (Burundi), *University of Ottawa*
G. Oduor (Kenya), *Imperial College, London*
A. J. Sumani (Zambia), *University College, Cardiff*
K. Tata-Hangy (Zaïre), *University College, Cardiff*
L. Traoré (Guinée), *University of Montreal*

Grain Legume Improvement Program (GLIP)

D. K. Ojo (Nigeria), *University of Ibadan*
L. Okosun (Nigeria), *University of Ibadan*
N. Ssemakula (Uganda), *University of Ibadan*

Resource and Crop Management Program (RCMP)

C. Anoka (Nigeria), *University of Nigeria, Nsukka*
P. Karinge (Kenya), *University of Nairobi*

Root, Tuber and Plantain Improvement Program (TRIPP)

C. M. Githungurei (Kenya), *University of Ibadan*
M. Ntimpirangeza (Burundi), *University of Nairobi*
S. N. G. Phiri (Malawi), *University of Ibadan*
N. W. Wanyera (Uganda), *University of Ibadan*

Research Fellows (PhD) who completed their research as of Dec. 1988.

Ambe-Tumanteh, J. Mr., *Cameroon*	University of Ibadan	Studies of some agronomic practices in cassava based cropping system in the Southwest province of Cameroon.
Asadu, Charles A. Mr., *Nigeria*	University of Nigeria, Nsukka	Comparative study and evaluation of yam — zone soils and performance of six cultivars of white yam (D. rotundata) in Southeastern Nigeria.
Diop, A. Mr., *Senegal*	Oregon State Univ.	An evaluation of weed interference in rice grown on hydromorphic soils in West Africa.
Durojaiye, J.A. Mr., *Nigeria*	University of Ibadan	Studies on the inheritance of resistance to stalk rot disease of maize (Zea mays L.) caused by Botryodiplodia theobromae pat. and fusarium moniliforme sheld.
Mebrahtu, S.B. Ms., *Ethiopia*	South Dakota Univ.	Cropping patterns, household time use, and child nutrition: A multidisciplinary approach.
Ngeve, J.M. Mr., *Cameroon*	Univ. of Maryland U.S.A.	Factors affecting yield stability among potato genotype.
Ogundipe, H. Mr., *Nigeria*	University of Ibadan	The use of vegetable protein to make processed meat products using soybeans and cowpeas.
Oke, D.B. Mr., *Nigeria*	University of Ibadan	Biochemistry basis of pest and disease resistance of cowpea.
Okorji, C.E. Mr., *Nigeria*	Univ. of Nigeria, Nsukka	Demand elasticities for food crops in major yam producing areas of Southeastern Nigeria.
Olatunde, G.O. Mr., *Nigeria*	University of Ibadan	Studies on host plant resistance in cowpea to pod-sucking Clavigralla tomentosicollis.
Vander Kruijs, A. Mr., *Netherlands*	Wageningen Agric. University	Management of nitrogen in acid low-activity clay soils in the humid tropics for food crop production.
Walangululu, M. Mr., *Zaire*	Inst. Facul. des Sciences Agronomique, Yangambi.	Evaluation of cassava clones for resistance to the green mite and cassava mealybug.

Research Scholars (MSc/MPhil) who completed their research as of Dec. 1988.

