International Institute of Tropical Agriculture
Annual Report
1999

About IITA

The International Institute of Tropical Agriculture (IITA) was founded in 1967 as an international agricultural research institute with a mandate for improving food production in the humid tropics and to develop sustainable production systems. It became the first African link in the worldwide network of agricultural research centers known as the Consultative Group on International Agricultural Research (CGIAR), formed in 1971.

IITA is governed by an international board of trustees and is staffed by approximately 80 scientists and other professionals from over 30 countries, and approximately 1300 support staff. Staff are located at the Ibadan campus, and also at stations in other parts of Nigeria, and in Benin, Cameroon, Côte d'Ivoire, and Uganda. Others are located at work sites in several countries throughout sub-Saharan Africa. Funding for IITA comes from the CGIAR and bilaterally from national and private donor agencies.

IITA's mission is to enhance the food security, income, and well-being of resource-poor people primarily in the humid and subhumid zones of sub-Saharan Africa by conducting research and related activities to increase agricultural production, improve food systems, and sustainably manage natural resources, in partnership with national and international stakeholders.

To this end, IITA conducts research, germplasm conservation, training, and information exchange activities in partnership with regional bodies and national programs including universities, NGOs, and the private sector. The research agenda addresses crop improvement, plant health, and resource and crop management within a food systems framework and targeted at the identified needs of three major agroecological zones: the savannas, the humid forests, and the midaltitudes. Research focuses on smallholder cropping and postharvest systems and on the following food crops: cassava, cowpea, maize, plantain and banana, soybean, and yam.

Cosponsored by the World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP), the CGIAR is an informal association of over 40 governments and about 15 international organizations and private foundations. The CGIAR provides the main financial support for IITA and 15 other international centers around the world, whose collective goal is to improve food security, eradicate poverty, and protect the environment in developing countries.

Website www.cgiar.org/iita

IITA
Annual Report
1999

International Institute of Tropical Agriculture
Ibadan, Nigeria

Contents

From the Director General

At a cursory glance 1999 might seem to have been a year of consolidation for IITA particularly with respect to the implementation of the research agenda through our 16 projects. A more careful look, however, shows a year of innovation and change, highlighting the dynamic nature of the Institute and its research that I am happy to report.

The activities of the International Cooperation Division have been transferred to other areas of the Institute. International cooperation and external liaison activities are now the direct responsibility of the Director General's Office and 'strengthening national agricultural research systems' has been integrated as an essential component of IITA's 16 research projects. This ensures that these activities become part and parcel of all the work carried out by the Institute. I am pleased to report the very positive effects of these changes. The projects are proving to be very effective tools that bring staff from the 3 technical divisions together in highly productive multidisciplinary teams. They also enhance the harmonious implementation of research activities, independent of their source of funding.

Lukas Brader

Relationships with partners have been further enhanced in the course of this year and partnerships have expanded to include a much more diverse range of organizations. For example through the Ecoregional Program for the Humid and Subhumid Tropics of Sub-Saharan Africa (EPHTA) closer links have been developed with nongovernmental organizations (NGOs) and community-based organizations.

EPHTA has also increased the participation of potential beneficiaries. As noted in the report of the Technical Advisory Committee of the CGIAR review team on Systemwide Programs with an Ecoregional Approach, '*The research in progress in the southern Cameroon benchmark area gives high priority to the involvement of farmers. It was very instructive to see at first hand what is actually required to involve farmers in research at the village level. Because of its complexity, this process places great demands on the skills of the researchers and even more on the professionalism of the coordinators who have to bridge the differences of scale back up to the creation of international public goods at the level of the* CGIAR. *It is a pity that more decision makers in the* CGIAR *do not have an opportunity to see what the participatory approach means in the real world.*' IITA's commitment involved the use of core funds to support EPHTA in 1999

A year of innovation and change, highlighting the dynamic nature of the Institute and its research

Linkages with other CGIAR centers and institutional partners have been broadened through, among others, the Systemwide Programs. Noteworthy are the new joint farmer participatory research activities in northern Nigeria to promote crop–livestock integration. This was started in 1997 by ICRISAT, ILRI, IITA, and the Institute of Agricultural Research in Nigeria through the development of a joint research plan that focused on a limited set of best-bet technologies The experiment was put in place for the first time by a small number of farmers in 1998. The results were so positive that a multitude of farmers wanted to become involved in the experiment in the 1999 growing season. These demands were met because of additional financial support

received from the local authorities and from the Systemwide Livestock Program. It is clear that together ICRISAT, ILRI, and IITA have been able to make a breakthrough towards achieving more sustainable production systems for what is potentially a very large group of resource-poor farmers in the dry savannas of sub-Saharan Africa.

Many centers and donors were involved with the Seeds of Hope project to help war-torn Rwanda. Now, happily there is a shift from relief to development. IITA is taking the lead as the coordinating agency to work with Institut des sciences agronomiques du Rwanda in a project to strengthen the logistics and research capacity of the national systems, and disseminate improved technologies to the farming community. The aim is to re-establish food security and work towards a market-oriented agriculture, with prospects for local and regional trade in several food and cash crops. Funded by the US Agency for International Development, this unique project brings together 4 national programs, 4 CGIAR centers, 5 NGOs, 2 policy support programs, 6 regional research networks, and many private sector groups. Together we hope to help Rwanda regain self-sufficiency and food security for the first time since 1994 by rebuilding the national program and forging strong links with farmers through NGOs.

Considerable attention has also been given to the best use of biotechnology for the benefit of agriculture in SSA. Wide-ranging discussions in the CGIAR in recent years have clearly shown the complexity of the scientific, social, and legal aspects of this new scientific tool. It is evident that it will become increasingly difficult for individual centers to stay fully on top of the rapid developments in biotechnology. We therefore welcome the joint action taken by the centers in setting up the Central Advisory Service. In addition,

IITA has explored opportunities for closer linkages with an advanced research institute that can effectively complement our limited biotechnology research capacity. We are happy to have concluded a Memorandum of Affiliation with the Center for Advanced Molecular Biotechnology for International Agriculture based in Australia. Similarly, we have agreed to joint appointments with the Natural Resources Institute, UK in the areas of virology and entomopathology.

We at IITA are proud of the significant contributions that we make to increasing the well-being of the poor people in Africa

Funding continues, of course, to be a constant concern and doing the same with less' has become a dominant feature in the day-to-day challenges of a center Director General. There is permanent pressure to increase efficiency, but without inflationary adjustment in our budget, we have reached the stage where we have to ask the staff to do less in order to reduce operational costs. We have now adopted a plan to subcontract support services to specialized private companies and see this as a means to focus our resources and our efforts on our primary responsibilities.

We completed the full cycle of center-commissioned external reviews (CCER) during the year. It was a very intensive process, but has enabled us to make positive adjustments to our research. We believe that the CCERs constitute a solid basis for IITA's forthcoming External Program and Management Review, and sincerely hope they will be given extensive consideration during the external review process.

1999 was a year of positive changes in our host country, Nigeria, from which we expect that IITA will also benefit. Thus, we look to the future with greater optimism. We at IITA are proud of the significant contributions that we make towards increasing the well-being of the poor people in Africa. I would like to express my sincere thanks to all our donors and partners for giving us the opportunity to carry out these rewarding research activities.

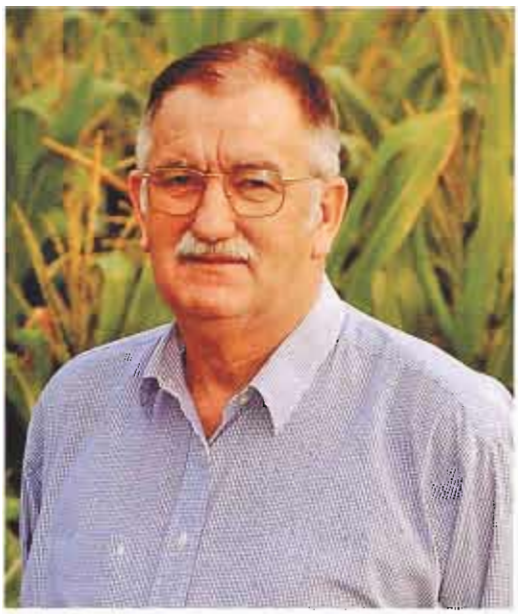
Le Mot du Directeur général

Un regard rapide sur 1999 permet de noter que cette année semble avoir été une année de consolidation pour l'IITA, en particulier par rapport à la mise en oeuvre de notre programme de recherche à travers nos 16 projets. Cependant, un regard plus attentif révèle une année d'innovation et de changement qui met en exergue la nature dynamique de l'institut et des ses activités de recherche que j'ai plaisir à présenter dans ce rapport.

Les activités de la Division de la coopération internationale ont été transférées dans d'autres domaines d'intervention de l'institut. A présent, les activités de coopération internationale et de liaison externe relèvent de la responsabilité directe de la Direction générale tandis que le volet «Renforcement des systèmes nationaux de recherche agricole» a été intégré, comme composante essentielle, dans les 16 projets de recherche de l'IITA. Cela permet une intégration effective de ces activités dans toutes les actions menées par l'institut. Je me réjouis de présenter un rapport sur les effets on ne peut plus positifs de ces changements. Les projets s'avèrent des outils très efficaces permettant au personnel de trois divisions techniques de travailler

dans des équipes pluridisciplinaires hautement productives. En outre, ils renforcent la mise en oeuvre harmonieuse des activités de recherche, indépendamment de leur source de financement.

Nos relations avec nos collaborateurs ont connu un renforcement supplémentaire au cours de cette année et notre collaboration a été étendue à une gamme d'organisations plus large. A titre d'exemple, grâce au Programme écorégional pour les tropiques humides et subhumides d'Afrique subsaharienne (EPHTA), nous avons réussi à établir des relations plus étroites avec les Organisations non gouvernementales (ONG) et les Organisations communautaires de base.


Lukas Brader

EPHTA a également permis une participation accrue des bénéficiaires potentiels. Tel que mentionné dans le rapport de la Revue du Comité technique consultatif du GCRAI (TAC) sur les programmes à l'échelle du système dotés d'une approche écorégionale, "*Dans les activités de recherche en cours dans la zone de référence du sud du Cameroun, la participation des agriculteurs est une priorité absolue. Il a été très instructif de constater de visu ce qui est effectivement requis pour impliquer les agriculteurs dans la recherche au niveau villageois. Compte tenu de sa complexité, ce processus exige beaucoup d'aptitudes de la part des chercheurs et même encore plus de professionnalisme de la part des coordonnateurs qui doivent aplanir les différences d'échelles dans l'appui à la création de biens publics internationaux au niveau du* GCRAI. *Il est dommage que davantage de décideurs du* GCRAI *n'aient pas l'occasion de constater dans la réalité ce qu'est l'approche participative*". L'IITA a utilisé des fonds du budget principal pour appuyer financièrement EPHTA en 1999.

Les liens avec les autres centres du GCRAI et partenaires institutionnels ont été élargis grâce, entre autres, aux Programmes à l'échelle du système. A cet égard, il convient de noter les nouvelles activités conjointes de recherches participatives menées dans le nord du Nigéria en vue de la promotion de l'intégration agriculture-élevage. Ces activités ont démarré en 1997 avec la participation de l'ICRISAT, de l'ILRI, de l'IITA et de l'Institut de recherche agricole du Nigéria, suite à l'élaboration d'un programme de recherche conjointe mettant l'accent sur un ensemble limité de technologies concluantes. Cette expérience a été mise en place pour la première fois par un petit groupe d'agriculteurs en 1998. Les résultats ont été tellement positifs qu'une multitude d'agriculteurs voulaient se joindre à cette expérience pendant la campagne culturale de 1999. Ces requêtes ont pu être satisfaites grâce au soutien financier supplémentaire des autorités locales et du Programme sur l'élevage à l'échelle du système. Il est évident qu'ensemble, l'ICRISAT, l'ILRI et l'IITA ont réalisé un pas vers la mise en place de systèmes de production plus durables à l'intention d'un groupe potentiel d'agriculteurs à faibles revenus dans les savanes arides d'Afrique subsaharienne.

Une année d'innovation et de changement qui met en exergue la nature dynamique de l'institut et des ses activités de recherche

Plusieurs centres et bailleurs de fonds ont participé au projet 'Semences de l'espoir' destiné à aider le Rwanda déchiré par la guerre. Fort heureusement, on note actuellement une tendance à remplacer les activités d'assistance par

les actions de développement. L'IITA se positionne en première ligne comme agence de coordination afin de travailler en collaboration avec l'Institut des sciences agronomiques du Rwanda dans le cadre d'un projet visant le renforcement des capacités logistiques et de recherche des systèmes nationaux et la diffusion des technologies améliorées auprès de la communauté agricole. L'objectif est de restaurer la sécurité alimentaire et d'oeuvrer pour l'avènement d'une agriculture de marché dotée de perspectives d'échanges locaux et régionaux de plusieurs cultures vivrières et cultures de rentes. Financé par l'USAID, ce projet singulier regroupe 4 programmes nationaux, 4 centres du GCRAI, 5 ONG, 2 programmes d'appui aux politiques, 6 réseaux régionaux de recherche et plusieurs groupes du secteur privé. Ensemble, nous espérons pouvoir aider le Rwanda à retrouver une autosuffisance et une sécurité alimentaires pour la première fois depuis 1994, en reconstruisant son programme national et en tissant des liens solides avec les agriculteurs à travers les ONG.

Une attention considérable a également été accordée à une meilleure utilisation de la biotechnologie au profit de l'agriculture en Afrique subsaharienne. Les discussions élargies récemment menées au sein du GCRAI ont clairement démontré la complexité des aspects scientifiques, sociaux et juridiques de ce nouvel outil scientifique. Il est évident qu'il sera de plus en plus difficile pour les centres individuels de se maintenir effectivement au diapason des développements rapides de la biotechnologie. Aussi, nous nous réjouissons de l'action conjointe des centres relative à la mise en place d'un Service consultatif central. Par ailleurs, l'IITA a exploré les possibilités de collaboration plus étroites avec un institut de recherche avancé susceptible de compléter nos ressources limitées en

matière de recherche biotechnologique. Nous nous félicitons de la signature d'un Accord d'affiliation avec le Centre de biotechnologie moléculaire avancée pour l'agriculture internationale basé en Australie. De même, nous sommes convenus de procéder à des recrutements conjoints avec l'Institut des ressources naturelles du Royaume Uni, dans les domaines de la virologie et de l'entomopathologie.

Les financements demeurent évidemment une préoccupation constante et 'réaliser le même travail avec moins de moyens' est devenu une caractéristique dominante dans les défis quotidiens de plus d'un Directeur général des centres. Nous subissons une pression permanente pour accroître l'efficacité de nos activités, mais sans ajustement inflationniste de notre budget et nous avons atteint le stade où nous sommes contraints de demander à notre personnel de restreindre certaines activités afin de réduire les frais de fonctionnement. Actuellement, nous avons adopté un programme de sous-traitance des services d'appui avec des sociétés privées spécialisées et nous considérons cette mesure comme un moyen de concentrer nos ressources et nos efforts sur nos propres responsabilités primaires.

Cette année, nous avons complété le cycle des Revues externes commanditées par les centres (CCER). Ce fut un processus très intensif qui nous a cependant permis de procéder à des ajustements positifs de nos activités de recherche. Nous croyons que les CCER constituent une base solide pour la prochaine Revue externe des programmes et de l'administration de l'IITA et nous espérons sincèrement qu'elles feront l'objet d'une grande considération au cours du processus de revue externe.

1999 fut une année de changements positifs au Nigéria, notre pays hôte et nous espérons que l'IITA en bénéficiera également. Aussi, sommes-nous plus optimistes quant à l'avenir. A l'IITA, nous sommes fiers de nos contributions significatives à l'amélioration du bien-être des populations pauvres d'Afrique. Je voudrais remercier sincèrement tous les bailleurs de fonds et nos partenaires pour nous avoir permis de réaliser toutes ces activités de recherche gratifiantes.

A l'IITA, *nous sommes fiers de nos contributions significatives à l'amélioration du bien-être des populations pauvres d'Afrique*

How IITA research reaches farmers

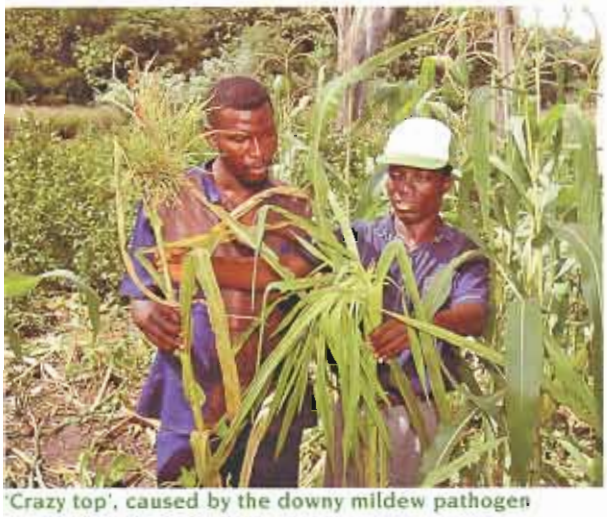
IITA does not conduct its research in academic isolation. The Institute has its feet firmly on the ground of sub-Saharan Africa where it consciously works in close collaboration with the intended beneficiaries of its results. And the research itself is conducted jointly with a wide range of local and national institutions which target the needs of farmers in their regions. Thus, the scope and priorities of our project portfolio are determined from a base of practical realism.

Nevertheless, it is still appropriate for IITA to be proactive in ensuring that the fruits of research do reach the farmers and others able to take advantage of them. This section of our 1999 Annual Report sets out to illustrate some of the ways in which we do just that. And then, by way of contrast, this is interspersed with examples from the other end of the spectrum: the conduct of far-reaching research as a springboard for tomorrow's more adaptive initiatives.

Stopping the scourge

Following 15 years work to produce downy mildew resistant maize varieties, an FAO-supported campaign, organized by IITA and the Nigerian Federal Ministry of Agriculture and backed by practical help from World Vision, successfully halted the spread of downy mildew disease of maize in Nigeria.

Downy mildew is a devastating disease that can wipe out maize crops. Caused by a fungus (*Peronosclerospora sorghi*) that also attacks sorghum, infection results in plants with stiff, narrow, yellowed leaves and inflorescences so distorted that cobs are not formed normally but are replaced by a mass of twisted leaves sometimes called 'crazy top'. Outbreaks have been reported from Mozambique, Uganda, Democratic Republic of Congo, and Nigeria, where by 1993, 7 states were affected and 1.2 million maize farmers were at risk. Pathologists monitored the epidemic through a network of spore traps which indicate the intensity of propagation and movement of downy mildew spores. The epidemic was spreading rapidly and there was concern it would reach Benin and other neighboring countries. The only hope was to alert all the farmers to the need to plant resistant varieties . . and to have enough seed available to ensure that they could.



'Crazy top', caused by the downy mildew pathogen

A campaign to alert farmers about the disease and to publicize available control measures was organized by IITA with the Nigerian Federal Ministry of Agriculture. Sponsored by the Food and Agriculture Organization of the United Nations, the World Bank, and Novartis, this campaign reached an estimated 600 000 (about 50%) of those at risk through radio broadcasts and other media.

IITA breeders had been working on the problem for 15 years using resistant sources of maize from Thailand and the Philippines provided by CIMMYT. A small stock of improved downy mildew resistant maize seed was available. It was calculated that 6000 tonnes of seed was needed, and it became apparent that this was beyond the capacity of either the local public or private sector seed multiplication and distribution systems to supply. Prospects for vulnerable maize farmers were not good.

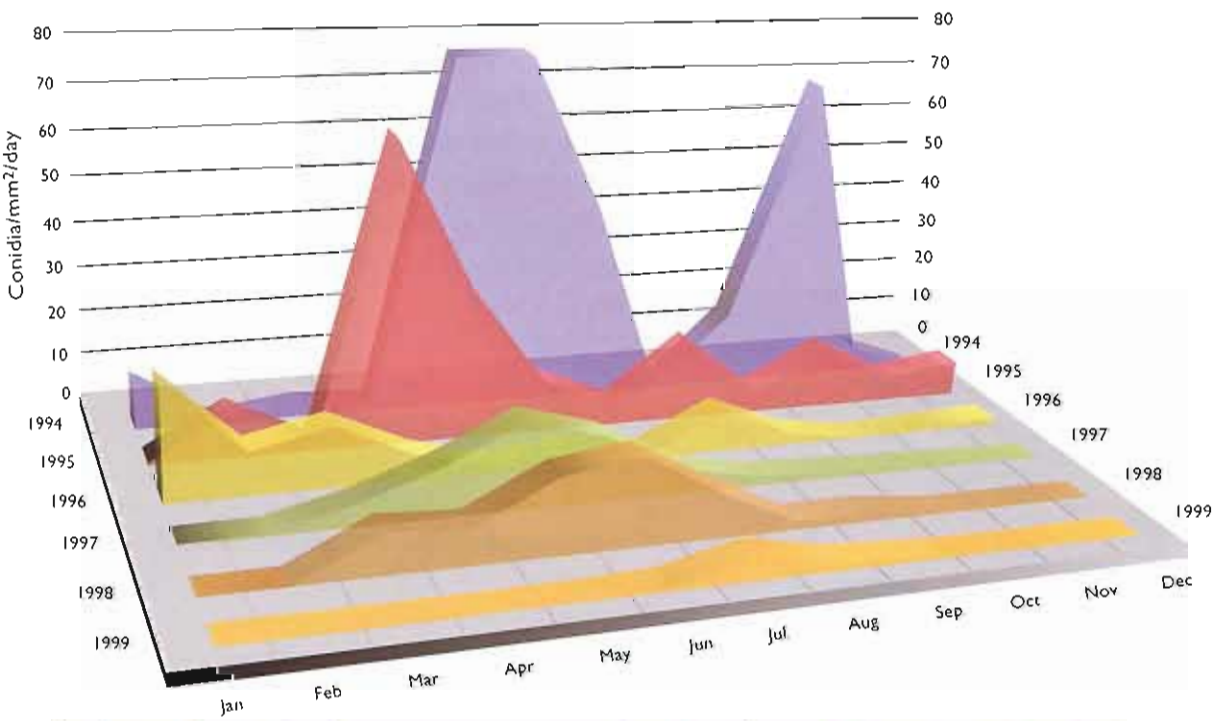
At this point an NGO, World Vision, joined forces with IITA to saturate one area with resistant varieties, working

Setting up a spore trap to monitor the spread and intensity of the downy mildew pathogen

with local farmers themselves to multiply seeds. In Oyo state, where downy mildew was causing serious losses each year, 9 villages were selected. Three farmers from each village were given seed, organic fertilizers, and guidance to produce seed. In the following season each farmer went to 3 new villages and to another farmer in each original village with seeds and with technical know-how imbibed from earlier training. A 'cascade' effect ensured that by the third year, 625 farmers in 159 villages were producing seed of resistant varieties and all had been trained in how to produce a healthy crop in field schools run by IITA scientists. Average yields increased by 50% as a result of the package of practices—from 1846 kg/ha in 1996/97 to 2763 kg/ha in 1998/99.

Sharing experiences in growing resistant varieties; farmers learn from each other in a field school

Many farmers were keen to use the new package, having seen the resistant varieties growing in fellow farmers' fields in their own or nearby villages when field days were held in Ogo-Oluwa and Orire. Nigerian government officials wholeheartedly backed the scheme, many of them having attended the field days and demonstrations, and showed interest in making fertilizer available to participants. The Soun of Ogbomosoland, the paramount traditional ruler of the area, received IITA and World Vision staff to personally thank them for helping farmers in his domain. Downy mildew-resistant maize is currently being grown on 450 km² in Ogo-



The dramatic drop in fungal spore count over 6 years shows how effectively the pathogen was defeated

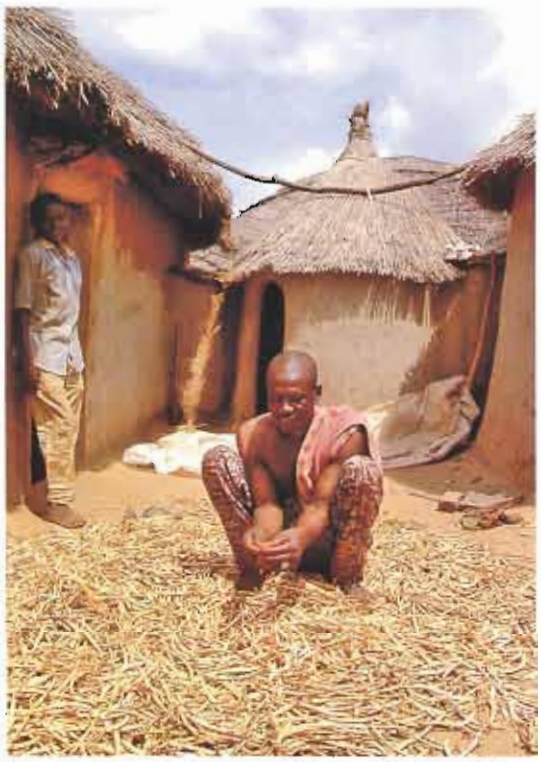
Oluwa and on 2400 km² in Orire. And, thanks to World Vision Australia and World Vision New Zealand which supported the project, the experiences gained in technology transfer are ready now to help farmers in the Democratic Republic of Congo, Mozambique, Uganda, and any other country where this or other pathogens may strike.

IITA's venture in working directly with multiple partners to develop and implement a strategy to meet an emergency has paid off. The epidemic was halted 65 km from the Benin border, and farmers have access to the seed they need to keep production levels steady. Ad hoc seed production will continue to spread and the disease is expected to disappear altogether.

Seeds for needs

IITA supports a number of community-based seed production projects, where farmers increase seeds of improved varieties and sell to other farmers.

Developing improved varieties does not, of itself, achieve anything. Benefits are only realized when the improved seeds are widely available to, and being grown by, the farmers who experience the conditions for which the varieties were developed. Formal seed production and distribution systems are not well established in most African countries, and even where they exist they tend to concentrate on maize and cash crops. To ensure that improved seeds of IITA's mandate crops really do reach farmers in viable quantities, IITA has been active in a number of community-based seed production projects.



Improved cowpeas put a smile on this Nigerian farmer's face

In northern Nigeria, with support from the German Agency for Technical Cooperation (GTZ), a cowpea seed production project was initiated in 1997 by IITA in collaboration with the Institute for Agricultural Research and the Kano Agricultural and Rural Development Authority. In that first year 36 farmers, who were experienced cowpea growers, were given 3 kg of breeder seed of an improved cowpea (IT 90K-277-2) on credit. Their fields served as demonstration plots; together they produced 6786 kg of seeds, most of which was sold to 262 farmers.

To maintain the genetic purity of the seed, a further 3 kg of fresh breeder seed was given to an expanded group of 51 farmers in 1998, and the seed they produced was sold to hundreds of farmers. In addition, the 262 farmers who had purchased the 1997 seed produced 11 802 kg of seed and sold it to very many farmers for the 1999 crop season. In 1999 over 2000 farmers grew the improved cowpea variety that is now firmly established in the region.

A similar exercise was initiated in northern Ghana in 1995 by the Savanna Agricultural Research Institute supported by IITA and GTZ and with funding from the European Union and the US Agency for International Development. Seed of improved varieties of cowpea, soybean, and groundnut was supplied

to farmers' groups from 6 different villages in 2 districts. Farmers were trained to produce seed with their subsequent activities monitored by staff of the Extension and National Seed Services of the Ministry of Forests and Agriculture and by research staff from Ghana's Council for Scientific and Industrial Research. Field days and demonstrations popularized the varieties so that the number of seed grower groups increased each year from 6 in 1995 to 102 in 1999, and spread from the original 2 districts of northern Ghana to 15 districts. Use of these seeds grew from zero in 1995 to 370 hectares of land cropped to improved groundnut, cowpea, and soybean in 1999.

Farmers with their crop of seed maize that will help improved varieties reach more farmers.

Seed problems also affect cereals. Working with the national programs of its member countries, the West and Central Africa Collaborative Maize Research Network (WECAMAN) is assisting farmers and seed producers to develop sustainable seed production systems. These are needed to provide a regular supply of high-quality seed of superior varieties for farming communities in the region. Network member countries have established revolving funds to ensure schemes can survive and reach more farmers each year. The network members provide seed, advice, and other inputs to collaborating farmers, who pay back after harvest with seed or with money from their sales. Seed dealers are encouraged to register, so communities can use those of repute. Retailers are encouraged and helped to sell not only seed, but also agrochemicals and fertilizers. Publicity to create awareness of the availability of good seed is important, as are small well-labeled bags of seed that are convenient for farmers. Teaching marketing and business skills to farmers is high on the WECAMAN agenda.

Despite the need to continue building on a good foundation, the results are already impressive. In Burkina Faso alone over 500 farmers have now been trained through the scheme, and production of quality seed more than trebled in 4 countries of the region over a 5-year period, from less than 100 tonnes to over 350 tonnes.

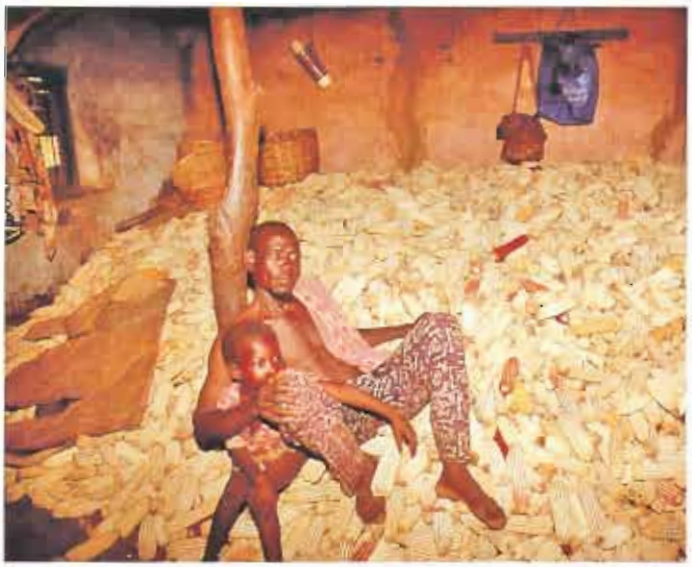
Safe to eat

A package of recommendations to reduce dangerous aflatoxins in stored maize is being developed by IITA. Improved food quality will benefit both rural and urban consumers.

What people eat should do them good, not harm. The quality of food involves not only its taste as recognized by consumers, but also freedom from threats due to hidden contaminants. Consumers may be aware that chemical pesticides can contaminate their food, but many do not know that the food itself can also harbor lethal toxins. As well as helping farmers to improve the quality of the food they produce, IITA is

involved in creating consumer awareness of the need to be sure food is safe to be eaten by their families and their livestock.

There are 10 000 species of fungi and many are useful and good for humans, but at least 50 species are potentially harmful to the health of humans and animals. In particular, fungi of the genus *Aspergillus* produce a group of toxins called aflatoxins. Aflatoxins are linked to cancer, exacerbate kwashiorkor in children, are associated with inhibition of vitamin A absorption, and may slow down the rate of immune system development and child growth. Worse still, they interact with hepatitis B to cause a very high risk of liver cancer in people who are exposed to both, and there are cases where people have died from acute aflatoxin poisoning. These strong poisons, which are not affected by cooking, can be passed from animal feeds to livestock, to humans who eat the livestock products, and even to babies from their mothers, either before they are born or as they are breast fed.



Badly stored maize can contain toxins that affect the health of the whole family

The German Federal Ministry for Economic Cooperation and Development (BMZ) was sufficiently concerned about this problem in 1990 to offer IITA funds to check levels of aflatoxin in stored maize in West Africa. Maize cultivation in the region had increased by 4 million hectares in a decade, but agricultural technology is resource-poor and internal food safety regulations are not necessarily enforced. Most maize in West Africa is produced by small-scale farmers whose crops yield from 1 to 2 tonnes/ha. The harvest is usually stored on-farm throughout the dry season (4–7 months).

IITA conducted extensive surveys. Of over 1000 samples collected over 3 years, approximately 30% had measurable levels of the toxin. And of those, 60% had more than 20 parts per billion (ppb) of toxin, the safety limit set by the World Health Organization. In northern Benin, in 1994, the situation was particularly bad: 56% of maize stored for more than 6 months had an average of 125 ppb of aflatoxin. Furthermore, the samples often contained other fungi that could increase risks from other mycotoxins.

Why were levels so high? IITA staff went back to the farmers to find out; as a result a lot more is now known about mold damage and how it can be prevented. Anything that damages grain renders it vulnerable to fungal infection. Drought stress, birds, rodents, and insects can all cause damage in the field and in stores. Researchers found that lower levels of toxin were related to good crop husbandry, use of fertilizer, timely harvesting, sun drying, sorting out damaged cobs at harvest prior to storage, and controlling insects in the store. High levels of toxin were found when maize was cropped in the same field for several years, when the harvest was delayed, when maize was left for more than 30 days to dry in the field, and when it was stored in certain types of storage structures. All these findings are being used to

produce a package of recommendations to help farmers reduce the risk of their crops becoming contaminated. Participatory testing and cost–benefit analyses are used to show which options are viable.

Maize cobs left in the field for too long after harvest run the risk of contamination

But the threat remains, and work continues. It is vitally important to let consumers know what they should avoid. In 1999 a new project was financed by BMZ to evaluate the possibilities of improving public health by improving maize quality, and to prepare to take positive action on the ways to do this in conjunction with a public awareness campaign sponsored by Rotary International. Ultimately it is hoped to alert consumers to buy products with a 'Seal of Quality' that ensures they have been tested and are safe to eat. Getting there will involve many organizations and institutions working together with all stakeholders, from policymakers to retailers.

Almost 60% of farmers in West Africa sell at least part of their crops to markets in urban centers. Consumer demand for food of high quality in urban markets is expected to provide an economic incentive for producers to adopt technologies and crop management options put forward by IITA and its partner national agricultural research and extension services. Concern for food safety is a worldwide issue and is particularly complex in Africa. IITA is in the forefront of confronting this challenge with many partners, keeping in mind that not only are large quantities of food needed . . . it is also imperative that food is nutritious and safe to eat.

Sorting out cobs before they are stored helps to prevent fungal attack

Trouble in store

IITA is building on earlier successes with biological control of the larger grain borer, to manage this and other pests that threaten crops in storage.

There are few things more disheartening to a farmer than to see a hard-won harvest dwindle in the store, ravaged by pests or diseases. In extreme cases it becomes a race against time: will there be enough to feed the family until the next crop is ready, or will pests spoil the entire stock? Sometimes pests become so numerous farmers can hear them feeding on the maize and can see the dust left behind. Reducing losses to pests can, like increasing productivity, play a role in poverty eradication. Researchers at IITA have been studying ways to control storage pests without using toxic chemicals. In the process they have unraveled several fascinating and useful facts that will help them to help farmers.

