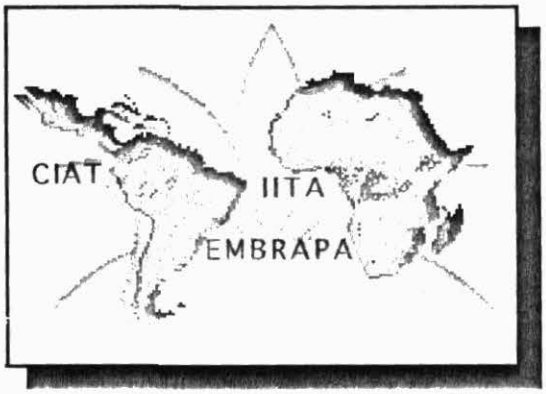
S. LAPOINTE

United Nations Development Programme

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

1994 Annual Report of Activities in South America



Prepared by project personnel in Colombia and Brazil.

South American component of a global project involving:

Centro Internacional de Agricultura Tropical (CIAT) at Cali, Colombia, the International Institute for Tropical Agriculture (IITA) in Nigeria, and the Empresa Brasileira de Pesquisa Agropecuária, Centro Nacional de Pesquisa en Mandioca y Frutales (EMBRAPA/CNPMF) at Cruz das Almas, Bahia, Brazil.

30 January, 1995

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

Technical Report on Activities conducted during 1994 by PROFISMA (Proteção Fitossanitária Sustentâvel da Mandioca): the South American component of a global UNDP project.

Project Ref. GLO/91/013

TABLE OF CONTENTS

PROFISMA (Proteção Fitossanitária Sustentâvel da Mandioca): the South American component of a global UNDP project "Ecologically Sustainable Cassava Plant Protection in South America and Africa."

Technical Report on Activities conducted during 1994.

1. Executive Summary

At the end of 1994, PROFISMA (Proteção Fitossanitária Sustentâvel de Mandioca) finished its second year and arrived at the mid-point in the project's proposed duration. Staffing of PROFISMA was complete with the arrival of the mite biocontrol specialist to CIAT headquarters in May. Highlights of the project during 1994 included: The first formal meeting of PROFISMA and ESCaPP personnel in May/June of this year at Cotonou, Benin; The first UNDP external review conducted in August, 1994; Training activities and diagnostic surveys were initiated and gained momentum through the course of the year thereby providing an essential framework for integrated activities by researchers, extensionists and farmers. The enthusiastic response of extension and other state-level agencies to training activities carried out by PROFISMA in collaboration with CIAT's IPRA program was gratifying. This self-propagating training is generating demand and expectations for future activities that will provide the necessary motivation for researcher involvement in project field activities.

In general, the project is making satisfactory progress towards its goal of delivering sustainable plant protection technology to growers. As the time remaining becomes short, distribution of resources between strategic research and implementation activities will require careful analysis. Establishing participatory activities in cassava-growing communities during 1995 will be critical to involve researchers in on-farm participatory trials and to select appropriate technologies for further development.

Training

A model for training and phytosanitary and socioeconomic diagnosis is evolving from the project's activities that will become a general model for developing farmer participatory projects. The model is advancing by accretion, combining elements of recent publications in the field of farmer participatory research with our own experience as PROFISMA progresses and we learn by doing. True to the spirit of client-driven research, extensionists and researchers are being trained in participatory methods with the goal of providing them with the means through which appropriate mechanism(s) for farmer involvement can evolve. Emphasis is placed on adapting methods to the social, economic and biological environment of northeastern Brazil. A training event in February, 1995 will provide

methods for researchers and extensionists to establish participatory trials in farmers' fields. The event will establish activities in the littoral and transition (Agreste) zones including a workplan for contacting communities identified from the extensive diagnostic phase. There will be visits by extensionists and researchers followed by meetings to finalize activities to be planted during the first semester, 1995.

Development of PROFISMA's training model has benefited from previous experiences generated in the project "Farmer Participation in Technology Design and Transfer" (IPRA Project), implemented by CIAT in Colombia since 1987 funded by the W.K. Kellogg Foundation. IPRA has contributed directly to implementation of PROFISMA's training activities through participation of IPRA's training staff in training events in Brazil during 1994. Training material on participatory methods developed by IPRA has been tailored to PROFISMA's objectives and working conditions.

At completion of the first stage of PROFISMA's training plan (Participatory Diagnosis), the project has provided a framework wherein farmers, researchers, and extensionists together produced participatory diagnoses in 74 communities located in 51 townships in four states of northeastern Brazil. Total number of farmers participating in these activities was 1,662 of which 335 (20%) were women.

Socioeconomic surveys

Results of extensive diagnostic surveys in four states emphasized soil fertility as a constraint to cassava production. The intensive survey, now under way, will further characterize the problem and identify areas where intervention is possible. Another constraint clearly identified in specific regions of the extensive surveys is root rot. This is an opportunity for the project to rapidly initiate validation and technology-testing activities with farmers using technologies already in hand, such as resistant varieties and appropriate planting systems. Few arthropod pests were immediately identified as important constraints. The intensive survey will validate this information and determine whether the low ranking given to arthropods reflects real conditions or farmers' perceptions of problems that are often difficult to diagnose or attributed to other causes. Training activities during 1995 will concentrate on training extensionists and researchers in methods for implementation of participatory trials and technology-testing with farmers in farmers' fields. Thus, training activities drive the socioeconomic surveys, implementation of participatory methods, and integration of researchers and extensionists with farmers.

Strategic research in Colombia and Brazil

Strategic research in acarology, pest management (cassava mealybug, whiteflies and cassava hornworm), plant pathology (management of root rots) and virology (CVMV) were conducted at CIAT and is reported under the respective headings in this report. Two

new activities were added to the project workplan for 1995, including genetic characterization of *Neozygites* and crop management. The former is a collaboration between acarology, CNPMF and the Biotechnology Unit of CIAT and was initiated in response to the high priority given to this activity during an international workshop held in Cruz das Almas on the mite pathogen[1] . The latter includes components for improved and integrated crop management systems for subhumid and seasonally dry ecosystems developed by the Physiology section of the CIAT Cassava Program. The inclusion of this activity is in response to the initial results of the participatory surveys wherein soil management was identified as a major constraint to cassava production.

Agronomy. Experiments planted in Brazil during 1994 continue to be evaluated and are scheduled for completion upon harvest in early 1995. These include studies on the use of leguminous cover crops and their role in retaining soil moisture, effects on soil fertility and erosion, weed control and yield. Cover crops are also being studies as potential refuges and/or food sources for pests and natural enemies. A similar study looks at weed vegetation and its effect on cassava productivity and will define the critical period for weed interference with cassava productivity. An experiment at Cruz das Almas to study the effects of weeds on yield determined that, in Cruz das Almas, it is not necessary to keep the cassava crop weed-free throughout the crop cycle. It appears that the critical period for weed interference begins 30 days after germination and lasts for 3 to 4 additional months. Leaving weeds in place when their removal will not influence yield may be an important practice for conserving soil moisture and providing refuge for natural enemies of arthropod pests. Similarly, *bagana*, a waste product of a species of palm (*carnauba*), was evaluated as mulch in semiarid regions. Increasing amounts of bagana increased root yield and weight of aerial parts. Use of *bagana* reduced weeding operations and promoted early plant development.

Acarology. Acarology at CIAT focuses on Brazil as a target for importation of phytoseiid predators to control the cassava green mite (CGM). Exportation of phytoseiids to northeastern Brazil began this year with three shipments of A. tenuiscutus from Colombia. These were quarantined at CNPMA and released by CNPMF in Bahia. Three releases have been made to date and six colonies of *T. tenuiscutus* at CNPMF produce approximately 2,000 mites per month. Releases and post-release monitoring will continue in 1995. In collaboration with IITA, individuals of *T. manihoti* were sent to the University of Amsterdam for quarantine and forwarding to IITA Biological Control Station at Benin.

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[1] "Development of the fungal pathogen *Neozygites* for biological control of the cassava green mite in Latin America and Africa". An international workshop held at Cruz das Almas, Bahia, Brazil, 7-11 November, 1994. Funds provided by the Cassava Biotechnology Network, Cali, Colombia. See attached report.

Three species of phytoseiid mites (Amblyseius idaeus, A. limonicus & A. aripo) from Brazil have become established in West Africa. Dispersal and effectiveness of these predators are being studied by IITA. CIAT and IITA now plan to initiate a search for candidates adapted to cooler, high-elevation regions corresponding to central and east Africa.

Isolates of *Neozygites* were collected from sites throughout northeastern Brazil and multiplied at CNPMF. Methods for multiplication, storage and culturing continue to be developed. Studies on within-plant distribution and spread within fields of cassava are generating new insights into the epizootiology of this important natural control agent.

A separate study to be concluded in early 1995 aims to separate the effects of water stress and CGM damage, a point that has generated much discussion but never addressed experimentally. Results analyzed to date indicate that CGM have a strong effect on leaf area reduction during the dry season.

Entomology. Activities in entomology at CIAT included production and shipment of parasitoids to Brazil for control of the cassava mealybug (CM), studies on parasitoid behavior (competition), transmission in the field of the cassava hornworm baculovirus, and surveys for species distribution and natural enemies of whiteflies.

At CNPMF, several parasitoids and predators of CM have been identified. At Cruz das Almas in May, 1994, CM were found infected by a fungus identified as *Neozygites fumosa* (Speare). High mortality of CM due to the pathogen was observed during May and June. Although *N. fumosa* has been reported as an efficient natural enemy of several mealybug species, little is known about its effect on *P. herreni* in northeastern Brazil.

E. diversicornis (parasitoid of CM) was released in Bahia in 1994 and a colony of *A. coccois* was established at CNPMF. In December, 1994, 1,700 individuals of *A. coccois* were released at Itaberaba. *A. vexans* will be introduced from CIAT in early 1995.

Plant Pathology. Work at CIAT focused on identification of promising fungi for biological control of cassava pathogens, greenhouse and field screening of *Trichoderma*, population dynamics of *Trichoderma* spp. under crop rotations, and the effect of *Trichoderma* on cassava germination and growth. At CNPMF, the distribution of the several pathogens capable of producing root rot was characterized. Surveys showed that root rot occurs in about 50% of fields where annual rainfall exceeds 1,200 mm. On-farm trials located at Taquarana, Alagoas and Areia, Paraíba showed that using disease-free propagative material of tolerant varieties, such as 'Osso Duro', and planting them on ridges in a vertical position, constitute the most promising control measures for root rots.

Virology. The complete sequence of Cassava Vein Mosaic Virus (CVMV) was determined during 1994. Primers and optimal conditions for PCR amplification were

analyzed and the method is ready to be used as a research and diagnostic tool. Progress has been made on purification of the virus and production of antisera at the Federal University of Ceará (UFCE). Convincing evidence has been collected to show that visual symptoms are not a reliable indicator of virus infection and that CVMV does spread rapidly in the field. Problems with nonspecific reaction to CVMV antisera are being worked on.

Collaboration between PROFISMA and ESCaPP. Collaboration between the African and Latin American projects includes production of training material, training of CNPMF staff in mass rearing of phytoseiid mites, agronomy and information management. The parallel efforts in Africa and South America rely on shared information, expertise and resources leading to economies of scale. The liaison between international institutions creates a bridge between national programs isolated within continents, but with similar cassava production problems, that provides access to natural enemies, resistant germplasm, and expertise essential for developing and implementing appropriate cassava plant protection technologies.

2 Project Coordination

PROFISMA (Proteção Fitossanitária Sustentâvel de Mandioca) has completed its second year of operation. Staffing was complete with the arrival of the mite biocontrol specialist to CIAT headquarters in May. Highlights of the project during 1994 included: The first formal meeting of PROFISMA and ESCaPP personnel in May/June of this year at Cotonou, Benin; The first UNDP external review conducted in August, 1994; Training activities and diagnostic surveys were initiated and gained momentum through the course of the year thereby providing a framework for integrated activities by researchers, extensionists and farmers. The enthusiastic response of extension and other state-level agencies to training activities carried out by PROFISMA in collaboration with CIAT's IPRA program was gratifying. This self-propagating training is generating demand and expectations for future activities and should provide the necessary motivation for researcher involvement in project field activities.

A model (presented in the training section 5.1) for training and phytosanitary and socioeconomic diagnosis is evolving from the project's activities in these areas that will contribute to a general model for developing farmer participatory projects regardless of crop or geographic context. The model is advancing by accretion, combining elements of recent publications in the field of farmer participatory research with our own experience as PROFISMA progresses.

Results of diagnostic surveys in four states within the target area emphasize soil fertility as a production constraint. Extensive surveys generated many references to "poor soil"..

The intensive survey, now under way, will attempt to distinguish the various components included in this term and identify areas where intervention is possible. Root rot was also identified in specific regions. In these areas, the project will initiate validation and technology-testing activities with farmers using technologies already in hand, such as resistant varieties and planting systems. Few arthropod pests were identified as major constraints. An objective of the intensive survey will be to validate this information and determine whether the low ranking of arthropods reflects real conditions or a lack of farmer perception of problems difficult to diagnose. Training during 1995 will concentrate on training extensionists and researchers in methods for implementation of participatory trials and technology-testing with farmers. Thus, training activities drive the socioeconomic surveys and implementation of participatory methods.

A workshop was held at Cruz das Almas entitled "Development of the fungal pathogen *Neozygites* for biological control of the cassava green mite in Latin America and Africa." Partial funding for the workshop was provided by the Cassava Biotechnology Network (CBN), jointly organized by PROFISMA and ESCaPP. Participants included scientists from Switzerland, The Netherlands, USA, Benin (ESCaPP), Kenya, CIAT, and Brazil. Results of the workshop included a prioritization and detailed workplan for future work on *Neozygites* (see attached report). The purpose of the workshop was to organize new initiatives for attracting ancillary funds to support work into this promising form of biological control of cassava green mite. The output provided a clear ordering of activities to be conducted or considered within the PROFISMA project.

Collaboration between PROFISMA and ESCaPP increased during 1994 as a result of direct interaction between project staffs. Several areas were discussed for possible collaboration including training material production, training of CNPMF staff in mass rearing of phytoseiid mites, agronomy and information management.

In general, the project is making satisfactory progress towards its goal of delivering sustainable plant protection technology to growers. As the time remaining becomes short, distribution of resources between strategic research and implementation activities will require careful analysis. Establishing activities in communities during 1995 will be critical to involve researchers in on-farm participatory trials and to selection of appropriate technologies for further development. A training event is scheduled for March, 1995, that will provide methods for researchers and extensionists to establish participator trials in farmers' fields. A direct output of the event will be the establishment of activities in the littoral and transition (Agreste) zones. However, as the planting season is December for the semi-arid Caatinga zone, it was decided to establish participatory trials in the Caatinga without the benefit of the formal training provided by the course. To this end, a meeting

was held at EBDA headquarters in Salvador in early November followed by a session at CNPMF in late November. The result was a workplan for contacting communities identified from the extensive diagnostic phase. There were visits by extensionists and researchers followed by a meeting to finalize activities to be planted during December, 1994. To date, however, there has been insufficient rain for planting.

At CIAT, junior staffing was reviewed due to significant increases in personnel costs due to continued inflation of the Colombian peso (approx. 20%) and a stable exchange rate. The decision was made to reduce field activities on the north coast as the project has capabilities for executing similar activities in the semi-arid region within the target area in northeastern Brazil. Two new activities were added to the project workplan for 1995 in response to priorities growing out of project activities: genetic characterization of *Neozygites* and crop management. The former is a collaboration between the acarology group at CIAT, CNPMF and the Biotechnology Unit of CIAT and was initiated in response to the high priority given to this activity during the *Neozygites* workshop. The latter includes components for improved and integrated crop management systems for subhumid and seasonally dry ecosystems developed by the Physiology section of the CIAT Cassava Program. The inclusion of this activity is in response to the diagnostic surveys wherein soil management was identified as a major constraint to cassava production.

The "Plan Real" whereby the Brazilian currency was converted to the *real* and pegged to the dollar, had a large impact on project finances. Personnel costs rose significantly due to continued inflation and devaluation of the dollar relative to the real of approximately 20%. This may be temporary as the real is expected to devaluate by mid 1995. If not, the project will consider reduction in personnel to maintain operational funds. Cost of supplies and services has also increased. Most supplies are approximately twice the US price. Due to the budget surplus of the project's first year, the projected budget for 1995 exceeds that projected in the initial project document. However, projected 1995 expenses plus overall expenses of the project to date are within those projected for the first three years.

