International Institute of Tropical Agriculture
IITA–Benin Station

Integrated Pest Management: Towards 2015

A business plan

IITA
Research to Nourish Africa

For further information contact:

Braima James
Officer in Charge (OiC)
IITA–Benin Station
08 B.P. 0932 Tri Postal, Cotonou
Republic of Benin
Tel: +229 350553
E-mail: b.james@cgiar.org
www.IITA.org

International Institute of Tropical Agriculture
IITA–Benin Station

Integrated Pest Management: Towards 2015

A business plan

IITA
Research to Nourish Africa

Contents

Foreword

Each week in Africa, an estimated 35 000 people die of chronic hunger. Almost half the region's population live on less than US$ 1 a day. In contrast to the world's other developing regions, the number of hungry and poor people in Africa is rising, and unless urgent action is taken the region will fail to achieve the Millennium Development Goals (MDGs) of halving hunger and poverty by the year 2015. The vital first step is to raise crop yields: the World Bank estimates that a 10% increase in yields could lead to a 9% decrease in the number of people living below the poverty line, saving millions from starvation.

We can effectively combat poverty and hunger in Africa by attacking one of the most significant causes of low crop yields: crop pests. Broadly defined, the concept of pests includes harmful animals or insects, disease-causing organisms (such as bacteria or viruses) and weeds. Acting alone or in combination, these pests can ruin harvests and destroy livelihoods.

Integrated pest management (IPM) is the key to tackling crop pests. Based on the use of biological control techniques, the IPM approach to crop protection significantly reduces the need for chemical pesticides, thereby lowering the costs of production at the same time as raising or sustaining yields. The socio-economic benefits of IPM have been shown to stretch far beyond the financial value of the yield increases achieved. They include dramatic improvements to human and animal health, and to the environment.

Over the past two decades the International Institute of Tropical Agriculture (IITA) has made some outstanding contributions to the use of IPM in Africa. Here at IITA–Benin, IPM is our business. Indeed, our work has the potential to help farmers achieve yield increases well in excess of the 10% figure mentioned above. Our aim is to further the practice and impact of IPM in Africa so as to maximize its contribution to hunger and poverty reduction. This business plan sets out the strategies we will employ to achieve our goals. Included are details of our four thematic work programmes and their associated economic benefits.

Attracting international funding for IPM research in Africa, IITA–Benin is a key resource in the struggle to turn the region's fortunes around. Our investment partners have already helped us to build a state-of-the-art research station where practical IPM solutions are developed. The station's collaborative activities, which are supported and complemented by work at other IITA bases in

Eastern, Central and Southern Africa, are delivering benefits at both the national and international levels. We now invite additional partners to invest in this work, in order to develop and spread the benefits of IPM still further. In becoming our partner, you will make a vital contribution to the gathering international effort to put an end to hunger and poverty in the region that Tony Blair, the Prime Minister of the United Kingdom, has called "a scar on the conscience of the world".

Peter Hartmann,
Director-General, IITA

Braima James,
OiC, IITA–Benin

The context

Introducing IITA–Benin

IITA's Benin research station opened in late 1985, with a remit to serve as a base for IITA's research, training and technology transfer activities in Benin and other French-speaking African countries.

In 1988, the station's infrastructure was considerably expanded to accommodate a custom-built insect-rearing and research facility, established to support a continent-wide classical biological control effort against cassava pests. The station's programme grew in size, complexity and scope, broadening to embrace other pest and disease problems of crop plants, the cropping environment, and food quality. A further major step in the development of the station – and of the institute as a whole – was taken in 1990 with the integration of most of IITA's crop protection work with activities based at IITA–Benin.

The original agreement establishing the Benin station included a grant of 50 ha of land adjacent to the National University of Abomey–Calavi, 12 km north of Cotonou, the commercial capital of Benin. This land now houses all the station's facilities, including experimental fields occupying approximately 35 ha, an administration block, physical plant services and workshops, and a conference hall/lecture theatre with bilingual interpretation facilities, as well as the biological control centre.

The main IPM building has an innovative 12-sided design and uses a blend of traditional and modern materials. Radiating 'fingers' provide high-quality plant-growth space in plastic greenhouses, secure insect-rearing rooms and dedicated areas for the production of entomopathogens – micro-organisms that kill insects – and for research on plant pathogens. The 'ring' provides office and laboratory space, while a central two-storey tower houses computer services, the library, a seminar room and additional office space. A more recent addition is a separate museum and biodiversity study facility.

IITA–Benin station.

Why invest in IPM?

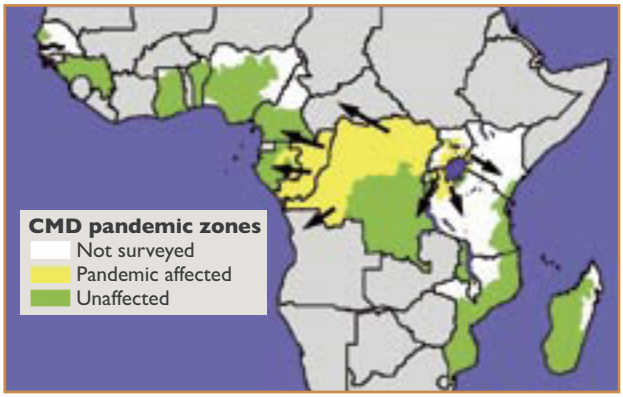
Food crop losses due to pests are very high in Africa. In Central and West Africa alone, the parasitic weed S*triga* or witchweed infests 20 to 40 million ha of farmland causing annual cereal losses worth up to US$ 7 billion. This is a preventable tragedy that regularly afflicts the lives of over 100 million people. Similarly, pests and poor agronomic practices have halved the production of cassava in recent years. These losses are borne by 300 million of the world's poorest producers and consumers. And around a third of the harvest of many staple cereals and legumes is commonly lost to post-harvest pests during the first 6 months of storage.

Farmers, policy makers and consumers are increasingly aware that the fight against crop pests cannot be won using chemicals alone. Excessive use of insecticides and herbicides disrupts ecologies as well as harming the health of farmers and consumers. IPM has grown out of the desire to reduce our reliance on chemicals to kill pests.

The current concept of IPM is broad and includes the complex of ecological factors that affect crop growth and development and seriously constrain agricultural production. Through the adoption of IPM practices, farmers are able to minimize pest damage and reduce the costs of production, leading to sustainable increases in crop production and farm income. Table 1 illustrates the cost savings achieved by four major IPM projects implemented by IITA and its partners. Control of all four pests was achieved and commodity yields were raised considerably, bringing significant economic benefits.