Prostephanus truncatus, the larger grain borer (LGB)

The first step in integrated pest management is to understand the diversity and general ecology of the pests. Each farmer's grain store is a mini-ecosystem with many insect species. Some of the species eat maize, some eat other insects, and others eat the leftovers. These insect populations change over time at different rates, and interact with each other and with insects outside the store. Of all these insects, only a few are really worth worrying about. Some important ones, such as the maize weevil (*Sitophilus zeamais*), are found almost everywhere maize is grown and have been studied for many years. Others are new on the scene. In the 1980s the larger grain borer (*Prostephanus truncatus* called LGB for short), a native of Central America, invaded sub-Saharan Africa. Most maize pests have natural enemies in Africa to check their population growth, but LGB had very few and rapidly became a serious problem. Fortunately, German Agency for Technical Cooperation researchers, building on work done by the Natural Resources Institute in the UK and the national agricultural research service in Mexico, found a predatory beetle, *Teretriosoma nigrescens*, that attacks LGB in its area of origin. The predator finds its prey using the LGB's own pheromones. Since the predator beetles were introduced to East and West Africa, the problem of severe infestation of LGB in grain stores has decreased in many places. Workers at IITA have mass-produced the predator and continue to monitor its spread.

Weevils harbor fungal spores; a dead *Sitophilus* covered with *Penicillium* (left) and *Aspergillus flavus* (right). Living weevils carry the fungus into stored grain

Sitophilus zeamais, a worldwide weevil pest of stored maize

Teretriosoma nigrescens, a beetle predator of the LGB

In spite of the introduction of the predator, LGB is still a problem in many areas. The predator finds upland areas less suitable than the hot lowlands, for example, and because much maize is grown at higher altitudes in eastern Africa LGB still causes severe losses in stores in that region. IITA continues to seek new solutions to the problem by studying the general LGB ecology to find where the pest might be most vulnerable. Most insect pests of stored

commodities are able to survive outside stores, and external conditions may have a profound effect on the populations in stores. LGB belongs to a group of insects that can attack wood, and it has been found living in African forests as well as in grain stores, just as it does in Mexico. IITA workers, funded by the Danish International Development Agency, are mapping populations in forest areas in Benin to find the main host of the LGB in the forest and to develop recommendations for farmers who store their maize near certain kinds of forests. Studies in natural habitats may find new potential means of control, for instance, by identifying additional natural enemies. Also, IITA is investigating the potential of fungi and protozoa that may help to control these pernicious beetles, in collaboration with the Centre for Agriculture and Biosciences International and the Kenya Agricultural Research Institute.

Entomologists work on the ecology of LGB and its predator

Researchers and plant protection services also have some complementary strategies ready to deploy in managing LGB and other stored product pests. Maize in much of sub-Saharan Africa is stored with the husk intact and local maize varieties, which often have a strong, tight husk cover, tend to suffer less damage. Some high-yielding varieties produce cobs with an incomplete husk cover, and they can suffer losses in storage that farmers no longer find acceptable. And it is known that some varieties can resist attacks by stem borers in the field as well as by storage pests. In collaboration with CIMMYT, both breeders and entomologists at IITA are searching for varieties that provide significant resistance to storage pests, either with strong husk cover or with particular grain qualities, as well as the advantages of higher yields.

Stored produce can also be attacked by molds, which may be carried into the grain stores by insects. Maize damaged by insects is more vulnerable to mold, which can attract even more insects, and a vicious circle develops.

Model farm stores help researchers monitor pests and work on control options

The Stored Product Pest Management group at IITA, in collaboration with the Danish Institute of Agricultural Sciences, has produced an electronic book about stored product pest research in Africa. The CD, sponsored by the Danish International Development Agency, contains decision-making tools, information on insects, simulation models, and sampling plans for grain stores, together with downloadable computer programs, maps, and data for all these topics.

Normally the molds themselves are not a problem, but certain strains of molds produce health-threatening toxins. IITA researchers have studied isolates of storage molds, and there is hope of introducing nontoxic strains to out-compete toxic ones.

IITA scientists have put weather and life history factors together to develop population models of LGB, the maize weevil, and the predator beetle. These weather-driven models help synthesize information about insect biology and behavior, together with the effects of biological control, varietal resistance, and chemical treatment on populations; this information can, in turn, be integrated with maize market price dynamics to see where farmers can save money. The models allow workers to estimate potential damage at different times and in different places, and to construct simple store evaluation procedures which help farmers find out about how many pests are in their store, what their options are, and how much each option will cost. IITA is currently working on expanding the models to other stored products such as cassava.

A season well spent

PEDUNE, a regional network for cowpea pest management, held successful training courses in 1999. Trainers were trained to run farmers' field schools, and farmers were trained in ecologically sound pest management techniques.

In early 1999, PEDUNE (Protection écologiquement durable du niébé) felt a need to find a rapid way to get the integrated pest management (IPM) message across to cowpea farmers in the Sahel and Savanna regions of West Africa. Accordingly, PEDUNE took representatives from 9 countries to Zimbabwe to see a farmers' field school organized by the Food and Agriculture Organization of the United Nations. The representatives were so enthused that they asked PEDUNE to provide similar training for their staff in their own region.

Ghana was chosen as the host country, and in June 1999, 27 people from 9 national programs arrived in Tamale to begin the program, which was supported by the Swiss Development Cooperation. They embarked on a training-of-trainers residential course that lasted until October, when they graduated with the technical knowledge and skills to establish and run farmers' field schools in ecologically sound cowpea IPM decision-making.

In Tamale, as a first step, a 3-day session identified issues and produced a work plan for the season. The emphasis was on environmentally sustainable production, record-keeping for people with nonformal education, and the economics of producing cowpea and preserving the crop as a commercial venture. The participants then moved on to participatory research trials, where trainers from the Ghana National IPM Program shared knowledge and

Learning in the field how to manage a cowpea crop involved both farmers and course participants

skills-building exercises so that the participants gained hands-on experience in growing cowpea in ways that they could teach to farmers in their own countries.

At the same time, 5 farmers' field schools were set up, each with 25 farmers from a neighboring village and a group of 5 participants who worked simultaneously with the farmers and on their IPM trials. When decisions needed to be made during the season, it was the farmers and trainees who together discussed and decided what to do.

The course coincided with the cowpea cropping season. To release a group of key extension staff for an entire cropping season shows considerable commitment on the part of any national program. To ensure they can transmit the skills and techniques they have learned takes even more support. The participants realized this, and during the course they asked PEDUNE to invite policymakers to come and see for themselves. In September, 6 countries sent Ministers, Directors of Agriculture, Heads of Research, and Project Directors to Tamale where they were joined by IITA Director General Lukas Brader, and Plant Health and Management Division Director Peter Neuenschwander. All the VIPs were enthusiastic, and obviously liked what they saw, as there are now requests for similar farmers' field schools in all the PEDUNE countries.

IITA also gained. Its IPM techniques, developed in collaboration with national agricultural researchers, were well received by the Ghanaian farmers. These techniques include the use of plant extracts to control pests

> *Before this program was brought to us, we were already planting cowpea, but we did not know that we should harrow the land before planting. We did not know that we had to conduct germination tests. At the school we realized that 80 seeds out of 100 germinated from selected seed but only 20 germinated from unselected seed. We did not know that some insects are beneficial, and can eat the insects which destroy our cowpea crop. Now we also know all the dangers involved in the use of Karate® and how to handle the chemical and we will avoid eating on the farm after spraying. What interests us most is that we can now use neem leaves instead of relying on Karate® to control insect pests.*
>
> ***Ghanaian farmer***

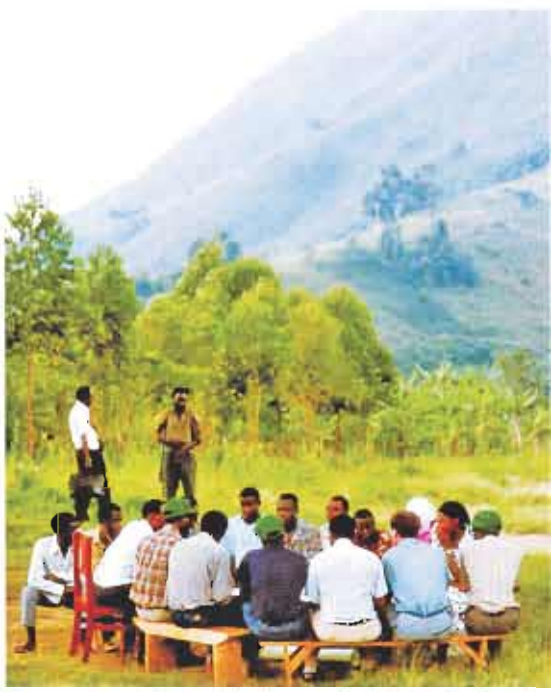
instead of dangerous and costly pesticides, improved seed storage methods, and IITA-improved cowpea varieties that have good resistance to *Striga*, aphids, and diseases. IITA staff members who took the course for the whole season alongside the country participants are now trained as trainers themselves and are in high demand to run similar courses.

The best of the bunch

Students in Uganda are benefiting from working with IITA scientists in banana research. After completing their PhD or Masters courses, they are well equipped to lead teams of researchers in the national programs.

Banana feeds about 20 million people in eastern and central Africa, but its production is threatened by a combination of weevil and nematode pests and declining soil fertility. IITA's Eastern and Southern Africa Regional Center based in Uganda started a banana integrated pest management program in 1991 using strategies based on soil and crop management and involving farmers in participatory research.

When the work started, the Ugandan National Banana Research Program (UNBRP) had only a single staff member with a PhD. Helped by the Rockefeller Foundation, IITA inaugurated an intensive program of sponsoring students to remedy this situation. By 1999, 4 staff members had acquired PhDs (2 in plant pathology, 1 in nematology, and 1 in plant taxonomy) and another had completed the requirements for an MSc in plant breeding, all under full sponsorship and supervision of IITA. Today, they are all back with UNBRP, busy leading teams of research assistants in their fields of specialization. Another student is conducting thesis research at benchmark sites in Uganda for a PhD in entomology, while two more are doing course work in the USA.



Farmers meet to decide how to fight the decline in their long-established plantations

While the students were registered at universities in Belgium, the Netherlands, South Africa, Uganda, UK, and USA; they all did their thesis research in Uganda. This involved field work, and hence interaction with farmers and extension agents. National program staff were trained by IITA scientists to do rapid and participatory rural appraisals, diagnostic surveys, and farmer participatory research, applying what they had learned to make nationwide surveys and establish benchmark sites.

As a result, current knowledge of the banana production constraints in the country is excellent. Information has been gathered on production problems, and detailed data are available on banana cultivar distribution and diversity, and on the criteria farmers use to select the varieties they grow. A major impact of the training programs is the ability of UNBRP scientists to move out of the gates of the research stations to the benchmark research sites where technologies are tested, evaluated, and demonstrated hand-in-

hand with the farming community and extension agents. A strong factor in this success is that the same staff who as students had identified the problems with farmers, are now back solving the constraints on-farm.

This positive way of ensuring that results reach farmers is augmented by group training courses for extension officers and technical staff. Farmers and local leaders also visit research stations and benchmark sites to see new emerging technologies for themselves, and to assist researchers in identifying which ones to take to the field. In the process the teams learn from each other, and everyone benefits from the booming banana production.

Loading bananas on their way to market in Uganda

In one parish in southwestern Uganda where UNBRP and IITA are working together with the local agricultural extension department, the changes made in just 3 years are testament to the real benefits that can be achieved. At the start of the experiment yields were declining, but no one could say why, or by how much. A core group of 21 farmers from the community of 600 volunteered to test a given package of technologies in their small plantations where the crop had typically been continuously cultivated on sloping hillsides without rotation for 35 years. This package included cleaning crops by weeding, and mulching to strengthen plant growth and increase soil fertility. It also involved making sure suckers were pared to remove weevils, and treated with hot water to kill nematodes before planting. Yields rose from 7 tonnes/ha in the first year to 9.2 tonnes/ha in the second, and 16.3 tonnes/ha in the third. Now 20% of all the farmers in the parish are using the demonstrated techniques, the rate of adoption is rising, and precious soil is being saved from erosion.

The thriving banana market, evidence of the crop's recovery in Uganda

Getting into hot water

Treatment of yam, banana, and plantain planting materials with hot water helps to control nematode populations and the damage they cause. IITA is spreading the word to farmers, and developing easy methods for carrying out the treatment.

In some parts of Nigeria, when seeking a bride a suitor must take up to 60 hefty tubers of yam to his prospective father-in-law before he can open negotiations. Yams play a significant role in traditional West African culture as well as commanding a high value in the market. It is a pity that the average yield of yams per hectare can be as low as 15% of its full potential. Where and how they are grown and stored, the type of yam, and the season all affect yams' vulnerability to a range of pests and pathogens.

Bananas and plantains are, like yams, a staple crop in many parts of Africa. Like all vegetatively grown crops, diseases and pests can be propagated from one year to the next on the planting materials which, in the case of bananas and plantain, are the suckers that emerge at the base of the mother plant. For yams, small tubers from the previous harvest or big tubers cut into setts are used as planting material.

Invisible to the naked eye, but found in and on the tubers and swarming through the soil, tiny worm-like nematodes are one of the most pernicious pests of yam, banana, and plantain. The damage they cause in the field prevents the plants from growing well. Yams may develop small, distorted, and unusable tubers, while the banana and plantain plants may not be able to remain standing in the field as their roots are damaged by nematodes. Even if the banana and plantain plants are able to produce bunches and edible fruits, the planting material for the next season may still be severely affected. When yam tubers are infested, both the edible part and the propagating material are affected. In yam stores the effect of the nematodes is increased, because the damage they cause makes the yams more vulnerable to secondary infections by fungi and bacteria.

A gas-heated hot water tank used to treat yams infested with nematodes

Before a yam crop is harvested, the two main types of nematodes (*Scutellonema bradys* and *Meloidogyne* spp.) can cause losses as high as 40%. And while the yams are in store between seasons or waiting to be sold, fungal dry rot and bacterial wet rot can render them unfit to sell, eat, or even plant. Nematodes live only 2–4 mm below the tuber skins where they convert starch to sugars. This alters the taste, reduces the moisture content, and even kills the yam meristems. On banana and plantain even more types of nematodes are the cause of significant losses of plants in the field. These include *Pratylenchus coffeae*, *Helicotylenchus multicinctus*, *Radopholus similis*, and *Meloidogyne* spp. Farmers really need a way to combat this unseen enemy. Working together to find a solution with colleagues in the UK,

IITA scientists in Nigeria, Benin, and Uganda are following several leads. Anything that cuts down soil populations, such as fallowing or growing a cover crop between yam seasons, can help. Farmers already tend to move to new land to avoid the problem of build-up of nematodes in their farms. Teaching farmers to recognize symptoms on banana and plantain plants and to avoid storing or planting infected yams also helps, but it is the nematodes hidden inside the tubers that must go

Testing water temperature with a candle ensures yams are not damaged by the treatment

For a long time scientists have known that plunging banana and plantain suckers into tanks of hot water will kill off the nematodes that lurk in their tissues. And for the last 25 years it has been known that the same treatment will also help solve the problem for yams. One main problem with persuading the farmers to voluntarily treat their suckers and tubers with hot water is that farmers are very suspicious that the treatment will not only kill the nematodes but also cook their yams and kill the suckers.

For yams, bananas, and plantain, farmers need to know how to handle planting material before treatment and then how to conduct the treatment. Banana and plantain suckers are usually pared to remove old and highly infested tissue before treatment. Yams are not so tough as bananas. If the water is not hot enough the nematodes survive, but if it is too hot the yams will be parboiled, will not grow, and are rendered prone to bacterial infection because their tissues are weakened.

IITA scientists have been working with national scientists, farmers, farmers' groups, and NGOs in Nigeria, Benin, Ghana, Tanzania, and Uganda to determine practical ways of making the hot water treatment workable and acceptable by farmers. IITA scientists and engineers are developing tank designs and methods of maintaining water within a narrow temperature range for the 25 minutes that is needed to kill the nematodes but not the yams, bananas, and plantains. In many cases, the farmers are already familiar with the idea of parboiling yams for yam chip production, and are able to maintain the appropriate temperatures for that treatment. Although it is likely that hot water treatment will be used by small groups under extension service supervision, in some cases farmers may want to treat their own material. The melting point of an ordinary wax candle is used as an indicator that the water is at the correct temperature.

Scientists are also investigating the ecology of the nematodes, the real effects of some traditional preventative measures such as soaking yams in a solution of wood ash, and breeders are evaluating yet more yams, bananas, and plantains in the search for those with higher resistance to nematodes. A combined approach may provide the answer. Recent acceptance by farmers of

the benefits of 'cooking' their yams, bananas, and plantains before planting is an encouraging step. Farmers are now telling the scientists who are explaining the technique that they should treat all their material in the next season and not leave some of the material untreated as a control. When hot water treatment is used for banana and plantain in combination with weevil traps and mulching of the crop stands, yields are significantly increased. Farmers who have treated their yams find that although the yield in the following season is not noticeably greater, the quality is much higher. In principle, yams could also be similarly treated prior to storage to kill nematodes at that stage; however that option has yet to be fully explored.

With the uptake of this hot water technology in both West and East Africa, IITA is helping farmers to win this part of their battle to grow healthy yams, bananas, and plantains. Although these hidden enemies may never be entirely eliminated, their impact can now be such that losses are reduced to an acceptable level.

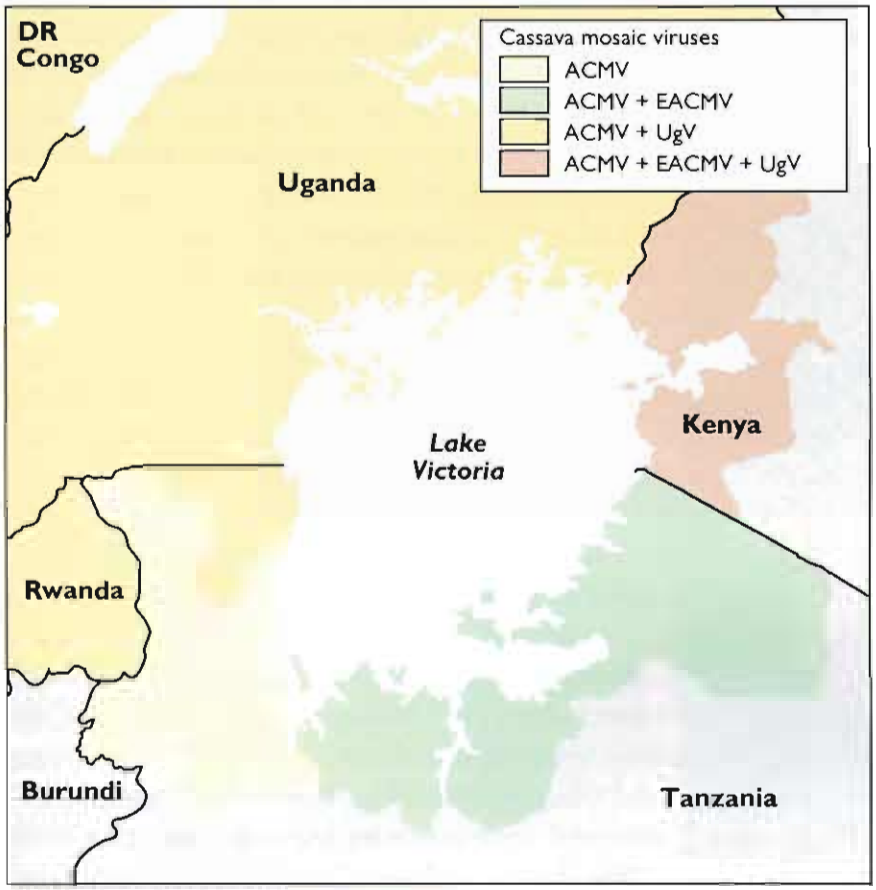
Committed to salvation

A pandemic of cassava mosaic disease across Africa is being tackled by IITA and collaborators, through multiplication and distribution of resistant cassava varieties.

For the last 20 years IITA and the Office of Foreign Disaster Assistance of the US Agency for International Development have been major investors in a fight against cassava mosaic disease (CMD). Over US$9 million has been spent, including contributions from such NGOs as CARE, Oxfam, and Sasakawa Global 2000, together with the Canadian International Development Research Centre and the Government of Uganda.

Cassava is the paramount staple food security crop in sub-Saharan Africa, and a mainstay of the rural, and increasingly also the urban population. Peak production in Uganda was 3.5 million tonnes in 1989, when a new CMD suddenly became so severe that cassava production fell by 35–40% within 10 years. The varieties farmers were growing were highly susceptible to this CMD. When these failed, and when drought struck at the same time, people starved, for they had no famine reserve. By the second half of the 1990s the situation was grave, and the CMD pandemic, as it was called by then, was spreading fast. It swept from Uganda to western Kenya, southward into Tanzania, and into Sudan, and has recently been detected in the Republic of Congo.

IITA worked on the vector of the cassava mosaic virus, a small whitefly called *Bemesia tabaci*, with funding from the Danish International Development Agency during 1997–99. IITA scientists and their NARS colleagues in eastern Africa monitored the spread of the disease and were able to forecast the areas under threat. Work on the virus itself revealed reasons why the problem was so severe—there are several strains of the African cassava mosaic virus (ACMV) involved. ACMV is found in southern Uganda and western Tanzania; the rest of Tanzania is mainly affected by ACMV together with East African cassava mosaic virus (EACMV), while Uganda has ACMV plus a particularly virulent variant known as the Uganda variant (UgV). In western Kenya along the shores of Lake Victoria and spreading into southeastern Uganda, there is a lethal combination of ACMV + EACMV + UgV. Annual cassava losses in



Distribution of cassava mosaic virus strains

Uganda were estimated at US$60 million, and in Kenya at approximately US$100 million.

Faced with the prospect of cassava crops failing across the region, an emergency program was started in 1998 and has had remarkable results. Rapid funding helped, as did the commitment and combined effort of IITA and the national programs. They worked together with NGOs and 2 regional networks to ensure not only that farmers had access to sufficient planting materials of resistant varieties, but also that they were involved in the multiplication process. Farmers also learned how to process and market their crops. The disease was monitored and mapped, and NARS technicians learned how to diagnose the viruses. The national programs have also been involved in developing new material in case the virus produces yet another variant causing currently resistant varieties to again become susceptible.

IITA has a long-term policy of breeding for resistance, and it was extremely fortunate that varieties held in trust in Nigeria, some of which had originated in eastern Africa many years ago, were found to be resistant to all the virus strains when tested across the region. Resistant material continues to be needed; each country will need 2000000 stems a year. In 1999 alone, 5834 bags of stems were sent out from various institutes in the region, enough for over 2000 farmers to plant 466 hectares.

Multiplication at other locations meant that materials reached 7000–8000 beneficiaries. Six new mosaic-resistant cassava varieties that had been developed in earlier projects were released to farmers. With funding from the

UK Department for International Development, the Uganda National Agricultural Research Organization published a National Strategy Document for Cassava.

Meanwhile, over 760 people were trained in processing and utilization, and 111625 kg of high-quality flour was produced; new market opportunities were surveyed and more machinery came into the region where 16 processing sites are operating with NGO support. Plant health aspects of the campaign were also successful, with pest and disease constraints evaluated at 265 locations, and monitoring and forecasting linked across the region. Through the CGIAR systemwide whitefly integrated pest management project, technicians went to the UK to learn new diagnostic protocols, and the virus diagnostic capacity was strengthened to include biotechnological techniques to detect both viruses and whiteflies. New germplasm development moved rapidly ahead in 1999, with thousands of clones being evaluated at several locations and selected elite clones moving into multilocational trials across the region.

More than 15 institutional stakeholders are now involved in the campaign. Its outstanding success is due to the broad commitment to ensuring that farmers' crops are saved, that food security is maintained, and that the region becomes self-sufficient in combating and containing the CMD menace. IITA's contribution has been, and continues to be, one of the mainstays of the campaign.

Processing pays

IITA's processing equipment greatly reduces processing losses and labor requirements, while enhancing food quality. Trends of increasing adoption were consolidated in 1999.

Producers and consumers in a band of countries that spans Africa are benefiting from the use of simple, sturdy machines designed and developed by engineers at IITA, and made by local fabricators. Commitment to quality and practicality is the key. IITA staff have trained 99 technicians from 8 countries since 1994 to make the machines. In turn, these manufacturers train their sales and maintenance staff who are in direct contact with the users. And the users, from individuals to cooperatives, NGOs, and women's groups, do not hesitate to say what they really need. Feedback rapidly reaches the design team, which regularly visits the manufacturers to suggest modifications, check on product quality, and give a 'seal of approval' to machinery that meets the design standards.

Maize producers queuing to use an IITA developed multi-crop thresher at a processing center

The results are soaring sales of both machines and products, and happy users, who can add value to their crops by processing them into foodstuffs that appeal to rural and urban consumers alike. Best of all, women are liberated from hours of backbreaking drudgery. It normally takes 6 hours to prepare enough cassava for a family to eat; using the IITA-developed package it takes only 2.

As agricultural production improves and farmers harvest more, they must be able to process their crops or risk losing them through poor storage and other postharvest losses. The longer produce waits to be processed and reach consumers, the lower its quality. Traditional processing methods are often slow, wasteful, and labor-intensive. To ask women, who usually do this work, to process more than their families need to eat is difficult, and takes them away from other tasks such as helping to grow crops that could be sold to generate money for education and health care.

Frying is the last stage in preparing *gari* from cassava

The Sasakawa Africa Association (SAA), a nonprofit NGO, teamed with Sasakawa Global 2000 to work on transferring appropriate food crop production and postharvest technologies through national programs. IITA was asked to help, and since 1994 funding has been provided through a Postharvest Development Fund.

The partnership is working well, as demonstrated by just 2 examples from over 20 pieces of equipment already developed, tested, and in use. In 1995, only 9 mechanized cassava graters were made and sold in Ghana and Benin. In 1999, 111 graters made in Ghana were sold to farmers and processors in countries including Côte d'Ivoire, Guinea, Uganda, and Zambia. This machine can reduce processing losses by 54%, equivalent to an additional crop yield of 500 kg per tonne of field yield. It can also save up to 75% of the labor needed for processing.

The second example, a multi-crop thresher, is driven by a small petrol engine similar to the one used for the grater. Earlier mechanical threshers used large diesel engines that were difficult to manage. The multi-crop thresher is mobile and highly versatile—it can be used on a range of crops

Many hands make light work as farmers gather to peel and process their cassava

that have different sized grains, from large maize to tiny teff. Introduction of the thresher to Benin encouraged farmers to grow more quality protein maize (QPM), which improves the nutrient content of consumers' diets. Before threshers were available, adoption of QPM had been slow because it is harder than local varieties and difficult to thresh and pound by hand. By 1999 the number of threshers in use in Benin had increased to 11. In Ethiopia, 3 threshers were introduced in 1998. Prior to this, teff was threshed by spreading it on the ground and driving cattle over it, which contaminated the grain. Local manufacturers had 20 threshers ready for distribution by the end of 1999.

Using the mechanized grater means less waste and more cassava to eat and sell

In some countries, model processing centers have been established where producers can see machines in action, try them out, and see a range of end products that they can sample and learn how to make in addition to their traditional foods.

As populations grow, the need for processed foods increases. This joint venture is helping to ensure that everything the farmers harvest, reaches hungry people in the form they prefer to eat it. And, as crop diversity widens, farmers can now choose to grow those better suited to their environments, such as cassava instead of traditional maize in drought-prone areas. If they are able to process and sell cassava products, these farmers can then buy the maize their families prefer to eat.

In Agodenou village in Benin, an active women's group works with representatives from SAA and IITA who visit from time to time to monitor the progress of the cassava-processing center they helped the group to establish. The women work in their fields in the mornings, and in the afternoons come together to collectively process their own crops and those of farmers from neighboring villages who pay for the service. The products are of such good quality that traders from the major town of Cotonou have heard about them and now regularly visit to buy direct from the village, saving the villagers from the wearying task of carrying heavy sacks to the local market 2 km away. In the same village, where a general air of optimism and well-being prevails, many farmers no longer process palm oil, preferring the profits from processed cassava. The women, who have abandoned their traditional hand processing methods,

> *They give us more and better food and we can still sell some. We have more time for our farm and family. We will tell the women in the other village. And we will teach them too!*
>
> **Mama Chindo**
> **Farmer/Head of family**
> **Bajama Village, Nigeria**

now employ a young man from the village to help run and maintain their machines. He also keeps detailed daily records that will be used to assess the project's impact. This group has done so well that they intend to extend their processing shed and buy more equipment to increase their capacity, certain of the demand for their services and the profits they can accrue.

Cassava catches on

Cassava production is being promoted in Sahelian countries, using drought-tolerant varieties selected for local conditions.

Over half of the world's cassava is produced in the humid and subhumid tropics of sub-Saharan Africa (SSA) where it is a major crop grown mainly by small-scale farmers. Cassava storage roots are a good carbohydrate staple, and its leaves are a cheap rich source of protein for humans and their livestock. Cassava adapts widely, is drought hardy, and can be grown in the cool highlands and sub-tropics. It can live in poor soils and can survive and recover from damage from some pests and diseases. Mature roots can be left in the field for up to 36 months to act as a food reserve. During the last decade, cassava has served as an emergency crop during civil unrest in Angola, Burundi, Liberia, Mozambique, Rwanda, Sierra Leone, and Uganda. In the severe droughts of the early 1990s in southern Africa, it provided food in areas where cereal crops had failed. Countries which try to bridge the food gap by importing cereals often face negative trade balances, and then when local currencies devalue, external debts escalate. The alternative is to produce enough food at home—and cassava can help to do just that.

Women farmers in Chad selecting cassava varieties to try on their farms

In recognition of cassava's potential, the International Fund for Agricultural Development and the Office of Foreign Disaster Assistance of the US Agency for International Development are supporting collaborative efforts to promote cassava production and use to avert famines and provide a source of cash income for farmers. This is being implemented through IITA in collaboration with CIAT.

There is also increasing interest in cassava in Sahelian countries where IITA has been using a farmer participatory approach to get good varieties to farmers who need them. A survey of 40 villages in each of the 5 target countries—Burkina Faso, Chad, Ghana, Niger, and Nigeria—helped to pave the way by providing authentic information on the constraints, opportunities, and priorities for cassava production. Within 3 years, 5 countries have received cuttings, seeds, or plantlets from IITA. They have tested, evaluated, and selected them in their local conditions, and already have material ready for release to farmers and on-farm trials.

Plantlets get used to local conditions in homemade humidity chambers

How was it possible to help the NARS of these countries so effectively? Firstly, IITA had the germplasm collection. Secondly, a wealth of knowledge about each germplasm accession and its potential was available in a catalog so that breeders could make selections. Thirdly, there were tried and proven techniques to ensure that any material that was sent to another country arrived safely and clean from known viruses and bacterial diseases. And, ways to multiply the planting material rapidly had been developed with many extension services staff and farmers taught to use them. Special care is needed to rear the small cuttings, and special skills are required to make protective covers for the tender plants from cheap local materials.

We visited the World Vision house where Paul Ilona is tending to the IITA cassava plantlets in Angola. At the time, things were going remarkably well. I don't think he had lost a single plant. Seeing this work going on in the bombed city of Ndalatando was a highlight of our meetings.

Joe DeVries
formerly of Food Security Program
Africa Region,
World Vision International

Farmers are discouraged if they cannot sell their extra produce, or if the prices are too low. Through the IITA-led campaign, 2 sets of recently developed cassava processing machinery were sent to each of the 5 participating countries, and producers have been shown how to use them to make value-added food products. For instance, in Niger and Burkina Faso, processed cassava in the form of *gari* was once imported from the humid zones. Now, women's groups and farmers' associations in rural areas are processing their own crops to produce *gari* for their own consumption and for export to larger cities such as Niamey and Ouagadougou. Now they can avoid market gluts and add value to their crops by turning out good quality processed products that appeal to consumers.

Over the last 3 cropping seasons, huge volumes of seed have reached all the campaign countries. These introductions include broad-based seed populations and clonal germplasm from IITA, clonal selections of African landraces, and seed populations sent from Latin America through CIAT. These valuable materials have been evaluated and selected by NARS, farmers, women's groups, and NGOs in on-farm trials.

By the end of 1999 some 600 women and 1000 men farmers had been involved in evaluating and selecting material in the 5 countries. Working with their national programs they had selected 49 improved genotypes: 14 in Burkina Faso, 14 in Chad, 6 in Ghana, 7 in Niger, and 4 in northern Nigeria. In the current 1999/2000 season, using Ghana as a typical example, at 68 locations 90 farmers are growing trials and 270 more are benefiting from them, and by the end of the season an additional 630 farmers will have access to improved genotypes.

Farmer field days have been held in all the countries over the past 3 seasons. A product and market development course was held at IITA's station in Benin in 1999, and in mid-1999 a 4-week training workshop was held at IITA's station in Ibadan, Nigeria. This course helped 14 national program scientists from 9 countries (including the 5 target countries) improve their knowledge and cassava breeding skills through an agroecological approach.

Bulk stocks of cassava stakes ready for distribution to farmers in northern Nigeria

Is this all working? Most certainly, and in all the countries. In 1999 in northern Nigeria the Practicing Farmers Association collaborated with IITA to ensure that 235 farmers received over 210 000 planting stakes of 4 varieties that will go into the ground this season. Similar numbers are reaching farmers in all the participating countries, and when they in turn share them with their neighbors cassava will really have caught on in the Sahelian region.

Cleared for take-off

Using in vitro meristem culture techniques to clean, multiply, and disseminate IITA's improved yam and cassava germplasm to reach beneficiaries in any location.

Moving plant material around the world is easy as seed, but not as vegetative material. In recent years the demand for large volumes of vegetative material has increased, partly due to the efforts of the US Office for Foreign Disaster Assistance (OFDA) programs to boost food production in several African countries. What can be done to make sure that crops multiplied as cuttings or parts of tubers are free from pests and diseases, particularly those caused by viruses? Biotechnologists at IITA blend sophisticated meristem culture protocols and practical containers to make sure that large quantities of living germplasm can travel safe and sound to distant destinations.

Cassava and yam are two crops that need to be multiplied quickly. They do set seeds, but these are highly heterozygous and clonal material is preferable. Traditionally, only 10 stakes are cut from each parent cassava plant. IITA has developed a way to make 2-node cuttings or ministakes that can make 50 plants from each parent. These ministakes are easily moved and protected in

plastic sacks until they can be grown on and hardened in individual plastic bags or nursery beds before being planted in the field. When yam 'seed' tubers are cut into large pieces and planted by farmers, only 6 new plants result from each parent. But if smaller pieces are cut and cared for properly, 20 pieces can be made from each parent. IITA has trained over 6000 farmers to use this technique in Uganda alone, through a program funded by OFDA.