Collaboration between PROFISMA and ESCaPP

Collaboration between PROFISMA and ESCaPP increased during 1994. Several areas were discussed for possible collaboration including training material production, training of CNPMF staff in mass rearing of phytoseiid mites, agronomy and information management. The parallel efforts in Africa and South America rely on shared information (arthropod, agroecological and socioeconomic databases, and simulation models), expertise (classical biological control, mass rearing systems, taxonomy, microbial control, plant pathology, modeling, population biology, information management) and resources (information systems, natural enemy sources, common quarantine arrangements) leading to economies

of scale. Liaison between international institutions creates a bridge between national programs isolated within continents, but with similar cassava production problems, that provides access to natural enemies, resistant germplasm, and expertise essential for developing and implementing appropriate cassava plant protection technologies.

The continuing classical biological control effort in Africa depends on replacement and new natural enemy species from South America. Natural enemy production and release technologies have been developed in anticipation of new predators and pathogenic fungi to be produced for experimental releases. As these systems develop, new candidate natural enemies are sent from CIAT and EMBRAPA through quarantine at the U. of Amsterdam to IITA's Biological Control Center for Africa in Benin. Many of the procedures and technologies developed for the practical implementation of biological control in Africa will be adapted for work planned on the cassava green mite and the cassava mealybug in northeastern Brazil. African experiences in mass rearing, release, and follow-up activities will be incorporated into biological control work in South America. Procedures developed for manipulating microbial agents, such as *Neozygites* and the cassava hornworm virus in South America, will be adapted for similar work planned in Africa.

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

3 National Coordination

Legal agreements were established between EMBRAPA/CNPMF and state institutions to provide logistic support for PROFISMA activities. Agreements were signed with the Bahia State Organization for Agricultural Development (EBDA), Pernambuco State Organization for Agricultural Research (IPA), Ceará State Organization for Agricultural Research (EPACE), and Ceará State Organization for Technical Assistance and Rural Extension (EMATERCE). An agreement is pending with the Paraiba State Organization for Technical Assistance and Rural Extension (EMATERPB).

The national coordinator assisted in acquisition of equipment, reagents and other required materials. Participation of project staff in scientific meetings and training events was facilitated. Project activities were promoted through trips to Ceará and Pernambuco and participation in meetings with cassava grower communities.

4.1 Training

Successful development of agricultural technology requires understanding and appreciation of native technologies in order to generate research agenda capable of solving problems at the farmer level. Farmer involvement in technology generation and transfer is also necessary to contribute to farmers' understanding of their needs, and to stimulate closer interaction between researchers, extension workers and farmers. The result of this process is generation of client-driven research agenda where the research process starts at the user level and communication mechanisms between farmers and scientists throughout the process are enhanced.

Participatory Research Methods have been proposed as an answer to the issues cited above. These methods involve interdisciplinary teams of scientists to look at problems currently facing a given farming community, with farmer participation. These methods transform the scientist into a learner from, and with, farmers. Collecting information about farmers' problems, needs and perceptions by means of participatory methods allows scientists to know more about the farming community in less time than the traditional interview schedule. This improved knowledge and understanding of rural conditions, combined with modern scientific expertise results in improved opportunities for making technological and development interventions that are meaningful and responsive to farmers' concerns.

PROFISMA's Training Model

Design of a training master plan for PROFISMA has been based on the importance of these concepts in modern agricultural research and development. The training model formulated includes four stages in developing and implementing participatory research for designing and evaluating sustainable technologies for cassava-based systems, with emphasis on plant protection practices. Development of PROFISMA's training model has benefited from previous experiences generated in the project "Farmer Participation in Technology Design and Transfer" (also known as IPRA Project), implemented by CIAT in Colombia since 1987 funded by the W.K. Kellogg Foundation. IPRA has contributed directly to implementation of PROFISMA's training activities through the participation of IPRA's training staff in two training events in Brazil during 1994. Training material on participatory methods developed by IPRA has been tailored to PROFISMA's objectives and working conditions.

Training activities for PROFISMA recognize four stages in developing and implementing participatory research methods for designing, testing and evaluating technologies, as follows:

1. Participatory diagnosis with farmers;
2. Planning technology-testing activities with farmer participation;
3. Evaluation of technology-testing activities by farmers;
4. Monitoring and impact assessment of technology testing with farmers.

Training strategy

A general training strategy for each stage includes classroom training in methods, supervised field work, independent post-training activities by trainees, and follow-up events to process information and design the subsequent stage (Figure 4.1.1). For each of the four stages, key training areas have been identified to assemble the minimum curriculum content for researchers and scientists to become effective participatory research practitioners.

Implementation of a given stage begins with selection of trainees. Trainees are nominated by supervisors in collaborating institutions. The nomination includes a commitment from the trainee's institution assuring continued participation of the trainee in PROFISMA activities. Following the training activity, trainees put into practice what they have learned through a series of activities designed and conducted by them, based on the module that they have just been taught. In the case of Participatory Diagnosis, for example, trainees execute a series of participatory diagnostics in regions selected by them in close coordination with PROFISMA's leaders to assure that the selected areas fulfill the project's criteria and objectives. Finally, a general meeting is held where scientists from PROFISMA and collaborating institutions evaluate the results and discuss trainees' performance and the effectiveness of the training thereby generating feedback for improvement of procedures and training materials. This meeting is also used for discussing planning and implementation strategy for the next training stage.

Training activities 1994.

Training activities during 1994 built capacity among researchers and extension workers from collaborating institutions in methods to conduct farmer participatory research. The first stage of participatory research to be emphasized was participatory diagnosis. In 1994, a seminar on Attitudinal Sensitization and two courses ("Methodologies for Participatory Diagnosis" and "Evaluation of Technology with Farmers") were conducted. The seminar was a one-day event that presented concepts and attitudes essential to participatory research to selected policy-makers and researchers from CNPMF, extension workers and administrators from EBDA, and PROFISMA research staff. The seminar was attended by 45 participants. Due to limited time, it was not possible to use a formal instrument to measure impact and effect on attitudes. However, the general opinion expressed by participants was that participatory methods are important for research and technology transfer at CNPMF and EBDA and that further training opportunities must be offered to their personnel to become familiar with knowledge, skills and attitudes essential to perform efficiently as participatory research practitioners. The two courses were conducted with participation of 51 scientists from seven state institutions and two national EMBRAPA research centers (CNPMF and CPATC). This group of researchers and extension workers comprises the basic cadre of collaborators that will

be involved in implementation of PROFISMA's activities.

The first course was held at CNPMF with 28 trainees representing nine institutions from six states. The group included three of PROFISMA's technical staff. Activities comprised participatory fieldwork by trainees in 17 farming communities to conduct surveys of 350 farmers (106 women) (Table 4.1.1). The course included a wrapping-up session during which results were assembled, presented and discussed. A draft of each diagnosis was produced. Further activities of EBDA's trainees completed the diagnoses for each community and provided feedback to the farmer groups. Post-training activities conducted by EBDA trainees included participatory diagnostics in eight additional communities during which a total of 122 farmers (37 women) were contacted (Table 4.1.2).

A similar course was held at CETREX(Training Center for Extension) in Fortaleza, Ceará, with logistical and administrative support from EMATERCE. A total of 23 trainees representing three institutions from three states participated. During the fieldwork, 15 communities from six townships were involved in participatory diagnoses. Post-training activities conducted by EMATERCE's trainees included participatory diagnoses in five additional communities. EMATERCE's trainees completed the diagnoses for each community and provided feedback to the farmer groups. Final results of the participatory diagnoses in Ceará included direct contacts with 20 communities in eight townships and the contribution of 549 farmers (85 women) towards the definition of PROFISMA's research agenda and target areas (Table 4.1.3).

Trainees from Pernambuco and Paraíba, after participating in the training events at CNPMF and CETREX, formulated work plans that, with financial support from PROFISMA, allowed the realization of participatory diagnoses in 19 communities in Pernambuco and 10 in Paraíba (Tables 4.1.4 and 4.1.5). Farmer participation in these diagnostic activities included 367 producers (74 women) in Pernambuco and 274 (33 women) in Paraíba.

At completion of the first stage of PROFISMA's training plan (Participatory Diagnosis), the project has provided a framework wherein farmers, researchers, and extensionists interacted to produce participatory diagnoses in 74 communities located in 51 townships in 4 states of northeastern Brazil. Total number of farmers participating in these activities was 1,662 of which 335 (20%) were women (Table 4.1.6).

Evaluation of training activities

To assess the relevance, effectiveness and immediate impact of training activities, a systematic process of collecting information was established for PROFISMA's training events. This is used for guiding decision making as to whether the proposed objectives for each activity have been achieved and/or which changes need to be made to improve future training activities. Data collected this year also included basic information about characteristics of the trainees as follows:

Trainee Characteristics

1. Total attendance for the two courses on participatory diagnosis was 51, 36 men and 15 women, from 6 states representing:
    a) 3 state level technology transfer agencies;
    b) 3 state level agricultural research institutions;
    c) 1 land reform agency;
    d) 2 EMBRAPA research centers.
2. Trainees background included:
    a) 31 Agronomists;
    b) 7 Sociologists;
    c) 1 Economist;
    d) 2 Pedagogues;
    e) 1 Social Worker;
    f) 9 Agricultural Technicians.
3. 12 trainees have a Master's Degree.
4. Mean trainee age was 42 yrs (women 43, men 41).
5. Average period of trainee's permanence in last job was 17.5 yrs;
6. 30% of trainees have less than 10 yrs permanence period in last job.
7. Only 17% of trainees have less than 5 year permanence period in last job.
8. Only 10% of trainees have less than one year experience with cassava.

Other training activities

In addition to the two courses on participatory diagnosis and the seminar, other training activities conducted by PROFISMA during 1994 are presented in Table 4.1.7 and 4.1.8. PROFISMA's training strategy included training opportunities designed to allow project personnel and research and extension staff from collaborating institutions to receive training in specific areas according to their needs and research activities as well as participation in relevant meetings, seminars and workshops.

Table 4.1.1. Number of farmer participants in participatory diagnostic field work in Bahia, 1994.

Township	Community	No. farmers	
		Men	Women
Conceição da Feira	Candeal	35	32
	Onze Mil Virgens	9	22
Cruz das Almas	Cadete	13	2
	Poções	4	3
Sapeaçu	Tapera	5	2
São Felipe	Genipapo	8	0
Piritiba	Sumaré	13	0
	França	19	4
Itaberaba	Guaribas	12	5
	Testa Branca	13	0
Amargosa	Palmeira	6	1
São Miguel das Matas	Barra	17	7
Crisópolis	Buril	17	0
Inhambupe	Colonia Agrícola R. Santos	23	0
Sátiro Dias	Arraial de Santana	13	21
Irará	Bento Simões	21	3
Aporá	Chapada	16	4
TOTALS			
14	17	244	106

Table 4.1.2. Number of farmer participants in post-training participatory diagnostic field work in Bahia, 1994.

Township	Community	No.farmers	
		Men	Women
Catú	Varões	3	5
Esplanada	São José	17	0
	Chapada Vigario	18	1
S.G. Campos	Canto Escuro	11	7
Anguera	Umbuzeiro	1	12
	Caldeirão	7	5
Mundo Novo	Umbuzeiro	13	0
Amargosa	Cambauba	15	7
TOTALS			
6	8	85	37

Table 4.1.3. Number of farmer participants in participatory diagnostic survey, Ceará, 1994.

Township	Community	No. farmers	
		Men	Women
Ubajara	Nova Veneza	22	0
	Tucuns	11	3
Tianguá	Valparaiso	25	3
	Bom Jesús	15	5
Acaraú	Mucuná	21	9
	Vila Moura	27	2
	Cauassú	53	28
	Almecegas	28	0
	Capão	30	15
	Lagoa Grande	20	0
Marco	São Pedro	16	6
Bela Cruz	Lagoa do Mato	15	1
Cruz	Cajuerinho	15	0
	Solidão	39	0
Tururú	Cemoaba	41	5
	Lagoa do Inácio	29	2
Itapipoca	Macaco	18	5
Santana do Cariri	Serra do São Gonçalo	10	0
	Serra do Cruzeiro	14	0
	Serra da Canafístula	15	1
TOTALS		464	85
9	20	549	

Table 4.1.4. Number of farmer participants in participatory diagnostic surveys, Pernambuco, 1994.

Township	Community	No. farmers	
		Men	Women
Lajedo	Pau Ferro	16	4
Caetes	Queimada Grande	23	0
	Barriguda	14	2
São João	Tiririca	6	4
Jupi	Mulungú	10	10
São Bento do Una	Tatu	14	4
Cupira	Riacho do Verissimo	13	2
Paranatama	Oulhodaguinha	9	1
Pombos	Pé da Serra	10	1
Belo Jardim	Batinga	14	5
Gloria de Goitás	Gameleira	16	6
Vitoria de Santo Antão	Campina Nova	13	2
Araripina	Serra da Boa Vista	7	2
Ouricurí	Lagoa Comprida	24	9
Ipubi	Serrolandia	38	3
Condado	Engenho Patrimóno	21	0
João Alfredo	Sitio Camará	13	7
Sitio Agostinho	Sitio Agostinho	23	10
Sitio Barroncos	Sitio Barroncos	19	2
TOTALS			
18	20	293	74

Table 4.1.5. Number of farmer participants in participatory diagnostic surveys, Paraiba, 1994.

Township	Community	No. farmers Men	Women
Areia	Gravatá	14	8
	Casa da Pedra	13	5
	Engenho Cipó	23	12
Alagoa Grande	Engenho Mares	33	0
	Quitéria	41	3
Alagoa Nova	Gameleira	19	0
Salgado São Félix	Aburá	26	0
	Souza	28	5
Araçagí	São Vicente	27	0
	Piabas	17	0
TOTALS			
5	10	241	33

Table 4.1.6. Total farmer participation in PROFISMA's participatory surveys, 1994.

State	No. townships	No. communities	No. farmers Men	Women
Bahia	20	25	329	143
Ceará	9	20	464	85
Pernambuco	18	19	293	74
Paraiba	5	10	241	33
TOTALS				
			1327	335
4	51	74	1662	

Table 4.1.7. In service training activities, 1994.

Subject	Instructor (Institution)	No. trainees	Place	Duration (days)
Rearing methods for Neozygites	R. Humber (USDA)	4	CNPMF	8
Mite rearing methods	L. Smith	1	CIAT	30
Participatory research	J. Ashby, T. Graça (CIAT)	1	CIAT UATAPPY Ecuator	15
Effect of biocontrol agents on non target organisms	G. de Moraes (EMBRAPA/CNPMA)	1	CNPMA Jaguariuna	5
Yield loss assessment due to pests	A.R.N. Farias (EMBRAPA/CNPMF)	3	CNPMF	5
Virology	L. Calvert (CIAT)	1	CIAT	1

Table 4.1.8. Participation of PROFISMA and EMBRAPA/CNPMF research staff in other training events, 1994.