The benefits of IPM extend well beyond the financial gains received by producers. They include substantial gains in human health for both producers and consumers. In the case of producers, these gains bring further advantages to farming efficiency, as healthy farmers have more energy to devote to their work and take better management decisions. And in the case of both producers

Poor soils aggravate Striga *problems.*



Cassava mosaic disease (CMD) pandemic zones in Africa

Table 1. Cost savings achieved by biological control campaigns launched by IITA–Benin

Pest species (year of first occurrence)	Typical yield loss (%)	Biological control agent	Start of campaign	Area under economic analysis	Loss reduction (%)	Estimated savings (US$ millions)
Cassava mealybug (1973)	40	Encyrtid wasp *Anagyrus lopezi*	1981	27 African Nations	90–95	7 971–20 226
Cassava green mite (1971)	35	Phytoseiid mite *Typhlodromalus aripo*	1983	Nigeria Ghana Benin	80–95	2 157
Mango mealybug (1980s)	90	Encyrtid wasp *Gyranusoidea tebygi*	1987	Benin	90	531
Water hyacinth (1980)	66	Weevil *Neochetina eichhorniae*	1991	Benin	36	260

Source: Adapted from Neuenschwander, P. 2004. Harnessing nature in Africa: Biological pest control can benefit the pocket, health and the environment. *Nature* 432, 801–802

and consumers there are wider gains to the whole economy, as the costs of health care borne by families and the state are reduced. The environment also benefits in several major ways: the leaching of chemicals into water resources is reduced or avoided altogether; the natural enemies or predators of pests, often killed by chemicals in addition to the pest itself, are preserved; and the biodiversity of production systems is further enhanced through such interventions as the introduction of trap crops or rotations as components of IPM packages. IPM can make a significant contribution to the challenges set by the Convention on Biological Diversity (CBD).

IPM also delivers broader economic benefits to society. The cost of food to consumers is reduced when supplies increase. The surpluses produced by farmers can be processed into higher value products, with further gains to the incomes of producers and processors and the creation of new employment opportunities. And the volume of trade increases, bringing benefits both locally and nationally.

For the developed world, the widespread adoption of IPM would reduce the costs of providing food aid. By contributing to prosperity, IPM would also promote the development of a more peaceful and stable world.

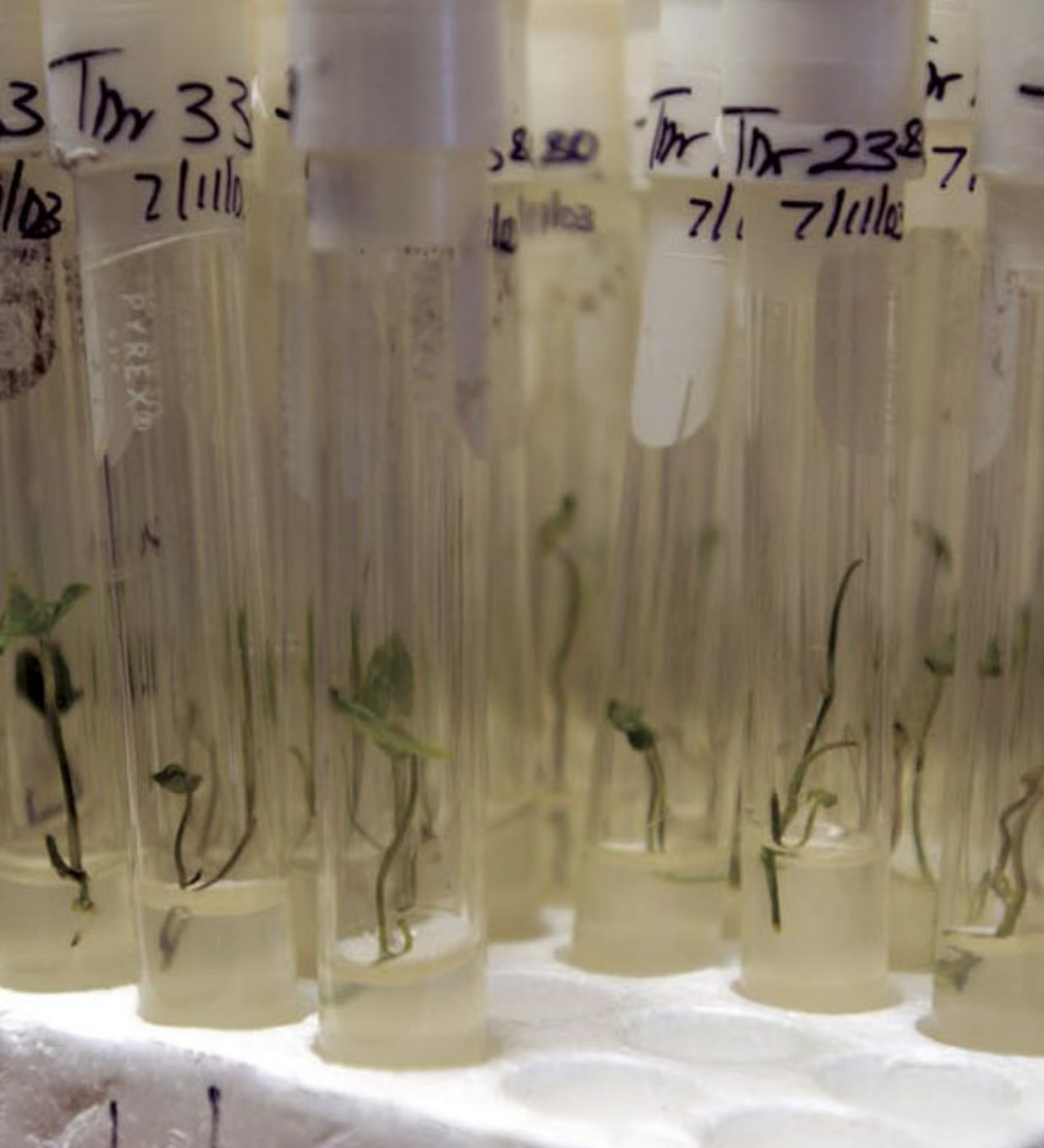
In July 2004, at a meeting of African heads of state in Addis Ababa, UN Secretary-General Kofi Annan called for a "uniquely African Green Revolution" in the 21st century to tackle the region's problems of hunger and poverty. We at IITA see IPM as an essential ingredient of that revolution, with its emphasis on more sustainable and environmentally friendly methods than those of the original Green Revolution experienced in Asia and Latin America. This business plan highlights how the IPM research conducted by IITA and its partners can contribute to the Millennium Development Goals (MDGs) of halving world hunger and poverty by 2015. Box 1 summarizes these contributions.

These goals have been embraced not only by the international community but also by such key African initiatives as the New Partnership for Africa's Development (NEPAD), which has endorsed IPM as central to its own strategy for eradicating poverty and hunger in Africa.

Lastly, investing in IPM in the region will ensure that Africa becomes a strategic player in agricultural science and technology. Like the development of a Biosciences Centre in Eastern and Central Africa, the creation of a strong IPM centre in West Africa will attract resources to the region, creating a critical mass of African scientists equipped to tackle the continent's most pressing challenges. The spill-over benefits of such a centre, both to other regions of the world and to other sectors besides agriculture, could be considerable.

