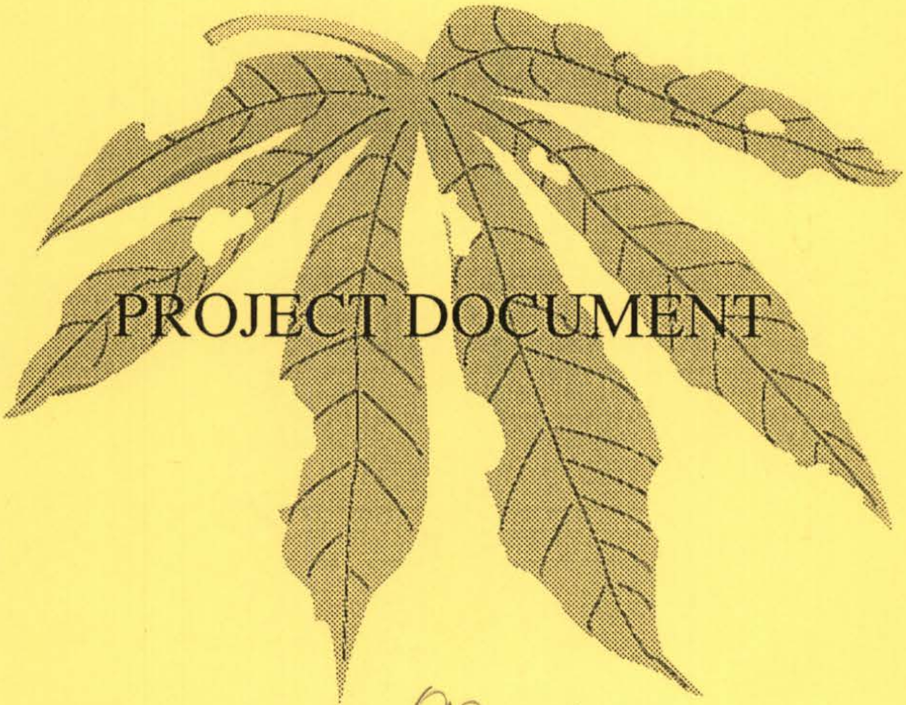
ECOLOGICALLY SUSTAINABLE CASSAVA PLANT PROTECTION IN SOUTH AMERICA AND AFRICA: AN ENVIRONMENTALLY SOUND APPROACH



PROJECT DOCUMENT

Global project involving:
CIAT, IITA, NARS of Benin, Cameroon, Ghana and Nigeria
Funded by: UNDP

Global project involving Centro Internacional de Agricultura Tropical (CIAT), International Institute of Tropical Agriculture (IITA), National Agricultural Research Systems (NARS) of Benin, Brazil, Cameroon Ghana, and Nigeria
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IN SOUTH AMERICA AND AFRICA
AN ENVIRONMENTALLY SOUND APPROACH

Centro Internacional de Agricultura Tropical (CIAT) and International Institute of Tropical Agriculture (IITA)

PROJECT SUMMARY

BACKGROUND

The shared mission of the Centro Internacional de Agricultura Tropical (CIAT) and the International Institute of Tropical Agriculture (IITA) is the alleviation of hunger and poverty in tropical developing countries This is being achieved by generating appropriate production and protection technologies which benefit the poor and enhance agricultural production while preserving the natural resource base The commodity portfolio of both instituies includes cassava a major source of carbohydrates, raw material for rural agroindustries, and food security, supporting 265 and 140 million people in Africa and Latin America, respectively

Most cassava is produced in marginal areas which are rainfed and have problem soils In the absence of external pressures for intensification of cassava production, the demand placed on the land to feed farm families and livestock is sustainable, i e , production demands are balanced with the capacity of the ecosystem such that the net effect on the environment and the quality of rural life is positive However, in many regions of Africa and South America, cassava is increasing in importance as a food and feed crop for the rapidly growing urban and rural populations Pressure for intensification is transforming the production system into a less sustainable state, imposing even greater risks for small-scale farmers in the future

The increasing demand for cassava combined with other pressures, such as declining land availability and mounting pest and disease constraints, are leading to poor agronomic practices and inappropriate use of agricultural chemicals which degrade the natural resource base available for cassava production Reversal of this process in areas where it already occurs, and its prevention in regions where production demands are still in balance with the capacity of the surrounding natural resource base, requires major effort and immediate attention Consequently, sustainable cassava production will increasingly depend on the availability of ecologically sound crop production and protection practices

Cassava growing areas characterized by intensification of production and faced with serious pest problems are prevalent in South America and Africa In some areas, increased production associated with increased commercialization of cassava (e g , dried cassava for animal feed, processed cassava products, starch) are creating an economic context favorable for the increased use of pesticides and other purchased, imported inputs The development and implementation of ecologically sustainable crop production and protection systems is especially urgent in such areas

In South America, the seasonally dry to semiarid zone of Northeast Brazil is a critical area in terms of the risk to agricultural sustainability associated with intensified cassava production Brazil is the world's largest cassava producer and 58 percent of this production (14 5 million tons) is concentrated in the Northeast, partly because the environmental conditions are unfavorable for the cultivation of most other crops Most cassava in this region is grown by tenant farmers who cultivate plots of less than one ha with generally low soil fertility and uncertain rainfall Cassava productivity in the northeastern states is 10 8 t/ha, a third lower than the rest of Brazil The Food and Agriculture Organization (FAO) considers this to be a serious calorie deficit problem explaining the mass emigration to rain forest ar^e^as

The rapidly growing rural and urban populations in Africa are accelerating the demand for cassava Africa presently accounts for 40% of the world s total cassava production 90% of which is used for human consumption One third of the continent s total production of 50 million tons comes from West Africa Cassava in this region is a food staple and the most important source of carbohydrates, providing more than two and a half times the calories contributed by the second and third-ranking crops, maize, and yams for 75 million people Cassava is grown by small-scale farmers on plots of less than 0 5 ha where production rarely exceeds 8 t/ha Fallow periods which traditionally restored the land to its original productivity have declined sharply in recent years as increasing production demands move local agroecosystems toward nonsustainability

Cassava pests including arthropods, pathogens, and weeds, reduce cassava production by an estimated 50% Yield losses vary with pest species and prevailing agronomic and edaphoclimatic conditions Severe pest problems in cassava tend to occur 1) in areas where exotic pests and diseases have been introduced, 2) where the available germplasm is not well adapted to the local ecological conditions, 3) where intensification of production over a long period has destabilized the agroecosystem balance achieved by farmers, or 4) where cassava cultivation has a short history and this adaptive process has not had sufficient time to evolve

In Africa, the widespread occurrence of severe pest problems on cassava, an introduced food crop, is related principally to the accidental introduction of arthropods and plant pathogens to areas where local germplasm is susceptible and where effective natural enemies are absent The exotic cassava mealybug in Africa can completely destroy its host plant and eliminate cassava production in extreme cases The exotic cassava green mite reduces yields 13 to 80% depending on soil fertility, pest load, time of planting time of harvest, and cultivar Other exotic pests include the larger grain borer which attacks harvested and processed cassava, the plant pathogen cassava bacterial blight which can devastate cassava in humid regions, and perhaps the whitefly vector of cassava mosaic virus

Cassava pest and disease problems are widespread in Northeast Brazil The extensive cultivation of cassava in the dry interior hinterlands of this region is a relatively recent development, related to the high rates of population growth in the area during this century The complex of pests and diseases includes the cassava green mite, cassava mealybug, cassava hornworm, lacebugs, whiteflies and root rot pathogens The causes underlying these problems relate to germplasm adaptation, the presence of exotic species under inadequate biological control in some cases, and the lack of an evolved tradition for managing pests and diseases Pest and disease impact is projected to increase as production intensifies However, farmer demand for crop production and protection technology already exists, providing favorable conditions for adoption of improved technology Presently, pesticide use on cassava is negligible in the region, however, a climate favorable to increased use is developing now that subsidies for wheat and other crops which compete with cassava have been removed and new markets for cassava have been opened Farmers who formerly could not afford to use pesticides may be increasingly able to do so

IITA and CIAT have worked together over the last decade to develop ecologically sustainable and agronomically acceptable cassava plant protection technologies for Africa and South America This liaison between international institutions created a bridge between national programs isolated within continents, but with similar cassava production problems and experiences This bridge provides access to natural enemies resistant germplasm, and expertise that is essential for national programs when developing and implementing appropriate cassava plant protection technologies Both institutes advocate a pest management philosophy which minimizes the need for artificial control tactics in favor of ecologically oriented control methods The first step with any suspected pest is to determine whether the damage caused is economically significant and to characterize why the problem occurs Ecological adjustments appropriate for specific environmental and socioeconomic conditions are then sought The ultimate objective has been to design crop management systems that prevent pest build up and, whenever necessary, respond to curative measures based on sound ecological principles and economic realities The technologies being developed, tested, and implemented are environmentally compatible and ecologically effective, given the sustainable production limits of the target ecosystem

Traditional systems of cassava-based cultivation are an ideal starting point for the development of plant protection practices which can contribute to sustainability in agroecosystems under pressure for intensification of production Appropriate combinations of biological control, resistant germplasm, and cultural practices are the basis of ecologically sound plant protection Remedial control tactics, such as the use of pesticides, are only recommended if and when the ecological approach fails to provide an adequate solution Pesticide use is negligible on cassava, and the incorporation of pesticides in crop protection technology for these systems is not anticipated where contributing to sustainability is a principal objective

This ecologically sound approach to plant protection is different from the concept of Integrated Pest Management (IPM) which calls for an ecologically rational suite of crop protection practices to limit the amount of pesticides applied in the ecosystem Ecological crop protection aims to prevent the need, and consequently, the use of pesticides, while IPM integrates biological and cultural control practices with the judicious use of pesticides IPM may be appropriate where pesticides are a part of the production system, but in the case of cassava production, pesticides should continue to be avoided This approach conserves the efficacy of natural enemies by avoiding the lethal contact and residual toxicity of most pesticides and preserves the environmental integrity of water resources and the food chain within the targeted agroecosystem

The catalyst that brought IITA and CIAT together was the introduction of the cassava mealybug from South America into Africa This exotic pest spread rapidly throughout the continent leaving widespread devastation in its wake IITA initiated a classical biological control campaign in the early 1980s as the mealybug problem engulfed the remainder of the cassava belt CIAT was engaged to do foreign exploration for natural enemies in South America while IITA implemented the release and follow up campaign in Africa A key to the success of this project was the active participation of national programs from both continents The cassava mealybug is now substantially controlled in most ecologies of Africa as a direct consequence of this project This concerted effort of international and national collaborators resulted in one of the most spectacular biological control campaigns ever undertaken in the history of the discipline A recent economic analysis shows that the benefit cost ratio of this control campaign was conservatively estimated at 149 1

The cassava mealybug project began a decade of collaboration between IITA, CIAT, and numerous national and international institutes that extended well beyond the original pest This project became a paradigm for developing environmentally sound and economically feasible plant protection for basic food crops in developing countries The momentum gained in research, training, and implementation was soon capitalized upon as other pests of cassava were targeted for control in both continents These activities gave rise to an overall management strategy for food crop production based on sustainable plant protection Dedicated to these principals an entire program at IITA was formed in 1988 (formally the Biological Control Program, now the Biological and Integrated Plant Protection Program)

IITA and CIAT along with several national programs, initiated a biological control campaign against another exotic pest of cassava in Africa - the cassava green mite It spread throughout the cassava belt of Africa in about 10 years and is now the most important pest on cassava in many regions of the continent In South America, where the cassava green mite is indigenous, locally selected cultivars and well adapted natural enemies keep the pest in check in some areas Natural enemies of the mite family Phytoseiidae were identified as the most promising predators of cassava green mites, consequently an extensive foreign exploration effort was launched by IITA in collaboration with CIAT and Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) Studies by CIAT and EMBRAPA show that phytoseiid natural enemies can prevent yield losses of about 30% Among the more than 50 phytoseiid species found associated with the mite in the Neotropics, a dozen promising species have been shipped to Africa for experimental releases Classical biological control of the cassava green mite is under implementation in Africa, and establishment of potentially effective phytoseiids has recently been documented

The cassava green mite has been the object of a pest management effort by EMBRAPA in Northeast Brazil since the 1970s Losses have been estimated at 10-50% depending on agroecological zone, variety, planting date, planting system, and length of the crop cycle During foreign exploration in Northeast Brazil for natural enemies of cassava green mite, CIAT and EMBRAPA observed that the most severe attacks occur in semiarid areas Phytoseiid natural enemies were absent in 30% of fields sampled across a range of humid to semiarid zones and in 32% of the fields in semiarid zones Only three species were consistently associated with cassava Fifty-six percent of fields had only one species and 28% were devoid of phytoseiids This result is in striking contrast to the situation in northern South America (Colombia, Venezuela, Ecuador) where 18 species of phytoseiids were common, up to twelve species were found per field, and 29% of fields had three or more species This suggests a potential for increasing the effectiveness of local natural enemies through augmentation and conservation practices, and for improving the level of biological control by introduction of exotic species Several of the species which have not been detected in Brazil, and different strains of species which do occur in Brazil, have been found in homologous seasonally dry and semiarid cassava-growing areas elsewhere in South America A pathogenic fungus with a high degree of host specificity has been found attacking the mite in seasonally dry areas of Colombia, Venezuela, and Northeast Brazil Feasibility studies indicate the fungus has potential as a biological control agent for both Africa and parts of Northeast Brazil in areas receiving between 800 and 1200 mm rainfall a year

Other pests of cassava have been studied by IITA and CIAT to determine the possibilities of ecologically sound pest control In Africa, IITA has examined the variegated grasshopper, a conspicuous pest found in the humid and subhumid ecologies, which can defoliate and kill cassava, the whitefly vector of the cassava mosaic virus, a disease estimated to cause up to 50% reduction in yield, and the larger grain borer, an exotic pest which can cause post-harvest losses of up to 100% In South America, CIAT has studied the cassava hornworm, a pest which causes 15 to 65% reductions in yield depending on soil fertility and number of attacks a complex of whitefly species which reduce photosynthetic activity through honeydew production and the growth of sooty molds, and as vectors of a number of detrimental plant viruses, the cassava mealybug *Phenacoccus herreni*, an exotic pest in Northeast Brazil which can cause losses as high as 80% and root rots which are the major production constraint causing an average of 40% yield loss in at least 300,000 ha of cassava in Northeast Brazil

Classical biological control is being pursued to constrain exotic pest species Promising natural enemies include predators for the cassava green mites and the larger grain borer, a parasitoid for the cassava mealybug *Phenacoccus herreni*, and a fungal pathogen for the cassava green mite Conservation and augmentation of existing natural enemies is also being used to enhance the impact of pathogens on the cassava hornworm, the variegated grasshopper, and some species of whiteflies, and predators on the cassava green mite in Northeast Brazil

Host plant resistance to cassava pests has been studied by IITA and CIAT for many years Both institutes historically concentrated their cassava plant protection efforts on resistance breeding They found that host plant resistance can contribute significantly to alleviating the negative impact of several important cassava pests on both continents In Africa, significant resistance was found to the cassava mosaic virus vectored by whiteflies Efforts to develop host plant resistance to cassava green mite, whiteflies, and other pests continue In South America host plant resistance offers potential in the control of root rots, cassava green mite, and whiteflies Resistance screening targeting these pests has led to identification of clones which have entered hybridization programs

The role of cultural practices in mediating cassava pest problems has received attention recently by IITA and CIAT Previous research indicated that good cassava production started with planting material free of avoidable plant pathogen and pest contaminants Weeds, mulching, time of planting, spacing, intercrops, and time of harvest have all been shown to influence the impact of a variety of cassava pests Recent simulation studies show that yield losses are often most severe on cassava of intermediate vigor In general, cultural practices that enhance plant growth also increase pest numbers (e g cassava green mites, whiteflies, and hornworms), but not necessarily plant damage The importance of cultural practices in management of root rots has already been mentioned Conservation of phytoseiid predators of cassava green mite through maintenance of weed refuges, the creation of seed plantings where high densities of phytoseiids can develop under field conditions for dissemination to the main area planting, and other available habitat management methods will be evaluated with farmers in the technology testing and adaptation phase of the project

In both West Africa and Brazil, cassava sustainability can only be achieved by considering the management of the system as a whole The socioeconomic and political environment in cassava-growing areas influences crop production characteristics in complex ways, and hence, affects the possibilities for implementation of sustainable crop production and protection practices The links between factors such as farm size, land availability and tenure, migration patterns gender issues market characteristics government agricultural policies, and crop production are under investigation in several studies currently underway in Africa and South America In Africa, IITA has several studies of this type in progress including the COSCA Survey, an extensive survey sponsored by the Rockefeller Foundation, which aims to characterize the structure of cassava-based cropping systems in order to improve the relevance and impact of agricultural research on cassava in Africa, and several smaller-scale, but more intensive studies in selected sites in Benin, Nigeria, and Cameroon In Northeast Brazil, the Kellogg-sponsored CIAT project for production, processing, and commercialization of cassava is generating information on agronomic and socioeconomic constraints to cassava production In addition, CIAT's existing databases on climate, soils, vegetation, and socioeconomic factors covering both Africa and South America are continually updated as new information is generated and represent an important analytic tool The Land Use Program, which will soon form part of CIAT's new Natural Resources Division will contribute to the design of rural surveys as a basis for analyzing the relationships between the socioeconomic environment and crop production and protection constraints and opportunities These surveys can also provide a basis for planning the development of improved technology and for assessing its impact

CIAT, in collaboration with EMBRAPA, has developed effective techniques for evaluating technology with farmers and has pioneered a highly successful demand-driven integrated approach to crop commodity research and development In the application of this approach to cassava, the identification and characterization of market opportunities provides the basis for the design and development of cassava production and processing technologies These technologies are subsequently tested and adapted with farmer participation under market conditions through research and development projects in representative production regions Monitoring and evaluation help to fine-tune the technologies for subsequent diffusion over a wider area and provide feedback for new research needs