These are relatively simple ways to speed up multiplication, but generating clean stocks and ensuring stored germplasm is free from known viruses is of paramount importance. IITA holds in trust genetic resources of cassava (2417 accessions) and yam (3190 accessions) including both wild and cultivated species. To date 400 of the cassava stocks and 70 yams have been through a series of lengthy procedures to rid them of undesirable organisms. After meristem culture, heat treatment, and virus indexing, clean virus-tested yam and cassava material has been sent to over 40 countries worldwide.

To produce each new plantlet for introduction and evaluation by a national program costs US$0.50–1.00, a worthwhile investment that is enabling breeders to get what they need. When breeders in the Democratic Republic of Congo wanted yellow root cassava that is rich in carotenoids and vitamin A, they used the IITA germplasm catalog and found 6 varieties they wanted to try. These were multiplied from virus-tested material held in the tissue culture laboratory at IITA in Ibadan, Nigeria, and were soon ready for shipment.

In 1999, 5404 yam plantlets ranging from 2 to more than 20 genotypes went as in vitro cultures to national programs in Chad, Ghana, Nigeria, and Rwanda for field evaluation, and to the UK and Australia for biotechnology research. The numbers of minitubers (produced in a screenhouse from plantlets) were even higher: 13 906 of 42 genotypes went to Benin, Chad, Ghana, and Togo, with the bulk to Sierra Leone. For cassava in 1999, 17 085 virus-tested plantlets went in 12 consignments to 11 countries, with the bulk to Tanzania and Chad. These included 22 selected African landraces and 386 improved genotypes. The 1999 total was only slightly lower than that of the peak year, 1997, when 21 040 plantlets were distributed, including over 18 000 sent in collaboration with World Vision International to Angola under the Seeds of Freedom Project. To reduce the bulkiness and for ease of transport, a compact packaging system for yam plantlets has been developed. Plantlets are packed into special plastic boxes (6.5 cm × 6.5 cm × 7.5 cm) that can each hold 100 to 120. The plantlets travel safely and can survive for 7–10 days in transit.

Culture incubation room for the production of cassava and yam plantlets

Because of the huge demand, material is constantly being multiplied and newly selected germplasm cleaned at IITA. It takes about 9–12 months to rid a plant of pathogens. Once the plants are cleaned they can be rapidly multiplied in vitro whenever needed. One plantlet can become 4–5 plantlets in just 3 weeks. For multiplication in special insect-protected screen houses

it takes 6–8 months for cassava plants to grow large enough to make mini-stakes, and yams 6–7 months to make minitubers.

Once plantlets and minitubers reach their destinations they must be carefully grown on by trained technicians in the national programs. IITA has worked with and helped to train national program staff in 10 countries to do this. Plants are then ready to be evaluated for their suitability to local conditions. These stalwart efforts are now making real differences in farmers' fields. Some of the IITA cassava and yam germplasm distributed as in vitro plantlets has been released for cultivation in several countries. One of the most significant contributions has been the release of 4 cassava varieties to farmers in Uganda and Tanzania to combat the devastating pandemic of cassava mosaic disease in eastern Africa. And far away in Western Samoa, 3 yam varieties from IITA are being cultivated by farmers in the Pacific region.

Yam plantlets are safely transported in specially designed plastic boxes

IITA is keen to strengthen regional capacity within the national agricultural research systems, by providing technical assistance in setting up tissue culture laboratories. In 1999 an IITA scientist went to Kenya to help the Muguga Plant Quarantine Service of the Kenya Plant Health Inspectorate Services with its plans to develop extended quarantine facilities. This was to ensure that virus-tested cassava material can move rapidly into and around eastern Africa where cassava mosaic disease is threatening farmers' livelihoods.

Blending tradition and biotechnology

Using the latest biotechnological techniques in combination with farmers' indigenous knowledge, scientists are unraveling the complex genomes of yams whilst exploring their rich genetic diversity.

Part of the cultural heritage of West Africa, yams are in constant demand and favored types command high prices. Yet surprisingly little improvement work on the crop was undertaken until IITA boosted its efforts 8 years ago. Most farmers still grow landraces in the traditional way and pay handsome premiums for those with preferred flavors, even if they are prone to rot and virus diseases. Seed yams, weighing an average of 400 g, cost approximately 10 US cents each, and it takes about 10 000 to plant a single hectare. If they do not buy new seed yams, 30% of farmers' crops must be used to plant in the following year.

Yams are a very convenient crop. They can be planted when the soil is dry and labor demands are low. Once planted they wait patiently for the rains, or send out a bare vine that is ready to put out its leaves when the rains come. Genotypes are strongly influenced by the environment in which they are grown. However, they do not like drought late in the growing season and

cannot survive it as well as cassava. Such traits may well deter a plant breeder, but the yam does have a rich wealth of biodiversity. IITA scientists have assembled genotypes from collections as far away as Puerto Rico and the South Pacific, and made collecting trips to several West African countries to widen the genetic base for breeding. Yams from Cameroon are particularly interesting, and countries such as the Central African Republic and the Democratic Republic of Congo may provide even more treasures to share.

At IITA, scientists are busy describing the physical and biochemical characteristics of each accession in the collection and assembling a catalog using internationally agreed descriptors. Biotechnologists are identifying molecular markers to facilitate selection for specific traits, and are developing techniques by which yams can be rapidly multiplied, both through tissue culture, and by using small pieces for field multiplication. The use of biotechnology in the detection of pathogens means that when collections of genotypes or planting material are sent to other countries, they have tested negative for known viruses. Meanwhile, breeders are aiming for plant types that can resist pests and pathogens and can yield well in less-fertile soils, but still taste good.

Farmers come into the picture very early in the development of new yam varieties. Mr Adepomola is a typical collaborator. He is the chairman of a farmers' cooperative in Osun State, Nigeria, and farms about 50 hectares himself. He has been helping to evaluate IITA material and in 1997 the cooperative was given 10 hectares of land by a local chief on which to multiply selected material from IITA. Mr Adepomola regularly visits IITA to see material in the field and to select the types he likes

Some yam varieties produce true seeds – but irregularly

Through collaborative evaluation of IITA-derived genotypes with the Nigerian National Root Crops Research Institute, 3 lines of white yam are now ready for official release in Nigeria. With support from the UK Department for International Development, more lines are in the pipeline, and root crop programs in Benin, Burkina Faso, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Sierra Leone, Tanzania, and Togo are also testing IITA-bred material. In Uganda, traditional genotypes are being combined with improved material from IITA and tested by 4000 farmers through a program supported by the US Office for Foreign Disaster Assistance.

Better understanding of available genetic diversity and the breeding potential of specific accessions is important for the efficient choice of parents for breeding. Yams are polyploid, male and female plants are separate, and both are needed for true seed to be set. Early testing of progenies from hybridization is complicated by yam's slow multiplication rate and a juvenile

phase during which it is unreliable to use conventional screens for some economic traits. Molecular markers are genetic tags that indicate the presence of genes that control economic traits. These markers enable selection for economic traits even at an early stage of the plant's growth, thus enhancing the speed and efficiency of selection. Funded by the Gatsby Foundation and working with the John Innes Institute and the Natural Resources Institute in the UK, a concerted effort has been made by IITA in the last 5 years to develop molecular techniques to unravel the yam genome. The international team of biotechnologists hopes to build a genome map and to use 'DNA probes' to locate the genetic traits responsible for resistance to viruses, anthracnose disease, and nematodes.

Selecting preferred types of yam in the IITA barns for farmers to multiply

By the end of 1999 considerable progress had been made in developing genetic linkage maps for 2 species of yam using molecular markers. For the first time genetic analysis has revealed that yams are allo-polyploid, a fact that strongly influences genetic analysis and breeding strategies. Clonal evaluation of 4 mapping populations and their reactions to viruses, anthracnose, and pests was progressing and adding to the linkage map that will eventually be used to provide a basis for marker-assisted genetic improvement.

Molecular techniques have also been developed to detect pathogens. International exchange of germplasm was limited because there was no way to detect viruses other than by growing plants and checking them for symptoms. With the current suite of detection tools, it is fast and simple to test a small disc of leaf material. Using these techniques coupled with meristem culture, material from Asia and Latin America can now be imported and cleaned to swell the gene pool.

About 2000 accessions in the IITA gene bank have now been comprehensively characterized by morphological descriptors, and molecular marker characterization is catching up. Using meristem culture and the enzyme-linked immunosorbent assay technique, 70 of the selected yam accessions in the gene bank have been cleaned from virus infection and other diseases, and are available for safe distribution worldwide.

The Australian-based Center for the Application of Molecular Biology to International Agriculture (CAMBIA) *and* IITA *have formed a close working relationship.* CAMBIA's *Executive Director is now also* IITA's *Director of Strategic and Applied Molecular Technologies. An agreement, signed in 1999, forms the basis for cooperative crop improvement work. This will allow* IITA *to take advantage of cutting edge developments in cellular and molecular biology and will allow* CAMBIA *to see its technologies applied to the reduction of poverty in sub-Saharan Africa.*

More than a security blanket

Cover crops can enhance soil nutrients and provide livestock fodder. Researchers linked by e-mail are conducting coordinated experiments across Africa and exchanging results.

Traditionally, land is often left fallow to allow natural vegetation to replenish soil organic matter and nutrients for subsequent crops. Yields of crops sown after a fallow are usually much higher than those of crops grown season after season on the same land. However, this period of natural regeneration can take many years. As population pressure increases in Africa, natural fallows have been shortened, to the extent that in some areas there is now a dangerous spiral of declining fertility and falling productivity.

When a cover crop is planted instead of leaving land fallow, the levels of organic matter, nitrogen, and other vital nutrients in the soil may increase at a faster rate. The cover crop itself can provide fodder for livestock, either to graze or as hay, while livestock manure in turn enriches the soil further. Soil blanketed by a cover crop is less likely to be invaded by weeds that would otherwise have to be laboriously removed by hand or treated with costly herbicides.

Few researchers can hope to master all the complex facets of investigation involved in evaluating the wide range of potential cover crops available and introducing the best ones to farmers. However, their task has been made a little easier by CIEPCA (Centre d'information et d'échanges sur les plantes de couverture en Afrique), a network supported by Canada's International Development Research Centre and coordinated by IITA, from the Institute's station near Cotonou, in the Republic of Benin. As well as publishing a newsletter, organizing workshops, and helping to distribute cover crop seed, CIEPCA has provided computers and e-mail facilities to link cover crop enthusiasts scattered throughout West Africa to one another and to their counterparts around the world. Such peer networking can help empower researchers to tackle the many complex tasks in sustainable agricultural development.

Sheep grazing a field of *Stylosanthes* pasture

But how well does Internet-based networking function in Africa, in the face of uncertain power supplies and other challenges associated with the region's limited infrastructure?

The CoverCropNet experiment launched by IITA in 1999, with support from the US Agency for International Development's AfricaLink program, is trying to find out. Although they rarely meet, except by e-mail, the 40 researchers participating in the trial managed to agree on the design of a field experiment, that was subsequently planted at some 30 sites across 7 West African countries. Formally, the experiment tests the hypothesis that specific cover

crop planting regimes will yield substantial benefits over the usual fallow in terms of soil fertility restoration, livestock feed, and weed control. Problems in design and implementation were discussed and resolved jointly. Other members of the network provided expert advice on-line, as soon as it was needed. In essence, it is one grand experiment, with coordination through the use of e-mail.

Ideally, all scientists would have access to high quality Internet services, but the penetration of Internet service providers varies widely across the region, and in some localities it simply was not feasible to provide e-mail facilities during this first year of the experiment. Participants at these sites planted the trial but technical support was provided by the CoverCropNet coordinator traveling, writing letters, faxing, or phoning from his base at IITA, Ibadan. This difference in the access to information provides the basis for a second-level experiment. Comparing how successfully the participants managed the trial, with and without the support of the e-mail-based network, will show the extent to which Internet technology really can provide cost-effective support to development efforts. The results of the experiment are still being gathered, but if the conclusion is that e-mail networking has demonstrable benefits, then every effort will be made to connect the rest of the experimenters.

Some types of fodder are preferred by livestock

Cover crops are not new. They have long filled a valuable niche in many different cropping systems. However, the time is ripe for them to play a wider role as the environmental situation worsens. Cover crops offer many potential benefits besides soil fertility and weed control. IITA has realized this and is now investigating cover crops as livestock feed, to enhance phosphorus nutrition for cereal crops that follow a herbaceous legume, and to control nematodes, speargrass (*Imperata cylindrica*), and *Striga* species. These initiatives bring together many associated aspects of research across the region, and involve IITA scientists from several disciplines and projects. For example, a collaboration with ILRI includes working on aspects of cover crops as livestock feed. This involves growing many cover crop species for seed so that network members can have access to a wide range of genotypes for evaluation and selection of those best suited to their crop/livestock system and the ecosystem in which they work and farm. Data from ILRI show that interest in cover crops is growing on a global scale: 27 000 adopters are growing forage legumes on 10 000 hectares in 15 countries. One thing is sure—e-mail provides a fast way to trade results and share experiences around the region.

Plants that make fertilizers

Phosphorus 'fixed' in the soil, and so unavailable to crops, can be freed by certain leguminous plants. These plants can also be used to break down widely available rock phosphates for use by following crops.

Phosphorus (P) is a vital plant nutrient, but unfortunately it is in short supply in many of the soils of West Africa. Without P crops cannot yield to their full potential. Legumes, which are crucial components of the low-input cropping systems of millions of poor farming communities, need access to P to enable their root nodules to fix nitrogen (N) optimally. Their ability to fix N means they can improve soil fertility and reduce the need for farmers to spend money on fertilizers. But P applied in costly fertilizers can be 'fixed' in the soil by iron or aluminum oxides, rendering it unavailable to plants. Can plants themselves break the links of these chains? Perhaps, and if so, can they be encouraged to do so by selecting and breeding for the ability to scavenge P?

Mucuna (above) that is treated with rock phosphate grows more luxuriantly than an untreated crop (below)

IITA scientists, working with colleagues in the national programs of Benin, Côte d'Ivoire, and Nigeria, and the Katholieke Universiteit Leuven, Belgium, funded since 1997 by the Belgian Government through the Belgian Administration for Development Cooperation, are hopeful that this can happen. The exciting possibility of breeding food crops like soybeans and cowpea and cover crops like *Mucuna* that could release the P chained up in savanna soils is coming nearer to reality.

Even more hopeful is the chance to capitalize on a locally available, inexpensive fertilizer source.

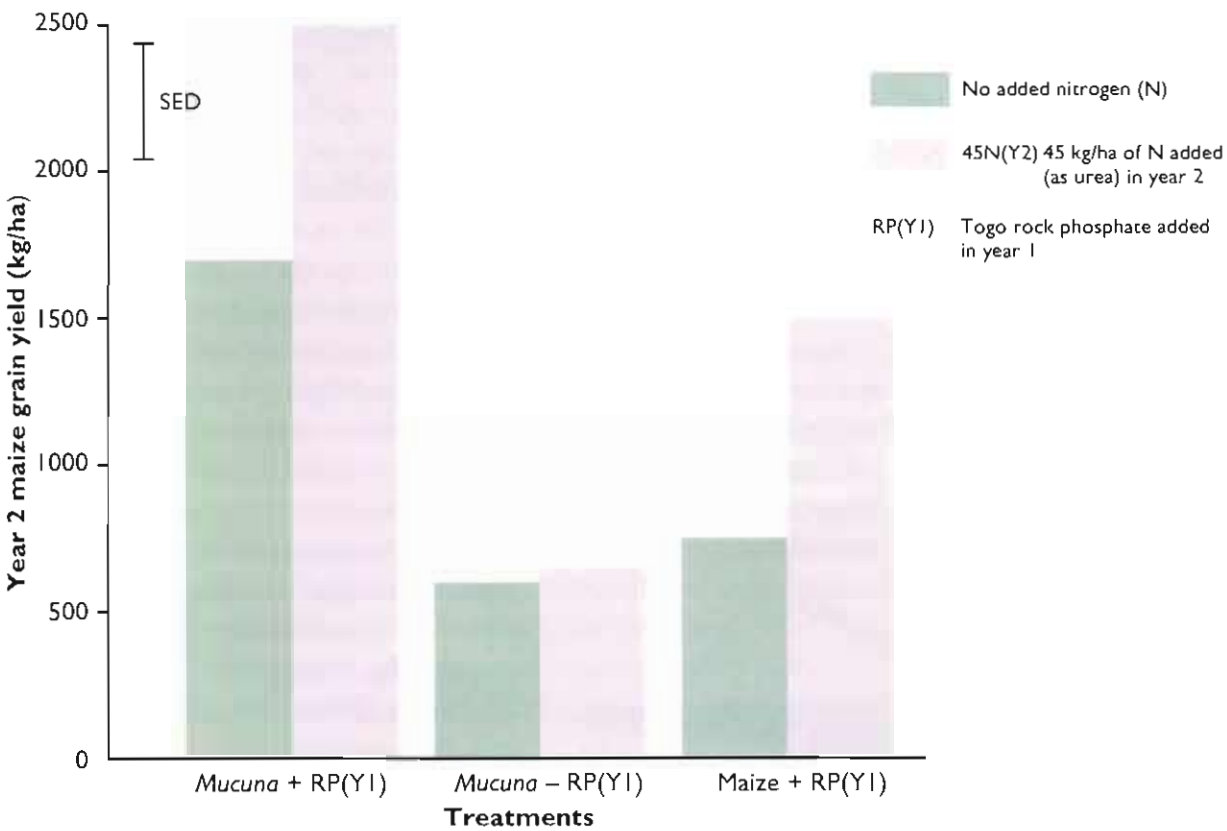
There are huge deposits of rock phosphates in several countries of West Africa, but few plants can use P in this form. The rock needs to be treated with acids before it can be applied to the soil, where P is released to plants. However, trials in Nigeria have shown that cover crop legumes like *Mucuna* can break down the rock phosphate, use it to grow luxuriantly themselves, and as a bonus, leave available P in the soil. Maize crops grown the following year yield far more grain than crops grown after a previous crop of maize. How can legumes do this? If the mechanisms were known they could be exploited.

The answer lies in the soil, but in a very specific part, the 'rhizosphere' or that part of the soil that is in immediate contact with a plant's root. It is in the rhizosphere that legume roots interact with soil fungi and bacteria that can act as catalysts to the reaction with P. And it is into the rhizosphere that legume roots exude the acids that dissolve rock phosphate. Researchers are delving deep into the rhizospheres of legumes to find out which ones are the most able to unchain bound P. They already know there are differences between species, and within species between genotypes.

This opens the door to the exciting possibility of selecting food crops like soybean, or cover crops like Mucuna *that could grow in P-deficient soils and make their own fertilizers.*

The implications are good news for farmers. If there is policy support to make rock phosphate available to farmers at a price they can afford and distributed to where they can buy it, then a really good package of practices could be developed. Growing legumes with added rock phosphate will increase the organic matter in the soil. If only half the amount of fertilizer P that is usually applied to a maize crop to obtain its optimum yield were to be used on a maize crop following the rock phosphate-treated legume, the maize yields would be optimized.

The comatose soils of West Africa certainly need the chance to be revived by plants that can make their own fertilizers. In combination with rock phosphate and a small quantity of fertilizers, herbaceous legumes offer the balanced nutrition system that cereals need to realize their potential.



Maize grain yields following different treatments over 2 years

Flexing green muscles

A biopesticide effective against locusts and grasshoppers has gained wide approval and is moving into commercial production.

In 1989 LUBILOSA (Lutte biologique contre les locustes et sauteriaux) researchers discovered an isolate of the fungal pathogen, now called *Metarhizium anisopliae* var. *acridum*, that can kill locusts and grasshoppers, and gained a new weapon in the fight against the pests that have devastated crops for millennia. LUBILOSA is a multi-institutional collaboration project involving CABI (the Centre for Agriculture and Biosciences International), IITA, the German Agency for Technical Cooperation, and the Interstate Committee on Drought Control in the Sahel.

An oil-based formulation of *Metarhizium* spores has been developed and named Green Muscle® for its powerful yet environmentally friendly effect. Using a small micron sprayer, a farmer can spray his crops with a barrier of spores that can survive in the environment for up to a year. Once skeptical farmers and plant protection officers saw the effects in participatory field tests, they were keen to spend the short time needed to spray their crops once with Green Muscle®, instead of several times a season with costly, risk-fraught pesticides.

A band of locust hoppers ready to swarm. Spraying them with Green Muscle® could save many farmers' crops

Now supplies of Green Muscle® are needed and donors are taking interest. Luxembourg-funded Lux Development, which supports the Niger Plant Protection Agency, has launched a purchase order for enough to treat 10 000 hectares. And in the Mopti Diocese of Mali, the Catholic group MISEREOR has bought the green product to kill the Sahelian grasshoppers that compete with drought to rob farmers of their meager harvests.

IITA scientists have been kept busy with these developments. In addition to confirming the effectiveness of Green Muscle® against a wide range of locust and grasshopper species, stringent tests were carried out to ensure that it had no negative effect on humans and their environment. Through these tests Green Muscle® won formal approval from the Food and Agriculture Organization of the UN. Green Muscle® has been registered in South Africa, and is expected to be accepted by the registration authorities in more countries of sub-Saharan Africa. It was originally hoped that enough Green Muscle® to meet demands could be manufactured under the control of several national agricultural research systems. The production process, however, proved to demand specialist facilities and quality

Schistocerca gregaria, the desert locust (adult)

The International Biopesticide Consortium for Development (IBCD) is a consortium of organizations committed to development cooperation through shared knowledge and partnership. It aims to enable the globalization of biopesticide technology, to contribute to the advancement of biopesticide enterprises in developing countries, and to ensure the successful utilization of biopesticides as a component of integrated pest management and sustainable agriculture. Objectives are to improve crop production, alleviate poverty, and reduce health and environmental costs associated with the use of chemicals.

IBCD brings together in partnership IITA, CABI, and the Natural Resources Institute in the UK, Biologische Bundes-Anstalt in Germany, PACE Consulting in the USA, and a former IITA scientist now operating in Turkey. A Memorandum of Understanding has been signed and donor funding is being actively sought for this worthwhile venture.

***Zonocerus variegatus*—adults (left) and nymphs (right) cause serious damage to cassava and other West African crops**

control procedures. Partnership was therefore sought with commercial enterprises willing to establish Green Muscle® production facilities on a scale that could service not only the countries in northern Africa, but also in southern Africa where additional locust and grasshopper species attack crops. Two such enterprises have been identified, National Plant Protection (NPP) in France and Biological Control Products (BCP) in South Africa. The know-how acquired by IITA in establishing its relatively modest production facility in Benin has been passed on to these companies. Once NPP and BCP are in volume production, an environmentally acceptable and highly effective weapon will be widely available. But the story is not over; there will still be a need for the LUBILOSA partners to be involved. Satellite-assisted surveys can suggest where locust bands might be, but local survey teams still need to confirm they are there. And the manufacturers need technical assistance as they gear up their production capacities. Greater impact is expected as countries such as Japan, one of the most important donors of insecticides to West Africa, register the product and support its use.

Viable alternatives

Alternative strategies to the traditional 'slash-and-burn' are needed to conserve the remaining half of Africa's forests. Effective research, conducted with coinciding benchmark areas.

Most projects start by spending a lot of time, money, and effort on selecting a place to work, and determining baseline information. How useful if someone is there before you and is willing to share information. How much more useful if the knowledge is linked in with a network covering the region or around the world, so that experiences can be compared and evaluated. The initial investment soon pays off as more organizations and researchers hear about the location and want to participate. Each brings their own research, and when results are shared the sum is greater than the parts.

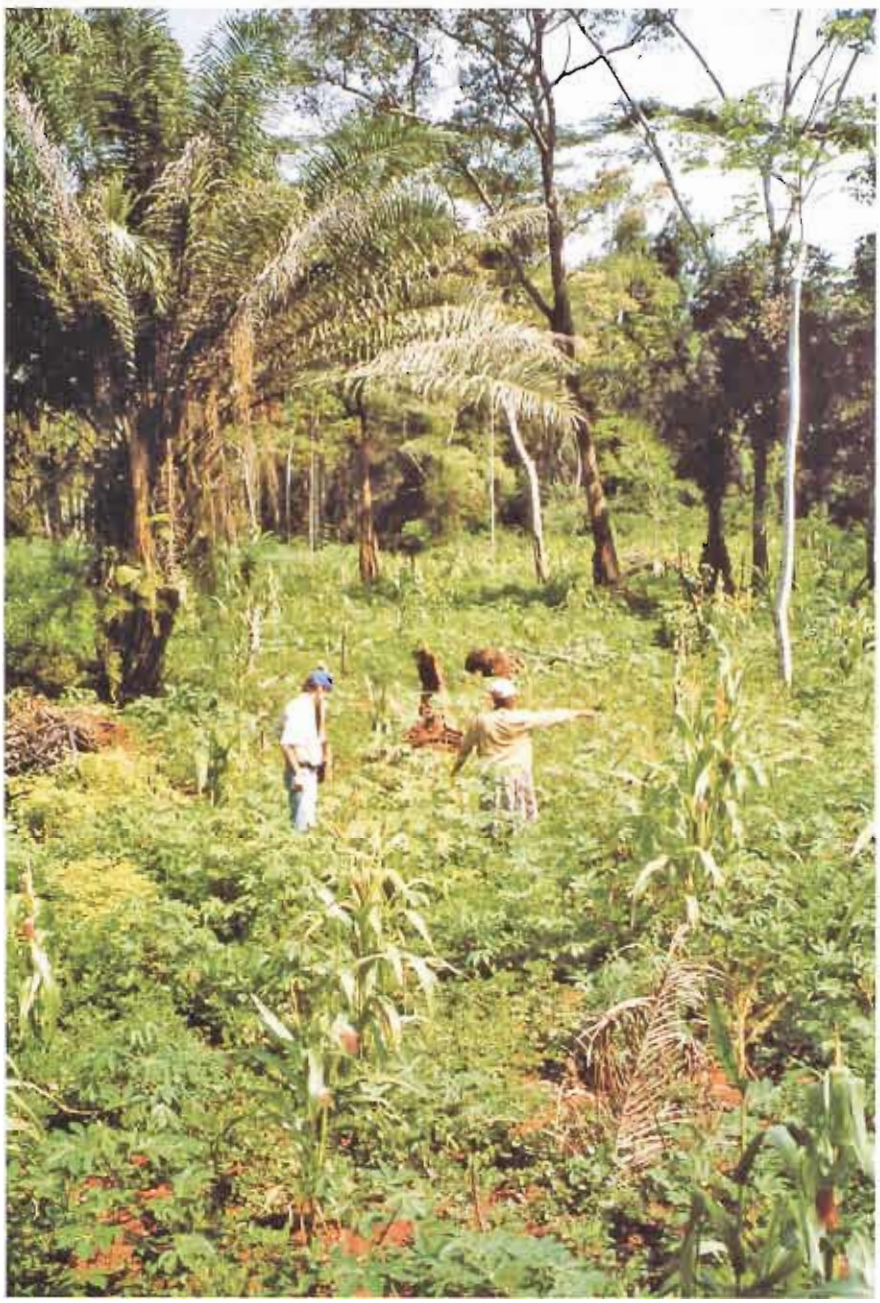
The more alternatives there are to slash-and-burn, the fewer trees will perish

The Global Initiative on Alternatives to Slash-and-Burn (ASB) is a systemwide program of the CGIAR, coordinated by ICRAF. Experimental benchmark sites have been established in Brazil, Indonesia, Thailand, Peru, and Cameroon. IITA and Institut de recherche agricole pour le développement (IRAD) are responsible for research in the forest margins benchmark in Cameroon. Supported by the European Union, the Cameroon component has funding for the next 3 years. Cameroon is also host to a benchmark of another program, the IITA-led Ecoregional Program for the Humid and Subhumid Tropics of Sub-Saharan Africa (EPHTA). Coinciding 2 benchmarks at the forest margins site in Cameroon benefits both programs, with considerable economies of scale. And IITA's research is disseminated throughout the ecoregion via EPHTA, ASB, and the new Sustainable Tree Crops Program, supported by the US Agency for International Development plus several chocolate manufacturers. The CGIAR acts as a catalyst, and the team approach to solving practical problems is having good results.

Arising out of the UN Conference on Environment and Development held in Rio de Janeiro in 1992, ASB's purpose is to develop and test strategies for reducing environmental degradation and improving the livelihoods of populations along the forest margins of the tropics. Work in Cameroon brings together 3 centers: CIFOR, ICRAF, and IITA. Several advanced research institutions are also involved—the Tropical Soil Biology and Fertility Programme (TSBF), IRAD, and the University of London—and there is active participation from the national agricultural research systems, through IRAD and the University of Yaoundé. Each institution takes the lead in their

last 150 years. The joint IITA/IRAD/TSBF work has demonstrated clearly that the carbon pools of the remaining forests, including the cocoa agroforests, become more important as land use is intensified.

The forest ecosystem is a complex mosaic managed by farmers. Any intervention must be made with regard to the whole system, through a holistic approach that considers all the costs and opportunities to each segment. The overall aim is to prevent further degradation. The forests must be maintained and sustainably managed, perennial tree crops increased in productivity and area, and annual crops intensified with appropriate inputs to minimize increases in the areas they cover. Underpinning all these efforts, policy support for sustainable management is vital. Helping this to happen is at the heart of IITA's involvement in ASB and the forest margins of Cameroon, because the world as a whole needs forests to be preserved.



Intensified inputs are needed for sustainable cropping in the forest margins

Research highlights

IITA's work is structured as 16 multidisciplinary research projects. Some projects focus on production systems for specific crops or crop combinations; others are thematically oriented and can involve many crops. Most of the projects cut across the agroecological zones for which IITA's work is targeted. IITA also serves as the convening institute for the systemwide program for integrated pest management.

This section presents the highlights of each project for 1999. These summaries are not a complete account of the work begun or completed during the year; rather, they describe some key scientific results and are intended to give the reader an insight into the breadth of the research themes and problems being investigated by IITA scientists.

Points saillants de la recherche

Les activités de l'IITA sont structurées en 16 projets de recherche pluridisciplinaire. Certains projets mettent l'accent sur les systèmes de production de cultures spécifiques ou de combinaisons de cultures, d'autres ont une orientation thématique et peuvent concerner plusieurs cultures. La plupart de ces projets couvrent les zones agroécologiques ciblées dans le cadre des activités de l'IITA. L'IITA sert également d'institut hôte du programme de lutte intégrée à l'échelle du système.

Cette section présente les points saillants de chaque projet en 1999. Ces résumés ne constituent pas un rapport exhaustif des activités qui ont démarré ou qui sont arrivées à terme au cours de l'année, ils mettent plutôt en exergue quelques résultats scientifiques-clés et sont censés fournir aux lecteurs un aperçu de l'ampleur des thèmes de recherche et des problèmes faisant l'objet d'une investigation par les chercheurs de l'IITA.

Short fallow systems

Project 1

- 491 seedlots totaling over 800 kg of herbaceous seed of cover crops were distributed to international agricultural research centers (IARCs), national agricultural research systems (NARS), and nongovernmental organizations (NGOs) in and outside Nigeria. This can be compared to a total of 355 seedlots weighing just over 300 kg in 1998 and 171 seedlots weighing just over 100 kg distributed in 1997.
- The ^{13}C natural labeling technique demonstrated that ^{13}C analysis of weed samples could be used to quantify how the proportion of C_3 and C_4 weeds in the biomass changes in response to shading by crops.
- Site- and species-specific responses of *Mucuna pruriens* and *Lablab purpureus* to the addition of Togo rock phosphate (RP) were observed for a series of trials on a toposequence representative of the northern Guinea savanna (NGS). *Mucuna* significantly enhanced the release of P from RP and increased grain yields of the following maize crop.
- Improved maize production and soil fertility management practices were tested in a participatory on-farm trial in the NGS. The improved practices (plant density, variety, fertilizer application) increased the yield and gross margin from 1.6 t/ha and 4600 naira/ha (farmers' practice) up to 4.1 t/ha and 19 600 naira/ha.

Systèmes de jachères de courte durée

Projet 1

- *491 lots de semences, au total plus de 800 kg de semences de cultures de couverture herbacées ont été distribués aux Centres internationaux de recherche agricole* (CIRA), *aux Systèmes nationaux de recherche agricole* (SNRA) *et aux Organisations non gouvernementales* (ONG) *présents au Nigéria et à l'extérieur de ce pays. Par rapport à* 1999, *un total de* 355 *lots de semences, c'est à dire à peine un peu plus de* 300 *kg, ont été distribués en* 1998 *et* 171 *lots de semences environ* 100 *kg ont été distribués en* 1997.
- *La technique de marquage au* ^{13}C *naturel a démontré que l'analyse au* ^{13}C *des échantillons d'adventices pourrait permettre de quantifier le degré de changement de la teneur en* C_3 *et* C_4 *des adventices au niveau de la biomasse, suite à l'effet d'ombrage des cultures.*
- *Les réponses – spécifiques aux sites et aux espèces – de* Mucuna pruriens *et de* Lablab purpurens *à l'apport en phosphate naturel du Togo* (PN) *ont été observées en vue d'une série d'essais sur une toposéquence typique de la savane nord guinéeene* (SNG). Mucuna *a, de manière significative, augmenté la diffusion de* P *du* PN *et contribué à l'accroissement du rendement en grains du maïs subséquent.*
- *Les pratiques améliorées de production de maïs et de gestion de la fertilité du sol ont été testées dans un essai participatif en milieu réel réalisé dans la* SNG. *Les pratiques améliorées (densité de population, variétés, application d'engrais) ont contribué à l'augmentation des rendements et de la marge bénéficiaire brute de* 1,6 *t/ha et* 4600 *naira/ha (pratique paysanne) jusqu'à respectivement* 4,1 *t/ha et* 19600 *naira/ha.*

Agroecosystems development strategies and policies

Project 2

- About 180 maize varieties and 200 cassava cultivars were released by NARS of 20 countries in SSA between 1965 and 1998. IITA materials represented about 50% for maize and 80% for cassava of the germplasm incorporated in the new varieties for the 1990s, which resulted in a yield advantage of about 53% for maize and 49% for cassava. This increase in annual production could deliver food security to a further 23 million people.
- Ex-post impact assessment at household level indicated high returns to investment (increases of 65–88% for maize yield, 31–71% for net income, efficiency in the use of other inputs, and risk reduction in both physical and financial returns) for farmers who had adopted *Mucuna* cover crop technology.
- An analysis of food consumption in the 2 major cities in the humid forest of Cameroon indicated that 43–50% of urban households consumed less than

the minimum requirement of 2400 kcal/day/adult equivalent. Between 18% and 46% of children aged 6–59 months were deemed stunted.

- Farmers in the dry savannas of Nigeria with good market infrastructure ranked indicators for measuring the likely impacts of the new dual-purpose cowpea variety as follows: income generation (55.1% of responses), food security (17.9%), social benefits (14.2%), and ecological benefits (12.8%). The same ranking was recorded in villages with poor markets though there was a higher preference for food security.
- Potential monetary returns (measured as discounted net present value) could range from US$550 to US$740/ha if carbon sequestered by conversions of degraded *Chromolaena odorata* bush land to multistrata cocoa agroforest were to be traded in a carbon market.