Box 1 Key links between IPM and the Millennium Development Goals

Millennium Development Goal	IPM's contribution
Eradicate extreme poverty and hunger	Increasing and stabilizing crop yields and improving food quality will make a major contribution to this goal. Healthier children will have an increased capacity to learn.
Promote gender equality and empower women	Women farmers often support IPM technologies, becoming major advocates and leaders in IPM. Women's participation in IPM increases their scientific literacy and enables them to make better farming decisions.
Reduce child mortality	IPM options can contribute to this goal by reducing hunger, food contamination by mycotoxins and post-harvest pests and exposure to toxic chemical pesticides.
Improve maternal health	IPM interventions offer direct health benefits to women and their unborn children by reducing their exposure to chemical pesticides and improving post-harvest food quality. Better nutrition helps combat HIV/AIDS and other diseases.
Develop a global partnership for development	IITA–Benin's IPM partnerships form part of the global web of relationships needed to achieve this goal.



IPM is our business

IPM is the principal activity at IITA–Benin. The research station builds on existing knowledge, resources and collaborative networks in biological control to develop and introduce improved IPM options to national pest control programmes and other stakeholders. These options include biopesticides and botanicals, together with other technologies such as resistant crop varieties or improved agronomic practices. Techniques and mechanisms for applying and extending IPM, such as experiential learning and farmer field schools, are also studied and promoted.

Diagnostic research is conducted with farmers to enable both farmers and scientists to understand the biological, ecological and sociological processes that underpin agriculture and the problems that arise when natural processes are disrupted. On-station multidisciplinary research to develop solutions is integrated with participatory field experimentation to test them. This on-farm phase gives extension agents and farmers the knowledge and skills needed to select and adapt crop and pest management technologies to suit individual needs. The participatory approach, adopted throughout our work, leads to the development of options that are more likely to be widely adopted in the farming community.

Partnerships are vital both to the development and to the delivery of IPM knowledge and technologies. IITA has developed strong partnerships with national programmes, other international agricultural research centres (IARCs), specialized agencies of the United Nations (UN), non-governmental organizations (NGOs), universities, advanced research institutions, policy-making and regulatory bodies and private-sector companies.

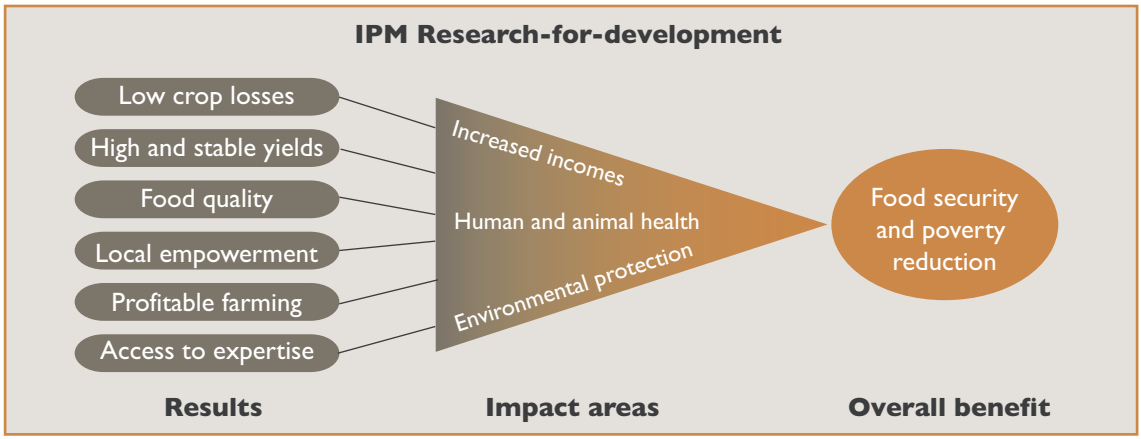
IITA works closely with national project coordinators to facilitate in-country project implementation, harmonize work plans and standardize methods so that results can be compared across locations. National coordinators in turn liaise with local communities to plan and implement activities, provide technical support to field activities and prepare progress reports. Local leaders collaborate with community members to identify and organize farmers' groups, prepare and supervise work plans, verify reports of new pest problems and monitor farmers' performance following training.

Key facilities: what we offer

The range and quality of its services make IITA–Benin a resource that is second to none in Africa. Facilities at the station include:

- A *biodiversity centre*. This holds a collection of insects, plants and micro-organisms of potential or actual use in the study of IPM and the development of new IPM technologies. The centre provides information and identification services to promote the use of biodiversity in IPM.
- A*n* IPM *outreach unit*. The unit engages in capacity building, participatory technology testing, technology dissemination and impact assessment.
- I*nsectaries*. Our rearing facilities allow for the mass production of arthropod biological control agents for release into diverse agro-ecosystems.
- A *biopesticide production unit*. The aim here is to move potential micro-organisms that are known to be both effective and safe from the experimental stage into commercial production and marketing for crop pests and weed control.
- F*ood quality control facilities*. These facilities are used to explore post-harvest IPM options, a vital component of future food security and safety.

Schematic presentation of IPM benefits



Leading by example: the effective use of our resources

The case studies outlined below demonstrate how IITA and its partners have been able to use the resources at the Benin station to implement IPM programmes across Africa. They highlight the impact that a combination of sound investment, cutting-edge research, and effective partnerships in technology development and dissemination can achieve on rural livelihoods across the continent. Some of the key partners and donor organizations involved are listed at the end of each case.

Biodiversity identification, foundation of IPM

The need

Within the past two decades, at least six alien invading pest species have damaged crops and undermined farmers' livelihoods in Africa. Taxonomic capacities – the institutions, infrastructure, and trained manpower needed to harness taxonomy and biosystematics to the development of viable IPM options – are generally weak in most African countries. Effective links among African countries for accessing and exchanging taxonomic information and products are also rare.

Our response

To develop and sustain national self-reliance in taxonomy, IITA–Benin has collaborated with the global taxonomic network BioNET INTERNATIONAL to establish and facilitate the West African Network for Taxonomy (WAFRINET). Through WAFRINET, IITA–Benin, which acts as the network's coordinating institute, continues to build capacity in taxonomy and associated fields across West and Central Africa.

Results

IITA has strengthened its own taxonomic capabilities in Benin to become one of the world's best equipped and most active biosystematics centres. Through its links with BioNET INTERNATIONAL, IITA is playing a catalytic role in fostering regional expertise through networking. National taxonomic capacity is built through group and individual training, the rapid transfer and sharing of taxonomic information among member countries, increased access for national scientists to external technical expertise and resources, the use of local taxonomy services, and the collaborative development of taxonomic technologies, products and information.