Strengthening the capacity of national research and development systems through training, collaborative research, timely logistic support, and networks to exchange information is a high priority for IITA and CIAT The global characteristic of this project provides national programs, having similar cassava production problems, access to ecological (e g , natural enemies, germplasm) and information resources (research, implementation and training experiences) otherwise unavailable because of political and continental boundaries In Africa, IITA in collaboration with FAO, has developed a comprehensive training program for national programs featuring the practical aspects of sustainable plant protection and pest management This program includes group training on the principles of sustainable plant protection at the Biological Control Center for Africa in Cotonou Benin, periodic in-country training on specialized topics, and study visits at IITA for selected national program staff IITA promotes and supports MSc and Ph D level training in plant protection for potential research leaders within national programs The Ph D candidates are required to return to Africa to do dissertation research according to the research needs in their countries In a recent development, IITA is collaborating with Winrock International's African Women Leaders in Agriculture and the Environment (AWLAE) Program to increase the number of trained women plant protectionist in national programs Women have primary responsibility for food production and a major influence on the natural resources associated with agriculture in Africa Presently they occupy only 7% of government extension services, and hold fewer than 4% of the professional agricultural positions, even though they produce as much as 70% of the domestically consumed food The African Women Leaders in Agriculture and the Environment (AWLAE) Program is Winrock International's human resource development initiative in sub-Saharan Africa Its goal is to prepare and enable women scientists and researchers to help lead their countries to ecologically sustainable food security To date, a total of 447 national program staff have been trained in the practical aspects of plant protection, while 25 and 18 post-graduates (men and women) have been trained to the MSc and Ph D level, respectively

Sixty-two Brazilians have been trained in intensive multidisciplinary cassava and plant protection courses held at CIAT, however, cassava-related training activities at CIAT have been progressively changing their focus and content Intensive multidisciplinary and plant protection courses targeted at young research workers and extension leaders with little or no previous experience are being supplanted by periods of in-service training Forty-seven professionals have received this type of intensive training to date Extension/development personnel and on-farm researchers with several years of experience with cassava require greater skills in problem and opportunity identification so as to respond to the changing needs of their client farmers This target group is served by participation in integrated modular courses on cassava production, processing and marketing, followed by a period of disciplinary specialization In addition to technical aspects of cassava research, the subjects of project management, farmer, and institutional organization, and methods of evaluating technology with farmers are also included Eighteen multidisciplinary courses of this type have been held to date in Brazil serving 262 Brazilian professionals Fourteen of these specialized courses have been held since 1986

Collaborative research of many kinds has been underway with national programs since the beginning of the mealybug project This contact has bolstered the capacity of national programs in the area of sustainable plant protection by providing much needed training, research experience, and timely logistic support for activities which achieve appropriate objectives It also helped link national programs with researchers in other national and international programs doing similar work, and provided a channel for information dissemination and exchange

The research of IITA and CIAT has been reviewed by independent experts periodically since the start of collaborative activities in the early 1980s A review commission by the consortium of donors supporting the project in 1987 praised the progress, direction, and scope of the work in sustainable plant protection and strongly recommended continued support by the international donor community IITA s leadership capacity in this field is evident in the 1990 review by the external program review of the Technical Advisory Committee of the CGIAR which commended the Biological Control Program as being a dynamic, productive, coherent, and strong research program" In the same year, IITA and CIAT shared the prestigious King Baudouin Award for 'outstanding achievements in the classical biological control of the cassava mealybug in Africa and for contributing to agriculture and human welfare in developing countries Recently, the director of IITA s Biological Control Program received the Rank Prize for his leadership in directing a program which has significantly contributed toward alleviating hunger in Africa

In summary, cassava cultivation in Africa and Northeast Brazil is practiced under a set of similar ecological, agronomic, and socioeconomic conditions and constraints Demand for cassava in both regions is increasing, and the resulting intensification of production will result in environmental degradation unless steps are taken to raise productivity in an environmentally sound manner The need for appropriate crop protection technology is especially urgent in West Africa and Northeast Brazil where agricultural sustainability is declining Pests represent a significant production constraint in both areas, and appropriate crop protection practices can contribute to both raising and sustaining productivity Through bilateral collaboration and networking with other international and national institutions, CIAT and IITA have developed the knowledge base, technology components training expertise and adoption methodology necessary to address sustainability problems through an integrated approach to crop protection The record of effective collaboration in crop protection held by IITA and CIAT afford these institutes a unique comparative advantage in future efforts directed towards maintaining the sustainability of fragile tropical agricultural zones in these areas

THE PROJECT

The project will develop test, and adapt sustainable plant protection technology for the most important cassava pests found in selected ecologies in Northeast Brazil in South America and in four West African countries - Ghana, Benin, Nigeria, and Cameroon The project will be a joint effort by CIAT and IITA in collaboration with national plant protection staff, extension workers, and farmers from the targeted countries The capacity of national programs to conduct environmentally sound crop protection research which incorporates farmer's input in the technology development and adaptation process will be strengthened through their direct participation in all phases of the project In order to increase the probability of technology adoption, extension workers and farmers will be specially trained in the principles and practices of sustainable plant protection This project will provide the essential logistic support needed to test, adapt, and implement crop protection technologies, identify problems which require the generation of new technology, develop a nucleus of trained and experienced plant protection researchers and practitioners, and generate timely information resources required by the crop protection networks established within each target country Development of new interventions will also be pursued where warranted The paradigm for developing, testing, and implementing ecologically sustainable plant protection by national programs proposed in this project will serve as a model for plant protection and pest management technologies and strategies for other cropping systems

In a special effort to enhance the status and representation of African women in agriculture, IITA in collaboration with Winrock International, will select at least 3 African women from each participating country for MSc or equivalent post graduate training Winrock International's African Women Leaders in Agriculture and the Environment (AWLAE) program is a special project to enhance women s credentials skills, positions, and influence in four arenas of agriculture and the environment policy, management, research and extension, and to build and sustain an enabling environment to achieve these goals The program aims to prepare a critical mass of African women as professionals and leaders with credentials management training, and long-term professional support who will be guided in the application and relevance of their work to women farmers Candidates selected for post-graduate training in this project will become part of the AWLAE program

The project will be divided into three interrelated and partially concurrent phases covering a period of 4 years The first phase will refine the existing knowledge base on major pests of cassava through diagnostic surveys This information will be linked to databases generated by the Rockefeller-funded Collaborative Study of Cassava in Africa (COSCA) and the CIAT s Land Use and Resource Management Program to permit integrated analysis of the relationships between pest constraints and socioeconomic factors In the second phase, farmers will participate in the development and testing of a range of crop protection technologies, and formal training of farmers, extension workers, and researchers in the principles and practices of sustainable crop production and protection will be provided In the third phase, progress in achieving training and technology implementation goals will be evaluated Many of these activities will require strategic research, methodology development, and information resources support

The specific objectives of the diagnostic phase (Phase I) are

1 Assemble multidisciplinary national program teams in each participating country, and together with international collaborators, develop detailed workplans, procedures, and protocols for interdisciplinary diagnostic surveys

2 Identify and map the major pest constraints, farmers perceptions, and current practices through extensive surveys, and initiate intensive follow up studies in representative sites in important agroecological zones where cassava production is a key part of the rural economy

3 Estimate the level and type of research appropriate for the major pest constraints identified through the diagnostic process

4 Identify sites for farmer evaluation of available plant protection technologies based on survey results and other agronomic and socioeconomic criteria Innovative farmers will be sought to participate in testing and adaptation activities

The specific objectives of the training, testing, and adaptation phase (Phase II) are

1 Develop plant protection training materials, methods, and syllabi for each target group (national program staff extension workers farmers, post-graduates), and train researchers, post-graduates (in Africa), extension workers, and farmers in the principles and practices of ecologically sustainable crop protection

2 Test, adapt, and evaluate pest control technologies on-farm in collaboration with farmers, extension workers and national program staff

3 Estimate potential impact of tested pest control technologies over a range of ecological, agronomic, and socioeconomic conditions

The specific objectives of the evaluation phase (Phase III) are

1 Evaluate the effectiveness and impact of the training program at all levels

2 Evaluate adoption and impact of the technology components tested and adapted in farmer trials

Methods will be developed for decentralized mass rearing and field release of biological control agents Strategic research will be required for strain selection of cassava green mite fungal pathogens, root rot etiology, identification of alternate root pathogen hosts, habitat management for biological control, feasibility of phytoseiid introduction to Brazil, effect of microbial biological control agents on non-target organisms, screening technology components for undesirable environmental effects, and development of strategic and tactical systems models

Support activities for the project include mass production of natural enemies for use in researcher and farmer-controlled trials, and distribution to national programs, multiplication of planting material, shipments of natural enemies from South America to Africa via quarantine in the Netherlands, shipments of natural enemies from CIAT to Brazil via quarantine at EMBRAPA/CNPDA, Jaguariuna, Sao Paolo, Brazil

Information resources will be developed to facilitate processing, summarization, interpretation, and communication of the large amount of multidisciplinary data collected throughout all phases of the project Much of the diagnostic survey and on-farm research data will be handled by inventory databases and *a priori* statistical designs respectively A systems approach will be used to develop strategic and tactical models for use in identification of critical interactions, evaluation of the potential impact of tested technologies, and which will provide national program researchers and extensionists with tools for day-to-day decision making in crop protection Accurate taxonomic information is essential to pest management, thus, taxonomic redescriptions and keys for important species of cassava pests on both continents will be prepared Regular meetings will be held between collaborators to exchange results, other information and related experiences Information resources will become part of the permanent legacy of this project remaining with participating national and international institutes

This project will be carried out in West Africa by IITA in collaboration with national programs in Ghana, Benin, Nigeria and Cameroon, and in

South America by CIAT in collaboration with EMBRAPA in Northeast Brazil These four countries in Africa were identified as an ecologically congruous cassava production subregion, easily accessible by road and air from the project headquarters in Benin, and readily supported by the infrastructure proposed in the project The activities to be carried out in this subregion will be a model for other countries and subregions in Africa and South America where cassava is an important crop Natural enemy quarantine will be carried out by the University of Amsterdam, systems modeling will be done by the University of California at Berkeley and Texas A & M University, and post-graduate training will be managed by Winrock International s AWLAE program The project will have a common process, with common objectives and methods on both continents The parallel efforts in Africa and South America will benefit from shared information, expertise, and resources, and will lead to economies of scale

The benefits of the project will include

* Establishment of crop protection practices which preserve environmental quality and human health

* Improved cassava productivity and/or root quality, and increased incomes for small scale cassava farmers

* Increased capability of national programs to conduct research on plant protection with maintenance of agricultural sustainability as an explicit objective

* Formulation of a crop protection model appropriate for complex diverse, and risk-prone agriculture

* Enhance the role of women in agriculture in Africa, particularly in the area of plant protection

* Improved knowledge base for crop protection in tropical agriculture, and an improved standard of crop protection in agroecosystems where cassava is important

* Reversal or avoidance of degradation of the natural resource base for agriculture in areas where cassava production is intensifying

* Development of information resources which will facilitate the implementation of similar initiatives in the future

In Africa, UNDP funds will be used to provide the following to IITA one plant protectionist, one production specialist, local support staff, equipment and supplies, operation costs, travel, subcontracts for quarantine and systems modeling, and support for national program activities in Benin requiring about 40% of the UNDP allocation, for training one international liaison officer local support staff, equipment and supplies, operation costs, travel, group training, subcontract for post-graduate training and workshops requiring about 25% of the UNDP allocation To each of the four national programs one project coordinator, three seconded counterpart scientists, equipment and supplies, and in-country training requiring about 34% of the UNDP allocation

In South America, UNDP funds will be used to provide the following to CIAT International staff one entomologist, and one information manager Local professional and support staff, equipment, supplies, operational costs, travel, and indirect costs accounting for 47% of the UNDP allocation for South America To EMBRAPA one environmentalist, one acarologist one insect pathologist, one extension specialist, one training coordinator, support staff, equipment, supplies, operational costs, travel, in-country training costs, and indirect costs accounting for 53% of the UNDP allocation for South America Training expenses account for 17% of the UNDP allocation for Brazil

UNDP's direct costs will finance end-of-project evaluations and contingencies to be made available for special projects related to sustainable plant protection activities to facilitate inter-institutional and inter-country cooperation These will be considered strictly on merit and subjected to availability of funds

The proposed UNDP contribution is $9,786 000 of which $4,343,000 will be for subcontracts, while direct costs will account for the remaining $5 443,000

Additional resources may be needed to provide for the participation of specialists from FAO and other agencies in project advisory committee meetings, in house reviews and to render other types of assistance which may be required by IITA, CIAT and the national programs of Brazil, Ghana, Benin, Nigeria, and Cameroon Details of this collaboration would be worked out between the above mentioned institutes and the concerned agencies, and actual costs incurred would be reimbursed directly by UNDP

PROJECT FORMULATION

COUNTRIES	Brazil, Ghana, Benin, Nigeria, and Cameroon Training and research paradigms developed by this project are applicable to all countries where cassava is an important crop
DATE	January 1993
PROJECT NUMBER	UNDP/IITA/CIAT/GLO/91/013
PROJECT TITLE	Ecologically Sustainable Cassava Plant Protection In South America And Africa An Environmentally Sound Approach
ESTIMATED DURATION	Forty-eight months

ESTIMATED COUNTERPART COSTS ($000)		
	CIAT	1,872
	IITA	1,700
	Winrock International	250
	Benin	20
	Brazil	1,418
	Cameroon	20
	Ghana	20
	Nigeria	20

Development Problems Intended To Be Addressed By The Project

At sectorial level

	CAUSES	EVIDENCE
1 Reduced food security	Rapid population growth increasing production demands unreliable and insufficient food production	Increased food imports malnutrition and famine
2 Declining food production	Production constraints especially declining soil fertility and pests	Reduced yield and quality
3 Environmental degradation	Demand for increased production use of non sustainable practices especially pesticides in South America	Declining soil productivity demand for pesticides and other nonsustainable inputs

At micro level

4 Pest constraints presently reduce production potential by 50% on average	Inadequate and insufficiently tested ecologically sustainable crop protection interventions	Insufficient use of sustainable crop protection technology by farmers
5 Lack of research paradigm for developing appropriate plant protection strategies	Limited research effort and inadequate resources for national and international institutes to test adapt and implement sustainable cassava crop protection	Limited research and implementation effort made by concerned institutes and absence of appropriate crop pro tection experiences in national programs
6 Limited capacity in national programs	Limited training and research opportunities and inadequate logistic support	Absence of specialists in national programs trained in sustainable crop protection

Concerned Parties/Target Beneficiaries

Concerned parties include IITA, CIAT, Winrock International the University of Amsterdam the University of California at Berkeley, and the national programs concerned with plant protection in Brazil, Ghana, Benin, Nigeria, and Cameroon, and other national and international research institutions and programs concerned with developing environmentally sound cassava plant protection worldwide

Beneficiaries targeted include National, regional, and international organizations involved in research and implementation of sustainable plant protection for cassava and related crops grown by small-scale farmers, and especially African women plant protection researchers, extensionist, educators, and farmers

Small-scale farmers in the cassava belts of Africa and Northeast Brazil are the direct beneficiaries of sustained productivity, reduced pest problems, stable income, food security, and a safe, pesticide-free environment Indirect benefits will accrue to neighboring regions which are affected through ecological links to the target area

Pre-Project and End Project Status

The present or pre project situation Cassava cultivation in Africa and Northeast Brazil is practiced under a set of similar ecological agronomic, and socioeconomic conditions and constraints Demand for cassava in both regions is increasing, and the resulting intensification of production will lead to environmental degradation in areas where the production demand exceeds the capacity of the natural resource base, unless environmentally sound ways to raise productivity are practiced Pests represent a significant production constraint in both areas, and appropriate crop protection practices can contribute to both raising and sustaining productivity Crop protection technologies have been developed by a network of collaborating national and international institutions and are available for testing and adaptation under farm conditions National crop protection capability in these areas is limited and resources for training, testing, and adapting technologies are lacking

The situation expected at the end of the proposed project A model for crop protection with the explicit goal of maintaining agricultural sustainability in complex diverse and risk prone, small scale farming systems will be in place Enhanced national research capability in sustainable crop protection will be evident in the target countries and regions Farmer knowledge of sustainable crop protection principles and practices will be greater as a consequence of basic training provided Technology adoption will be facilitated by direct farmer participation in training and in technology development, testing and adaptation Cassava yields and/or quality should improve significantly on farms where technologies have been adopted Information resources developed during the project will facilitate the implementation of similar efforts in the future

Special Consideration

The current crop protection situation in West Africa and Northeast Brazil has been analyzed as a consequence of long-standing collaboration between national and international institutions in Africa and South America Of particular importance is the decade of continuous collaboration by IITA and CIAT to control exotic cassava pests in Africa Benefits of this collaboration applicable to current crop protection efforts include development of several sustainable pest control technologies, knowledge of critical interactions and production constraints in cassava agroecosystems, and practical field experience on both continents It also provides a link between national programs, ecologically similar subregions, and continent-restricted resources needed to develop and implement ecologically sound cassava plant protection Use of this accumulated knowledge to benefit small-scale farmers will require an intensive implementation process, involving the integration of researchers, extension worker, and farmers

The success of the activities in both continents will depend on sharing complementary expertise and information held by the collaborators and on extensive links to other disciplines of direct importance to development and implementation of crop protection (e g breeding, agroecological studies, biotechnology, agronomy socioeconomics, training, and communications) The unified approach to developing, testing, and implementing the plant protection technologies which has been developed by IITA and CIAT is unique and will contribute to efficient use of resources for achievement of the objectives of this project

Other Participating Agencies

IITA and CIAT are the only CGIAR institutes directly involved in developing, testing, and implementing sustainable cassava plant protection with national programs in Africa and Northeast Brazil Many donor countries contribute to related research, training, and implementation activities through bilateral aid programs IITA and CIAT collaborate closely with these agencies and institutes

Development Objective and its Relation to Country Programs

Ensuring food security and sustained productivity are primary objectives of developing countries where cassava is grown The development of ecologically sustainable plant protection for these cassava ecosystems contributes both to country objectives and to the sustainability of agriculture in areas which are at risk of environmental degradation

Most national programs have insufficient resources and few trained personnel with enough research experience to develop, test, and implement plant protection strategies which contribute to sustainability

Equally important, national programs, isolated by political and geographical boundaries do not have access to ecological and information resources present in other countries and other parts of the world These deficits will be addressed in this project through the extensive collaborative research and training activities with participating national programs

The project will be a model for developing and implementing ecologically sound plant protection technologies that can be used for other crops and other pests

