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Ecologically Sustainable Cassava Plant Protection: A Global Strategy

A project proposal submitted by the

International Institute of Tropical Agriculture

(coordinating agency for Africa in collaboration with participating national programs in Benin, Ghana, Nigeria, Cameroon, Uganda and Mozambique)

and the

International Center of Tropical Agriculture

(coordinating agency for Latin America in collaboration with participating national programs in Brazil, Paraguay, and Cuba)

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Table of Contents

EXECUTIVE SUMMARY

Cassava, a tropical root crop, is increasingly important as a food and income source for the rapidly expanding rural and urban populations in Africa and Latin America, playing a key role in poverty alleviation. The storage roots are processed, usually by women, into various food products and animal feed ingredients for domestic use and export. Cassava is also an emergency food reserve under adverse environmental and socio-political conditions when most other crops fail. However, pests[1] and poor agronomic practices reduce cassava crop production by an estimated 50%. The losses affect more than 300 million of the world's poor, including as many as 43 million malnourished children. The diversity and geographic range of cassava pest constraints require comprehensive regional R&D approaches to develop and implement holistic intervention technologies that improve cassava plant health, increase yields and ensure good production environments. A previous UNDP-sponsored project "Ecologically Sustainable Cassava Plant Protection in South America and Africa" (known as ESCaPP in Africa and PROFISMA in South America) executed by IITA and CIAT in collaboration with the NARS in Benin, Ghana, Cameroon and Nigeria in Africa and Brazil in Latin America made significant achievements in this regard. However, there remains the need to address further plant protection constraints to cassava production at regional and national levels in new regions, and on prioritized constraints in previously served regions.

At the request of regional organizations and participating countries, the ESCaPP/PROFISMA paradigm will be implemented in three regions with a mix of five previously served countries and four new countries. This geographic coverage includes the previously served countries Benin, Cameroon, Ghana and Nigeria (West and Central Africa), new countries Uganda and Mozambique (East and Southern Africa), and in Latin America, Brazil (previously served), Cuba and Paraguay (new countries). Working through existing national R&D structures in the three regions, the project will establish innovative models for the development of integrated pest management (IPM) in cassava by diagnosing, prioritizing and investigating key plant protection constraints; develop, test and adapt sustainable IPM technologies to control the most important cassava plant protection problems; extend and adapt biological control and other IPM technologies which have reduced key pest populations and increased root yields by at least 30% in targeted agroecological zones; and strengthen participatory research and training expertise to address current and subsequent pest problems.

The proposed new project has a modular structure focusing on regional R&D activities to underpin country-specific modules in six countries in Africa and three countries in Latin America.

- Regionally, extensive diagnoses by multi-disciplinary teams will provide inputs needed to establish R&D priorities. In Africa, the strategy is to

[1] "pests" includes arthropods, vertebrates, pathogens and weeds

concentrate on collaborative activities in the six targeted countries and with potential NARS collaborators in associated countries. Plant protection themes that cut across major agroecological, environmental, production or socio-economic concerns, the development of postharvest processing and marketing micro-industries, specialized training of researchers and extensionists in IPM disciplines and in participatory methods and processes will be emphasized. Also, cassava information resources will be updated and distributed world-wide. In collaboration with NARS and donor partners, the project will evaluate its capacity to deliver planned activities and to increase cassava productivity on small farms with minimal environmental degradation.

- In country-specific modules, project activities will be contingent upon and incremental to underpinning regional modules. The activities focus on training and technology implementation, are restricted to targeted countries but, subject to modular funding, can be extended to associated countries where regional modules exist. Specifically, country modules will institutionalize participatory methods and processes for cassava IPM research, training and implementation; promote cassava IPM implementation, particularly in stem cutting (vegetative planting material) sanitation, biological and cultural control, evaluation of germplasm, postharvest IPM and pilot postharvest processing plants; train extensionists and farmers groups in cassava IPM; promote experimentation by farmers at Farmers Field Schools (FFS) in Africa and farmer participatory research committees (COPALs) in Latin America targeting more women farmers; and prepare decision support materials for cassava IPM research, training and implementation.

The targeted beneficiaries of the project are farmers, extensionists and researchers associated with participating national and international research institutions. These partners will benefit from reduced pest load, increased IPM capacity to manage cropping systems and to increase and stabilize cassava productivity, provide income and food security, and foster a pesticide-free environment. R&D organizations will benefit from international collaboration and exchange of information and genetic resources.

PROJECT OBJECTIVES

Goal

To increase and stabilize the productivity of small-scale cassava-based agricultural production systems to alleviate rural poverty and increase food security in Africa and in Latin America.

Purpose

To enhance national and regional capacity in integrated pest management (IPM), biological control, training and participatory methods and processes to reduce cassava losses caused by pests, poor production and postharvest practices.

Expected Results

1. Principal constraints to cassava production and postharvest IPM identified and sustainable intervention technologies developed, tested and implemented against national/regional priority constraints and adopted by farmers to reduce cassava losses in targeted regions.

2. Human resources enhanced through training, participatory methods and processes to integrate farmers, extensionists and researchers as partners in cassava plant protection and post-harvest technology development.

3. Cassava information resources developed, tested and adapted for sustainable cassava plant protection and post-harvest interventions and to facilitate future implementation of similar efforts in other regions.

4. National multidisciplinary teams assembled and equipped with technical and material resources needed to foster interdisciplinary approaches to integrated cassava plant protection R&D activities in participating countries and regions.

Time Frame

Four years beginning in 1998

Budget: (Regional and country-specific activities)

West and Central Africa[2]	$4,122,600
East and Southern Africa[3]	$2,527,900
Latin America[4]	$5,281,700

[2] West and Central Africa countires: Benin, Ghana, Nigeria and Cameroon.
[3] East and Southern countires: Uganda and Mozambique.
[4] Latin America countires: Brazil, Paraguay and Cuba.

A. CONTEXT

A.1 Introduction

Cassava, *Manihot esculenta* Crantz (Euphorbiaceae), a woody perennial shrub from the Neotropics, occurs worldwide, generally between latitudes 30°N and 30°S from sea level up to 2300 m near the equator. The crop is common in lowland tropical regions receiving between 750 to 3000 mm rainfall. It is a key component of the traditional cropping system in most of the lowland humid and sub-humid tropics in Sub-Sahara Africa (SSA) and in many poor regions in Latin America. The crop is relatively easy to grow, even under harsh agronomic conditions. It is cultivated by planting vegetative cuttings, usually during the wet season, and optimally harvested 8 to 18 months after planting, but sometimes up to 36 months after planting. Although cassava grows best in deep loamy soil of reasonable fertility, it is capable of providing a reliable food source in soils too depleted to support most other food crops. Consequently it is often planted in marginal areas. Once rooted, cassava can withstand prolonged periods of drought and pest attacks by reducing biomass production and remobilizing food reserves from the stems and roots. Cassava is frequently an emergency food reserve crop under adverse environmental and socio-political conditions when most other crops fail and there is insufficient alternative food supplies.

Cassava is a plant of indeterminate growth, both the aerial portion of the plant and the storage roots increase in biomass simultaneously. It has no distinct critical period during which fruit and/or seeds must develop prior to harvest, therefore cassava is more tolerant to pest attacks compared to many other crops. However, there is considerable genetic variation in the production and allocation of dry matter within plants between cassava cultivars. Thus, the impact of the major cassava pests on cassava production depends largely on the time of attack relative to the age of the host plant, the genetic susceptibility of the cultivar, length of drought stress and soil conditions. These various attributes of cassava have largely contributed to the crop's widespread adoption as an important and dependable source of calories in the poorer regions of the developing world.

Cassava is increasingly important as a food and income source for the rapidly expanding rural and urban populations in Africa and Latin America. The storage roots are used mainly as food (fresh, boiled or in processed forms) and animal feed ingredients (chips and pellets as substitutes for grains in feed rations in poultry, pork and fish farming), and, to a lesser extent, as industrial and domestic products. The major processed food products are *gari, lafun, foufou* and *attiéké* in most of West and Central Africa, *farinha de mandioca* mainly in Brazil and its neighboring countries or various breads such as *casaba , pan de bono, pão de queijo* and *chipa* in Latin America. The IITA project, "Collaborative Study of Cassava in Africa", COSCA[5] estimates that *gari* alone accounts for 70% of cassava

[5] Al-Hassan, R. M (1989): COSCA Working Paper # 11. IITA.

consumption in Nigeria and 40-59% in Ghana, Cameroon and Côte d'Ivoire. Cassava leaves are also consumed as vegetables to provide proteins and vitamins in most of West and Central Africa. According to FAO[6] , Africa's average shares of the global use of cassava as food increased from 57% in 1982-84 to 65.7% in 1992-94. In 1982-84 and 1992-94, the average annual per capita cassava food consumption in Africa were 87.8 and 96.5 kg., respectively. On a national basis, the 5 highest annual consumption rates in 1992-94 were 382, 240.6, 207.3, 203 and 178.4 kg., in the Democratic Republic of Congo (formerly Zaire), Tanzania, Ghana, Mozambique and Nigeria, respectively. In Latin America the annual per capita cassava food use in 1982-84 and 1992-94 were 28.4 kg., and 23.7 kg., respectively. Paraguay showed highest annual per capita consumption in Latin America at 158.7 kg., and 140.3 kg., in 1982-84 and 1992-94, respectively, followed by Brazil at 58.6 kg., and 48.0 kg.

Export of cassava, through increased private sector awareness of international market opportunities for cassava chips and pellets as animal feed ingredients, is strengthening the value of the crop and provides another tool in the fight against poverty. Africa and Latin America are, however, relatively small suppliers of cassava to the world market, compared to Thailand (80%) and Indonesia (10%) which together supply most of the export cassava in all its forms. Africa's average share of the global feed use increased from 6.3% in 1982-84 to 11.6% in 1992-94, but still far less than in Latin America which accounted for 37.1% and 33.1% in the respective time periods[6]. The main African exporters of cassava feed ingredients are Ghana, Madagascar, Nigeria and Tanzania. In Ghana, the initial export of 500 tons of cassava chips in 1993 increased to 19750 tons in 1996 with export earnings of ca. US $2m[7]. Cross-border/inter-regional cassava trade may also add to the economic value of cassava, but reliable records on such transactions are largely unavailable in both Africa and Latin America.

In cassava growing households in Africa, COSCA[8] estimates that approximately 26% of cash income from all food crops can be derived from sale of cassava. In such areas, cassava frequently forms the basis of cottage industries to produce *gari, lafun, foufou* and *attiéké* for domestic consumption and local/export markets. According to COSCA[9], the proportion of cassava sold by small scale producers is positively correlated with the proportion of fields owned by women. Women groups also increase their returns on cassava through an emerging import substitution for cassava flour and industrial starch in parts of Nigeria. Nigerian biscuit manufactures put a higher premium on "improved" cassava flour produced by a new method than on the traditionally produced *lafun*

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[6] Anon (1997): The World Cassava Economy: Recent trends and medium-term outlook. Chapters III and V. FAO working notes, "Workshop on Global Cassava Development Strategy", IFAD, Rome, 10-11 June 1997.

[7] Anon (1996): Cassava the Old Crop Reborn. Ministry of Food and Agricluture, Ghana.

[8] Nweke, F. I (1996): COSCA Working Paper #14. IITA.

[9] Nweke, F. I (1994): COSCA Working paper #12.

cassava flour. Some women's groups which had concentrated on *gari* production are taking advantage of this more lucrative market. Estimates indicate that with a 15% substitution rate of wheat flour with cassava, Nigeria could save up to $14.8 million in foreign exchange annually, with $12.7 million going to cassava processors and $4.2 million to cassava farmers[10]. Expanding the types of cassava products and markets would therefore further increase farmer income and local employment, especially in postharvest processing.

An example of how cassava can play a role in development is the project "Agro-industrial Development of Cassava in the Atlantic Coast of Colombia" executed by CIAT and the Colombian Integrated Rural Development Program (DRI) with additional financing by CIDA (1981-1996). This project established 2 pilot plants to produce dry cassava chips to use as animal fodder. This created a stable bottom price for cassava, which motivated farmers to independently increase their production. Within two years the price of cassava in a nearby city, Baranquilla, dropped by 27% from 4.5 to 3.3 (1978 Colombian pesos), with total benefits of about US$4 million per year to the urban population. The success of the pilot plants stimulated an expansion of small agroindustries, which numbered 192 by 1992. The region now has at least 40 plants and is selling about US$1 million of dry chips per year. Economic studies have shown, that this integrated project generated a return of US$18 for every dollar invested. The benefit to rural farmers has not been measured, nor have been the secondary profits to the users of the chips.

FAO medium term outlook[6] indicates that global demand for cassava as direct food is likely to rise by 2.2% annually, from 95 million tons in the early 1990s to 124 million tons by the year 2005, mainly as a reflection of demographic pressures in developing countries. In 1990, for example, Africa accounted for 19% of the world's poor, and this figure is expected to rise to 28% by the year 2005[11]. The demand for cassava as food on the continent is projected to rise at an annual rate of 2.5% to reach 84 million tons by the year 2005. In Latin America and the Caribbean, cassava food use is expected to increase at a far lower rate (0.8% per year) than in Africa. However, the overall trend in Latin America is towards increased use of cassava in processed products, including starch and animal feed[12]. The global demand for cassava as animal feed is likely to decline at an annual rate of 2.8% by 2005. This will largely be in response to changing trade policies favoring grain feed use in European Union countries, traditionally the major importers of the world total cassava feed ingredients, which will primarily

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[10] Djussou and Bokanga, M (1995): Cassava Flour Production-Background Information to the Site Visits. IITA

[11] Anon (1997): Towards Sustainable Development in Africa. IITA Medium-term Plan, 1998-2000. IITA.

[12] Henry, G. And M. V. Gottret (1995): Global cassava sector trends: reassesing the crop's future. CIAT, Cali, Colombia. 30pp.

affect the Asian export market. Use of cassava feed ingredients in developing countries is likely to increase in Africa and Latin America.

A.2 Host Region Strategy

Ensuring food security and sustained productivity are primary objectives of developing countries where cassava is grown. Cassava plays a critical role in many regions providing a secure source of calories; however, it is also a cash crop, which offers the possibility of increasing farmer income. Improving processing, utilization and markets will foster increasing productivity, which will help supply a growing population with nutrition and employment. 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.