Event	Site	Date	Participants
IV Symposium on Biol. Control	Rio Grande do Sul, Brazil	May 14-20	6
IV International Symp. for Pest Ants	Belo Horizonte, Brazil	Nov 21-28	2
Coordination Meeting	CIAT, Colombia	Feb 18-26	2
Coordination Meeting	IITA, Cotonou, Benin	May 23 - Jun 2	2
External Advisory Comm. review	Cruz das Almas, Brazil	Aug 29 - Sep 2	33
Course on Biological Control	CNPMA, Jaguariuna, SP,Brazil	Oct 17-21	4
Brazilian Cassava Society Congress	Salvador, BA, Brazil	Nov 8-12	8
10th Symp. of the International Soc. for Tropical Root Crops (ISTRC)	Salvador, BA, Brazil	Nov 13-19	6
International Workshop on *Neozygites*	Cruz das Almas, Brazil	Nov 8-12	3

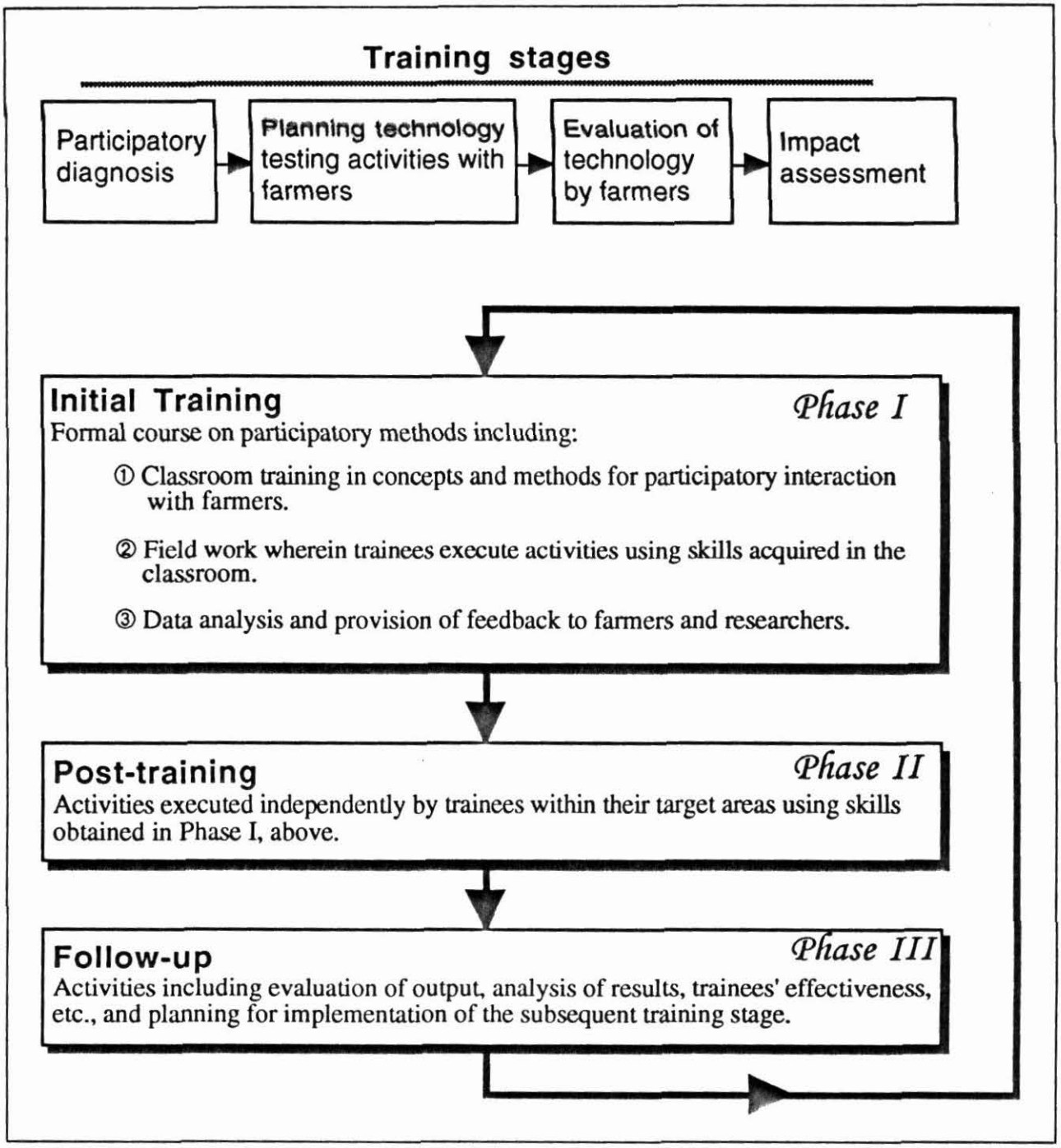


Figure 4.1.1. PROFISMA training model including four stages (above), each comprised of three training phases (below) with feedback to the initial phase of the subsequent training stage.

4.2 Socioeconomics

Socioeconomic and phytosanitary diagnostic surveys

Phase I (Diagnosis) of PROFISMA's survey activities in 1994 included extensive surveys in 74 communities located in 51 townships of Bahia, Ceará, Paraíba and Pernambuco. Surveys were conducted in each state by multidisciplinary teams consisting of researchers and extension workers from collaborating state institutions. The teams worked autonomously in each state in formulation of work plans, selection of target areas and execution of activities. PROFISMA provided logistic support. The teams received training in participatory diagnostic methods from PROFISMA (see section of training activities). A total of 1652 farmers (28% women) participated in the surveys.

Table 4.2.2 presents PROFISMA's framework for socioeconomic activities, divided into three interrelated phases and Table 4.2.3 represents the activites to be undertaken in evaluation and monitoring of training and participatory research results. Results obtained in Phase I of the training model follow.

Bahia.

Extensive surveys in Bahia included three ecosystems (Table 4.2.1).

Table 4.2.1 Climatic conditions of the three principal ecological zones surveyed in Bahia.

Ecological Zone	Mean temperature (°C)	Mean rainfall (mm/yr)	Rainy season	Dry season
Semiarid (Caatinga)	26.0	600 - 800	Oct. - Jan.	Feb. - Sept.
Transition (Agreste)	24.5 - 25.5	900 - 1400	Mar. - Aug.	Sept. - Feb.
Sub-humid (Littoral)	22.8 - 24.0	700 - 1200	April - Aug.	Oct. - Feb.

Semiarid Region (Caatinga). Cassava is cultivated predominantly by small growers, who utilize family labor to maintain their plantings. However, total area cultivated by small growers is less than that cultivated by medium and large cassava growers.

Soil preparation occurs from August through December in the communities of Caldeirão, Sumaré and França, (Piritiba), Umbuzeiro, (Mundo Novo), and Testa Branca, (Itaberaba). During August to October, vegetation is cut, arranged in a pile and burned. During September to December, soil is hoed or plowed and by November/December planting takes place. Pre-planting selection of propagative material (stakes) is not a common practice in semiarid cassava growing areas because availability of planting material is very low. For the same reason, size of stakes varies from 5 to 20 cm, smaller than recommended for optimal establishment and yield. Planting is usually performed in furrows (1.0 x 0.4 to 0.6 m) intercropped with either cowpea, pumpkin, gherkin,

watermelon or other crops. In farms bigger than 20 ha, grasses are used as intercrops as fodder. Weeding is done throughout the crop cycle but concentrated in February/March and July to September. No pesticides use was reported except for leafcutter ant control that is conducted throughout the year. Root yield in the semiarid zone averages 10 ton/ha, considered low, probably due to intensive cultivation. Cassava is used mainly for human food as flour.

Transition region (Agreste). Similar to the semiarid, the cassava industry in the transition zone is composed largely of small growers who utilize family labor. Crops includes cassava, beans, cowpea, corn, pumpkin, sweet potato, yam, peanuts, etc., depending on rainfall. Chicken, ducks, turkey, and pigs are also raised. Cassava is grown in poor soils often exhaused due to intensive utilization. Fertilizer application is not common. In some communities, cattle or chicken manure is applied. The aerial part of the cassava plant is used mainly as propagative material but, during drought periods, it is also used as animal feed. Mean root yield, about 10 ton/ha, is considered low and is probably due to fact that cassava has been grown on the same area for several years.

In the surveyed transition zone, cassava is used for human consumption either as flour, "beiju" (a pancake made from cassava starch), or tapioca (cassava starch). Another common mode of cassava consumption is "massa puba" also known as "carimã", a fermentation product of cassava roots immersed in water. Cassava aerial parts are used mainly as propagative materials but, if a long dry season occurs, they are used for animal feed.

Sub-humid region (Littoral). Important crops in the sub-humid zone were cassava, corn, beans, peanuts, yam, pumpkin, sweet potato, orange, and tobacco. Cassava was the main source of income. Soil preparation for cassava plantings starts in January by cutting and burning vegetation. From March to April, soil is usually hoed, sometimes plowed, followed by planting. Labor is performed mainly by family members. Cassava may be planted as single crop or intercropped with corn, beans, or peanuts. Sometimes cattle or chicken manure is used as organic fertilizer.

Results of Extensive Surveys.

See appendix I for partially analyzed results of the extensive participatory surveys. More complete analysis, tabulation and publication of the data will be a priority activity during 1995.

Ecological stratification of the target area.

Using data files provided by the Agroecological Studies Unit of CIAT, maps were prepared of the major vegetation zones of the northeast (Fig. 4.2.1) and by state (Figs. 4.2.2 - 4.2.7). For Bahia, these are presented by vegetation zone (littoral, agreste and

caatinga) with major constraints to cassava production by zone identified (Figs. 4.2.3 - 4.2.5) It is evident from these maps that more precise determination of environmental conditions of the target communities will be required, perhaps through the use of simple rain gauges in each. Although extensionists identified communities appearing in Fig. 4.2.3 as occurring in the littoral zone, they appear in all three vegetation zones of the map generated by the geographical data base. Communities were located on the map by latitude and longitude coordinates attained by a Global Positioning System (GPS) receiver. More precise determination would be useful to characterize biotic constraints to production by ecological zone. This information will be produced during the intensive surveys to be conducted during 1995.

Table 4.2.1 PROFISMA's framework of socioeconomic activities.

PHASE	ACTIVITY	OBJECTIVES	METHODS	LEVEL	PARTICIPANTS	EXPECTED RESULTS
I DIAGNOSIS	Extensive Diagnostic Survey	To identify: 1. target areas 2. problems/needs 3. traditional practices 4. potential collaborators	1. Semi-structured group interviews 2. Selected communities (pre-stratified) 3. Problem ID & ranking 4. Cause/effect analysis of top problems	Community	1. Multidisc. teams of researchers and extensionists from state instituions 2. Project personnel 3. Farmers	1. Selection of pilot sites 2. Identification of problem priorities from farmers perception 3. Potential farmers collaborators.
	Intensive Diagnostic Survey	1. Quantification & validation of cassava constraints & priorities identified in extensive surveys 2. Characterization of production, processing, market & utilization system 3. Evaluation of existing best-bet technologies. 4. Creation of ex-ante baseline for M & E studies	1. Structured questionnaire 2. Sample includes pilot sites, collaborator, & non-collaborator farmers in "similar" communities (control)	Farmer households including men and women.	1. Multidisc. teams of researchers and extensionists from state instituions 2. Project personnel 3. Farmers	1. Cost/benefit analysis of farm level production . 2. Knowledge of traditional production &protection practices. 3. Qantification of: a. pest & disease damage b. cost/benefit analysis c. frequency 4. Farmers interested in validation & adaptation.
	Analysis of technology gaps	Interdisc analysis of available data & in-house technologies to define gaps (opportunities) between needs (demand) & technologies (supply).	1. Interdisc. meetings to analyze surveys & define demand. 2. Comparison of needs w/existing technology	Research center	1. Multidisc. team of state researchers and extensionists. 2. Project personnel 3. Farmers	Definition of porfolio of technology options for prioritized needs
	Development of a monitoring and evaluation system (M&E)	Compilation, analysis, packaging & feedback to relevant audiences of project activities, results & benefits.		Research center, state insitutions, farmer s groups	1. Multidisc. team of state researchers and extensionists. 2. Project personnel 3. Farmers	Relevant audiences informed of project results and benefits
II FARMER PARTICIPATORY RESEARCH ACTIVITIES (FPR)	Implementation of FPR activities with porfolio of technology options.	1. Generate, validate & adapt technologies at farm level 2. Select appropriate technological options	Farmer participatory research	Selected farmers	1. Multidisc. team of state researchers and extensionists. 2. Project personnel 3. Farmers	Testing, selection, adaptation and adoption of technological components
	Socioeconomic validation of experimental technologies.	1. Soco-economic validation of technology components. 2. Cost/Benefit analysis of technology options	1. Cost/benefit analysis 2. Ex-ante analysis 3. Partial budgets	Research center	1. Researchers 2. Extension workers	Technology options appropriate for cassava production systems in target areas
III ADOPTION & IMPACT	1. Base-line intensive survey 2. Follow-up, last yr. of project	Characterization of social, economic, institutional & environmental impact.	1. Analysis of intensive survey & follow-up data 2. External assessment at project end.	Farmers, research center, state institutions	1. Multidisc. team of state researchers and extensionists. 2. Project personnel 3. Farmers	Assessment of project implementation according to proposed objectives.

Table 4.2.2 Evaluation and monitoring system for PROFISMA.

Factor	Data Base	Diagnosis		Intensive follow-up to technology testing	Training	Adoption
		Extensive	Intensive			
Population	a. Communities. b. Producers participating in technology testing. c. Producers not participating in technology testing.	Communities	Farmers	Subsample of intensive diagnosis survey.	Researchers and producers	Year 3 & 4, same sample as intensive diagnostic survey.
Objectives	a. Basic information about ativities and project beneficiaries b. Create subsamples for extrapolation with results from surveys & intensive follow-up.	a. Prioritize areas & quantify problems b. Information about traditional production and protection practices c. Identification of farmer collaborators	a)Characterize production & marketing systems b)Quantify principal production constraints. c)Cost/benefit analysis. d)Determine damage severity & frequency	Determine short-term adoption of technology.	Determine efficiency of training program in implementing ecologically sound production practices.	Determine project's ability to achieve objectives.
Areas	Secondary data: areas production productivity soils climate major constraints	Major constraints Most affected areas Traditional protection practices Potential farmer collaborators	Characterization of production & marketing systems Cultural practices Cost/benefit estimated for new technologies. Severity & incidence of losses determined	No. farmers participating. No. farmers adopting new practices No. components validated. No. components adopted. No. farmers adopting components over time.	No. trained technicians No. trained farmers No. demonstrative areas. No. training events	Technical, social, economic, environmental & institutional impact.
Method	Collection of secondary information	Participatory group surveys at communities level, representative sample	Farmer surveys, representative sample.	Periodic visits to subsamples selected from data base.	Survey of subsample selected from data base.	Comparative anlysis of intensive and follow-up survey data; External assessment

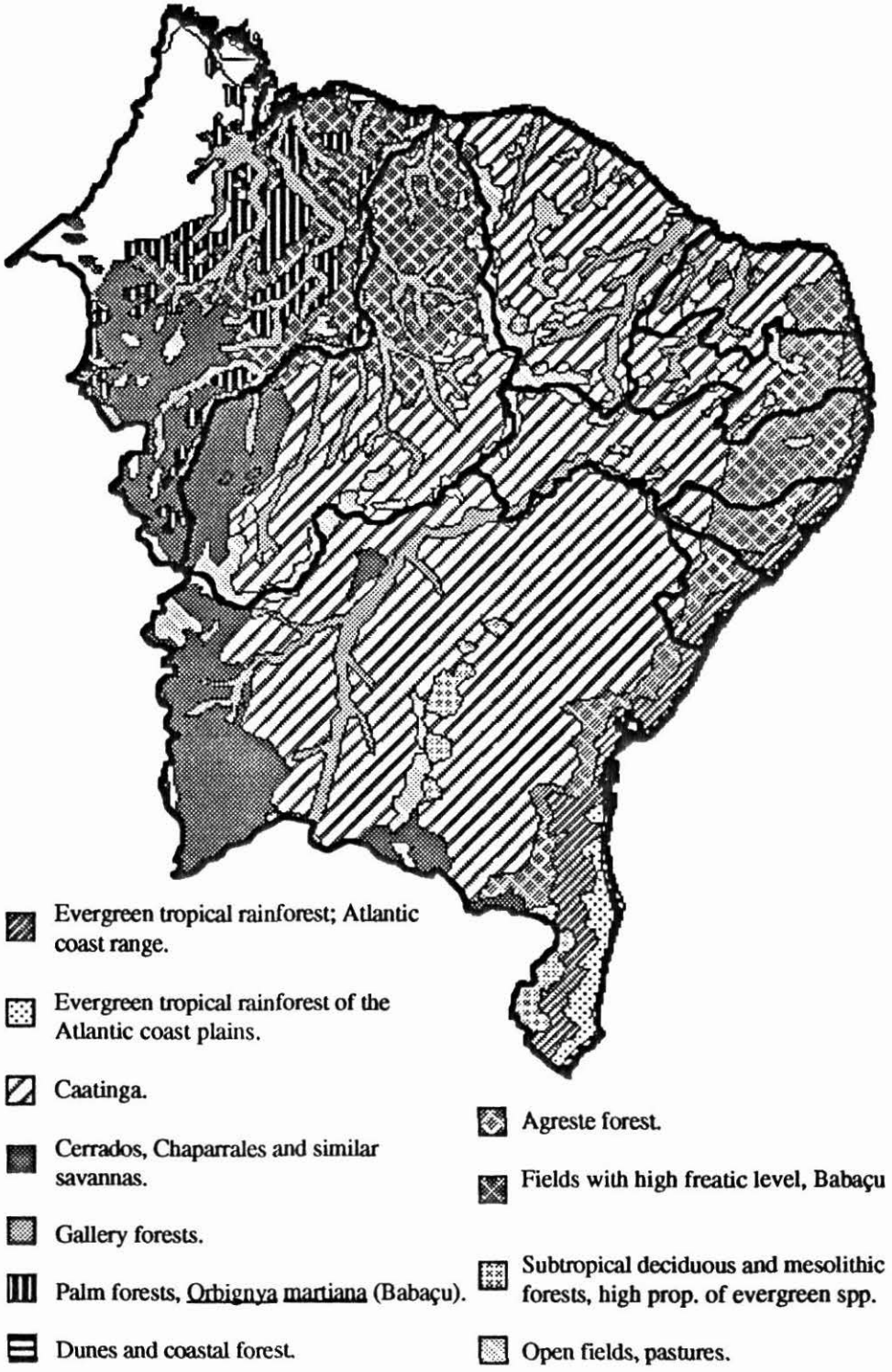


Fig. 4.2.1 Vegetation zones of nine states of northeastern Brazil. Source: CIAT.