The insect collection at IITA–Benin contains over 200 000 specimens, including over 4000 identified insect species and 120 000 mite specimens from the region. Information about the collection is electronically indexed and easily accessible. The biodiversity centre offers

A biological control agent of the mango mealybug.

identification services free-of-charge, handling an average of around 1500 identification requests annually from national scientists, university students and other stakeholders.

IITA–Benin has developed diagnostic facilities for the identification of live micro-organisms (particularly fungi) that cause crop diseases. The collection of plant pathogens is freely available to all stakeholders for resistance testing of different crop varieties. The collection contains pathogens recovered from diseased weed and insect pests, which may prove useful in the development of new technologies for commercialization.

Lessons

Inclusive partnerships between IITA and national institutes are vital for the provision of taxonomic services across the region. Networks such as WAFRINET are needed to foster the development and sharing of regional expertise, information, technologies, collections and infrastructure. Technology transfer between countries and organizations, achieved through IITA–Benin, allows all stakeholders in the region increased access to technical expertise and related resources.

Partners

- National programmes in Benin, Burkina Faso, Cameroon, Cape Verde, Côte d'Ivoire, The Gambia, Ghana, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo
- Regional networks of BioNET INTERNATIONAL
- Donor agencies in Austria and Switzerland

Biological control options using exotic predators and parasitoids

The need

Over the past 20 years exotic pests have been accidentally introduced into Africa with increasing frequency. Examples include the cassava mealybug (*Phenacoccus manihoti*), cassava green mite (*Mononychellus tanajoa*), mango mealybug (*Rastrococcus invadens*), spiralling whitefly (*Aleurodicus dispersus*) and floating water weeds. Freed from the pressure of their natural enemies, these pests have multiplied rapidly, causing devastating losses in the agriculture, forestry and fisheries sectors across whole subregions.

Often the first response by governments and the private sector is to apply massive doses of insecticides or herbicides, typically on a calendar basis with little regard for the status of the pest or disease concerned. Such indiscriminate application of pesticides leads to the destruction of populations of beneficial organisms such as pollinators and natural enemies of pests. There is clearly a need to develop alternative control options.

*Cassava green mite (*Mononychellus tanajoa).

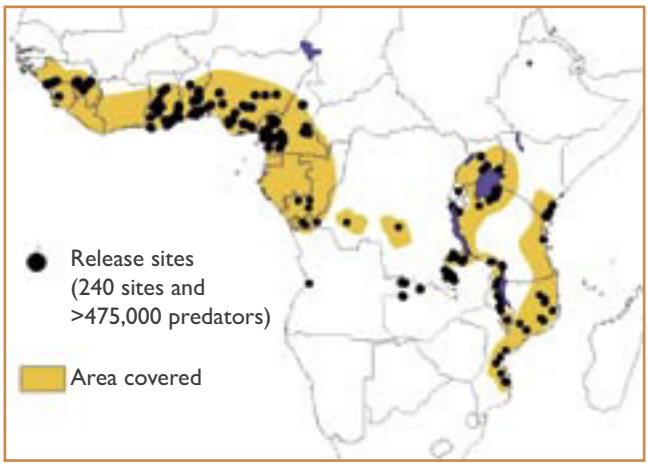
Our response

In collaboration with national and international partners, IITA has targeted all these new pests with classical biological control programmes.

One or more predators have been introduced to combat each pest. In the case of the two cassava pests and the mango mealybug, these predators had first to be discovered in the pests' original habitats – South America and India respectively. In other cases, we rely on the information and results from biological control projects in other continents and use organisms already identified and released there. And in still other cases, such as spiralling whitefly, the parasitoids have introduced themselves spontaneously.

Symptoms of cassava green mite damage.

All exotic predators are quarantined outside Africa, before being brought into the region for study and mass-rearing at IITA–Benin. In collaboration with national programmes in participating countries, beneficial natural enemies are then released and, if they establish, their dispersal and impact are studied.



Fighting the cause: cassava green mite biocontrol release sites

This approach has been extended to cover so-called indigenous pests, some of which were introduced many years ago. This has led to projects to control the cowpea thrips (*Megalurothrips sjostedti*) and the cowpea pod borer (*Maruca vitrata*), as well as cereal stemborers such as *Sesamia calamistis*.

Results

In all the cases mentioned above, while some natural enemies perished, one or two species have established and spread, eventually covering the entire area of distribution of the pest in Africa. Generally, impact has been achieved within a few years of release. As predicted by host range studies, none of these exotic natural enemies has ever been found to have a negative impact on non-target species. Impact on the target pests, in contrast, has often been spectacular and sustained.

For both cassava pests and the mango mealybug the economic returns have been found to be substantial, with cost-benefit ratios ranging from 1:140 to 1:600. In other words, for every US$ 1 spent, US$ 140 to 600 were saved over the life of the project, depending on the country. In the case of cassava mealybug, the project's leader was honoured with the 1995 World Food Prize.

Lessons

Classical biological control offers excellent chances of success against most introduced pests, including weeds. This method is worth extending to so-called pan-tropical pests, i.e. organisms that spread across the tropics before IPM researchers could track them. Strong collaborative partnerships, particularly with the lead institutions of beneficiary countries, are essential, together with full documentation of impact on both target and non-target species.

Partners

- National programmes and government services in Benin and 25 other African countries
- African, European and American universities
- Inter-African Phytosanitary Council (IAPSC)
- CAB International, UK
- Food and Agricultural Organization of the United Nations (FAO)
- International Fund for Agricultural Development (IFAD)
- African Development Bank (ADB)
- Donor agencies in Austria, Belgium, Canada, Denmark, Germany, Italy, the Netherlands, Switzerland and the UK

Biopesticides and botanicals as alternatives to chemical pesticides

The need

The undesirable effects of chemical pesticides include the contamination of food supplies, health risks through poor handling and the disruption of ecosystems. Due to the broad-spectrum nature of these pesticides, the natural enemies of pests and other non-target organisms can also be adversely affected. To these hidden costs should be added those that arise when stocks are no longer usable for health or regulatory reasons: national authorities and international donors are forced to spend millions on their safe disposal.

Farmers have expressed a strong need for safer alternatives to harmful chemical pesticides. Both biopesticides and botanical extracts can provide such alternatives.

Our response

IITA–Benin has researched a number of microbial organisms as possible control agents for use in biopesticides. The most successful to date is the fungus *Metarhizium anisopliae* var. *acridum*, found to be effective against locusts and grasshoppers in a wide variety of environments. Other fungi investigated include another sub-species of M. *anisopliae* for termite control, *Beauveria bassiana* for the control of diamond back moth and of banana weevil, and *Neozygites tanajoa* against cassava green mite. Insect viruses are also studied, among which the *Pxy*GV granulovirus shows considerable promise for the control of diamond back moth. Other studies have also revealed interesting insecticidal and/or repellent properties of aqueous extracts from leaves of the African mint *Hyptis suavolens*, papaya and neem.

Locust killed by the fungus Metarhizium.

Results

Virus-infected (left) and uninfected (right) caterpillars of the cowpea pod borer, Maruca.