Projet 2

Stratégies et politiques de développement des agroécosystèmes

- *Environ 180 variétés de maïs et 200 cultivars de manioc ont été distribués par les* SNRA *de 20 pays d'Afrique subsaharienne entre 1965 et 1998. Le matériel de l'*IITA *a représenté respectivement pour le maïs et le manioc environ 50% et 80% du matériel génétique incorporé dans les nouvelles variétés au cours des années 90, ce qui s'est traduit par un gain en rendement de l'ordre de 53% pour le maïs et de 49% pour le manioc. Cette augmentation de la production annuelle pourrait assurer une sécurité alimentaire pour 23 millions de personnes supplémentaires.*
- *L'évaluation ex-post de l'impact au niveau des ménages a indiqué des taux de rentabilité élevés du capital investi (accroissement de 65–88% du rendement du maïs, 31–71% du revenu net, efficacité de l'utilisation d'autres intrants et réduction des risques relatifs aux rendements physiques et financiers) par les agriculteurs qui ont adopté la technologie de culture de couverture à base de* Mucuna.
- *Une analyse de la consommation alimentaire dans deux villes principales dans la zone de forêt humide du Cameroun a indiqué que 43–50% des ménages urbains consommaient moins que le minimum de calories requis : 2400 kcal/adulte. Entre 18 et 46% des enfants âgés de 6 à 59 mois étaient considérés comme chétifs.*
- *Les agriculteurs dans les zones de savane aride du Nigéria dotées de bonnes infrastructures de commercialisation ont procédé à une hiérarchisation des indicateurs de mesure des impacts possibles de la nouvelle variété de niébé à usage double et les résultats se présentent comme suit : génération de revenus (55,1% des réponses), sécurité alimentaire (17,9%), bénéfices sociaux (14,2%) et bénéfices écologiques (12,8%). La même hiérarchisation a été notée dans les villages moins nantis en marchés, même si la sécurité alimentaire a reçu un pourcentage plus élevé.*
- *Les revenus monétaires potentiels (mesurés en termes de valeur nette actualisée) pourraient se situer entre 550$ des* EU *et 750$ des* EU *si le carbone absorbé suite aux conversions des forêts dégradées de* Chromolaena odorata *en agroforêts de cacao, devait être vendu sur le marché de carbone.*

Project 3

Biological control and biodiversity

- In Benin, socioeconomic studies confirmed that termites are a priority pest, paving the way for the development of a microbial control product.
- Green Muscle®, developed by Lutte biologique contre les locustes et sauteriaux (LUBILOSA), has been recommended by the FAO locust pesticide referee group as the only product having 'low environmental risk' over all categories, and 'unlikely to present acute hazard in normal use' according to the WHO human toxicity classes, opening the doors to the widespread use of this novel technology.
- Under the stewardship of LUBILOSA, and following its successful registration in South Africa, NPP, a commercial producer of Green Muscle®, has applied for registration to the Interstate Committee on Drought Control in the Sahel (CILSS) Pesticide Committee in most Sahelian countries.
- Commercialization of Green Muscle®: NGOs in Mali and Niger have bought Green Muscle® for the first time, and a large order has been placed by a major

stakeholder (Lux Development together with the Niger DPV) involved in grasshopper control.

- The impact of biological control on water hyacinth is now clearly visible over large areas and was publicly acclaimed in Uganda, Tanzania, and Benin by the local population and by national authorities.
- Within the framework of functional biodiversity, the insect museum has been updated by 21000 specimens and now houses the second largest insect reference collection in West Africa.
- More than 100 national scientists, technicians, and students were trained at various levels in biological control methods, IPM, geographic information systems, and impact assessment. Audio and visual materials were produced on water hyacinth and *Striga* control.

Lutte biologique et biodiversité — Projet 3

- *Au Bénin, des études socioéconomiques ont confirmé que les termites s'avèrent les ravageurs prioritaires susceptibles de servir dans l'élaboration d'un produit de lutte microbienne.*
- *Green Muscle®, mis au point par le projet de Lutte biologique contre les locustes et sauteriaux (LUBILOSA) a été recommandé par le Comité d'arbitrage de la FAO sur les pesticides antiacridiens comme étant le seul produit 'à faibles risques pour l'environnement', toutes catégories confondues et 'probablement dépourvu de toute toxicité aiguë en condition d'utilisation normale' selon les classes de toxicité de l'OMS, ce qui laisse augurer une utilisation très répandue de cette nouvelle technologie.*
- *Sous la direction de LUBILOSA et suite à l'homologation de Green Muscle® en Afrique du Sud, NPP, une société qui commercialise ce produit, a introduit une demande auprès du Comité des pesticides du Comité inter-Etats de lutte contre la sécheresse dans le Sahel (CILSS) en vue d'une homologation dans la plupart des pays sahéliens.*
- *Commercialisation de Green Muscle® : Les ONG au Mali et au Niger ont acheté du Green Muscle® pour la première fois et une large commande a été placée par une partie prenante majeure (Lux Development et la DPV du Niger) impliquée dans la lutte antiacridienne.*
- *L'impact de la lutte biologique contre la jacinthe d'eau est clairement visible à présent sur de vastes superficies et a été acclamé publiquement par les populations et les autorités publiques en Ouganda, en Tanzanie et au Bénin.*
- *Dans le cadre de la biodiversité fonctionnelle, le musée d'insectes a été mis à jour avec 21000 spécimens et il abrite à présent la plus grande deuxième collection d'insectes de référence en Afrique occidentale.*
- *Plus de 100 chercheurs nationaux, techniciens et étudiants ont bénéficié d'une formation à différents niveaux dans les domaines suivants : lutte biologique, méthodes de lutte intégrée, systèmes d'information géographique et évaluation de l'impact. Du matériel audio-visuel a été produit sur la lutte contre la jacinthe d'eau et le Striga.*

Integrated management of legume pests and diseases — Project 4

- Orchid and snowdrop lectins were found to be insecticidal to *Maruca vitrata* and hence may be used to control this pest through transgenic approaches.
- Affinity-purified lectins from African yam beans (*Sphenostylis stenocarpa*) were tested against pod-sucking bugs (*Clavigralla tomentosicollis*) and cowpea weevils (*Callosobruchus maculatus*) using an artificial seed system, and were demonstrated to be lethal to both pests.
- A thorough screening of *Mucuna* spp. as a possible source of insecticidal compounds revealed a novel protein that is highly toxic to *M. vitrata*.
- Pre-release surveys to assess thrips species composition and their natural enemies on cultivated and wild host plants were carried out from the coastal savanna of Ghana through the Sudan savanna of Burkina Faso between March and September 1999. The flower thrips *Megalurothrips sjostedti* was present on all known host plants. The local parasitoid *Ceranisus menes* was the only species found associated with the thrips on some host plants. This confirms results from previous studies in Benin.

- The exotic thrips parasitoid *Ceranisus femoratus* was successfully established at the IITA Benin Station. After the initial release on *Tephrosia candida*, the parasitoid is already spreading on adjacent cowpea fields and on *Centrosema pubescens*. First experimental releases in southern Ghana were effected late October on *C. pubescens*.
- Investigation of the efficacy and dynamics of *C. femoratus* in Cameroon was continued. The parasitoid is now ca. 150 km from Yaoundé, where it was first seen.
- Twentyseven extension trainers from 9 countries participating in the cowpea IPM project were trained as facilitators of participatory learning and experimentation in farmers' field schools. They, in turn, trained 125 farmers at 5 cowpea IPM farmers' field schools.

Projet 4

Lutte intégrée contre les ravageurs et les maladies des légumineuses

- Des effets insecticides des lectines d'orchidée et de perce-neige sur Maruca vitrata ont été découverts d'où la possibilité de les utiliser dans la lutte contre ce ravageur grâce aux méthodes transgéniques.
- Des lectines du pois manioc africain (Sphenostylis stenocarpa) purifiées par chromatographie d'affinité ont été testées contre les punaises suceuses de gousses (Clavigralla tomentosicollis) et les charançons du niébé (Callosobruchus maculatus) en utilisant un système de semences artificielles et elles se sont avérées létales pour ces deux ravageurs.
- Un criblage exhaustif de Mucuna spp. comme source potentielle de composés insecticides a révélé une nouvelle protéine qui présente une toxicité élevée sur M. vitrata.
- Des enquêtes de pré-lâcher visant une évaluation de la composition des espèces de thrips et de leurs ennemis naturels sur des plantes hôtes cultivées et sauvages ont été menées à partir de la savane côtière du Ghana jusqu'à la savane soudanienne du Burkina Faso, entre mars et septembre 1999. Les thrips sur fleurs Megalurothrips sjostedti a ont été retrouvés sur toutes les plantes hôtes connues. Le parasitoïde Ceranisus menes était la seule espèce associée aux thrips sur certaines plantes hôtes. Cela confirme les résultats des études précédentes menées au Bénin.
- Le parasitoïde exotique des thrips Ceranisus femoratus s'est bien installé en station (Station de l'IITA-Bénin). Après le premier lâcher sur Tephrosia candida, le parasitoïde se propage déjà dans les champs de maïs adjacents et sur Centrosema pubescens. Les premiers lâchers expérimentaux ont été réalisés sur C. pubescens dans le sud du Ghana en octobre dernier.
- Des enquêtes sur l'efficacité et la dynamique de C. femoratus ont été poursuivies au Cameroun. Le parasitoïde se trouve à présent à environ 150 km de Yaoundé où sa présence avait été notée pour la première fois.
- 27 formateurs en vulgarisation de 9 pays membres du projet sur la lutte intégrée appliquée au niébé ont reçu une formation de modérateurs pour les séances de formation et d'expérimentation des 'écoles paysannes'. Ils ont, à leur tour, formé 125 formateurs pendant les séances de 5 'écoles paysannes' portant sur la lutte intégrée appliquée au niébé.

Project 5

Integrated management of maize pests and diseases

- A sustained reduction of downy mildew of maize in Nigeria has been achieved through a combination of public and private support for the extension of agrotechnological solutions.
- Simplified store evaluation procedures, designed to help farmers reduce pesticide use and make sound economic decisions, were developed and incorporated in extension courses conducted by IITA in collaboration with NGOs.
- It was discovered that planting of trap plants (grasses) as border rows of maize fields is not a viable option for stem borer control in West Africa because it considerably increased maize damage by rodents.
- As part of collaborative research work with the US Department of Agriculture (USDA), 76 IITA inbred lines were evaluated for resistance to aflatoxin

accumulation, using a laboratory kernel screening assay. At least 18 inbred lines were found to have aflatoxin levels as low as or lower than the most promising resistant genotypes identified by USDA. These lines also showed protein profiles which were not found among inbred lines developed in the US.

- Five maize varieties with varying levels of resistance to *Sesamia* and/or *Eldana* were identified to have cross-resistance to *Busseola fusca*. These varieties were successfully deployed in on-farm trials in the Cameroon forest region.

Lutte intégrée contre les ravageurs et la maladies du maïs

Projet 5

- *Une réduction durable du mildiou du maïs a été réalisée au Nigéria grâce à la combinaison d'un soutien des secteurs publics et privés dans la vulgarisation des solutions agrotechnologiques.*
- *Des méthodes de stockage simplifiées, conçues pour aider les agriculteurs à réduire le recours aux pesticides et à prendre des décisions économiques solides, ont été élaborées et incorporées dans les stages de formation en vulgarisation menés par l'*IITA *en collaboration avec les* ONG.
- *Il a été découvert que le semis de cultures pièges (graminées) en bordure des champs de maïs n'était pas une option viable de lutte contre les foreurs de tiges en Afrique occidentale, compte tenu de l'augmentation considérable des dégâts causés par les rongeurs.*
- *Dans le cadre des activités de recherche associative avec le Département de l'agriculture des* Etats Unis d'Amérique (USDA), *76 lignées endogames de l'*IITA *ont été évaluées pour la résistance à l'accumulation d'aflatoxine grâce à un essai de criblage des graines au laboratoire. Au moins 18 lignées endogames ont présenté des teneurs en aflatoxine aussi faibles ou plus faibles que celles des génotypes les plus résistants et prometteurs identifiés par l'*USDA. *Ces lignées ont également présenté des profils protéiques qui n'avaient pas été identifiés chez les lignées endogames mises au point au* Etats Unis.
- *Cinq variétés de maïs dotées de différents niveaux de résistance à* Sesamia *et/ou* Eldana *ont présenté une résistance croisée à* Busseola fusca. *Ces variétés ont été déployées de manière concluante dans des essais en milieu réel en zone de forêt au Cameroun.*

Integrated management of cassava pests and diseases

Project 6

- Africa-wide implementation of cassava green mite (CGM) biological control by exotic phytoseiid predators continued. The exotic phytoseiid predator *Typhlodromalus aripo* is now found in 17 countries, and has newly colonized parts of the dry savanna of West, Central, and East Africa. The predator has been recently established in parts of the subhumid tropics in Malawi, Mozambique, and Zambia. Where this predator has been present for 3 or more years, cassava productivity has increased between 15 and 43%.
- Brazilian isolates of the fungus *Neozygites floridana* have been successfully established in southern Benin. This pathogen can potentially complement CGM biocontrol on cassava varieties that are not preferred by exotic phytoseiid predators.
- To combat cassava mosaic virus disease (CMD) in northwestern Tanzania, Kenya, and Uganda, IITA, in collaboration with its public and private sector partners, facilitated the multiplication and distribution of resistant cassava and imposed phytosanitary restrictions on the movement and cultivation of CMD-diseased cassava germplasm.
- The hybrid virus associated with the spread of severe CMD in East Africa, and known to be present only in the Great Lakes region, was recently found in a CMD outbreak area in the central plateau of Congo.
- Among 24 widely grown cassava varieties in Togo, 4 from IITA and 4 from Togo were shown to be resistant to several highly virulent cassava bacterial blight strains collected from wide geographic origins.
- Two MSc and 3 PhD students completed their studies, and 72 NARS staff received training on various aspects of integrated management of cassava

pests. In addition, NARS and farmers in 7 countries participated in field evaluation of the impact of pests and diseases on cassava productivity.

Projet 6

Lutte intégrée contre les ravageurs et les maladies du manioc

- *Le programme de lutte biologique contre l'acarien vert du manioc* (CGM) *à l'échelle du continent africain grâce aux prédateurs phytoseïdes exotiques a été poursuivi. Le prédateur phytoseïde exotique* Typhlodromalus aripo *a été retrouvé dans 17 pays et a récemment colonisé des parties de la savane aride en Afrique occidentale, centrale et orientale. Le prédateur s'est récemment établi dans des régions des tropiques humides du Malawi, du Mozambique et de la Zambie. Partout où ce prédateur a été présent pendant 3 années ou plus, la productivité du manioc a augmenté de 15 à 43%.*
- *Des isolats du champignon* Neozygites floridana *du Brésil se sont bien installés dans le sud du Bénin. Ce pathogène peut potentiellement compléter la lutte biologique contre l'acarien vert du manioc chez les variétés qui ne sont pas préférées par les prédateurs phytoseïdes exotiques.*
- *Pour lutter contre le virus de la mosaïque du manioc* (CMD) *dans le nord-ouest de la Tanzanie, du Kenya et de l'Ouganda, l'*IITA, *en collaboration avec ses partenaires des secteurs publics et privés, a facilité la multiplication et la distribution de variétés de manioc résistantes et a imposé des restrictions phytosanitaires sur le mouvement et la culture du matériel génétique infecté par la* CMD.
- *Le virus hybride associé à la propagation des cas sévères de* CMD *en Afrique orientale et qui s'avère présent uniquement dans la région des Grands Lacs, a été récemment retrouvé dans une zone d'infestation de* CMD *dans le plateau central du Congo.*
- *Parmi les 24 variétés de manioc cultivées au Togo, 4 de l'*IITA *et 4 du Togo se sont révélées résistantes à plusieurs souches de bactérioses virulentes de manioc provenant d'une vaste gamme géographique.*
- *Deux étudiants de Maîtrise et trois de troisième cycle* (Doctorat) *ont terminé leurs études, 72 agents des* SNRA *ont bénéficié d'une formation sur différents aspects de la lutte intégrée contre les ravageurs du manioc. En outre, les* SNRA *et les agriculteurs de 7 pays ont participé à l'évaluation au champ de l'impact des ravageurs et des maladies sur la productivité du manioc.*

Project 7

Improving plantain- and banana-based systems

- RAPD and AFLP markers were used to assess the genetic diversity and phylogenetic relationships of representative samples of East African highland bananas (EAHB) and West African plantains. Safety duplication of the *Musa* collection was also achieved.
- Ploidy levels and genome composition of elite *Musa* germplasm were determined, and genetic bridges for crossing between plantain cultivars (triploids), that cannot be directly intercrossed, were developed. A silver staining procedure was developed to visualize pre-prophase meiotic *Musa* chromosomes and facilitate analysis of reproductive behavior across ploidy and genome groups. This has enhanced breeding methodology for plantain improvement at Onne.
- One diploid and 3 tetraploid hybrid progenies of EAHBs were selected for their superior bunch weight and resistance to black Sigatoka. The first seeds from tetraploid x diploid crosses were also obtained.
- A root sampling method based on soil cores, which captures more than 80% of the root size but only requires 5% of the time needed for whole plant excavation, was developed. Likewise, an efficient screening method for resistance to plant parasitic nematodes was developed, enabling host resistance assessment within 3 months from inoculation of single root segments.
- Screening of 45 accessions against banana weevil showed that plantains were the most susceptible, followed by EAHB, exotic bananas, and then wild or hybrid diploids. Antibiosis associated with corm hardness, corm size, and

resin/sap production was the most important resistance mechanism. The heritability of total inner damage was 87%, indicating that selection for resistance would be efficient. Insect-repellent green manures *Canavalia*, *Mucuna*, and *Tephrosia* had no effect on weevil adult numbers or rhizome damage, due to the sedentary life of the weevil.

- IITA collaborated with NGOs (Shell, Agip) in Nigeria to disseminate new cooking banana varieties which have now been adopted by farmers and occupy about 26% of total fields, representing a 9-fold increase since introduction nearly 2 decades ago.
- To promote the use of clean planting materials and reduce the spread of nematodes, training was carried out for 1623 farmers in Uganda, 659 in Zanzibar, and 234 in Rwanda, resulting in the treatment of 4480 suckers in Uganda, 5000 in Zanzibar, and 1050 in Rwanda.

Amélioration des systèmes à dominante plantain et banane

Projet 7

- *Les marqueurs* RAPD *et* AFLP *ont été utilisés pour évaluer la diversité génétique et les relations phylogénétiques des échantillons représentatifs des bananes d'altitude d'Afrique orientale* (EAHB) *et des plantains d'Afrique occidentale. Une duplication de sécurité de la collection de* Musa *a également été réalisée.*
- *Les niveaux de ploïdie et la composition du génome du matériel génétique élite de* Musa *ont été déterminés et les ponts génétiques pour les croisements entre les cultivars de plantain (triploïdes) qui ne peuvent pas être directement intercroisés, ont été mis au point. Une méthode de coloration à l'argent a été mise au point pour visualiser les chromosomes méiotiques en pré-prophases de* Musa *et faciliter l'analyse du comportement reproductif des groupes ploïdiques et génomiques. Cela a renforcé la méthodologie de sélection pour l'amélioration du plantain à Onne.*
- *Un diploïde et trois descendants tetraploïdes de* EAHB *ont été sélectionnés pour le poids supérieur de leurs régimes et leur résistance à la cercosporiose. Les premières graines des croisements tetraploïdes x diploïdes ont également été obtenues.*
- *Une méthode d'échantillonnage des racines à l'aide de carottes qui permet de mettre en exergue plus de 80% de la taille de la racine mais qui ne nécessite que 5% du temps requis pour l'excavation totale de la plante, a été mise au point. De même, une méthode de criblage efficace pour la résistance aux nématodes a été élaborée et elle permet l'évaluation de la résistance de la plante hôte au bout de trois mois après l'innoculation d'un seul segment racinaire.*
- *Le criblage de 45 obtentions pour détecter les charançons du bananier a indiqué que les plantains étaient les plus sensibles, suivis des* EAHB, *des bananes exotiques et des diploïdes sauvages ou hybrides. L'antibiose associée à la dureté, à la taille du bulbe et à la production de résine/sève s'est révélée le mécanisme de résistance le plus important. L'héritabilité des dégâts internes totaux était de 87%, ce qui indique que la sélection pour la résistance pourrait être efficace. Les engrais verts insectifuges* Canavalia, Mucuna *et* Tephrosia, *n'ont eu aucun effet sur le nombre de charançons adultes ou sur les dégâts au niveau du rhizome, à cause de la vie sédentaire des charançons.*
- *L'*IITA *a collaboré avec les* ONG (Shell, Agip) *au Nigéria dans la diffusion des variétés de bananes à cuire qui ont été adoptées à présent par les agriculteurs et occupent environ 26% des champs, soit 9 fois plus que les superficies au moment de leur introduction, il y a déjà 2 décennies.*
- *Afin de promouvoir l'utilisation de matériel de plantation sain et de réduire la propagation des nématodes, 1623 agriculteurs ont bénéficié des activités de formation en Ouganda, 659 au Zanzibar et 234 au Rwanda, ce qui a permis le traitement de 4480 rejets en Ouganda, 5000 au Zanzibar et 1050 au Rwanda.*

Integrated management of Striga *and other parasitic pests*

Project 8

- Results of on-station legume rotation trials in Mokwa, Nigeria, showed that 2 years of legume rotation is more beneficial than 1 year legume rotation or continuous cereal cropping for improving soil conditions and reducing the impact of *Striga* on subsequent cereal crops.

- Two *Striga hermonthica*-tolerant varieties of maize, EV DT-W 99 STR C0 and TZEW-Pop × 1368 STR C0, showed superior performance in regional *Striga* trials.
- Results of experiments conducted to improve methods for artificial infestation with *Striga* in maize breeding trials and to reduce the cost of infestation revealed that higher levels of infestation were attained when maize was grown in single stands at 25 cm intra-row spacing than with 2 plants per hill at 50 cm spacing. Rates of 3000 germinable *Striga* seeds per hill were sufficient to achieve a good level of infestation.
- Tests revealed that the modified agar gel assay method works well for screening maize genotypes for low production of *Striga* germination stimulant, and for identifying maize genotypes that are high stimulant producers and yet tolerant to *Striga* infestation due to other mechanisms of resistance.
- Molecular markers have been identified that show polymorphism between *Striga*-susceptible and -resistant genotypes. Reliable phenotype data were obtained in field trials at two locations, which will be utilized in mapping the resistance genes in these populations.

Projet 8

Lutte intégrée contre le Striga et d'autres phanérogames parasites

- *Les résultats des essais de rotation de légumineuses menés en station à Mokwa (Nigéria) ont démontré que 2 années de rotation sont plus bénéfiques qu'une année de rotation de légumineuses ou une culture continue de céréales pour améliorer les conditions du sol et réduire l'impact du* Striga *sur les cultures céréalières subséquentes.*
- *Deux variétés de maïs tolérantes à* Striga hermonthica, EV DT-W 99 STR C0 *et* TZEW-Pop × 1368 STR C0, *ont eu des rendements élevés dans les essais régionaux sur le* Striga.
- *Les résultats des expériences menées en vue d'améliorer les méthodes d'infestation artificielle de* Striga *dans les essais de sélection du maïs et de réduire le coût des infestations ont démontré qu'il est possible d'obtenir des niveaux d'infestation plus élevés lorsque des pieds de maïs uniques sont plantés selon un écartement de 25 cm entre les rangs, contrairement au semis de deux pieds par poquet selon un écartement de 50 cm. Des taux de 3000 graines de* Striga *par poquet ont suffi pour obtenir un bon niveau d'infestation.*
- *Des tests ont révélé que la méthode des essais de gel d'agar modifié est efficace pour le criblage des génotypes de maïs en vue de la production de stimulant de germination de* Striga *et pour l'identification des génotypes de maïs qui sont hautement producteurs de stimulants tout en demeurant tolérants à l'infestation de* Striga *à cause d'autres mécanismes de résistance.*
- *Des marqueurs moléculaires indiquant un polymorphisme lent entre les génotypes sensibles au* Striga *et les génotypes résistants ont été identifiés. Des données fiables sur les phénotypes ont été obtenues dans des essais au champ dans deux sites et serviront pour cartographier les gènes de résistance de ces populations.*

Project 9

Improving postharvest systems

- Four groups of 15 farmers from Burkina Faso, Cameroon, and Côte d'Ivoire were trained by farmers from Benin in the technique of yam chip processing and derived culinary preparations in Benin. The trained farmers have started to disseminate the technique in their own countries.
- A regional agricultural research and development network called FOODNET was set up in Eastern and Central Africa to focus on market research and promote production and sale of value-added agricultural products. It seeks to strengthen links between the private and public sector and to provide regional training in market analysis. A web site for the project (http://www.cgiar.org/foodnet) became accessible in December 1999.
- For the first time, cassava germplasm was screened for iron and zinc content in the tuberous roots; a wide genetic variation was found (1.3–64.80 ppm for iron content and 1.40–36.10 ppm for zinc content). A weak and positive relationship was observed for iron and zinc.

- Fifty improved cowpea varieties were evaluated for food composition and physicochemical characteristics. Results obtained indicated that there were significant differences among the varieties for all the parameters evaluated.
- Studies on tropical ataxic neuropathy in Nigeria showed that the condition is still prevalent, but that low intake of fish and beef, the major sources of sulphur-containing amino acids in this community, rather than dietary cyanide exposure from cassava consumption is the likely causative factor. It was also established that excessive cassava production was not necessarily linked to high dietary cyanide exposure and the disease 'konzo' when cassava processors adhered to safe processing practices.
- An auger-type husking and polishing mechanism (rice mill) coupled with a suction blower for cleaning was developed. The mill, which has a capacity of 60–80 kg/h, tested satisfactorily for parboiled rice with a milling recovery as high as 68%, hulling efficiency up to 90% on first pass and 98% on second pass, and with broken milled rice below 20%.
- In Ghana, two small-scale companies, Delabac Ventures and Darkruby Enterprise, were given training in soybean processing and were assisted to obtain a grant from the Organization of African Unity /Semi-Arid Food Grain Research and Development (SAFGRAD) Technology Transfer and Commercialisation Program. Delabac Ventures has launched 5 soy-based products: Soya Yoghurt, Soya Vita, Soya Vita Plus, Soyalac, and Pure Soya Powder.

Amélioration des systèmes post-récolte

Projet 9

- *Quatre groupes de 15 agriculteurs du Burkina Faso, du Cameroun et de la Côte d'Ivoire ont reçu une formation de la part des agriculteurs du Bénin sur une technique de transformation de cossettes d'igname et des préparations culinaires dérivées du Bénin. Les agriculteurs formés ont commencé à diffuser cette technique dans leurs pays respectifs.*
- *Un réseau régional de recherche et de développement agricoles – FOODNET – a été créé en Afrique orientale et centrale afin de mettre l'accent sur la recherche sur les marchés et de promouvoir la production et la vente de produits agricoles dotés d'une valeur ajoutée. Son objectif est de renforcer les liens entre les secteurs publics et privés et de fournir des activités de formation en analyse des marchés au niveau régional. Le site Internet de ce projet est accessible depuis décembre 1999 à l'adresse suivante : http://www.cgiar.org/foodnet*
- *Pour la première fois, du matériel génétique de manioc a été criblé pour la teneur en fer et en zinc des racines tubéreuses. Une grande variation génétique a été identifiée (1,3 – 64,80 ppm pour la teneur en fer et 1,40 – 36,10 ppm pour la teneur en zinc). Une relation faible et une relation positive ont été observées pour le fer et le zinc.*
- *Cinquante variétés améliorées de niébé ont été évaluées pour leur composition alimentaire et leurs caractéristiques physiques et chimiques. Les résultats obtenus ont indiqué une différence significative parmi les variétés pour tous les paramètres évalués.*
- *Des études menées sur la neuropathie ataxique au Nigéria ont indiqué que cette maladie était encore répandue mais que la cause semblait liée à une consommation insuffisante de poisson et de viande de boeuf – les principales sources d'acides aminés sulfurés – dans cette communauté plutôt qu'une exposition au cyanure suite à la consommation de manioc. Il a également été établi qu'une consommation excessive de manioc n'était pas nécessairement liée à une forte exposition au cyanure et au 'konzo' lorsque les transformateurs de manioc observaient des pratiques de transformation dans de bonnes conditions de sécurité.*
- *Un mécanisme de décorticage et de polissage à vrille (moulin à riz) équipé d'un système de nettoyage par aspiration a été mis au point. Le moulin qui a une capacité de 60–80 kg/ha, a été testé de manière concluante avec du riz étuvé et a donné un taux de récupération de l'ordre de 68% et un taux de décorticage atteignant 90% au premier passage et 98% au deuxième passage et moins de 20% avec des brisures de riz usiné.*
- *Au Ghana, deux entrepises à petite échelle, Delabac Ventures et Darkruby Enterprise, ont bénéficié d'une formation en transformation du soja et d'une assitance pour obtenir une*

subvention du Programme de transfert de technologies et de commercialisation SAFGRAD/ Organisation de l'unité africaine. Delabac Ventures a lancé 5 produits à base de soja : Soya Yoghurt, Soya Vita, Soya Vita Plus, Soyalac et Pure Soya Powder.

Project 10

Farming systems diversification

- Long-term cocoa agroforest establishment trials were initiated on degraded lands with 34 farmers in southern Cameroon.
- Ongoing characterization of existing cocoa agroforests in southern Cameroon revealed that these are among the most biologically diverse and the most 'forest like' of agricultural land-use systems in SSA.
- The Multi-institutional Sustainable Tree Crops Program in West and Central Africa was launched. A program coordinator to be based at IITA will be in place early in the year 2000.
- Agronomic factorial trials showed significant yield response from wood ash in combination with poultry manure on 2 important peri-urban agricultural enterprises—tomatoes and the leafy vegetable known as jute mallow *Corchorus olitorius*. The combined use of ash and manure proved more profitable than the predominant practice of using inorganic fertilizer.
- Estimates on the economic efficiency of mixed farming systems in the drier savannas of Nigeria indicated that there are high potentials for improving crop–livestock systems because only 15% of farmers achieved more than 80% of efficiency and only 1.25% could be considered as having reached the efficiency frontier (> 90% of efficiency), out of a random sample of 559 crop–livestock farmers.
- Results from goal mathematical programming models from another sample of farmers with livestock in the northern Guinea savanna of Nigeria indicated that making systems efficient in areas with poor market access produces benefits to the small-scale farmers that are similar to those achieved by systems in areas with good market infrastructure.

Projet 10

Diversification des systèmes de production

- *Des essais d'établissement d'agroforêts de cacao de longue durée ont été mis en place sur des terres dégradées avec la participation de 34 agriculteurs du sud du Cameroun.*
- *Une caractérisation, en cours, des agroforêts de cacao dans le sud du Cameroun a révélé que ces dernières figuraient parmi les systèmes les plus différents au plan biologique et les systèmes d'utilisation les 'plus forestiers' de terres agricoles en Afrique subsaharienne.*
- *Le Programme multi-institutionnel durable sur les cultures arboricoles en Afrique occidentale et centrale a été lancé. Le Coordonnateur du programme devant être basé à l'IITA rejoindra son poste en début de l'an 2000.*
- *Des essais agronomiques factoriels ont montré des réponses en redements significatifs de la cendre de bois combinée avec de la fumure de volaille dans deux entreprises périurbaines importantes – les tomates et les légumes verts, une malvacée –* Corchorus olitorius. *La combinaison de la cendre et de la fumure s'est avérée plus bénéfique que la pratique prédominante d'utilisation d'engrais inorganiques.*
- *Les estimations de l'efficacité économique des systèmes de culture mixte dans les savanes arides du Nigéria ont indiqué l'existence de potentiels élévés d'amélioration des systèmes agriculture-élevage parce que seulement 15% des agriculteurs ont pu atteindre plus de 80% d'efficacité et seulement 1,25% pourraient être considérés comme ayant atteint la marge d'efficacité (>90% d'efficacité) sur un échantillon aléatoire de 559 agriculteurs-éleveurs.*
- *Les résultats de modèles de programmes mathématiques provenant d'un autre échantillon d'agriculteurs ayant du bétail dans la savane nord guinéenne du Nigéria ont indiqué qu'en assurant l'efficacité des systèmes dans les zones où l'accès aux marchés est difficile, les bénéfices produits pour les petits exploitants sont similaires à ceux réalisés grâce aux systèmes dans les zones dotées de bonnes infrastructures de commercialisation.*

Cowpea–cereals systems improvement in the dry savannas

Project 11

- Some of the new improved cowpea varieties combining resistance to major diseases, insect pests, and *Striga gesnerioides* showed over 50% higher yield potential than existing improved varieties, with 1.5 t/ha grain and 3 t/ha fodder in the Sahel and 3 t/ha grain and 5 t/ha fodder in the Sudan savanna.
- Dry season cowpea became very popular in Nigeria and over 2000 farmers grew the improved cowpea variety IT89KD-288.
- A date of planting trial in the dry season indicated that some heat-tolerant cowpea varieties can be successfully grown between 25 March and 25 June permitting a wheat–cowpea–rice intensive crop rotation in northern Nigeria where large irrigation schemes are in operation.
- Screening for drought tolerance and root characteristics revealed that cowpea varieties IT96D-604, IT95K-222-3, IT90K-222-5, and IT95K-1115-10 were most drought tolerant. IT96D-605 also showed a deeper root system under drought-stressed conditions than other varieties.
- An IITA/German Agency for Technical Cooperation (GTZ) initiative on farmer-to-farmer diffusion of improved cowpea seed gained popularity in northern Nigeria. From the initial 36 farmers in 1997, over 2500 farmers produced seed of the improved cowpea variety IT90K-277-2 in 1999.
- Food quality analysis of 52 cowpea varieties indicated significant genetic variability for protein, fat, and iron content. The top 4 improved varieties had 17% higher protein and 12% higher iron content than the mean of 4 popular local varieties.
- IITA, ILRI, ICRISAT, the International Fertilizer Development Center, and the University of Durham, UK, have begun working together to develop a novel holistic approach to on-farm research, bringing together complementary component technologies from the various institutes in a 'best bet' (BB) package. The BB package includes recommended crop varieties as well as crop, livestock, and soil management practices. These are being evaluated in terms of biophysical and socioeconomic parameters, together with the farmers. With funding from the Systemwide Livestock Program, and working with NARS partners in northern Nigeria, the approach expanded from 11 farmers in one village in 1998, to 23 farmers in this same village and a further 21 farmers at a new location in 1999. Crop grain and fodder yields were substantially more for the BB treatments as compared to local practices; likewise, small ruminants fed with the harvested fodder gained more weight on BB than on local treatments. Similar trials have also commenced with 18 farmers in Niger, and preparatory characterization studies are underway in Mali.