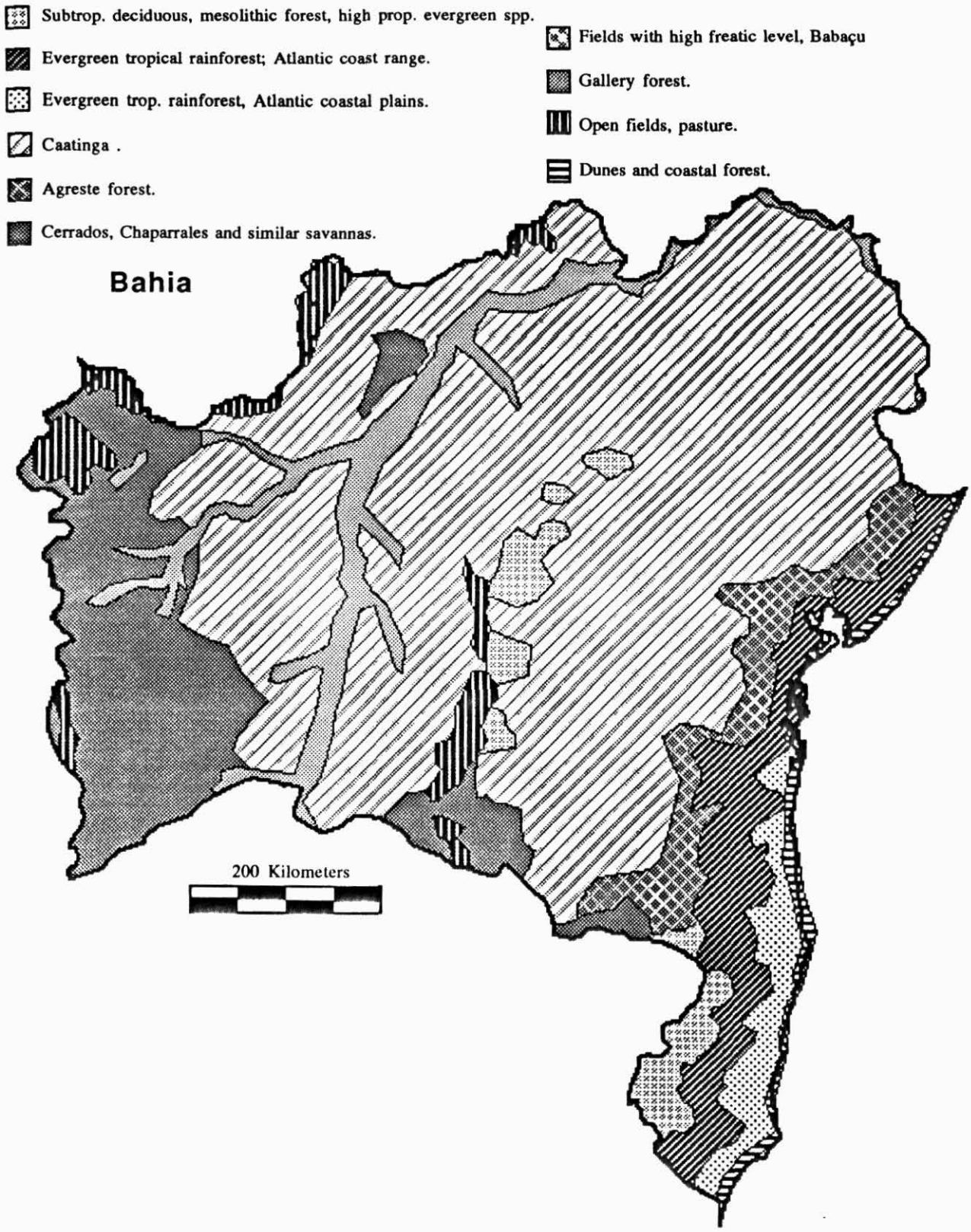


Fig. 4.2.2 Vegetation zones of Bahia, Brazil. Source: CIAT.

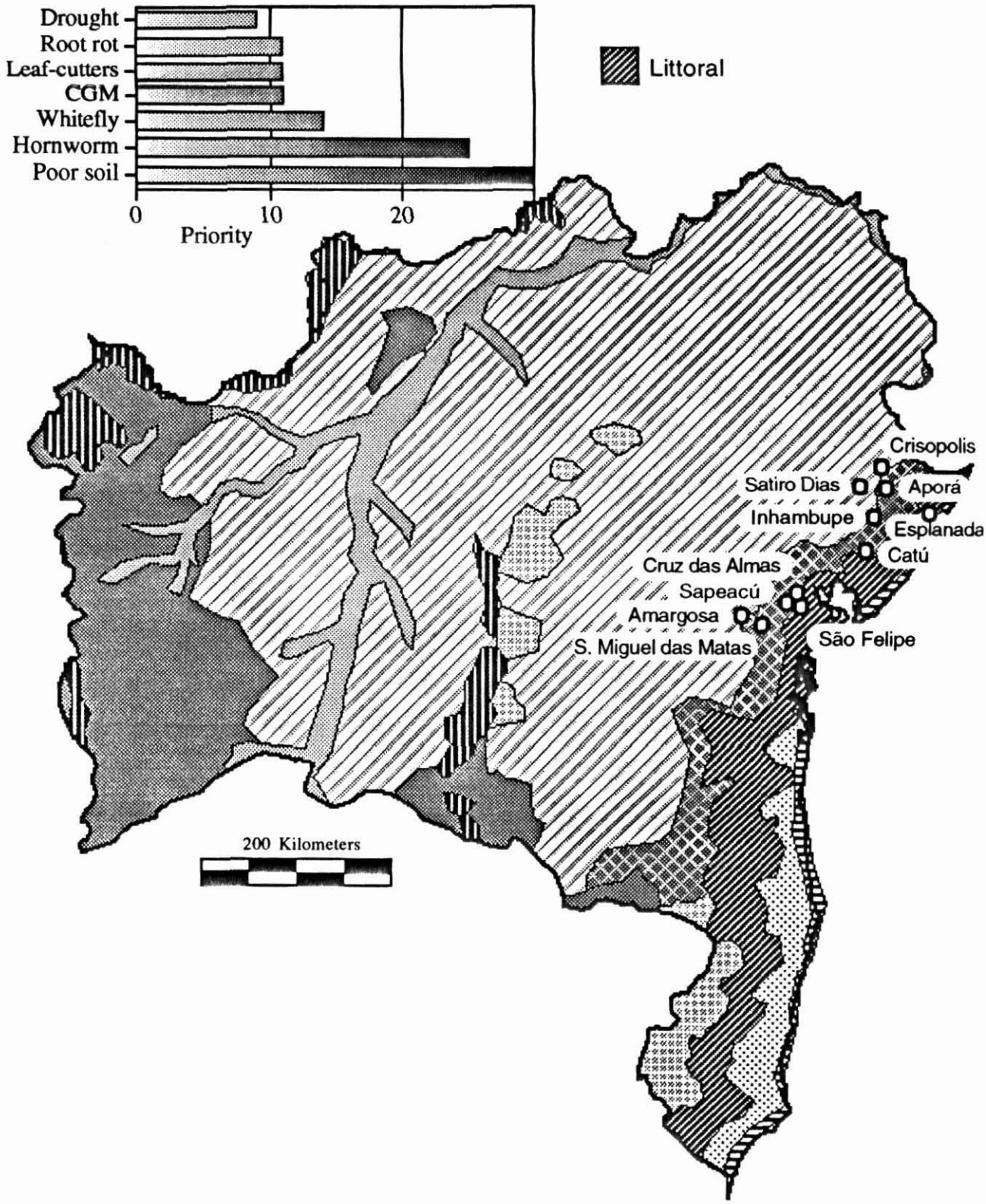


Fig. 4.2.3 Fourteen communities surveyed in the littoral zone of Bahia during extensive phytosanitary surveys, with problems prioritized by cassava farmers.

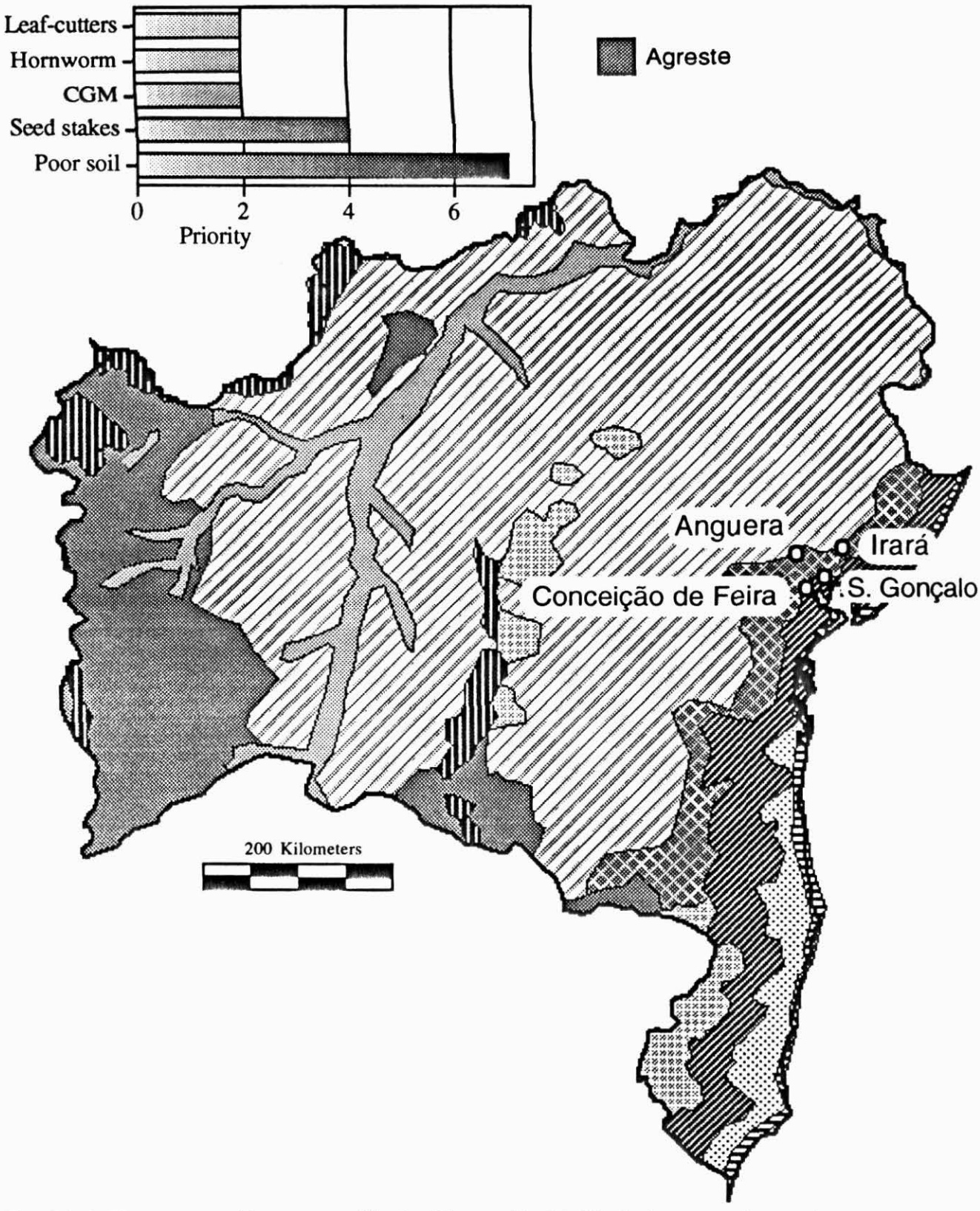


Fig. 4.2.4 Five communities surveyed in the "Agreste" of Bahia during extensive phytosanitary surveys, 1994, with problems prioritized by cassava farmers.

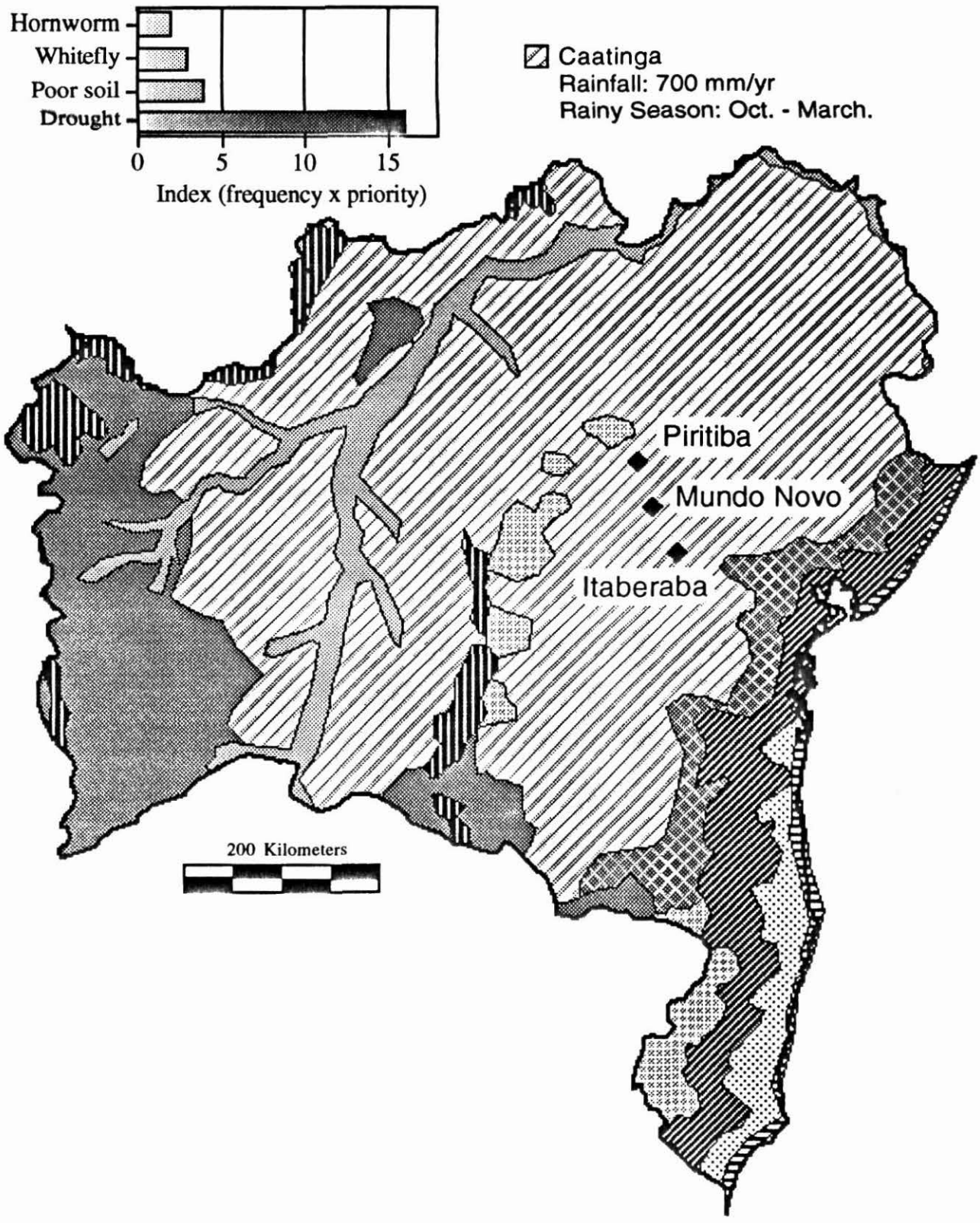


Fig. 4.2.5 Six communities surveyed in the "Caatinga" of Bahia during extensive phytosanitary surveys, 1994, with problems prioritized by cassava farmers.