Metarhizium anisopliae var. *acridum* has been shown to be so effective in controlling grasshoppers and locusts, which are potentially devastating pests, that it has, over the past 12 years, been developed into a commercial product called Green Muscle™. The product has been licensed to a South African company, which is selling it in Eastern and Southern Africa and the Middle East. As part of the development process, a pilot production plant

was set up at IITA–Benin. This is still producing supplies for West Africa and is now being used for the development and testing of other products based on similar fungi.

The other pathogens, especially *Neozygites* and the granulovirus, are at various stages of development, and some show strong potential. Among the botanicals, *Hyptis suavolens* extracts appear particularly useful in reducing damage by the legume pod borer *Maruca vitrata*, while fresh papaya leaf extracts show good control of flower thrips.

Lessons

The development of biopesticides and botanicals requires a multidisciplinary approach involving and integrating expertise in entomology, pathology, botany and ecotoxicology, as well as in product formulation and application. The development of viable commercial products therefore depends critically on inter-institutional partnerships. It is also a process that takes many years, needing dedicated investment partners. The most difficult phase is commercialization: markets in Africa are still small and attitudes towards biopesticides and botanicals are hesitant. Such factors explain why most of the region's countries still do not have a regulatory framework for registering these natural products. While recognizing these difficult market conditions, we at IITA feel that our biopesticide production plant will eventually inspire local entrepreneurs.

Partners

- National research institutes, crop protection services and NGOs in Benin, Burkina Faso, Cameroon, Cape Verde, Chad, The Gambia, Ghana, Guinea-Bissau, Kenya, Mali, Mauritania, Mozambique, Niger, Nigeria, Senegal, South Africa, Sudan, Tanzania, Togo and Uganda
- Advanced research institutions in the UK
- International Centre of Insect Physiology and Ecology (ICIPE)
- Donor agencies in Canada, Denmark, Germany, the Netherlands, Switzerland, the UK and the USA

Improved waterways, more profitable fishing

The need

Water weeds threaten the survival of lakeside and riverine communities across Africa. They kill aquatic life by blocking out light, harbour the carriers of such diseases as malaria and bilharzia, impede transport, threaten biodiversity, and stifle commerce, fishing and irrigation. Three such weeds are particularly damaging:

- The water hyacinth (*Eichhornia crassipes*). This is the most troublesome aquatic weed worldwide. In addition to the kinds of damage mentioned above, it inhibits hydroelectricity generation

by reducing the volume of water available (by increasing evapotranspiration) and by physically blocking turbines. Physical removal of the weed is difficult because of the vast areas infested, the rapid re-growth and the low commercial value of the plant (it is 95% water). Chemical control is expensive and can harm water quality as well as other organisms.

- Water lettuce (*Pistia stratiotes*). This is a widespread floating weed that is a nuisance mainly on closed water bodies such as shallow pools used to water cattle.
- Water fern (*Salvinia molesta*). This is found in South Africa, Republic of Congo (Brazzaville), Côte d'Ivoire and Senegal, where it forms dense floating mats that kill fish.

Waterways blocked by water hyacinth.

Our response

Through national programmes, IITA has deployed various weevils (small beetles) to control all three weeds in West and Central Africa and the Lake Victoria Basin. Training has also been provided and monitoring techniques have been developed.

Results

The weevil *Neohydronomus affinis* achieved complete control of water lettuce within a short period. In the Congo, control of water fern by another weevil, *Cyrtobagous salviniae*, was equally successful. Monitoring studies of water hyacinth in Benin have shown significant reductions in plant growth and regeneration due to two other weevil species, *Neochetina eichhorniae* and *N. bruchi*, that have also proved particularly successful on Lake Victoria.

For Benin alone, the control of water hyacinth is estimated to have brought returns of US$ 260 million, calculated (with depreciation) over a 20-year period. However, control by weevils is limited in environments where plant roots are seasonally exposed to shallow or muddy water, creating conditions in which weevil larvae cannot pupate and develop. The need for additional control strategies to complement the activity of weevils has led to further experimentation using other insects and fungal pathogens. Among the fungal pathogens investigated, *Alternaria eichhorniae* exhibited the greatest potential. It is host-specific, indigenous to Africa, widely distributed and virulent on leaves and occasionally stems. Infection by *A. eichhorniae* is dependent on available water on the leaf surface. This has been provided through the formulation of an appropriate mycoherbicide (a herbicide based on a living fungus). Infection rates have been further increased through the addition of abrasive agents and surfactants to the formulation. These reduce surface tension and enhance application.

Lessons

Effective and sustainable control of aquatic weeds is possible using naturally occurring insects and fungal pathogens. While the biological control of water lettuce and water fern by weevils is mostly successful without further intervention, the control of water hyacinth needs careful management of the entire water body. Careful monitoring, together with more detailed study of relevant ecological interactions, is needed in order to quantify control and make sure that IPM options deliver lasting success.

Success stories in water hyacinth control: clear waterways and healthy catches of fish.

Partners

- National research institutes, government services and universities in Benin, Côte d'Ivoire, Ghana, Mali, Niger, Nigeria, South Africa, Senegal, Tanzania, Uganda and Zimbabwe
- CAB International (UK and Africa Regional Centre)
- United States Department of Agriculture, Agricultural Research Service (USDA-ARS)
- Donor agencies in Denmark and Switzerland
- International Fund for Agricultural Development (IFAD)

Food quality, improved health and trade

The need

Globally, at least one-fifth of agricultural produce either does not reach consumers at all or is of unsatisfactory quality when it does. In Africa, food quality is greatly reduced by a range of contaminants that cause ill-health in humans and livestock. These contaminants include insects and mites, mycotoxins (toxins produced by fungi) and excessive pesticide residues.

The most harmful of the mycotoxins are aflatoxins, colourless and odourless by-products of the fungus *Aspergillus flavus* that cause mouldiness in a wide range of stored foods including cereals, food legumes and roots and tubers. Aflatoxins can cause serious health problems in humans, including stunted growth and liver cancer.

As agricultural export markets become more competitive, there is a growing need to empower African farmers and traders to reduce the incidence of contaminants in compliance with international food quality regulations and standards. Appropriate post-harvest IPM technologies are needed, combined with public awareness campaigns.

Mouldy maize is a major source of aflatoxin contamination in food.

Our response

IITA's post-harvest IPM research in Benin focuses on the control of arthropod pests and mycotoxins. Resistance breeding, biological control and crop management strategies have been identified and tested on food storage pests and mycotoxins.

We have also launched public awareness campaigns, particularly to improve food quality in Africa's major food crop, maize. To this end we formed a partnership with Rotary Clubs in Benin, Togo, Ghana, France and the USA. Launched with the slogan 'Quality Maize for Better Health', the purpose of the campaign was to educate the general public and government policy makers about aflatoxins, the risk of contamination and how to avoid it.