Amélioration des systèmes niébé-céréales dans les savanes arides

Projet 11

- *Certaines nouvelles variétés améliorées de niébé combinant une résistance aux principales maladies, aux ravageurs et à* Striga gesnerioides *ont présenté un potentiel de rendement supérieur à 50% par rapport aux variétés améliorées existantes, avec 1,5 t/ha de grains et 3 t/ha de fourrage au Sahel et 3 t/ha de grains et 5 t/ha de fourrage dans la savane soudanienne.*
- *Le niébé de saison sèche est devenu très populaire au Nigéria et plus de 2000 agriculteurs cultivent la variété amélioré de niébé* IT89KD-288.
- *Un essai sur la date de semis pendant la saison sèche a indiqué que la culture de certaines variétés de niébé tolérantes à la sécheresse peut réussir entre le 25 mars et le 25 juin, ce qui permet une rotation de culture intensive (blé-niébé-riz) dans le nord du Nigéria où existent de larges périmètres irrigués.*
- *Le criblage pour la tolérance à la sécheresse et les caractéristiques racinaires a révélé que les variétés de niébé* IT96D-604, IT95K-222-3, IT90K-222-5 *et* IT95K-1115-10 *étaient les plus tolérantes à la sécheresse.* IT96D-605 *a également présenté un système racinaire plus profond en condition de stress hydrique, par rapport aux autres variétés.*
- *Une initiative conjointe de l'*IITA *et de l'Agence allemande de coopération technique* (GTZ) *portant sur la diffusion, d'agriculteur à agriculteur, de semences de niébé amélioré devient*

de plus en plus populaire dans le nord du Nigéria. 36 agriculteurs ont participé au démarrage en 1997 et plus de 2500 agriculteurs ont produit des semences de la variété améliorée de niébé IT90K-277-2 *en* 1999.

- *L'analyse alimentaire de 52 variétés de niébé a indiqué une variabilité génétique significative en ce qui concerne la teneur en protéine, en matières grasses et en fer. Les 4 meilleures variétés ont présenté des teneurs en protéine et en fer respectivement supérieures de 17% et de 12%, par rapport à la moyenne de 4 variétés locales populaires.*
- *L'IITA, l'ILRI, l'ICRISAT, le Centre international pour le développement des engrais et l'Université de Durham (Royaume Uni) ont travaillé en collaboration pour élaborer une nouvelle approche holistique en matière de recherche en milieu réel en regroupant des volets technologiques complémentaires des différentes institutions en un paquet de 'concluantes technologies'. Ce paquet comprend les variétés de cultures récommandées ainsi que des pratiques de gestion des cultures, des animaux et des sols. Ces aspects font l'objet d'une évaluation selon des paramètres biophysiques et socioéconomiques, en collaboration avec les agriculteurs. Grâce à un financement du Programme sur l'élévage à l'échelle du système et à la collaboration avec les partenaires du* SNRA *dans le nord du Nigéria, cette approche qui a concerné au départ 11 agriculteurs dans un village en 1998, s'est étendue à 23 agriculteurs dans le même village et à 21 agriculteurs supplémentaires dans une nouvelle localité en 1999. Les rendements en grains et en fourrage des traitement basés sur les 'concluantes technologies' étaient substantiellement plus élevés que ceux des pratiques locales; de même, les petits ruminants nourris avec le fourrage récolté dans le traitement technologie ont eu un gain en poids supérieur à celui obtenu avec les traitements locaux. Des essais similaires ont également commencé avec 18 agriculteurs au Niger et des études de caractérisation préliminaire sont en cours au Mali.*

Project 12

Improvement of maize–grain legume production systems in West and Central Africa

- In a late-maturing open-pollinated maize variety trial tested across locations, the 3 top ranking new varieties produced 11–15% higher yields than a commercial hybrid check, Oba Super I. A new stem borer-resistant variety, Ama TZBR-W, had 10% higher yield than Oba Super I. A *Striga*-resistant variety, ACR97 TZL COMP1-W, was as productive as the commercial hybrid.
- Two *Striga*-resistant, early-maturing maize varieties produced over 7000 kg/ha yields at Sinematialli under *Striga*-free conditions, which were comparable to yields of the best early-maturing varieties. These varieties also performed well under artificial *Striga* infestation at Ferkéssedougou.
- Thirteen maize varieties were compared at 0, 30, and 90 kg N/ha in Mokwa, Nigeria. Grain yields of the latest cycle of selection from the low N-tolerant pool (C2) were comparable to that of an N-efficient hybrid, Oba Super II, at low and medium N levels. This variety produced higher yields than Oba Super II at the high N level and had good agronomic features.
- Three early-maturing soybean varieties, TGx1871-12E, TGx 1740-2F, and TGx1871-5E, produced 20–35% higher grain yields and 9–27% more fodder than TGx1485-1D in the Guinea and Sudan savanna zones. These varieties also have increased resistance to pod shattering and enhanced nodulation.
- A cowpea–maize rotation trial was conducted for 2 years (1998–99) in 2 villages in the derived savanna. In the relatively poor fields, application of 45 kg urea-N/ha and 45 kg cowpea haulm-N/ha produced maize grain yields comparable to those of plots receiving 90 kg urea-N/ha. In the relatively fertile soils, the combined use of urea and cowpea haulm yielded about 80% of the grain of those plots receiving 90 kg urea-N/ha.
- An on-farm trial comparing the benefits of legume–maize double cropping systems to that of full-season maize with up to 90 kg N/ha fertilizer was carried out for 2 years (1998–99) in degraded fields in the NGS. A partial budget analysis showed that double cropping maize with legumes was more profitable than full-season maize. For each year, grain legume–maize double cropping systems and full-season maize gave higher benefits per hectare than *Mucuna*–maize double cropping.

Amélioration des systèmes de production maïs - légumineuses à graines en Afrique occidentale et centrale

Projet 12

- *Dans un essai sur des variétés tardives de maïs à pollinisation libre testées dans différentes localités, les trois meilleures nouvelles variétés ont eu un rendement supérieur de 11–15% à celui d'un temoin commercial hybride,* Oba Super 1. *Une nouvelle variété résistante au foreur de tiges,* Ama TZBR-W *a eu un rendement supérieur de 10% à celui de* Oba Super 1. *Une variété résistante au* Striga, ACR97 TZL COMP1-W *a eu une production égale à celle de l'hybride commercial.*
- *Deux variétés précoces de maïs résistantes au* Striga *ont eu des rendements de plus de 7000kg/ha à Sinematialli sans infestation de* Striga, *ce qui était comparable aux rendements des meilleures variétés précoces. Ces variétés ont également eu une bonne performance en condition d'infestation artificielle de* Striga *à Ferkéssedougou.*
- *Treize variétés de maïs ont été comparées à* 0, 30 *et* 90 *kg de* N/ha *à Mokwa* (Nigéria). *Les rendements en grains du dernier cycle de sélection des ressources génétiques tolérantes aux faibles niveaux de* N (C2) *étaient comparables à ceux de l'hybride sensible à* N, Oba Super II, *à des niveaux de* N *faibles et moyens. Cette variété a produit des rendements plus élevés que Oba Super* II *à un niveau élévé de* N *et a présenté de bonnes caractéristiques agronomiques.*
- *Trois variétés précoces de soja,* TGx1871-12E, TGx 1740-2F *et* TGx1871-5E *ont produit des rendements en grains supérieurs de 20–35% et des rendements en fourrage supérieurs de 9–27% par rapport à ceux de* TGx1485-1D *dans les zones de savane guinéenne et soudanienne. Ces variétés ont également une plus grande résistance à l'égrenage naturel et une meilleure nodulation.*
- *Un essai de rotation niébé-maïs a été mené pendant deux ans* (1998–99) *dans deux villages dans la savane dérivée. Dans des champs dont les sols sont relativement pauvres, l'application de 45 kg d'urée-*N/ha *et de 45 kg de fanes de niébé-*N/ha *a produit des rendements en grains de maïs comparables à ceux des parcelles ayant reçu un apport de* 90 *kg d'urée-*N/ha. *Sur des sols relativements fertiles, l'utilisation combinée de l'urée et des fanes de niébé a produit environ* 80% *de grains des parcelles qui recevaient un apport de* 90 *kg d'urée-*N/ha.
- *Un essai en milieu réel comparant les bénéfices des systèmes de double culture de légumineuses-maïs à ceux du maïs cultivé pendant toute une campagne avec un apport atteignant* 90 *kg de* N/ha, *a été mené pendant deux ans* (1998–99) *dans des champs dégradés dans la* SNG. *Une analyse partielle du budget a indiqué que la double culture du maïs avec les légumineuses était plus rentable que le maïs pendant toute la campagne. Pour chaque année, les systèmes de double culture légumineuses à graines – maïs et de culture du maïs pendant toute la campagne ont produit plus de bénéfices par hectare que la double culture* Mucuna *– maïs.*

Improvement of yam-based systems

Project 13

- Only yam mosaic virus, genus Potyvirus, and *Dioscorea alata* virus, genus Potyvirus, were found to infect *D. rotundata* and *D. alata* in Ghana while many of the leaf samples with virus-like symptoms tested negative for the 7 viruses known to infect yams in West Africa.
- New sources of genetic resistance to yam mosaic virus were identified. Five accessions of *D. rotundata*, 2 of *D. alata*, and one of *D. bulbifera* were demonstrated to have high levels of resistance to the virus.
- Application of recently developed screening techniques to 220 accessions of *D. rotundata* revealed variation in susceptibility to the yam nematode (*Scutellonema bradys*) and the root knot nematode (*Meloidogyne incognita*). Two accessions of *D. dumetorum* (from Ghana and Cameroon) proved highly resistant to *S. bradys*.
- A survey was carried out on the domestication of wild yams in 2 regions of Benin as part of an investigation of its potential role in farmer participatory selection. During interviews of 360 farmers in 36 villages, 93% of the farmers in Nago region and 70% in Fon knew of the practice, 36% and 22%, respectively, could describe the techniques used, and 14% in both regions are practicing it or had done so recently.

- The number of virus-tested yam clones certified for international distribution increased to 70 with the addition of 5 each of *D. rotundata* and *D. alata*. About 26 000 in vitro plantlets and 16 000 minitubers of such clones were produced out of which 5400 and 13 906, respectively, were distributed to NARS collaborators.

Projet 13

Amélioration des systèmes à dominante igname

- *Seulement le virus de la mosaïque de l'igname, genre Potyvirus et le virus* Dioscorea alata, *genre Potyvirus ont infecté* D. rotundata *et* D. alata *au Ghana, tandis que plusieurs échantillons de feuilles présentant des symptômes de virus apparents ont été négativement testés pour les 7 virus censés infecter les ignames en Afrique occidentale.*
- *De nouvelles sources de résistance génétique au virus de la mosaïque de l'igname ont été identifiées. Cinq obtentions de* D. rotundata, *2 de* D. alalta *et une de* D. bulbifera *ont présenté des niveaux de résistance élevés au virus.*
- *L'application de techniques de criblage, récemment mises au point, à 220 obtentions de* D. rotundata *a révélé une variation de sensibilité aux nématodes de l'igname* (Scutellonema bradys) *et aux nématodes à galles* (Meloidogyne incognita). *Deux obtentions de* D. dumetorum *(du Ghana et du Cameroun) se sont avérées résistantes à* S. bradys.
- *Une étude a été réalisée sur la domestication des ignames sauvages dans deux régions du Bénin dans le cadre d'une enquête sur son rôle potentiel dans la sélection participative. Au cours des entretiens auprès de 360 agriculteurs dans 36 villages, 93% des agriculteurs dans la région de Nago et 70% dans la région de Fon connaissaient la pratique, 36% et 22% respectivement, pouvaient décrire les techniques utilisées et 14% dans les deux régions pratiquaient ou avaient pratiqué la technique récemment.*
- *Le nombre de clones d'igname testés contre les virus et certifiés pour une distribution internationale s'est élevé à 70 en plus de 5 autres* D. rotundata *et* D. alata. *Environ 26 000 vitroplants et 16 000 minitubercules de ces clones ont été produits et 5400 et 13 906 clones de ce matériel ont été respectivement distribués aux collaborateurs au niveau des* SNRA.

Project 14

Cassava productivity in lowland and midaltitude agroecologies of sub-Saharan Africa

- Genotypes with high levels of resistance to CGM, CMD, and cassava brown streak disease have been identified for the midaltitude, highland, and lowland ecologies of East and southern Africa.
- 408 genetically broad-based and certified virus-free cassava genotypes were made available for international distribution. A total of 17 085 in vitro plantlets were distributed to 11 NARS in SSA, including 10 000 and 4000 CMD-resistant genotypes provided to Tanzania to combat the CMD outbreak and to Chad national programs for drought mitigation, respectively. In addition, 451 092 seeds from 405 families of genetically broad-based and special trait populations segregating for desirable traits were distributed to 13 NARS in SSA.
- 581, 496, and 263 advanced cassava clones adapted to the midaltitude and highland agroecologies of East and southern Africa were introduced from IITA's Eastern and Southern Africa Regional Center (ESARC), Uganda, to Kenya, Tanzania, and Rwanda, respectively, under the open quarantine facility. 84 and 81 clones from these stocks were also introduced to the Democratic Republic of Congo and Burundi national programs from the national program of Rwanda.
- Over 500 landraces and 400 improved genotypes have been characterized into 6 distinct diversity groups, which will form the basis of future heterotic studies. Furthermore, the landraces had higher sources of resistance to root rots than improved genotypes.
- 400 clones evaluated in performance trials at ESARC gave storage root yields ranging from 8.3 to 114 t/ha with most clones having dry matter content

between 35 and 40%, while 30% of the clones outyielded the local check and 4 clones yielded over 100 t/ha. In addition, 10 of the clones evaluated in western Kenya showed a yield potential of over 150 t/ha, suggesting that the cassava yield plateau has been shattered.

- Genotypes with higher root nitrogen (1.1–10.1 g/kg DM), low cyanogenic potential (1.12–12.93 mg HCN/100 mg of fresh weight of roots), and high zinc (1.40–36.10 ppm) and iron content (1.3–64.80 ppm) have been identified. This indicates the potential for genetically fortifying cassava with iron and zinc while enhancing higher root N and low cyanogenic potential.
- Uganda and Malawi officially released 6 and 3 additional CMD-resistant varieties, respectively, from IITA-derived germplasm.
- The capability of NARS and NGOs to undertake cassava research was enhanced through a training workshop for 14 breeders from 9 African countries, and courses on agronomy and rapid multiplication techniques for 110 technicians and extension workers in East and southern Africa.

Productivité du manioc dans les agroécologies de terres basses et d'altitude moyenne en Afrique subsaharienne

Projet 14

- *Des génotypes dotés d'une résistance élevée à l'acarien vert du manioc (CGM), à la mosaïque du manioc (CMD) et à la striure brune du manioc ont été identifiés pour les écologies d'altitude moyenne, d'altitude plus élevée et de terres basses d'Afrique orientale et australe.*
- *408 génotypes de manioc à base génétique large et certifiés exempts de virus ont été mis à disposition pour une distribution internationale. Au total, 17085 vitroplants ont été distribués à 11 SNRA en Afrique subsaharienne dont 10 000 et 4000 génotypes résistants à CMD fournis respectivement à la Tanzanie pour lutter contre l'infestation de la mosaïque et aux programmes nationaux du Tchad en vue de juguler les effets de la sécheresse. En outre, 451 092 semences de 405 familles à base génélique large et des populations ségrégantes dotées de caractères spéciaux pour les traits recherchés ont été distribuées à 13 SNRA en Afrique subsaharienne.*
- *581, 496 et 263 clones avancés de manioc adaptés aux agroécologies d'altitude moyenne et d'altitude élevée d'Afrique orientale et australe ont été introduits en provenance du Centre régional pour l'Afrique orientale et australe (ESARC) en Ouganda vers le Kenya, la Tanzanie et le Rwanda respectivement dans le cadre de l'assouplissement des services de quarantaine. 84 et 81 clones de ces stocks ont également été introduits auprès des programmes nationaux de la République Démocratique du Congo et du Burundi, en provenance du Rwanda.*
- *Plus de 500 cultivars locaux et 400 génotypes améliorés ont été carctérisés en 6 groupes distincts de diversité et constitueront la base des futures études hétérotiques. Par ailleurs, les cultivars locaux ont présenté des sources de résistance plus élevée aux pourritures racinaires que les génotypes améliorés.*
- *400 clones évalués dans les essais de performance à l'ESARC ont présenté des rendements en racines d'accumulation de l'ordre de 8,3 à 114 t/ha avec la plupart des clones ayant une teneur en matières sèches entre 35 et 40%, tandis que 30% des clones ont eu un rendement supérieur à celui du témoin local et 4 clones ont donné des rendements de plus de 150 t/ha, ce qui suggère un dépassement total du palier de rendement du manioc.*
- *Des génotypes dotés d'une teneur en azote plus élevée (1,1–10,1 g/kg de matières sèches), d'un faible potentiel cyanogène (1,12–12,93 mg HCN/100 mg du poids des racines fraîches) et d'une teneur élevé en zinc (1,40–36,10 ppm) et en fer (1,3–64,80 ppm) ont été identifiés. Cela indique une possibilité de fortification génétique du manioc avec du fer et du zinc tout en renforcant le potentiel d'augmentation de la teneur en azote des racines et la réduction du potentiel cyanogène.*
- *L'Ouganda et le Malawi ont officiellement distribué 6 et 3 variétés supplémentaires résistantes à l'acarien vert du manioc respectivement en provenance du matériel génétique dérivé de l'IITA.*
- *La capacité des SNRA et des ONG à entreprendre des recherches sur le manioc a été renforcée grâce à un atelier de formation organisé à l'intention des sélectionneurs de 9 pays africains et aux stages de formation sur l'agronomie et les techniques de multiplication rapide pour 110 techniciens et agents de vulgarisation en Afrique orientale et australe.*

Project 15

Molecular and cellular biotechnology for crop improvement

- Progress has been made in the optimization of parameters for cowpea transformation through: (a) transient GUS gene expression following *Agrobacterium*-mediated transformation, (b) establishment of antibiotic thresholds for selection of transformed cowpea tissues, and (c) development of shoot elongation and rooting media. Having well-rooted cowpea plantlets in tissue culture helps to avoid loss of these plantlets when they are transferred to soil for hardening.
- T1 plants transformed with viral coat protein and insect resistance genes have been generated and preliminary screening of 30 T1 plants by polymerase chain reaction amplification of the viral coat protein sequence has revealed 6 positive lines.
- A genetic linkage map of yam (*D. rotundata*) based on AFLP markers was developed with 107 markers in 12 linkage groups (total length 585 cM) for the male parent and 116 markers in 13 linkage groups (total of 700 cM) for the female parent.
- A genetic linkage map of yam (*D. alata*) based on AFLP markers was developed. The map consisted of 338 markers mapped on 20 linkage groups with a total length of 1055 cM.
- AFLP and RAPD markers associated with QTL for yam mosaic virus (YMV), genus Potyvirus, were identified.
- Polyclonal antisera were raised against 3 *Dioscorea* viruses, 3 viruses infecting herbaceous legumes, one cassava virus, and one banana virus.
- An improved protocol for cassava cryopreservation was developed with 60% recovery. Cryopreservation of yam meristems gave a maximum of 35% recovery.
- A culture medium that can support growth and plantlet formation of 2 week old immature seeds of *D. alata* was developed and used to rescue one *D. alata* cross.
- Cyclic somatic embryogenesis was achieved from meristems and immature leaf lobes of both local and improved cassava genotypes. Organogenesis (shoot formation) was obtained from cotyledon pieces of those somatic embryos.
- A Memorandum of Affiliation was signed between IITA and the Center for the Application of Molecular Biology to International Agriculture (CAMBIA).

Projet 15

Biotechnologie moléculaire et cellulaire pour l'amélioration des cultures

- *Des progrès ont été réalisés dans l'optimisation des paramètres de transformation du niébé grâce : (a) l'expression transitoire du gène* GUS *suite à une transformation par* Agrobacterium, *(b) l'établissement de seuils antibiotiques pour la sélection des tissus de niébé transformés et (c) mise au point de milieux de l'élongation des pousses et des racines. Un bon développement radiculaire des vitroplants de niébé en culture de tissus permet d'éviter des pertes de ces plantules au moment de leur transplantation pour un renforcement de leur vigueur.*
- *Des plants* T1 *transformés à l'aide des protéines de l'enveloppe virale et des gènes de résistance aux insectes ont été générés et le criblage préliminaire de* 30 *plants* T1 *par amplification en chaine par polymérase de la séquence des protéines de l'enveloppe virale ont révélé* 6 *lignées positives.*
- *Une carte de la liaison génétique d'une igname* (D. rotundata) *à l'aide de marqueurs* AFLP *a été établie avec* 107 *marqueurs dans* 12 *groupes de liaison (longueur totale de* 585 cM) *pour le parent mâle et* 116 *marqueurs dans* 13 *groupes de liaison (total de* 700 cM) *pour le parent femelle.*
- *Une carte de liaison génétique de* D. alata *à l'aide de marqueurs* AFLP *a été établie. La carte consiste en* 338 *marqueurs cartographiés sur* 20 *groupes de liaison d'une longueur totale de* 1055 cM.
- *Des marqueurs* AFLP *et* RAPD *liés au* QTL *pour le virus de la mosaïque de l'igname* (YMV), *genre* Potyvirus, *ont été identifiés.*

- Des antisérums polyclonaux ont été élaborés contre 3 virus de Dioscorea, 3 virus infectant les légumineuses herbacées, un virus du manioc et un virus de la banane.
- Un protocole amélioré pour la cryoconservation du manioc a été mis au point avec un taux de récupération de 60%. La cryoconservation des méristèmes d'igname a permis un taux de récupération maximum de 35%.
- Un milieu de culture pouvant supporter la croissance et la formation de plantules de semences imatures de D. alata de 2 semaines, a été élaboré et utilisé pour récupérer un croisement de D. alata.
- Une embryogénèse somatique cyclique a été réalisée à partir de méristèmes et de lobes de feuilles imatures de génotypes de manioc local et amélioré. L'organogénèse (formation de pousses) a été obtenue à partir des morceaux du cotyledon de ces embryons somatiques.
- Un Accord d'affiliation a été signé entre l'IITA et le Centre de biotechnologie moléculaire avancée pour l'agriculture internationale (CAMBIA).

Conservation and utilization of plant biodiversity

Project 16

- Investigation on storage of yam pollen under liquid nitrogen for long-term conservation and for use in hybridization programs showed great promise.
- Through meristem culture, over 200 accessions of germplasm of 5 cultivated yam species and 6 wild species were successfully transferred from fields to in vitro culture. The National Root and Tuber Improvement Program in Ghana was assisted in the cleaning-up of viruses from 7 varieties of sweetpotato for large-scale multiplication and distribution to farmers for cultivation.
- The efficiency of conventional serological diagnostics has been increased by developing protocols that reduce the duration of enzyme-linked immunosorbent assays from about 2 days to just over 1 hour.
- Selective media have been standardized to enhance quick identification of highly destructive bacteria (*Xanthomonas manihotis*, *X. cassavae*, and *Pseudomonas*) in cassava.
- Agronomic and botanical descriptors and RAPD markers were used to assess the potential breeding values and genetic diversity, and to help identify probable duplicates of local cassava germplasm collected from West Africa. Fortyeight accessions identified as having high levels of resistance to African cassava mosaic disease exhibited considerable variation in agronomic performance, morphological characteristics, and DNA banding patterns.
- Ploidy levels and genome composition of elite *Musa* germplasm were determined, and genetic bridges for crossing between plantain cultivars (triploids), that cannot be directly intercrossed, were developed. This has enhanced the breeding method for plantain improvement.
- A computerized database for IITA maize international trials developed over the past 10 years was established. Efforts are being made to link this with a GIS, for use in targeting introduction and development of germplasm for specific environments, to enhance the impact at farm level.

Conservation et utilisation de la biodiversité végétale

Projet 16

- L'étude sur le stockage du pollen de l'igname à l'aide de l'azote liquide en vue d'une conservation de longue durée et d'une utilisation dans les programmes d'hybridation s'est avérée très prometteuse.
- Grâce à la culture de méristèmes, plus de 200 obtentions de matériel génétique de 5 espèces d'igname cultivée et 6 espèces sauvages ont été transférées de manière concluante des champs en culture in vitro. Le Programme national d'amélioration des plantes à racines et tubercules du Ghana a contribué à l'élimination des virus de 7 variétés de patate douce en vue d'une multiplication et d'une distribution à grande échelle auprès des agriculteurs pour leur exploitation.
- L'efficacité des diagnostiques sérélogiques conventionnels a été augmentée suite à l'élaboration de protocoles réduisant la durée des essais par immunosorbant lié à une enzyme d'environ deux jours à seulement un peu plus d'une heure.

- Des milieux sélectifs ont été standardisés pour accroître la rapidité de l'identification de bactéries extrêmement destructrices (Xanthomonas manihotis, X. cassavae et Pseudomonas) chez le manioc.
- Des descripteurs agronomiques et botaniques ainsi que des marqueurs RAPD ont été utilisés pour évaluer les valeurs potentielles de sélection et la diversité génétique et pour identifier des doubles probables du matériel génétique de manioc collecté en Afrique occidentale. 48 obtentions identifiées comme ayant des niveaux de résistance élevée à la mosaïque africaine du manioc, ont présenté une variation considérable en matière de performance agronomique, de caractéristiques morphologiques et de profil de bandes d'ADN.
- Les niveaux de ploïdie et la composition du génome du matériel génétique élite de Musa ont été déterminés et les ponts génétiques pour les croisements entre les cultivars de plantain (triploïdes) qui ne peuvent pas être directement intercroisées, ont été mis au point. Cela a renforcé les méthodes de sélection pour l'amélioration du plantain.
- Une base de données informatisées pour les essais internationaux de l'IITA sur le maïs élaborés pendant les dix dernières années, a été mise en place. Des efforts sont en cours afin de lier cette base de donnée à un SIG en vue d'une utilisation dans le ciblage de l'introduction et de la mise au point de matériel génétique pour des environnements spécifiques susceptibles d'accroître l'impact au niveau des champs.

Systemwide program

Integrated pest management

- NGOs are playing an increasingly important role in encouraging farmers to adopt IPM approaches to crop protection problems. With the support of the CGIAR NGO Committee and the SP-IPM, IITA-Benin hosted a workshop for NGO participants from 14 African countries, providing them with insights into the latest IPM technologies and extension approaches. Participating researchers from 4 international research organizations, in turn, gained a better understanding of NGO perspectives on the research-to-implementation process. An e-mail discussion group was formed to enable participants to continue to work together on various IPM research and extension issues.
- Continuing in its efforts to achieve better coordination and broader awareness of the IPM research of the IARCs, the SP-IPM worked with the Impact Assessment Group of the CGIAR to collect information documenting the role of IPM research in sustainable agricultural development. The work of IITA on cassava pests was among the efforts highlighted in a report tabled at International Centers Week and soon to be available for wider distribution.

Programme à l'échelle du système

La lutte intégrée

- Les ONG jouent un rôle de plus en plus important en matière d'encouragement des agriculteurs à adopter les approches de lutte intégrée pour faire face aux problèmes de protection des végétaux. Grâce au soutien du Comité du GCRAI sur les ONG et au Programme sur la lutte intégrée à l'échelle du système (SP-IPM), l'IITA-Bénin a abrité un atelier pour les ONG concernés représentant 14 pays africains qui ont pu avoir un aperçu des technologies de lutte intégrée et des approches de vulgarisation les plus récentes. Les chercheurs participants représentant 4 organisations internationales de recherche ont également eu l'occasion, à leur tour, de mieux comprendre les perspectives des ONG concernant le processus recherche-mise en oeuvre. Un groupe de discussion par courrier électronique a été mis en place afin de permettre aux participants de continuer à travailler ensemble sur les différentes questions de recherche sur la lutte intégrée et la vulgarisation.
- Toujours dans le cadre des efforts visant une meilleure coordination et une plus grande prise de conscience de la recherche sur la lutte intégrée menée par les Centres internationaux de recherche agricole (CIRA), le SP-IPM, a travaillé en collaboration avec le Groupe sur l'évaluation de l'impact du GCRAI afin de collecter des informations pour la documentation du rôle de la recherche sur la lutte intégrée dans le développement agricole durable. Les travaux de l'IITA sur les ravageurs du manioc ont figuré parmi les efforts mis en exergue dans un rapport soumis lors de la Semaine de centres internationaux et qui sera bientôt disponible pour une diffusion plus vaste.

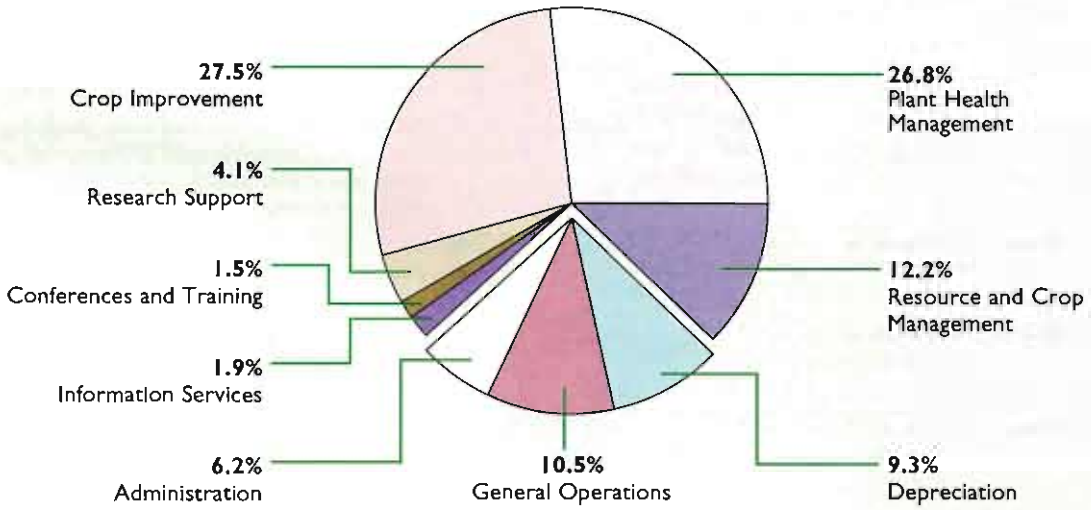
Graduate research completed in 1999

Degree	Country	University	Sponsor	Name	M/F	Research topic
Crop Improvement Division						
MSc	Nigeria	University of Ibadan	Self	Ohuruogu, C.J.	F	In vitro regeneration and transformability of soybean [*Glycine max* (L.) Merrill] via *Agrobacterium tumefaciens*
MSc	Nigeria	University of Ibadan	Self	Olaniyi, O.T.	M	The development of a low-cost medium for the micropropagation of white yam (*Dioscorea rotundata* Poir.)
MSc	Nigeria	University of Ibadan	Self	Oladimeji, M.O.	F	Development of low-cost media for cassava micropropagation
MSc	Nigeria	University of Ibadan	Self	Neh, E.	F	Effect of storage containers on varietal response of yam chips (*Dioscorea* spp.) to infestation by storage beetles
MSc	Nigeria	University of Ibadan	Self	Fatunbi, A.	M	Effects of fertilizer application on the performance of white yam (*Dioscorea rotundata*) seedlings in a nursery
MSc	Belgium	Katholieke Universiteit Leuven	IITA/KUL	Blanckaert, I.	F	Root system of banana and plantain with capacitance meter
MSc	Kenya	University of Natal, South Africa	Rockefeller Foundation	Ngoya, J.	M	Statistical methods in determining factors affecting weevil, nematode, and disease infestation in bananas
MSc	Uganda	University of the Orange Free State, South Africa	Rockefeller Foundation	Kigundu, A.	M	Host-plant interactions and mechanisms of resistance to banana weevil *Cosmopolites sordidus* (Germar) in Uganda
PhD	Nigeria	University of Ibadan	IITA/Self	Adetula, O.A.	F	C-banding and fluorescent in situ hybridization in cowpea
PhD	Nigeria	University of Ibadan	Self	Gungula, D.T.	M	Growth and nitrogen use efficiency in maize (*Zea mays* L.) in the southern Guinea savanna of Nigeria
PhD	Benin	University of Abidjan Côte d'Ivoire	IITA	Dansi, A.A.	M	Morphological, molecular, and cytological diversity of the cultivated yams of the *D. cayenensis–D. rotundata* complex from Benin
PhD	Nigeria	University of Ibadan	Self	Onalo, J.L.	F	Nonchemical control methods of the yam nematode —*Scutellonema bradys*
PhD	Uganda	Makerere University, Uganda	IITA	Tukamuhabwa, P.	M	Genetics of shattering in soybean and the effect of environment on shattering rate
PhD	Nigeria	University of Ibadan	IITA/Self	Ilori, C.O.	M	Transformability studies on cowpea [*Vigna unguiculata* (L.) Walp.]
PhD	Nigeria	University of Ibadan	IITA/Self	Ogundiwin, E.A.	M	Inheritance studies and mapping of cowpea mottle virus resistance genes in cowpea [*Vigna unguiculata* (L.) Walp.]
Plant Health Management Division						
MSc	Nigeria	University of Ibadan	Self	Yusuf, T.	M	Identification of viruses infecting *Mucuna pruriens* and *Pueraria phaseoloides*
MSc	Cameroon	University of Ibadan	Self	Dihewou, L.	F	Direct tissue blotting immunoassay: A reliable field technique for African cassava mosaic geminivirus (ACMV) detection
PhD	Cameroon	University of Hanover, Germany	IITA/IFAD	Ndemah, R.	F	Towards developing a sustainable pest management strategy for the African stalkborer, *Busseola fusca* (Fuller) Lepidoptera Noctuidae in Cameroon
PhD	Cameroon	University of Ibadan	IITA	Koona, P.	M	Anatomical and biochemical bases of resistance of wild and cultivated *Vigna* species to the coreid bug *Clavigralla tomentosicollis* Stål.
PhD	Nigeria	University of Ibadan	IITA	Oigiangbe, N.O.	M	Bases of resistance in some *Vigna* species and their effects on the nutritional ecology of *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae)
PhD	Zambia	Imperial College of Science, UK	DANIDA/ IITA	Mebelo, M.	M	Screening phytoseiids for the control of cassava green mites in Zambia