A.3 Prior and Ongoing Assistance

IITA and CIAT both maintain regional R&D activities directed at the production, processing, utilization and marketing of cassava. In an effort to develop a inter-regional strategy for sustainable production based on improved plant protection, a joint IITA and CIAT project was recently implemented. The Ecologically Sustainable Cassava Plant Protection (ESCaPP) project began in 1993 as a regional project to develop, test and adapt sustainable cassava plant protection technologies for the most important pests in Benin, Cameroon, Ghana and Nigeria with a parallel component in northeastern Brazil involving CIAT. Multi-disciplinary teams of national plant protection experts joined regionally with international experts to share expertise and pool efforts across agroecozones. Project activities were divided into three interrelated and overlapping phases. The major cassava pests were identified in targeted agroecozones through initial diagnostic surveys. In the second phase, farmers' participation highlighted the development and testing of appropriate intervention technologies. Concurrently, in-service training was provided to researchers, extension agents, and farmers in the principles and practices of sustainable crop production and protection. Postgraduate training was offered to women to strengthen their professional resource base in plant protection development activities. The third phase has been an evaluation of the training objectives and technology implementation. Unique features of the project included nationally seconded

multi-disciplinary teams, shared local expertise on a regional basis and activities based on local diagnoses. The project has become a model for integrating multi-disciplinary plant protection R&D. The original ESCaPP/ PROFISMA project built on a long collaboration between IITA and CIAT in cassava development that included exploration in Latin America for natural enemies of cassava pests introduced into Africa, mapping of climate homologies between the continents, evaluation of natural enemies, and exchange of germplasm, expertise and knowledge.

Major accomplishments

ESCaPP created a paradigm for addressing cassava plant protection that never before existed in the participating countries or in the region. The project established local networks of scientists, extension agents and non-governmental organizations (NGOs) to respond to the demands of client farmers. Thus, scientists and their technologies had direct access to interested farmers through existing national structures. The research, training, implementation and evaluation paradigm of ESCaPP/PROFISMA is a model for appropriate sustainable crop management. Specific accomplishments of the PROFISMA/ ESCaPP project by 1997 include:

Global Achievements

- Explored and introduced natural enemies from Brazil and northern South America into Africa for control of the cassava green mite.
- Mapped climate homologies between regions of South America and Africa for targeting natural enemy explorations.
- Characterized the biological and genetic attributes of natural enemies
- Conducted specialized training for African and South American technicians.
- Compiled, produced and shared cassava information resources on CD-ROM.
- Conducted technical exchange visits and global project coordination meetings between Africa and South America.

Achievements in Africa

Intervention Technology Development, Testing & Dissemination:

- Diagnosed cassava agroecosystems in the target countries for seasonal plant protection, agronomic and socioeconomic production constraints; digitized

survey database as a basis of cassava R&D priority setting, nationally, regionally and/or by agroecozones.

- Identified research and implementation priorities for specific ecozones based on the results of diagnostic surveys.

- Established 27 collaborative research activities with NARS scientists for technology validation and generation and to strengthen existing institutional capacities in the region. On a competitive basis, 29.6% of the activities were in each of Benin and Nigeria, 25.9% in Ghana and 14.8% in Cameroon.

- Implemented classical biological control of the cassava green mite and the pest's populations declined an average of two thirds and yields increased by a third in the target areas where the exotic natural enemies were established - an added value estimated at US $70 per hectare, which when extrapolated over the region may be as much as US $50 million per season.

- Decentralized to the NARS partner institutions appropriate biological control technologies for local mass rearing of imported natural enemies.

- Discovered two new cassava diseases (*Curvularia* leaf and stem blight and *Nattrassia* root and stem rot) in Benin, Ghana and Nigeria.

Human Resource Development:

- Prepared a unified curriculum for sustainable cassava plant protection training based on identified needs of farmers, extensionists and researchers.

- Conducted in-country training of over 194 extension trainers, 1800 extension agents and 2400 farmers' groups in the region; and established at least 25 cassava Farmer Field Schools within the NARS extension and NGOs systems for action learning and research by farmers.

- Conducted specialized training of over 24 national researchers in various NARS cassava R&D need areas.

- Increased the professional human resource base of women agriculturists through training of 12 African women scientists at post-graduate level in various plant protection and rural development disciplines.

Information Resource Development:

- Developed a CD-ROM of hyper-linked cassava information resources which includes directories of personnel, institution, cassava projects; databases of grey literature, existing bibliographies, field guides, handbooks, general cassava references and databases for cassava plant protection decision making, most of which were initially created by the project.

- Mapped ecosystem-based national and regional incidence and severity of pest, agronomic and socioeconomic cassava production constraints.
- Prepared a new set of didactic cassava IPM materials targeted at extension trainers and farm-level use for training, awareness and management of pest and agronomic cassava production constraints.
- Compiled indigenous knowledge on cassava plant protection and production in 2 target countries.

Mechanisms for Coordination:

- Established and equipped multi-disciplinary national project teams to work in interdisciplinary approach with other collaborating NARS researchers, extensionists and trainers for cassava R&D activities. This model has been adapted for other R&D activities at IITA and in participating countries.

Achievements in Latin America

Biological Control:

- Introduced and established 3 species of parasitoids for control of the cassava mealybug *Phenacoccus herreni* in Northeast Brazil.
- Established a phytoseiid predator mite from northern South America in Northeast Brazil for control of the cassava green mite.
- Developed methods for the production and genetic characterization of the fungal pathogen *Neozygites* for control of the cassava green mite in Africa.
- Participated in the biological control of cassava green mite in Africa in collaboration with ESCaPP through climate homologue mapping, and collection and biological and genetic characterization of pest and predator mites.
- Identified whitefly parasitoids including 4 new species and mapped whitefly and parasitoid distributions in northern South America.
- Identified antagonistic microorganisms for control of root rot pathogens.

Genetic Control:

- Identified sources of host plant resistance to the cassava green mite.
- Developed inoculation (bioassay) and genetic characterization methods to screen germplasm for resistance to root rot pathogens.

- Conducted genetic characterization of cassava vein mosaic virus (CVMV), providing the basis for creating a test kit to determine if plant material is infected.

- Identified sources of host plant resistance to whitefly (*Aleurotrachelus socialis*).

Farmer Participatory Research (FPR):

- Conducted extensive and intensive participatory diagnostic surveys of >1,600 cassava growers in NE Brazil through which the biotic and abiotic production constraints in small-scale cassava production systems were identified, emphasizing farmers' perceptions and priorities.

- Trained 51 state extensionists and national program scientists in FPR methods.

- Established 20 Local Agricultural Research Committees (COPALs) in 4 states of NE Brazil.

- COPALs planted and evaluated two cycles of experiments in their communities addressing production constraints identified by their communities.

- Internalized farmer participatory research approach into national program and state agency development strategies.

A.4 Institutional Framework

A.4.1 Current Research Programs

IITA's mission is to improve the nutritional status and well-being of poor people in the humid and subhumid zones of sub-Saharan Africa by conducting research and related activities in collaboration with other institutions to increase sustainable agricultural production. The research focus is on food crop production, and soil and crop management. IITA maintains a comprehensive cassava production strategy through plant protection, commodity improvement and crop management R&D activities in three complementary research divisions. The Resource and Crop Management Division (RCMD) has relevant activities in projects designed to 1) arrest resource degradation through the development of short fallow systems and 2) to increase the productivity and cash income of smallholders through the diversification of farming systems. The Commodity Improvement Division (CID) has relevant activities in projects that 1) develop, evaluate and promote improved and adapted cassava germplasm, and 2) increase income-generating capacity and improve the nutritional status of farmers, processors and consumers. The Plant Health Management Division (PHMD) has five projects to develop and implement sustainable plant protection

technologies for a range of commodities and agroecosystems. Linkages between divisions is maintained through research on constraints and socio-economic factors that affect the entire production system.

At IITA, there is an evolving strategy for an institutional approach to cassava R&D. The ESCaPP project falls within this approach in which related core and special projects compliment each other to enhance farm-level cassava production, plant protection, post-harvest and utilization in Africa. The projects are components in an institute-wide system of "internal producers and consumers" in which results of discipline specific projects feed into others. In the control of the cassava green mite, for example, ESCaPP integrates host plant resistance with biological control through collaboration with another IITA project to evaluate cassava germplasm with sources of the pest's resistance into agronomically acceptable cultivars offering a further potential for control of the pest. Similarly, to increase the profitability of cassava producing systems, another IITA project which generates a range of postharvest technologies to provide competitive commercial options for farmers, processors and consumers in the food, feed and agro-industrial sectors will serve as an internal source of input into ESCaPP. These kinds of linkages enable IITA projects to focus on their respective core identities whilst tapping into internal expertise/resources to impact on specified development objectives. Project implementation planning tools (e.g., a detailed Plan of Operations) identify key areas in which the system of "internal producers and consumers" provide the desired synergy between projects to enable IITA to impact on its agricultural development objectives. The project is, therefore, a cassava plant protection project with existing and potential linkages with other IITA projects which have a comparative advantage in specific areas to further increase the productivity and profitability of cassava production systems in SSA.

PHMD has evolved from a project targeting two pests of cassava to a full division dedicated to sustainable plant protection of primary food crops in Africa. The division'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. Division 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, cowpea pests, mango mealybug, weevils on banana and plantains and a range of foliar, stem and root diseases of the mandate crops.

Recent independent reviews of PHMD in general, and ESCaPP in particular, praised the "increasing involvement of NARS scientist as genuine collaborators, and the stronger links being developed in the field", and recommended ESCaPP

as a model for other IITA IPM collaborative activities with NARS. The evaluation report[13] of the IITA Centre Commissioned External Review of PHMD, commended the mixed portfolio of basic, strategic and applied research, and in particular, the emphasis on strategic or applied research was regarded as appropriate given specific NARS capacities. In a report by the UNDP commissioned External Advisory Committee[14] on ESCaPP, the experts observed that "The achievements of ESCaPP have already yielded economic, social, scientific and environmental benefits for West Africa". The same team recommended that "Because of the remarkable success of the first phase of [the project], and the probability of continuing success in the future, the Project Leaders of both ESCaPP and PROFISMA should be encouraged to apply for support of a second phase of the project."

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. The emphasis of this mission is on growth, equity and enhancement of the resource base. In order to fulfill this mission, CIAT pursues various avenues of research related to sustainable crop production, plant protection, postharvest processing, market development and natural resource protection. Gender and equity play increasing important roles in influencing research objectives and activities. Scientists working on cassava collaborate closely with national programs, such as EMBRAPA, the Brazilian national agricultural research agency, in the local development and adaptation of technologies and in the training of national scientific and extension personnel. CIAT has also worked closely with IITA in the deployment of classical biological control of the cassava mealybug and the cassava green mite in Africa, exchange of cassava germplasm, and in basic research on cassava pests. The internal organization of research at CIAT has changed from one focusing on programs (such as the former Cassava Program) to one involving projects, of which there are currently 16. The objective of this change was to design a system that encouraged more interdisciplinary collaboration, provided more transparency of our CIAT's activities to donors, and permitted flexibility to focus research on specific problems only so long as they justified attention. Some of the projects involved in cassava research include:

- Integrated Conservation of Neotropical Genetic Resources (SB-1),
- Roots and Development: Genetic Enhancement of Cassava with a Global Perspective (IP-3),
- IPM for a Safer Environment: Integrated Pest Management in Major Agroecosystems in the Americas (PE-1),

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[13] Anon (1996): Report of the Internally Commissioned External Review Panel on PHMD-related Projects at IITA. IITA.

[14] Anon (1996): Report of the External Advisory Committee. GLO/91/013 Ecologically Sustainable Cassava Protection in South America and Africa (ESCaPP). UNDP.

- Productive and Regenerative Agricultural Systems for Marginal and Degraded Soils of Tropical Latin America (PE-2)
- Integrated Resource Management for Intensifying Smallholder Systems (PE-5),
- Rural Agroenterprise: Linking Smallholders to Growth Markets for Improved Resource Management (SN-1),
- Methods of Farmer Participation in Research and Gender Analysis for Technology Development (SN-3).

New projects are always developed directly with national programs. The new project proposals with Brazil, Paraguay, Cuba and Ecuador that are closely linked to the present proposal, each originated when these countries approached CIAT with proposal drafts and a request for CIAT to collaborate and help in proposal development and project execution.

CIAT scientists are dedicated to applying farmer participatory research (FPR) methods, which were originally developed by CIAT's Participatory Research Unit, to develop, evaluate and adapt new technologies with farmers for improved cassava germplasm, crop management, integrated pest management and postharvest processing. CIAT has found FPR to be extremely productive because early input from farmers helps to prioritize research objectives and identify potential solutions that are most likely to be adopted. Farmer-conducted field trials reduce research costs, and participating farmers become teachers of their peers and accelerate the dissemination of the new technologies.

CIAT has also pioneered a highly successful demand-driven integrated approach to crop commodity research and development, which is currently being applied in cassava R & D projects. First, local market opportunities for various cassava products are identified and characterized, with particular emphasis on value-added products that can increase the income of farmers and rural processors, and that have elastic demand, which helps to stabilize prices in the presence of seasonal and annual fluctuations of supply. Given access to such markets, farmers have incentives to increase production and adopt new technologies for production, crop protection and postharvest processing. Meanwhile, surveys of farmers identify principal local constraints to production and increasing prosperity. Farmer participatory methods are used to identify, develop and test technologies to solve farmer problems in selected communities (pilot sites). Technologies approved by these farmer research committees are then disseminated over the surrounding area by farmer field days and extension programs. Input from farmers is repeatedly used to evaluate effectiveness and adoption of the new technologies and to target new research objectives.

The Land Uses Unit at CIAT provides geographic information systems (GIS) capability, which is used to define and map cassava microregions in Latin America, integrating edaphoclimatic and socioeconomic data. This has greatly facilitated targeting regions to explore in the search for biological control agents that would be best adapted for release in Africa or other Latin American

countries. The CIAT biotechnology Unit provides powerful new molecular tools (RAPD, AFLP, gene sequencing, DNA probes) to help identify new species and strains of pests and biological control agents, and to detect them in field samples.

A.4.2 Current Outreach and Training Programs

IITA - The institute's outreach and training program creates a bridge between national programs isolated in the cassava belt of Africa, 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 cassava-related training aims at broadening the knowledge and skills base of national programs in the theory and practice of sustainable crop improvement, research and crop management, plant health management and post-harvest development. In 1988-1992, cassava plant protection training was mainly on biological control, and organized by the then IITA Africa-wide biological control project. Within this period, classical biological control interventions by IITA and its collaborators reduced the status of cassava mealybug from a major pest problem to minor one in Africa[15]. The benefits included significant yield increases and a strengthened regional capacity to tackle new/other pest problems. In terms of training, 558 biological control training courses were provided, distributed as 51%, 38%, 6% and 5% in-country training, centre-based short-term group training, inter-country training and general refresher courses respectively[16]. Approximately 80% of these courses were sponsored by UNDP/FAO. Within the same period a total of 54 postgraduates (13 M.Sc., 15 M. Phil and 26 Ph.D.) from 17 African countries received IPM training, mostly in cassava, under IITA supervision. The representative NARS countries are provided with the logistic means needed to support specific cassava and other crops plant protection activities. This includes modest, but timely, financial support from IITA to national programs and help in arranging bilateral funding. Building on the cassava centered outreach and training activities, IITA 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 recent years, cassava plant protection training at IITA has concentrated, through the ESCaPP project, largely on in-country and field-based training of extension agents and farmers groups to update their knowledge and skills in sustainable cassava plant protection. To date the project has trained over 194 extension trainers, 1800 extension agents and 2400 farmers' groups in Benin, Cameroon, Ghana and Nigeria; and established at least 25 cassava Farmer Field Schools within the NARS extension and NGOs systems for action learning and research by farmers. In a special effort to enhance the role of women in plant

[15] Neuenschwander, P (1990): Biological control of the cassava mealybug by *Epidinocarsis lopezi* in Africa: a review of impact. IITA *Research* 1: 1-4.