Project Formulation Framework
AFRICA

IN COUNTRY DIAGNOSIS

Immediate Objective 1

Determine major pest constraints in each cassava ecology

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
1 1 Identification of the major cassava pests in all distinct ecologies of each targeted country	1 1 1 Extensive surveys to determine the important cassava ecologies suspected major pest species and concerns and perceptions of farmers	IITA and national programs
	1 1 2 Intensive field studies to monitor pest population dynamics and measure their yield impact and to validate previously collected socioeconomic data	IITA and national programs

Immediate Objective 2

Select sites for subsequent on-farm trials to test pest control technologies

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
2 1 On farm sites for testing pest control technologies to be selected in each participating country	2 1 1 Using data collected during the diagnostic phase and input from the COSCA Survey sites representative of key ecological agronomic and socioeconomic features will be selected for on farm trials	IITA and national programs

Immediate Objective 3

Determine additional development and adaptive research needs

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
3 1 Strategic research on pests that are poorly known but are significant constraints	3 1 1 Laboratory and on station studies to determine the impact and develop interventions for selected pests	IITA and national programs

ON FARM TESTING AND ADAPTIVE RESEARCH

Immediate Objective 4

Create on farm trials of selected pest control technologies

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
4 1 On farm tests of developed pest control technologies	4 1 1 Prepare intervention technologies to be tested including clean planting material from multiplication plots prepared locally and shipment of promising natural enemies from the Neotropics to Africa via quarantine Mass production of natural enemies of selected pests Cultural control information resources needed by extension workers and farmers also to be made available	IITA CIAT EMBRAPA University of Amsterdam and national programs
	4 1 2 Identify appropriate combinations of intervention technologies (treatments) to be tested in each site based on diagnosis Make technologies available to national programs and participating farmers	IITA national programs and farmers
	4 1 3 Implement field trials with farmers and monitor prescribed ecological agronomic and socioeconomic parameters throughout the growing season	Farmers national programs and IITA

Immediate Objective 5

Adapt and test multitrophic and multidisciplinary models

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
5 1 Multitrophic and multidisciplinary systems analysis for characterizing important interaction and measuring impact at different levels	5 1 1 Adapt multitrophic ecosystems models using existing model with data from Africa and South America Compare cassava ecosystems in the two continents via simulation Develop multidisciplinary subroutines and determine critical interactions between ecological agronomic and socioeconomic factors	IITA University of California Berkeley CIAT and national programs

Immediate Objective 6

Test newly developed and recently adapted pest control technologies

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
6 1 Evaluation of recently developed/adapted pest control technologies	6 1 1 Establish on station trials to measure the potential impact of recently developed/adapted pest control technologies	IITA and national programs

TRAINING, IMPLEMENTATION, AND INFORMATION EXCHANGE

Immediate Objective 7

Assemble and train national program counterpart teams

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
7 1 National program counterpart teams Appropriate workplans procedures and protocols for activities planned in each participating country	7 1 1 Select and train national program counterparts in the discipline specific procedures and practices required for the diagnostic and on farm trial phases of the project	IITA and national programs
	7 1 2 Prepare a general workplan define protocols and outline procedures to be used by all participants in the project Prepare a specific detailed workplan for each country	IITA CIAT and national programs

Immediate Objective 8

Develop plant protection training syllabi

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
8 1 Sustainable plant protection training module for national programs	8 1 1 Develop syllabi for training national program researchers extension workers and progressive farmers in the principles of ecologically sound protection	IITA CIAT national programs extension workers and farmers
	8 1 2 Prepare materials (handouts pamphlets field guides etc) concerning sustainable plant protection to be used as training aids	IITA CIAT national programs extension workers and farmers

Immediate Objective 9

Select and train national program support staff, extension workers, farmers, and post graduates

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
9 1 Strengthened national capacity in the area of ecologically sound plant protection	9 1 1 Select national program candidates for post graduate training in a range of disciplines related to sustainable plant protection Each country to receive at least 3 MSc fellowships for women	Winrock International IITA and national programs
	9 1 2 Select and train national program research staff that contribute to the project in each country Training will be done annually during the first two years of the project A total of 10 national program staff per country will be trained	IITA and national program coordinators
	9 1 3 Train extension workers and farmers in each country Training will be done annually following the first year A total of 50 extension workers and 350 farmers per country to be trained	National programs extension workers and IITA

Immediate Objective 10

Evaluation and follow up training for selected national program staff, extension workers, and farmers

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
10 1 Measured impact of the training program at all levels within each country and retraining of selected national program staff extension workers and farmers as needed	10 1 1 Retraining selected national staff extension workers and farmers in year three A total of 15 extension workers and 50 farmers to be retrained per country Evaluate the training at all levels within each country in year four	IITA and national programs

Immediate Objective 11

Measure impact, acceptability, and availability of tested intervention technologies

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
11 1 Measured impact acceptability and availability of the tested intervention technologies by ecology in each participating country	11 1 1 Evaluate the impact of the tested technologies by measuring yield performance in the on farm test sites determine the acceptability availability and spread at the village level	IITA and national programs

Immediate Objective 12

Provide workshops to exchange information related to sustainable plant protection activities

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
12 1 Information exchange among all collaborators of the project	12 1 1 A scientific workshop to be held the first and third years of the project to exchange results other information and experiences that relate to sustainable plant protection activities in Africa and South America	IITA CIAT University of California Berkeley University of Amsterdam and national programs

SOUTH AMERICA

Immediate Objective 1

Refine and map information on incidence, severity, and distribution of pest and disease problems, and key ecological and socioeconomic factors affecting cassava production in Ceara, Pernambuco, and Bahia

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
1 1 Site selection and baseline data for project impact assessment	1 1 1 Carry out diagnostic surveys employing Rapid Rural Assessment techniques for socioeconomic data with additional field surveys for detection of pests and diseases in cassava Also generate basic information on pest and disease constraints in principal crops rotated with or intercropped with cassava	EMBRAPA and CIAT
	1 1 2 Integrate survey information with socioeconomic and ecological data already available from other sources (Kellogg Project CIAT agroecological databases and EMBRAPA agroecological zoning project)	CIAT and EMBRAPA
	1 1 3 Identify candidate sites for on farm trails based on survey results and validate information through intensive surveys	EMBRAPA and CIAT
	1 1 4 Identify farmers who will participate in technology testing and adaptation	EMBRAPA
	1 1 5 Identify sites for researcher controlled studies	EMBRAPA and CIAT
	1 1 6 Set up a research and extension network to link cassava crop protection workers with personnel working in related crops	

Immediate Objective 2

Test and adapt available crop protection technology components and crop production practices which directly affect crop protection, develop new components where necessary

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
2 1 Crop protection technology components appro priate for and attractive to small scale farmers in target regions	2 1 1 Test components in researcher controlled trials in principal cassava growing areas in major agroecological zones within the target area	EMBRAPA and CIAT
	2 1 2 Test components in demonstration plots	EMBRAPA and CIAT
	2 1 3 Test and adapt components in farmer controlled trials	EMBRAPA and CIAT
	2 1 4 Use results to screen and refine components retest refinements of most promising components	EMBRAPA and CIAT
	2 1 5 Conduct strategic research and develop methodology in support of the technology development and implementation process	CIAT EMBRAPA and IITA
	2 1 6 Develop information resources and strategic and tactical systems models in support of the technology development and implementation process	CIAT EMBRAPA and IITA
	2 1 7 Share information resources and experiences with members of networks linking crop protectionists working on related crops and with the other institutions involved in this project	CIAT EMBRAPA and IITA

Immediate Objective 3

Analyze potential contribution to agricultural sustainability of improved crop protection technology

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
3 1 Technology which has been screened for possible negative environmental consequences	3 1 1 Identify technology components which have low long run potential to contribute to maintaining agricultural sustainability within the target region Identify components which may be appropriate in limited areas under certain ecological conditions Identify where these can be deployed The focus will be on the interaction between crop protection technology components and water and fertility management Use simulation models and other ecological impact assessment techniques	EMBRAPA and CIAT
	3 1 2 Assess impact of biological control agents on non target organisms	

Immediate Objective 4

Improve national program capacity in development and implementation of ecologically sustainable crop protection technology

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
4 1 Improved capability in crop protection for cassava and related crops and consequent increases in cassava productivity and/or root quality	4 1 1 Formal training of national program researchers in principles and practice of ecologically sustainable crop protection	CIAT and EMBRAPA
	4 1 2 Formal training of extension workers in principles and practice of ecologically sustainable crop protection	EMBRAPA
	4 1 3 In service training through collaboration in all project phases between counterpart national and international program teams	CIAT and EMBRAPA

Immediate Objective 5

Improve probability of adoption of cassava crop protection technology in Northeast Brazil

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
5 1 Adoption of improved technology by participating farmers	5 1 1 Direct training of farmers in crop protection practices	EMBRAPA and CIAT
	5 1 2 Direct involvement of farmers in technology testing and adaptation	EMBRAPA and CIAT

Immediate Objective 6

Assess project progress and exchange information between collaborators

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
6 1 Improved efficiency of resource use particularly of information	6 1 1 Sponsor collaborator workshops	CIAT IITA and National programs
6 2 Improved overall project performance	6 1 2 Prepare a global information management strategy	CIAT

Immediate Objective 7

Measure impact of training at all levels, and evaluate adoption of improved technology by farmers

OUTPUT	ACTIVITIES	PARTY RESPONSIBLE
7 1 Training impact estimates	7 1 1 Evaluate effectiveness and appropriateness of training at all levels Use feedback to improve training materials and methods	EMBRAPA and CIAT
7 2 Technology impact estimates	7 2 1 Adoption studies in and at various radii from project sites	EMBRAPA and CIAT

ECOLOGICALLY SUSTAINABLE CASSAVA PLANT PROTECTION IN SOUTH AMERICA AND AFRICA
AN ENVIRONMENTALLY SOUND APPROACH

CONTEXT

DESCRIPTION

The livelihood of one quarter of the world's population depends on the sustained productivity of land in unfavorable or difficult areas which are mainly tropical, rainfed, and have fragile or problem soils In the absence of external pressures for intensification of production, the demands placed on the land to feed farm families and livestock in these areas are modest and compatible with the concept of sustainable agriculture In this sense, sustainability is defined as the practice of balancing production demands with the capacity of the ecosystem such that the net effect on the environment and the quality of life for the farmer is positive However, in many areas of the tropics where the agriculture is complex, diverse, and risk-prone intensification of production resulting from population growth and other external pressures is rapidly transforming the production system into a less sustainable state

Cassava is often a key component of the traditional cropping system in Africa and South America Today, cassava is a crop which contributes significantly to meeting the caloric demand of the rapidly growing urban and rural populations Easy to grow, even under harsh agronomic conditions, cassava is a primary source of carbohydrates, animal feed, and food security for more than 300 million of the poorest people in Africa and South America Cassava also provides raw material for rural agroindustries, an important source of rural income

Historically, locally available and ecologically sustainable agronomic inputs were part of crop production and protection traditions evolved by farmers However, rapidly increasing demand for cassava production in Africa and South America is transforming these delicately balanced and often fragile agroecosystems In Africa farmers have reduced fallow periods and now cultivate increasingly marginal areas In some areas of South America, increases in production associated with increased commercialization of cassava (e g , dried cassava for animal feed, processed cassava products starch and alcohol production) have created an economic context favorable for the use of pesticides and other nonsustainable inputs The development and implementation of ecologically sustainable inputs is especially urgent in these situations

Ecological crop protection aims to prevent the need, and consequently, the use of pesticides, while Integrated Pest Management (IPM) integrates biological and cultural control practices with the judicious use of pesticides IPM may be appropriate where pesticides are a part of the production system, but in the case of cassava production, pesticides should continue to be avoided This approach conserves the efficacy of natural enemies by avoiding the lethal contact and residual toxicity of most pesticides, and preserves the environmental integrity of water resources and the food chain within the targeted agroecosystem

Traditional systems of cassava cultivation are the ideal starting point for the development of ecologically sound plant protection practices Appropriate crop protection practices can contribute to both raising and sustaining productivity Since the underlying causes of pest problems in Africa and South America are similar, many of the plant protection activities and experiences can be mutually beneficial Cassava crop protection technologies have been developed by a network of collaborating national and international institutions and are available for testing and adaptation under farm conditions A broad knowledge base of other related production constraints, as they affect pests, is now being generated through this collaborative process However, ensuring that farmers are the beneficiaries of this expertise requires an intensive implementation process, involving the integration of researchers, extension workers, and farmers to assure impact An objective of this process will be to develop a cadre of skilled agro-ecosystems managers including farmers, extension workers, and national program researchers who collaborate in the development and implementation of appropriate intervention technologies National crop protection capability in these areas is limited, and resources for training, testing, and adapting technology is lacking

Cassava cultivation in Africa and South America is practiced under a set of similar ecological, agronomic, and socioeconomic conditions and constraints Demand for cassava in both regions is increasing, and the resulting intensification of production will lead to environmental degradation in areas where the production demand exceeds the capacity of the natural resource base, unless environmentally sound ways to raise productivity are practiced The need for improved crop protection technology is particularly urgent in West Africa and Northeast Brazil Pests, including arthropods, weeds, and pathogens, represent significant constraint to production in both areas causing estimated losses of 50% and reducing dry matter content resulting in lowered or unacceptable root quality for processing and fresh consumption

CURRENT RESEARCH PROGRAMS

The Biological and Integrated Plant Protection Program of IITA has evolved from a project targeting two pests of cassava to a full program dedicated to sustainable plant protection of primary food crops in Africa The program s research philosophy is to identify the ecological imbalances in the system causing pest problems and to provide environmentally and economically appropriate solutions Consequently, the approach is interdisciplinary and often multi-institutional "Pests' are carefully evaluated for their real pest status before extensive research commitments and control campaigns are initiated Program activities include basic research, intervention technology development, training, implementation, technical support to national programs, and post-implementation follow up Presently, besides the work on cassava pests, investigations are in progress on stem borers and the larger grain borer on maize, pre- and post-flowering pests of cowpeas, mango mealybugs, and weevils on banana and plantains

CIAT's mission is to contribute to the alleviation of hunger and poverty in tropical developing countries by generating technology options which benefit the poor and contribute to lasting increases in agricultural output while preserving the natural resource base In order to fulfill this mission, CIAT pursues various avenues of research which bear relation to sustainable crop production and protection technology The Cassava Program collaborates closely with EMBRAPA, the Brazilian national agricultural research program, in the development of crop protection technology for many pests and diseases of importance in Northeast Brazil, and it has worked closely with IITA in the deployment of classical biological control of the cassava mealybug and the cassava green mite in Africa The program is applying and refining techniques for evaluating technology with farmers, originally developed by CIAT s Participatory Research Unit, for the development and dissemination of improved cassava germplasm and cultural practices Additionally, it has pioneered a highly successful demand-driven integrated approach to crop commodity research and development In the application of this approach to cassava, the identification and characterization of market opportunities provides the basis for the design and development of cassava production and processing technologies These technologies are subsequently tested and adapted with farmer participation under market conditions through research and development projects in representative production regions Monitoring and evaluation help to fine-tune the technologies for subsequent diffusion over a wide area and provide feedback for new research needs Cassava production sustainability research focuses on the relationships between fertility and water management, erosion control, and cultural practices It has received high priority in CIAT since the 1970s The Agroecological Studies Unit, which defines and maps cassava microregions in Latin America, integrating edaphoclimatic and socioeconomic data, and the cassava demand studies conducted by the program in Latin America in the early 1980s, were the forerunners of and provided the impetus for the IITA COSCA Survey currently underway in Africa

CURRENT OUTREACH AND TRAINING PROGRAMS

Because of the cooperation needed to successfully develop, test, and implement sustainable plant protection, IITA has established a comprehensive outreach and training program to strengthen national programs throughout the cassava belt of Africa The liaison between international institutions creates a bridge between national programs isolated within continents but with similar cassava production problems and experiences, and provides access to natural enemies, resistant germplasm, and expertise that is essential for national programs developing and implementing appropriate cassava plant protection technologies The first priority has been to broaden the knowledge of national programs in the theory and practice of sustainable plant protection through short-term group training, specialized in-country training, and post graduate training To date, a total of 447 national program staff have been trained in collaboration with FAO in the practical aspects of plant protection, and IITA post-graduate fellows have completed 25 MSc and 18 Ph D (men and women) in related subjects over the past 6 years Many of these training activities were supported by UNDP The second priority has been to provide the logistic means needed to support specific plant protection activities in targeted countries This includes modest, but timely, financial support from IITA to national programs and help in arranging bilateral funding Finally, IITA has initiated the establishment of national biological control committees to draw attention to sustainable methods of plant protection and to facilitate similar activities in the future

In a special effort to enhance the role of women in plant protection in Africa, IITA has joined with Winrock International s African Women Leaders in Agriculture and the Environment (AWLAE) program Women have primary responsibility for food production and a major influence on the natural resources associated with agriculture in Africa Presently, they occupy only 7% of government extension services and hold fewer than 4% of the professional agricultural positions, even though they produce as much as 70% of the domestically consumed food The AWLAE program aims to improve women s credentials skills, positions, and influence in four arenas of agriculture and the environment policy, management, research, and extension, and to build and sustain an enabling environment to achieve these goals The program aims to prepare a critical mass of African women as professionals and leaders with credentials, management training, and long-term professional support who will be guided in the application and relevance of their work to women farmers The program emphasizes building an enabling environment for these women to gain access to leadership positions and institutionalizing the program through networks, monitoring activities, and professional support mechanisms for successive generations Candidates selected for post-graduate training in this project will join the AWLAE program

Cassava-related training activities at CIAT have been progressively changing their focus and content Intensive multidisciplinary and plant protection courses targeted at young research workers and extension leaders with little or no previous experience are being supplanted by periods of in-service training Forty-seven Brazilian professionals have received this type of intensive training to date Extension/development personnel and on-farm researchers with several years of experience with cassava require greater skills in problem and opportunity identification so as to respond to the changing needs of their client farmers This target group is served by participation in integrated modular courses on cassava production, processing, and marketing, followed by a period of disciplinary specialization In additional to technical aspects of cassava research, project management, farmer and institutional organization, and methods of evaluating technology with farmers are also included Eighteen courses of this type have been held to date in Brazil serving 262 Brazilian professionals UNDP contributed significantly to the funding of these training activities