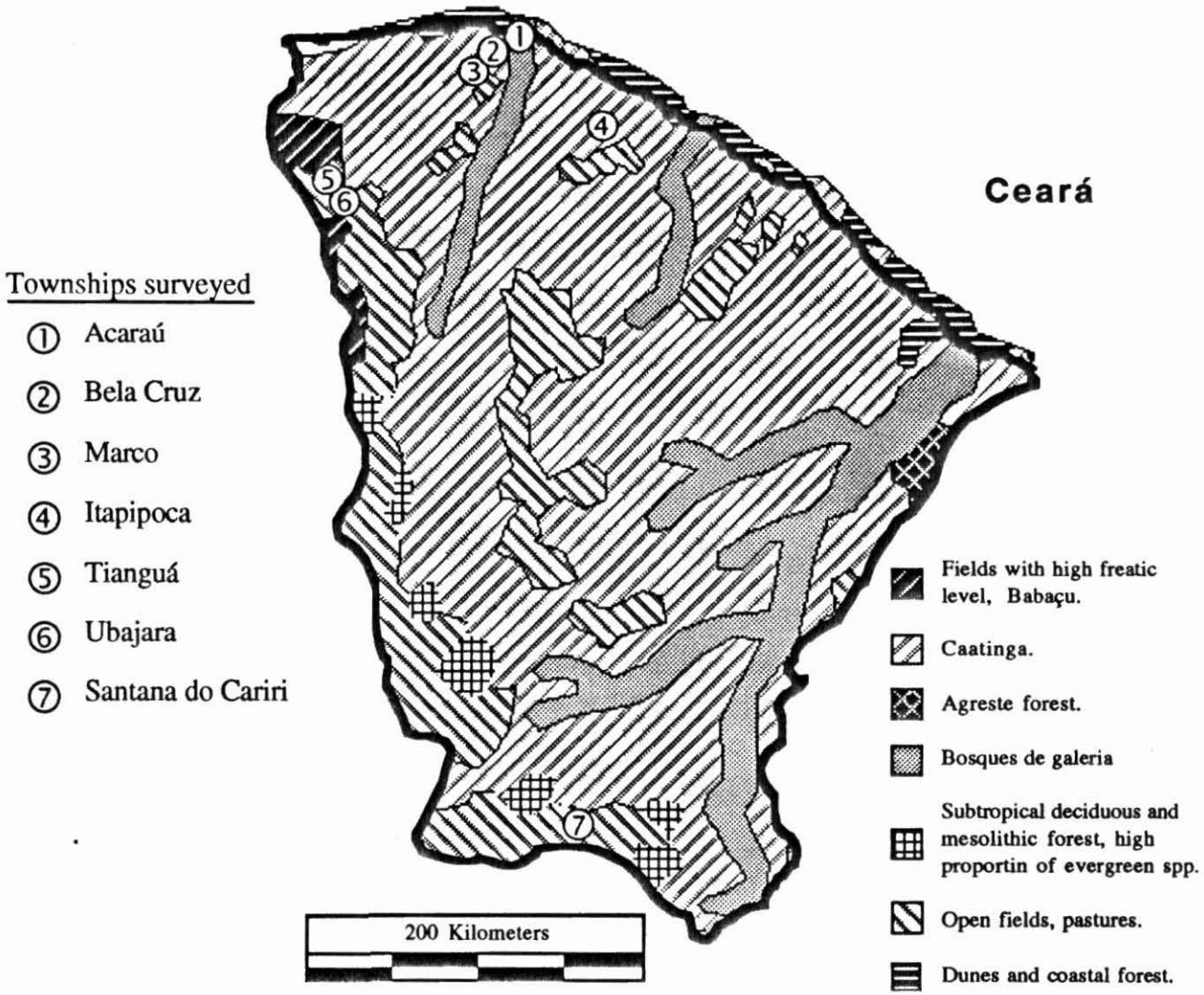
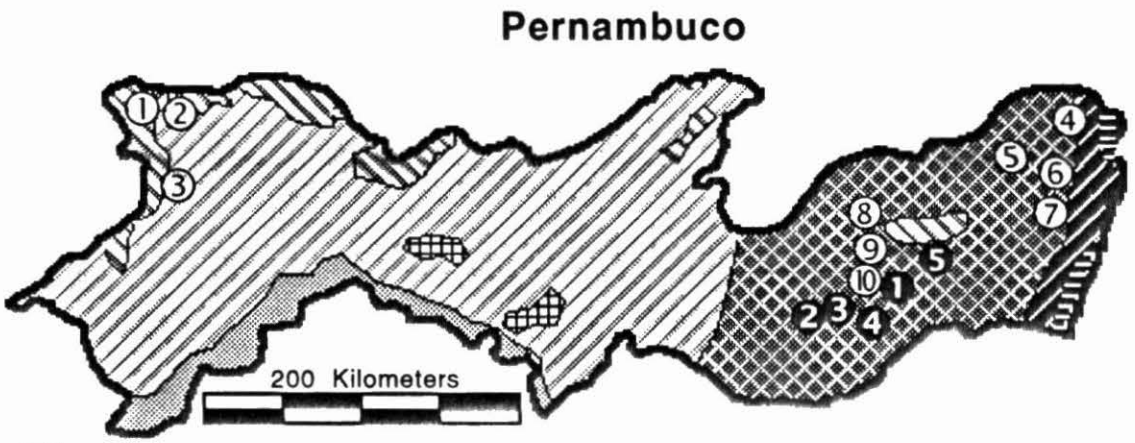


Fig. 4.2.6 Communities surveyed in the state of Ceará during the extensive phase of PROFISMA's phytosanitary diagnosis.



Evergreen tropical rainforest; Atlantic coastal range.

Caatinga

Agreste forest.

Gallery Forest.

Subtropical deciduous and mesolithic forest, high prop. evergreen spp.

Open fields, pastures.

Dunes and coastal forest.

Townships surveyed

① Araropina
② Ipubi
③ Ouricurí
④ Condado
⑤ João Alfredo
⑥ Gloria de Goitás
⑦ Pombos
⑧ Belo Jardim
⑨ São Bento do Una
⑩ Jupi
❶ Lajedo
❷ Paranatama
❸ Caetes
❹ São João
❺ Cupira

Fig. 4.2.7 Communities surveyed in the state of Pernambuco during the entensive phase of PROFISMA's phytosanitary diagnosis.

5. Strategic Research at CIAT, Colombia

5.1 Acarology

Work in acarology at CIAT focuses on Brazil as a target for importation of phytoseiid predators to control the cassava green mite (CGM). Three species of phytoseiid mites (Amblyseius idaeus, A. limonicus & A. aripo) from Brazil have become established in West Africa. While dispersal and effectiveness of these predators are being studied by IITA, CIAT will search for candidates adapted to cooler high-elevation regions corresponding to central and east Africa. Exportation of phytoseiids to northeastern Brazil began this year with three shipments of A. tenuiscutus from Colombia. The quarantine facility CNPMA, Jaguariuna, Brazil can now accept mites on cassava leaves, which greatly increases the number and quality of mites being shipped. A. tenuiscutus has been released by CNPMF at carefully monitored sites in Piritiba, Bahia. Fresh cultures of mites are being established to provide relatively "wild" material for exportation. We are currently reviewing old exploration and exportation data to identify the most promising geographic locations and phytoseiid species for future exportation.

Predation Rates

Field survey data indicate a negative correlation between number of phytoseiid species present and size of CGM population. Thus, multiple predator species may be required to provide satisfactory control. Species that complement each other in their preference for different prey developmental stages are more likely to coexist and increase the level of control.

The rate of consumption of different developmental stages of CGM by A. tenuiscutus was studied. Two geographic strains (Quevedo, Ecuador and Los Córdobas, Colombia) were compared. The Quevedo strain consumed more prey than the Los Córdobas strain, and both strains consumed more eggs and larvae than adult prey, while an intermediate number of nymphs were consumed (Fig. 5.1.1). However, in terms of prey biomass, both strains consumed more larvae and nymphs than eggs or adults (Fig. 5.1.2). Thus, when modeling population dynamics for this predator-prey system, the difference in contribution of each developmental stage of the prey to predator nutrition must be considered as well as prey mortality by stage. Similar experiments with the predator A. idaeus are being completed.

Alternate prey.

Alternate prey to the diet of phytoseiids attacking CGM can sustain predator population in seasons when CGM population is low, and may be critical for establishment and persistence in the field. Determining prey-specificity is also important for assessing

potential impact on non target species. Response of the Quevedo and Los Córdobas strains of A. tenuiscutus to presence of alternate prey was tested. Alternative prey included spider mites (Tetranychus urticae), thrips (Frankiniella williamsi), whitefly (Aleurotrachelus socialis), and a plant fungus (Oidium manihotis) that grows on cassava leaves (cassava ash). Previous experiments have shown that phytoseiids can obtain nutrition from all of these food sources. Two-choice experiments exposed one female adult predator mite for 24 h to 10 or 60 CGM in the presence of 10 or 60 T. urticae, 10 larvae of F. williamsi, 10 A. socialis pupae, or a leaf infested with O. manihotis. Almost all prey at the 10-CGM density were consumed, so this density was considered too low to permit a realistic measure of preference. At the 60-CGM density, consumption of CGM changed slightly with respect to the presence of alternate prey. The Las Córdobas strain of A. tenuiscutus consumed more than the Quevedo strain (Figs. 5.1.3 and 5.1.4). The tendency to consume fewer CGM in the presence of T. urticae or F. williamsi suggests that these prey may be competing with CGM in the predators' diet. Equal numbers of CGM and T. urticae were consumed by the predators and a substantial proportion (30-40%) of the thrips were also eaten (Fig. 5.1.5). No measurements were made of honeydew or cassava ash consumption. Oviposition by A. tenuiscutus was higher in the presence of T. urticae and F. williamsi (Fig. 5.1.6). Whether this is caused by consumption of more biomass or due to qualitative nutritional differences in the prey was not determined. The latter might indicate a dependence on a mixed diet, which could be important for mass rearing and understanding the field ecology of these predators.

Functional response

The change in consumption rate with respect to availability of prey is known as the "functional response". For most arthropods, the number of prey attacked increases with prey availability, but at a decreasing rate. This produces a "Type 2" curve that gradually reaches an asymptote, representing the maximum number of prey that can be consumed in a given time interval. This was measured for two strains of A. tenuiscutus attacking several densities of CGM during 24 h exposures. Differences in the attack rate of the two strains appeared only at the highest prey density tested (130) (Fig. 5.1.7). These data can be used, in combination with development time, age-specific fecundity and survivorship, to build a computer simulation model of predator-prey population dynamics. Such a model can be used to plan and manage mass-rearing programs, and predict population changes in the field.

Electrophoretic studies

Electrophoresis provides a potential solution for two constraints in phytoseiid biological control research: taxonomic identification of individual mite predators and their prey.

Traditional taxonomic identifications based on morphological characters require time and skill. Biochemical methods of identification could increase our capability to identify specimens in field experiments. Currently, it is almost impossible to determine what predators are feeding on in the field. Biochemical analysis of stomach contents provides the possibility of making such identifications.

Laboratory studies

Electrophoretic "fingerprints", based on a and b esterases, were identified for seven phytoseiid species and four tetranychid species based on preparations of laboratory-reared mites. Esterases from tetranychid mites could also be identified from the gut contents of laboratory-reared phytoseiids. However, staining patterns associated with prey in gut contents can disappear after 3-6 hours of starvation. Geographical strains of phytoseiids could also be detected, demonstrating that electrophoresis can be used to discriminate some strains. Host plant esterases can appear in electrophoretic patterns of tetranychids, thereby complicating identification. Developmental stage of tetranychid prey also affected staining patterns. Electrophoresis of phytoseiid gut contents failed to provide a quantitative tool for measuring number of tetranychid prey consumed in laboratory experiments. (Note: Figures showing electrophoretic patterns were excluded due to difficulty with reproduction. See Acarology, CIAT Cassava Program Annual Report 1994.)

Field studies

Field-collected mites were more difficult to identify than laboratory-reared mites. Mites were collected from 27 sites in Ecuador and were stored in liquid nitrogen until analysis. Only 22% of phytoseiids could be identified based on electrophoretic patterns, compared to 79% of tetranychids (Figs. 5.1.8, 5.1.9). For phytoseiids, the main problem was insufficient staining. Nevertheless, prey could be identified from gut contents of one third of phytoseiids that had weak staining patterns (Fig. 5.1.10). For phytophagous mites, there were also a substantial number of unknown patterns (13%). The representation of tetranychid species based on analysis of phytoseiid gut contents generally reflected the distribution of the tetranychids (Fig. 5.1.9), although M. mcgregori and T. urticae were less frequently identified in the gut contents than as mites.

Characterization of CGM populations by "DNA fingerprinting"

It would be useful to know the genetic relationships among geographic CGM populations. These may provide clues to the origin of populations in Africa and northeastern Brazil and indicate the most promising regions for natural enemy exploration. This would also provide an evolutionary framework for organizing biological data from these subpopulations. Six geographic strains of CGM and three strains of the closely related M. caribbeanae were analyzed using ribosomal RAPD (random amplified

polymorphic DNA). Specific primers were used for PCR (polymer chain reaction) amplification of the regions ITS1 and ITS2. At present, the base sequences of six CGM strains have been analyzed (Table 5.1.1). Preliminary analysis suggests that both Brazil and Uganda populations are most closely related to one from Guajira, northern Colombia.

Table 5.1.1. Number of differences in DNA bases at the ITS1 locus of CGM.

Locality	Brazil	Uganda	Venezuela	Guajira
CIAT	5	5	6	4
Brazil	4	4	6	3
Uganda			3	1
Venezuela				2

Quantification of reproduction of Phytoseiids in laboratory colonies.

To plan mass-rearing programs for release of introduced phytoseiids, information is needed on production rates of laboratory cultures. Production rate of Amblyseius tenuiscutus and A. idaeus is currently being studied in laboratory cultures using the Mesa-Bellotti rearing system. These data will provide a baseline for comparing efficiency of alternate rearing methods to minimize unit cost of mass production.

Effect of relative humidity on four species of phytoseiids

Current target regions in northeastern Brazil and Africa include semi-arid areas. Performance at low relative humidity (RH) is an important criterion for selection of candidate phytoseiid species. Studies of the sensitivity of phytoseiid life history characters (egg survivorship, development time, fecundity) to low RH on 10 geographic populations of A. tenuiscutus, A. manihoti, A. californicus, and A. idaeus are just being completed.

Field studies

Several studies in a dry climate similar to target areas in Africa and northeastern Brazil are being conducted at Pivijay, northern Colombia. These include the effect of intercropping with maize and sorghum, use of small proportions of CGM-susceptible cassava varieties to help conserve phytoseiid populations, the effect of mulching, and evaluation of cassava varieties. At CIAT, a study evaluating the effect of different numbers of cages to protect phytoseiids during the first two weeks of establishment is just being completed.

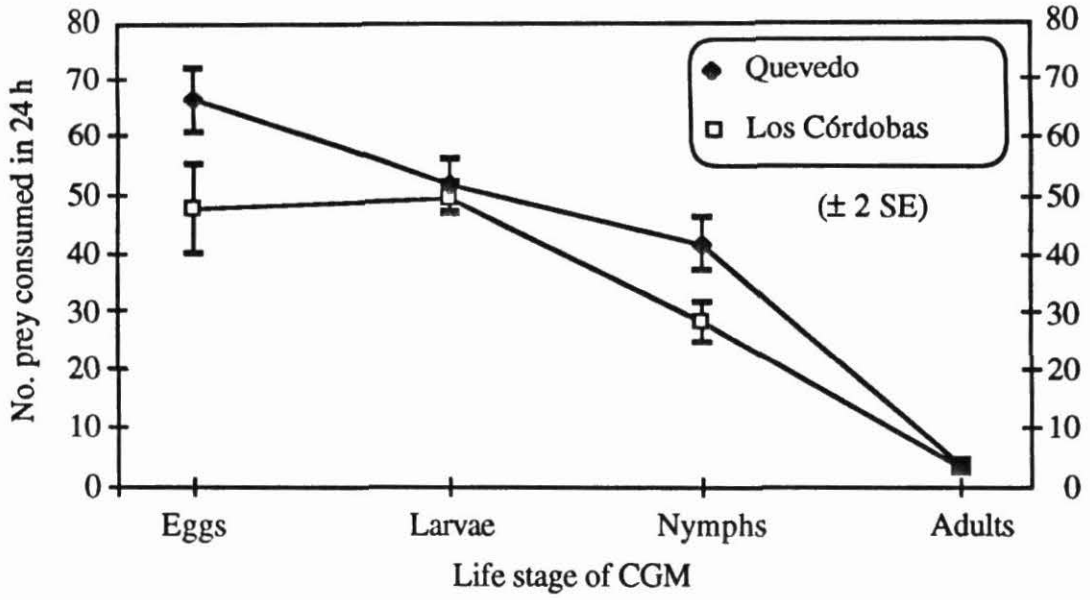


Figure 5.1.1. Effect of prey developmental stage on number of individuals consumed by female adult T. tenuiscutus.

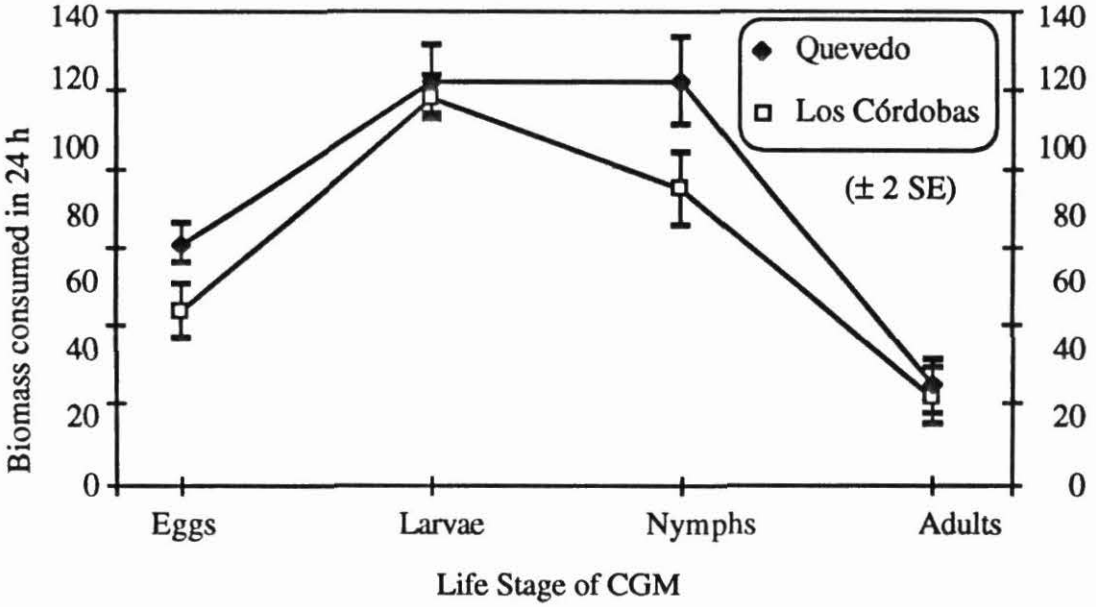


Figure 5.1.2. Effect of prey developmental stage on biomass consumed by female adult T. tenuiscutus.