[16] Anon (1992): UNDP Country Information Source. Africa-Regional Biological Control of Food Crop Pests. RAF/87/142 Country Information Source. IITA

protection in Africa, IITA has a training collaboration 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 IITA/Winrock collaboration aims to improve women's credentials, skills, positions, and influence in four arenas of agriculture and the environment: policy, management, research, and extension by preparing 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. In 1993-97, 12 women candidates were provided with academic training post-graduate fellowships.

CIAT - 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 addition 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.

B. PROJECT JUSTIFICATION

B.1 Present Situation and Problems to be Addressed

While the population in sub-Saharan Africa (SSA) continues to grow at about 3% at year, per capita food availability, currently only 82% of the average for developing countries, is not keeping pace. In 1990, SSA's share of the world's poor was 19%[11]. This is projected to increase to 28% by the year 2000 - more than 300 million people including as many as 43 million malnourished children. Investment in agricultural research by the public sector as a share of the agricultural GDP has also declined drastically, as has overseas development assistance in recent years. There is also concern that as much as 10% of the

overall consumption in the region is based on consumption of assets, particularly natural resources. SSA is characterized by vast areas of low fertility, fragile soils and erratic rainfall. As much as 65% of the agricultural land is affected by degradation with more threatened. Addressing these problems will require interventions in natural resource management, sustainable food security and poverty alleviation.

In Latin America the 1980s were considered a lost decade in which the region's debts took on unmanageable proportions, reaching US$415 billion by 1989. Economic growth stopped, inflation became rampant and by 1990 people were 10% poorer than in 1980. Poverty affects about 37% of the population and more than 55 million people are malnourished or at serious nutritional risk. However, agriculture maintained a growth rate of 2.2%, which was higher than that for industry (1.0%). Nevertheless, the increase in food production has barely kept pace with population growth rate. During the 1990s exchange rates became realigned, generally increasing local prices, protection against imports was lowered, increasing competition, and free markets have been encouraged. A large portion of the rural poor have moved to cities; however, those remaining in the countryside occupy regions with poor soils, dry climates and hillsides, where erosion, soil degradation and deforestation are serious threats to sustainable production and conservation of natural resources. Food security for both the rural and urban poor depends on sustainable and economic production of basic staples such as cassava.

An interesting development in many parts of Latin America is the appearance of more medium-sized farms that are producing crops for local markets and export. The agricultural sector is widely regarded as an essential contributor to future economic growth, but it needs cost-reducing technologies to increase productivity, methods to add value to farm products, and methods to help conserve natural resources and restore damaged agroecosystems. Cassava has great potential to provide raw material for value-added products ranging from foods for people, feed for livestock and chickens, starch for industry and processed foods.

B.1.1 Cassava Production

Increasing food supply should improve food security, increase income, generate opportunity for new products, lower food costs, and contribute to increased commercialization. Cassava is an important crop in both Africa and Latin America. For instance, FAO[6] estimates that 50.6% and 18.2% of the global production of 162.3 million tons between 1992-94, occurred in Africa and Latin America, respectively. The higher supply in Africa was due more to area expansion than to increased productivity. Africa's average shares of the global land area under cassava increased from 54.5% in 1982-84 to 60.9% in 1992-94, while in Latin America it is 19.1% and 15.5% respectively. In Africa, over 60% of the total production of root and tuber crops is produced in the moist savanna

zone, and the remainder in the humid forest zone[17]. Cassava pest incidence and damage are generally higher in these moist and humid zones than in drier ecozones (see Table 1).

The main cassava producers in Latin America are Brazil, Paraguay and Colombia followed by Peru, Haiti, Venezuela, Bolivia, Cuba, Argentina, Dominican Republic, and Ecuador, with Brazil accounting for almost 80% of the region's cassava output. Cassava production in Latin America had remained almost unchanged at 29 million tons with a growth rate of 0.2% per year between 1983-93[6]. This stagnation has been attributed to the lack of production incentives and rising demand for cereals for food and feed. In 1992-94, Brazil was the world's second largest cassava producer at 22736 tons with Nigeria (in Africa) topping the list at 30030 tons[6]. Approximately half of Brazil's cassava production is concentrated in the Northeast, one of the poorest parts of the country. Cassava is important in this region because the environmental conditions are unfavorable for the cultivation of most other crops. In the Northeast, 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 10.8t/ha. FAO considers that a major calorie deficit problem exists in the area. The states of Bahia, Ceará, Pernambuco, Paraíba, Maranhão and Piauí are targeted for this 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.

The 5 biggest cassava producers in Africa are Nigeria, the Democratic Republic of Congo (formerly Zaire), Ghana, Tanzania and Mozambique, in that order. Between 1965 and 1995, the biggest increase in the share of production on the African continent occurred in Nigeria which increased its share from 22% to 38%, and in Ghana which increased its share from 4% to 8%. The reasons for the observed increase in production on the continent vary according to ecozones. According to IITA-COSCA databases, the 6 main reasons are the reliability upon cassava in time of famine/hunger (19.6%), pests and diseases tolerance (13.5%), higher prices and market access (9.4%), increasing population growth (8.6%), high yields (8.5%) and crop's tolerance to drought (3.2%). COSCA found that farmers across all ecozones consistently indicate the reliability of cassava in times of famine/hunger and the crop's better tolerance to pests and diseases as the most important reasons for the increasing trend. This supports the view that cassava is planted as a food security crop. Within this context, however, market related factors and trade policies drive increases in production. For example, in Nigeria, the agricultural trade policy which banned wheat and rice imports in 1987 largely stimulated cassava production from 11.2 million tons in 1982-84 to 30 million

[17] Spencer, D (1997): Cassava in Africa: Past, Present and Future. IITA.

tons in the early 1990s, amounting to a 10.4% annual rate of growth within the period.

Between 1982 and 1994, the global average yields of cassava remained under 10 tons/ha., associated with an annual growth rate of 0.6% to 9.9% for the decade[6]. In Africa, most cassava farms are less than 0.5 ha., risk prone and with average yields only occasionally exceeding 9 tons/ha., (e.g., in Nigeria, Ghana, Cameroon and Tanzania). Current average yield in Latin America is 11.2 ton/ha., while the estimated potential yield is 21.3 ton/ha[18]. The yields in Northeast Brazil (which is less-developed and drier) range from 4-10 ton/ha., whereas South Brazil (which is more developed and more humid) produces 20-25 ton/ha. Current rates of production are 5.2 ton/ha., in Cuba, 14.8 in Paraguay, and 4.3 in coastal Ecuador. Yield and area planted remained constant for all of Latin America during 1984-93. However, in Colombia the annual growth rates for the same period were 2.3% for yield and 1.2% for area cultivated. These increases occurred primarily in the North Coast, which is seasonally dry. The increases can largely be attributed to the impact of joint CIAT-Colombian projects that helped evaluate and distribute new cassava varieties and develop postharvest processing plants using the methods of farmer participatory research. The PROFISMA project in Northeast Brazil, which focused more on pest management, has increased yields on participating farmers' fields by up to 50%. In Africa, yields rose by 1.4% a year in the 1980s compared to 1.7% a year in the previous decade. The higher yields in the 1980s are highly associated with the provision of new higher yielding varieties and successful classical biological control of the cassava mealybug by IITA.

According to FAO's medium term outlook[6], world cassava production is projected to grow at 1.9%, from 162.3 million tons in 1992-94 to 202.7 million tons by the year 2005. The increased growth is expected to be more rapid in Africa (2.4% per year) than in the other cassava producing regions, Latin America (1.5% per year) and Asia (1.1% per year). As in the past, most of the production increase in Africa is expected to be due more to area expansion than to yield increases. In Latin America, however, the projected 1.5% growth rate will be a result of both area and yield expansion. The area under cassava is projected to increase by 1.5% and 0.7% in Africa and Latin America respectively. In Brazil, a previous reduction in area under cassava is expected to be reversed, largely in response to increased demand for both food and animal feed. In Paraguay, the area cultivated is decreasing but yield improvements are expected to compensate for the diminished area.

[18] Henry, G (1995): Global cassava sector constraints and estimated future R&D benefits. CIAT, Cali, Colombia.

B.1.2 Pest Constraints on Cassava Production

Increasing production demands together with finite agricultural resources threaten the sustainability of the cassava agroecosystems. The productive land available for cultivation will decline as the traditional fallow periods are being shortened. The poor agronomic conditions and practices ultimately degrade the natural resource base of the cassava agroecosystem and combine with pests to reduce the actual/potential value of cassava as a food security and poverty alleviation crop. In an ESCaPP participatory project planning workshop[19], the focal cassava plant protection problem in West/Central Africa was identified as "unhealthy cassava" which leads to yield and production losses. The workshop participants from IITA, Winrock International and four national programs analyzed the problem environment and summarized that the focal problem was caused by pest infestations and introductions, use of pest prone varieties, poor production practices, low soil fertility, poor cassava storage practices and inadequate farm-level cassava plant protection training and practices. Being mobile, and frequently transported via infested planting material, cassava pests pose significant threats to the further development of national and regional cassava sub-sectors.

Although cassava is native to Latin America and has co-evolved with pests and natural enemies of these pests for a long time, there are several regions where pests are locally common and appear to lack predators or parasites which are found in other regions. This creates an opportunity for implementing classical biological control of such pests. In Africa, the economically important pests have mainly been exotic arthropods that were accidentally introduced from the Americas. A variety of foliar, stem and root damaging pathogens, and weeds also cause varying degrees of crop damage and yield losses in both regions.

Various yield loss data are available for most of cassava pests in Africa and Latin America. These data are invariably discipline-/pest-/location-specific, and inherently provide information more on the pests' potential to reduce food supply and income from cassava than on the actual production losses caused. In Africa, cassava pests including arthropods, pathogens and weeds reduce crop production by an estimated 50%[20]. Depending on cassava variety, cultural practices, local agroecological conditions, and pest strains, estimated pest-specific root yield losses are 30-80% for the cassava green mite in Latin America[21] and

[19] Nkum, J. O. C (1993): Report on Goal Oriented Project Planning Workshop to Plan the Implementation of the ESCaPP Project: 1993-1997. IITA.

[20] Yaninek, J. S (1994): Cassava plant protection in Africa. Proc. 5Th Symp. ISTRC-AB, 1994: 26-34

[21] Byrne, D. H., Bellotti, A. C. And Guerrero, J. M (1983): The cassava mites. Tropical Pest Management 29: 378-394.

Africa[22] and 16-100%[23] for the cassava mosaic disease, with actual annual production loss due to this disease alone estimated at 28-40%[24] in Africa. The cassava bacterial blight can cause a reduction in yield of 50%, while the larger grain borer can reduce stored cassava chip biomass by up to 74% after 4 months of infestation[25]. It is estimated that weeds can cause as high as 80% production losses[26], if left unchecked, particularly during the first 3-4 months after planting. In Latin America, the native mealybug, *Phenacoccus herreni*, can cause 80% yield loss in northeastern Brazil[27]. In low soil fertility areas, the cassava hornworm causes 15 to 46% yield losses after one attack, and up to 64% after two consecutive attacks[28]. The virus diseases (Cassava Common Mosaic Virus, CsCMV; Cassava Vein Mosaic Virus, CVMV; Cassava Frogskin Disease, CFSD) can cause 30-100%, especially where any of the diseases are endemic; and yield losses by root rots of 40% are reported for at least 300,000 ha., of cassava in northeastern Brazil[29].

The key components of pest-induced yield and production losses are area covered (site incidence), proportion of plants infested (plant incidence), proportion of the field plants in various pest damage categories and season/duration of peak attack. In Africa, the ESCaPP multidisciplinary diagnostic survey database provides these kinds of information for the target countries (Benin, Cameroon, Ghana and Nigeria) and on a regional basis (Table 1). Table 1 provides a basis for setting comprehensive cassava plant health targets against which the effectiveness of intervention technologies can be monitored.

Table 1. Peak incidence/coverage of cassava pests and damage levels across all ecozones in targeted countries in West and Central Africa, 1994/95 (RF = Rain

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[22] Yaninek, J.S. and Herren, H. R. (1988): Introduction and spread of the cassava green mite, *Mononychellus tanajoa* (Bondar) (Acari: Tetranychidae), an exotic pest in Africa and the search for appropriate control methods: a review. Bull. Ent. Res. 78: 1-13.

[23] Fauquet, C. and D. Fargette (1990): African cassava mosaic virus. Current Topics in Vector Research 4: 73-91.

[24] Thresh J. M., Fishpool L. D. C., Otim-Nape G. W. and Fargette D. (1994). African cassava mosaic virus disease: an under-estimated and unsolved problem. Trop. Sci. 34, 3-14.

[25] Hodges, R. J., Meik, J., and Denton, H. (1985): Infestation of dried cassava (*Manihot esculenta* Crantz) by *Protesphanus truncatus* (Horn) (Coleoptera:Bostrichidae). J. Stored Prod. Res., 21: 73-77.

[26] Akobundu, I. O. (1980): Weed science research at International Institute of Tropical Agriculture and research needs in Africa. Weed Sci., 28: 439-444.

[27] Bellotti, A. C., Varela, A., M and Reyes, J. A. (1982): Observations of the biology and behavoir of *Phenacoccus herreni* and *P. Gossypii* on cassava. In: Biological control and host plant resistance to control the cassava mealybug and green mite in Africa: Proceedings of an International Workshop, December 6-10, 1992 , IITA, Ibadan, Nigeria. p116-127.

[28] Arias, B., and Bellotti, A. C. (1984): Perdidas en rendimiento (dano simulado) causadas por *Erinnyis ello* (L) y niveles criticos de poblaciones en diferentes etapas de desarrollo en tres clones de yuca. Revista Colombiana de Entomologia. 10(3-4): 28-35.

[29] Fukuda and Lozano, J. C., (1990): Doencas da mandioca. [Cassava disease]. Work presented at 7th. Curso Intensivo Nacional de Mandioca, Cruz das Almas-BA, Brasil, 1990. EMBRAPA, CNPMF, 46p

forest; TF = Transition forest; WS = Wet savanna; DS = Dry savanna; MS = Mid altitude savanna).