PROJECT JUSTIFICATION

PRESENT SITUATION AND PROBLEMS TO BE ADDRESSED

Cassava farmers in Africa grow about 40% of the worlds total production The production of cassava in Africa continues to climb, but the rate of increase has dropped sharply compared to population growth rates Most cassava production in Africa is for human consumption About 70% of the continent's cassava production and half of its sub Saharan population are found in West and Central Africa The countries participating in this project, Ghana, Benin, Nigeria, and Cameroon, represent about a third of the total sub-Saharan population of 400 million and about a third of the total cassava production of 50 million tons per annum These four countries account for the most significant cassava growing area in West Africa, plus the transition area between west and central cassava growing regions of the continent

They form an ecologically congruous subregion where cassava is a food staple and the most important source of carbohydrates (more than two and half times the calories provided by the second and third-ranking crops, maize and yams, in the region) for about half the total population (ca 65 million people) It is a subregion where the population and demand for cassava in the humid and subhumid ecologies are rapidly increasing, especially in urban centers Cassava in this region is grown by small-scale farmers on an average plot of less than half a hectare and production averages 6 8 t/ha

Fallow periods, which traditionally restored the land to its original productivity, have declined sharply in recent years as increasing production demands move these agroecosystems away from a once sustainable equilibrium Nigeria, Africa s most populated country, is by far the largest producer of cassava in the region at 12 million tons per annum, about a quarter of the total production for Africa The other countries, representing three of the five next most important cassava producers in West Africa, include Ghana Benin, and Cameroon at 2, 0 7, and 0 60 million tons, respectively In terms of calories consumed per capita per day, Benin tops the list here with 470, followed by Ghana at 416, then Nigeria and Cameroon at 250 each Besides representing an ecologically congruous cassava production subregion, these four countries are easily accessible by road and air from the project headquarters in Benin and readily supported by the infrastructure proposed in the project The activities to be carried out in this subregion will be a model for other countries and subregions in Africa and South America where cassava is an important crop

Brazil is the world s largest cassava producer Fifty eight percent of Brazil's cassava production (14 5 million tons) is concentrated in the Northeast Cassava is important in this region because the environmental conditions are unfavorable for the cultivation of most other crops Most cassava farmers cultivate plots of less than 1 ha with generally low soil fertility in a region with only a minimum infrastructure of roads, electricity, and services Cassava productivity in the northeastern states is 37% lower than the average for the rest of Brazil The average yield in the region is 10 8 t/ha FAO considers that a major calorie deficit problem exists in the area The states of Bahia, Pernambuco, and Ceara are targeted for the project because of their importance as cassava producing regions the widespread incidence of cassava pest problems, and because of complementary CIAT/EMBRAPA activities in the area A regional development project funded by the Kellogg Foundation for integrated production, processing, and commercialization of dry cassava for animal feed is generating farmer demand for crop production and protection technology and will thus facilitate the technology implementation process

Pesticide use on cassava is negligible in Africa and Northeast Brazil However, a climate favorable to increased use is developing in Brazil now that subsidies for wheat have been removed and new markets for cassava have been opened through development of cassava-based animal feeds and fresh cassava conservation methods Cassava production is increasing in response to the new demand, and farmers who formerly could not afford to use pesticides may increasingly be able to do so

Significant increases in pesticide use could result in severe problems of environmental contamination in an area where 63% of the population live and where water is the major factor limiting agriculture over 70% of the region Pesticide-related health problems could also be anticipated in this area where high rates of malnutrition, illiteracy, and infant mortality are related to widespread poverty and underdevelopment of the region Ecological crop protection technologies are needed to prevent the need for, and consequently, the use of pesticides This approach will conserve the efficacy of natural enemies by avoiding the lethal contact and residual toxicity of most pesticides, and preserve the environmental integrity of water resources and the food-chain within targeted agroecosystems

Pest Constraints on Cassava Production

Biological constraints on cassava production commonly include weeds, plant pathogens, and phytophagous arthropods However, few studies of the impact and economic importance of these constraints on a regional or continent-wide basis exist Considerable information is available on the impact of weeds in the broad sense, while little is known about the effect of individual weed species and their importance as a refuge for natural enemies of cassava pests The important plant pathogens in Africa and South America (cassava bacterial blight, cassava mosaic virus, anthracnose, and root rots) are presently the subject of resistance breeding, biological control, and cultural practice research by both national and international institutions

Biological constraints to cassava production frequently depend on production practices Although the influence of agronomic practices on cassava production are well known their effect on pest populations requires further investigation Good quality planting material and practices to conserve soil moisture and fertility (appropriate intercropping, mulching, fallow periods, etc) usually enhance productivity but often exacerbate pest problems

The socioeconomic and political environment in cassava growing areas influences crop production characteristics in complex ways and hence, affects the possibilities for sustainable crop production and protection practices The links between factors such as farm size, land availability and tenure system, migration patterns, gender issues, market characteristics, government agricultural policies, and crop production are under investigation in several on-going studies in Africa and South America

In Africa, IITA has several studies of this type in progress including the Rockefeller-sponsored COSCA Survey, an extensive study designed to target the most important cassava growing regions of the continent, and several smaller-scale, but more intensive studies in selected sites in Benin, Nigeria, and Cameroon

In Northeast Brazil the Kellogg-sponsored CIAT/EMBRAPA project for production, processing, and commercialization of cassava is generating information on agronomic and socioeconomic constraints and opportunities in cassava production In addition, CIAT's existing databases on climate, soils, vegetation, and socioeconomic factors cover both Africa and South America, and are continually updated as new information is generated These represent an important analytic tool In addition, the Land Use Program which will soon form part of CIAT's new Natural Resources Division will contribute to the design of rural surveys as a basis for analyzing relationships between the socioeconomic environment and crop production and protection constraints These surveys can also provide a basis for planning the development of improved technology and for assessing its impact

In Africa, the widespread occurrence of severe pest problems on cassava, an introduced food crop, is related principally to the accidental introduction of arthropod species to an area where the local germplasm is susceptible to attack, where effective natural enemies are absent, and where a tradition of practices evolved by farmers to cope with the introduced pests does not exist This has been the case with the well known cassava mealybug (*Phenacoccus manihoti*) and the cassava green mite (*Mononychellus tanajoa*) Other important pests of cassava in Africa include the recently introduced larger grain borer (*Prostephanus truncatus*), which attacks harvested and processed storage roots, the seasonally abundant grasshopper (*Zonocerus variegatus*) sometimes found in devastating numbers at the end of the dry season, and the whitefly (*Bemisia tabaci*), a vector of cassava mosaic virus

In Northeast Brazil, the extensive cultivation of cassava in the dry interior hinterlands is a relatively recent development related to the high rates of population growth in the area during this century A complex of pests and diseases occurs in the region including the cassava green mite, cassava mealybug (*Phenacoccus herreni*) cassava hornworm (*Erinnyis ello*), lacebugs (*Vatiga illudens*), whiteflies, and root rots The causes underlying these pest problems are similar to those described for Africa, and relate to germplasm adaptation, possibly exotic species in some cases, and the lack of an evolved tradition for managing pests

The impact of the best known constraints to cassava production in Northeast Brazil and in sub-Saharan Africa can be summarized as follows

Cassava mealybugs (Phenacoccus manihoti, P herreni) Both species are native to South America *P manihoti* is a pest only in Africa and achieved pest status after accidental introduction to the continent *P herreni* is native to Venezuela and became a pest after invading Brazil *P manihoti* has been the target of one of the most successful classical biological control campaigns The cassava mealybug caused rapid and widespread devastation as it spread over the cassava belt of West and Central Africa before the start of the control campaign In many regions, cassava production ceased when the mealybug destroyed both the cassava in the field and local sources of planting material Yield losses of 100% were common in infested areas The mealybug is now significantly controlled in most ecologies by the introduced parasitoid *Epidinocarsis lopezi* However, in areas where cassava is grown on extremely poor, sandy soils (less than 5% of the total cassava area in West Africa), the parasitoid appears unable to develop properly on the apparently inferior mealybug hosts This leads to an explosion in the pest population and conspicuous plant damage

P herreni causes leaf yellowing, curling and cabbage like malformation of the growing point Yield reductions as high as 80% have been reported, as well as reduction of root quality and destruction of planting material Greater losses occur in drought years *P herreni* currently occurs primarily in coastal areas of Northeast Brazil Intensification of production is expected to lead to more frequent attacks over a broader geographical area in the future

Cassava green mite (Mononychellus tanajoa) The cassava green mite is another pest native to South America that was introduced into Africa in the early 1970s It spread throughout the cassava belt of Africa in a relatively short 10 year period and is now the most important pest on cassava in many regions of the continent The green mite causes yield losses ranging from 30 to 80% depending on variety cultural practices and local agroecological conditions threatening food security in many regions of the continent

The cassava green mite has been one of the principal targets of pest management efforts by EMBRAPA in Northeast Brazil since the 1970s In recent surveys conducted as part of collaborative research between EMBRAPA, CIAT, and IITA, the areas most seriously affected by the cassava green mite were in semiarid zones (450 to 800 mm precipitation per year) Yield loss assessment trials indicate that 10-50% losses occur in seasonally dry and semiarid zones depending on variety, planting date, planting system, and the length of the crop cycle Root dry matter content is also reduced, affecting quality of roots and reducing acceptability for both fresh consumption and processing

Cassava hornworm (Erinnyis ello) Neotropical hornworms can cause complete defoliation of a cassava crop and thus are more likely to lead to pesticide use by farmers than other cassava pests, even though pesticide applications may be economically unwarranted Repeated attacks can occur and may be stronger due to elimination of natural enemies by pesticides Yield loss depends on plant age the number of consecutive attacks, and soil fertility conditions Yield losses in low fertility areas are from 15 to 46% after one attack and up to 64% after two consecutive attacks Yield loss in plants attacked after six months of age is generally less severe than on younger plants, but root quality is adversely affected

Whiteflies (Bemisia tabaci, B tuberculata, Aleurothrixus aepim, Aleurotrachelus socialis, and Trialeurodes variabilis) Whiteflies cause direct damage to cassava in Northeast Brazil through their feeding and the sooty mold that grows on their excretion which reduces photosynthesis Prolonged attacks lasting throughout the growing season are common and can result in yield losses as high as 80% One or more of the Brazilian whitefly species is thought to be the vector of cassava vein mosaic virus in the region Experience in other regions of South America has shown that increased incidence and severity of whitefly attacks are commonly associated with intensification of production

The only species found in Africa *B tabaci* occurs throughout the cassava belt of the continent but does not attack cassava in Brazil However the damage it causes is mostly indirect as a vector of the cassava mosaic virus a plant pathogen estimated to cause up to 50% reduction in yield The virus attacks the leaves causing chlorosis and shriveling This ultimately reduces yield because the photosynthetic activity of the plant is reduced

Variegated grasshopper (Zonocerus Variegatus) The conspicuous variegated grasshopper is indigenous to West and Central Africa where it is found in the humid and subhumid ecologies It is a pest which emerges as a synchronized mass of nymphs from soil-borne eggs during the dry season It feeds on a wide variety of green vegetation including cassava, often the only significant crop found in farmers fields during this period Grasshopper populations reach maturity by the beginning of the wet season Adult females concentrate their egg laying in the soils of undisturbed habitats Large concentrations of the grasshopper can defoliate a cassava field and kill the plants when the bark is chewed off the stems

Cassava lacebug (Vatiga illudens) Surveys have shown that lacebugs are widespread in Northeast Brazil Heavy infestations leading to extensive leaf damage are frequent however, the damage/yield relationship has not been studied sufficiently, and the extent of yield losses is not known Yield losses of up to 40% have been reported under experimental conditions Lacebug attack occurs during the dry season and high populations cause severe defoliation In other cassava-growing regions of South America, intensification of production has been associated with increased frequency and intensity of attacks and the dissemination of lacebug species to formerly unaffected areas

Larger grain borer (Prostephanus truncatus) The larger grain borer, introduced into Africa in 1981 is a serious pest of stored maize but also attacks harvested and processed cassava Losses of up to 70% after three months of infestation have been reported

Plant pathogens A number of foliar and root pathogens commonly affect cassava production in Africa and South America In Africa, the most important plant pathogen is the cassava mosaic virus a pathogen found throughout the cassava belt Cassava mosaic virus is so common in some parts of Africa that the farmers do not consider leaves exhibiting virus symptoms to be diseased However yield losses of 25 to 60 percent have been estimated in susceptible germplasm In the more humid regions, cassava bacterial blight and anthracnose damage can exceed that of mosaic virus The extent of damage depends on the timing of infection, environmental conditions, pathogenic virulence, and cassava variety Similar problems with related viral and bacterial foliar pathogens are found in South American Root rots including *Fusarium*, *Phytophthora*, *Diplodia Scytalidium* and *Verticillium* spp are also major production constraints in both continents Yield losses of 40% are reported for at least 300 000 ha of cassava in Northeast Brazil

Weeds Numerous weed species can cause severe cassava production losses some estimated as high as 80% if left unchecked Cassava is most susceptible to weeds during the first month after planting and periodically during the rainy season Although traditional practices have evolved in most regions to keep weed problems under control, the labor required, about 45% of the total production costs, can be a limiting factor Among the most troublesome weeds in Africa and South America are *Imperata cylindrica*, *Chromolaena odorata*, *Panicum* spp, *Andropogon* spp, *Hyperrhania* spp, *Pennisetum* spp, *Mimosa* spp, and *Commelina* spp

Status of Intervention Technologies

The plant protection technologies available for testing and adaptation can be grouped into three categories of interventions biological control, host plant resistance, and cultural practices In Africa and Northeast Brazil, a strategy involving a combination of biological control, host plant resistance and cultural practices will be followed

Biological control consists of three basic strategies In classical biological control, ecologically well adapted natural enemies are introduced from outside the target area Conservation involves the use of cultural practices and manipulation of the habitat in order to enhance the occurrence, activity and persistence of natural enemies already present in the system Augmentation involves the multiplication and release of locally occurring natural enemies in order to increase their impact

Cassava pests have been studied by IITA and CIAT for many years in view of developing host plant resistance Resistance to several important pests and diseases in Africa and South America has been incorporated into elite germplasm for use by national programs and has resulted in the release of cassava varieties with resistance to pests and diseases Resistant germplasm will be a component of the technology tested in this project

The role of cultural practices in enhancing cassava production is well understood Good cassava production starts with quality planting material free of avoidable plant pathogens and pest contaminants Additionally, it involves optimization of agronomic practices such as weeding, mulching time of planting, spacing intercrops, and time of harvest However knowledge of agronomic practices as they affect pests and diseases must be assembled so that it can be passed to farmers through properly trained national research and extension workers

Specific Pest Interventions

Cassava green mite In South America where the cassava green mite is indigenous, locally selected cultivars and well adapted natural enemies keep this species in check in many areas Studies by CIAT and EMBRAPA show that natural enemies alone prevent yield losses of about 30% IITA decided early on to pursue classical biological control of the cassava green mite as the first intervention option Natural enemies of the mite family Phytoseiidae were identified as the most promising predators of cassava green mite

An extensive foreign exploration effort was launched in 1984 by IITA in collaboration with CIAT and EMBRAPA Among the more than 50 phytoseiid species found associated with the mite in the Neotropics, a dozen promising species have been shipped to Africa for experimental releases Two of these species have been identified as viable field candidates based on establishment and preliminary impact studies These include *Neoseiulus idaeus* and *Typhlodromalus limonicus sensu lato* from Brazil Other species will be tried during the course of the project based on recent field studies in the Neotropics They include *N anonymus*, *T aripo*, and *T limonicus sensu stricto* which are all from Brazil and other phytoseiids from elsewhere in the cassava green mite's range in South America Each of these species/populations has special attributes or ecological preferences of interest for the cassava ecologies under consideration in Africa

Another group of natural enemies being exploited for spider mite control are pathogens In the case of the cassava green mite, a fungus has been found attacking the mite in the drier areas of Northeast Brazil The fungus, *Neozygites sp*, is an Entomophthorales with a high degree of host specificity Studies have been underway for the last two years by EMBRAPA and CIAT as part of ongoing collaboration with IITA Preliminary results from epidemiology, infectivity and specificity studies show the fungus as a promising classical biological control agent in areas receiving between 800 and 1200 mm rainfall per year In a project to be funded by USAID at the end of 1991, IITA and EMBRAPA will continue to study the specificity and epidemiology of the fungus, and develop procedures for culturing and transporting mass-cultured stock for experimental manipulation Strain characterization and selection will be done as part of the UNDP sponsored activities The fungus will be shipped to IITA at the end of 1992 in time to include it in the on-farm trials of phase two of this project

In Northeast Brazil, phytoseiid natural enemies of the cassava green mite were absent in 30% of fields sampled across a range of humid to semiarid ecological zones and in 32% of fields in semiarid zones Only three species were consistently reported Eighteen species of phytoseiids were common in fields sampled in Northern South America (Colombia, Venezuela, Ecuador) across a comparable range of humid to semiarid zones where 93% of the fields had low populations or were devoid of cassava green mite This suggests a potential for increasing the effectiveness of local natural enemies through augmentation and conservation techniques Several species of natural enemies that have not been detected in Brazil and some different biotypes of species that do occur in Brazil have been detected in homologous seasonally dry and semiarid cassava growing areas elsewhere in South America, suggesting a potential role for classical biological control The selection and introduction of virulent strains of the fungus *Neozygites* in certain agroecological areas is also planned

Maintenance and mass production of natural enemies requires a unique technical capacity and infrastructure IITA and CIAT have developed these capacities over the years while working on a wide variety of natural enemies including parasitoids, predators, and pathogens Small-scale culture methods appropriate for implementation by national programs in both continents and by farmer cooperatives in South America are under development for several species of natural enemies These methods can be used in the regional dissemination of exotic species and in augmentation of native species or strains

The incorporation of sources of cassava green mite resistance into agronomically acceptable cultivars offers potential for the control of cassava green mite in Africa and Northeast Brazil IITA is developing promising cultivars that will be available for testing in on-farm trials in Africa during the project The IFAD-sponsored CIAT/EMBRAPA/IITA project for breeding and selection of cassava for semiarid areas is developing germplasm pools for evaluation in South America and Africa Resistance to cassava green mite is one of the selection criteria in the IFAD project Materials from these projects and from the national cassava programs will be multiplied and tested with farmers as part of this project