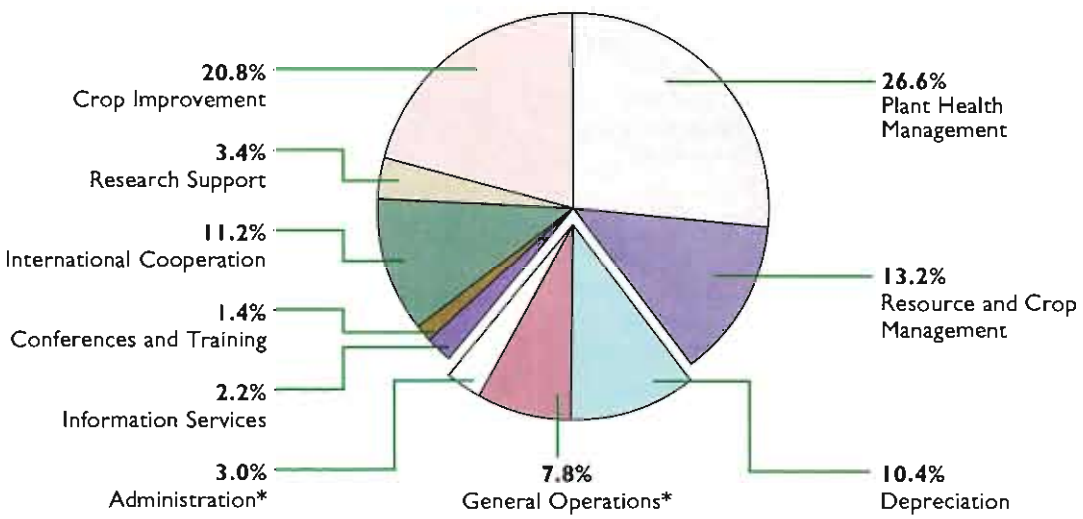
Graduate research completed in 1999

Degree	Country	University	Sponsor	Name	M/F	Research topic
PhD	Cameroon	University of the Orange Free State, South Africa	IITA	Ngoko, Z.	M	Mycotoxin contamination of maize in relation with fungi infection, cellular practices, and agroecology in Cameroon
PhD	Nigeria	University of Ibadan	IITA/Self	Dongo, L.N.	F	Viruses of *Dioscorea* spp. in Nigeria
PhD	Germany	University of Bonn, Germany	BMZ	Niere, B.I.	M	Fungal endophytes for the biological control of banana nematodes
PhD	Benin	University of Ghana, Legon	BMZ	Godonou, I.	M	Studies on the biology of banana weevil and possibilities of biological control with fungal pathogens
PhD	Benin	University of Gottingen, Germany	GTZ	Afouda, L.	M	Biological control of *Macrophomina phaseolina* (Tassi) Goid. the causal agent of charcoal rot and development of serological methods for its detection in cowpea [*Vigna unguiculata* (L.) Walp.]
PhD	Benin	University of Gottingen, Germany	GTZ	Fanou, A.A.	M	Epidemiological and ecological investigations on cassava bacterial blight and development of integrated control methods in Africa
PhD	Benin	University of Gottingen, Germany	GTZ	Sikirou, R.	F	Epidemiological investigations and development of integrated control methods of cowpea bacterial blight in Africa
PhD	Nepal	University of Gottingen, Germany	GTZ	Khatri-Chhetri, B.	M	Detection and characterization of *Xanthomonas campestris* pv. *vignicola* strains, incitant of cowpea blight and pustule, and studies on genotype/strain interactions
PhD	Benin	University of Hanover, Germany	Self	Setamou, M.	M	Ecology and pest status of *Mussidia nigrivenella* Ragonot (Lep.: Pyralidae), a cob borer of maize in West Africa
PhD	Senegal	University of Ghana, Legon	Ford Foundation	Diop, K.	F	The biology of *Ceranisus menes* (Walker) (Hym., Eulophidae), a parasitoid of the bean flower thrips *Megalurothrips sjostedti* Trybom (Thys., Thripidae)
Resource and Crop Management Division						
MSc	Nigeria	University of Ibadan	Self	Komolafe, M.	F	The role of symbiotic microorganisms in rock-phosphate solubilization
MSc	Belgium	Katholieke Universiteit Leuven	IITA/KUL	Oorts, K.	F	Combining organic and inorganic inputs for efficient N nutrition of maize
MSc	Belgium	Katholieke Universiteit Leuven	IITA/KUL	Sammels, L.	F	Importance of N leaching in the N balance of maize-based farming systems
MSc	Niger	University of Ibadan	Self	Abarchi, I.	M	Quality and nutrients release of *Mucuna* and *Lablab* residues as affected by the application of rock phosphate and toposequence
MSc	Belgium	Katholieke Universiteit Leuven	IITA/KUL	Cools, J.	M	Investigation in the variability of on-farm trials on balanced nutrient management practices in the northern Guinea savanna benchmark of Nigeria
PhD	Benin	University of Cocody, Abidjan	Self	Honlonkou, N.A.	M	Economic impact of *Mucuna* fallow diffusion in the south of Benin Republic
PhD	Nigeria	Obafemi Awolowo University	IITA	Bamire, S.A	M	Factors influencing the adoption of intensification technologies in Osun State of Nigeria
PhD	Benin	University of Ibadan	Self	Gbego, T.	M	Protein and energy improvement on the reproductive performances of female goats on farms in Mono province (South Benin)
PhD	Nigeria	University of Ibadan	Self	Ogoke, J.I.	M	Response of soybean to phosphorus fertilizer and its residual effects on subsequent maize performance in the Nigerian moist savanna
PhD	Japan	Texas A&M University, USA	Self	Yuji, N.	M	Ca and Mg movement on kaolinitic Alfisol
SARRNET						
PhD	Swaziland	University of Pretoria, SA	SARRNET	Nsibande, L.M.	M	The spatial and temporal dynamics of the major sweetpotato insect pests in Swaziland
PhD	Tanzania	University of the Orange Free State, SA	SARRNET	Kanju, E.E	M	Inheritance of several agronomic and quality characteristics in sweetpotato [*Ipomoea batatas* (L.) Lam.]

Core costs by operating segment, 1999

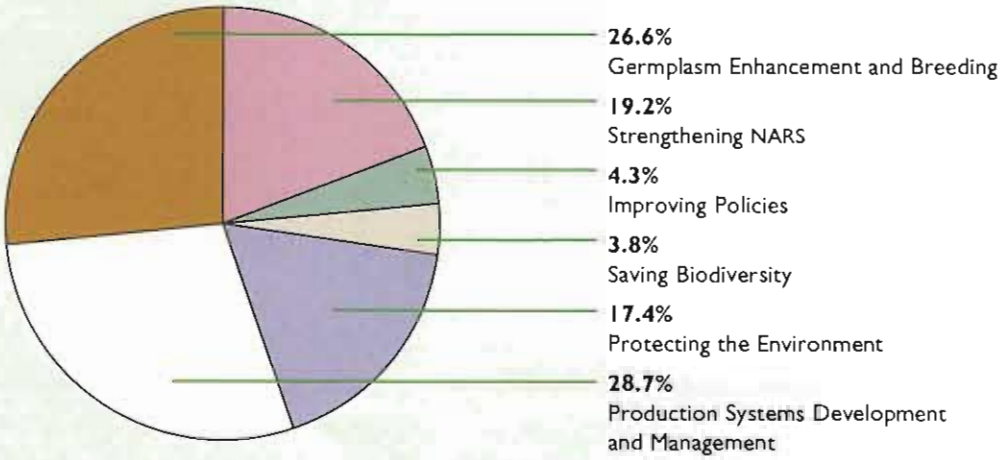


Core costs by operating segment, 1998

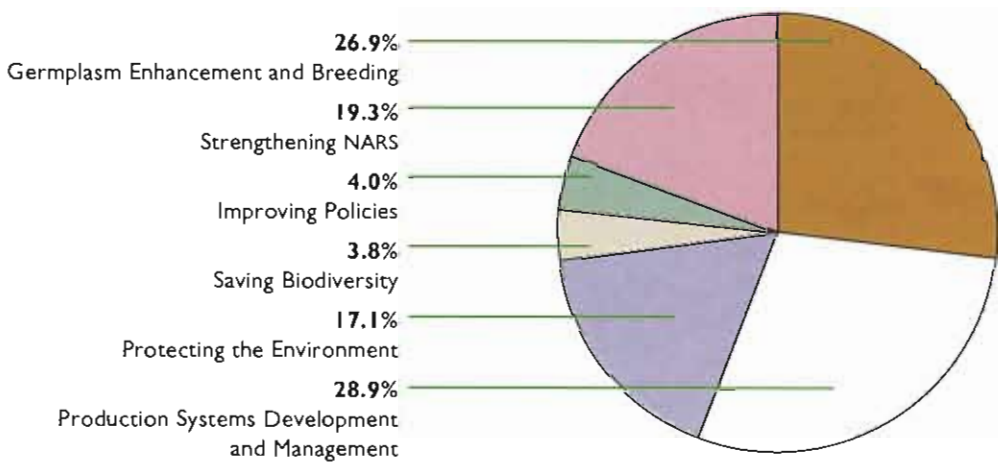


* Net of accruals reversed amounting to US$0.985 million in compliance with International Accounting Standard (IAS) 37.

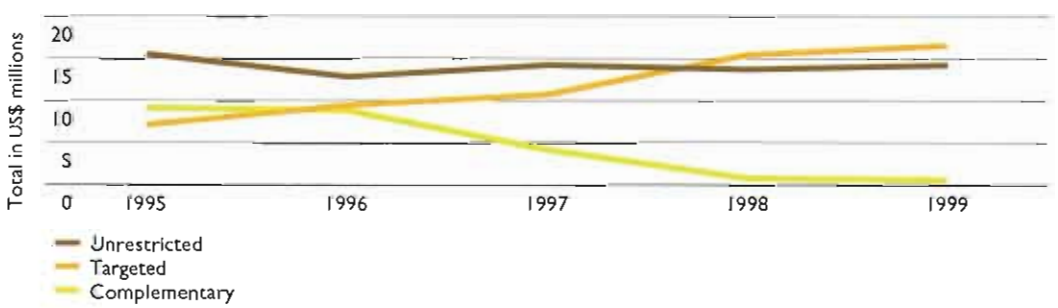
Core research expenditure by CGIAR program, 1999



Core research expenditure by CGIAR program, 1998



Core (unrestricted and targeted) with complementary funding, 1995–99



Note: The core budget is used to fund those research-related activities essential in meeting CGIAR objectives for developing countries.

Statement of Financial Position

For the year ended 31 December—in US$ thousands

	1999	1998
Assets		
Current assets		
Cash and cash equivalents	18,223	19,551
Accounts receivable—donors	5,804	4,304
Accounts receivable—others	601	549
Inventories	1,205	1,212
Prepaid expenses	198	302
Other assets	192	233
Total current assets	26,223	26,151
Fixed assets		
Property, plant, and equipment	76,145	74,584
Less: accumulated depreciation	(45,571)	(43,246)
Total fixed assets—net	30,574	31,338
Total assets	56,797	57,489
Liabilities and fund balances		
Current liabilities		
Accounts payable and other liabilities	3,147	2,952
Accrued salaries and benefits	5,272	5,156
Payments in advance	6,630	7,496
Total current liabilities	15,049	15,604
Net assets		
Capital invested in fixed assets	30,574	31,338
Capital fund	5,168	4,350
Operating fund	6,006	6,197
Total net assets	41,748	41,885
Total liabilities and net assets	56,797	57,489

Statement of Activity

For the year ended 31 December—in US$ thousands

	1999	1998
Revenue		
Grants	30,791	29,221
Investment income	368	819
Total revenue	31,159	30,040
Expenses		
Research programs	20,636	20,389
Conferences and training	1,606	1,819
Information services	632	664
General administration	2,014	918
General operations	3,413	2,386
Depreciation	3,049	3,188
Total expenses	31,350	29,364
Excess/(shortfall) of revenue over expenses	(191)	676

Statement of Cash Flow

For the year ended 31 December—in US$ thousands

	1999	1998
Cash flows from operating activities		
Excess/(shortfall) of revenue over expenses	(191)	676
Adjustments to reconcile net cash		
Provided by operating activities:		
Depreciation	3,049	3,188
Gain on disposal of assets	86	379
Decrease (Increase) in assets:		
Accounts receivable—donors	(1,500)	(1,017)
Accounts receivable—others	(52)	312
Inventories	7	37
Prepaid expenses	104	(185)
Other assets	41	(44)
Increase (Decrease) in liabilities:		
Accounts payable and other liabilities	195	(1,704)
Accrued salaries and benefits	116	197
Payments in advance	(866)	(776)
Total adjustments	1,180	387
Net cash provided by operating activities	989	1,063
Cash flow used in investment activities:		
Acquisition of fixed assets	(2,317)	(1,975)
Net decrease in cash and cash equivalents	(1,328)	(912)
Cash and cash equivalents: End of year	18,223	19,551
Beginning of year	19,551	20,463
Decrease in the year	(1,328)	(912)

Donors

For the year ended 31 December—in US$ thousands

	1999		1998	
	Core Funding	Complementary Funding	Core Funding	Complementary Funding
African Development Bank	411	–	–	–
Austria	876	31	946	(31)
Belgium	1,369	–	1,705	–
BMZ, Germany	1,220	–	1,215	–
Brazil	–	–	20	–
Canada	709	–	741	–
Commission of the European Communities	355	–	872	–
Denmark	1,798	–	2,072	–
Department for International Development–UK	724	–	646	–
Food and Agriculture Organization	33	–	23	–
Ford Foundation	53	–	14	–
France	547	–	607	–
Gatsby Charitable Foundation	383	–	374	–
International Centre for Research in Agroforestry	26	–	61	–
International Development Research Centre	135	–	142	–
International Fund for Agricultural Development	603	–	416	–
International Institute of Biological Control	333	–	620	–
Italy	280	–	285	–
Japan	4,274	–	3,882	–
Korea, Republic of	50	–	50	–
Netherlands	870	–	1,047	–
Nigeria	1,513	–	148	–
Norway	761	–	847	–
Rockefeller Foundation	524	–	402	–
Sasakawa Africa Association	96	–	158	–
South Africa	65	–	40	–
Sweden	479	–	371	–
Switzerland	1,997	–	1,512	–
United Nations Development Programme	362	–	215	–
United States Agency for International Development	6,656	–	6,576	–
United States Department of Agriculture	5	–	106	–
University of Hohenheim	–	15	–	72
World Bank	3,064	–	2,950	–
Miscellaneous Projects	171	–	82	–
Closed Projects	–	3	–	35
Total	30,742	49	29,145	76

Publications by IITA *staff*

Contributions by IITA staff to scientific literature that became available during 1999, including journal articles, books and book chapters, papers in monographs or conference proceedings, published abstracts, research notes, and disease reports. Also included are publications based on work done by IITA staff prior to their joining IITA, especially where the work reported is of interest to IITA, and publications by staff who have left IITA, which are based on work done while they were at the Institute.

Journal articles

Abera, A.M.K., C.S. Gold, and S. Kyamanywa. 1999. Timing and distribution of attack by the banana weevil (Coleoptera Curculionidae) in East African Highland Banana (*Musa* spp.) Florida Entomologist 82: 631–641.

Adejuyigbe, C.O., G. Tian, and G.O. Adeoye. 1999. Soil microarthropod populations under natural and planted fallows in southwestern Nigeria. Agroforestry Systems 47: 263–272.

Adipala, E., G. Bigirwa, I.P. Esele, and K.F. Cardwell. 1999. Development of sorghum downy mildew on sequential plantings of maize in Uganda. International Journal of Pest Management 2: 147–154.

Aihou, K., N. Sanginga, B. Vanlauwe, O. Lyasse, J. Diels, and R. Merckx. 1999. Alley cropping in the moist savanna of West Africa I. Restoration and maintenance of soil fertility on "terre de barre" soils in Benin Republic. Agroforestry Systems 42: 213–227.

Aiming, Q., T.R. Wheeler, J.D.H. Keatinge, R.H. Ellis, R.J. Summerfield, and P.O. Craufurd. 1999. Modelling the effects of temperature on the rates of seedling emergence and leaf appearance in legume cover crops. Experimental Agriculture 35: 327–344.

Aiming, Q., R.H. Ellis, J.D.H. Keatinge, T.R. Wheeler, S.A. Tarawali, and R.J. Summerfield. 1999. Differences in the effects of temperature and photoperiod on progress to flowering among diverse *Mucuna* spp. Journal of Agronomy and Crop Science 182: 249–258.

Akobundu, I.O., F. Ekeleme, and D. Chikoye. 1999. The influence of fallow management system and frequency of cropping on weed growth and crop yield. Weed Research 39: 241–256.

Akparobi, S., A.O. Togun, and I.J. Ekanayake. 1999. Low temperature effects on sprouting and early establishment of cassava clones. Nigerian Journal of Science 33: 277–286.

Amissah-Arthur, A.A. and S. Jagtap. 1999. Geographic variation in growing season rainfall. Theoretical and Applied Climatology 63: 107–116

Amissah-Arthur, A., S.S. Jagtap, and K. Dashiell. 1999. Plant density effects on growth and yield of tropical soybeans. Tropical Science 39: 162–167.

Aritua, V., J.P. Legg, N.E.I.M. Smit, and R.W. Gibson. 1999. Effect of local inoculum on the spread of sweetpotato virus disease: limited infection of susceptible cultivars following widespread cultivation of a resistant sweetpotato cultivar. Plant Pathology 48: 655–661.

Asghar, A., J.D.H. Keatinge, S. Ahmed, and B. Roidar Khan. 1999. Shiraz-96, first improved lentil variety for the arid highlands of Balochistan, Pakistan. Pakistan Journal of Biological Science 2: 1540–1542.

Asghar, A., J.D.H. Keatinge, S. Ahmed, B. Roidar Khan, and I.A. Qamar. 1999. Kohak-96, first cold and drought tolerant vetch variety for the arid uplands of Balochistan, Pakistan. Pakistan Journal of Biological Science 2: 1427–1431.

Ayertey, J.N., W.G. Meikle, C. Borgemeister, M. Camara, and R.H. Markham. 1999. Studies on predation of *Prostephanus truncatus* (Horn) (Col., Bostrichidae) and *Sitophilus zeamais* Mots. (Col., Curculionidae) at different densities on maize by *Teretriosoma nigrescens* Lewis (Col., Histeridae). Journal of Applied Entomology 123: 265–271.

Badejo, M.A. and G. Tian. 1999. Abundance of soil mites under four agroforestry tree species with contrasting litter quality. Biology and Fertility of Soils 30: 107–112.

Bailey, A., T. Rehman, J. Park, J.D.H. Keatinge, and R.B. Tranter. 1999. Towards a method for the economic evaluation of environmental indicators for UK integrated arable farming systems. Agriculture, Ecosystems and Environment 72: 145–156.

Baiyeri, K.P., A. Tenkouano, B.N. Mbah, and J.S.C. Mbagwu. 1999. Genetic and cropping system effects on biological value and market potential of *Musa* spp. L. in southeastern Nigeria. African Crop Science Journal 7: 1–7.

Baiyeri, K.P., A. Tenkouano, B.N. Mbah, and J.S.C. Mbagwu. 1999. Ploidy and genomic group effects on yield components interaction in bananas and plantains across four environments in Nigeria. Scientia Horticulturae 1459: 1–12.

Barker, D.J., J.D.H. Keatinge, and R. Asiedu. 1999. The potential of physical means for the manipulation of yam dormancy. Tropical Science 39: 204–213.

Barker, D.J., J.D.H. Keatinge, and R. Asiedu. 1999. Yam dormancy: potential mechanisms for its manipulation. Tropical Science 39: 168–177.

Bock, C.H., M.J. Jeger, L.K. Mughogho, and K.F. Cardwell. 1999. Effect of dew point temperature and conidium age on germination, germ-tube growth and infection of maize and sorghum by an isolate of *Peronosclerospora sorghi* from Zimbabwe. Mycological Research 103: 859–864.

Bonato, O. and F. Schulthess. 1998. Selecting a character for identifying larval instars of the stemborers *Sesamia calamistis* Hampson (Noctuidae) and *Eldana saccharina* Walker (Pyralidae) on maize. Insect Science and its Application 2: 101–103.

Bonato, O., F. Schulthess, and J.U. Baumgaertner. 1999. Simulation model for maize crop growth based on acquisition and allocation processes for carbohydrate and nitrogen. Ecological Modelling 124: 11–28.

Borgemeister, C., K. Schäfer, G. Goergen, S. Awande, H.M. Poehling, and D. Scholz. 1999. Host-finding behavior of *Dinoderus bifoveolatus* (Coleoptera: Bostrichidae), an important pest of stored cassava: the role of plant volatiles and odors of conspecifics. Annals of the Entomological Society of America 92: 766–771.

Carsky, R.J., B. Oyewole, and G. Tian. 1999. Integrated soil management for the dry savanna zone of West Africa: legume rotation and fertilizer N. Nutrient Cycling in Agroecosystems 55: 95–105.

Cherry, A.J., C.J. Lomer, D. Djegui, and F. Schulthess. 1999. Pathogen incidence and their potential as microbial control agents in IPM of maize stem borers in West Africa. BioControl 44: 301–327.

Chikoye, D., F. Ekeleme, and I.T. Ambe. 1999. Survey of distribution and farmer perceptions of speargrass *Imperata cylindrica* in cassava based cropping systems in West Africa. International Journal of Pest Management 45: 305–312.

Chineke, T.C., S.S. Jagtap, and J.I. Aina. 1999. Application of a weather simulation model based on observed daily meteorological data in humid tropical climate. Theoretical and Applied Climatology 64: 15–25.

Colucci, G., I. Machuka, and M.J. Chrispeels. 1999. cDNA cloning of a class III acid chitinase from the African yam bean (*Sphenostylis stenocarpa*) (Accession no. AF137070). Plant Physiology 120: 633.

Cotty, P.J. and K.F. Cardwell. 1999. Divergence of West African and North American communities of *Aspergillus* section *flavi*. Applied and Environmental Microbiology 5: 2264–2266.

Crouch, J.H., H.K. Crouch, A. Tenkouano, and R. Ortiz. 1999. VNTR-based diversity analysis of 2x and 4x full-sib *Musa* hybrids. Electronic Journal of Biotechnology 2(3) (http://www.ejb.org/).

Crouch, J.H., H.K. Crouch, H. Constandt, A. Van Gysel, P. Breyne, M. Van Montagu, R.L. Jarret, and R. Ortiz. 1999. Comparison of PCR-based molecular marker analyses of *Musa* breeding populations. Molecular Breeding 5: 233–244.

Dansi, A., H.D. Mignouna, J. Zoundjihékpon, A. Sangaré, R. Asiedu, and F.M. Quin. 1999. Morphological diversity, cultivar groups and possible descent in the cultivated yams (*Dioscorea cayenensis/D. rotundata*) complex in Benin Republic. Genetic Resources and Crop Evolution 46: 371–388.

Egbe, E.A., D.O. Ladipo, L.C. Nwoboshi, and M.I. Swift. 1998. Potentials of *Millettia thonningii* and *Pterocarpus santalinoides* for alley cropping in humid lowlands of West Africa. Agroforestry Systems 40: 309–321.

Ferris, S., R. Ortiz, and D Vuylsteke. 1999. Fruit quality evaluation of plantains, plantain hybrids, and cooking bananas. Postharvest Biology and Technology 15: 73–81.

Fessehaie, A., K. Wydra, and K. Rudolph. 1999. Development of a new semiselective medium for isolating *Xanthomonas campestris* pv. *manihotis* from plant material and soil. Phytopathology 89: 591–597.

Fokunang, C.N., C.N. Akem, T. Ikotun, and A.G.O. Dixon. 1999. Effect of planting season on cassava anthracnose disease development. Crop Protection 18: 407–413.

Fokunang, C.N., C.N. Akem, T. Ikotun, and A.G.O. Dixon. 1999. Seed survival and transmission of cassava anthracnose disease and seed treatment effect on seedling growth. Pakistan Journal of Biological Science 2: 849–854.

Gold, C.S., P. Nemeye, and R. Coe. 1999. Recognition and duration of larval instars of banana weevil, *Cosmopolites sordidus* Germar, in Uganda. African Entomology 7: 49–62.

Gold, C.S., M.I. Bagabe, and R. Ssendege. 1999. Banana weevil, *Cosmopolites sordidus* (Germar) (Coleoptera: Curculionidae) tests for suspected resistance to carbofuran and dieldrin in Masaka District, Uganda. African Entomology 7: 189–196.

Gold, C.S., E.B. Karamura, A. Kiggundu, F. Bagamba, and A.M.K. Abera. 1999. Geographic shifts in highland banana (*Musa*, group AAA-EA) production in Uganda: site and data summaries. African Crop Science Journal 7: 223–298.

Gold, C.S., E.B. Karamura, A. Kiggundu, F. Bagamba, and A.M.K. Abera. 1999. Geographic shifts in highland cooking banana (*Musa* spp., group AAA-EA) production in Uganda. International Journal of Sustainable Development and World Ecology 6: 45–59.

Gutierrez, A.P., J.S. Yaninek, P. Neuenschwander, and C.K. Ellis. 1999. A physiologically based tritrophic metapopulation model of the African cassava food web. Ecological Modelling 123: 225–242.

Henriet, J., G.A. van Ek, S.F. Blade, and B.B. Singh. 1997. Quantitative assessment of traditional cropping systems in the Sudan savanna of northern Nigeria: I. Rapid survey of prevalent cropping systems. Samaru Journal of Agricultural Research 14: 37–45.

Henriet, J., G.A. van Ek, S.F. Blade, and B.B. Singh. 1997 Quantitative assessment of traditional cropping systems in the Sudan savanna of northern Nigeria: III. Importance of trees, shrubs and secondary crops in the cropping systems. Samaru Journal of Agricultural Research 14. 61–66.

Honlonkou, A.N., V.M. Manyong, and N'G. Tchetche. 1999. Farmers' perceptions and the dynamics of adoption of a resource management technology: the case of *Mucuna* fallow in southern Benin, West Africa. International Forestry Review 1: 228–235.

Hughes, J.d'A. and S.A. Tarawali. 1999. Viruses of herbaceous legumes in sub-Saharan Africa. Tropical Science 39: 70–76.

Jagtap, S.S. and A. Amissah-Arthur. 1999. Stratification and synthesis of crop–livestock production systems using GIS. GeoJournal 47: 573–582.

Jagtap, S.S. and O. Adeleye. 1999. Nutrient recovery and productivity of a soybean–maize rotation in the derived savanna ecology of West Africa. Journal of Sustainable Agriculture 15: 75–86.

Jagtap, S.S., F.I. Abamu, and I.G. Kling. 1999. Long term assessment of nitrogen and fertilizer technologies on attainable maize yields in Nigeria using CERES-Maize. Agricultural Systems 60: 77–86.

Kadiata, B.D., K. Mulongoy, and B. Mambani. 1998. Pruning effect on nitrogen nutrient release in the root zone of *Albizia lebbeck* and *Leucaena leucocephala*. Biology and Fertility of Soils 26: 187–193.

Kamara, A.Y., D. Chikoye, and S.C. Jutzi. 1999. Differences in weed seed banks in planted tree fallows in southwestern Nigeria. Journal of Applied Botany (Angewandte Botanik) 73: 38–42.

Kamara, A.Y., I.O. Akobundu, D. Chikoye, and S.C. Jutzi. 1999. Weed seed bank size and composition in an arable crop mulched with pruning from three multipurpose trees in south-western Nigeria. Journal of Applied Botany (Angewandte Botanik) 73: 25–30.

Kang, B.T., F.E. Caveness, G. Tian, and G.O. Kolawole. 1999. Long-term alley cropping with four hedgerow species on an Alfisol in southwestern Nigeria—effect on crop performance, soil chemical properties and nematode population. Nutrient Cycling in Agroecosystems 54: 145–155.

Keatinge, J.D.H., Q. Aiming, T.R. Wheeler, F. Musitwa, N.A.P. Franks, D. Kuribuza, R.H. Ellis, and R.J. Summerfield. 1999. Selecting potential annual-sown legumes for cover crops, trash lines, mulching material, green manure or short-fallow replacement in the low-input systems in the East African Highlands: the example of SW Uganda. Mountain Research and Development 19: 345–353.

Keatinge, J.D.H., O.I. Aiming, T.R. Wheeler, M Subedi, P.B. Shah, R.H. Ellis, and R.J. Summerfield. 1999. Selecting annual legume species with potential as autumn-sown green manures/cover crops in the low-input farming systems of Nepal. Mountain Research and Development 19: 325–332.

Korie, S., S.J. Clark, J.N. Perry, M.A. Mugglestone, P.W. Bartlett, E.J.P. Marshall, and J.A. Mann. 1998. Analyzing maps of dispersal around a single focus. Environmental and Ecological Statistics 5: 317–344.

Kormawa, P.M., A. Kamara, Y. Jutzi, and N. Sanginga. 1999. Economic evaluation of using mulch for multipurpose trees in maize-based production systems in south-western Nigeria. Experimental Agriculture 53: 101–109.

Koutika, L.S., F. Andreux, J. Hassink, Th. Choné, and C.C. Cerri. 1999. Characterisation of soil organic matter in the topsoils under rain forest and pastures in the eastern Brazilian Amazon Basin. Biology and Fertility of Soils 29: 309–313.

Koutika, L.S., Th. Choné, F. Andreux, G. Burtin, and C.C. Cerri. 1999. Factors influencing organic carbon decomposition of topsoils from the Brazilian Amazon Basin. Biology and Fertility of Soils 28: 436–438.

Lahai, M.T., I.J. Ekanayake, and J.B. George. 1998. Reactions of leaf retention and pest and disease incidence of cassava (*Manihot esculenta* Crantz) genotypes to leaf harvesting. Tropical Agriculture (Trinidad) 75: 154–159.

Lahai, M.T., I.J. Ekanayake, and J.B. George. 1999. Cassava *Manihot esculenta* Crantz growth indices, root yield and its components in upland and inland valley agroecologies of Sierra Leone. Journal of Agronomy and Crop Science (Berlin) 182. 239–247.

Langewald, J., C. Kooyman, R. Bateman, M. Thomas, Z. Ouambama, A. Mamadou, and C.J. Lomer. 1999. Use of *Metarhizium flavoviride* for control of *Oedaleus senegalensis*: a model, linking cage mortality in the laboratory with population reduction in the field. Biocontrol Science and Technology 9: 199–214.

Legg, J.P. 1999. Emergence, spread and strategies for controlling the pandemic of cassava mosaic virus disease in east and central Africa. Crop Protection 18: 627–637.

Legg, J.P. 1999. Fighting cassava mosaic pandemic: networking critical. Agriforum 7: 1, 12.

Legg, J.P., R. Kapinga, J. Teri, and J.B.A. Whyte. 1999. The pandemic of cassava mosaic virus disease in East Africa: control strategies and regional partnerships. Roots 6: 10–19.

Lomer, C.J., R.P. Bateman, H. deGroote, D. Dent, C. Kooyman, J. Langewald, D. Johnson, R. Peveling, and M.B. Thomas. 1999. Development of strategies for the incorporation of microbial pesticides into the integrated management of migratory pests. Agricultural and Forest Entomology 1: 71–88.

Machuka J., E.J.M. van Damme and W.J. Peumans, and L.E.N. Jackai. 1999 Effect of plant lectins on larval development of legume pod borer, *Maruca vitrata*. Entomologia Experimentalis et Applicata 93: 179–187.

Machuka, J.S., O.G. Okeola, E.J.M. van Damme, M.J. Chrispeels, F. van Leuven, and W.J. Peumans. 1999. Isolation and partial characterization of new galactose-specific lectins from African Yam Beans, *Sphenostylis stenocarpa* Harms. Phytochemistry 51: 721–728.

Machuka, J. 2000. Characterization of the seed proteins of velvet bean *Mucuna pruriens* from Nigeria. Food Chemistry 68: 421–427.

Maiga, I.H., O.K. Douro-Kpindou, C.J. Lomer, and I. Langewald. 1999. Utilisation de *Metarhizium flavoviride* Gams et Roszypal contre les sauteriaux dans des essais paticipatifs en milieur paysan au Niger. Insect Science and its Application 18: 279–284.

Mai-Kodomi, Y., B.B. Singh, O. Myers, J.H. Yopp, P.J. Gibson, and T Terao. 1999. Two mechanisms of drought tolerance in cowpea. Indian Journal of Genetics 59: 309–316.

Meikle, W.G., R.H. Markham, B. Djomamou, H. Schneider, K.A. Vowotor, and N. Holst. 1998. Distribution and sampling of *Prostephanus truncatus* (Coleoptera: Bostrichidae) and *Sitophilus zeamais* (Coleoptera: Curculionidae) in maize stores in Benin. Journal of Economic Entomology 91: 1366–1374.

Meikle, W.G., N. Holst, and R.H. Markham. 1999. Population simulation model of *Sitophilus zeamais* (Coleoptera: Curculionidae) in grain stores in West Africa. Environmental Entomology 28: 836–844.

Menkir, A. and J.G. Kling. 1999. Effect of reciprocal recurrent selection on grain yield and other traits in two early-maturing maize populations. Maydica 44: 159–165.

Mudiope, J., P.R. Speijer, N.R. Maslen, and E. Adipala. 1998. Evaluation of yam host-plant response to root-knot nematodes in Uganda. African Plant Protection 4: 119–122.

Ndubuisi, A., J. Zeddies, V.M. Manyong, and J.W. Smith 1998. Crop–livestock integration along the gradient of resource-use intensification in the northern Guinea savanna of Nigeria. Quarterly Journal of International Agriculture 37: 105–115.

Norgrove, L. and S. Hauser. 1999. Effects of tree density and crop management upon earthworm cast production in a young timber plantation after introducing understorey crops. Pedobiologia 43: 666–674.

Norgrove, L. and S. Hauser. 1999. Effect of earthworm surface casts upon maize growth. Pedobiologia 43: 720–723.

Nukenine, E.N., A.T. Hassan, and A.G.O. Dixon. 1998. Field interactions of green spider mite *Mononychellus tanajoa* Bondar with indigenous phytoseiid predators and red spider mite (*Oligonychus gossypii* Zacher) as influenced by varietal resistance in cassava. Journal of Plant Protection in the Tropics 11: 126–141.

Nukenine, E.N., A.G.O. Dixon, A.T. Hassan, and J.A.N. Asiwe. 1999. Evaluation of cassava cultivars for canopy retention and its relationship to field resistance to green spider mite *Mononychellus tanajoa* Bondar. African Crop Science Journal 7: 47–57.

Nwoko, H. and N. Sanginga. 1999. Dependency of promiscuous soybean and herbaceous legumes on arbuscular mycorrhizal fungi and their response to bradyrhizobial inoculation in low P soils. Applied Soil Ecology 13: 251–258.

Obatolu, V.A., H.A. Cole, and B.B. Maziya-Dixon. 1999. Nutritional quality of complementary food prepared from unmalted and malted maize fortified with cowpea using extrusion cooking. Journal of the Science of Food and Agriculture 79: 1–5.

Oikeh, S.O., J.G. Kling, W.J. Horst, V.O. Chude, and R.J. Carsky. 1999. Growth and distribution of maize roots under nitrogen fertilization in plinthite soil. Field Crops Research 62: 1–13.