Pests	Season	% sites infested	% plants infested	% plants with moderate/severe damage				
				RF	TF	WS	DS	MS
Cassava green mite	Dry	85	58	46.1	35.5	25.3	5.7	30.8
Cassava mealybug	Dry	51	11	8.3	10.5	8.3	3.1	3.3
Variegated grasshopper	Dry	18	4	0.3	1.3	0.0	0.0	0.0
Termites	Dry	52	13	0.6	3.1	0.6	1.2	0.8
Cassava root scale*	Dry	22	59	27.7	60.0	0.0	0.0	0.0
Cassava mosaic disease	Dry	96	77	42.3	31.6	35.9	45.0	25.4
Cassava bacterial blight	Wet	39	14	1.5	15.0	13.3	7.7	4.7
Cassava anthracnose dis.	Wet	57	34	42.2	10.0	10.6	0.0	4.1

* Recorded only in Cameroon
Source: ESCaPP project: Diagnostic survey database. IITA/PHMD

In Africa, future project research themes were established during a two week multi-disciplinary regional workshop to set research priorities. The exercise consisted of evaluating 1994 diagnostic survey results, identifying and ranking the importance of pest problems (including diseases and weeds) across and within different ecozones, determining potential research gaps, and compiling a prioritized list of new research themes/activities. As expected from a project focused on plant protection, most new research themes (19 of 37) were protection in nature (Table 2). The themes for production (10 of 37) and socioeconomics (8 of 37) generally provided support to proposed protection activities. Among the future themes, half concerned characterization, a third adaptive/strategic research, and the remainder, implementation (Table 3).

Table 2 Research themes by ecozone in Africa

Theme	Rain forest	Transition forest	Moist savanna	Dry savanna	Highland savanna
Cutting sanitation	X	X	X	X	X
BC of green mites	X	X	X		X
Disease control	X	X	X		
Ecosys-specific pests	X	X	X	X	X
Postharvest pests	X	X	X	X	X
Root scale	X				
Natural resources	X	X	X	X	X

X refers to importance with respect to project priorities

Table 3 Research themes by functional approach in Africa

Theme	Characterization	Strategic Research	Implementation
Cutting sanitation		X	X
BC of green mites		X	X
Disease control		X	
Ecosys.-specific pests	X	X	X
Postharvest pests	X	X	
Root scale	X		
Natural resources	X	X	

X refers to importance with respect to project priorities

In terms of relative importance of cassava pests, farmer participatory surveys by the PROFISMA project in northeast Brazil indicate that root rots, cassava green mite, mealybugs, whiteflies (including the recently arrived silverleaf whitefly), cassava hornworm, and leafcutting ants are the leading pests. Viruses such as Cassava vein mosaic virus are probably also very important, but overlooked because of lack of detection capability. In Paraguay the principal pests include bacteriosis, root rots, anthracnose, common mosaic virus, cassava hornworm, whiteflies and stemborers. In Cuba the principal pests include cassava hornworm cassava green mite, shoot flies and stemborers; and diseases such as bacteriosis, superelongation and frogskin disease, root rots and viruses.

B.1.3 Status of Intervention Technologies

Cassava in Africa was neglected by agricultural researchers early in the 20th century. Work on cassava eventually began with resistance breeding on African cassava mosaic virus in the 1930s and continued that way for the next 30 years. In the 1960s, research on cassava in Africa expanded beyond disease resistance and yield improvement to include agronomy and early farming systems research. Research on cassava became multi-disciplinary in the 1970s, but lacked the interaction with the client farmers needed to assure adoption. Research to develop, test and adopt "appropriate" technologies on-farm flourished during the 1980s. And by the 1990s, a systems approach with biological control and farmers' participation as the center pieces became the basis for developing environmentally sound and economically feasible plant protection for basic food crops in Africa and Latin America.

The cassava plant protection technologies available for testing and adaptation can be grouped into three categories of sustainable interventions - biological control, host plant resistance and cultural practices. Chemical controls are impractical, uneconomical, non-sustainable, and hazardous to the environment and to the farmers, and therefore, are not considered.

Biological control consists of three basic strategies. These include classical biological control where ecologically adapted natural enemies are introduced from outside the target area, conservation of natural enemies present in the system through cultural practices which enhance their activity, and augmentation where local natural enemies are multiplied and released to increase their impact. IITA and CIAT collaboration has focused largely on classical biological control of the exotic pests, cassava mealybug, and cassava green mite. Maintenance and mass production of the natural enemies used in classical biological control 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 cultural methods appropriate for implementation by national programs in both continents and by farmer cooperatives in Latin 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.

Cassava pests have been studied for many years in view of developing host plant resistance. Plant breeding for resistance was the earliest plant protection technology pursued. Although, recent breeding efforts by both national and international research institutes are been put into developing varieties which are high yielding and early maturing fast producing, selection for pest resistance is being integrated into the breeding programs as proactive pest management measures.

The role of cultural practices in enhancing cassava production is well known, but poorly documented where pests are concerned. Pest constraints to cassava production are frequently related to other production practices, although their effect on pest populations are only now being investigated. Appropriate cultural practices can already be identified based on systems' research, even though much work remains to be done. Good cassava production starts with quality planting material free of avoidable plant pathogen and pest contaminants. Other potential production constraints such as weeds, mulching, time of planting, spacing, intercrops and time of harvest are usually moderated by appropriately timed and properly implemented agronomic practices. Fallow management can reduce undesirable weeds, while maintaining desirable refuge for natural enemies.

B.1.4 Status of Human Resources

The focus of the human resource development activity of the ESCaPP and PROFISMA projects has been training of extensionists and farmers in the principles and practices of sustainable cassava plant protection and postgraduate academic training of African women scientists. In Africa, the current extension and farmer training partners are the *Centre d'Action Régionale pour le Développement Rural* (CARDER) in Benin, National Agricultural Extension Training Program (NAETP) in Cameroon, Department of Agricultural Extension Services (DAES) in Ghana and selected Agricultural Development Programs (ADP) in Nigeria. These extension services adopt the donor funded unified extension system with its built-in training and visit (T&V) approach. This approach emphasizes frequent and simultaneous contact with large numbers of extension trainers, extension agents and farmers through a series of short duration training workshops in each annual production cycle.

In collaboration with the NARS partners, ESCaPP assessed cassava plant protection training needs of extension trainers, extension agents and farmers in 1993/94. Extension trainers and extension agents showed adequate conversance with cassava agronomy and general agriculture but lacked adequate prior knowledge in cassava plant protection. Farmers' training need areas were in close agreement with those of their trainers. The regionally adopted T&V extension model was identified as a sustainable approach for training delivery and access to farmers. ESCaPP developed a training curriculum based on the identified needs and primarily for use by resource persons.

ESCaPP conducted in-country refresher courses for extension trainers in Benin, Cameroon, Ghana and Nigeria to up-grade their technical cassava plant protection knowledge and equip them with skills and materials needed to effectively train extension agents and farmers. Sixty-eight percent more extension trainers were trained than had been projected, mainly due to cost sharing collaboration with NGOs. Following the refresher courses, periodic training of extension agents and farmers groups provided the continuous and frequent contacts needed to improve upon the identified low cassava plant

protection knowledge and implementation experience of these participants. The training sessions have focused on hands-on field activities and demonstrations followed by visits to individual farmers' fields during which extension agents assist with technology implementation. The numbers of extension agents and farmers groups reached through periodic training were 8 and 5 times more than the respective 1994 projected figures. This was largely due to the multiplier effect of the T&V training approach. The common farmer training methods in the unified extension systems are group discussions and farm visits. However, ESCaPP training monitoring in 1995 showed a need for more effective participatory farmer methodologies. In this regard, the project established 25 cassava Farmer Field Schools (FFS) to introduce action research and learning into the national extension systems. FFS farmers conducted experiments to test technologies, generated new information, coined local names for pests, diseases and weeds and participated in biological control releases and post-release monitoring.

Various short-term group and individual training have been conducted by ESCaPP for researchers and technicians who provide technical support to the NARS and national extension systems. ESCaPP academic training activities were subcontracted to Winrock International's African Women in Agriculture and the Environment program. The training was specifically provided to African women participants from the project's partner NARS. Twelve of the planned 20 fellows were placed, over half of whom have successfully completed the courses and returned to their respective national programs.

B.1.5 Status of Information Resources

Information resource activities initiated by the ESCaPP/PROFISMA projects to facilitate processing, summarization, interpretation and communication of multi-disciplinary data have included the development of text references, taxonomic resources, digitized interactive information resources and decision support systems. A cassava plant protection information CD-ROM was developed by ESCaPP with the University of Florida during the first phase of the project. The information consists of a cassava plant protection directory of personnel, projects and institutions, full text of important cassava management documents, photographic quality color images of major production constraints and natural enemies, bibliographies, the entire series of CIAT/IITA cassava newsletters, training modules, an expert system as a decision support tool, and a series of databases including cassava mites of Africa, ESCaPP protection, production and socio-economic diagnosis, collaborative study of cassava in Africa, and long-term African meteorological data. In the 'beta' or prototype interactive information resource consisting of a cassava plant protection directory of personnel and institutions, a digitized version of the Handbook on Cassava Green Mite, and a bibliography of plant protection literature for Africa was developed for testing and updating before going to final production. Some of these documents have also been placed on a World Wide Web site

(http://hammock.ifas.ufl.edu). New sets of training materials have also been prepared as training reference materials to improve extension and farmer training. These materials include 4 cassava IPM extension posters which were field tested by Farmer Field Schools participants in Benin, Cameroon, Ghana and Nigeria and 4 NARS vetted cassava IPM extension guides with accompanying slide sets.

B.2 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. This will lead to significant reductions in the key components (site incidence, plant incidence, and damage levels) of pest-induced yield and production losses, as quantified by multidisciplinary diagnostic survey databases. In addition, ecological crop protection technologies should help 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.

Table 1 provides a basis for setting comprehensive cassava plant health targets against which the effectiveness of intervention technologies can be measured. IITA, CIAT and their NARS partners will aim to effectively implement intervention technologies against at least two targeted pests in at least one affected ecozone per participating country. Through a multiplier effect, the implemented sustainable technologies, practices, training and information dissemination will significantly reduce plant incidence and proportions of plants showing moderate/severe damage in the years following project termination. Cassava yields and/or root quality will improve significantly on targeted farms where technologies have been adopted. For example, recent evaluations in Benin on the impact of the establishment of one mite predator introduced from Brazil show an increase in yields equal to US $70/ha/year, which corresponds to about $50 million per year for the four original target countries (Nigeria, Benin, Cameroon & Ghana), if the predator becomes widely established and remains equally efficient. Another example is the 90% reduction in root rot incidence and 3-fold increase in yields achieved by a similar project executed by Centro de Pesquisa Agroforestal da Amazonia Occidental, EMBRAPA, and CIAT, through the adoption of appropriate cultural practices and tolerant cassava varieties in the Amazon. Adoption of new pest and crop management technologies will increase the prosperity of poor rural families and reduce environmental degradation associated with cassava production. Development of postharvest processing and markets for cassava products by closely affiliated projects at IITA and CIAT will help increase and stabilize the incomes of rural communities. Farmer

communities (including women who play important roles in cassava production and processing) will have greater control over their well being as a result of learning how to work with others to define their problems, develop solutions and test them. Information resources developed during the project will facilitate the implementation of similar efforts in other areas in the future. Skills and effectiveness of national program research and extension staff will be improved by training and practice of farmer participatory research methods.

B.3 Targeted Beneficiaries

The immediate beneficiaries of this project are the participating farmers, extensionists and researchers of the state, national and international research institutions involved in this project. Poor, small-scale farmers (many of whom are women) in the cassava-belts of Africa, Brazil, Paraguay, Ecuador and Cuba struggling to grow cassava under tropical, rain-fed, low soil-fertility conditions, often in semi-arid regions, will benefit from the technologies that will be adopted to control their principal pests. The adoption of methods to control pests and diseases and manage their cropping system will increase and stabilize their productivity and income, provide food security, and foster a pesticide-free environment. It will also help prevent further environmental degradation of both their fields and the surrounding vegetation that is subjected to slash/burn agriculture. Staff at national, regional, and international organizations involved in research and implementation of sustainable plant protection for cassava will benefit from the international collaboration and exchange of information that this project provides. Hiring and training of personnel will emphasize gender equity. The open flow of communication between scientists, extensionists and farmers is critical to target efficient research goals and develop technologies that suit the local needs of farmers. National program scientists and extensionists are extremely isolated from the information that exists in other countries and regions and benefit greatly from the knowledge and experiences of others. All of the countries involved in this project have actively sought involvement and participated in planning and development of this proposal. Indirect benefits of improving sustainability of agriculture in fragile agricultural environments will extend to neighboring regions and countries which have access to publications, information and experiences generated by this project.

B.4 Project Strategies

B.4.1 Global

Collaboration between IITA, CIAT and national programs for exploration and introduction of natural enemies for control of introduced pests in Africa will target additional ecozones of East and Central Africa, Brazil, Paraguay and Cuba. Because other countries in Africa and Latin America have requested participation in projects similar to the previous ESCaPP/PROFISMA project, the geographic range of this proposal has expanded. Experience gained on both continents in

participatory methods and on-farm testing will be shared through training workshops for national and regional extensionists and researchers. Global research strategies for cassava green mite, cassava root rot pathogens, bacterial blight and viruses, and the production of quality planting material will be developed through research, workshops and scientist exchanges. Compilation and dissemination of information will make available diverse resources to a wide audience of cassava workers. IITA and CIAT will provide overall project coordination and will liaise with national programs, regional research thrusts, training and implementation activities, and other interested organizations. Global collaboration will emphasize areas of common interest (biological control, integrated pest management, training) and comparative advantage (host plant resistance, participatory methods, biotechnology, GIS, information resources).

B.4.2 Africa

Coverage in West and Central Africa, the region that hosted the original ESCaPP project, will include Benin, Cameroon, Ghana and Nigeria with regional collaborative research opened to other countries in the region. Countries in this region are members of the *Conference des Responsables de Recherche Agronomique Africains* (CORAF) cassava network, an organization which officially requested future collaboration with ESCaPP. Coverage in the new target region of East and Southern Africa will include Uganda and Mozambique. In this new region, the project will be implemented in collaboration with the regional networks East African Root and Tuber Crops Research Network(EARRNET) and Southern African Root and Tuber Crops Research Network (SARRNET), which overlap with the regional coordinating body ASARECA (Association for the Strengthening of Agricultural Research in Eastern and Central Africa). In both old and new regions the program will follow four project outputs/results: Intervention Technology Development, Human Resource Development, Information Resource Development, and Mechanisms for Coordination.

Intervention Technology Development
In the original regions, the project will shift from pest characterization (mainly completed) and focus largely on strategic research on previously prioritized themes which cut across major environmental, production or socio-economic concerns (see Tables 2 and 3, section B.4). While most of the identified themes are plant protection oriented by design, activities in production and socioeconomics will provide essential support. In the new regions, intervention technology development activities will be divided sequentially into characterization (largely by extensive and intensive diagnosis), strategic research and implementation, but will begin in the series according to the available knowledge. Pest constraints will be characterized for their importance through multidisciplinary diagnostic surveys. The original survey protocols will be adjusted to account for location-specific/village level ethnocentric differences between regions/countries. While the list of themes in Tables 2 and 3 is comprehensive for West and Central Africa

and would be relevant to regions with ecological similarities, additional themes will be identified in the new regions following pest diagnoses.