Appropriate cultural practices for cassava green mite can be identified based on systems research, even though much work remains to be done Field studies recently corroborated by computer simulations indicate that cassava planted early in the wet season suffers low mite-induced yield reductions compared with cassava planted later in the season, and that a positive relationship exist between soil fertility (organic matter nitrogen, water), plant vigor, and mite density The relationship between mite density and yield is nonlinear with the greatest mite-induced yield losses occurring in plants of intermediate vigor This identifies mite-infested cassava grown on soils of intermediate fertility as the most likely target for cultural practices that improve soil fertility and water-holding capacity Conservation of phytoseiid predators of cassava green mite through maintenance of weed refuges the creation of "seed' plantings where high densities of phytoseiids can develop under field conditions for dissemination to the main planting area, and other available habitat management methods will be evaluated with farmers in the technology testing and adaptation phase of the project

Cassava hornworm Effective control of hornworm has been achieved in southern Brazil with the hornworm baculovirus The technology for hornworm control is well developed and is already being implemented by farmers Adaptation of the technology for Northeast Brazil will depend upon assured availability of sufficient quantities of virulent strains of the virus, the preparation of regional distribution plans, and development of propagation and application methods appropriate to conditions in Northeast Brazil

Variegated grasshopper Most of the damage caused by this grasshopper in Africa is compensated for by the plant if the harvest can be delayed for a few months after attack This does not help farmers who rely on the foliage as a vegetable or harvest the root a few weeks after a grasshopper attack In these cases, the use of microbial agents to control the grasshopper can be implemented As the humidity increases toward the end of the dry season, the pathogenic fungus *Entomophaga grylli* attacks the grasshopper and usually devastates the population soon after the start of the wet season Augmentation of *E grylli* or the application of another virulent fungus at the time of attack should prove efficacious IITA is presently working on several fungal interventions and application technologies in connection with a project to control both the migratory locust and the variegated grasshopper Promising virulent strains of *E grylli* and another fungus, *Metarrhizium anisopliae*, are presently available for on farm testing Cultural practices which reduce breeding sites and the availability of preferred host plants such as *Chromolaena odorata* will also be recommended to farmers as a way to reduce source populations

Cassava mealybugs (*Phenacoccus manihoti* & *P herreni*) In Africa, the cassava mealybug is now significantly controlled in most ecologies by the introduced parasitoid *Epidinocarsis lopezi* However in areas where cassava is grown on poor sandy soils the parasitoid appears unable to develop properly because the mealybug hosts are inferior The efficacy of *E lopezi* in these situations may be improved by promoting cultural practices that enhance the fertility and water holding capacity of the soil (e g mulching weed management, selected intercrops, and proper fallow periods) In addition releases of exotic predators into these pockets of infestation are planned Two coccinellids from South America, *Hyperaspis notata* and *Diomus* sp, have already been established locally in several countries and more species are being released This should improve the quality of the mealybug hosts and the efficiency of the parasitoid

A highly specific and efficient parasitoid of the mealybug *P herreni* has been identified from its area of origin in Venezuela This species *Anaesius n vexans*, is available in culture at CIAT A decision to introduce this species to Brazil will depend on evaluation of the extent and level of damage caused by *P herreni* as estimated by diagnostic surveys The experience of IITA with classical biological control of *P manihoti* in Africa will provide guidelines for this effort particularly in the adaptation of mass rearing and dissemination methods

Whiteflies In Northeast Brazil, a broader knowledge of the biology, ecology, and natural enemies of whiteflies in cassava is needed to guide the development of control methods The fungal pathogens *Cladosporium* sp and *Verticillium dahliae* cause significant mortality of whiteflies under field conditions Low cost culture methods will be adapted from existing procedures and farmer participation in trials of application methods and field-to field transfer techniques will be initiated Resistance screening has led to identification of 50 promising and five highly resistant cultivars These have entered into a hybridization program and the progeny are under evaluation At this time, the impact of whiteflies in Africa as vectors of cassava mosaic virus is best controlled through resistant germplasm presently developed and distributed by IITA and national programs

Larger grain borer Recently, an introduced histerid beetle predator *Teretriosoma nigrescens* from Costa Rica has been released against this pest in Togo, West Africa IITA is also involved in a project to identify, import, and release promising natural enemies of the larger grain borer from Central America into Africa Promising intervention technologies that are available will be tested in this project

Lacebug If yield loss trials justify further attention, the feasibility of incorporating genetic resistance against the lacebug in Brazil will be considered Ninety-four promising clones have been identified in preliminary germplasm screening

Plant pathogens A number of cassava varieties resistant to several plant pathogens have been developed by national and international institutes and are available for on-farm testing in Africa and South America IITA has developed and distributed to African national programs a number of cassava lines that are highly resistant to cassava mosaic virus and cassava bacterial blight Some national programs are now incorporating these sources of resistance into locally acceptable cultivars which are available for on-farm testing In a project executed by Centro de Pesquisa Agroforestal da Amazonia Occidental, EMBRAPA, and CIAT, the implementation of appropriate cultural practices and tolerant varieties led to 90% reductions in root rot incidence and 3-fold increases in yields This technology has been adopted in 40 municipalities in North Brazil in 40-50 ha of cassava per municipality Adaptation of this technology for affected areas of Northeast Brazil will require the development and deployment of tolerant germplasm and cultural practices appropriate for the region The highest levels of resistance are found in germplasm from the Amazonian region However, these genotypes are poorly adapted to the ecological conditions of the Northeast Resistance must be transferred to local material through breeding A germplasm collection and a root rot working group consisting of collaborators from state research institutions from Northern, Northeast Brazil the national cassava research center, and CIAT has been assembled

Weeds The principle method of weed control in cassava is by hand weeding early in the growing season and periodically thereafter depending on the species, rainfall, and cassava variety But because of the amount of labor required, alternate methods of control would be attractive if appropriate Commercial herbicides are potential risks to the environment and usually beyond the economic reach of most cassava farmers Biological control has a great theoretical potential but remains largely unexplored for tropical weeds Cultural practices hold the greatest promise Profusely branching cassava cultivars, plus carefully selected and properly timed intercrops, significantly reduce the amount and frequency of weeding required In a similar manner, some noxious weeds in cassava have been successfully managed with selected low growing herbaceous legumes

Ecological Risks Several types of risks may be associated with the exploitation of biological control agents of arthropod pests An acceptable degree of specificity for the target pest must be assured in order to guarantee that biological control agents will not cause damage to crops or to other beneficial insects Possible displacement of native populations of beneficial organisms can result as a consequence of introductions of exotic species or strains of natural enemies An additional risk in the case of microbial control agents is the possibility of effects on human health

The specificity of the parasitoid *Anaesius vexans* proposed for introduction to Northeast Brazil for control of cassava mealybug has been studied extensively *A vexans* does not utilize foods of plant origin nor parasitize non-mealybug hosts, and is highly specific for *Phenacoccus herreni*

In native vegetation and in agricultural systems, phytoseiids are known to consume plant exudates, leaf microflora, pollen, and arthropods such as thrips They have also been know to consume phytophagous acarine prey and other species of phytoseiids when phytophagous acarine prey are scarce Some species of phytoseiids practice cannibalism when other food sources are scarce The use of alternate or supplemental foods of plant origin, however, has not been associated with crop damage in any case where phytoseiids have been employed as biological control agents Cannibalism and the consumption of non-target species of arthropods as a means to avoid local extinction when acarine prey are scarce occurs in undisturbed systems and in systems where phytoseiids have been deployed as biological control agents In our opinion, the level of risk implied by this phenomenon is acceptable when balanced against the benefits of successful control of the cassava green mite

Little is known about the chain ecological consequences which may result if displacement of native natural enemies occurs after introduction of exotic species of phytoseiids or other natural enemies Exotic species are introduced when native species are shown to be infective or inadequate in controlling pest populations Many phytoseiids can occur on a range of plant species It is possible that native phytoseiids could be important as biological control agents of other acarine species in non-target crops or in native vegetation, and that cassava represents an alternate habitat or temporary refuge for these species The risk of perturbing such a system through the introduction of exotic species must be balanced against the benefits of successful control on cassava green mite

The hornworm baculovirus belongs to a group of highly host specific organisms which have been extensively used in biological control No evidence has been found that the hornworm baculovirus or green mite fungal pathogen, *Neozygites* infect other biological control agents The baculovirus has been deployed in the North Coast of Colombia and in Southern Brazil since 1984 with no reports of human health effects Further investigation of possible negative environmental consequences of the use of microbial control agents and of other crop protection technology components will be undertaken as part of this project in Northeast Brazil

Project Strategies

The success of the project will be based on the complementary expertise and comparative advantages of the collaborating institutions, and the unified approach to developing, testing, and implementing plant protection technologies The parallel efforts in Africa and South America will rely on shared information (arthropod, agroecological and socioeconomic databases, and simulation models), expertise (e g , classical biological control, mass rearing systems, taxonomy, microbial control, modeling, population biology, information management) and resources (e g , information systems, natural enemy sources, common quarantine arrangements) leading to economies of scale The liaison between international institutions will create a bridge between national programs isolated within continents, but with similar cassava production problems, that provides access to natural enemies, resistant germplasm, and expertise essential for developing and implementing appropriate cassava plant protection technologies

Teams of national and international counterparts from each continent will be formed at the beginning of the project and will meet in planning workshops to prepare detailed workplans, survey protocols, and sampling procedures prior to initiating field activities The overall objective will be to identify significant pest constraints in important cassava-growing regions of each country, then test available intervention technologies on farms through the participation of trained national program staff and farmers The project will be divided into three interrelated and partially concurrent phases covering a total of 4 years The first phase will refine the existing knowledge base on major pests of cassava through diagnostic surveys In the second phase, farmers will participate in the development and testing of a range of crop protection technology components Additionally, formal training of farmers, extension workers, and researchers in the principles and practices of sustainable crop production and protection will be provided In the third phase, progress in achieving training and technology implementation will be evaluated

Biological control interventions will be the core technologies tested and adapted in Africa Consequently, the continuing classical biological control effort in Africa will depend on the prompt and adequate supply of replacement and new natural enemy species from South America Natural enemy production systems and release technologies will be developed in anticipation of new predators and pathogenic fungi which will be produced for experimental releases As these systems are developed, new candidate natural enemies will be sent from CIAT and EMBRAPA through quarantine at the University of Amsterdam to IITA's Biological Control Center for Africa in Benin

Many of the procedures and technologies developed for the practical implementation of biological control in Africa will be adapted for work planned on the cassava green mite and the cassava mealybug, *Phenacoccus herreni*, in Northeast Brazil In particular, African experiences in mass rearing, release, and follow-up activities will be incorporated into biological control work in South America Likewise, procedures developed for manipulating microbial agents, such as the cassava green mite fungus and the cassava hornworm virus in South America, will be adapted for similar work planned in Africa

Training activities in Africa and South America will be conducted through national programs and linked through the development of similar syllabi and training materials Because of extensive experiences in plant protection training in Africa, IITA will take the lead in developing training elements Related to this, will be the placement of post-graduate trainees from one collaborating institution to another where a comparative advantage in research opportunity and supervision may exist

In Africa, a special initiative will be made in collaboration with Winrock International to enhance the status and influence of women in agriculture by providing post graduate training opportunities to women involved in research, training, and implementation activities related to sustainable plant protection in the participating countries

Increases in productivity of cassava, a key food staple in Northeast Brazil should result in improved food availability which could directly benefit women and children in the region Although the participation of women in cassava production in Northeast Brazil is limited, women and children are heavily involved in artisanal cassava processing activities and could ostensibly benefit indirectly from increases in productivity CIAT and EMBRAPA are already involved in a number of activities to ensure that women will benefit from improved cassava-related production and processing technology in Northeast Brazil

Women have traditionally contributed unpaid labor to artisanal farinha production in communally owned, rural production facilities Some 0 5 million women in the state of Ceara alone, are estimated to participate in the production of farinha from cassava roots The construction of drying plants in Ceara has resulted in diversion of cassava from production of farinha to production of dry chips which are sold to the animal feed industry at a profit This is creating additional economic opportunities by diverting some of the formerly unpaid labor of women to activities which generate income The Kellogg Foundation is providing funds to set up a women s communally-managed chicken production pilot project in Ceara which will eventually involve artesanal production of chicken feed rations based on dried cassava roots and foliage Increases in cassava productivity obtained through improved crop protection can, therefore, contribute to raising the standard of living of rural women and children in Northeast Brazil

A high proportion of the EMBRAPA and state research and extension personnel are women, particularly in fields related to crop protection This will facilitate the involvement of women in all phases of the implementation of this project in Northeast Brazil
Information resources will be developed to facilitate processing, summarization, interpretation, testing, and communication of the large amount of multidisciplinary and interdisciplinary data generated during the project This will include the preparation of database systems appropriate for the different kinds of information and end users, and systems models which characterize critical interactions in the cassava ecosystem and which have both strategic and tactical capability Taxonomic information concerning the arthropods associated with cassava agroecosystems in Africa and South America will be refined throughout the project Information and experiences of national and international collaborators will be exchanged in regularly scheduled workshops Information resources will become part of the project s legacy to crop protectionists in the target countries

EXPECTED END OF PROJECT SITUATION

Enhanced national research capability in sustainable crop protection will be evident in the target countries and regions Farmer knowledge of sustainable crop protection principles and practices will be greater as a consequence of basic training provided to the farmer Technology adoption will be facilitated by direct farmer participation in training and its development, testing, and adaptation Cassava yields and/or root quality should improve significantly on farms where technologies have been adopted Information resources developed during the project will facilitate the implementation of similar efforts in the future

Targeted Beneficiaries

National, regional, and international organizations involved in research and implementation of sustainable plant protection for cassava and related crops grown by small-scale farmers under tropical, rain-fed, low-fertility conditions in complex, diverse and risk-prone cropping systems will benefit from this project Small-scale farmers in the cassava-belts of Africa and Northeast Brazil are the direct beneficiaries of sustained productivity, reduced pest and disease problems, stable incomes, food security, and a pesticide-free environment Indirect benefits of improving sustainability of agriculture in fragile agricultural environments will extend to neighboring regions and countries which are affected through ecological links to the target areas

Immediate Beneficiaries

The immediate beneficiaries are the participating farmers, extensionists, and researchers of the national and international research institutions involved in this project

Reasons for External Assistance from UNDP

Research on sustainable plant protection technologies is a relatively recent phenomenon Few institutes work specifically in this area IITA and CIAT, the CGIAR institutes concerned with cassava, have joined forces to develop environmentally sound plant protection technologies with the collaboration of national programs and farmers for a crop that, until recently, attracted little plant protection attention This project fills a gap in the development and implementation of ecologically sound plant protection technology It links national programs with similar cassava plant protection problems and experiences through international institutes, and provides access to ecological (natural enemies germplasm) and information (expertise, research and implementation experiences) resources that are otherwise out of reach UNDP and FAO have supported training and implementation components of this collaborative effort since 1984

However, support for sustainable plant protection projects has been limited It is for this reason that UNDP is requested to help maintain the momentum gained between collaborating institutions in the development, testing, and implementation of successful intervention technologies by supporting this project

Special Considerations

The current crop protection situation in West Africa and Northeast Brazil has been analyzed as a consequence of long standing collaboration between national and international institutions in Africa and South America Particularly important is the decade of continuous collaboration by IITA and CIAT to control exotic cassava pests in Africa Benefits of this collaboration applicable to current crop protection efforts include development of several sustainable pest control constraints in cassava agroecosystems, and practical field experience in both continents It also provides a link between national programs, ecologically similar subregions and continent restricted resources needed in the development and implementation of ecologically sound cassava plant protection

Use of this accumulated knowledge to benefit small scale farmers will require an intensive implementation process involving the integration of researchers, extension workers, and farmers The success of the activities in both continents will depend on sharing complementary expertise and information held by the collaborators, and on extensive links to other disciplines of direct importance to development and implementation of crop protection (e g , breeding, agroecological studies, biotechnology agronomy socioeconomics, training, and communications) The unified approach to developing testing and implementing the plant protection technologies which has been developed by IITA and CIAT is unique and will contribute to efficient use of resources for achievement of the objectives of this project

PROJECT COORDINATION AND MANAGEMENT ARRANGEMENTS

CIAT and IITA will be responsible for coordination of project activities in South America and Africa, respectively A scientific project leader from IITA and one from CIAT will be responsible for the research activities in Africa and South America respectively Liaison with the national programs will be maintained through the project leaders and the national coordinators Activities between continents will be coordinated through the two scientific project leaders Research at IITA and CIAT is organized on a program basis, and there is a program director/coordinator responsible for the coordination and integration of the cassava plant protection activities in each institute These program leaders report to a Director of Research who has overall responsibility to the Director General and the Board of Trustees for research and management in each institute

Project collaborators will hold a yearly internal review meeting for the purposes of exchanging information and setting priorities This meeting will be attended by IITA s Biological Control Program Director, the Project Leader for the African Component IITA scientists (2) CIAT s Cassava Program Entomologist the Project Leader for the South American Component CIAT scientists (2) and the Project Leaders from each of the national programs Responsibility for organization of the meeting will rotate between CIAT and IITA

A project advisory panel will be set up by CIAT and IITA and will be expected to attend the yearly review meeting The advisory panel will review the progress made on technical matters, provide advice on the relevance of the work undertaken, and recommend changes when needed The panel will also approve the annual workplans

Experts, such as the following will be asked to serve on this panel Drs P Kenmore (FAO), I Oka (Indonesia) B Okigbo (Nigeria), F Moscardi (Brazil), C Kramer (Resource of the Future Washington, D C) K Andrews (Zamorano, Honduras)

The travel, per diem, and other incidental costs incurred by the advisory panel will be covered by separate funds provided by UNDP for that purpose

Funds destined for South America and Africa will be disbursed to CIAT and IITA, respectively Funds destined for Northeast Brazil will be disbursed to EMBRAPA/CNPMF by CIAT EMBRAPA/CNPMF will be responsible for management and administration of these funds and will provide financial status reports to CIAT s chief financial officer quarterly