Okogbenin, E., I.I. Ekanayake, and M.C.M. Porto. 1999. Effect of planting methods and soil moisture on cassava performance in the semi-arid Sudan savanna belt of Nigeria. African Journal of Crop Science 17: 21–33.

Okoh, I.A., M.A. Badejo, I.T. Nathaniel, and G. Tian 1999. Studies on the bacteria, fungi and springtails (Collembola) of an agroforestry arboretum in Nigeria. Pedobiologia 43: 18–27.

Okoruwa, A.E., J.G. Kling, and B.B. Maziya-Dixon. 1999. Physical, chemical and water absorption properties of improved, open-pollinated maize cultivars. African Crop Science Journal 7: 153–163.

Olatinwo, R.O., K.F. Cardwell, M.L. Deadman, A. Menkir, and A.M. Julian. 1999. Inheritance of resistance to *Stenocarpella macrospora* (Earle) ear rot of maize in the mid-altitude zone of Nigeria. European Journal of Plant Pathology 105: 535–543.

Olatinwo, R.O., K.F. Cardwell, M.L. Deadman, and A.M. Julian. 1999. Epidemiology of *Stenocarpella macrospora* (Earle) on maize in the mid-altitude zone of Nigeria. Journal of Phytopathology 147: 347–352.

Olatinwo, R.O., M.L. Deadman, K.F. Cardwell, and A.M. Julian. 1999. Survey on incidence and severity of *Stenocarpella macrospora* (Earle) leaf blight of maize in the mid-altitude zone of Nigeria. International Journal of Pest Management 45: 259–262.

Omitogun, O.G., L.E.N. Jackai, and G. Thottappilly. 1999. Isolation of insecticidal lectin-enriched extracts from African yam bean (*Sphenostylis stenocarpa*) and other legume species. Entomologia Experimentalis et Applicata 90: 301–311.

Oussou, R., W.G. Meikle, and R.H. Markham. 1999. Factors affecting the development and survivorship of larvae of *Teretriosoma nigrescens* Lewis (Coleoptera: Histeridae). Insect Science and its Application 18: 53–58.

Park, J.R., A.P. Bailey, J.D.H. Keatinge, T. Rehman, R.B. Tranter, and C. Yates. 1999. Do integrated arable farming systems provide a more sustainable form of agricultural production: the UK case. Farm Management 10. 379–391.

Perry, J.N., W.E. Parker, L. Alderson, S. Korie, J.A. Blood-Smyth, R. McKinlay, and S.A. Ellis. 1998. Simulation of counts of aphids over two hectares of Brussels sprout plants. Computer and Electronics in Agriculture 21: 33–51.

Peters, M., S.A. Tarawali, R. Schultze-Kraft, J.W. Smith, and A. Musa. 1999. Performance of legume–legume mixtures under small-plot periodic grazing. Journal of Agronomy and Crop Science 182: 25–35.

Peveling, R., S. Attignon, I. Langewald, and Z. Ouambama. 1999. An assessment of the impact of biological and chemical grasshopper control agents on ground-dwelling arthropods in Niger, based on presence/absence sampling. Crop Protection 18: 323–339.

Qamar, I.A., J.D.H. Keatinge, N. Mohammed, A. Asghar, and M. Ajmal Khan 1999. Introduction and management of vetch/barley forage mixtures in the rainfed areas of Pakistan 1. Forage yield. Australian Journal of Agricultural Research 50: 1–9.

Qamar, I.A., J.D.H. Keatinge, N. Mohammed, A. Asghar, and M. Ajmal Khan. 1999. Introduction and management of vetch/barley forage mixtures in the rainfed areas of Pakistan 2. Forage quality Australian Journal of Agricultural Research 50: 11–19.

Qamar, I.A., J.D.H. Keatinge, N. Mohammed, A. Asghar, and M. Ajmal Khan. 1999. Introduction and management of vetch/barley forage mixtures in the rainfed areas of Pakistan 3. Residual effects on following cereal crops. Australian Journal of Agricultural Research 50: 21–27.

Risasi, E.L., G. Tian, B.T. Kang, and E.E. Opuwaribo. 1999. N-mineralization of roots of maize and selected woody species. Communications in Soil Science and Plant Analysis 30: 1431–1437.

Salako, F.K., O. Babalola, S. Hauser, and B.T. Kang. 1999. Soil macroaggregate stability under different fallow management systems and cropping intensities in south-western Nigeria. Geoderma 91: 103–123.

Sanginga, N., R.J. Carsky, and K.E. Dashiell. 1999. AMF respond to rhizobial inoculation and cropping systems in farmer's fields in the Guinea savanna. Biology and Fertility of Soils 30: 179–186.

Schill P., K. Afreh-Nuamah, C.S. Gold, and K.R. Green. 2000. Farmers' perceptions of constraints to plantain production in Ghana. International Journal of Sustainable Development and World Ecology 7: 1–13.

Schulz, S., J.D.H. Keatinge, and G.J. Wells. 1999. Productivity and residual effects of legumes in rice-based cropping systems in a warm-temperate environment 1. Legume biomass production and N fixation Field Crops Research 61: 23–35.

Schulz, S., J.D.H. Keatinge, and G.J. Wells. 1999. Productivity and residual effects of legumes in rice-based cropping systems in a warm-temperate environment 2 Residual effects on rice Field Crops Research 61. 37–49.

Sétamou, M., F. Schulthess, N.A. Bosque-Pérez, H.-M. Poehling, and C. Borgemeister. 1999. Bionomics of *Mussidia nigrivenella* (Lepidoptera: Pyralidae) on three host plants. Bulletin of Entomological Research 89: 465–472.

Simwambana, M.S.C., I.J. Ekanayake, and T.U. Ferguson. 1998. Growth and flowering behavior of four cassava genotypes in two soil types and locations in Southern Nigeria. Tropical Agriculture (Trinidad) 75: 160–165.

Singh, B.B. and H.K. Adu-Dapaah. 1998. A partial male sterile mutant in cowpea. Crop Science Journal 6: 97–101.

Singh, B.B., Y. Mai-Kodomi, and T. Terao. 1999. A simple screening method for drought tolerance in cowpea. Indian Journal of Genetics 59: 211–220.

Speijer, P.R. and F. Ssango. 1999. Evaluation of *Musa* host plant response using nematode densities and damage indices. Nematropica 29: 189–196.

Speijer, P.R., I. Mudiope, F. Ssango, and E. Adipala 1998. Nematode damage and densities at different plant growth stages of East African highland banana (*Musa* AAA), cv Mbwazirume. African Plant Protection 4: 19–25.

Speijer, P.R., Ch. Kajumba, and F. Ssango. 1999. East African highland banana production as influenced by nematodes and crop management in Uganda. International Journal of Pest Management 45: 41–49.

Speijer, P.R., E. Boonen, D. Vuylsteke, R.L. Swennen, and D. de Waele. 1999. Nematode reproduction and damage to *Musa* sword suckers and sword sucker derived plants. Nematropica 29: 197–207.

Tarawali, G., V.M. Manyong, R.J. Carsky, P.V. Vissoh, P. Osei-Bonsu, and M. Galiba. 1999 Adoption of improved fallows in West Africa: lessons from *Mucuna* and *Stylo* case studies. Agroforestry Systems 47: 93–122.

Tenkouano, A., J.H. Crouch, H.K. Crouch, D. Vuylsteke, and R. Ortiz. 1999. Comparison of DNA marker and pedigree-based methods of genetic analysis in plantain and banana (*Musa* spp.) clones I. Estimation of genetic relationships. Theoretical and Applied Genetics 98: 62–68.

Tenkouano, A., J.H. Crouch, H.K. Crouch, D. Vuylsteke, and R. Ortiz. 1999. Comparison of DNA marker and pedigree-based methods of genetic analysis in plantain and banana (*Musa* spp.) clones II. Predicting hybrid performance. Theoretical and Applied Genetics 98: 69–75

Tian, G. and G.O. Kolawole. 1999. Phosphorus availability of phosphate rock incubated with plant residues with various chemical compositions. Agroforestry Forum 9: 40–42.

Tian, G., G.O. Kolawole, F.K. Salako, and B.T. Kang. 1999. An improved cover crop-fallow system for sustainable management of low activity clay soils of the tropics. Soil Science 164: 671–681.

Tossah, B.K., D.K. Zamba, B. Vanlauwe, N. Sanginga, O. Lyasse, J. Diels, and R. Merckx. 1999. Alley cropping in the moist savanna of West Africa II. Impact on soil productivity in a north-to-south transect in Togo. Agroforestry Systems 42: 229–244.

Udensi, U.E., I.O. Akobundu, A.O. Ayeni, and D. Chikoye. 1999. Management of cogongrass *Imperata cylindrica* with velvetbean *Mucuna pruriens* var. *utilis* and herbicides. Weed Technology 13: 201–208.

van Ek, G.A., J. Henriet, S.F. Blade, and B.B. Singh. 1997. Quantitative assessment of traditional cropping systems in the Sudan savanna of northern Nigeria II. Management and productivity of major cropping systems. Samaru Journal of Agricultural Research 14: 47–60.

Vanlauwe B., S. Aman, K. Aihou, B.K. Tossah, V. Adebiyi, N. Sanginga, O. Lyasse, J. Diels, and R. Merckx. 1999. Alley cropping in the moist savanna of West Africa III. Soil organic matter fractionation and soil productivity. Agroforestry Systems 42. 245–264.

Vanlauwe, B., O.C. Nwoke, N. Sanginga, and R. Merckx. 1999. Evaluation of methods for measuring microbial biomass C and N and their relationship with soil organic matter particle size classes for soils from the West-African moist savanna zone. Soil Biology and Biochemistry 31: 1071–1082.

Vowotor, K.A., W.G. Meikle, J.N. Ayertey, C. Borgemeister, and R.H. Markham. 1999. Intraspecific competition in larvae of the larger grain borer, *Prostephanus truncatus* (Horn) with maize grains. Insect Science and its Application 18: 171–175.

Wheeler, T.R., O. Aiming, J.D.H. Keatinge, R.H. Ellis, and R.J. Summerfield. 1999. The selection of legume cover crops for Bolivian hillside environments. Mountain Research and Development 19: 318–324.

Wilson, V., A. Tenkouano, C. Pasberg-Gauhl, and F. Gauhl. 1999. Heterotic responses of tetraploid and triploid plantain hybrids in southeast Nigeria. African Crop Science Journal 7: 117–123.

Books/book chapters

Asiedu, R., C.A. Fatokun, I.H.D. Mignouna, S.Y C. Ng, and F M Quin. 1999. Underresearched tropical food crops. cowpea, banana and plantain, and yams. Pages 187–216 *in* Biotechnology of food crops in developing countries, edited by T. Hohn and K.M. Leisinger. Springer, Vienna, Austria.

Badu-Apraku, B., M.A.B. Fakorede, M. Ouédraogo, and F.M. Quin (eds). 1999. Strategy for sustainable maize production in West and Central Africa. Proceedings of a regional maize workshop, Cotonou, Benin, 21–25 April 1997. WECAMAN/IITA, Cotonou, Benin.

Crouch, J.H. and A. Tenkouano (eds). 1999. DNA marker-assisted improvement of the staple crops of sub-Saharan Africa Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996. IITA/CTA, Ibadan, Nigeria.

Ekanayake, I.J., R. Asiedu, and P. Bieler. 1999. Production and delivery systems of good quality cassava planting materials in sub-Saharan Africa. Pages 267–281 *in* Tropical tuber crops: food security and nutrition, edited by C. Balagopalan, T.V.R. Nayar, S. Sundaresan, T. Premakumar and K.R. Lakshmi. Oxford/IBH, New Delhi, India.

Frison, E.A., C.S. Gold, E.B. Karamura, and R.A. Sikora (eds). 1999. Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998. INIBAP, Montpellier, France.

Ng, N.O. and J.d'A. Hughes. 1998. Theoretical and practical considerations in the regeneration of cowpea germplasm at IITA. Pages 76–80 *in* Regeneration of seed crops and their wild relatives, edited by J.M.M. Engels and R.R. Rao. IPGRI, Rome, Italy.

Ng, N.O. and S.Y.C. Ng. 1999. Yam field genebank management at IITA. Pages 16–18 *in* Management of field and *in vitro* germplasm collections, edited by F. Engelmann. IPGRI, Rome, Italy.

Ng, S.Y.C. and N.O. Ng. 1999. Yam *in vitro* genebank management at IITA. Pages 124–126 *in* Management of field and *in vitro* germplasm collections, edited by F. Engelmann. IPGRI, Rome, Italy.

Ng, S.Y.C., S.H. Mantell, and N.O. Ng. 1999 Biotechnology in germplasm management of cassava and yams. Pages 179–209 *in* Plant conservation biotechnology, edited by E.E. Benson Taylor and Francis, London, UK.

Schilder, A.M.C., D.A. Florini, D.K. Berner, J.d'A. Hughes, S.Y.C. Ng, N.O. Ng, G. Thottappilly, and T.M. Haug. 1999. International Institute of Tropical Agriculture. Pages 65–78 *in* Containment facilities and safeguards for exotic plant pathogens and pests, edited by R.P. Kahn and S.B. Mathur. APS Press, St Paul, MN, USA.

Conference papers

Akparobi, S., A.O. Togun, and I.J. Ekanayake. 1999. Mineral composition of leaves, stems, and tuberous roots of cassava. Pages 165–167 *in* Sustainability of the Nigerian livestock industry in 2000AD. Proceedings of the 4th annual conference of the Animal Science Association of Nigeria, edited by A.D. Ologhobo, G.N. Egbunike, M.K. Adewumi, A.M. Bamgbose, E.A. Iyayi, and A.O.K. Adesehinwa. Animal Science Association of Nigeria, Lagos, Nigeria.

Asiedu, R. 1999. Potential for molecular breeding of yam at IITA Pages 207–208 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Assigbétsé, K., V. Verdier, K. Wydra, K. Rudolph, and J.P. Geiger. 1999. Genetic variation of the cassava bacterial blight pathogen, *Xanthomonas campestris* pv. *manihotis*, originating from different ecoregions in Africa. Pages 223–229 *in* Plant pathogenic bacteria. Proceedings of the IXth international conference, Madras, India, edited by A. Mahadevan. Madras, India.

Bokanga, M. 1999. Promoting improvements in postharvest systems in sub-Saharan Africa: the role of IITA. Pages 27–31 *in* Enhancing postharvest technology generation and dissemination in Africa. Proceedings of a workshop, Cotonou, Benin, 26–28 October 1998, edited by J. Kwarteng. Sasakawa Africa Association, Mexico City, USA.

Carsky, R.J., S.S. Jagtap, G. Tian, N. Sanginga, and B. Vanlauwe. 1998. Maintenance of soil organic matter and N supply in the moist savanna zone of West Africa. Pages 223–236 *in* Soil quality and agricultural sustainability, edited by R. Lal. Ann Arbor Press, Chelsea, MI, USA.

Carsky, R.J. and E.N.O. Iwuafor. 1999. Contribution of soil fertility research/maintenance to improved maize production and productivity in sub-Saharan Africa. Pages 3–20 *in* Strategy for sustainable maize production in West and Central Africa. Proceedings of a regional maize workshop, Cotonou, Benin, 21–25 April 1997, edited by B. Badu-Apraku, M.A.B. Fakorede, M. Ouedraogo, and F.M. Quin. WECAMAN/IITA, Cotonou, Benin.

Crouch, J.H., A. Tenkouano, and F.M. Quin. 1999. Future strategies for the application of DNA markers at IITA. Pages 211–219 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Dashiell, K.E. and C.A. Fatokun. 1999. Potential for molecular breeding of soybean at IITA. Pages 141–144 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

de Waele, D. and P.R. Speijer. 1999. Nematode resistance in *Musa*. Pages 119–126 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier, France.

Dixon, A.G.O. and E. Okogbenin. 1999. Potential for molecular breeding of cassava at IITA. Pages 188–197 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Fatokun, C.A. 1999. Identification and utilization of gene synteny among species. Pages 97–100 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Fatokun, C.A. and K.E. Dashiell. 1999. Application of DNA markers in soybean. Pages 138–140 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Fatokun, C.A. and H.D. Mignouna. 1999. Applications of DNA markers in cowpea. Pages 147–148 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Ferris, R.S.B., R. Best, F. Goletti, and C. Wheatley. 1999. Towards closer collaboration and co-ordination in the postharvest sector—a CGIAR strategy perspective. Pages 182–198 *in* From biological control to a systems approach in post-harvest. Proceedings of the workshop on integrated control of insect pests in rural maize stores, with particular reference to the larger grain borer *Prostephanus truncatus* (Horn) (Col.: Bostrichidae), and the future development of the post-harvest sector in sub-Saharan Africa, Calavi, Benin, 13–15 October 1997, edited by C. Borgemeister, O. Mueck, and A. Bell. IITA/GTZ, Cotonou, Benin.

Fessehaie, A., K. Wydra, and K. Rudolph. 1999. Cefazolin-Trehalose agar medium, a semi-selective medium for *Xanthomonas campestris* pv. *manihotis* (Xcm), the incitant of cassava bacterial blight. Pages 100–106 *in* Plant pathogenic bacteria. Proceedings of the IXth international conference, Madras, India, edited by A. Mahadevan. Madras, India.

Gold, C.S., N.D.T.R. Rukazambuga, E.B. Karamura, P. Nemeye, and G. Night. 1999. Recent advances in banana weevil biology, population dynamics and pest status with emphasis on East Africa. Pages 35–50 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier, France.

Green, K.R. and K. Afreh-Nuamah. 1999. Plantain IPM in Ghana—a case study. Pages 201–208 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier, France.

Hartman, J.B. and D. Vuylsteke. 1999. Breeding for fungal resistance in *Musa*. Pages 83–92 *in* Genetics and breeding for crop quality and resistance. Proceedings of the 15th EUCARPIA Congress, Viterbo, Italy, 20–25 September 1998, edited by G. Scarascia, T. Mugnozza, E. Porceddu, and M.A. Pagnotta. Kluwer, Dordrecht, the Netherlands.

Hasyim, A. and C.S. Gold. 1999. Potential of classical biological control for banana weevil, *Cosmopolites sordidus* Germar, with natural enemies from Asia (with emphasis on Indonesia). Pages 59–71 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier, France.

Holderness, M., W.K. Tushemereirwe, and C.S. Gold. 1999. Cultural controls and habitat management in the integrated management of banana leaf diseases. Pages 149–163 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier, France.

Jagtap, S.S. and N.O. Ng. 1999. Integrating a geographic information system with germplasm databases. Pages 85–92 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Jeon, Y.W. and L. Halos-Kim. 1999. Characterizing the desirability of postharvest technologies for African conditions. Pages 36–46 *in* Enhancing postharvest technology generation and dissemination in Africa. Proceedings of a workshop, Cotonou, Benin, 26–28 October 1998, edited by J. Kwarteng. Sasakawa Africa Association, Mexico City, USA.

Jeon, Y.W., T. Mado, and L. Halos-Kim. 1999. Partnership in developing postharvest technology for small-scale farmers. Pages 31–42 *in* Partnerships for rural development in sub-Saharan Africa. Proceedings of a workshop, Villars-sur-Ollon, Switzerland, 11–15 September 1998, edited by S.A. Breth. Center for Applied Studies in International Negotiations, Geneva, Switzerland.

Kashaija, I.N., R. Fogain, and P.R. Speijer. 1999. Habitat management for control of banana nematodes. Pages 109–118 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier, France.

Khatri-Chhetri, G., K. Wydra, and K. Rudolph. 1999. Development of a semi-selective medium for quick and easy detection of *Xanthomonas campestris* pv. *vignicola*, incitant of cowpea bacterial blight. Pages 127–134 *in* Plant pathogenic bacteria. Proceedings of the IXth international conference, Madras, India, edited by A. Mahadevan. Madras, India.

Khatri-Chhetri, G., K. Wydra, and K. Rudolph. 1999. Variability of strains of *Xanthomonas campestris* pv.

vignicola, incitant of cowpea bacterial blight and bacterial pustule, collected in several African and other countries. Pages 296–302 *in* Plant pathogenic bacteria. Proceedings of the IXth international conference, Madras, India, edited by A. Mahadevan. Madras, India.

Kiggundu, A., D. Vuylsteke, and C. Gold. 1999. Recent advances in host plant resistance to banana weevil, *Cosmopolites sordidus* Germar. Pages 87–96 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier France.

Kling, J.G., A. Menkir, S.O. Ajala, and F.M. Quin. 1999. Potential for molecular breeding of maize at IITA. Pages 124–135 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Legg, J.P., P. Sseruwagi, J. Kamau, S. Ajanga, S.C. Jeremiah, V. Aritua, G.W. Otim-Nape,A. Muimba-Kankolongo, R.W. Gibson, and J.M. Thresh. 1999. The pandemic of severe cassava mosaic disease in East Africa: current status and future threats. Pages 236–251 *in* Food security and crop diversification in SADC countries: the role of cassava and sweetpotato. Proceedings of the scientific workshop of the Southern African Root Crops Research Network (SARRNET), Lusaka, Zambia, 17–19 August 1998, edited by M.O. Akoroda and J.M. Teri. SADC/IITA/CIP.

Manyong, V.M , K.E. Dashiell, B. Oyewole, and G. Blahut. 1998. Spread of new soybean varieties in a traditional soybean growing area of Nigeria. Pages 151–162 *in* Towards sustainable farming systems in sub-Saharan Africa. Proceedings of the second international symposium of the African Association of Farming Systems Research, Extension and Training (AAFSRET), Ouagadougou, Burkina Faso, 21–23 August 1996, edited by T. Bezuneh, S. Ouedraogo, I.M. Menyonga, I.D. Zongo, and M. Ouedraogo. AAFSRET, Ouagadougou, Burkina Faso.

Meikle, W.G., N. Holst, C. Nansen, J.N. Ayertey, B. Boateng, and R.H. Markham. 1999. Developing decision-support tools for post-harvest pest management in grain stores in West Africa. Pages 145–155 *in* From biological control to a systems approach in post-harvest. Proceedings of the workshop on integrated control of insect pests in rural maize stores, with particular reference to the larger grain borer *Prostephanus truncatus* (Horn) (Col.: Bostrichidae), and the future development of the post-harvest sector in sub-Saharan Africa, Calavi, Benin, 13–15 October 1997, edited by C. Borgemeister, O. Mueck, and A. Bell. IITA/GTZ, Cotonou, Benin.

Menkir, A. 1999. Application of DNA markers in maize. Pages 117–123 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Menkir, A., J.G. Kling, and J.M. Fajemisin. 1999. Breeding stable, high-yielding maize hybrids for West and Central Africa. Pages 93–109 *in* Strategy for sustainable maize production in West and Central Africa. Proceedings of a regional maize workshop, Cotonou, Benin Republic, 21–25 April 1997, edited by B. Badu-Apraku, M.A.B. Fakorede, M. Ouedraogo, and F.M. Quin. WECAMAN/IITA, Cotonou, Benin.

Mignouna, H.D. 1999 Application of DNA markers in cassava. Pages 185–187 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Mignouna, H.D 1999. Application of DNA markers in yam. Pages 200–202 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Mignouna, H.D., C.A. Fatokun, and G. Thottappilly. 1999. Choice of DNA marker system. Pages 9–15 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Muimba-Kankolongo, A., N.M. Mahungu, J. P. Legg, M.P. Theu, M.D. Raya, A. Chalwe, P.A. Muondo, A.A. Abu, and G. Kaitisha. 1999. Importance of cassava mosaic disease and strategies for its control in southern Africa. Pages 212–235 *in* Food security and crop diversification in SADC countries: the role of cassava and sweetpotato. Proceedings of the scientific workshop of the Southern African Root Crops Research Network (SARRNET), Lusaka, Zambia, 17–19 August 1998, edited by M.O. Akoroda and J.M. Teri. SADC/IITA/CIP.

Ng, N.O., G. Thottappilly, and H.D. Mignouna. 1999. Germplasm characterization at IITA. Pages 78–84 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Niere, B., P.R. Speijer, C.S. Gold, and R.A. Sikora. 1999. Fungal endophytes from banana for the biocontrol of *Radopholus similis*. Pages 313–318 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura and R.A. Sikora. INIBAP, Montpellier, France.

Niere, B.I., P.R. Speijer, C.S. Gold, and R.A. Sikora. 1999. Fungal endophytes from bananas for the biocontrol of *Radopholus similis*. Pages 313–318 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura and R.A. Sikora. INIBAP, Montpellier, France.

Okech, S.O., E.B. Karamura, and C.S. Gold. 1999. Banana IPM in Uganda. Pages 225–236 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura and R.A. Sikora. INIBAP, Montpellier, France.

Reddy, S., K.V., C.S. Gold, and L. Ngode. 1999. Cultural control strategies for banana weevil. Pages 51–57 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura and R.A. Sikora. INIBAP, Montpellier, France.

Schulthess F. and S.O. Ajala. 1999. Recent advances in the control of stemborers West and Central Africa. Pages 35–52 *in* Strategy for sustainable maize production in West and Central Africa. Proceedings of a regional maize workshop, Cotonou, Benin Republic, 21–25 April 1997, edited by B. Badu-Apraku, M.A.B. Fakorede, M. Ouedraogo and F.M. Quin. WECAMAN/IITA, Cotonou, Benin.

Singh, B.B. 1999. Potential for molecular breeding of cowpea at IITA. Pages154–158 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA

markers. Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. CTA/IITA, Ibadan, Nigeria.

Singh, B.B. and A.M. Emechebe 1998. Increasing productivity of millet–cowpea intercropping systems. Pages 68–75 *in* Pearl millet in Nigerian agriculture: production, utilization and research priorities. Proceedings of the pre-season planning meeting for the nationally coordinated research programme for pearl millet, Maiduguri, Nigeria, 21–24 April 1997, edited by A.M. Emechebe, M.C. Ikwelle, O. Ajayi, M. Aminu Kano, and A.B. Anaso. Lake Chad Research Institute, Maiduguri, Nigeria.

Speijer, P.R. and R. Fogain. 1999. *Musa* and *Ensete* nematode pest status in selected African countries. Pages 99–108 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier, France.

Ssenyonga, J., F. Bagamba, C.S. Gold, W.K. Tushemereirwe, E.B. Karamura, and E. Katungi 1999. Understanding current banana production with special reference to integrated pest management in southwestern Uganda. Pages 291–310 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura and R.A. Sikora. INIBAP, Montpellier, France.

Tarawali, S.A., E. Rege, O. Hanotte, and J. Hanson. 1999. DNA markers for forage and livestock improvement. Pages 107–112 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A.Tenkouano. CTA/IITA, Ibadan, Nigeria.

Tenkouano, A., J.H. Crouch, and R. Ortiz. 1999. Performance evaluation and parental selection in *Musa*. Pages 176–182 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Thottappilly, G., J.H. Crouch, and F.M. Ouin. 1999. Overview of DNA marker research at IITA. Pages 3–8 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Thottappilly, G., J.H. Crouch, and R. Ortiz. 1999 DNA markers for plant health management. Pages 101–106 *in* DNA marker-assisted improvement of the staple crops of sub-Saharan Africa. Proceedings of a workshop on DNA markers, Ibadan, Nigeria, 21–22 August 1996, edited by J.H. Crouch and A. Tenkouano. IITA/CTA, Ibadan, Nigeria.

Tian, G. 1999. Improved cover crop fallow. Pages 51–52 *in* Soil fertility initiative for sub-Saharan Africa. Proceedings of the SFI/FAO consultation, World Soil Resources Reports, Rome, Italy, 19–20 November 1998. FAO, Rome, Italy.

Vuylsteke, D.R. and J.B. Hartman. 1999. Advances in breeding for host plant resistance to banana diseases. Pages 165–175 *in* Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM, Nelspruit, South Africa, 23–28 November 1998, edited by E.A. Frison, C.S. Gold, E.B. Karamura, and R.A. Sikora. INIBAP, Montpellier, France.

Wydra, K. and K. Rudolph. 1999. Development and implementation of integrated control methods for major diseases of cassava and cowpea in West Africa. Vol. 133, pages 174–180 *in* Tropentag 1998. Stabilisierung und nachhaltige Entwicklung land- und forstwirtschaftlicher Systeme in den Tropen. Goettinger Beitraege zur Land- und Forstwirtschaft in den Tropen und Subtropen, edited by H.S.H. Seifert, P.L.G. Vlek, and H.J. Weidelt.

Wydra, K., A. Fessehaie, A. Fanou, R. Sikirou, J. Ianse, and K. Rudolph. 1999. Variability of strains of *Xanthomonas campestris* pv. *manihotis*, incitant of cassava bacterial blight, from different geographic origins in pathological, physiological, biochemical and serological characteristics. Pages 317–323 *in* Plant pathogenic bacteria. Proceedings of the IXth international conference. Madras, India, edited by A. Mahadevan. Madras, India.

Wydra, K., V. Zinsou, and A. Fanou. 1999. The expression of resistance against *Xanthomonas campestris* pv. *manihotis*, incitant of cassava bacterial blight, in a resistant cassava variety compared to a susceptible variety. Pages 583–592 *in* Plant pathogenic bacteria. Proceedings of the IXth international conference. Madras, India, edited by A. Mahadevan. Madras, India.

Abstracts

Akparobi, S.O., A.O. Togun, and I.I. Ekanayake. 1998. Cassava tuberization under mid-altitude and lowland Savannah agro-ecological zones of Nigeria [abstract]. Tropical Agriculture (Trinidad) 75: 327.

Briddon, R.W., I.A. Farquhar, C. Roussot, G.K. Banks, I.D. Bedford, I. Legg, and P.G. Markham. 1999. Geminiviruses and whiteflies across Africa. Pages 75–76 *in* Abstracts of the VIIth International Plant Virus Epidemiology Symposium, Aguadulce (Almeria), Spain, 11–16 April 1999.

Daniel, I.O., T.O. Tayo, N.O. Ng, and A.O. Togun. 1999. Potential contributions of pollen banks to yam improvement. Page 24 *in* Genetics Society of Nigeria anniversary souvenir brochure and book of abstracts, 1999 annual conference and 25th anniversary celebrations, National Cereal Research Institute, Badeggi, 7–9 September, 1999.

Ekanayake, I.J. and O. Lyasse. 1999. Physiological deterioration response of cassava roots associated with wounding and its genotypic variability. American Society of Plant Physiology Abstract No. 363.

Ishida, F. and G. Tian. 1999. Toposequence effect on soil properties and nutrient stock. Agronomy Abstracts 269.

Legg, J.P. and G. Okao-Okuja. 1999. Progress in the diagnosis and epidemiological characterisation of cassava mosaic geminiviruses in East Africa. Pages 74–75 *in* Abstracts of the VIIth International Plant Virus Epidemiology Symposium, Aguadulce (Almeria), Spain, 11–16 April 1999.

Makumbi-Kidza, N.N., P.R Speijer, and R.A. Sikora. 1999. The influence of root-knot nematodes on plant growth and storage root formation of cassava at different ages. Page 24 *in* Abstracts of the 14th symposium of the Nematological Society of Southern Africa, Dikhololo, South Africa, 30 May–2 June.

Meerman, J.C. and P.R. Speijer. 1999. On-farm testing and large scale distribution of nematode-free yam planting material in Southern Nigeria. Page 54 *in* Abstracts of the 14th symposium of the Nematological Society of Southern Africa, Dikhololo, South Africa, 30 May–2 June.

Oyetunji, O.J., I.I. Ekanayake, and O. Osonubi. 1998. Photosynthetic photochemical response of cassava *Manihot esculenta* Crantz to water stress and mycorrhizal inoculation [abstract]. Tropical Agriculture (Trinidad) 75: 328–329.

Singh, B.B., S.A. Tarawali, S.C. Gupta, R. Tabo, S. Nokoe, and C. Odion. 1999. Farmer participatory evaluation of improved strip intercropping systems in northern Nigeria. Agronomy Abstracts 37.

Speijer, P.R., C. Kajumba, and J. Dusabe. 1999. Nematode induced production loss for the cultivars Nabusa (*Musa* AAA, 'Matooke' group), Pisang Awak (*Musa* ABB) and Sukali Ndizi (*Musa* AB) in Uganda. Page 32 *in* Abstracts of the 14th symposium of the Nematological Society of Southern Africa, Dikhololo, South Africa, 30 May–2 June.

Speijer, P.R., C.S. Gold, and J. Dusabe, J. 1999. Relative importance of nematodes, weevils (*Cosmopolites sordidus*) and leaf diseases as *Musa* production constraints in central Uganda. Page 16 *in* Abstracts of the 14th symposium of the Nematological Society of Southern Africa, Dikhololo, South Africa, 30 May–2 June.

Sseruwagi, P., J.P. Legg, and G.W. Otim-Nape. 1999. An overview of the incidence of cassava mosaic disease in East Africa, 1998 update. Pages 87–88 *in* Abstracts of the VIIth International Plant Virus Epidemiology Symposium, Aguadulce (Almeria), Spain, 11–16 April 1999.

Talwana, H.L., P.R. Speijer, and D. De Waele. 1999. Spatial distribution of nematode population densities and nematode damage in roots of three banana cultivars in Uganda. Pages 37–38 *in* Abstracts of the 4th African Crop Science Conference, 11–14 October 1999, Casablanca, Morocco.

Thottappilly, G., S.Y.C. Ng, and S. Winter. 1999. Supply of pest free stock. Page 86 *in* Abstracts of the XIVth International Plant Protection Congress (IPPC), Jerusalem, Israel, 25–30 July 1999.

Tian, G., C.O. Adejuyigbe, and G.O. Adeoye. 1999. Faunal interactions in litter decomposition and nutrient turnover. Agronomy Abstracts 221.

Wydra, K. and K. Rudolph. 1999. Integrated control of bacterial diseases and root rots of cassava and cowpea in West Africa: report on a collaborative project [abstract]. Phytomedizin 29: 35–36.

Other reports/miscellaneous

Adesina, A.A., O. Coulibaly, V.M. Manyong, P.C. Sanginga, D. Mbila, J. Chianu, and D.G. Kamleu. 1999. Policy shifts and adoption of alley farming in West and Central Africa. Impact series. IITA, Ibadan, Nigeria.

Aigbe, S.O., B. Fawole, and D.K. Berner. 1999. A cowpea seed rot disease caused by *Fusarium equiseti* identified in Nigeria [disease note]. Plant Disease 83: 964.

Best, R., S. Ferris, F. Goletti, and G.J. Scott. 1999. Post-harvest processing and market research on roots, tubers, cooking bananas and plantains within the CGIAR: looking forward to the 21st Century. Pages 59–66 *in* CGIAR post-harvest research and CASCA: working for effective post-harvest systems, CASCA executive seminar 10, 3–4 June 1998, edited by G.J. Johnson and F. Mazaud. FAO, Rome, Italy.

Danso W.O., K.R. Green, S. Adjei-Nsiah, and K. Afreh-Nuamah. 1999. Financial appraisal of plantain sucker production in Ghana. *Mus*Africa 13: 4–7.