Good quality maize, free from aflatoxins, fetches a higher price at market.

Results

IITA and its partners have assessed the presence and distribution of arthropod pests and mycotoxigenic fungi and their resultant mycotoxins in maize, groundnut, yam chips, cowpea and cashew nuts. Forty-four percent of maize samples from Benin, Togo and Ghana tested positive in aflatoxins and zones with the highest prevalence were identified. In Benin, tests show aflatoxin contamination of the blood in almost all children aged one to five. This high exposure is significantly linked to stunted growth.

Several strategies for the control of post-harvest pests and aflatoxins have been made available. Scientists have identified maize varieties that are less susceptible to aflatoxin accumulation.

Testing a child for aflatoxin contamination.

Husbandry practices that reduce the risk of mycotoxin contamination in maize and groundnut have also been identified.

An impact assessment of the aflatoxin awareness campaign showed that a large proportion of target farmers, traders and consumers are now better informed about aflatoxin and its health risks. National capacity has been increased through technology transfer and the training of food standards personnel in Benin, Togo and Ghana.

Lessons

IITA–Benin's post-harvest IPM activities are an important first step in reducing food and feed contamination in Africa. Appropriate local food quality standards, technological innovation and government support are now needed to sustain progress and develop new ways forward.

Partners

- National programmes in Benin, Burkina Faso, Cameroon, Ghana, Mali, Nigeria and Togo
- Universities in Benin, Burkina Faso, Germany, Ghana, South Africa and the USA
- Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), France
- Medical Research Council, South Africa.
- Danish Institute of Agricultural Sciences (DIAS)
- United States Department of Agriculture (USDA)
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
- Rotary International, with clubs in Benin, France, Ghana, Togo and the USA
- Donor agencies and programmes in Denmark and the USA

Ownership and impact of IPM: farm-level implementation

The need

The success of IPM depends on how well farmers can understand the approach and apply it to their needs. First-class research and good working relationships with partners are wasted if the results

Cabbage severely damaged by diamond back moth.

Larvae of diamond back moth.

are not implemented at ground level. Farmers need to combine new knowledge of biological and ecological processes with their farming experience to develop and select options that reduce losses to pests, increase agricultural productivity and meet the demands of local and global markets, while still remaining feasible in terms of their demands on labour and other resources. A number of promising options are available, but adoption of IPM at farm level remains generally slow in Africa. Poor communication between researchers, field extension agents and farmers is widely believed to be a major constraint. There is an urgent need to involve farmers and farmer-based organizations more actively in the research and development process.

Our response

IITA adopts farmer participatory research and learning approaches to make IPM research more understandable, useful and acceptable to farmers. Our IPM projects promote experiential learning models, such as farmer field schools (FFS), at pilot sites. Through FFS, national institutions learn to develop more effective farmer–scientist–extension partnerships, with better communication and information delivery.

Monitoring of cabbage crops by IPM-trained farmers.

Results

Farmers at pilot sites have combined different IPM technologies according to their resource base and the problems they face. The following IPM interventions have proved particularly popular:

- High-yielding cowpea, cassava and maize varieties resistant to key insect pests, diseases and weeds
- Botanical insecticides to combat cowpea insect pests
- Improved maize varieties and legume/cereal rotations that suppress *Striga*
- Solar drying and triple-bagging storage techniques against post-harvest pests.

Lessons

As with all knowledge-intensive technologies, IPM faces major challenges in scaling up. Committed national and local partners who can take responsibility for and ownership of activities after the pilot phase are essential if these challenges are to be met.

Our experiences suggest that trained farmers can become community organizers and train other farmers, thereby contributing to the large-scale dissemination of IPM information and technologies. Another important role of these farmer groups lies in their networking with external sources of inputs, credit and market information. FFS mentoring and networking by community organizers can increase community access to information and expertise, promote the secondary adoption of IPM, prepare the way for the withdrawal of external facilitation of FFS, and aid eventual transition to self-supporting schemes.

Maize storage platform with rat guards in southern Benin.

Partners

- National programmes in Benin, Burkina Faso, Cameroon, Ghana, Mali, Mozambique, Niger, Nigeria, Senegal and Togo
- Food and Agriculture Organization of the United Nations (FAO) and the Global IPM Facility
- Systemwide Programme on Integrated Pest Management (SP-IPM) of the Consultative Group on International Agricultural Research (CGIAR)
- Donor agencies in Italy, Norway and Switzerland
- The World Bank.


ERY
SEF

The way forward

Objectives and targets

IITA–Benin has three objectives, to:

- Promote sustainable production by developing and introducing IPM options
- Strengthen local, national and regional capacity for IPM
- Provide information on IPM options, expertise and partnership opportunities.

Two targets for achievement by 2015 have been identified:

- A million African farmers should have reduced pest damage to their main food and cash crops by at least 30%
- A quarter of a million African farmers should have reduced their use of harmful pesticides by 60%.

Strategy 2005–2015

IITA–Benin's strategy for contributing to the MDGs is to build the capacity for IPM by making suitable IPM options available to stakeholders, training stakeholders in their use and dissemination, and ensuring that IPM is supported by appropriate policies and institutions.

Our strategy comprises four inter-related elements:

- Development of national IPM policy frameworks
- Development of IPM options
- Capacity strengthening for IPM implementation
- IPM impact assessment.

Each element is implemented through a strategic work programme.

Work programmes

We have the following four work programmes.

Development of national IPM policy frameworks

This work programme provides governments with information on available technical expertise, supporting institutions and the resources required to address pest threats to national food security and poverty reduction. It is carried out in partnership with sub-regional organizations, agencies and international development partners, including the African Union, IAPSC, FAO and the Global IPM Facility, and the Forum for Agricultural Research in Africa (FARA).

Principal activities:

- Conduct thematic reviews of national IPM capacities and regulatory frameworks. The reviews highlight strengths, weaknesses, threats and opportunities, enabling policy makers, research directors and other decision makers to plan and implement sound IPM programmes.
- Develop and update legislation and regulations to encourage national compliance with international conventions and guidelines on IPM and food quality.
- Encourage the establishment of multi-stakeholder bodies to advise on legislation and regulations governing the manufacture, registration, importation, distribution and use of chemical pesticides, biopesticides and botanicals. These bodies also deal with such issues as pest quarantine, alien invasive species, and the need for transgenic crops and organisms in IPM.
- Provide reports and other information products on available IPM technologies and approaches to extension services, NGOs and farmers' groups. The aim is to empower farming communities to integrate IPM into mainstream agriculture.

Inservice training of plant quarantine staff, Nigeria.

Development of eco-friendly IPM options

This work programme increases the range of crop and pest management options available to farming communities in diverse production systems.

Principal activities:

- Provide reliable methods for estimating production and post-harvest losses caused by pests of primary concern to farming communities.