IITA will disburse funds to the African national programs of Benin, Ghana Nigeria, and Cameroon Each national program will be responsible for management and administration of these funds and will provide financial status reports to IITA s chief financial officer quarterly IITA will provide semiannual financial reports for the African component of the project to CIAT In turn CIAT will be responsible for submitting a global semiannual financial progress report and a global financial statement at the completion of the project

Accountability for project expenditures remains the responsibility of IITA for the Africa based component of the project and CIAT for the Latin America based portion

COUNTERPART SUPPORT CAPACITY

Cooperative research and training programs with national programs are developed by direct interaction between scientists and outreach officers within the international institutions and the national institutions These arrangements are regularly reviewed by the interacting programs

LINKAGES WITH OTHER INSTITUTIONS

Both IITA and CIAT maintain strong links with institutions that have a comparative advantage in carrying out specialized research and training, or facilitating the dissemination of information between institutions The University of Amsterdam provides quarantine services The University of California, Berkeley and the Swiss Federal Institute of Technology are developing a cassava ecosystems model The Knowledge Laboratory of Texas A & M University has expertise in the development of tactical and strategic models with user-friendly interfaces The University of Massachusetts, Amherst, has expertise in the behavior and ecology of *P herreni* and several of its natural enemies The University of Amsterdam collaborates on behavior and biology studies of natural enemies, and many other universities (University of British Colombia, University of California, Berkeley, Purdue University, McGill University, University of Laval, Wye College, Imperial College Reading University, ETH/Zurich, University of Regensburg, Ohio State University University of Ibadan University of Port Harcourt, University of Nairobi) train post-graduates selected from national programs participating in the control campaign The Organization of African Unity (OAU) and the Food and Agriculture Organization (FAO) facilitate information exchange between institutions and help create an atmosphere conducive for sustainable plant protection research in the third world through education and training programs

Linkages with International Research Institutions

The international research institutions mentioned above offer important comparative advantages in certain aspects of research and training IITA has had considerable research, quarantine, and training links with the International Institute of Biological Control (formally the Commonwealth Institute of Biological Control) since the early 1980s In a recent development, IITA linked up with Winrock International in a special program to select and train African women agriculturalists in the principles and practices of sustainable plant protection

Linkages with National Research Institutions and Extension Services

IITA provides scientific, technical, and financial assistance (both direct and indirect) to African countries with a desire to develop biological and other ecologically sound pest and disease control approaches to plant protection This project also provides African national programs a link to natural enemy and germplasm resources, plus expertise and relevant cassava plant protection experiences found in national and international institutions in South America Currently, IITA has a network of 24 countries in the cassava belt of Africa participating in a Biological and Integrated Plant Protection Network IITA s goal is to develop and transfer the expertise and technologies needed for plant protection research and implementation to national or regional programs This is being achieved by working with national programs on collaborative research activities, providing institutional infrastructure and support, and by training technical staff

The country program counterpart teams needed for this project will be identified by the participating national programs in consultation with IITA and CIAT The project 'Recherche Appliquee en Milieu Reel Benin (RAMB)" initiated by IITA six years ago, with support from the Dutch government and the Near East Foundation, is a multidisciplinary team of national agriculturalists working on food production problems in selected sites in Benin This approach has proven to be a very successful working paradigm and will serve as a model for assembling and organizing multidisciplinary national program teams in Africa

This project will contribute to a comprehensive effort to improve rural incomes, stabilize agricultural production and maintain sustainability in Northeast Brazil through collaborative integrated research and development of cassava as a staple food and as a raw material for rural agroindustries, and through development of germplasm resources The collaborators in this effort are CIAT, EMBRAPA, state agricultural institutions, and other participants in the Brazilian national agricultural research and development system

DEVELOPMENT OBJECTIVES

The principal objectives of this project are 1) to develop crop protection networks of trained farmers, extension workers, and researchers familiar with the elements of sustainable crop protection and 2) to test and adapt ecologically sound technology components with farmers in order to obtain feedback on the appropriateness of intervention options, and thereby facilitate the adoption of improved technology Development and adoption of effective crop protection technology will contribute to the reduction of pest losses, to stabilizing cassava yield and root quality, and to maintaining the sustainability of agriculture in the tropical, rain-fed, low soil fertility areas where much of West African and Brazilian cassava production is concentrated Widespread adoption of this approach to plant protection should assure the environmental quality of cassava-based agroecosystems by avoiding or minimizing increases in pesticide use

IMMEDIATE OBJECTIVES, OUTPUTS, AND ACTIVITIES

IMMEDIATE OBJECTIVE 1

Determine major pest constraints in principal agroecological zones

The major cassava pest constraints in each of the principal agroecological zones where cassava is important will be determined through a combination of extensive country-wide/region-wide surveys followed by intensive site-specific studies in each country Extensive surveys will be used to determine the important cassava ecologies, suspected major pest species, and the concerns and perceptions of farmers and extension workers in the targeted areas Intensive field studies to monitor pest population dynamics and measure their yield and root quality impact, and to validate the socioeconomic data recorded during the extensive surveys will follow in sites selected for suspected pest problems These results will be used to determine which pest constraints should receive priority, and where the on-farm test sites should be located in each country Interdisciplinary teams consisting of crop protection and production specialists will be assembled by IITA, CIAT, and by the participating countries and will be responsible for project activities in Africa and South America, respectively

Output 1

National program counterpart teams and appropriate workplans, procedures and protocols for activities planned in each participating country

Program Activity 1

Select and train national program counterparts in the discipline specific procedures and practices required for the diagnostic and on farm trial phases of the project

Program Activity 2

Prepare general workplan define protocols, and outline procedures to be used by all participants in the project Prepare specific detailed workplans for each country

Output 2

Identification of the major cassava pests in major agroecological zones of each targeted country

Research Activity 1

Extensive surveys to determine the important cassava agroecological zones, suspected major pest species, current crop protection practices, and concerns and perceptions of farmers and extension workers

Research Activity 2

Intensive field studies to monitor pest population dynamics and measure their yield and root quality impact, and to validate previously collected socioeconomic data

Output 3

Selection of sites for subsequent on farm trials to test pest intervention technologies

Research Activity 1

Sites representative of important ecological, agronomic, and socioeconomic features will be selected for on-farm trials using the extensive and intensive survey data collected plus input from the Rockefeller sponsored COSCA Survey in Africa and from the Kellogg Project and EMBRAPA in Brazil

Output 4

Identification of additional research needs for pests which are significant constraints to production, but for which control technology components have not been developed are inadequately developed or have not been tested at the farm level

Research Activity 1

Laboratory and on-station studies to determine the potential impact and possible interventions of selected pests If necessary, intervention technologies will be developed and tested on-station followed by on farm evaluation

IMMEDIATE OBJECTIVE 2

Test and adapt selected crop protection technology components in farmer-controlled trials

On-farm trials will be set up to test selected intervention technologies given specific combinations of ecological agronomic, and socioeconomic factors These trials will be initiated and monitored by national program counterparts who have been trained to carry out these activities, while the actual field trials will be implemented by carefully selected farmers In addition, progressive and innovative farmers will be encouraged to implement plant protection practices in their fields This presumes that intervention technologies in demand (quality planting material, natural enemies, expert advice) will be made available in a timely manner by trained extension workers participating in this project These technologies will include an array of biological control agents, resistant germplasm, and cultural control techniques

Output 1

Effective, ecologically sustainable crop protection interventions which are attractive to and implementable by farmers

Program Activity 1

Prepare intervention technologies to be tested including clean planting material from multiplication plots established locally, shipment of promising natural enemies to Africa and Brazil via quarantine Mass production of natural enemies (predators, parasitoids and pathogens, root rot pathogen biological control agents) of selected pests Cultural control information resources needed by extension workers and farmers also to be made available

Research Activity 1

Implement farmer-controlled field trials and monitor (national program staff) prescribed ecological, agronomic and socioeconomic parameters throughout the growing season

Output 2

Multitrophic and multidisciplinary systems analysis for characterizing important interactions and measuring impact at different levels

Research Activity 1

Adapt existing multitrophic ecosystems model with data from Africa and South America Develop strategic multidisciplinary systems models which can be used to study critical interactions between ecological, agronomic, and socioeconomic factors which are too complex and/or costly to study through field experimentation These models will also have tactical capability, permitting their use as tools for day-to-day decision making in crop protection Accordingly, they will be designed for widely available microcomputer equipment and will have user-friendly interfaces making them accessible to national program research and extension staff

Output 3

Evaluation of newly developed and recently adapted crop protection technology components

Research Activity 1

Test newly developed and recently adapted pest control technologies This work would be restricted to activities which support the testing and adaptation of developed pest control technologies or address pressing new pest problems not previously anticipated In Africa, these activities will be carried out by the IITA staff and post-graduate students being trained by the project

IMMEDIATE OBJECTIVE 3

Train farmers extension workers, and national program researchers in the principles and practice of ecologically sustainable crop protection

Training in the theory and practice of sustainable plant protection as applied to cassava ecosystems, and given the interests and background of each target group, will continue throughout this phase Extension workers, extension worker trainers, and farmers will participate in developing the syllabi to be used during the subsequent training The appropriateness of the training program and the impact and acceptability of the tested technologies will be evaluated by national programs The availability of natural enemies, quality planting material, a selection of institutional varieties and extension worker advice on a wide variety of topics (e g planting time, spacing, mulching and weeding practices, harvest time and post harvest measures to prevent pest damage) will also be measured Retraining and additional training will be offered to selected individuals where potentially beneficial At this stage, the technologies and the training will be rigorously evaluated on farm by the project staff in collaboration with national program staff, along with an impact assessment of the various activities undertaken during the project An exchange of information between all collaborators of the project will be held on a regular basis

Output 1

Training modules covering the principles and practices of sustainable cassava plant protection developed for national program staff, extensionists, and farmers by project collaborators in Africa and South America This will include training syllabi training aids (e g , handouts, brochures, pamphlets field guides, etc) The training material will be developed with the input of national program participants targeted for the training

Training Activity 1

Develop syllabi for training national program researchers, extension workers, and progressive farmers in the principles of ecologically sound plant protection practices This will be done in consultation with IITA, CIAT, the national program staff, extension workers, and farmers

Training Activity 2

Prepare didactic materials (e g , handouts brochures pamphlets, field guides videos, etc) which emphasize the importance of integrating biological control, cultural practices and host plant resistance as the basis of ecologically sustainable plant protection

Output 2

Trained networks of national program support staff extension workers farmers and post graduates (in Africa) with knowledge of the theory and practice of sustainable plant protection Training for researchers and extension workers will be multidisciplinary drawing upon information from plant protection (entomology pathology, acarology nematology etc), agronomy (plant physiology soil sciences, etc) and socioeconomics In Africa, at least 3 MSc in various aspects of plant protection will be trained Specialization will depend on the needs of the national programs in the four participating African countries

Training Activity 1

Select national program candidates for post-graduate training in a range of disciplines related to the sustainable plant protection needs of each participating country Each country will receive at least 3 MSc fellowships each The post-graduate training activities will be subcontracted to Winrock International's African Women Leaders in Agriculture and Environment program

Training Activity 2

Select and train national program research staff who will contribute to the project in each country In the first year, the national counterparts in each country will be selected and trained, followed by essential support staff the next year Training will be discipline specific and will provide the tools and experience needed to perform the diagnosis, implement, and monitor the on-farm trials In Africa, 15 national program staff will be trained per country

Training Activity 3

Train extension workers and farmers in sustainable plant protection practices in each participating country In Africa, training will be done annually after the first year A total of 50 extension workers and 350 farmers per country will be trained

Training Activity 4

Retrain selected national staff, extension workers, and farmers in Africa in year three A total of 15 extension workers and 50 farmers per country will be retrained Evaluate the training impact at all levels within each country in year three

IMMEDIATE OBJECTIVE 4

Assess impact of training, as well as the impact and adoption of improved crop protection technology

Output 1

Evaluation of the tested intervention technologies in each participating country

Output 2

Evaluation of the training program at all levels within each country

Research Activity 1

Evaluate the impact of the tested technologies by measuring effect on yield and root quality at on-farm test sites and by determining the adoption and spread of these technologies at the community level

Output 3

Exchange of information related to sustainable plant protection activities being carried out in Africa and South America

Program Activity 1

A scientific workshop will be held the first and third years of the project to exchange results other information and experiences that relate to sustainable plant protection activities in Africa and South America

INPUTS

IITA INPUT

IITA will provide the equivalent of 5 5 scientist-years their technical support staff needed to provide the pest intervention technologies and to backstop research activities, plus appropriate research, training, and administrative facilities during the life of the project - a financial commitment of ca US$1 7 million per year

CIAT INPUT

CIAT will provide the equivalent of 2 senior staff positions, 50% of the technical support staff, research and training facilities, and administrative support

WINROCK INTERNATIONAL INPUT

In addition to Winrock s monetary contribution of $250,000 per annum to the development of the AWLAE program, Winrock US -based and field staff will devote significant attention and assistance to the project Supplemental in-kind support from Winrock available to project fellows includes the West African country and regional infrastructure of the AWLAE program (Country Advisory Committees and Regional Coordinator) and its accompanying activities (professional and scientific networks, short term technical workshops, regional forums)

EMBRAPA INPUT

EMBRAPA will provide 4 5 professional staff positions and 1 7 technical support positions State research institutions in Northeast Brazil will provide 1 8 professional positions and 7 5 extension positions In addition, training and research facilities and administrative support will be provided

AFRICAN COUNTRIES INPUT

The national programs in each participating country will provide, on secondment three counterpart research staff needed to comprise the local research teams, and the research and training facilities required to implement the proposed activities This will include the basic salary allowances and social benefits normally accrued to national staff, plus necessary laboratory facilities, rearing rooms, and office space needed to carry out the proposed research and implementation activities The logistic support that can be expected from the African national programs is negligible

UNDP INPUT

UNDP is being requested to provide US$9,900,000 to support the proposed sustainable plant protection activities in the cassava ecosystems in Africa and South America from 1993 to 1996 IITA and CIAT currently allocate approximately 25% and 13%, respectively, of their cassava research funds to these activities and the requested UNDP contribution would represent about 27% of the estimated total needs in the four year period Support to national programs, including training, would be allocated 25% of UNDP funds Budget allocations on a yearly basis for the four year period are shown by continent in the Appendix

RISKS

The testing and adaptive research proposed in this project involve technologies which are well known, widely accepted as safe, and already practiced in various forms around the world In addition, all natural enemies imported from abroad for use in Africa or Northeast Brazil are passed through authorized and recognized quarantines before being certified as free of plant and animal contaminants before being released Therefore no major constraints are foreseen that could impede the proposed activities or threaten the livelihood of either the project team members or participating farmers and the environment

PRIOR OBLIGATIONS AND PREREQUISITES

IITA and CIAT have well established research and training facilities which will be made available, as required, to carry out the proposed activities Both institutes have the highly skilled staff in research, training, outreach, and administration required to successfully undertake the activities described in this project IITA and CIAT are recognized worldwide as centers of excellence with leaders in the field of plant protection in the tropics

PROJECT REVIEWS, REPORTING, AND EVALUATIONS

The project will be reviewed and its scientific and financial status reported annually A report on the research, implementation, and training activities will be made by each national program, and by IITA and CIAT on the continent wide activities for Africa and South America, respectively Audited financial statements will be provided by the chief financial officers of IITA and CIAT The project will be reviewed internally in the third year by all participants as part of the programmed workshop objectives Independent external reviews will be arranged at UNDP's request Representatives of UNDP are invited as observers at the annual meetings of the Boards of Trustees of IITA and CIAT when reports of the research and training programs are discussed

LEGAL ASPECTS

The Rockefeller and Ford foundations signed comprehensive Memoranda of Agreements with the governments of Nigeria and Colombia, on behalf of IITA and CIAT in 1967 to establish each as *autonomous, non-profit organizations, international in character and* governed by Boards of Trustees, respectively The goals of IITA are to increase the productivity of key food crops and to develop sustainable agricultural systems that can replace bush fallow, or slash-and-burn cultivation in the humid and subhumid tropics Crop improvement programs focus primarily on cassava, maize, and cowpeas Yams, soybean, and plantain are also major research concerns Research findings are shared through international cooperation programs, which include training, information, and germplasm exchange activities

CIAT's mission is to contribute to the alleviation of hunger and poverty in tropical developing countries by applying science to the generation of technology that will lead to lasting increases in agricultural output while preserving the natural resource base

CIAT has global responsibility for cassava, field beans and tropical forage species in acid soils and regional responsibility for rice in Latin America and the Carribean At the same, time CIAT will assume ecoregional responsibility for selected agroecosystems in Latin America as part of its strategic plan for the 1990s and beyond In close collaboration with other international, regional, and national institutions, CIAT proposes to develop integrated technology options for these agroecosystems from a macroscopic perspective that takes into consideration socioeconomic data alternative land use patterns and policy considerations In addition a microscopic perspective will focus on soil/plant, plant/plant and plant/animal interrelationships and how the farmer manages these relationships As an ecoregional center, CIAT will seek to provide an international platform for participating institutions to develop a common research agenda in which the various participants can contribute according to their particular comparative advantage

WORKPLANS

AFRICA

Diagnostic Surveys

Training national program staff and post graduates

Select and train multidisciplinary counterpart teams within each national program in survey techniques and on-farm procedures

Develop training syllabi covering the principles and practices of sustainable plant protection for national program research staff, extension workers, and farmers Prepare and print training aids targeting the different groups of trainees

Select fellows for MSc training and initiate post graduate programs This will include the special component of African women in agriculture to be executed by Winrock International

Train support staff of national program counterparts in the principles and practices of sustainable plant protection (group training)

Identify the major pest constraints in all distinct ecologies where cassava is grown using a combination of extensive country wide surveys followed by intensive studies in selected sites in each target region or country

Develop workplans, protocols and procedures for extensive surveys and intensive field studies in a planning workshop of all collaborators

Conduct extensive country wide surveys in wet and dry seasons to determine the important cassava ecologies suspected major pest species, and the concerns and perceptions of farmers in the targeted areas

Initiate intensive field studies of selected pests in two sites per ecology to monitor their population dynamics and yield impact during the growing season, and to validate the socioeconomic data recorded during the extensive surveys

Determine the significant pest constraints in each ecology and any species that may require additional development research

Identify two sites per ecology with three fields each where cassava, selected pests, and the concerns of the farmers come together to test pest intervention technologies on farm

Develop information resources to facilitate processing, summarization, interpretation, and communication of multi disciplinary data