Ekanayake, I.J. 1999. Activities in cassava modelling, productivity and food security, and global change. START Report No. 1. International START Secretariat, Washington DC, USA.

Gregg, B.R. and A.J.G. van Gastel. 1999. Good seed, extension and farmers. West Africa Seed Development Unit Publication No. 2. WASDU, Accra, Ghana.

Gregg, B.R., A.J.G. van Gastel, A.W. Ebert, L.L. Delimini, and E.A. Asiedu. 1999. Preparing a realistic business plan for successful seed companies. West Africa Seed Development Unit Publication No. 3. WASDU, Accra, Ghana.

GCTE. 1999. GCTE Focus 3 Cassava Network. Prepared by I.J. Ekanayake. University of Guelph, Ontario, Canada and IITA, Nigeria.

Hartman, J., D. Makumbi, R.S.B. Ferris, and D. Vuylsteke. 1999. Variation in *matooke* quality among East African highland banana landraces. PhAction News 1: 3–5.

Inaizumi, H., B.B. Singh, P.C. Sanginga, V.M. Manyong, A.A. Adesina, and S. Tarawali. 1999. Adoption and impact of dry-season dual-purpose cowpea in the semiarid zone of Nigeria. Impact series. IITA, Ibadan, Nigeria.

Manyong, V.M., V.A. Houndékon, P.C. Sanginga, P. Vissoh, and A.N. Honlonkou. 1999. *Mucuna* fallow diffusion in southern Benin. Impact series. IITA, Ibadan, Nigeria.

Meikle, W.G., P. Degbey, R. Oussou, N. Holst, C. Nansen, and R.H. Markham. 1999. Pesticide use in grain stores: an evaluation based on survey data from Benin. PhAction News 1: 5–9.

Nweke, F.I., G.W. Otim-Nape, A.G.O. Dixon, C.L. Asadu, A. Bua, O. Ajobo, B.O. Ugwu, Y. Baguma, and H. Masembe-Kajubi. 1999. Production prospects for cassava in Uganda. Collaborative Study of Cassava in Africa (COSCA) working paper no. 17. IITA, Ibadan, Nigeria.

Ogbe, F.O., G.I. Atiri, D. Robinson, S. Winter, A.G.O. Dixon, F.M. Quin, and G. Thottappilly. 1999. First report of East Africa cassava mosaic begomovirus in Nigeria [disease note]. Plant Disease 83: 398.

Pillay, M., D.C. Nwakanma, and A. Tenkouano. 1999. Identification of RAPD markers linked to A and B genome sequences in *Musa*. Info*Musa* 8: VII–VIII.

Rey, B., K. Agyemang, W. Thorpe, G. Mullins, M. Diedhiou, S. Nokoe, and B.M. Shapiro. 1999. A research methodology for characterising dairy production systems. Market-oriented smallholder dairy research working document no. 4. ILRI, Nairobi, Kenya.

Sanginga, P.C., A.A. Adesina, V.M. Manyong, O. Otite, and K.E. Dashiell. 1999. Social impact of soybean in Nigeria's southern Guinea savanna. Impact series. IITA, Ibadan, Nigeria.

Speijer, P.R. 1999. Clean planting materials for bananas and yams. Agriforum 9: 4.

Tarawali, S.A., M. Peters, and R. Schultze-Kraft. 1999. Selecting and testing forage legumes for sustainable agriculture and livestock production in subhumid west Africa. International Livestock Research Institute (ILRI) project report. ILRI, Nairobi, Kenya.

Vuylsteke, D., J. Hartman, and A. Tenkouano. 1999. Breeders' perspective on biotechnology for *Musa* improvement. Info*Musa* 8: VI–VII.

Governing Board

Enrico Porceddu, Chair
Professor, Universita degli Studi della Tuscia
Viterbo, Italy

Umaru Alkaleri**
Permanent Secretary, Federal Ministry of Agriculture and Natural Resources
Abuja, Nigeria

Lukas Brader**
Director General, IITA
Ibadan, Nigeria

Abdoulaye Babale
Chair, Board of Trustees
Institut de recherche agricole pour le devéloppement, Yaoundé, Cameroon

Limamoulaye Cisse
Head, Agronomy Division
Institut mondial du phosphate, Casablanca, Morocco

Volker Hoffmann
Professor, Universität Hohenheim
Stuttgart, Germany

Jørgen Jakobsen
Research Director
Danish Institute of Agricultural Sciences, Slagelse, Denmark

Assétou Kanouté
Executive Secretary, Association for Development of Activities of Promotion and Formation (ADAF)–Gallé
Bamako, Mali

Joy Kwesiga
Dean, Faculty of Social Science
Makerere University, Kampala, Uganda

Anastasios Leventis
Leventis Overseas
London, UK

Constance McCorkle*
Senior Research Scientist and Consultant
Washington, DC, USA

Geoffrey Mrema
Executive Secretary, Association for Strengthening Agricultural Research in Eastern and Southern Africa (ASARECA), Entebbe, Uganda

Kyoko Saio
Tokyo Metropolitan Food and Technology Research Center
Tokyo, Japan

Julius Okojie**
Vice Chancellor, University of Agriculture
Abeokuta, Nigeria

Michel Sedogo
Directeur General, Centre national de la recherche scientifique et technologique, Ouagadougou, Burkina Faso

Suri Sehgal
Hoechst Schering AgroEvo GmbH
Frankfurt, Germany

Eric Tollens
Professor, Faculty of Agricultural Sciences
Katholieke Universiteit Leuven, Heverlee, Belgium

* Left during 1999.
** Ex-officio.

Professional Staff

Director General

L. Brader, PhD, *Ibadan*

Office of the Director General

R.H. Booth, PhD, deputy director general, *Ibadan*

I. Cramer, BA, executive assistant to the director general, *Ibadan*

C.F. McDonald, MSc, assistant to the deputy director general, *Ibadan*

F.O. Oke, record/archival officer, *Ibadan*

Division Directors

K.E. Dashiell, PhD, director, crop improvement division, *Ibadan*

H. Grimme, PhD, director, resource and crop management division, *Ibadan**

R.A. Jefferson, PhD, director affiliate, strategic and applied molecular technologies, *Australia*

I D.H. Keatinge, PhD, director, resource and crop management division, *Ibadan*

P. Neuenschwander, PhD, director, plant health management division, *Benin*

W. Powell, BSc, director, corporate services division, *Ibadan**

P. Watts, BSc, director, corporate services division, *Ibadan*

Agroecological Zone Working Group Leaders

R. Carsky, PhD, moist savanna AEZ working group leader, *Benin*

D Vuylsteke, Ir, midaltitude AEZ working group leader, *Uganda*

S. Weise, PhD, humid forest AEZ working group leader, *Cameroon*

IITA Stations and Officers in Charge

P. Austin, BSc, High Rainfall Station, *Onne*

J. Fajemisin, PhD, Ferkessédougou Station, *Côte d'Ivoire**

P. Neuenschwander, PhD, Biological Control Center for Africa, *Benin*

B.B. Singh, PhD, Kano Station, *Kano*

D. Vuylsteke, Ir, Eastern and Southern Africa Regional Center (ESARC), *Uganda*

S. Weise, PhD, Humid Forest Ecoregional Center (HFC), *Cameroon*

Project Coordinators

R. Asiedu, PhD, Improvement of yam-based production systems, *Ibadan*

E.A. Atayi, PhD, Ecoregional Program for the Humid and subhumid Tropics of Africa (EPHTA), *Ibadan*

D. Berner, PhD, Integrated management of *Striga* and other parasitic plants, *Ibadan**

M. Bokanga, PhD, Improving postharvest systems, *Ibadan*

H. de Groote, PhD, Biological control and biodiversity, *Benin**

A.G.O. Dixon, PhD, Cassava productivity in lowland and midaltitude agroecologies of sub-Saharan Africa, *Ibadan*

J. Gockowski, PhD, Farming systems diversification, *Cameroon*

R. Hanna, PhD, Integrated management of cassava pests and diseases, *Benin*

I.G. Kling, PhD, Improvement of maize–grain legume systems in West and Central Africa, *Ibadan*

O. Ng, PhD, Conservation and utilization of plant biodiversity, *Ibadan*

I. Langewald, PhD, Biological control and biodiversity, *Benin*

V.M. Manyong, PhD, Agroecosystems development strategies and policies, *Ibadan*

R. Markham, PhD, Systemwide program on integrated pest management (SP-IPM), *Ibadan*

A. Melake Berhan, PhD, Integrated management of *Striga* and other parasitic plants, *Ibadan*

H.D. Mignouna, PhD, Molecular and cellular biotechnology for crop improvement, *Ibadan*

N. Sanginga, PhD, Short fallow systems, *Ibadan*

F. Schulthess, PhD, Integrated management of maize pests and diseases, *Benin*

B.B. Singh, PhD, Cowpea–cereals systems improvement in the dry savannas, *Kano*

M. Tamò, PhD, Integrated management of cowpea pests and diseases, *Benin*

D. Vuylsteke, Ir, Improving plantain- and banana-based systems, *Uganda*

Crop Improvement Division

K.E. Dashiell, PhD, breeder/geneticist, director, *Ibadan*

Scientists

S.O. Ajala, PhD, maize breeder/geneticist, *Ibadan*

M.I. Andrade, PhD, agronomist, *Mozambique*

R Asiedu, PhD, yam breeder/geneticist, *Ibadan*

B. Badu-Apraku, PhD, breeder, coordinator WECAMAN, *Côte d'Ivoire*

M. Bokanga, PhD, biochemist and food technologist, *Ibadan*

A.G.O. Dixon, PhD, cassava breeder/geneticist, *Ibadan*

A.W. Ebert, PhD, planting materials specialist, IITA/GTZ/CSIR seed project, *Ghana*

I. Fajemisin, PhD, breeder, research liaison scientist, *Côte d'Ivoire**

C.A. Fatokun, PhD, cowpea breeder/geneticist, *Ibadan*

I N. Kasele, PhD, multiplication expert, *Zimbabwe*

B.W. Khizzah, PhD, agronomist, *Uganda*

J.G. Kling, PhD, maize breeder/geneticist, *Ibadan*

J.S. Machuka, PhD, molecular biologist, *Ibadan*

A. Menkir, PhD, maize breeder/geneticist, *Ibadan*

H.D. Mignouna, PhD, molecular biologist, *Ibadan*

N.Q. Ng, PhD, germplasm scientist, *Ibadan*

S.Y.C. Ng, MSc, tissue culture specialist, *Ibadan*

B.B. Singh, PhD, cowpea breeder/geneticist, *Kano*

A. Tenkouano, PhD, *Musa* breeder/geneticist, *Onne*

J. Teri, PhD, pathologist, coordinator SARRNET, *Malawi*

A.J.G. van Gastel, PhD, seed specialist and project coordinator, IITA/GTZ/CSIR seed project, *Ghana*

P. Vernier, PhD, yam specialist (CIRAD), *Benin*

D. Vuylsteke, Ir, *Musa* agronomist/breeder, *Uganda*

I.B.A. Whyte, PhD, breeder, coordinator EARRNET, *Uganda*

Associate Scientists

A. Melake Berhan, PhD, molecular biologist, *Ibadan*

M. Pillay, PhD, *Musa* cytogeneticist, *Onne*

Postdoctoral Fellows

M Gedil, PhD, cassava molecular geneticist, *Ibadan*

I. Hartman, PhD, *Musa* breeder/geneticist, *Uganda*

H. Matsui, PhD, physiologist, *Kano*

M. Tshiunza, PhD, *Musa* socioeconomist, *Onne**

G. Ude, PhD, *Musa* molecular geneticist, *Onne*

Associate Experts

G. Blomme, Ir, *Musa* agronomist (VVOB), *Onne**

B. de Schutter, Ir, *Musa* agronomist (VVOB), *Onne**

Visiting Scientists

B. Asafo-Adjei, PhD, coordinator OFDA maize, soybean and cowpea project, *Ibadan*

E. Asiedu, PhD, seed technologist, IITA/GTZ/CSIR seed project, *Ghana*
M. Houssou, PhD, plant breeder, *Ibadan**
B. Maziya-Dixon, PhD, maize food technologist, *Ibadan*
A. Ndiaye, PhD, maize breeder/geneticist, *Ibadan**
N. Wanyera, PhD, yam agronomist, *Uganda*
C. Yallou, MSc, maize breeder, *Ibadan*

Consultants

A. Akano, PhD, cassava tissue culture specialist, *Ibadan**
J.K. Ikea, PhD, molecular biologist, *Ibadan**
A. Okoruwa, MSc, soybean food technologist, *Ibadan**

Research Farms Unit

P. Austin, BSc, unit head, *Onne*
J. Olobasola, BSc, assistant head, *Ibadan*

Administration and Support Services

J.N. Agba, BSc, station administrative manager, *Onne*
M.B. Alti, MBA, station administrative manager, *Kano*
E.A. Kyeyune, BComm, project manager, *Uganda**

Plant Health Management Division

P. Neuenschwander, PhD, entomologist, director, *Benin*

Scientists

D. Berner, PhD, parasitic weeds biologist, *Ibadan**
K.F. Cardwell, PhD, pathologist, *Benin/Ibadan*
A. Cherry, PhD, entomologist (joint appointment with NRI), *Benin*
H. de Groote, PhD, agricultural economist, *Benin**
G. Goergen, PhD, entomologist, *Benin*
C. Gold, PhD, entomologist, *Uganda*
W.N.O. Hammond, PhD, entomologist, coordinator PEDUNE, *Benin*
R. Hanna, PhD, acarologist, *Benin*
J. d'A. Hughes, PhD, virologist, division representative, *Ibadan*
L.E.N. Jackai, PhD, entomologist, *Ibadan**
J. Langewald, PhD, insect pathologist, *Benin*
P. Le Gall, PhD, entomologist (ORSTOM), *Benin*
C.J. Lomer, PhD, insect pathologist, *Benin**
R.H. Markham, PhD, entomologist, *Ibadan*
W. Meikle, PhD, entomologist, *Benin*
F. Schulthess, PhD, ecologist, *Benin*
P. Speijer, PhD, nematologist, *Uganda*
A.A. Sy, PhD, pathologist, head, technology testing and transfer unit, *Benin*
M. Tamò, PhD, insect ecologist, *Benin*
K. Wydra, PhD, pathologist, *Benin**
M. Zweigert, Dipl.ng, head, training and technology transfer unit (GTZ), *Benin**

Associate Scientists

K. Green, PhD, pathologist, coordinator IITA/GTZ West African plantain project, *Ghana**
J. Legg, PhD, entomologist, *Uganda*

Postdoctoral Fellows

K. Hell, PhD, pathologist, *Benin*
M. Tindo, PhD, entomologist, *Cameroon*

Associate Experts

C. Dochez, MSc, biologist, *Uganda*
T. Hoffstadt, MSc, fungal ecologist, *Benin*
J.C. Meerman, MSc, nematologist, *Ibadan*
C. Nansen, MSc, entomologist, *Benin*

Visiting Scientists

V. Adenle, PhD, pathologist, *Ibadan**
O. Coulibaly, PhD, agricultural economist, *Cameroon/Benin*
A. Hounsa, MD, medical epidemiologist, *Benin*
B.D. James, PhD, entomologist, *Benin*
S.H.O. Okech, PhD, entomologist, *Uganda*
P. Ragama, PhD, statistician, *Uganda*
M. Toko, PhD, entomologist, *Benin*

Consultant

O.G. Omitogun, PhD, electron microscopist, *Ibadan*

Germplasm Health Unit

J.d'A. Hughes, PhD, head, *Ibadan*

Visiting Scientist

M. Ayodele, PhD, pathologist, *Ibadan*

Administration and Support Services

C.A. Soboyejo, MPhil, station administrator, *Benin*
J.B. Akinwumi, MSc, engineer, *Benin*
J.B. Adjovi, chief accountant, *Benin**
C. Egunlaye, BSc, computer specialist, *Benin*
A. Gbaguidi, MSc, computer specialist, *Benin*
S. Korie, MSc, statistician, *Benin*
S. Nyampong, executive assistant to the director, Benin
A. Ratié, maintenance service officer, *Benin*
R.W. Yussuf, MA, multimedia specialist, *Benin*

Resource and Crop Management Division

H. Grimme, PhD, soil scientist, director, *Ibadan**
J.D.H. Keatinge, PhD, agronomist, director, *Ibadan*

Scientists

R.J. Carsky, PhD, agronomist, *Benin*
S. Ferris, PhD, postharvest technologist, *Uganda*
J. Gockowski, PhD, agricultural economist, *Cameroon*
L.S. Halos-Kim, MSc, food and agricultural engineer, *Ibadan*
S. Hauser, PhD, soil physicist, *Cameroon*
V.M. Manyong, PhD, agricultural economist, *Ibadan*
C. Nolte, PhD, soil fertility specialist, *Cameroon*
J. Russell, PhD, agronomist, coordinator ISAR/IITA/USAID project, *Rwanda*
N. Sanginga, PhD, soil microbiologist, *Ibadan*
S. A. Tarawali, PhD, agronomist (joint appointment with ILRI), *Ibadan*
G. Tian, PhD, soil fertility specialist, *Ibadan*
S. Weise, PhD, weed scientist, *Cameroon*
J. Wendt, PhD, soil chemist, *Cameroon*

Associate Scientists

D. Chikoye, PhD, weed scientist, *Ibadan*
J. Diels, PhD, modeler, *Ibadan*
B. Douthwaite, PhD, impact assessor, *Ibadan*
B.P. Vanlauwe, PhD, soil microbiologist, *Ibadan*

Postdoctoral Fellows

F. Ishida, PhD, soil scientist, *Ibadan*
P. Kormawa, PhD, agricultural economist, *Ibadan*
L.-S. Koutika, PhD, soil scientist, *Cameroon*
S. Schulz, PhD, agronomist, *Ibadan*

Associate Experts

O. Lyasse, Ir, agronomist (VVOB), *Ibadan*
O.K. Nielsen, MSc, weed scientist, *Ibadan*

Visiting Scientists

S. Dury, PhD, agricultural economist (CIRAD), *Cameroon*
C. Jannot, PhD, agronomist (CIRAD), *Cameroon*

Analytical Services Unit

J. Uponi, MSc, laboratory manager, *Ibadan*

Biometrics Unit

S. Nokoe, PhD, unit head, *Ibadan*
S. Korie, MSc, statistician, *Benin*

Professional Staff

Administration and Support Services

Y. Aboubakar, station administration supervisor, *Cameroon*

E. Ndindjock, MBA, finance officer, *Cameroon*

C. Yumga, station assistant, *Cameroon*

Information Services and Training

R.P. Eaglesfield, BSc, head, *Ibadan*

Information Services

J. Reeves, PhD, head, *Ibadan**

A. Moorhead, MSc, chief science editor, *Ibadan*

Y. Adedigba, MA, head, library and documentation, *Ibadan*

A.A. Adekunle, MSc, public awareness publications coordinator, *Ibadan*

I.I. Adeyomoye, MLS, principal librarian, *Ibadan*

O. Ajayi, BEd, audiovisual specialist, *Ibadan**

T. Babaleye, MCA, public affairs manager, *Ibadan*

E.O. Ezomo, MLS, principal librarian, *Ibadan*

Y. Olatunbosun, BSc, editor, *Ibadan*

T.T. Owoeye, MLS, coordinating editor, *Ibadan*

A. Oyetunde, MA, editor, *Ibadan*

Consultant

P. Philpot, BA, multimedia specialist, *Ibadan*

Training

M. Ajayi, MSc, research training specialist, *Ibadan*

R. Obubo, MSc, group training coordinator, *Ibadan*

C. Okafor, MBA, manager, individual training, *Ibadan*

O.A. Osinubi, MSc, research training specialist, *Ibadan**

Interpretation and Translation Unit

C.H. Dia, MA, unit head, *Ibadan*

External Liaison Office

Project Liaison

A.P. Uriyo, PhD, head, *Ibadan*

O.M. Ogunyinka, MSc, monitoring and evaluation manager, *Ibadan*

NARS Liaison

E.A. Atayi, PhD, agricultural economist, *Ibadan*

Scientists of Other IARCs and AROs Resident at IITA

K. Agyemang, PhD, animal scientist, ILRI, *Ibadan**

M. Bernard, MSc, soil scientist, coordinator University of Hohenheim research project, *Benin**

A. Cherry, PhD, entomologist, NRI (joint appointment with IITA), *Benin*

S. Dury, PhD, agricultural economist, CIRAD, *Cameroon*

C. Jannot, PhD, agronomist, CIRAD, *Cameroon*

A. Larbi, PhD, agronomist, ILRI, *Ibadan*

P. Le Gall, PhD, entomologist, ORSTOM, *Benin*

O. Ndoye, PhD, forest economist, CIFOR, *Cameroon*

O. Osiname, PhD, soil scientist, WARDA, *Ibadan*

S.A. Tarawali, PhD, agronomist, ILRI (joint appointment with IITA), *Ibadan*

P. Vernier, PhD, yam specialist, CIRAD, *Benin*

M. Zweigert, DipIng, head, training and technology transfer unit, GTZ, *Benin**

Internal Audit

R.S. Lafond, CA, head, *Ibadan*

A. Ajakaiye, ACA, intermediate auditor, *Ibadan*

R.A. Fagbenro, ACA, senior internal auditor, *Ibadan*

Corporate Services Division

W. Powell, BSc, director, *Ibadan**

P. Watts, BSc, director, *Ibadan*

Personnel

O.I. Osotimehin, BSc, personnel manager, *Ibadan*

J.B. Adenuga, AMIPM, employee services manager, *Ibadan*

A. Ohanwusi, MBA, planning/training manager, *Ibadan*

Medical Unit

F.O.A. Ajose, MD, head, IITA clinic, *Ibadan*

E.O. Lawani, MD, physician, *Ibadan*

F. O'Dwyer, BSc, nurse/practitioner, *Ibadan*

I.I. Anetor, MSc, medical laboratory services officer, *Ibadan**

P.O. Ojo, MSc, medical laboratory services officer, *Ibadan*

Budget and Finance

G. McIntosh, CMA, chief financial officer, *Ibadan*

B. Draper, materials logistics manager, *Ibadan*

B.A. Adeola, FCIS, senior accountant, *Ibadan*

L.O. Afemikhe, MSc, senior technical analyst, *Ibadan*

J.E. Bolarinwa, MBA, payroll accountant, *Ibadan*

N.N. Eguzozie, BSc, financial information systems manager, *Ibadan*

O. Oduberu, ACA, financial information systems senior analyst, *Ibadan*

S. Ogunade, treasury manager, *Ibadan*

K.O. Olatifede, ACA, special projects accountant, *Ibadan*

O. Sholola, ACA, corporate accounting manager, *Ibadan*

S.J. Udoh, AMNIM, chief accountant, *Ibadan*

Physical Plant Services

A. Bhatnagar, BSc, head, *Ibadan*

A.C. Micheletti, construction site engineer/services officer, *Ibadan*

S.W. Quader, BSc, electronic services officer, *Ibadan*

E.O. Akintokun, research vehicle services officer, *Ibadan*

F.K. Alude, HND heavy equipment and fabrication services manager, *Ibadan*

P.T. Lamuren, BSc, telecommunication services officer, *Ibadan*

M.A. Oyedeji, C&G(FTC), electrical services officer, *Ibadan*

O.O. Taiwo, HND, buildings and grounds services officer, *Ibadan*

Computer Services

J. Scott, MSc, manager, *Ibadan*

M. Atalobhor, BSc, user support coordinator, *Ibadan**

Auxiliary Services

A. Beard, manager, hotel and catering services, *Ibadan**

D. Errington, MSc, specialist science teacher, *Ibadan*

C. Eykyn, BSc, specialist science teacher, *Ibadan**

C. Inniss-Palmer, MA, specialist English teacher, *Ibadan*

A. Jackson, deputy head, international school of IITA, *Ibadan*

N. Jackson, head, international school of IITA, *Ibadan*

I. Neish, HCIMA, manager, hotel and catering services, *Ibadan*

D.J. Sewell, manager, aircraft operations, *Ibadan*

W. Ekpo, ACIS, security manager, *Ibadan*

C.A. Enahoro, HND, head, travel services, *Lagos*

M.O. Olanrewaju, HND, assistant manager, hotel and catering services, *Ibadan*

Italics are used for *country* of work location other than for Nigeria when *location* within Nigeria is given.

* Left during 1999.

Awards and distinctions

Kitty Cardwell and **Joe Fajemisin** Made Fellows of the Maize Association of Nigeria in recognition of their outstanding contributions to the development of maize in Nigeria.

Nakato Makumbi-Kidza Prize for the best student presentation at the Nematological Society of Southern Africa symposium for her presentation on "The influence of root-knot nematodes on plant growth and tuber formation of cassava at different stages of development".

Michael Pillay Elected member of Sigma Xi, The Scientific Research Society, Louisiana State University Chapter, for research achievements.

Paul Ilona CGIAR award for the most outstanding Local Scientific Support Staff for his contributions to the development of cassava varieties and their adoption by farmers of sub-Saharan Africa.

James Legg CGIAR award for the Most Promising Young Scientist for his outstanding contributions to strengthening research for the control of cassava mosaic virus disease in Africa.

Guanglong Tian Young Scholar Award from the Soil and Water Management and Conservation Division of the Soil Science Society of America for his work on the development of a cover cropping system for humid tropical Africa.

Sagary Nokoe Elected to serve on the Council of the International Biometric Society from 1 Jan 2000 to 31 Dec 2003.

John Hartman, Paul Speijer, and Dirk Vuylsteke

The Institute was devastated and saddened by the news of the crash of the Kenya Airways airliner at Abidjan on Sunday, 30 January 2000 in which 3 IITA scientists lost their lives. They were working at IITA's Eastern and Southern Africa Regional Center in Uganda and were on their way to Ibadan for our annual work planning week.

Dirk Vuylsteke, of Belgian nationality, was the leader of our *Musa* improvement project. He leaves behind his wife Kathelyne and their daughter and son, Sarah and Yannick.

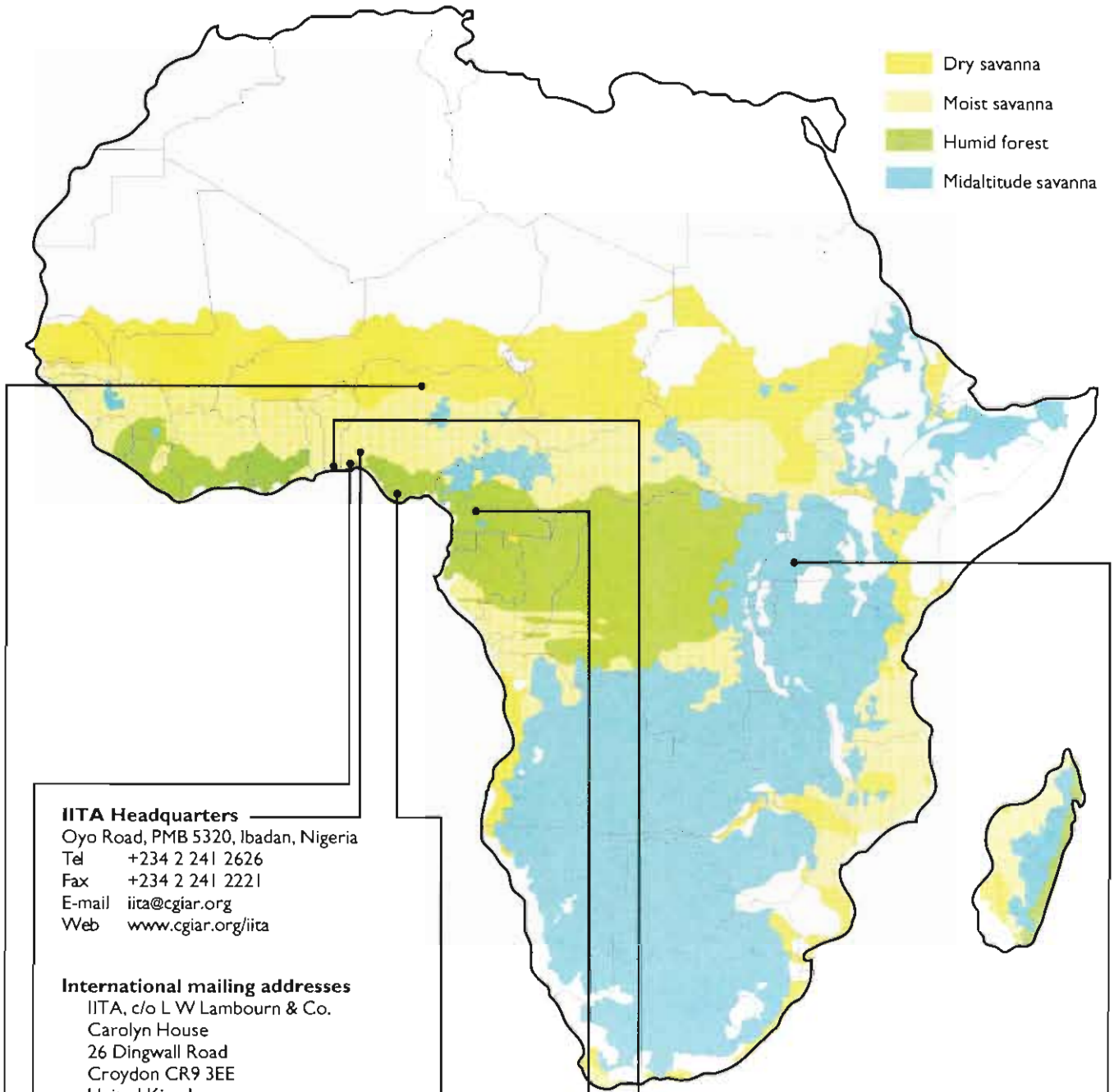
Paul Speijer, of Dutch nationality, was our nematologist. He leaves behind his wife Nicole and their 3 children, Tim, Tessa, and Eva.

John Hartman from the USA was our banana breeder. He leaves behind his wife Miriam and their daughter and son, Clara and Noah.

Some of the considerable contribution to IITA's mission made by all 3 during 1999 features in this report – in both the main section and in the publications listing. We salute our lost colleagues and convey our deepest sympathy to their families.

Abbreviations used in this report

ACMV	African cassava mosaic virus
AFLP	amplified fragment length polymorphism
ARO	Advanced research organization
ASARECA	Association for Strengthening Agricultural Research in Eastern and Southern Africa
ASB	Global Initiative on Alternatives to Slash-and-Burn
BCP	Biological Control Products (South Africa)
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
CABI	Centre for Agriculture and Biosciences International (UK)
CAMBIA	Center for the Application of Molecular Biology to International Agriculture
CCER	Center-commissioned external review
CGIAR	Consultative Group on International Agricultural Research
CGM	cassava green mite
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
CIEPCA	Centre d'information et d'exchanges sur les plantes de couverture en Afrique
CIFOR	Center for International Forestry Research
CILSS	Comité interétats de lutte contre la sécheresse dans le sahel (Interstate Committee on Drought Control in the Sahel)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Center)
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (France)
CMD	cassava mosaic disease
CSIR	Council for Scientific and Industrial Research (Ghana)
DANIDA	Danish International Development Agency
DFID	Department for International Development (UK)
DNA	deoxyribonucleic acid
EACMV	East African cassava mosaic virus
EAHB	East African highland banana
EARRNET	Eastern Africa Root Crops Research Network
EPHTA	Ecoregional Program for the Humid and Subhumid Tropics of Sub-Saharan Africa
ESARC	Eastern and Southern Africa Regional Center (IITA)
FAO	Food and Agriculture Organization of the United Nations
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Cooperation)
HFC	Humid Forest Ecological Center (IITA)
IARC	international agricultural research center
IBCD	International Biopesticide Consortium for Development
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development (Italy)
ILRI	International Livestock Research Institute
IPM	integrated pest management
IRAD	Institut de la recherche agricole pour le développement (Cameroon)
KUL	Katholieke Universiteit Leuven (Belgium)
LGB	larger grain borer
LUBILOSA	Lutte biologique contre les locustes et sauteriaux
NARS	national agricultural research system
NGO	nongovernmental organization
NPP	National Plant Protection (France)
NRI	Natural Resources Institute (UK)
OFDA	US Office for Foreign Disaster Assistance
ORSTOM	Institut français de recherche scientifique pour le développement en coopération
PEDUNE	Protection écologiquement durable du niébé
QPM	quality protein maize
RAPD	random amplified polymorphic DNA
SAA	Sasakawa Africa Association
SAFGRAD	Semi-Arid Food Grain Research and Development [Project]
SARRNET	Southern Africa Root Crops Research Network
SP-IPM	Systemwide Program on Integrated Pest Management
SSA	sub-Saharan Africa
TSBF	Tropical Soil Biology and Fertility Programme
UNBRP	Ugandan National Banana Research Program
UgV	Uganda variant (of ACMV)
USAID	US Agency for International Development
USDA	US Department of Agriculture
VVOB	Vlaamse Veveniging voor Ontwikkelingssamenwerking en dtechnische Bijstand
WARDA	West African Rice Development Authority
WECAMAN	West and Central Africa Collaborative Maize Research Network



IITA Headquarters
Oyo Road, PMB 5320, Ibadan, Nigeria
Tel +234 2 241 2626
Fax +234 2 241 2221
E-mail iita@cgiar.org
Web www.cgiar.org/iita

International mailing addresses
IITA, c/o L W Lambourn & Co.
Carolyn House
26 Dingwall Road
Croydon CR9 3EE
United Kingdom

IITA, PO Box 025443
Miami, FL 33102, USA

Lagos/Ikeja Office
Plots 531 & 532 WEMPCO Road, Ogba Estate
PO Box 145, Ikeja, Nigeria
Tel +234 1 921147 or 920251

IITA Kano Station
Sabo Bakin Zuwo Road
PMB 3112, Kano, Nigeria
Tel +234 64 645350, 645351, 645353, 624046
Fax +234 64 645352
E-mail iita-kano@cgiar.org

IITA High Rainfall Station, Onne
PMB 008, Nchia-Eleme
Port Harcourt, Rivers State, Nigeria
Fax +871 68 234 1882
Tel +871 68 234 1880-1
E-mail iita-onne@cgiar.org

République du Bénin
IITA/Benin Research Station
BP 08-0932 Cotonou, Bénin
Tel +229 350553/350188/350600
Fax +229 350556
E-mail iita-benin@cgiar.org

Cameroon
IITA Humid Forest Ecoregional Center
BP 2008 (Messa)
Yaoundé, Cameroon
Phone +237 237434; 237518
Fax +237 237437
E-mail iita-humid@cgiar.org

Uganda
Eastern and Southern Africa Regional Center (IITA-ESARC)
Namulonge, PO Box 7878
Kampala, Uganda
Tel +256 41 223460
Fax +256 41 223459
E-mail iita-uganda@cgiar.org

International Institute of Tropical Agriculture
a member of the
Consultative Group on International Agricultural Research

ISSN 0331-4340