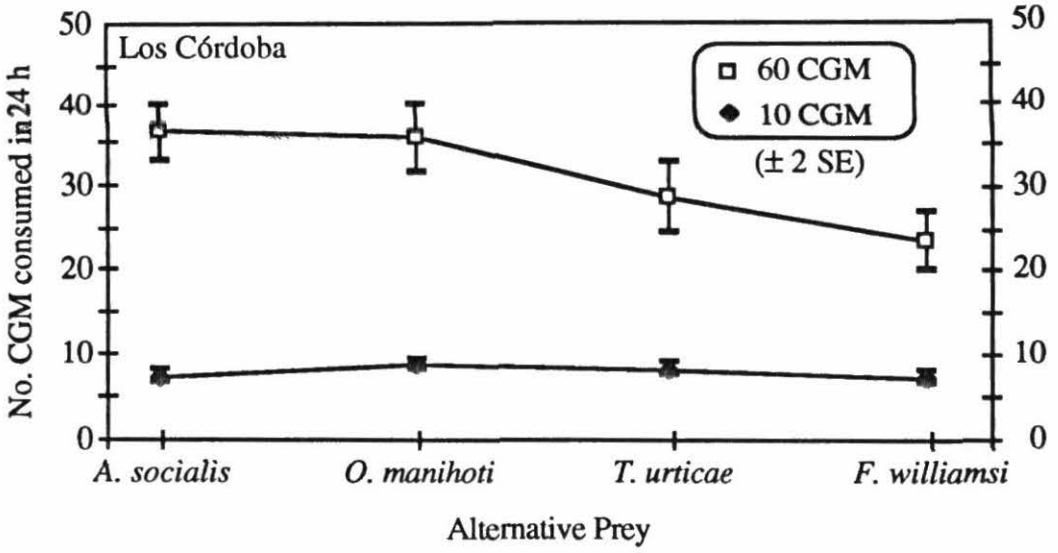


Figure 5.1.3. Effect of presence of alternate prey on number of CGM individuals consumed by female adult T. tenuiscutus from Los Córdobas.

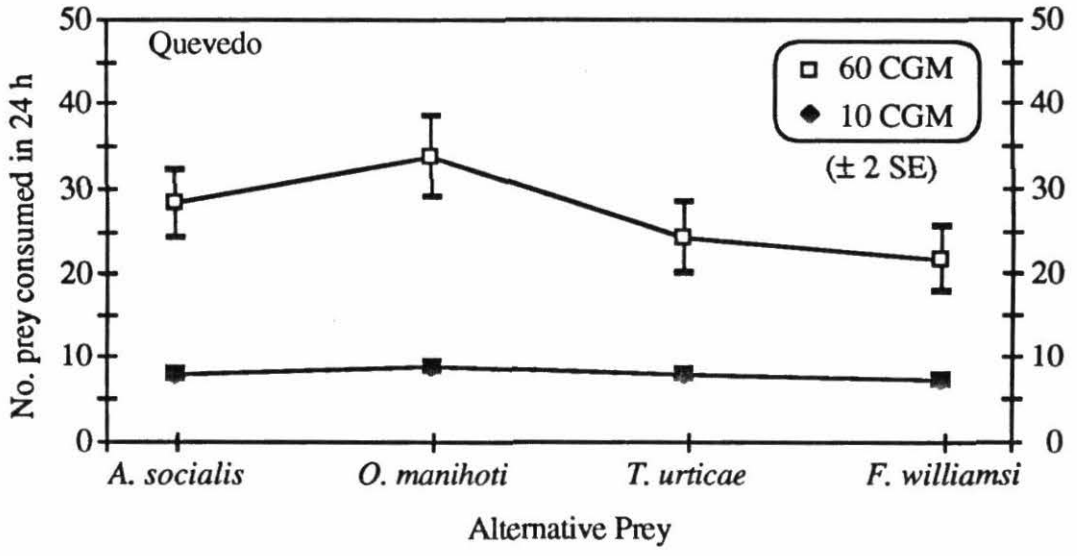


Figure 5.1.4. Effect of presence of alternate prey on number of CGM individuals consumed by female adult T. tenuiscutus from Quevedo.

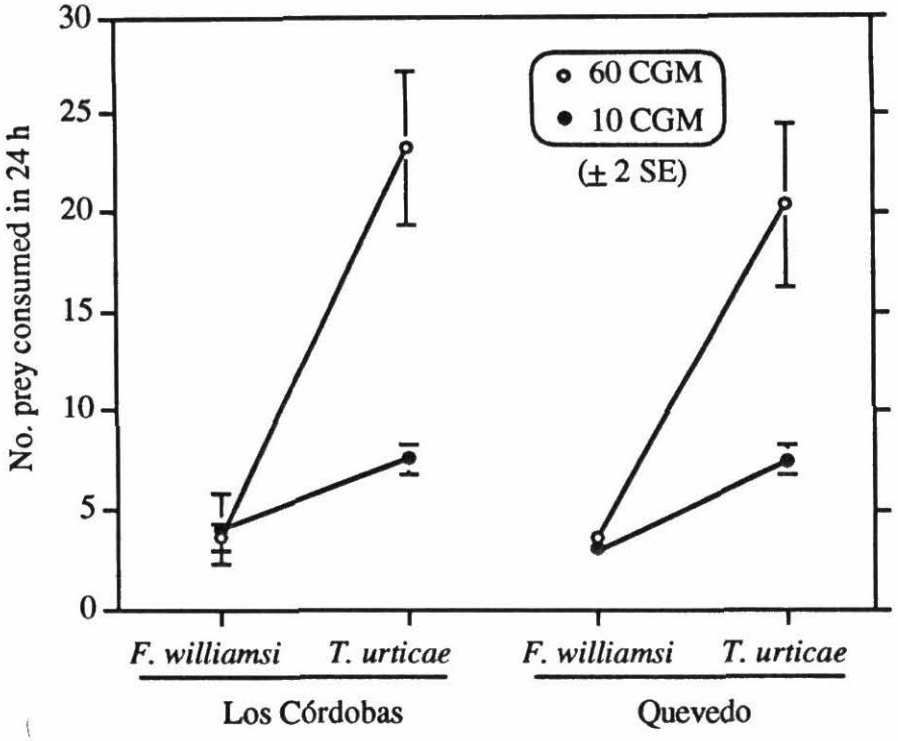


Figure 5.1.5. Number of alternate prey (10 thrips F. williamsi; 10 or 60 T. urticae) consumed in the presence of CGM, at two densities.

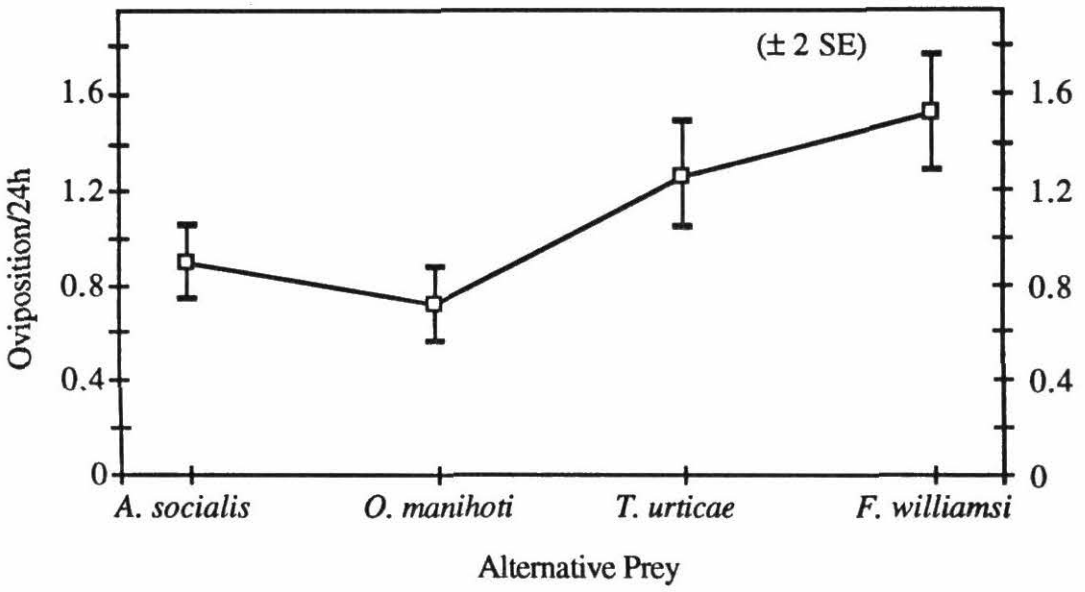


Figure 5.1.6. Effect of presence of alternate prey on oviposition by female adult T. tenuiscutus collected at CIAT.

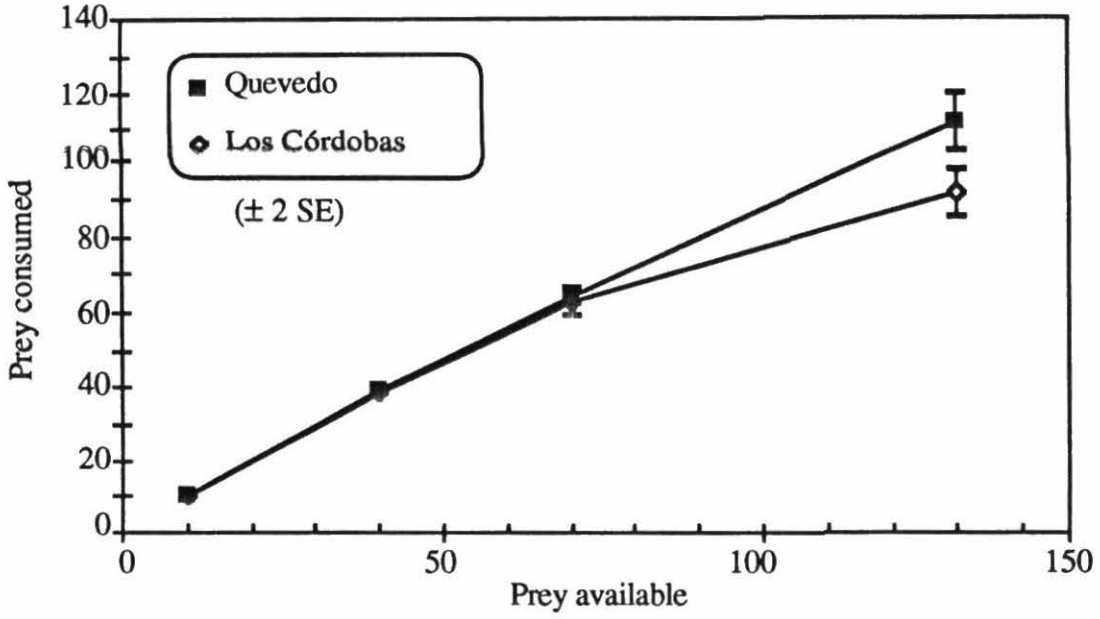


Figure 5.1.7. Functional response of two geographic strains of T. tenuiscutus in a laboratory arena.

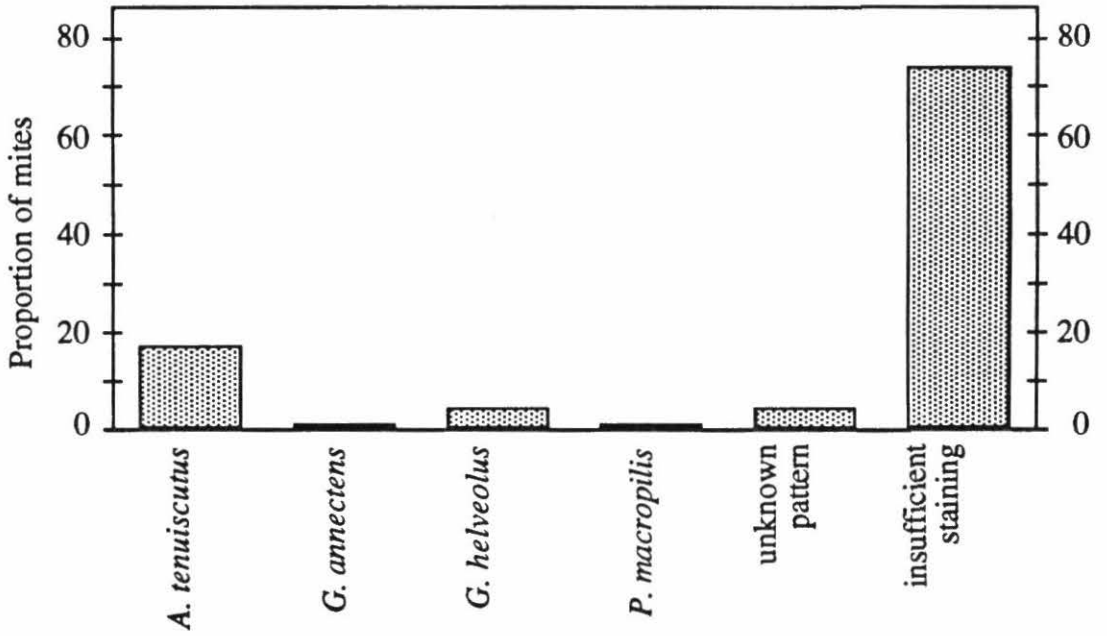


Figure 5.1.8 Identification, based on electrophoretic analysis, of phytoseiids collected from cassava at 27 sites in Ecuador.

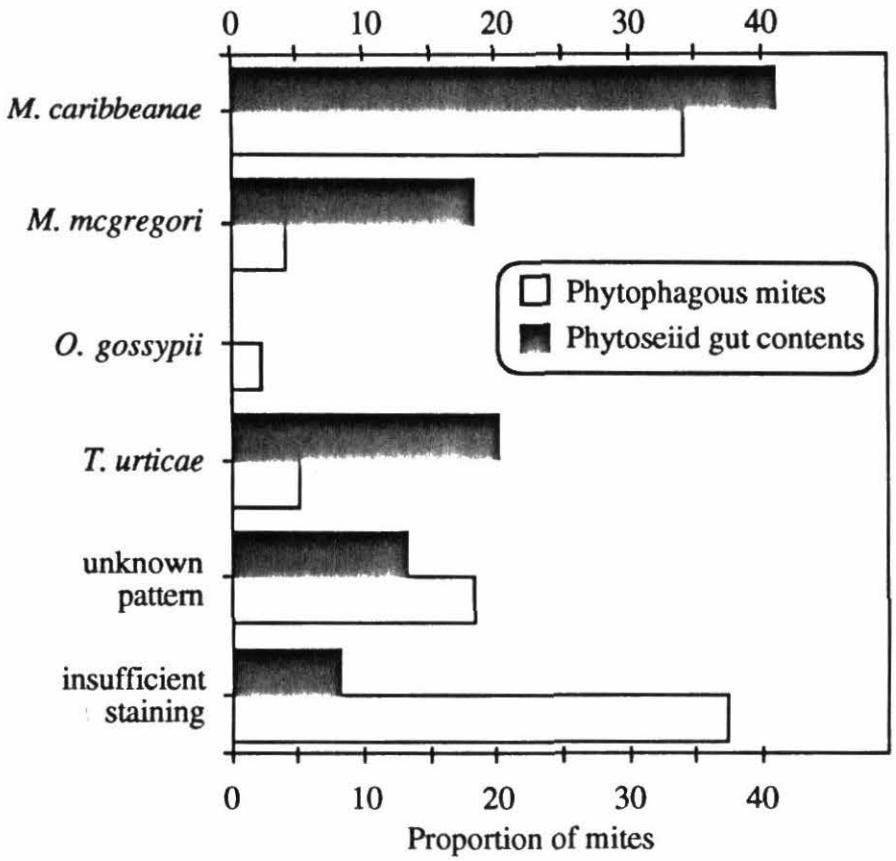


Figure 5.1.9 Comparison of electrophoretic analysis of phytophagous mites and gut contents of phytoseiids collected from cassava at 27 sites in Ecuador.