In both regions intervention technology development activities will be conducted through collaborative laboratory and field studies, decentralized intervention technologies, and participatory on-farm trials. Progress in achieving research objectives and technology implementation will be routinely evaluated throughout the life of the project, with a particular focus on consumer acceptance and farmer adoption of recommended technologies. The specific research themes are the following:

Stem cutting sanitation and management practices. This theme will seek to develop and implement a strategy to produce and maintain clean and vigorous cassava planting material given the specific requirements of the major cassava growing ecozones. The unavailability of stem planting material with sufficient vigor and clean from pests is often a factor limiting cassava production. This is due largely to insufficient knowledge concerning criteria appropriate for vigorous and clean cutting selection, propagation, and maintenance. Whereas transmission of cassava mosaic virus and cassava bacterial blight in stem cuttings is well documented, little is known concerning the dissemination of a whole range of fungal pathogenic agents through this medium. Protocols for identifying and eliminating pests and poor plant vigor in cassava stem cuttings will therefore be developed in collaboration with participating national programs to select, propagate and manage clean cuttings by extension agents and farmers in a sustainable manner.

Cassava green mite biological control. In parts of West Africa, the exotic predatory mite, *T. aripo* reduces populations of the cassava green mite by half and increases yields by a third in targeted areas. However, much still remains to be done to achieve similar success in other ecozones, countries and regions of the continent. The strategy will be to address the mite problem on a regional basis where local experiences and ecological constraints are similar. This project will therefore collaborate with the IITA project on biological control of the pest to support classical biological control of the pest by enhancing national capacities to mass produce, release and monitor the establishment, spread and populations dynamics of exotic natural enemies; test new candidate natural enemy species selected for targeted ecozones; quantify the ecological, agronomic and economic impact of natural enemies, and enlighten extension agents and farmers with knowledge on the benefits of biological control. *T. aripo* and other phytoseiid predator species which have shown promise in the field given specific agroecological conditions will be the primary agents for implementation. Other natural enemies, including pathogenic fungi, will be selected and tested in specific ecozones. In collaboration with related IITA project this project will also seek to incorporate sources of cassava green mite resistance into agronomically acceptable cultivars offering a potential for control of the pest through host plant resistance. Furthermore, appropriate cultural practices will be identified based on

systems research. These methods will be tested, adapted and evaluated with farmers in a participatory manner.

Cultural and biological control of diseases. This theme will seek to identify and establish appropriate cropping systems and biological control techniques to effectively manage cassava diseases in targeted ecozones. The project will elucidate the effect of cultural practices such as seedbed preparation, field management practices, crop density and time of planting, harvesting procedures, and types of intercrops on the incidence and severity of cassava mosaic disease, cassava bacterial blight and other leaf diseases, and *Curvularia* leaf and stem blight. Appropriate cultural and biological control methods (e.g., use of antagonists against root rot pathogens) and cropping systems will be developed, tested and established mainly through Farmer Field School networks. In all ecozones, this project will characterize fungal, bacterial and virus pathogens and develop respective quick detection methods.

Ecosystem-specific pests. This theme will seek to characterize the importance of ecosystem-specific pests in each ecozone, and initiate strategic research on those diagnosed as important or already known to be a problem. During prior extensive diagnostic surveys in Africa, a number of pest constraints were identified as being associated with specific ecozones, but not exclusively on cassava. These include weed species (e.g., *Imperata cylindrica, Panicum* spp., *Andropogon* spp., *Pennisetum* spp., *Mimosa* spp., and *Commelina* spp) in all ecozones, the weed *Chromolaena odorata* in the humid forest, the variegated grasshopper in the transition forest and moist savanna, termites in the moist and dry savanna, nematodes in all ecozones, vertebrates pests and root rots (e.g., *Fusarium, Phytophthora, Diplodia, Botryodiplodia, Scytalidium* and *Verticillium* spp) in the rain and transition forests. Pest constraints such as these are usually relegated to orphan status when R&D activities are targeted to specific commodity. This project will take the lead in diagnosing these problems, but may require additional expertise to develop and implement sustainable control strategies. The strategy here will be to identify and liaise with individuals and institutions that have a comparative advantage in working on the specific pests.

Postharvest pests. Although cassava is relatively easy to grow, the storage roots are difficult to keep after harvest because they quickly deteriorate. Some of the microorganisms, (e.g., *Aspergillus flavus,* and *Fusarium moniliforme*) which invade and reduce the quality of stored products produce mycotoxins which have been shown to be carcinogenic to humans. This theme will seek to improve the harvesting and processing of cassava, the preservation of stored fresh cassava and processed products. In collaboration with related IITA projects, this project will establish an inventory of existing indigenous and "improved" cassava handling and processing methodologies in the regions; elucidate farmers preference for the methodologies; identify pests and microorganisms associated with the existing processing and preservation methodologies; investigate the extent of the damage of stored products and the types and quantities of mycotoxins produced; quantify

the economic losses; reduce losses due to poor handling and storage of cassava and cassava products; and seek to generate a range of postharvest technologies to provide competitive commercial options for farmers, processors and consumers in the food, feed and agro-industrial sectors. Through participatory methods and processes, this project will reduce constraints to farmer adoption of the improved methodologies.

Cassava root scale. This theme will seek to identify the extent and severity of the cassava root scale problem in Africa. The pest status of the cassava root scale, *Stictococcus vayssierei,* which is native to Africa, is yet to be fully quantified. However, it is generally regarded as an important cassava production constraint in the Central African region. Research on the pest is scanty and little is known about its natural hosts or indigenous natural enemies. This project will conduct intensive diagnosis to elucidate the pest's biology, ecology, crop and farming systems interactions in targeted agroecozones affected by the scale. This project will also evaluate indigenous knowledge with the aim of developing, testing and implementing sustainable interventions.

Natural enemy and germplasm resources. This theme will seek to characterize and preserve desirable local natural enemies and germplasm, and identify, select and import promising exotic natural enemies and germplasm for subsequent intervention technology development. The germplasm will be evaluated for specific pest and disease resistance by ecozones to provide inputs into on-going breeding programs. This project will elucidate knowledge of the pest control capacity of indigenous natural enemies of the variegated grasshopper, termites, cassava root scale and nematodes and provide a basis for evaluating foreign exploration needs. In the control of the introduced spiraling whitefly in Africa, this project will continue to monitor the establishment, spread and impact of the parasitoid, *Encarsia ?haitiensis,* on the continent. This project will collaborate with the IITA-based project on the larger grain borer to monitor the establishment, spread and impact of the introduced predatory beetle *Teretriosoma nigrescens* against the pest in stored dry cassava chips in Africa. IITA/CIAT foreign exploration will be focused on cassava green mite predators and fungal pathogens.

Human Resource Development

The focus of the human resource development activity in the original and new project regions in Africa will continue to be training in the principles and practices of sustainable cassava plant protection. In new project regions, training needs will be assessed through participatory processes with NARS trainers, extentionists and Farmer Field School (FFS) groups. Curricula will be developed and revised to capture emerging needs during project implementation. In both old and new project regions national extension systems will continue to provide the opportunity for incorporating cassava plant protection training within existing NARS authority and operational structures. The project will build upon the cassava IPM knowledge base it had improved through previous training of

researchers, extensionists, farmers and NGO participants to strengthen participatory approaches in the development of cassava IPM technologies and practices.

Farmer Field School training model will be used for action learning and research within the extension systems. Researchers and extensionists will be trained in facilitation skills, methodologies and processes to understand the organization and functioning of farmers groups. Through FFS, the project will increase farmers' ability to improve on their experiments and experimental methods; develop, test, adapt and evaluate cassava IPM technologies and practices; encourage the participation of women farmers in IPM decision making; integrate research with training and extension; integrate indigenous knowledge in IPM technology development; ensure that research and extension services target resources at farmers real needs; and increase the chances of farm-level adoption of technically feasible technologies. Specialized training courses will be provided according to the expressed needs of the NARS and to promote the integration of the project's research into training and implementation activities. The project will strive to institutionalize FFS models within national extension systems and constitute FFS participants into regional farmers networks for in-country and inter-country exchange of ideas and farmers as training resource persons.

In collaboration with the NARS, pertinent IARCs and NGOs, the project will continue to prepare training and extension support materials stressing the need for farmers to focus on growing a healthy crop of cassava. Source books will be provided/prepared as training reference manuals for extension trainers and FFS facilitators. Didactic materials will be designed to promote the understanding and application of cassava IPM technologies and practices. Participants will be trained in the art of preparing these didactic materials to foster a "self-help" approach in training material preparation at national levels. Selected print materials will be adapted into a multimedia cassava IPM software on growing a healthy cassava crop.

Information Resource Development

There is an plethora of information available for many crop production systems including cassava. The problem is how to access and use these data to make informed management decisions. Large multi-disciplinary databases like those generated during the regional diagnostic survey of the original project are examples of information that are best exploited by a systems approach specifically designed to update, manage and interpret dynamic data. The project will continue to develop pertinent information resources to facilitate processing, summarization, interpretation and communication of the large amount of multi-disciplinary data anticipated from old and new project regions. Relevant databases already compiled will be updated. Strategic and tactical models will be developed to identify critical interactions, and evaluate the potential impact of tested technologies. Validated inter-disciplinary systems models will provide the tools for evaluating the response of simulated agroecosystems under a range of

conditions, and a basis for day-to-day decision-making in cassava plant protection. A cassava systems model developed by IITA, the University of California, Berkeley and ETH, Zürich will provide the basis. The project will improve and update its cassava plant protection information CD-ROM developed with the University of Florida during the first phase of the project, and place the same information in a web site available over the Internet. Additionally, IITA staff will be trained to prepare documents for conversion into an interactive format and to develop an independent capacity to create interactive cassava information resources.

Mechanisms for Coordination

Project coordination provides the structure for organizing and managing project activities within and between participating regions, countries and individuals. This will include identification, selection and preparation of multidisciplinary national teams and planning country activities, organization of regional workshops, evaluations and reporting. The preliminary organizational activities will involve presentation of the project to new collaborating countries at consultative meetings with national cassava scientists and farmers, the selection of national counterpart teams following country consultations, the preparation of work plans and budgets and the provision of technical and material logistics support. Project implementation agreements signed between IITA and participating countries will continue to guide the project's operations at national levels. In addition to stipulating responsibilities, commitments and other contractual obligations, the agreements will also stipulate contractual agreements for the participating NARS scientist seconded to form the nucleus of national multidisciplinary project teams. Additional contracts will be needed to implement, natural enemy quarantine, digitized information resources, and decision support systems. Regional workshops will provide a formal structure for participating scientists to meet and exchange ideas. Regular international scientific and technical interactions will be conducted among regional staff, international collaborators and national teams. Through these interactions various resources, opportunities and features of national programs and other country institutions relevant for project activities will be identified.

Research activities will be supported and coordinated through a competitive collaborative research program. The program encourages strategic and innovative scientific inquiry and fosters research collaboration with a wide range of individuals from universities, government ministries, other national research systems, and NGOs in the region; it also increases contact between scientists and cassava farmers. A committee representing each regional project team will convene to select proposals previously short listed within discipline groups for support. Awards will be made in areas relevant to the overall framework of the project, with the highest priority given to proposals addressing farmers' plant protection problems.

B.4.3 Latin America

Strategic and applied research at CIAT in entomology (including cassava green mite, mealybug, hornworm, whiteflies, etc.), plant pathology (including root and stem rots, bacteriosis), virology (CsCMV, CVMV, ACMV, frogskin disease), biotechnology, geographic information systems, and participatory research will collaborate directly with research at IITA to help develop solutions to principal cassava pests and cassava production problems on both continents. Emphasis will be on biological control and integrated pest management (which involves resistant crop varieties, cultural management, and sanitation of planting material). Fungal, bacterial and virus pathogens will be characterized, and detection methods developed. Cultural control methods and cassava varieties resistant to key pests and diseases will be developed and tested through COPAL (Farmer research committee) networks. CIAT scientists will also work directly with national program scientists in Brazil, Paraguay and Cuba to solve regional and local problems and to provide training. National program capacity to mass-produce, store and distribute hornworm baculovirus will be developed. New activities to evaluate market possibilities and develop postharvest processing and micro-industries through COPAL (farmer research committee) networks will help stabilize the price and profitability of cassava production in rural communities and improve rural prosperity.

CIAT will be directly involved in "satellite" bilateral projects in Brazil, Paraguay and Cuba that will be closely linked to this project. However, each of these satellite projects is for "integrated crop development"; i.e., they include management of soil, crop, and pests and development of postharvest processing and markets. Initial surveys of markets and of farms will be conducted (where prior information is not available) to prioritize constraints and opportunities. In selected communities, farmers will be organized into participatory research committees (COPALs) and trained in farmer participatory research methods (FPR). National program scientists and extensionists will receive similar training, and together with farmers and international scientists will identify, develop and test practical solutions to their problems.

- The region in Northeast Brazil targeted by the preceding PROFISMA project (Bahia, Ceará, Pernambuco and Paraíba) will be expanded to include Maranhão and Piauí. Satellite project activities will expand to include emphasis on the principal constraints identified by the preceding PROFISMA project (soil quality, planting material, cassava green mites, hornworms, whiteflies, root rots, witch's broom, viruses, development of postharvest processing and markets). This project will also have direct interaction with an IFAD development project in Sergipe, which specifically requested collaboration with former PROFISMA personnel, and with another CIAT-CNPMF IFAD-sponsored project on improving cassava varieties for semiarid conditions.

- A new satellite project will begin in Paraguay with particular emphasis on developing postharvest processing and markets. It will also include diagnostic surveys, development of COPALs, farmer participatory research on crop production and pest management, and training. There will be direct collaboration with a CIRAD economist.

- A new satellite project will begin in Cuba, starting with diagnostic surveys of constraints and opportunities for production and markets. National program scientists and extensionists and existing farmer cooperatives will be trained in farmer participatory research methods and will help develop and test crop production, pest management, and postharvest processing technologies.

B.5 Reasons for External Assistance from Donors

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 donors are requested to help maintain the momentum gained between collaborating institutions in the development, testing, and implementation of successful intervention technologies by supporting this project.

B.6 Special Considerations

The current crop protection situation in Africa and Latin America 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. CIAT has the CGIAR world mandate for cassava and cassava germplasm outside Africa, and IITA has the mandate for cassava 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 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 integration of extensionists with researchers and farmers will continue within the context of human resource development through training as described in sections B 1.4 and D.2, especially through participatory methods and processes. 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.

Because cassava is a hardy crop that withstands drought and tolerates poor soil quality, it often plays a critical role in providing a reliable source of food to poor people who live in marginal agricultural environments. Increasing cassava productivity using ecologically sustainable crop protection methods increases food security and income. It also reduces or avoids the need to apply pesticides, thereby helping to protect local biodiversity. Ecologically sustainable crop management methods also help to conserve and improve soil quality, reduce erosion and slow down the destruction of forest in slash-burn agricultural systems. Processing cassava into starch, chips and other food products in local artisanal mills provides an important source of employment and income, especially to women. The farmer participatory methods employed by this project help empower individuals and communities to define their problems and begin to find their own solutions and develop skills which can be helpful in other areas of their lives.