Develop computerized inventories of the multidisciplinary databases generated by the project Determine a priori statistical designs for on-farm trials

On-farm Testing and Adaptive Research

Development, production, and distribution of pest inter vention technologies

Receive shipments of natural enemies (predatory mites and pathogenic fungus) of cassava green mite from the Neotropics via quarantine

Develop and decentralize mass rearing technology appropriate for national programs

Mass produce natural enemies for distribution to target countries

Identify institutional varieties to be tested in each trial and prepare clean, vigorous planting material in local multiplication plots

Prepare and make available cultural control information resources needed by extension workers and farmers

Test and adapt a selection of pest control technologies in a series of on farm trials designed to measure the most important combinations of ecological, agronomic and socioeconomic factors across the most important ecologies in each target region or country

These trials will be initiated and monitored by national program counterparts trained to carry out these experiments while the actual field trials will be implemented by carefully selected farmers

Monitor relevant ecological, agronomic, and socioeconomic features in each on farm trial

Cassava Systems Analysis

Adapt existing cassava multitrophic ecosystems model with data from Africa and South America

Validate and compare ecosystems to identify the most important interactions and to measure technology impact

Develop multidisciplinary and interdisciplinary subroutines for agroecosystems model

Repeat validation and comparisons for these new subroutines

Identify critical interactions in the African and South American ecosystems and evaluate the impact of intervention technologies given a range of ecological agronomic, and socioeconomic conditions

Compare the cassava ecosystems in South America and Africa

Test and adapt new pest intervention technologies

Laboratory studies of biotic potential

On station trials of field impact

Train trainers, extension workers, and farmers in the principles and practices of sustained plant protection

Train trainers extension workers and farmers (in country)

Train progressive farmers who will participate in the on-farm trials

Implementation, Evaluation, and Retraining

Measure the effectiveness of the training program and re train selected collaborators

Evaluate the pest control knowledge of trained individuals at all levels within the national programs

Retrain and provide additional training to selected national program staff, extension workers, and farmers where potentially beneficial

Evaluate the impact of the tested pest interventions Determine the availability of intervention technologies needed by farmers through the national programs

Monitor the ability of progressive farmers to implement what they have learned

Determine the impact of the tested intervention technologies at the farm level

Develop taxonomic information resources

A taxonomic revision of the phytoseiid species associated with cassava in Africa and South America

Prepare reference collections of all major pests and associated natural enemies in each targeted region or country

Timetable for Africa

Research Activities

Year 1 = 1993

No	Activity	Involved	Period
	<u>Phase I Diagnostic Survey</u>		
1	Select multidisciplinary teams	IITA/National Programs	January June
2	Develop workplans protocols & procedures	IITA/National Programs	June-September
3	Initiate extensive countrywide surveys	IITA/National Programs	July December
4	Initiate intensive field studies	IITA/National Programs	September December
5	Initiate information systems development	CIAT/IITA National Programs	July-December

Year 2 = 1994

No	Activity	Involved	Period
	<u>Phase I. Diagnostic Survey</u> (continued)		
1	Complete extensive countrywide surveys	IITA/National Programs	January June
2	Complete intensive field studies	IITA/National Programs	January December
3	Complete information systems development	CIAT/IITA National Programs	January December
4	Receive shipments of natural enemies	IITA/CIAT/EMBRAPA/ Univ Amsterdam	January December
5	Develop decentralized mass rearing systems	IITA	January December
6	Prepare cultural control information resources	IITA/CIAT/National Programs	January December
7			July December
	<u>Phase II. On-farm Testing/Adaptive Research</u>	National Programs/IITA	
8	Initiate on farm trials		January December
9	Develop & test new technologies	IITA	July December
	Initiate multitrophic & multidisciplinary models	IITA/CIAT/U C Berkeley	

Research Activities (cntd)

Year 3 = 1995

Nº	Activity	Involved	Period
	Phase II On farm Testing/Adaptive Res.(cont.)		
1	Continue on farm trials	National Programs/IITA/CIAT	January December
2	Complete testing new technologies	IITA/CIAT	January December
3	Continue multitrophic & multidisciplinary models	IITA/CIAT/U C Berkeley	January December
	Phase III Implementation & Evaluation		
4	Provide intervention technologies to trained farmers	National Programs/IITA/CIAT	July December
5	Evaluate impact of tested technologies	National Programs/IITA/CIAT	July December

Year 4 = 1996

No	Activity	Involved	Period
1	Phase II On farm Testing/Adaptive Res (cont.) Complete on farm trials	National Programs/IITA	January June
2	Validate multitropic & multidisciplinary models	IITA/CIAT/U C Berkeley	January September
3	Phase III Implementation & Evaluation (cont.)	National Programs/IITA	January December
4	Provide intervention technologies to trained farmers	National Programs/IITA	January September
5	Evaluate impact of tested technologies	IITA/CIAT/National Program	July December
	Prepare final report		

Training Activities and Implementation

Year 1 = 1993

No	Activity	Involved	Period
1	Develop Training Modules a) For plant protection staff b) For extension agents c) For farmers	IITA/CIAT/National Programs	March December
2	Postgraduate Training a) Select candidates b) Initiate programs	Winrock Int /IITA/National Programs	June December September December
3	Recruit National Program Staff a) Recruit counterparts	IITA/National Programs (4 positions per country)	February June
	b) Training national program counterparts & develop detailed workplans (2 week session)	IITA/National Programs (5 staff each)	September
	c) Workshop for national & international collaborators (2 week session)	IITA/CIAT/National Programs (5 staff each)	September

Year 2 = 1994

No	Activity	Involved	Period
1	Finalize Training Modules a) Syllabus & training aids for researchers extension agents & farmers	IITA/CIAT/National Programs	January June
2	Postgraduate Training a) Select candidates b) Initiate programs	Winrock Int /IITA/National Programs	January December January December
3	National Program Staff a) Group training (2 week session)	IITA/National Programs (5 staff per country)	June
4	Extension Agents & Trainers a) Train extension agents trainers (1 week session)	IITA/National Programs (25 extension agents per country)	January December
5	Farmers Training a) On farm trial participants (4-day session)	IITA/National Programs (5 in village sessions per country with 1 farmers each)	March September

Training Activities and Implementation (cntd)

Year 3 = 1995

No	Activity	Involved	Period
1	National Program Staff a) Workshop for national & international collaborators (1 week session)	IITA/CIAT/National Programs (5 staff per country)	September
2	Extensions Agents a) Train extension agents & trainers (1 week session)	IITA/National Programs (25 extension agents per country)	January December
3	Farmers a) Train farmers (4-day session)	IITA/National Programs (10 in village sessions per country with 15 farmers per village)	January December

Year 4 = 1996

No	Activity	Involved	Period
1	Extension Agents a) Retrain selected extension agents (1 week session)	IITA/National Programs (15 extension agents per country)	March September
	b) Training assessment	IITA/National Programs	March September
2	Farmers a) Train farmers (4-day session)	IITA/National Programs (10 in village sessions per country with 15 farmers per village)	January June
	b) Retrain selected farmers (1 week session)	IITA/National Programs (10 in village sessions per country with 5 farmers per village)	March September
	c) Training assessment	IITA/National Programs	January September

SOUTH AMERICA

Project Team

Entomologists from CIAT and EMBRAPA will be assigned to coordinate the project An information management specialist headquartered at CIAT will be assigned global responsibility for setting up information resources and systems for the entire project Counterpart national and international research teams will be assembled At CIAT, the team will consist of an entomologist, a rearing specialist, and an insect pathologist to be hired by the project, in addition to the project coordinator (entomologist) and the information management specialist Personnel from core funds as detailed in the CIAT contribution to the project (see budget) will also be provided

In Northeast Brazil, a national team comprised of entomologists (6), pathologists (6), breeders (1), agronomists (5), soil scientist (3), socioeconomists (1), ecologists (2), and extensionists (60) will be completed by hiring an environmentalist, extension coordinator, insect pathologist, acarologist, and a training coordinator The national coordinator will be provided by EMBRAPA Personnel, other than the national coordinator, will be assigned to the project on a part-time basis as detailed in the estimate provided of EMBRAPA's contribution to the project (see budget)

Diagnostic Surveys

Representatives of the national and international teams will meet in a workshop held early in the first year in order to define objectives and priorities and to design survey protocols and sampling procedures A survey team will be formed for each state Extensive surveys will be conducted in order to determine and map major and potential pest and disease constraints, existing crop protection methods, and the related concerns and perceptions of farmers Information on socioeconomic and phytosanitary constraints will be gathered in Bahia however, only phytosanitary constraints will be considered in Ceara and Pernambuco where sufficient socioeconomic information is already available

Regions in different agroecological areas of each state will be ranked according to the importance of cassava production, degree of pest and disease impact, and existence of active farmer cooperatives with interest in crop production and protection technology Candidate regions in each state will be identified for follow-up intensive surveys to monitor pest population dynamics, measure yield and root quality impact, verify the information on socioeconomic and production constraints, and farmer demand for improved crop production and protection technology generated during the extensive surveys Based on survey results, sites for on-farm research will be identified in areas where the incidence of serious cassava pest and disease problems coincides with farmer demand for improved technology, and where production increases have the potential to translate into increased farm incomes by providing raw material for rural cassava processing activities Ten farmers in one community per state in Ceara and Pernambuco, and ten farmers in each of three communities in Bahia will be selected for participation in technology testing and adaptation activities

Selection of farmers within communities for participation in technology testing and adaptation activities and selection of sites for researcher-controlled investigations will depend on survey results

Technology Testing and Adaptation

Testing and adaptation of improved crop protection technology components will be accomplished through a combination of researcher controlled trials, farmer-controlled trials, and demonstration plots

Many of the technology components available for controlling pest and disease constraints affecting cassava production in Northeast Brazil have been developed and implemented elsewhere and require testing and adaptation to local conditions prevailing in the Northeast Initial feedback from extensionists and farmers will be obtained about the relative feasibilities of candidate technology components through the diagnostic surveys Based on the results of these surveys, farmer and researcher controlled investigations will be set up in five sites identified in the diagnostic phase in order to test and adapt the most promising components

Farmers will be asked to try improved technology components alongside traditional methods The resulting trials will be monitored by making periodic field visits to solicit feedback from the farmer and to evaluate the condition of the trails

Demonstration plots will be established in each site and will be used to further test components which have been successful in farmer trials Demonstration plots apply components of improved technology in combination with components of traditional technology in an area larger than that used in classical experimental work This serves as a means to assess how well improved technology integrates with already existing practices and performs in local agronomic contexts The demonstration plots also serve as a means of publicizing technology among farmers who do not participate directly in trials and as a didactic tool for farmer and extensionist training programs Some technology components effective against diseases and pests, such as the use of good quality planting material, improved germplasm the use of double lanes and planting on ridges, have been sufficiently tested in Northeast Brazil and can enter farmer trials and demonstration plots without further evaluation or adjustment in researcher-controlled experiments Technology components developed and tested outside Northeast Brazil, technology which has not yet been tested at the farm level and technology under development, will require a period of screening and adjustment or further development in researcher-controlled trials before entering farmer trials or demonstration plots The handling of these is described in the subsequent section on strategic research and methodology development

Strategic Research and Methodology Development

Strategic research is required to adapt technology components developed and tested outside Northeast Brazil to test technology which has not yet been tested at the farm level and to continue development of promising technology components which are still in the research stage The following strategic research activities are planned as researcher-controlled trials

1 Strain selection of CGM fungal pathogens

2 Measure effect of pathogenic biological control organisms on non target organisms

3 Screen for possible negative environmental effects of improved crop protection technology components

4 Determine feasibility of introduction of phytoseiid natural enemies to Brazil from other areas of South America

5 Perform etiological studies of root rot pathogens

6 Identify potential root rot pathogen biological control agents

7 Develop systems models appropriate for use by researchers Such strategic models will simulate interactions between cassava the agroecosystem, pests and natural enemies, and will be used to analyze interactions too complex or too costly to study through field experimentation

8 Develop tactical capability for systems models in order to provide researchers and extensionists with tools for day-to-day decision-making in crop protections This will require that models be designed to run on widely available microcomputer equipment and the development of user friendly interfaces

Methodology development Some improved technology components will require modification or up scaling of researcher controlled methods Methods requiring further development are mass production of biological control agents and plant pathogen field detection and screening Specifically these are

1 Culture of *Neozygites*, the cassava green mite fungal pathogen

2 Field release methods for phytoseiid predators of cassava green mite, baculovirus of cassava hornworm, *Cladosporium* fungus of whiteflies, and microbial antagonists of root rot pathogens

3 Simple, decentralized rearing methods for natural enemies

4 Screening and field detection methods for root rot pathogens

Strategic research and methodology development will be carried out at EMBRAPA and state research stations and in field sites under appropriate agroecological conditions CIAT will assume responsibility for strategic research for aspects where it holds a comparative advantage and will collaborate extensively with EMBRAPA in methodology development and in strategic research for areas where EMBRAPA must take the leading role because of the site specificity constraints

Training of Researchers, Trainers, Extensionists, Farmers, and Local Leaders

Training of the national research team headquartered at Cruz das Almas, Bahia, in the principles of ecologically sustainable crop protection and in research and crop protection methodology will be provided by the national coordinator in collaboration with experts from CIAT In addition, in-service training in specialized topics, such as natural enemy rearing methods will be provided during the first year of the project A refresher workshop will be given during the third year of the project

In order to foster establishment of crop protection networks in Northeast Brazil, and to achieve an integrated approach to crop protection in an area where cassava is generally intercropped or rotated with other crops, training in principles and methodology will be provided in the form of two workshops to researchers working in related crops

One extensionist from each state will be selected to lead the training efforts in that state This group of three extensionists will be closely involved in strategic research and methodology development as a form of in-service training A two week course for these extensionists will be conducted in 1993 in order to define objectives and set priorities In 1994, two additional extensionists will be selected and a two week course will be provided to prepare the full group of five extensionists who will be responsible for supervision of the five sites hosting farmer trials and demonstration plots These five will also be responsible for providing training to 15 additional extensionists in each state through a series of one week courses commencing in 1994

Training for extensionists will involve the principles of ecologically sound crop protection and its practice in agroecosystems involving cassava Extensionists will be organized into a network in order to foster exchange of information and experience between states Four hundred and fifty farmers will receive training in crop protection practices through a series of field days to be held several times each year in the last two years of the project Farmers will be repeatedly exposed to demonstration trials and will be brought into contact with the farmers who participate directly in testing and adapting technology components State and community leaders will be invited to workshops (one in 1994, another in 1996) where they will be exposed to the concepts goals, and achievements of the project

The importance and integrated role of host plant resistance, cultural practices, and biological control in crop protection will be stressed in training at all levels Farmers and extensionists will be familiarized with specific technology components available for each of these tactics Extensionists and farmers will be trained to recognize the characteristics of pest and disease tolerant varieties and to distinguish beneficial arthropods (natural enemies) from pests Farmers will be trained to recognize and manage alternative host plants which provide refuges for pest and disease species, and will be exposed to techniques of natural enemy augmentation and conservation

In order to provide baseline information to be used in assessing the impact of the training program at all levels all groups receiving training will be surveyed in advance to characterize their knowledge of crop protection principles and practices

Appropriate manuals, audiovisuals, pamphlets, and other materials will be developed for each audience by the training coordinator in collaboration with national and CIAT team members and with IITA

Monitoring and Evaluation

Monitoring and evaluation of the project will include a system for monitoring on farm technology testing and adaptation trials, farmer adoption studies to assess the acceptance and impact of improved technology components, and surveys to assess impact of training at all levels
A system for monitoring on-farm technology testing and adaptation trials and results of demonstration plots will be set up in each state by the project information management specialist in collaboration with the national research and extension teams The design and implementation of computer databases for these activities will draw from the experiences of the Kellogg project in Ceara

Adoption studies will be conducted in order to assess the impact of the project Surveys will be made to estimate the number of farmers implementing crop protection technology components Adoption rates for participating and non-participating farmers in the same communities at various distances from the participating communities will be compared Socioeconomic characteristics of the farmers and agroecological characteristics of the farms will be compared among farmers adopting and not adopting technology in the communities surveyed

The impact of the training program at all levels will be assessed by surveying *participants after they complete training in order to assess* the efficacy of the program in imparting information on the principles and practice of ecologically sustainable crop protection

Support Activities

Support activities essential to the workplan include the development of information management systems, mass production of natural enemies for use in strategic research, farmer trials and demonstration plots, taxonomic services, multiplication of planting materials for testing of improved germplasm, natural enemy shipment and natural enemy quarantine

In collaboration with IITA and the national programs of Brazil, Nigeria, Ghana Benin and Cameroon CIAT will develop a global information management plan to be used on both continents The plan will involve database structures for socioeconomic bioecological, and phytosanitary information to be generated by the project, a priori statistical designs and standardized sampling protocols This will facilitate the comparison and integration of information and results from both continents

Natural enemies will be mass produced at the national cassava research center (CNPMF) in Cruz das Almas, Bahia for distribution to each state for use in on farm trials researcher-controlled experiments, and demonstration plots

Germplasm with resistance to pests and diseases selected by the national cassava research center in collaboration with CIAT will be multiplied by the project for distribution to and evaluation by farmers in on farm trials and demonstration plots

CIAT and EMBRAPA will provide natural enemy shipments to IITA upon request via the International Quarantine for Mite Predators, University of Amsterdam CIAT will also provide natural enemies to EMBRAPA upon request via quarantine facilities at Centro Nacional de Pesquisa para Defesa da Agricultura (CNPDA), Jaguariuna, Sao Paolo CNPDA will provide taxonomic services to all project collaborators