Adeyemi, O. Mr., *Nigeria*	O.A.U. Ife	Effect of pruning on nodulation, nitrogen fixation and nutrient released by Leuceana.
Afun, J. Mr., *Ghana*	Wye College, London	A comparative study of "calendar" and "guided" insecticide applications for control of cowpea pests.
Agwaranze, F.N. Ms., *Nigeria*	University of Ibadan	Micropropagation of male sterile cowpea Vigna unguiculata (L.) Walp and its application in hybrid seed production programme.
Gautam, D. Mr., *India*	University of Ibadan	Evaluation of harvesting methods of cowpea.
Kunda, M.N. Mr., *Zaire*	Catholic Univ. of Leuven	Influence of cropping and fallow systems on soil organic matter in Southern Nigeria.
Maobe, S.N. Mr., *Kenya*	University of Nairobi	Effect of nitrogen application and seedling ages on yield of rice.
McIvor, A. Mr., *Britain*	Silsoe Coll. of Agric.	Research station management.
Mugalu, S.J. Mr., *Uganda*	Wye College, London	Biocontrol of the green cassava mite and false codling moth — important pests of cassava and citrus respectively.
Myaka, F.A. Mr., *Tanzania*	Wye College, London	Responses of soybean (Glycine max (L) Merrill) selections to drought during seedling and pod filling stages in Nigeria.
Oduor, G. Mr., *Kenya*	Imperial College, London	Biology and behaviour of cassava green mite.
Onabolu, A.O. Ms., *Nigeria*	University of Ibadan	The utilization of soybean in Nigeria.
Smet, Kris Mr., *Belgium*	Catholic Univ. of Leuven	A physiological study of the growth promotion and growth inhibition of suckers of plantain (Musa c.v. aab).
Sneyers, S.T.J. Mr., *Belgium*	Catholic Univ. of Leuven	Microbial biomass measurements in tropical soils; calibration of different methods.
Valanzuolo, S., *Italy*	Universita Degli Studi di Napoli	Cytogenetic of cowpea and related species: Two genotypes of Vigna unguiculata (TVu 91 and TVu 1977 and two of Vigna vexillata (TVnu 226 and TVnu 226)
Verstappen, B. Mr., *Belgium*	Catholic Univ. of Leuven	Yield losses in improved resistant and susceptible cowpeas due to cowpea storage weevil, Callosobruchus maculatus
Willaumez, S. Ms., *Belgium*	Catholic Univ. of Leuven	Mycorrhizal infection of trees and population size of their rhizobia in farmers' field.

IITA's research support units provide essential services to the scientific programs. The program presently includes six units: Genetic Resources, Virology, Biometrics, Analytical Services, Farm Management, and Biotechnology. The functions and early activities of the new Biotechnology Unit, established in 1988 and scheduled for full operation in 1989, are described in a separate article, p. 23.

Genetic Resources

The Genetic Resources Unit is responsible for the Institute's germplasm collections of cowpeas, rice, and root and tuber crops. For cowpea and yam, and for the African races of two cultivated rice species, *Oryza glaberrima* and *O. sativa*, the unit has a mandate from the International Board for Plant Genetic Resources to preserve and document world germplasm collections. To provide even greater genetic diversity to plant breeders, the unit's scientists also explore Africa to collect the wild relatives of cultivated species.

Under the aegis of the International Board, and in collaboration with scientists from national programs and national authorities, the unit fielded five plant-exploration expeditions in 1988, in Congo, Lesotho, Nigeria, Somalia, and Swaziland. These brought to 53 the total number of IITA plant-exploration missions, to a total of 29 African countries. The 1988 missions returned to Ibadan with a total of 963 samples: 370 cowpeas and 154 wild cowpea relatives; 111 cereals; 86 yams; 175 cassava; 39 plantains and bananas; and 21 other plants. Duplicate samples from each mission were provided to the host government. The unit received another 874 samples of various crops in 1988 from collaborators in national programs and from the International Board.

By 1988, the unit's germplasm collections counted more than 30,000 accessions: 15,100 of cowpea and 810 of wild cowpea relatives, 12,000 of rice, 2,000 of bambara groundnut, 1,500 of soybean, and 500 of maize, plus samples of several hundred other species. The collections are preserved under safe, controlled conditions at IITA's new seed-storage facility, completely renovated and expanded in 1986/87 with funds from the government of Italy.

During 1988, approximately 7,000 different germplasm samples from the seed bank were grown out for multiplication or rejuvenation. Some 10,000 samples were withdrawn for research use, three quarters of them by IITA scientists, the rest by collaborators in 36 countries around the world.

The Genetic Resources Unit's 1988 research agenda included: the seed-storage capabilities of cowpea, soybean, groundnut, and African rice; the distribution of cowpea and rice subspecies in Africa; interspecific crosses between cultivated cowpeas and their wild relatives; interspecific and intraspecific crosses between and within selected subspecies of African and Asian rice; the genetic diversity and yield potential of groundnut; and the genetic inheritance of certain characteristics in crop species.