B.7 Project Coordination and Management Arrangements

IITA and CIAT will be responsible for coordination of ESCaPP and PROFISMA project activities in Africa and Latin America respectively. Research at IITA and CIAT is organized on a project basis, and there is a project coordinator responsible for the coordination and integration of the cassava plant protection activities in each institute. The project coordinators report to their respective Directors of Research and/or Division Director (as at IITA) who are each responsible for their respective Director General and Board of Trustees. Accountability for project expenditures remains the responsibility of IITA for the Africa component and CIAT for the Latin America component of the project, respectively. Project leaders appointed by IITA and CIAT will be the institutional contact personnel

responsible for coordinating project activities in Africa and Latin America, respectively and for liaison between the two regions.

At the national level, this project will be coordinated and managed through multidisciplinary national teams to reach the various stakeholders. At intervals, the national teams will join regionally to identify and develop management tools guiding project implementation, prepare technical protocols and set R&D priorities based on prior diagnoses. Earlier, in 1993, ESCaPP conducted a Goal Oriented Project Planning workshop in Africa with participants from the NARS, IITA and Winrock International. The workshop participants developed and harmonized regional and country-specific plan of operations and budgets; set performance indicators for a monitoring and evaluation plan; related targets to available inputs, personnel, funds, equipment, materials, etc.; set deadlines by when activities should begin and end; and assigned responsibilities to team members and/or collaborating agencies. These kinds of consultative planning tools which remove ambiguities about responsibilities during project implementation will continue in the future.

Additionally, implementation agreements, between IITA and the respective Governments, which stipulate responsibilities, commitments and other contractual obligations to guide project operations will continue to be adhered to. National project coordinators will be responsible for the management and administration of project activities in the participating countries and liaison with IITA or CIAT. Other team members will ensure interdisciplinarity in national project planning and implementation. National scientists, in Africa, other than the seconded team members, will be provided with an opportunity to contribute towards the project's overall goal and purpose through a competitive collaborative research program addressing aspects of the problem environment and to serve as national/regional training resource persons. In Latin America, national programs participated in development of this proposal and the bilateral satellite proposals, and they will also conduct annual reviews of their activities and revise their work plans and budgets. Exchange visits will be organized between project partners to enhance technical interactions, supervision and monitoring of project activities.

Working within existing national systems will have the advantage of enabling structured access to farmers, extensionists and researchers to avoid duplication of efforts and provide for sustainability of the project's developed R&D processes and results. The national teams will form a "hub" around which the project will link partner NARS institutions to natural enemy, germplasm resources, regional and international expertise and experiences for cassava R&D. Additionally, the collaborative mechanisms will provide for cost-sharing with relevant NGOs for farm-level training, technology and technical material testing and implementation, appropriate targeting of resources and technologies, and sharing of hitherto "unidentified" regional expertise between the NARS. The NARS

capacity to undertake independent cassava R&D activities will be increased through technical and material support and training.

Project collaborators will hold a yearly internal review meeting for the purposes of exchanging information and setting priorities. This meeting will be attended by the IITA Plant Health Management Division Director, the Project Leader for the African Component, associated participating IITA scientists, the Project Leader for the Latin American Component, participating CIAT scientists, and the Project Coordinators from each of the national programs. Responsibility for organization of the meeting will rotate between CIAT and IITA. A project advisory panel comprising of NARS, IITA and CIAT representatives will be set up and expected to meet at yearly intervals. The panel will approve the annual work plans and subsequently review progress made on technical matters, provide advice on the relevance of the work undertaken, and recommend changes when needed. The project will be advised by national Governments on the status of national progress towards the agreed goal and purpose through the advisory panel.

IITA will have primary responsibility for all financial matters in Africa. National program funds will be disbursed by IITA following institutional accounting procedures. Each national program will be responsible for the management and administration of these funds and will provide financial status reports to IITA's chief financial officer on a quarterly basis. International collaboration, e.g., with universities and technical development organizations, will continue to be conducted strictly through sub-contractual agreements with IITA. CIAT will have primary responsibility for all financial matters in Latin America. National program funds will be disbursed by CIAT following institutional accounting procedures. Each participating national program in Latin America will be responsible for the management and administration of these funds and will provide financial status reports to CIAT's chief financial officer on a semi-annual basis. Both IITA and CIAT will provide financial progress reports to the donors as required.

B.7.1 Linkages with International Institutions

This project is built on the long collaboration between IITA, CIAT and, national and international programs in cassava research and development. Both IITA and CIAT maintain strong links with advanced research institutions that have a comparative advantage in carrying out specialized research and training, or facilitating the dissemination of information. Postgraduate training of candidates selected from national programs participating in the project is also an important contribution to our objectives. Collaborating institutes are the University of Amsterdam; CIRAD, ORSTOM, the University of California, Berkeley; the Swiss Federal Institute of Technology (ETH, Zürich); University of British Colombia; Purdue University, USA; University of Laval; Wye College; Imperial College; Reading University; University of Regensburg; Ohio State University; University

of Florida; University of Massachusetts; Boyce Thompson Institute, USA; University of Sào Paulo, Brazil; University of Ibadan, Nigeria; University of Port Harcourt; and University of Nairobi. In a recent development, IITA linked up with Winrock International in a special program to select and train African women agriculturists in the principles and practices of sustainable plant protection. The University of Amsterdam and CNPMA (in Brazil) will provide quarantine services; the University of California, Berkeley and the Swiss Federal Institute of Technology are developing a cassava ecosystems model. The University of Amsterdam collaborates on behavior and biology studies of natural enemies. The Organization of African Unity (OAU) and the United Nations 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.

B.7.2 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 will also provide 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 an informal network of 24 countries in the cassava belt of Africa participating in a Biological and Integrated Plant Protection Network. IITA also actively participates in subregional networks in West and Central (CORAF), East and Southern (EARRNET and SARRNET), and parts of East and Central (ASARECA) Africa. 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.

In Latin America, the principal collaborators in this project are CIAT; national research and extension programs in Brazil, Paraguay and Cuba; and state agricultural institutions in Bahia, Ceará, Pernambuco, Paraíba, Maranhão and Piauí. See list in appendix VIII.

B.7.3 Linkages with Regional Development Projects

A recently approved IFAD project in Sergipe, Brazil, specifically requested that participants interact with personnel participating in this project to take advantage of the existing COPAL (farmer research committee) network and to work on solving cassava root rot problems. CNPMF plant pathologists, plant breeders and trainers who worked with the preceding PROFISMA project are collaborating directly with the new IFAD project. COPALs developed by PROFISMA also

collaborated with the evaluation of cassava varieties being funded by another IFAD project in northeastern Brazil. Activities of the satellite project in Paraguay are being coordinated with an IFAD development project directed at developing "panaderías", small bakeries that use cassava flour.

B.8 Counterpart Support Capacity

Each of the national programs participating in this project in Africa and Latin America have operating programs for research and agricultural extension on cassava production. Many key personnel have received previous training from IITA and CIAT in various aspects of cassava production, pest management and postharvest processing over the past 20 years. Previous participants in the PROFISMA project in Northeast Brazil (at CNPMF and the state extension agencies of Bahia, Pernambuco, Paraìba and Cearà) are particularly advanced in their training as a result of that project. However, many of the national research personnel lack training in farmer participatory research and the use of recently developed integrated pest management technologies. Their laboratories often lack key equipment such as microscopes, computers or software which are needed to meet the objectives of this project.

C. DEVELOPMENT OBJECTIVES

The development objective of this project is to increase the productivity and profitability of small-scale cassava based agricultural systems in Africa and Latin America, and thereby contribute to increased food security and poverty alleviation in the regions. This will be done through the development and implementation of ecologically-sustainable cassava production and plant protection intervention technologies, mostly through participatory methods and processes. The key areas of intervention will be integrated pest and crop management, biological control, postharvest and marketing. The national and regional cassava research and extension capability of participating countries will be strengthened through training, international collaboration and access to more technical information.

D. IMMEDIATE OBJECTIVES, OUTPUTS, AND ACTIVITIES

D.1 Immediate Objective 1: Intervention Technology Development

Determine major cassava production constraints in principal agroecozones. Test, adapt and implement selected crop protection, production and postharvest processing technology components. Develop new technologies where suitable ones are lacking. This includes extensive and intensive diagnosis, on-farm trials, strategic laboratory and field studies, decentralized intervention technologies, and implementation and evaluation.

Table 4. Intervention Technology Development

Project Area	Expected Output	Activities
Global:		
Natural enemy & germplasm resources	Useful natural enemy & germplasm resources identified & added to intervention tools	Characterize selected natural enemies & local germplasm, e.g., explore, identify, import & release predators & fungal pathogens of CGM; identify & characterize useful genes in local germplasm
Control of root rot pathogens	A global strategy for reducing losses root rots through biological & cultural control developed	Characterize pathogens & their ecogeographical distribution, develop inoculation & screening methods & PCR-based detection kits; international workshop on root rot management & biological control; international & national scientist exchange visits; selection & testing of antagonistic microorganisms
Crop management	Increased yield through improved crop management; generation of a global research strategy	International workshop on crop production systems & production of quality planting material
Africa:		
Cassava planting material sanitation & management	Cassava productivity increased & sustained through cutting sanitation & management practices	Develop & implement procedures to reduce pests & diseases and manage vigor of cassava cuttings
Biological control of cassava green mite (CGM)	Losses due to CGM reduced in targeted ecozones through release of natural enemies	Characterize import, quarantine, multiply, & distribute natural enemies; assess impact
Cultural control of plant pathogens	Cultural controls for selected disease constraints made available	Develop sustainable cultural control strategies for selected diseases in specific ecozones; characterize pathogens; develop inoculation & screening methods targeted to ecozones; select & test antagonistic microorganisms
Ecosystem-specific pests (ESP), e.g., weeds, termites, nematodes, vertebrates	Strategies for addressing ESP developed, tested & implemented in targeted ecozones	Include ESP in cassava R&D & develop, test & implement appropriate interventions, e.g., introduce cover crop for weed & soil deficiency problems
Postharvest pests & diseases	Importance of postharvest pests & pathogens assessed, & control strategies developed	Characterize the pest status of insect pests & fungi associated with stored products; develop control strategies

Cassava root scale (CRS)	Importance of CRS in humid forest ecozone of Central Africa diagnosed	Determine extent and severity of CRS; develop & test preliminary intervention technologies
Latin America:		
Biological control of cassava green mite (CGM)	Introduction of exotic natural enemies to reduce losses to CGM in Africa, NE Brazil & Cuba	Collect, identify, evaluate & export mite predators to Africa, NE Brazil and Cuba; collect, characterize & export *Neozygites* to Africa
Control of root rot pathogens	Reduced losses to root rots in targeted ecozones of Latin America and Africa	Characterize root rot pathogens; develop inoculation & screening methods; select & test biological control agents; participatory testing of cropping systems & varieties to control root rot pathogens
Control of virus diseases	Reduced losses to virus diseases in targeted ecozones of Latin America and Africa	Characterize viruses; develop inoculation & screening methods; participatory testing of cropping systems & varieties to control viruses
Control of bacteriosis	Reduced losses to bacteriosis in targeted ecozones of Latin America and Africa	Characterize bacterial pathogens; develop inoculation & screening methods; participatory testing of cropping systems & varieties to control bacteriosis
Biological control of cassava hornworm	Increase control of hornworm; reduce pesticide use	Modify and adopt methods to produce, store & deliver hornworm baculovirus to affected areas
Ecosystem specific pests (ESP), e.g., weeds, whiteflies, white grubs, leafcutting ants, stemborers, burrowing bug	Strategies for addressing ESP developed, tested & implemented in targeted ecozones	Determine importance of pest; develop, test & implement appropriate interventions (biological, cultural & genetic control)
Crop production (in bilateral satellite projects)	Increase production by >20%; extend the harvest period from ca. 4 months to 12 months in subtropics & reduce environmental degradation	Develop, test & adopt methods to produce & select planting material, manage soil quality & planting systems, & cassava varieties
Postharvest processing and marketing (in bilateral satellite projects)	Diversification of the uses of cassava; increased and stabilized market demand; profitability of cassava products increased	Conduct market surveys; design & construct processing plants for dry chips, flour, starch; evaluate the operation/impact of pilot plants on markets procured incomes

D.2 Immediate Objective 2: Human Resource Development

Train farmers, extension workers, and national program researchers in the principles and practice of ecologically sustainable crop protection and production, farmer participatory research, and postharvest processing. This includes the development of plant protection curriculum and training materials, individual and group training.

Table 5. Human Resource Development

Project Area	Expected Output	Activities
Africa:		
Needs assessment	Training requirements, inventory of training resources & opportunities determined	Conduct participatory workshops & focus group interviews with the NARS and FFS groups
Training of researchers, extensionists & trainers	Effectiveness of researchers, extensionists & trainers increased	Conduct training workshops in the principles & practices of sustainable cassava plant protection, participatory skills for FFS & FPR implementation & didactic materials preparation
Farmer training	Farmer participation integrated into the process of developing cassava IPM technologies & practices	Establish FFS for action learning & research; catalogue & validate indigenous cassava plant protection knowledge, technologies & practices; constitute FFS into a regional farmers group network
Specialized training	Research ability of NARS enhanced	Provide specialized training demanded in the region, e.g., GIS, statistics, tissue culture, characterization, databases
Curriculum adoption	Ability of NARS to deliver sustainable plant protection training enhanced	Develop & deliver curriculum to trainers in collaborating NARS
Training evaluation	Overall and specific value of training to collaborating NARS determined	Conduct formative and final monitoring and evaluation of training activities

Latin America:		
Participatory research & extension methods	Disseminate of participatory research & extension models to new areas in Latin America; farmer conducted research & validation; prioritization of research & extension needs in new target areas	Regional workshops for national & regional personnel on farmer participatory methods for cassava production; train trainers; establish Local Agricultural Research Committees (COPAL); conduct participatory diagnostic surveys and FPR on-farm experiments
Specialized training	Research ability of NARS enhanced	Provide specialized training in the region, e.g., GIS, statistics, tissue culture, characterization, databases
Crop management	Cassava productivity and sustainability improved environmental degradation reduced	Develop, test & adopt methods to produce & select planting material, manage soil quality & planting systems
Curriculum adoption	Ability of NARS to deliver sustainable plant protection training enhanced	Develop & deliver curriculum to trainers in collaborating NARS
Improve postharvest processing & marketability	Stabilized local market prices & increased profitability of cassava products	Develop, test & adopt new products & processing of cassava; conduct market surveys

D.3 Immediate Objective 3: Information Resource Development

Increase availability of technical information to national program scientists and extensionists and to scientists working on cassava around the world.