Timetable for South America

Research and Training Activities 1993 1996

Activity	Site	1993	1994	1995	1996
DIAGNOSIS					
Socioeconomic	BA	JAN DEC			
Phytosanitary constraints	BA, CE, PE	JAN DEC	JAN DEC		
TESTING AND ADAPTATION					
Farmer trials	BA CE, PE			JUL-DEC	JAN DEC
Demonstration trials	BA, CE, PE			JAN DEC	JAN DEC
STRATEGIC RESEARCH					
CGM fungal pathogen strain selection	BA CIAT	JAN DEC	JAN DEC	JAN DEC	
Root rot etiology	BA CE, CIAT	JAN DEC	JAN DEC		
Identify alternate pathogen hosts	BA, CE, PE	JAN DEC	JAN DEC		
Habitat management	BA		JAN DEC	JAN DEC	
Feasibility of Phytoseiid introductions	BA CE, PE	JAN DEC	JAN DEC	JAN DEC	JAN DEC
Mulching	BA	JAN DEC			
Impact assessment					
Effect of pathogens on non target organisms	JA		JAN DEC		
Screening for negative environmental effects	BA		JAN DEC	JAN DEC	JAN DEC
Modeling	CIAT, BA	JAN DEC	JAN DEC	JAN DEC	JAN DEC
METHODOLOGY DEVELOPMENT					
Decentralized mass rearing	CIAT	JAN DEC	JAN DEC		
Culture methods for Neozygites	BA CIAT	JAN DEC	JAN DEC		
Natural enemy field releases					
Phytoseiids	BA		JAN DEC	JAN DEC	
hornworm baculovirus	BA		JAN DEC	JAN DEC	
Cladosporium	BA		JAN DEC	JAN DEC	
Root pathogen antagonists	BA, PE, CE		JAN DEC	JAN DEC	
TRAINING/NETWORKING					
Develop training materials	BA CIAT	JAN DEC	JAN DEC	JAN DEC	JAN DEC
Train researchers					
internal					
workshop (15)	BA CIAT	MAR		MAR	
in-service (15)	BA CIAT	JAN JUN			
from related crops					
workshop (10)	BA CIAT		MAR		MAR
Train extension workers (3)					
2 wk course	BA	OCT			
Train trainers (5)					
2 wk course	BA		OCT		
Train extensionists (45)					
1 wk course	BA CE, PE		NOV DEC		
Train farmers (450)					
field days	BA CE, PE			Mar/Jul/Oct	Mar/Jul/Oct
Train community leaders (45)	BA, CE, PE		AUG		AUG
SUPPORT ACTIVITIES					
Develop information management systems	CIAT	JAN DEC	JAN DEC	JAN DEC	
Mass production of natural enemies	PE	JAN DEC	JAN DEC	JAN DEC	JAN DEC
Phytoseiids	BA		JAN DEC	JAN DEC	JAN DEC
	BA	JAN DEC	JAN DEC	JAN DEC	JAN DEC
Neozygites	BA		JAN DEC	JAN DEC	JAN DEC
Baculovirus	BA		JAN DEC	JAN DEC	JAN DEC
Cladosporium	JA	JAN DEC	JAN DEC	JAN DEC	JAN DEC
Taxonomic services	BA, PE, CE		JUL DEC	JAN DEC	JAN DEC
Multiplication of planting material	BA	6-8/YR	6-8/YR	6-8/YR	6-8/YR
Natural enemy shipments	JA	JAN DEC	JAN DEC	JAN DEC	JAN DEC
Natural enemy quarantine					
MONITORING AND EVALUATION	BA, PE, CE			JUL-DEC	JAN DEC
Adoption studies					
Impact of training	BA, CE, PE		OCT DEC	OCT DEC	OCT DEC
on extension workers	BA, CE, PE			OCT DEC	JUN-SEP
on farmers	CIAT JA				SEP DEC
Prepare final report					

BA BAHIA PE PERNAMBUCO CE CEARA JA CNPDA JAGUARIUNA

Ecologically Sustainable Cassava Plant Protection
Protection in South America and Africa
An Environmentally Sound Approach

AFRICA COMPONENT

Proposed budget for 1993 1996
(in thousands of US dollars)

LINE ITEM	notes	1993	1994	1995	1996	Total
Personnel	A					
IITA protectionist		70 8	73 5	77 2	81 0	302 5
IITA productionist		70 8	73 5	77 2	81 0	302 5
IITA trainer/liaison off		87 5	99 8	104 7	110 0	401 9
IITA technicians		37 5	47 3	49 6	52 1	186 4
IITA assistants		12 5	15 8	16 5	17 4	62 1
IITA laborers		8 3	10 5	11 0	11 6	41 4
National liaison off (NARS)		50 0	63 0	66 2	69 5	248 6
Supplies and Expenses						
IITA						
Vehicle maintenance	B	6 0	18 0	18 0	18 0	60 0
Fuel	C	20 0	20 0	20 0	20 0	80 0
Expendable supplies	D	60 0	50 0	40 0	15 0	165 0
Communications	E	10 0	10 0	10 0	10 0	40 0
Scientific publications	F	5 0	5 0	5 0	5 0	20 0
NARS						
Vehicle maintenance	B	4 0	12 0	12 0	12 0	40 0
Fuel	C	40 0	40 0	40 0	40 0	160 0
Expendable supplies	D	40 0	40 0	40 0	40 0	160 0
Operations						
IITA						
Workshop	G	30 0	0 0	30 0	0 0	60 0
Group training	H	20 0	20 0	0 0	0 0	40 0
Syllabus prep	I	30 0	15 0	0 0	0 0	45 0
Translation	J	15 0	20 0	0 0	0 0	35 0
Printing	K	25 0	25 0	0 0	0 0	50 0
Document prep	L	20 0	20 0	20 0	20 0	80 0
NARS						
Field trials	M	0 0	20 0	20 0	20 0	60 0
In country training	N	0 0	15 0	25 0	25 0	65 0
Interventions	O	0 0	15 0	15 0	15 0	45 0
Travel	P					
IITA regional		40 0	40 0	40 0	40 0	160 0
IITA international		30 0	30 0	25 0	25 0	110 0
NARS		120 0	120 0	120 0	120 0	480 0

Subcontractors						
ZOPP moderator	Q	10 0	0 0	0 0	0 0	10 0
Postgrad train (Winrock)	R					
MSc local		30 0	60 0	30 0	0 0	120 0
MSc overseas		86 0	172 0	86 0	0 0	344 0
Training aids (U Florida)	S	28 0	0 0	0 0	0 0	28 0
Quarantine (U Amsterdam)	T	95 0	95 0	0 0	0 0	190 0
Mass rearing specialist	U	30 0	0 0	0 0	0 0	30 0
Systems modelling	V	0 0	45 0	45 0	45 0	135 0
Subtotal		1131 4	1290 3	1043 4	892 5	4357 6
Central Services	W					
IITA (18 8%)		164 9	181 5	132 6	103 6	582 6
NARS (4 0%)		10 2	13 0	13 5	13 7	50 3
Capital						
Vehicles	X	175 0	0 0	0 0	0 0	175 0
Computers	Y	95 0	0 0	0 0	0 0	95 0
Training equipment	Z	90 0	0 0	0 0	0 0	90 0
Field equipment	AA	80 0	30 0	0 0	0 0	110 0
Entopathology lab	AB	35 0	0 0	0 0	0 0	35 0
Mass rearing facilities	AC	290 0	0 0	0 0	0 0	290 0
Laboratory equipment	AD	65 0	40 0	0 0	0 0	105 0
Totals		2136 5	1554 7	1189 5	1009 8	5890 5

Africa Component Budget Notes

A Personnel - includes salaries and benefits for international and support staff recruited by IITA National liaison officers are recruited with each country at the level of national program officer according to the established UN scale in each country A list of allowances and benefits for international and support staff can be found in the appendix These costs are apportioned according to the time allocated to each activity Note that the 1993 budget covers only a 10 month period

B Vehicle maintenance - estimated at ca $80 per month per vehicle for routine servicing during the first year of operation These costs are apportioned according to the time allocated to each activity

C Fuel - each international scientist (3) national program coordinator (4) and national program team (4) will require sufficient fuel to cover 75,000 km per year, e g , $15,000 for IITA research $5,000 for IITA training, and $10,000 for each national coordinator and program team These costs are apportioned according to the time allocated to each activity

D Expendable supplies laboratory (chemicals for diet studies and electrophoresis, glass and plastic ware, forceps probes, cotton wool, reference Manuals) and field supplies (coolboxes, paper and plastic bags pesticides, plastic stakes spring balances) These costs are apportioned according to the time allocated to each activity

E Communications covers the cost of the post telex fax and telephone These costs are apportioned according to the time allocated to each activity

F Publications - covers the cost of publishing manuscripts in scientific journals

G Workshop a planning meeting of all national and international program participants in the project to determine objective-oriented goals review procedures, and establish operating procedures The meeting will be conducted in phases with participants in the African region meeting a few days before the global meeting

H Group training - programmed for each national program prior to a regional workshop to harmonize activities This will include an initial 1 week session in each country followed by a regional 1 week session at IITA

I Syllabus preparation - costs associated with the development and production of cassava plant protection syllabus including editing, design, layout, and production of training support materials such as audio/visual aids, pamphlets, brochures, field guides, and manuals

J Translation - all English training materials will be translated into French

K Printing cost of reproducing training materials

L Document preparation an editor to assist national programs to produce protocols and extension manuals, progress and annual reports, and scientific and miscellaneous publications These costs are apportioned according to the time allocated to each activity

M Field trials - land acquisition, preparation, planting and other costs associated with developing and maintaining on farm plots

N In-country training for national research staff, extension agents, and farmers

O Intervention e g , plots to multiply disease-free planting material, technology to produce natural enemies in-country, and other necessary technical assistance

P Travel - IITA - regional research ca 200 scientists-days per year @ $150 per day, training/liaison ca 65 scientists-days per year @ $150 per day, IITA - international research ca five 10-day trips @ $4,000 per trip for project staff to confer with South American and other international colleagues Travel includes tickets and per diems NARS covers daily and overnight expenses (ca 500 staff-days per year @ $60 per day for coordinator, three scientists and support staff) Note that rates will vary for each country These costs are apportioned according to the time allocated to each activity

Q Team Consult Berlin - consultant to moderate the objective oriented planning workshop

R Winrock International - subcontractor that will manage the African women's postgraduate and leadership fellowships

Includes support for 3 local and 4 overseas MSc fellowships the first year

S University of Florida - subcontractor that will develop and produce a CD-ROM plant protection database with an intelligent user interface

T University of Amsterdam - International Quarantine for Mite Predators and Pathogens, subcontractors for quarantine services

U Mass Rearing Specialist - consultant to develop and decentralize mass rearing technologies to national programs

V Systems modeling - subcontractor to develop a multidisciplinary computer simulation model linking ecological, agronomic and socioeconomic parameters with a university still to be determined

W Central services - 18 8% for IITA activities and 4% for NARS activities An accounting of these charges is provided in the project appendix

X Vehicles - 4X4 vehicles (landcruisers and pickups, as appropriate, given the road conditions in each country) and a minivan This includes one vehicle per international scientist (3) and national coordinator (4), plus a pool of two vehicles to support regional research and training activities, surveys in the larger countries, and to replace damaged vehicles These costs are apportioned according to the time allocated to each activity

Y Computers - for information management data analysis, resource management and development, graphics, and communications Two large-capacity workstations with graphics support (laser printers) to develop and manage regional databases and other information resources, e g , newsletters, publications, and bibliographies For the field and laboratory operations, national and international scientists will each operate on similar hardware (portable computers, inkjet printers, CD ROM drive, harddisk backup medium) and software platforms (word processing, database, spreadsheet, statistics graphics), and have the capacity to prepare reports digitize and manage data access CD-ROM and other database media, and communicate locally and remotely within the region These costs are apportioned according to the time allocated to each activity

Z Training equipment - slide and overhead projectors, photographic and video equipment, blackboards, electronic stencils photocopying machines, and portable tables and chairs

AA Field equipment - portable weather station, portable refrigerator ground positioning system, altimeter, weighing scales, and water and fuel reservoirs

AB Entomopathology lab - laminar flow hood, autoclave, incubators, remodeling facilities to insulate against possible contaminants, and adding an electrophoresis unit, e g , precision power supply, gel molds, band separation basin water distiller

AC Construction and upgrading of ca 800 m^2 of mass rearing facilities to provide the natural enemies required by the national programs (e g , clean cassava cuttings and natural enemy amplification) during the life of the project This includes a new screen house with the following elements - structure ($25,000), roofing and screens ($23,000), climate control ($22,000) and transport and construction ($20,000) for a total of $90,000 And upgrading existing greenhouses with structural modifications ($50 000) climate control equipment ($50 000) and transport and installation ($10,000) for a total of $110,000

AD Laboratory equipment - phase contrast (IITA), fluorescent (IITA), binocular microscopes, hygrothermographs, humidifiers and dehumidifiers electronic balance, leaf temperature meter portable photosynthesis analyze, refrigerator, and drying oven

SOUTH AMERICA COMPONENT

Proposed budget for 1993 1996
(in thousands of US dollars)

Portion Administered by CIAT

LINE ITEM	1993	1994	1995	1996	Total
Personnel					
International					
Entomologist	85	89	94	98	366
Information Specialist	50	53	55	58	216
Local					
Entomologist	32	34	35	37	138
Rearing Specialist (1)	11	12	12	13	48
Insect Pathologist (1)	12	13	13	14	52
Database Mgt Assistant (1)	8	8	9	9	34
Laboratory Technicians (3)	21	22	23	24	90
Field Workers (4)	19	20	21	22	82
Total personnel	238	251	262	275	1026
Travel					
International	16	16	14	14	60
National	5	6	6	7	24
Total travel	21	22	20	21	84
Operations					
Supplies	25	28	32	30	115
Vehicles (Fuel maintenance)	7	7	7	7	28
Natural enemy shipments	3	3	3		9
Telecommunications	2	2	2	3	9
Publications/Presentations	2	2	3	4	11
Contingencies	3	3	3	3	12
Total operations	42	45	50	47	184
Consultancy					
Travel	10	10	8	8	36
Per diems	5	5	4	5	19
Total consultancy	15	15	12	13	55
Indirect Costs	63	67	69	71	270
Capital					
Computer hardware/software	25	5	2		32
Microscope	15				15
Electrophoresis equipment	5				5
Hydrothermographs	5				5
Air conditioners/extractors	10				10
Laboratory modifications	25				25
Liquid N canisters	3				3
Insect pathology equipment	5	3			8
Other		4	4	4	12
Total capital	93	12	6	4	115
CIAT TOTAL	472	412	419	431	1734

SOUTH AMERICA COMPONENT

Proposed budget for 1993 1996
(in thousands of US dollars)

Portion Administered by EMBRAPA

LINE ITEM	1993	1994	1995	1996	Total
Personnel					
Environmentalist	28	29	31	32	120
Extension Specialist	28	29	31	32	120
Insect Pathologist	28	29	31	32	120
Acarologist	35	37	39	41	152
Training Coordinator	28	29	31	32	120
Secretary	7	7	8	8	30
Laboratory Technicians (6)	30	32	33	35	130
Field Workers (5/10)	10	11	22	23	66
Total personnel	194	203	226	235	858
Travel					
International	16	16	16	16	64
National	30	30	30	32	122
Total travel	46	46	46	48	186
Operations					
Supplies	32	32	35	35	134
Vehicles (Fuel maintenance)	15	16	17	18	66
Natural enemy shipments	3	3	2	2	10
Telecommunications	5	5	5	5	20
Publications/Presentations	2	2	3	4	11
Quarantine service		15	15	15	45
Contingencies	5	5	5	5	20
Total operations	62	78	82	84	306
Consultancy					
Travel	8	8	8	9	33
Per diems	4	4	4	5	17
Total consultancy	12	12	12	14	50
Indirect Costs	13	14	15	15	57
Implementation and training					
Equipment (Audiovisual etc)	20				20
Publication didactic materials	5	10	10	15	40
Room and board (Trainees)		12	12	12	36
Travel (Trainees)		10	10	10	30
Support to collaborative Inst	25	25	28	28	106
Demon plots/Field days		10	15	15	40
Multiplication planting materials	6	15	10	10	41
Pilot production natural enemies		5	10	15	30
Total Implementation and training	56	87	95	105	343

Portion of Budget Administered by EMBRAPA Continued

Capital					
Computer hardware/software	20	5	2		27
Vehicles (3)	25			10	35
Microscope	15				15
Environmental chamber	5				5
Electrophoresis equipment	10				10
Hydrothermographs	5				5
Air conditioners	3				3
Laboratory modifications	10				10
Greenhouse	20				20
Photographic equipment	3				3
Office equipment	6	2		2	10
Other	4	4	4	3	15
Total Capital	126	11	6	15	158
EMBRAPA TOTAL	509	451	482	516	1 958

SOUTH AMERICA BUDGET SUMMARY

CIAT Subtotal	472	412	419	431	1 734
EMBRAPA Subtotal	509	451	482	516	1 958
SOUTH AMERICA TOTAL	981	863	901	947	3 692

CIAT Budget Notes

Personnel includes arrival allowance, salaries and benefits for international staff, salaries and benefits for national staff, plus allowance for an annual increment of 5% International staff includes one senior scientist and one senior research fellow for the positions of entomologist and information specialist, respectively The entomologist will also serve as the project coordinator for South America

Travel covers all local and international expenses including tickets and per diems

Operations covers vehicle maintenance, fuel, expendable laboratory and field supplies, costs of operating field trials and maintaining cultures of natural enemies pests and pathogens, natural enemy shipments, telecommunications, publication and presentation costs, and contingencies

Consultancy covers the costs of air travel and per diems for experts from the University of California, Berkeley and Texas A & M University participating in collaborative systems modeling for the project and for consultants from other institutions working in cassava crop protection research

Indirect costs are calculated as 20% of the total personnel, travel, operations and consultancy costs per year

Capital includes the purchase of specialized instruments and laboratory equipment, computers, and laboratory modifications

EMBRAPA Budget Notes

Personnel includes salaries and benefits plus a 5% yearly increment for national staff hired to complement the staff to be provided by the EMBRAPA centers CNPDA, CNPMF, CPATSA, and state agricultural and extension institutions in Brazil The Brazilian contribution to personnel is detailed separately (see budgets)

Travel as per CIAT

Operations as per CIAT

Consultancy as per CIAT

Indirect costs are calculated as 4% of total personnel travel, operations, and consultancy per year

Training covers the costs of equipment, preparation of manuals, audiovisuals and other didactic material, overland travel room and board of trainees, support to collaborating institutions (CPATSA, CNPDA, state research and extension institutes in Ceara, Bahia, and Pernambuco), and the costs of operating demonstration plots, field days and farmer trials, including production of natural enemies

Capital includes the purchase of 3 vehicles computer equipment and software specialized instruments and equipment laboratory modifications, and greenhouse construction costs