In its research on the potential of wild cowpea germplasm for improvement of cultivated cowpeas, and its research on cytology and chemical characterization of cowpeas, the Genetic Resources Unit is collaborating with Italian universities and research institutions to explore the uses of biotechnology. The most promising applications of these advanced techniques will be in overcoming the natural inability of wild species to hybridize with cultivated species. By overcoming this barrier, scientists hope to transfer desirable genetic traits, including the wild species' inherent resistance to many pests and diseases, into high-yielding cultivars.

The unit's future projects include using its existing computer equipment to establish a database for the yam, cassava, and plantain collections. A new phytosanitary, or seed health, laboratory will improve the unit's ability to distribute disease-free germplasm materials. The unit will assess the value of electrophoretic techniques for identifying genetic materials, for eliminating duplication in the germplasm collections, and for establishing the relationships of species.

Virology Unit

The Virology Unit works closely with the crop improvement programs to develop cultivars that can resist the viral diseases of crops in Africa. The unit's virologists investigate the viruses — their etiology, geographical distribution, ecology, and pathogenic variation — as well as their associations with the plants they infect. The unit also produces the purified viral material that breeders use to test plants for resistance. The constant improvement of techniques for purifying viral material is a major preoccupation.

The unit also develops and refines techniques for detecting viruses and viral infections. When they find an unknown virus, or a well-known virus that has assumed an unfamiliar form or a new virulence, the virologists identify and describe the pathogen, develop antisera, and isolate typical specimens for reference and comparison. Because viral diseases often inflict devastating costs on African agriculture, virologists are major contributors to all IITA training programs in crop production.

In 1988, the unit tested the resistance of advanced cowpea and maize genotypes to newly recognized viruses or viral strains. A survey in six West African countries gathered information about the geographical distribution of viruses infecting cowpeas in various agro-ecological zones. Among the survey's findings were previously unrecognized types of the aphid-borne mosaic virus that infect cowpeas in the dry savanna zone.

IITA virologists also made significant progress during 1988 in purifying important viruses and characterizing others; and in applying monoclonal antibodies and other advanced methods to the detection and diagnosis of viral diseases in African agriculture. The unit will transfer the new technologies to scientific colleagues in national programs.

Biometrics Unit

The Biometrics Unit advises all IITA scientists and graduate students doing thesis research at the Institute on the applications of mathematics and statistics to agricultural research. Scientists and students come to the unit for assistance in designing surveys and experiments, analyzing and interpreting data, using statistical information in publications and presentations, and applying appropriate mathematical and statistical techniques in their particular research. The unit is also responsible for designing and teaching the statistics components that are important features of most IITA training courses, and for conducting occasional, more specialized Institute courses in statistics and statistical computing. As resources permit, the unit's biometrician provides assistance to other research institutions and to Nigerian universities.

The unit depends on continuous improvements in its computer software to keep up with the volume and complexity of IITA's mathematical and statistical workload. In 1988, the unit acquired and installed an improved version of its basic statistical package and its adaptation of the Farm Survey Analysis Program of the International Maize and Wheat Improvement Center. The new programs were promptly used to analyze several complex surveys, including two on nutrition in rural Nigeria; and to test the accuracy of survey data on farm work, especially on farmers' estimates of plot sizes and time devoted to various farming operations.

Also in 1988, the interest of IITA plant breeders in analyzing entire series of cooperative trials at multiple sites was sparked by a visiting scientist from Queensland University, where the necessary analytical tools have been developed. The Australian software, obtained by the Biometrics Unit and [illegible] microcomputer, enabled the IITA scientists to perform a sophisticated cluster analysis of data from a set of international cowpea trials. Other programs acquired by the unit in 1988 were useful to IITA researchers in specialized genetic analyses, in bivariate analysis of intercropping trials, and in randomizations for experiment design.