- Develop and evaluate IPM options through cohesive farmer–scientist–extension agent partnerships that integrate scientific knowledge of biological and ecological processes with farmers' indigenous knowledge and experiences of agricultural production and post-harvest storage.
- Investigate, develop, produce and promote biologically based alternatives to hazardous pesticides and increase farmers' access to them and to other inputs.
- Evaluate transgenic crops and other organisms, where national biosafety protocols and legislation allow, for their ecological and economic relevance as IPM resources.
- Develop post-harvest technologies to prevent human health hazards caused by biological agents that contaminate stored produce, thereby improving farmers' opportunities to benefit from export trade.

Capacity strengthening for IPM implementation

This work programme aims to strengthen national and community capacities for informed IPM decision-making, thereby reducing production and post-harvest losses caused by pests and promoting healthier production environments.

Principal activities:

- Facilitate participatory problem diagnoses to specify the pests and plant health risks of priority concern to farming communities.
- Facilitate farmers' planning and implementation of location-specific activities at pilot sites and ensure partnerships for effective IPM implementation.
- Promote experiential learning so as to empower pilot-site farmers, particularly women, to analyze pest problems and evaluate IPM options, with the emphasis on alternatives to chemical pesticides.
- Encourage farmer-led extension to promote IPM options and the safe use of chemical pesticides.
- Encourage local entrepreneurs to produce and market biologically based alternatives to hazardous pesticides.
- Organize training to strengthen technical expertise for effective action against pests.
- Establish collaborative research grant schemes and fellowship programmes for national universities and research institutions in order to promote relevant strategic and applied research.
- Adapt scientific information into user-friendly decision-support tools and extension materials and disseminate these in order to increase IPM literacy among farmers, policy makers, consumers and the general public.
- Increase awareness of IPM and its advantages and foster common understanding of IPM issues through public awareness campaigns, workshops, field days and other means.
- Promote the exchange of expertise, experiences and information on methods and results among stakeholder groups through networking.

IPM impact on sustainable development

This programme aims to evaluate the impact of IPM and to use the information emerging from impact assessment to design more effective IPM interventions in the future.

Principal activities:

- Evaluate impact on food security using such indicators as decreases in crop losses, increases in food production and improvements in food quality.
- Evaluate impact on poverty reduction using indicators such as incomes in farming communities and effective demand for quality food, health and education.
- Evaluate impact on gender and equity issues using indicators such as access to technologies, learning opportunities and income level among women and disadvantaged groups.
- Evaluate impact on the environment and human health using indicators such as savings in pesticide use, changes in biodiversity, health costs and farmers' perceptions.
- Publicize the benefits of investment in IPM through case studies.
- Build the capacity of national agricultural research systems in impact assessment.

Principles for success

The following five principles for IPM success underpin the implementation of our work programmes:

IPM *interventions must contribute to food security and income.* Farmers and other stakeholders will not adopt, support or promote IPM interventions unless it is in their interests to do so. In poor countries, this means that interventions must raise their net incomes and improve their food security, preferably in the short as well as the medium and longer terms. In the short term, farmers participating in IPM activities should be empowered to reduce pest damage significantly in targeted fields and stores. In the medium term, they should be able to increase crop yields by at least 20% over current traditional practices. In the longer term, a wider set of mutually reinforcing opportunities for raising incomes should become available, including new commercial ventures in such areas as local production of alternatives to chemical pesticides, seed multiplication schemes for resistant crop varieties and the processing and marketing of healthier foods.

IPM *projects and programmes must be owned by local people and institutions.* This is vital if the benefits of IPM are to continue to spread once external funding and support is withdrawn. National oversight committees play pivotal roles in the coordination of IPM activities developed by IITA–Benin. This institutional arrangement is designed to strengthen local ownership, which is further reinforced by the participatory approach adopted by IITA and its institutional partners. In this regard,

participatory learning will provide the key to both capacity building and local ownership of IPM interventions.

Effective intervention in farmers' fields depends on strong partnerships among local, national and international institutions. These partnerships are critical in bringing global scientific expertise to bear on the priority problems of resource-poor farmers. They provide national IPM programmes, NGOs and farmers' groups with access to information and expertise and help keep the strategic research agenda at the international level relevant to stakeholders' needs. They also assist in raising the profile of IPM on the agenda of national policy makers.

An approach that integrates research and development is essential for spreading IPM knowledge and practices. Our work uses a programmatic approach in which applied research on cross-cutting issues underpins location-specific implementation activities in local communities. This approach will ensure farmers' access to technical innovations developed elsewhere, increase the range and applicability of IPM options, contribute to the global knowledge base on such topics as the dynamics of pest infestations, and enrich the dialogue on how to scale up IPM and maximize its impact. Activities at community level will focus on extension and farmer training, experimentation by farmers' groups, and participatory testing and implementation.

IPM *practitioners should mainstream gender equality at all levels.* Women in farming households are important direct beneficiaries of IPM and should be included in the groups that develop and test IPM innovations. Gender analysis will form part of the baseline activities that guide the partnership arrangements for implementing projects. The criteria used to select project participants will ensure that, in addition to women farmers, more women researchers, technicians and extension agents are included in capacity-building activities. Through field days, national policy makers will be exposed to the results achieved by women's groups; this will increase the profile of women's contributions to national economic growth. The greater scientific literacy we expect to see among women at all levels of society should eventually contribute substantially to the adoption of IPM options by and for women.

How our partnerships will evolve

If we are to implement our strategy successfully we must create effective partnerships with key stakeholders. This means identifying relevant individuals, organizations and governments at an early stage of planning new projects, so that they are involved and take ownership from the start.

Our most important stakeholders are farmers' groups (particularly women farmers), NGOs responsible for location-specific activities, national agricultural research and extension services,

FFS analysis by farmers.

government agencies, international research and development centres and organizations, and universities.

In the years ahead we envisage a stronger role for NGOs. In addition to taking on location-specific development activities, NGOs can, through these activities, sensitize policy makers to the concept and benefits of IPM, helping to raise awareness of its contribution to national development. In time, the stronger NGOs should be able to identify, select and mobilize the necessary resources to plan and implement projects independently of external support. Trained NGO staff should also be able to facilitate experiential learning, particularly in FFS.

International research centres and development organizations, together with universities, will continue to serve as important partners in research on cross-cutting issues. In particular, we will maintain strong links with other international centres engaged in IPM-related work, notably through the SP-IPM of the CGIAR. University involvement in our work, already considerable, will also expand in the coming years, as topics requiring more specialized attention increasingly come onto the research agenda.

Monitoring and evaluation

IITA–Benin's monitoring and evaluation process seeks to identify the extent to which project results and outputs contribute to the following set of pre-determined performance indicators.

Capacity to inform

Measured by:

- Types and number of participatory learning sessions and other training courses delivered
- Category and number of extension agents and farmers trained and reached
- Category and number of participants reached (beyond baseline figures)
- Practical skills/techniques most frequently demanded by extension agents and farmers
- IPM and crop management practices preferred by farmers.