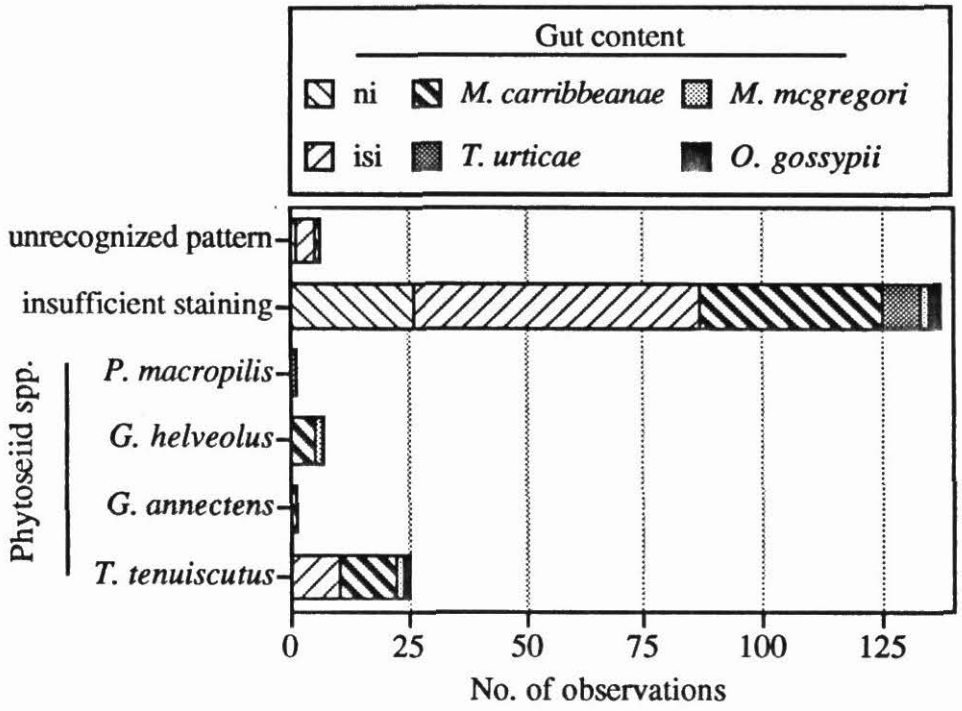


Figure 5.1.10. Identification of prey based on gut contents of phytoseiid species, both identified by electrophoresis patterns (ni = unrecognized pattern, isi = insufficient staining).

5.2 Entomology

The Cassava Mealybug: *Phenacoccus herreni*

Biological control is the most important and successful means for controlling the cassava mealybug (CM). Adequate levels of host plant resistance have not been identified. Numerous natural enemies of CM have been identified and evaluated in the Neotropics. Three parasitoid species (*Aenasius vexans*, *Epidinocarsis diversicornis* and *Acerophagus coccois*) have been studied in detail. During 1994, *E. diversicornis* and *A. coccois* were shipped to EMBRAPA for release into cassava fields in northeastern Brazil (Bahia, Pernambuco, and Ceará). Colonies of the three species are maintained at CIAT and periodically renewed from the field. Shipments of approximately 300 parasitoids in the pupal stage are periodically sent to CNPMA (Jaguariuna) where they pass quarantine through at least one generation before being sent to CNPMF (Cruz das Almas) where parasitoid colonies are established based on methodologies developed at CIAT.

Competition between parasitoid species was studied at CIAT during 1994. Competition between *A. coccois* and *E. diversicornis* was studied for 20 generations in cages (0.5 x 0.5 x 0.8m) in a glasshouse. Fluctuations over time of the populations of the two species were recorded (Fig. 5.2.1). Populations of *A. coccois* were consistently higher than *E. diversicornis* through 20 generations. Although *E. diversicornis* numbers remained low, the species was not eliminated, indicating that these species may be able to co-exist in the field thereby providing better or more stable biological control of CM.

Baculovirus Transmission

The midge ectoparasite, *Forcipomyia eriophora* (Williston) (Diptera: Ceratopogonidae), will feed on larvae of the cassava hornworm (CH) and is capable of transmitting the CH baculovirus (*Baculovirus erinnyis*) from infected to non-infected CH larvae. *F. eriophora* females are more abundant than males. Flight ability is limited obliging them to rest on cassava leaves or on hornworm larvae. Females compliment their diet with nectar but are obliged to feed on hornworm hemolymph to acquire proteins needed for egg development.

Until this year, laboratory studies on virus transmission by *F. eriophora* have been hampered due to difficulty in maintaining a virus-free CH colony. CH larvae raised on cassava leaves were subject to virus contamination from the food source. To insure an experimental supply of virus-free CH larvae, a semiartificial diet was developed. This diet consists primarily of lyophilized cassava leaves, cornmeal, soybean, nutrients and preservatives. Three virus-free generations of CH were produced for virus transmission experiments. (After three generations on the diet, a marked reduction in CH egg fertility was noted.) Beginning with the second instar, CH larvae were reared on artificial diet in individual plastic containers to avoid virus contamination. Adult female midges were

allowed to feed on 4th and 5th instar virus-infected CH larvae for 24 hours. These were then transferred to 3rd, 4th or 5th instar healthy CH larvae and allowed to feed for an additional 24 hours. CH larvae were observed for five days.

Individuals from all three CH instars became infected following exposure, indicating virus transmission by *F. eriophora* (Fig. 5.2.2). Forty-two percent of CH larvae became infected. Virus symptoms appeared most rapidly in the 3rd instar compared with 4th and 5th instars. Virus symptoms appeared three, five and seven days after exposure in 3rd, 4th and 5th instars, respectively.

Whiteflies

Whiteflies are a major pest of cassava in several regions of the Neotropics. The most important species in Colombia are *Aleurotrachellus socialis*, *Bemisia tuberculata* and *Trialeurodes variabilis*. *Aleurothrixus aepim* is the predominant species in northeastern Brazil, although *B. tuberculata* and *T. variabilis* are also present. Previous research at CIAT in Colombia and more recent studies by CNPMF scientists in Brazil show that high populations of *A. socialis* or *A. aepim* cause significant reduction in cassava yield. On-farm experiments in Bahia, Brazil measured root yield losses of over 40%. Research at CIAT and CNPMF on whitefly control have concentrated on host plant resistance. More recently, biological control has received increased emphasis.

The role of natural enemies in the control of cassava whiteflies is not well understood nor extensively researched. The first phase of research on biological control of whiteflies has been initiated, i.e., exploration of cassava-growing regions of Colombia and Venezuela for natural enemies. The objectives of these explorations are:

- To determine the geographic distribution of whitefly species on cassava.
- To identify possible whitefly biotypes through electrophoresis.
- To record natural enemy species associated with different whitefly species.

Eight states in Venezuela (Guarico, Apure, Amazonas, Bolivar, Monagas, Sucre, Anzoategui, and Miranda) were surveyed (Fig. 5.2.3). Whitefly species recorded were *A. socialis* and *B. tuberculata* (Table 5.2.1). During the survey months (June and July, 1993) whitefly populations were relatively low except for two states, Amazonas and Monagas, where *A. socialis* populations were high. No *A. socialis* populations were detected in Apure, Anzoategui, and Miranda. *B. tuberculata* populations were low throughout the survey area but detected in all states.

In Colombia, cassava is more extensively planted than in Venezuela and surveying has been more intensive. During 1994, the Colombian Atlantic Coast (Sucre, Cordoba, Bolivar, Atlantico, and Magdalena) and Cauca were extensively surveyed (Fig. 5.2.3). On the Atlantic Coast, the most predominant species was *A. socialis*, followed by *B.*

tuberculata (Table 5.2.2). Populations of *T. variabilis* were low at all sites surveyed. Low populations of a previously unrecorded species on cassava, *Tetraleurodes sp.*, was found in Cordoba. *A. socialis* was found at all sites surveyed, but highest populations were found at Pivijay, Magdalena.

In Cauca department, whitefly populations were low during the survey period. Populations of *T. variabilis* were slightly higher than *A. socialis* (Table 5.2.3). *B. tuberculata* populations were negligible.

To determine natural enemy populations, leaves were collected from cassava fields and placed in containers in the laboratory. Parasitoids that emerged were collected and identified. Whitefly species were caged separately to determine parasitoids associated with each. On the Atlantic Coast, two parasitoids were identified; *Encarsia* sp. and *Eretmocerus* sp. were observed parasitizing *A. socialis*. Only *Eretmocerus* sp. was collected from *B. tuberculata*, and *Encarsia* sp, in very low populations, only from *T. variabilis* . In Cauca, *Encarsia* sp. and *Amitus* sp. were collected from *T. variabilis* (Table 5.2.4).

Table 5.2.1 Numbers of whiteflies recorded from 18 cassava leaves (6 randomly selected from each of 3 plant levels) in farmers' fields in eight Venezuelan states. 1993.

		* Total population (eggs, nymphs, pupae)	
State	No. sites visited	*A. socialis*	*B. tuberculata*
Guarico	4	13	534
Apure	2	0	832
Amazonas	6	20,033	271
Bolivar	10	968	115
Monagas	8	12,826	183
Sucre	3	793	86
Anzoategui	1	0	9
Miranda	3	0	120

Table 5.2.2 Whitefly distribution and populations recorded from cassava fields on the Colombian North Coast. 1994.

		Total Whitefly Populations*			
Department	Municipality	*A. socialis*	*B. tuberculata*	*T. variabilis*	*Tetraleurodes sp.*
Magdalena	Pivijay	11,168	83		
"	"	20,419	712		
Atlantico	S. Tomas	1,431	3,338	24	
Bolivar	S. Pedro	36	151	48	
"	M. Baja	1,117	75	64	
"	S. Onofre	133	76	3	
Sucre	Betulia	89	59		
"	Palmira	24	131	64	
"	Toluviejo	106	178	34	
"	S. Pues	228	179	5	
Cordoba	Chinu	480	113	6	7
"	"	902	97		64
"	Momil	219	172	14	5
"	Sahagun	194	78	45	
Totals		36,546	5,442	307	76

* Total number of eggs, nymphs and pupae from 15 cassava leaves per site.

Table 5.2.3 Whitefly populations recorded from cassava fields in Cauca, Colombia during 1994.

		No. Whiteflies*		
Department	Municipality	*A. socialis*	*B. tuberculata*	*T. variabilis*
Cauca	Patia			92
"	"	313	6	12
"	"	31	19	6
"	"	4	3	175
"	"	26		359
"	Mercaderes	54		47
"	Bolivar	141	3	58
Totals		569	31	749

* Total number of eggs, nymphs and pupae from 15 cassava leaves per site.

Table 5.2.4 Microhymenopteran parasitoids associated with whitefly species on cassava collected from the Atlantic Coast and Cauca department, Colombia. 1994.

		Parasitoid species		
Whitefly species	Site	*Encarsia* sp.	*Eretmocerus* sp.	*Amitus* sp.
Aleurotrachelus socialis	Atlantic Coast	59	38	0
Bemisia tuberculata	Atlantic Coast	0	24	0
Trialeurodes variabilis	Atlantic Coast	3	0	0
Trialeurodes variabilis	Cauca	2	0	12

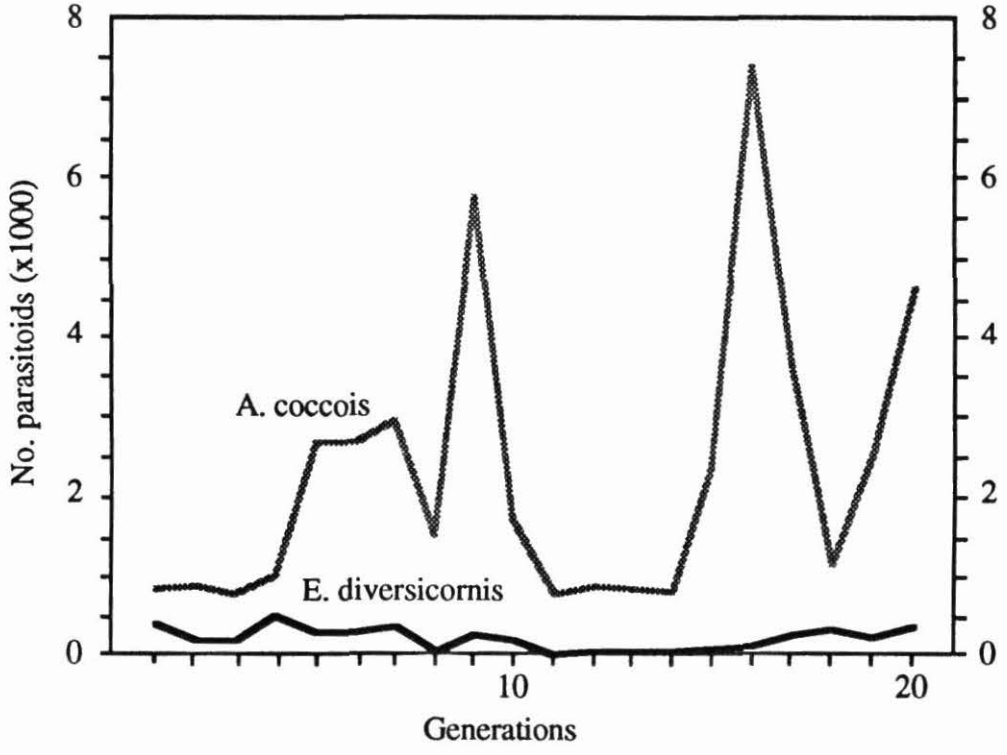


Figure 5.2.1 Populations of the parasitoids *Acerophagus coccois* and *Epidinocarsis diversicornis* preying in competition on *Phenacoccus herreni* in cages in a glasshouse. CIAT Palmira, 1994.

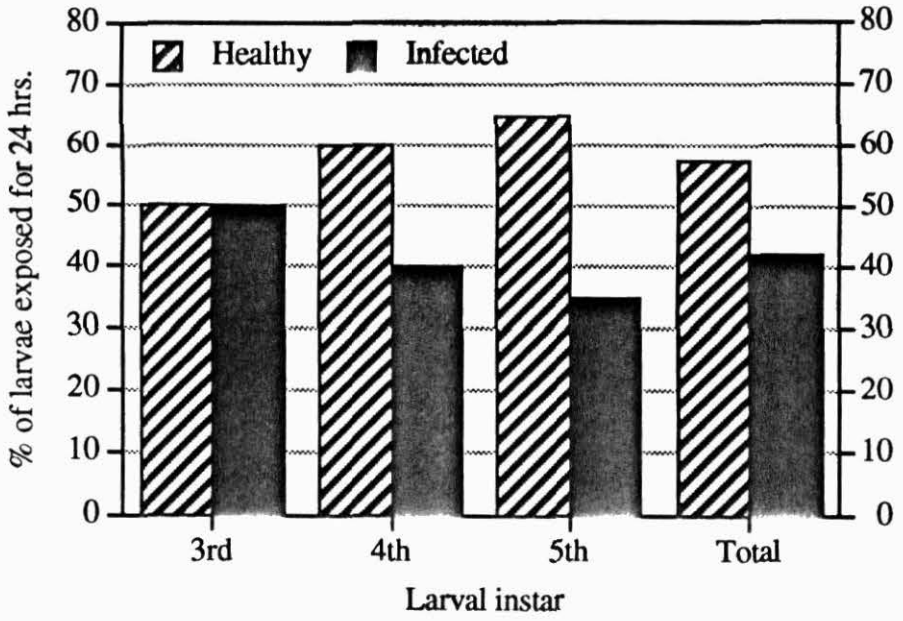


Figure 5.2.2 Transmission of *Baculovirus erinnyis* between larvae of the cassava hornworm by the midge *Forcipomyia eriphora.*

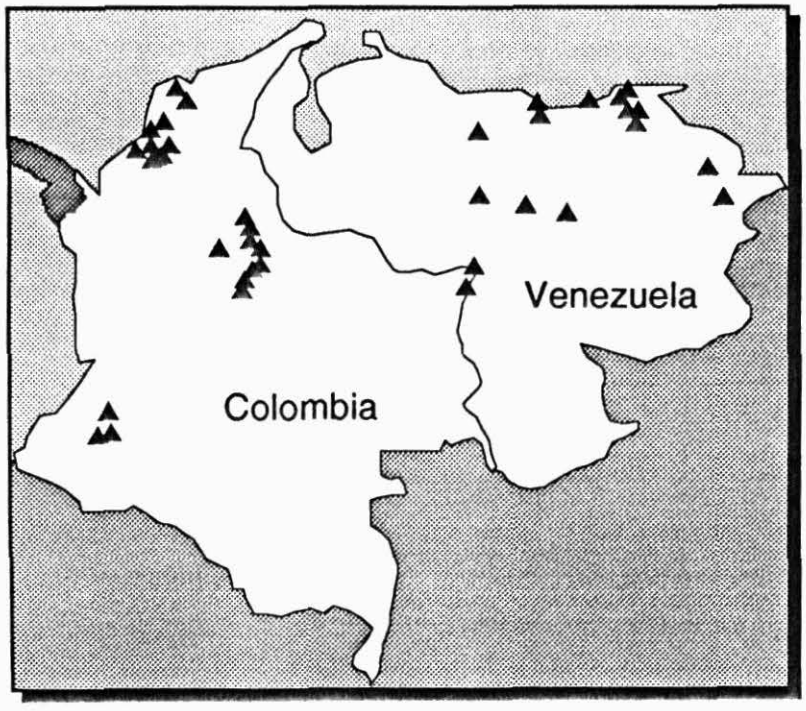


Figure 5.2.3 Explorations for cassava whiteflies and their natural enemies in Colombia and Venezuela during 1993 and 1994.