Table 6. Information Resource Development

Project Area	Expected Output	Activities
Africa and Latin America:		
Needs assessment	Information needs of scientists, extension agents & farmers assessed	Identify information needs of scientists, extension agents & farmers in participating countries
Materials preparation	Information resources compiled	Compile & update directories of personnel & projects, current cassava bibliography, local gray literature, other specialized directories

Publications	Information resources published	Produce & publish information briefs, proceedings, field guides, CD-ROM, web page, didactic materials & other relevant materials
Dissemination	Information resources disseminated	Distribute information briefs, proceedings, field guides, CD-ROM, web page, didactic materials & other relevant materials
Decision support	Decision support tools for sustainable plant production developed, adapted & utilized	Develop a cassava plant protection decision support system which links expert systems w/ existing databases
Didactic materials development	Effectiveness of NARS training & extension improved	Develop, produce & distribute participatory workbooks & cassava IPM didactic materials

D.4 Immediate Objective 4: Mechanisms for Coordination

Plan and manage activities within and between participating countries, regional networks and international centers, and provide project evaluation and accountability.

Table 7. Mechanisms for Coordination

Project Area	Expected Output	Activities
Global:		
Regional meetings & exchange visits	Goal oriented project plans established & outputs documented	Plan regional goal-oriented projects; identify regional activities & responsibilities; technical workshops; exchange visits
Africa:		
Team organization	Regional teams identified & selected	Select national coordinators; national workshop to intro. project; select national team; implement agreements; establish team logistics
Work planning	Work plan & budget revised annually	Prepare annual work plans and budgets
Collaborative Research Program	Competitive research support distributed according to the priorities of the region	Announce competitive support program; outline priority areas; short list proposals by discipline; select finalists via multi-disciplinary committee

Regional meetings & exchange visits	Goal oriented project plans established & outputs documented	Regional goal oriented project planning; identify regional activities & responsibilities; technical workshops; exchange visits
Reporting, evaluation & monitoring	Project evaluations & reports	Conduct regional project reviews; prepare annual and final reports
Latin America:		
Team organization	Regional teams identified & selected	Select national coordinators; national workshop to intro. project; select national team; implement agreements; establish team logistics
Work Planning	Work plan & budget revised annually for CIAT & each country	Prepare annual work plans and budgets
Reporting, evaluation & monitoring	Project evaluations & reports	Conduct regional project reviews; prepare annual and final reports
Regional meetings & exchange visits	Revise overall project plans & outputs documented	Conduct regional project planning; hold technical workshops & exchange visits

E. INPUTS

E.1 IITA Input

IITA will provide the equivalent of ca 15 scientist-years through its Cassava IPM and Cassava Production projects, their technical support staff needed to provide the desired 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 $3 million per year.

E.2 African Countries Input

The national programs in each participating country will provide, on secondment, four 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.

E.3 CIAT Input

At least 15 CIAT scientists and other senior staff will be directly involved in project activities. CIAT's annual contribution, including senior and support staff, expendible expenses and operation and maintenance of laboratories, greenhouses, library, computing facilities, field plots, vehicles and general infrastructure represents at least $2 million. This does not include the capital investment in the facilities, accumulation of cassava germplasm and biological control agents, and accumulated knowledge and experience.

E.4 Latin American Countries Input

The national programs in each participating country will provide the necessary research and extension staff and research and training facilities needed to meet within country objectives. This will include the basic salary, allowances and social benefits normally accrued to national staff, plus office space and most of the necessary laboratory facilities, rearing rooms, and vehicles needed to carry out the proposed research and implementation activities. Each country will also provide about 50% of the operating expenses budgeted for the project activities within their country.

E.5 Donors' Input

The donors are requested to provide a total of US $11,932,200 ($4,122,600 for West and Central Africa, $2,527,900 for East and Southern Africa, and $5,281,700 for Latin America) to support the proposed sustainable plant protection R&D activities in at least 6 countries in two regions of Africa and three countries in Latin America from 1998 to 2001.

F. 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 Latin America 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.

G. 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.

H. 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 Latin 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 the donors; request. Representatives of the donors' 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.

I. 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 ecoregional responsibility for rice and other selected agroecosystems in Latin America and the Caribbean. The center shares its research results and germplasm with national programs, international centers, research institutions and the general public.

J. BUDGETS

J.1 Africa Component

The Africa component is divided into separate West and Central, and East and Southern region budgets. Each budget is comprised of costs associated with Regional Coordination provided by IITA, Regional R&D activities opened to all

interested collaborators in a region on a competitive basis, Implementation activities designated for selected priority countries in each region, Central Services reflecting the overhead costs to IITA for project operations, Implementation Capital also designated for targeted countries, and Regional Capital for IITA and collaborating NARS. A 5% cost of living increase is anticipated in personnel costs during the project. Future increases affecting other costs are expected to fall within the proposed budget.

Regional R&D and Implementation activities are budgeted to reflect priorities and project scope. While precise budget allocations by expected line item expenditures e.g. supplies and expenses, per diem, travel and capital are not possible for proposals yet to be developed by participating NARS and, exceptionally by international collaborators, the rule of thumb expected to be applied here comes from the successful proposals in the first phase of the project e.g. 25% for supplies and expenses, 35% for per diem, 25% for travel and 15% for capital.

About three quarters of the Africa budget is designated for participating NARS, and is divided approximately evenly into Implementation, Intervention Technology Development, Human Resource Development, Information Resource Development, and Coordination. Line items in the summary and itemized budgets below refer to project outputs as follows:

Implementation: national and international expertise, associated supplies, expenses, travel and capital for implementation of proven technologies, and associated coordination costs.

Intervention technologies: national and international expertise, associated supplies, expenses, travel and capital for diagnosis, strategic R&D, and associated coordination costs.

Human resources: national and international expertise, associated supplies, expenses, travel and capital for needs assessment, curriculum development, in-service, farmer, bench/specialized, and associated coordination costs.

Information resources: national and international expertise, associated supplies, expenses, travel and capital for information resource needs assessment, update and development of reference resources and other didactic materials, publications, decision support, and associated coordination costs.

Coordination: national and international expertise, associated supplies, expenses, travel, capital and central services for project management; planning meetings, workshops, exchange visits, and evaluations.

Table 8. Budget Summary by Region and Output (US $000)

	1998	1999	2000	2001	Total
West & Central Africa					
Implementation	223.9	167.0	159.9	161.2	712.0
Intervention technologies	238.9	182.0	174.9	176.2	772.0
Human resources	283.9	227.0	199.9	161.2	872.0
Information resources	198.9	187.0	184.9	151.2	722.0
Coordination	323.4	224.6	239.4	257.1	1,044.6
Total	1,268.9	987.6	959.2	907.0	4,122.6

	1998	1999	2000	2001	Total
East & South Africa					
Implementation	139.7	145.1	108.7	87.3	480.9
Intervention technologies	159.7	125.1	118.7	117.3	520.9
Human resources	149.7	115.1	98.7	77.3	440.9
Information resources	139.7	135.1	133.7	92.3	500.9
Coordination	193.5	117.5	130.7	143.3	584.2
Total	782.4	638.0	589.9	517.5	2,527.9

J.1.1 West & Central Africa Itemized Budget (US $000)

	notes	1998	1999	2000	2001	Total
Regional Coordination (IITA)	A					
Technical Expertise	B					
Training coordinator		118.0	126.3	135.1	144.6	523.9
Research coordinator		118.0	126.3	135.1	144.6	523.9
Support staff		39.5	42.3	45.2	48.4	175.4
Supplies and Expenses	C					
Vehicle maintenance		10.0	10.0	10.0	10.0	40.0
Fuel		15.0	15.0	15.0	15.0	60.0
Expendable supplies		15.0	15.0	15.0	15.0	60.0
Communications		10.0	10.0	10.0	10.0	40.0
Travel	D					
Regional		15.0	15.0	15.0	15.0	60.0
International		10.0	10.0	10.0	10.0	40.0
Subtotal		350.5	369.8	390.4	412.5	1,523.2
Regional R&D (all NARS)	E					
Intervention Technology Develop.:	F					
Cutting sanitation		15.0	15.0	15.0	15.0	60.0
Cultural control of diseases		15.0	15.0	15.0	15.0	60.0
Ecosystem-specific pests		15.0	15.0	15.0	15.0	60.0
Postharvest pests		10.0	10.0	10.0	10.0	40.0
Natural enemy & germplasm		10.0	10.0	10.0	10.0	40.0
Cassava root scale		10.0	10.0	10.0	10.0	40.0
Information Resource Development:	G					
Info. res. update		10.0	15.0	15.0	10.0	50.0
Decision support		0.0	20.0	20.0	10.0	50.0
Materials development		5.0	15.0	20.0	10.0	50.0
Publications/printing		10.0	20.0	30.0	20.0	80.0
Coordination:						
Goal oriented project planning	H	10.0	0.0	0.0	0.0	10.0
Collaborators workshops	I	35.0	0.0	20.0	35.0	90.0
Subtotal		145.0	145.0	180.0	160.0	630.0
Implementation (targeted NARS)	J					
Coordination:	K					
National liaison officers		15.0	15.8	16.5	17.4	64.7
Vehicle maintenance		2.5	2.5	2.5	2.5	10.0
Fuel		2.5	2.5	2.5	2.5	10.0
Expendable supplies		2.5	2.5	2.5	2.5	10.0

J.1.1 West & Central Africa Itemized Budget (US $000) continued

	notes	1998	1999	2000	2001	Total
Travel		2.5	2.5	2.5	2.5	10.0
Information Resource Development:	L					
Compile inform. res.		2.5	2.5	0.0	0.0	5.0
Human Resource Development:	M					
Farmer Field Schools		15.0	15.0	10.0	5.0	45.0
Training trainers		10.0	10.0	5.0	5.0	30.0
Bench/specialized training		5.0	5.0	10.0	5.0	25.0
Diagnosis & Technology Impiemen.:	N					
Implementation		15.0	15.0	15.0	15.0	60.0
NARS overheads (5.0%)	O	3.6	3.7	3.3	2.9	13.5
Subtotal for 4 countries		304.5	307.7	279.5	240.9	1,132.5
Central Services (W&C)	P					
IITA operations (18.8%)		65.9	69.5	73.4	77.5	286.4
Regional & NARS operations (4.0%)		18.0	18.1	18.4	16.0	70.5
Implementation Capital (NARS)	Q					
Vehicle		30.0	0.0	0.0	0.0	30.0
Computers		5.0	0.0	0.0	0.0	5.0
Training equipment		5.0	2.5	0.0	0.0	7.5
Office equipment		5.0	2.5	0.0	0.0	7.5
Subtotal for 4 countries		180.0	20.0	0.0	0.0	200.0
Regional Capital (IITA& NARS)	R					
Vehicles		90.0	0.0	0.0	0.0	90.0
Computers		30.0	20.0	5.0	0.0	55.0
Training equipment		10.0	5.0	0.0	0.0	15.0
Field equipment		20.0	10.0	5.0	0.0	35.0
Laboratory equipment		40.0	15.0	5.0	0.0	60.0
Office equipment		15.0	7.5	2.5	0.0	25.0
Subtotal		205.0	57.5	17.5	0.0	280.0
Regional Total		1,268.9	987.6	959.2	907.0	4,122.6

J.1.2 East & Southern Africa Itemized Budget (US $000)

	notes	1998	1999	2000	2001	Total
Regional Coordination (IITA)	A					
Technical Expertise	B					
Research coordinator		118.0	126.3	135.1	144.6	523.9
Support staff		13.2	14.1	15.1	16.1	58.5
Supplies and Expenses	C					
Vehicle maintenance		5.0	5.0	5.0	5.0	20.0
Fuel		5.0	5.0	5.0	5.0	20.0
Expendable supplies		5.0	5.0	5.0	5.0	20.0
Communications		3.0	3.0	3.0	3.0	12.0
Travel	D					
Regional		7.5	7.5	7.5	7.5	30.0
International		3.5	3.5	3.5	3.5	14.0
Subtotal		160.2	169.3	179.2	189.7	698.4
Regional R&D (all NARS)						
Intervention Technology Develop.:	F					
Cutting sanitation		15.0	15.0	15.0	15.0	60.0
Cultural control of diseases		15.0	15.0	15.0	15.0	60.0
Ecosystem-specific pests		10.0	10.0	10.0	10.0	40.0
Postharvest pests		10.0	10.0	10.0	10.0	40.0
Natural enemy & germplasm		10.0	10.0	10.0	10.0	40.0
Emerging pest problems		10.0	10.0	10.0	10.0	40.0
Information Resource Development:	G					
Information resources update		10.0	15.0	15.0	10.0	50.0
Decision support		10.0	20.0	20.0	0.0	50.0
Materials development		5.0	10.0	20.0	15.0	50.0
Publications		10.0	20.0	30.0	20.0	80.0
Coordination:						
Goal oriented project planning	H	10.0	0.0	0.0	0.0	10.0
Collaborators workshops	I	35.0	0.0	20.0	35.0	90.0
Subtotal		150.0	135.0	175.0	150.0	610.0
Implementation (targeted NARS)	J					
Coordination:	K					
National liaison officers		15.0	15.8	16.5	17.4	64.7
Vehicle maintenance		2.5	2.5	2.5	2.5	10.0
Fuel		2.5	2.5	2.5	2.5	10.0
Expendable supplies		2.5	2.5	2.5	2.5	10.0
Travel		2.5	2.5	2.5	2.5	10.0

J.1.2 East & Southern Africa Itemized Budget (US $000) continued

	notes	1998	1999	2000	2001	Total
Information Resource Development:	L					
Needs assessment		5.0	5.0	0.0	0.0	10.0
Compile information resources		2.5	2.5	0.0	0.0	5.0
Human Resource Development:	M					
Farmer Field Schools		15.0	15.0	10.0	5.0	45.0
Training trainers		10.0	10.0	5.0	5.0	30.0
Bench/specialized training		5.0	5.0	10.0	5.0	25.0
Diagnosis & Technology Implemen.:	N					
Diagnostic survey		5.0	25.0	10.0	0.0	40.0
Implementation		20.0	20.0	20.0	20.0	80.0
NARS overheads (5.0%)	O	4.4	5.4	4.1	3.1	17.0
Subtotal for two countries		183.8	227.3	171.2	131.0	679.3
Central Services (E&S)	P					
IITA operations (18.8%)		30.1	31.8	33.7	35.7	131.3
Regional & NARS operations (4.0%)		13.4	14.5	13.8	11.2	52.9
Implementation Capital (NARS)	Q					
Vehicle		30.0	0.0	0.0	0.0	30.0
Computers		5.0	0.0	0.0	0.0	5.0
Training equipment		5.0	2.5	0.0	0.0	7.5
Office equipment		5.0	2.5	0.0	0.0	7.5
Subtotal for two countries		90.0	10.0	0.0	0.0	100.0
Regional Capital (IITA&NARS)	R					
Vehicles		60.0	0.0	0.0	0.0	60.0
Computers		25.0	15.0	5.0	0.0	45.0
Training equipment		10.0	5.0	0.0	0.0	15.0
Field equipment		15.0	10.0	5.0	0.0	30.0
Laboratory equipment		30.0	15.0	5.0	0.0	50.0
Office equipment		15.0	5.0	2.0	0.0	22.0
Subtotal		155.0	50.0	17.0	0.0	222.0
Regional Total		782.4	638.0	589.9	517.5	2,527.9

J.1.3 Africa Budget Notes

A Regional Coordination - refers to the technical expertise and project support provided by IITA to a given region.