Analytical Services Unit

The unit's laboratory assays soil, plant, and water samples submitted by IITA researchers and their collaborators. The lab analyzes soil samples for various physical and chemical properties. Plant samples are analyzed for primary and secondary nutrients and for micronutrients. Water samples are analyzed for nitrate, phosphate, and ammonium content; cations; pH; and electrical conductivity.

The unit performed over 225,000 assays in 1988, more than double the previous year's total. Analytical Services researchers developed new methods or improved existing methods for measuring available potassium and assaying silica and minhydrin-reactive nitrogen in soils.

Farm Management Unit

The Farm Management Unit is responsible for the development, management, and maintenance of IITA's three experimental farms in Nigeria: at the Institute's Ibadan headquarters, in the forest/savanna transition zone; at Ikenne, 65 kilometers south of Ibadan; and at Onne, in southeastern Nigeria, on acid soils in the humid-forest zone. On these farms, the management unit supports field [illegible]

The unit's mobile team supports research projects in many parts of Nigeria, traveling 16,000 kilometers in 1988.

The farm-management staff collaborates with resource-management scientists on studies of soil-conserving tillage methods. For the purposes of these studies, most trials on IITA farms are planted with no-till methods that reduce soil erosion and degradation. The unit also multiplies improved crop varieties developed by IITA scientists and their collaborators, distributing up to 100 tons of seed annually to government seed services, seed companies, and farmers, in Nigeria and other African countries. At Ibadan, the Farm Management Unit maintains a demonstration area, where the latest crop varieties and farming technologies are demonstrated to more than 2,000 visitors each year.

In collaboration with the crop improvement programs, the farm management staff is currently planning three new research stations, to be established in northern Nigeria, Côte d'Ivoire, and Cameroon.

Organizational Information

Information Services

During 1988, Information Services — the new name for the Documentation, Information, and Library program — was partially reorganized. Publications, graphics and printing, and audiovisual and photography functions were merged into a single publications unit to encourage coordination and efficiency.

The public affairs unit, monitoring the coverage of IITA in the press during 1988, counted a total of 117 articles in 15 Nigerian newspapers, 10 articles in 7 foreign newspapers, and 31 features in 17 magazines. The Institute's work was also featured from time to time on Nigerian television and radio, as well as on BBC and VOA broadcasts. More than 500 visitors, many of them prompted by articles in the press, came to Ibadan for a firsthand look.

The unit also received visiting farmers, journalists, diplomats, officers of commercial and farming organizations, and other professionals, with a variety of interests. The unit guided 43 groups of high-school and university students, averaging 50 students each, on tours of IITA's experimental fields.

The library service extended its hours in response to steadily increasing use of the library by staff members, trainees, and visitors. Library staff continued to offer training in the use of the on-line public access catalog, and completed drafts of a new procedures manual and a users' guide to the library.

The service supplied scientific information in response to 236 requests by mail from 37 countries, including 16 in Africa. The staff developed an effective procedure for detecting and correcting errors in the library database, to which 6,380 records were added in 1988. The library acquired compact disk (CD-ROM) information-retrieval hardware and a CD-ROM agriculture database.

The interpretation/translation unit translated more than 4,000 pages of texts from English into French; and provided simultaneous interpretation for 16 training courses and 13 meetings and conferences, both inside and outside of Nigeria. The Conference Center provided support for 25 meetings and conferences of IITA and outside organizations.

During 1988 the publications unit acquired improved equipment for word processing, computer typesetting, and desktop publishing. In collaboration with the EEC donor agency, the Technical Center for Agricultural and Rural Cooperation (CTA), the unit hosted a two-week workshop on editing and publishing for 24 trainees from Cameroon, Ghana, Liberia, Nigeria, and Sierra Leone.

Information Services published 34 titles in 1988, including five translations from English into French. *IITA Strategic Plan 1989-2000* and *IITA Medium-Term Plan 1989-1993* were produced for discussion by the Technical Advisory Committee and CGIAR donors during Centers' Week.