Capacity to motivate

Measured by:

- Category and number of farmers who correctly apply the skills they have learnt
- New management practices adopted by farmers
- Category and number of other farmers trained by project-trained farmers

- Rate of adoption of IPM practices
- Impact on production.

Socio-economic benefits

Measured by:

- Increases in crop production
- Increases in farm income
- Improvements in farmers' health
- Reductions in pesticide purchase and use
- Numbers of farming families engaged in monitoring biodiversity.

Milestones

For each project, milestones will be established on the basis of the five principles outlined earlier.

Finance and funding

IITA relies on donor organizations for the financial resources to implement its work programmes. Our top 10 donors currently support 33 IPM projects, with large donations received from Austria, Denmark, the Netherlands, Italy, Norway, Switzerland, the UK and the USA.

Continued investment funding is essential, preferably over periods longer than the conventional 3-year project cycle. Over the coming years, IITA will seek to attract increased funding, both from traditional investors and from possible new sources such as NEPAD, FARA, the private sector and charitable foundations.

Work plans and budgets for each project proposed under this business plan will be developed through consultative planning workshops. These will enable local stakeholders and other partners to define the needs of end-users, specify project inputs and outputs, identify technical and administrative responsibilities, and agree on contractual obligations. Proposed work plans and budgets will need to be approved at national level by the country or countries requesting technical assistance as well as by the donor organizations funding the work.

Table 2 outlines the financial resources needed for IITA–Benin to implement its four strategic work programmes in each participating country. A total budget of US$ 3.1 million per country over 5 years will be needed. The case studies provided earlier give an idea of the returns that can be expected to this level of investment.

Table 2. Financial resources[1] required to address priority pest problems per country over 5 years

Work programme	Principal activities	US$[2]
1. Development of national IPM policy frameworks	Thematic reviews of national IPM capacities and regulatory frameworks	25,000
	Develop/update legislation and regulations to encourage national compliance with international conventions and guidelines on IPM and food quality	10,000
	Encourage the establishment and functioning of multi-stakeholder oversight bodies to advise on IPM legislation and regulations	5,000
	Provide information on available IPM strategies to extension and farming communities	50,000
	Strengthen the capacity to identify and store plant pathogens	30,000
	Subtotal work programme 1	**120,000**
2. Development of eco-friendly IPM options	Develop reliable methods for estimating production and post-harvest losses caused by priority pest problems	55,000
	Develop and evaluate IPM options through cohesive farmer–scientist–extension partnerships	550,000
	Investigate, develop, produce and promote biologically based alternatives to hazardous pesticides and increase farmers' access to them and to other inputs	350,000
	Evaluate transgenic organisms, where national biosafety protocols and legislation allow, for their ecological and economic relevance as IPM resources	150,000
	Develop post-harvest technologies to prevent human health hazards caused by biological agents that contaminate stored produce	160,000
	Subtotal work programme 2	**1,210,055**
3. Capacity strengthening for IPM implementation	Facilitate participatory problem diagnoses to specify pests/plant health risks	75,000
	Facilitate farmers' planning and implementation of location-specific activities and ensure partnerships for effective IPM implementation	35,000
	Promote experiential learning so as to empower farmers, particularly women, to analyze pest problems and evaluate IPM options	350,000
	Encourage farmer-led extension to promote IPM options and the safe use of chemical pesticides	85,000

Table 2. Financial resources required to address priority pest problems per country over 5 years (continued)

Work programme	Principal activities	US$
3. Capacity strengthening for IPM implementation (continued)	Encourage local entrepreneurs to produce and market biologically based alternatives to hazardous pesticides	15,000
	Organize training to strengthen technical expertise for effective action against pests	450,000
	Establish collaborative research grant schemes and fellowship programmes for national universities and research institutions	250,000
	Adapt scientific information into user-friendly decision-support tools and disseminate these	140,000
	Increase awareness of IPM and its advantages and foster common understanding of IPM issues	150,000
	Promote the exchange of expertise, experiences and information among stakeholder groups through networking	55,000
	Subtotal work programme 3	**1,605,000**
4. IPM impact on sustainable development	Evaluate impact on food security	25,000
	Evaluate impact on poverty reduction	25,000
	Evaluate impact on gender and equity	25,000
	Evaluate impact on the environment issues and human health	25,000
	Publicize the benefits of investment in IPM	15,000
	Build the capacity of national programmes in impact assessment	65,000
	Subtotal work programme 4	**180,000**
	Grand total	**3,125,055**

[1] Modular funding approach to cover one or more work programmes according to national needs
[2] Cost per country will be less where a regional approach is funded to benefit a number of neighbouring countries

IITA will take primary responsibility for the financial aspects of this business plan. We will disburse operational funds on the basis of approved work plans and budgets. Specialized activities requiring outsourcing will be subcontracted. IITA will provide audited financial statements according to the Institute's accounting procedures and as agreed with investment partners and beneficiary country programmes.


APPETONE

Conclusion

Through its businesslike approach to IPM, IITA can provide sustainable eco-friendly options for the protection of crops and other natural resources, thereby contributing positively to Africa's economic growth.

Our comprehensive multidisciplinary approach to IPM research and development, backed by purpose-built facilities and trained technical staff, together with our close links with farmers and policy makers, mean that we are uniquely equipped to maximize the returns to donors' investments. The benefits will be realized in higher and more stable commodity yields, improved food quality and increased opportunities for producers to gain access to national, regional and international markets.

Credits:

Figures:
Ousmane Coulibaly and Braima James/IITA, p. 10; James Legg/IITA/Natural Resources Institute (NRI), p. 5; John S. Yaninek and Rachid Hanna/IITA, p.13

Photos:
Cyrille Adda/IITA: p. 19 (above); Cyprien Atcha/IITA: pp. 21 (bottom) and 30; Trygve Bolstad/Still Pictures: front cover bottom left and p. 24; Andy Cherry/IITA/NRI: p. 15 (bottom left); Fen Beed/IITA: p. 17; Georg Goergen/IITA: pp.12, 13 (top), 21 (top right) and 26; Kerstin Hell/IITA: p. 22; IITA: pp. 4, 13 (below),15 (above right), 20 and 26; Braima James/IITA: p. 21 (top left); Peter Neuenschwander/IITA: p. 18 (left); Peter Neuenschwander and Obinna Ajuonu/IITA: p.18 (right); Giacomo Pirozzi/Panos Pictures: front cover top right and p. iv; Jacob Silberberg/Panos Pictures: front cover top left and bottom right, pp. 8 and 34; Remi Yussuf/IITA: pp. 3 and 19 (below)

Writing: Braima James, Manu Tamo, Anthony Youdeowei and colleagues/IITA
Editing, design and layout: Green Ink Ltd, UK (www.greenink.co.uk)
Printing: Pragati Offset Pvt. Ltd, India


IITA
Research to Nourish Africa
FUTURE
HARVEST