B Technical Expertise - a single Training coordinator, separate Research coordinators for each region, plus associated support staff (scaled by a third for East & Southern Africa).

C Supplies and Expenses - operational costs associated with project management including vehicle maintenance, fuel, miscellaneous expendable supplies and communications (scaled by a third for East & Southern Africa).

D Travel - includes airfare and per diem associated with regional and international travel; (scaled by 0.44 for East & Southern Africa).

E Regional R&D - research and development topics identified as priorities for a given region; support available to interested NARS and exceptionally to international collaborators on a competitive basis.

F Intervention Technology Development - collaborative research targeting cutting sanitation, cultural control of diseases, ecosystem-specific pests, postharvest pests, natural enemy and germplasm resources, cassava root scale (not included for East & Southern Africa) and emerging pest problems to be identified.

G Information Resource Development - concerns region-wide activities related to resource updates, decision support development, materials development and publication.

H Goal-oriented project planning - workshop to be held during the first year of the project to harmonize detailed national work plans into a single regional plan of operations.

I Collaborators workshops - region-wide workshops to facilitate interactions and information exchange planned for the first and fourth year. Smaller specialized workshops on topics of strategic importance planned for the second and third year.

J Implementation - refers to extension service, farmer and field-level implementation activities proposed for targeted countries in each region.

K Coordination - refers to the national coordinator and associated support provided by each participating country.

L Information Resource Development - training and information needs assessment for East and Southern Africa only, and information resources updated and compiled.

M Human Resource Development - in-service training of extension agents and trainers, farmer training and specialized bench training for NARS staff on specific topics.

N Diagnosis & Technology Implementation - diagnosis of pest production constraints for priority setting and delivery of proven cassava plant protection technologies including new natural enemies & germplasm through international quarantine in East and Southern Africa only.

O NARS overheads - 5% of Implementation costs for NARS hosting project coordination in each country.

P Central Services - 18.8% of Regional Coordination costs and 4% of Regional R&D and Implementation costs for IITA operations.

Q Implementation Capital - includes a vehicle, computer, training and office equipment as required to support a national coordination office in targeted countries.

R Regional Capital - includes vehicles, computers, training and office equipment as required for IITA, NARS and international collaborators to support coordination, information management, collaborative research and training activities in a given region (scaled by 0.8 for East and Southern Africa).

J.2 Latin America Component

The budget designated for CIAT involves tranportation to and participation in planning and training workshops, scientist exchanges, backstopping research activities and development and distribution of information resources. These activities will benefit not only the direct participants, but also other scientists and extensionists around the globe who depend on this type of technical information. The total budget is divided into Intervention Technology Development (49%), Human Resource Development (22%), Information Resource Development (14%), and Coordination (15%). Line items in the summary and itemized budgets below refer to project outputs as follows:

Intervention technologies: - national and international expertise, associated supplies, expenses, travel and capital for diagnosis, strategic research and development, implementation of proven technologies, and associated coordination costs. Areas of expertise include: Acarology, Entomology, Plant

Pathology (fungi & bacteria), Virology, Postharvest Processing, Economics, Farmer Participatory Research, and Information Management.

Human resources: - national and international expertise, associated supplies, expenses, travel and capital for needs assessment, curriculum development, in-service, farmer, specialized and postgraduate training, and associated coordination costs.

Information resources:- national expertise, associated supplies, expenses, and capital for information resource needs assessment, update and development of reference resources and other didactic materials, publications, decision support, and associated coordination costs.

Coordination: - national and international expertise, associated supplies, expenses, travel, capital and central services for project management; planning meetings, workshops, exchange visits, and evaluations.

J.2.1 Latin America Itemized Budget (US $000)

Table 9. Budget Summary by Output (four-year total, US $000)

	Intervention technologies	Human resources	Information resources	Coordination	Total
Latin America	2,595.8	1,172.5	724.3	789.1	5,281.7

Table 10. Latin America Itemized Budget (US $000)

Item		1998	1999	2000	2001	TOTAL
PERSONNEL						
International	A	483.0	496.5	546.2	642.9	2,168.6
National	B	255.9	304.7	365.6	438.7	1,364.8
SUPPLIES & SERVICES	C	91.4	90.6	101.2	108.4	391.6
TRAVEL	D					
International		73.8	63.7	67.9	88.5	293.9
National		9.0	10.8	13.0	15.6	48.3
TOTAL TRAVEL		82.8	74.5	80.9	104.1	342.2
PROJECT MANAGEMENT	E					
CIAT (23%)		216.2	222.2	251.6	297.6	987.6
CAPITAL						
Computer, office	F	18.0	0.0	0.0	0.0	18.0
Laboratory	G	8.8	0.0	0.0	0.0	8.8
TOTAL CAPITAL		26.8	0.0	0.0	0.0	26.8
GRAND TOTAL		1,156.0	1,188.5	1,345.5	1,591.7	5,281.7

J.2.2 Latin America Budget Notes

A International Project Coordinator $126,500, Biological Control Specialist $126,500, FPR Training Specialist $83,380 (who will work extensively within each country), Economist (0.5), $63,250 (shared with CIRAD), Plant Pathologist hired by CIAT seconded to CNPMF $83,380.

B National personnel includes 6.25 assistants, 5 technicians, 3 workers, 1 computer programmer, 0.5 secretary.

C Supplies and Expenses - operational costs associated with project execution and management including laboratory, office and miscellaneous expendable supplies, communications, computer and vehicle maintenance, fuel, document preparation.

D Includes airfare, ground transportation and per diem associated with regional and international travel. International workshops are planned for the first and last year of the project.

E Project management includes fixed costs charged by CIAT (23% of internal budgets).

F Computers and software purchased for data processing, statistical analysis, graphics, writing, scanning and formating information for publication and transfer to CD-ROM and World Wide Web.

G PCR & electorphoresis equipment, controlled temperature water bath.

K. ABBREVIATIONS AND ACRONYMS

ACMV	African cassava mosaic virus
AFLP	Amplified fragment length polymorphism
CBN	Cassava Biotechnology Network
CD-ROM	Compact disk, read-only memory
CFSD	Cassava frogskin disease
CGIAR	Consultative Group of International Agricultural Research
CGM	Cassava green mite
CIAT	International Center for Tropical Agriculture, Cali, Colombia
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (International Center for Cooperation in Agronomic Research for Development, Montpellier, France)
CNPMA	Centro Nacional de Pesquisa de Monitoramento e Avaliação de Impacto Ambiental (National Center for Research on Monitoring and Evaluation of Environmental Impact, Jaguariúna, São Paulo, Brazil)
CNPMF	Centro Nacional de Pesquisa de Mandioca e Fruticultura Tropical (National Center for Research on Cassava and Tropical Fruits, Cruz das Almas, Bahia, Brazil)
COPAL	Farmer research committee (Portuguese acronym)
COSCA	Collaborative Study on Cassava in Africa
CPATC	Centro de Pesquisa Agropecuária dos Tabuleiros Costeiros, Petrolina, Pernambuco, Brazil.
CPATSA	Centro de Pesquisa Agropecuária do Trópico Semi-Arido, Petrolina, Pernambuco, Brazil.
CsCMV	Cassava common mosaic virus
CVMV	Cassava vein mosaic virus
DEAG	Dirección de Extensión Agraria (Department of Agricultural Extension, Paraguay)
DGSV	Dirección General de Sanidad Vegetal (National agricultural extension system of Cuba)
DIA	Dirección de Investigación Agrícola (Department of Agricultural Investigation, Paraguay)
DNA	Deoxyribonucleic acid
EAC	External Advisory Committee
EBDA	Brazil (Empresa Baiana de Desenvolvimento Agrícola (Agency for Agricultural Development of the State of Bahia)
EMATER-CE	Empresa de Assistência Técnica e Extensão Rural do Ceará (Ceara State Technical Assistance and Rural Extension Agency, Brazil)
EMATER-PB	Empresa de Assistência Técnica e Extensão Rural do Paraíba (Paraíba State Technical Assistance and Rural Extension Agency, Brazil)
EMATER-PE	Empresa de Assistência Técnica e Extensão Rural do Pernambuco (Pernambuco State Technical Assistance and Rural Extension Agency, Brazil)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (National Agency for Agricultural Research, Brazil)
EMEPA	Empresa Estadual de Pesquisa Agropecuária de Paraíba (State Agency of Agricultural Research of Paraíba)
EPACE	Empresa de Pesquisa Agropecuária do Ceará (Ceara State Agricultural Research Agency)
ESCaPP	Acronym used in Africa for the previous UNDP project "Ecologically Sustainable Cassava Plant Protection in South America and Africa: An Environmentally Sound Approach", known as PROFISMA in Latin America.
ETH	Swiss Federal Institute of Technology, Zürich
FAO	Food and Agriculture Organization
FCA	Facultad de Ciencias Agrarias (University of Agricultural Sciences, Paraguay)

FFS	Farmer field school
FPR	Farmer participatory research
GIS	Geographic information system
IFAD	International Fund for Agricultural Development, Rome, Italy
IICA	Inter-American Institute for Cooperation in Agriculture
IITA	International Institute of Tropical Agriculture
INIAP	Instituto Nacional Autonomo de Investigaciones Agropecuarias (National Autonomous Institute of Agricultural Research, Portoviejo, Ecuador)
INIVIT	Instituto de Investigaciones de Viandas Tropicales (Institute of Research on Roots Tubers and Plantain, Santo Domingo, Cuba).
IPA	Empresa Pernambucana de Pesquisa Agropecuária (State Agency of Agricultural Research of Pernambuco)
IPM	Integrated Pest Management
IPTA	National Agricultural Research Institute, Paraguay
NARES	National Agricultural Research and Extension Systems.
NARS	National Agricultural Research Systems.
NE	Northeast
ORSTOM	Institute Français de la Recherche Scientifique pour le Développement en Coopération.
PCR	Polymerized chain reaction
PROFISMA	Acronym used in Latin America for the previous UNDP project "Ecologically Sustainable Cassava Plant Protection in South America and Africa: An Environmentally Sound Approach", known as ESCaPP in Africa.
R&D	Research and development
SEED	Sustainable Energy and Environment Division of UNDP
UATAPPY	la Unión de Asociationes de Trabajadores Agrícolas, Productores y Procesadores de Yuca (Union of Associations of Agricultural Workers, Producers and Processors of Cassava in Manabí, Ecuador).
UFAL	Universidade Federal de Alagoas (State Agency of Agricultural Research of Alagoas)
UFC	Universidade Federal do Ceará (State Agency of Agricultural Research of Ceará)
UNDP	United Nations Development Programme
UNICAMP	State University of Campinas, São Paulo (Universidade Estadual de Campinas)

L. APPENDICES

L.1 Collaborating National and State Institutions in Africa

Benin:
CARDER - Centre d'Action Régionale pour le Développement Rural.
INRAB - Institut National de Recherche Agronomique au Bénin, Niaouli.
SPVCP - Service Protection des Végétaux et Contrôle Phytosanitaire, Porto Novo.
UNB - Université Nationale du Bénin, Cotonou.

Cameroon:
IRAD - Institute of Agricultural Research for Development, Ministry of Scientific and Technical Research.
NAETP - National Agricultural Extension Training Program, Directorate of Agricultural Operations, Ministry of Agriculture.
UB - University of Buea, Buea.

Ghana:
CRI - Crops Research Institute, Kumasi.
CSD - Crop Services Department, Ministry of Food and Agriculture.
DAES - Department of Agricultural Extension Services, Ministry of Food and Agriculture.
PPMED - Policy, Planning, Monitoring and Evaluation Department, Ministry of Food and Agriculture.
PPRSD - Plant Protection and Regulatory Services Department, Ministry of Food and Agriculture.
UCC - University of Cape Coast, Cape.

Nigeria:
ADP - Agricultural Development Programs (20 State ADPs).
FUTO - Federal University of Technology, Owerri.
NRCRI - National Root Crops Research Institute, Umudike.
UNAAB - University of Agriculture, Abeokuta.

Mozambique:
SARRNET - Southern African Root and Tuber Crops Research Network (with Plant Protection Department, Biological Control Sector, Ministry of Agriculture and Fisheries, Maputo, Mozambique).

Uganda:
EARRNET - East African Root and Tuber Crops Research Network (with National Agricultural Research Organization, NARO, Kampala, Uganda).

L.2 Collaborating National and State Institutions in Latin America

Brazil:

CNPMA/EMBRAPA - National Center for Research on Monitoring and Evaluation of Environmental Impact, Jaguariùna, Sào Paulo, Brazil (Centro National de Pesquisa de Monitoramento e Avaliaçào de Impacto Ambiental). This center is within EMBRAPA (Empresa Brasileira Pesquisa Agropecùaria), the national agricultural research agency.

CNPMF/EMBRAPA - National Center for Research on Cassava and Tropical Fruits, Cruz das Almas, Bahia , Brazil (Centro Nacional de Pesquisa de Mandioca e Fructicultura Tropical).

CPATC - Centro de Pesquisa Agropecùaria dos Tabuleiros Costeiros, Petrolina, Pernambuco, Brazil.

CPATSA/EMBRAPA - Centro de Pesquisa Agropecùaria do Tròpico Semi-Arido, Petrolina, Pernambuco, Brazil.

EBDA - Agency for Agricultural Development of the State of Bahia, Brazil (Empresa Bainaa de Desenvolvimento Agrìcola).

EMATER-CE - Ceara State Technical Assistance and Rural Extension Agency (Empresa de Assistência Técnica e Extensào Rural do Cearà).

EMATER-PB - Paraiba State Technical Assistance and Rural Extension Agency (Empresa de Assistência Técnica e Extensào Rural do Paraìba).

EMATER-PE - Pernambuco State Technical Assistance and Rural Extension Agency (Empresa de Assistência Técnica e Extensào Rural do Pernambuco).

EMEPA - State Agency of Agricultural Research of Paraiba (Empresa Estadual de Pesquisa Agropecùaria de Paraìba).

EPACE - Ceara State Agricultural Research Agency (Empresa de Pesquisa Agropecùaria do Ceara).

IPA - State Agency of Agricultural Research of Pernambuco (Empresa Pernambucana de Pesquisa Agropecùaria).

UFAL - State Agency of Agricultural Research of Alagoas (Universidade Federal do Alagoas)

UFC- State Agency of Agricultural Research of Ceara (Universidade Federal do Ceara).

UNICAMP - State University of Campiras, Sào Paulo (Universidade Estadual de Campiras).

Cuba:

DGSV - National agricultural extension system of Cuba (Direcciòn General de Sanidad Vegetal).

INIVIT - Institute of Research on Roots Tubers and Plantain, Santo Domingo, Cuba (Instituto de Investigaciones de Viandas Tropicales).

Paraguay:

DEAG - Department of Agricultural Extension, Paraguay (Direcciòn de Extensiòn Agrarìa).

DIA - Department of Agricultural Investigation, Paraguay (Direcciòn de Investigaciòn Agrìcola).

FCA - University of Agricultural Sciences, Paraguay (Facultad de Ciencias Agrarias).