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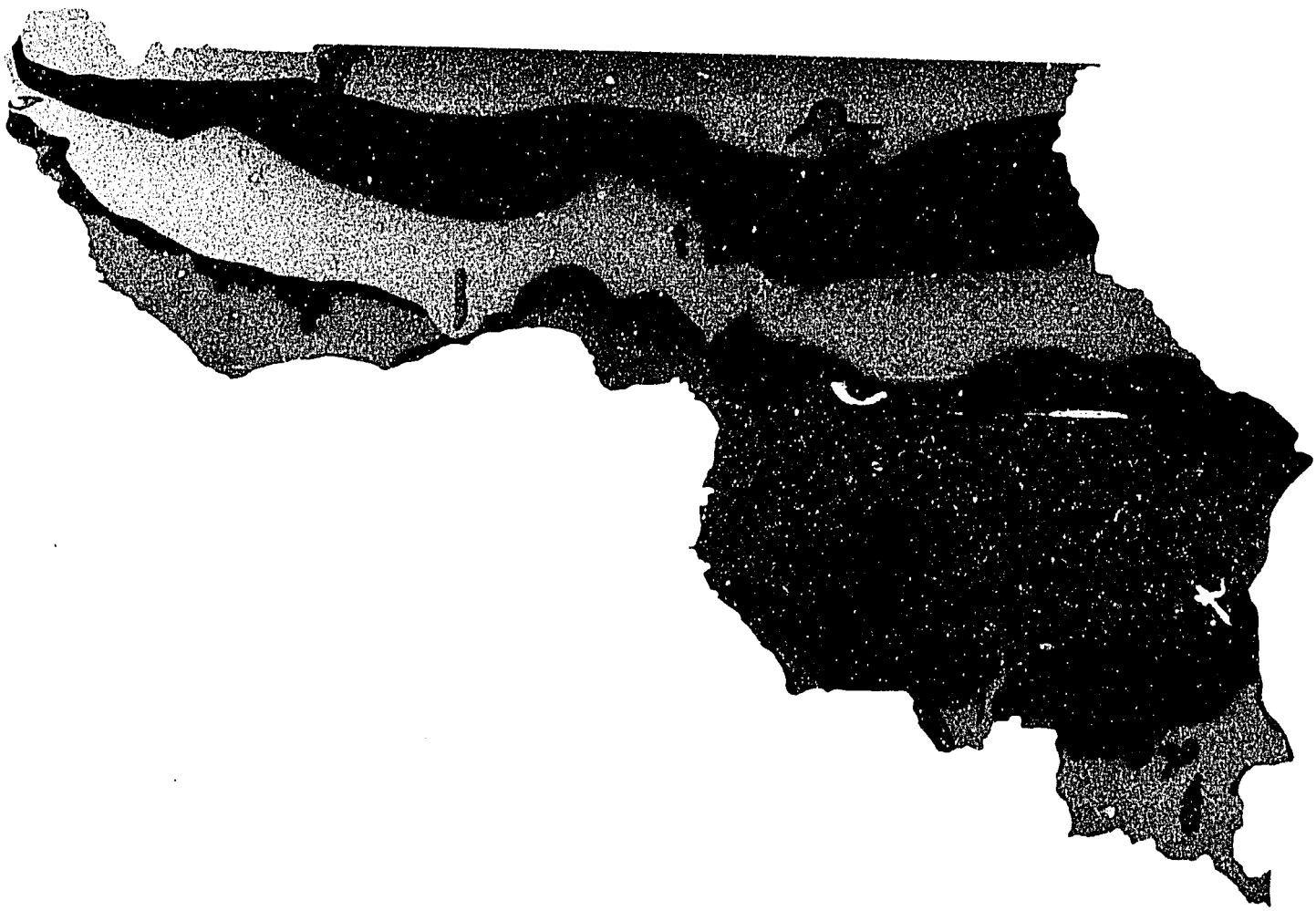

Humid Forest

Forest-Savanna Mosaic (Transition Zone)

Moist (Guinea) Savanna

Dry (Sudan) Savanna

Sahel and Desert

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