5.3 Plant Pathology and Virology

Biological Control of Cassava Pathogens

Work in 1994 focussed on identification of promising fungi for biological control of cassava pathogens, greenhouse and field screening of *Trichoderma*, population dynamics of *Trichoderma* spp. under crop rotations, and the effect of *Trichoderma* on cassava germination and growth.

Screening for potential *Trichoderma* spp. biocontrol isolates. Soil was collected from the upper 5 cm in commercial fields in Colombia, Brazil, Ecuador and Venezuela. A total of 317 fungal isolates were collected from 70 fields sampled. There were 110 isolates of *Trichoderma* with an average of 1.7 and a range of 0-6 isolates per field. Only six of 70 sampled fields did not possess *Trichoderma* spp. All isolates were stored under low temperature and are being tested for their potential as biocontrol agents (Table 5.3.1).

Biological control of root rot diseases of cassava *in vivo*. Twenty three isolates of *Trichoderma* were analyzed for biocontrol of *Phytophthora parasitica*. One-month-old cuttings from vegetatively produced stock of clones highly susceptible to *Phytophthora* root rots were used (CMC 40, MCOL 1684, HMC-1, MBRA 12, MBRA 451, SM 643-17 and CM 7397-1). Significant differences in disease control were noticed depending of the time span between introduction of pathogen and biocontrol agent. In general, disease control was low when the pathogen was inoculated before the biocontrol agent while control increased when the pathogen was inoculated after the agent. The best disease control was observed when the pathogen was inoculated two weeks after inoculation of the *Trichoderma* isolates. Six isolates of 23 controlled *P. parasitica in vivo*. The most effective isolates (14 PDA-4 and 19 TMS-3A) chosen as biocontrol agents for future experiments since were effective in at least 50% of the experimental trials (Table 5.3.2).

Field evaluation of *Trichoderma* spp. for control of *Diplodia manihotis*. Efficacy of isolates 14 PDA-4 and 19 TMS-3A for control of *Diplodia manihotis* was determined on cassava clones CM 7397-1 (susceptible), CM 7310-1 (susceptible), and HMC-1 (tolerant), and a combination of the two. Treatments with biocontrol agents improved germination of clones CM 7397-1 and HMC-1 compared with the control. There was no response by the clone CM 7310-1. This clone exhibited a resistant reaction to the pathogen in the field contrary to the reaction reported previously, suggesting the existence of a pathogen/host interaction or the existence of pathotypes. The existence or not of races within this pathogen needs to be clarified in the near future for breeding purposes (Table 5.3.3).

Population dynamics of *Trichoderma* spp. in crop rotations. Population dynamics of *Trichoderma* were studied in 14 fields with different crop rotations: Beans (B), Maize (M), Sorghum (S), Crotalaria (CR), Sunflower(SU), Cassava (C) and Fallow (F) or not

planted. The crop rotation patterns were: 1) C-C, 2) B-M-C, 3) B-S-C, 4) C-C 87-92, 5) C-C 89-92, 6) CR-C, 7) F-C, 8) M-B-C, 9) M-M-C, 10) M-S-C, 11) S-B-C, 12) S-M-C, 13) S-S-C, 14) SU-C. Presence and number of colony forming units (CFU) of *Trichoderma* were analyzed on three to five replications (fields per rotation pattern) and soil was evaluated on two dates: a week before cassava harvest, and at harvesting of the crops. Treatments were compared by calculating the mean of percentages of 1) total number of CFU on TSM medium, 2) number of CFU per gram of soil, and 3) percentage of dishes (TSM and PDA media) with presence of *Trichoderma* spp. Populations of *Trichoderma* spp. were enhanced in crop rotations with maize and sorghum but reduced in rotations with beans, sunflower and crotalaria. Populations at the end of the cassava crop depended on the preceding crop. Cassava after cassava exhibited low populations of *Trichoderma* while fallow was better than cassava. Due to the variability observed within each rotation in populations of *Trichoderma* with the detecting method used, the experiment will be repeated using alternative methods for detecting the fungus (Tables 5.3.4 and 5.3.5).

Effect of *Trichoderma* spp. on germination and growth of two cassava clones. The effect of *Trichoderma harzianum* on the germination and growth of two clones (CM-523-7 and CM 3306-4) was evaluated in in a greenhouse and a growth chamber at CIAT. In one experiment, stakes used of the clone CM 3306-4 were either fresh or stored for one month before use. *Trichoderma* isolates used were: CIAT HQ, 14 PDA-4, 19 TSM-3A, and 26 TSM-2. Treatments with the fungus were conducted as described previously (immersion in a spore suspension for 30 minutes and application of 40 ml of colonized sorghum at planting time). In the first experiment, effects were determined on plant height, fresh and dry weight of leaves and stems, fresh and dry weight of roots. Significant differences were only found on the effect of the isolate CIAT HQ on the increase in dry weight of roots (0.1 g/plant) of the clone CM-523-7.

In the second experiment, there were no significant differences on the effects of *Trichoderma* applications on fresh or dry stem and leaf weight, and on fresh or dry root weight. There were differences on the effects on germination of clone CM 3301-4. These effects were observed at either 23 or 37 days after planting, but not at 66 days after planting. Differences in germination were associated with the age of stakes and not with the use of *Trichoderma*. Germination was better for stakes stored for one month (54 - 87% at 23 days, 83 - 96% at 37 days) than for fresh stakes (25 - 33% at 23 days, and 50 - 54% at 37 days). There were no differences at 66 days when all treatments had more than 87% germination. In conclusion, *Trichoderma* spp. had no effect on germination and growth of the cassava clones used (Tables 5.3.6 and 5.3.7).

Studies of Cassava Root Rot Pathogens. Pathogenic species associated with root rot diseases in different cassava growing regions in Latin America were identified and quantified. Soil was sampled from three areas in Colombia (Carimagua, Villavicencio, Maria La Baja). Samples included soil under cassava cultivation, one year fallow, or under rotation with other crops. Identification of fungal isolates was based on macroscopic, microscopic and cultural characteristics. In general, the most common species recovered from all samples were *Fusarium oxysporum*, *F. solani*, and a probably non-pathogenic *Fusarium* sp. *F. solani* was found in higher proportion than *F. oxysporum* and was more commonly associated with infected cassava roots. In general, the frequency of these pathogens was lower in non-cultivated than in cultivated fields. Contrary to expectations, *Phytophthora* spp. was not detected in samples from Maria La Baja. It is not known if its absence is associated with the method used for pathogen isolation, or an effect of cultural practices established in the sampled areas to manage cassava diseases. Pathogenicity tests of various isolates are being conducted.

Root and stem rot pathogens identified from fields at CIAT. *F. oxysporum* was always recovered from infected samples exhibiting severe damage. Pathogenicity tests of several isolates identified highly aggressive isolates. Cassava clone CM 3306-4 was severely affected (0% germination) while clones MCOL1505 and MCOL1684 were highly and moderately resistant, respectively. One of these isolates will be used for screening cassava germplasm for *Fusarium* resistance.

Analysis of infected cassava roots from Ecuador yielded mainly *D. manihotis* and *F. oxysporum*. These isolates were more aggressive than isolates of the same species found in Colombia (Table 5.3.8). Studies will attempt to determine if a cultivar/isolate interaction exists in these host-pathogen systems. Identification and quantification of root rot pathogens in samples received from Brazil are being conducted.

Cassava Vein Mosaic Virus (CVMV).

Most of the objectives in the 1994 workplan were achieved during the year. The complete sequence of CVMV was determined. Primers and optimal conditions for PCR amplification were analyzed and the method is ready to be used as a research and diagnostic tool. Progress has been made on purification of the virus and production of antisera. Convincing evidence has been collected to show that visual symptoms are not a reliable indicator of virus infection and that CVMV does spread rapidly in the field.

Molecular characterization of CVMV. To understand the pathogen and develop control strategies, the complete sequence of CVMV was determined. The genome is 8158 bp in size and contains a $tRNA^{met}_{i}$ binding site that probably acts as a primer for minus-strand synthesis. The genome contains five open reading frames (OFRs) that potentially encode

proteins with predicted molecular weights of 186, 9, 77, 24, and 26 K. The 186 K protein has a zinc finger-like RNA-binding domain that is a common element in the capsid proteins of pararetroviruses. The 186 K protein also has an intercellular transport domain. The predicted 77 K protein had regions with similarity to aspartic proteases, reverse transcriptase, and RNase H of pararetroviruses. The genomic organization of CVMV was grouped between the caulimoviruses and badnaviruses. It appears CVMV is distinct from other, well-characterized plant pararetroviruses.

Analysis of CVMV isolates. Approximately 3,000 bases of a CVMV isolate from Petrolina, Brazil have been cloned using PCR. These clones have been partially sequenced; there is approximately 95% homology with the original CVMV clone. There is also some sequence data on a CVMV isolate from Araripina, Brazil; it shared 96% homology with the original CVMV clone. Although additional analyses are needed, preliminary data indicate a high degree of homology between CVMV isolates.

Development of rapid CVMV diagnostic techniques. PCR-based detection techniques have been developed for CVMV. The method is most sensitive and accurate when total nucleic acids are extracted from fresh leaves. When leaves are dried, extraction is not efficient and positive samples often appear to be negative. The fault is with the extraction of nucleic acid, since it is not possible to amplify PCR products using ribosome RNA primers.

Cassava plants infected with CVMV display a range of symptoms including chlorosis of the veins that can coalesce to form a mosaic. There is often leaf distortion and epinasty of young leaves. CVMV is transmitted readily through stem cuttings used as vegetatively-propagated planting material. When CVMV-infected stem cuttings germinate, plants are often stunted. This is normally followed by a flush of leaves with no apparent symptoms. Virus symptoms occur in flushes throughout the growing cycle. Using the PCR test, CVMV can be detected in asymptomatic leaves. Thus, even leaves without symptoms may contain virus. This stresses the importance of immunological diagnostic methods.

Production of antisera to CVMV. Production of antisera to CVMV has proceeded through two methods. In the laboratory of Dr. J.A. Lima (UFCE) methods for purification of CVMV are being developed. Partially purified viral preparations were made and used to produce antiserum. In a Western blot, this antiserum reacts with two major proteins. One is a plant protein produced in large quantities by cassava. The other protein is believed to be CVMV capsid protein. Further efforts will produce an antiserum by elution of the capsid protein from polyacrylamide gels and for use as the immunogen.

At CIAT, the part of the genome that encodes for the capsid protein has been put into a bacterial expression vector. The vector is being put into a protease-negative strain of bacteria and the capsid protein will be purified from the bacteria. It is expected that antisera

without reactions to healthy cassava will soon be produced using both methods.

Epidemiology trial to determine the vector of CVMV. An epidemiology trial to determine if CVMV spreads within a planting and the rate of spread in the field was planted at Petrolina, PE, Brazil in April. Results are inconclusive due to CGM damage; some planting material was contaminated with CVMV. This emphasizes the difficulty with using symptom expression for selection of clean planting material. Some varieties are CVMV-free but not well-adapted to Petrolina and suffered defoliation from CGM attacks. Stem cuttings from introduced varieties will be evaluated during the next growing cycle for CVMV symptoms. In Araripina, many of the breeding trials of Dr. Wania Fukuda (CNPMF) became contaminated with CVMV by the second planting cycle. The source of these breeding trials is true cassava seed. CVMV is not seed transmitted - another indication CVMV is transmitted in the field. Attempts to identify the vector will continue into 1995.

Table 5.3.1. Collection of potential *Trichoderma* spp. biocontrol agents.

Sample Site	Agroecological zone[1]	No. of isolates	No. of different isolates[2]
Brazil			
Belém	6A	11	6
Guariabo	6A	12	7
Manaus	6A	35	22
Colombia			
Buga	7A	25	5
Bajo Calima	6A	13	
Calarca	7J	28	9
Carimagua	2,6E	14	10
Circasia	2J/7J	15	9
Maria La Baja	7C	61	
Montenegro	2J/7J	15	6
Palmira	4C	38	25
Sincelejo	7C	5	3
Villavicencio	6A	13	11
Ecuador			
Sto Domingo	7A	28	
Venezuela			
Monagas	5A	7	
TOTAL		317	110

[1] A: Lowland tropical
C: Lowland semihot isothermic
E: Lowland hot isothermic
J: Highland tropical
2: Soils with permanent depth restrictions.
4: Soils with seasonal moisture restriction (annual flooding or drainage problems).
5: Soils with permanent moisture and/or salinity restriction.
6: Soils with acidity restrictions.
7: Soils without restrictions.

[2] Based on macro observations: texture, growth, pattern of colony, colour at PDA and malt-extract agar.

Table 5.3.2. Effect of six isolates of *Trichoderma* spp. on survival time of cassava cuttings.

Trial	SURVIVAL TIME (DAYS)[1]								No. OF TRIALS	
	1	2	3	4	6	8	9	10	Control	No control
Isolate No.	CMC 40	CMC 40	CMC 40	MCOL 1684	MBRA 12	MBRA 451	SM 643-17	CM 7397-1		
Control	13 a[2]	42 a	19 a	24 a	24 a	14 a	28 a	25 a		
P. parasitica	8 bc	27 bc	12 c	5 c	12 b	4 d	9 c	16 bc		
11 TSM-4	-	-	-	-	-	8 b	-	-	1	0
14 PDA-4	12 ab	36 ab	13 bc	10 b	11 b	-	17 b	-	5	1
16 PDA-1	-	-	-	-	-	7 bc	-	-	1	0
19 TSM-3A	13 a	28 bc	15 b	-	13 b	-	-	13 c	2	3
26 TSM-2	12 a	29 b	-	-	16 b	-	-	-	2	1
48 TSM-1	-	-	-	-	-	7 b	-	-	1	0
C.V. (%)	14.1	18.9	10.9	11.9	26.7	19.6	16.9	14. 9		

[1]Survival time = mean no. days after introduction of pathogen that plantlets did not show symptoms.
[2]Means within columns followed by the same letter do not differ by DMRT, (α=0.05).

Table 5.3.3 Efficacy of two isolates of*Trichoderma* spp. for field control of *Diplodia manihotis*.

Clone/ isolate		Germination (%)	Plants infected by *D. manihotis* (%)		Weak sprouts	Plants w/ dead buds (%)	Defoliated plants (%)
Clone	Isolate	29 dap[1]	39 dap	106 dap	29 dap	29 dap	106 dap
HMC-1	14 PDA-4	92a	0 a	0 a	2.1 a	6.3 a	8.3 a
HMC-1	19 TSM-3A	94a	0 a	0 a	2.1 a	2.1 a	2.1 a
HMC-1	Control	65 b	13 b	10 b	23 b	8.3 a	2.1 a
CM 7397-1	14 PDA-4	74 b	4.9 ab	13 b	16 b	4.9 ab	0.7 a
CM 7397-1	19 TSM-3A	99 a	0.7 a	0.7 a	0.7 a	0 a	11 b
CM 7397-1	Control	83 b	4.2 ab	3.5 ab	9.0 ab	5.6 b	4.2 a
CM 7310-1	14 PDA-4	89 a	4.2 a	4.2 a	4.2 a	4.2 a	5.2 a
CM 7310-1	19 TSM-3A	91 a	4.2 a	4.2 a	5.2 a	2.1 a	1.0 a
CM 7310-1	Control	57 b	18 a	17 a	28 b	9.4 a	1.0 a

1 dap: Days after planting.

2 Means within columns followed by the same letter do not differ by Duncan's Multiple Range Test (α=0.05).

Epidemiology trial to determine the vector of CVMV.

An epidemiology trial to determine if CVMV spreads within a planting and the rate of spread under field conditions was planted at Petrolina, Pernambuco, Brazil in April, 1994. Results are inconclusive due to CGM damage and because some planting material was contaminated with CVMV. This emphasizes the difficulty with using symptom expression for selection of clean planting material. Some varieties are CVMV-free, but these are not well-adapted to Petrolina and suffered defoliation from CGM attacks. Stem cuttings from introduced varieties will be evaluated during the next growing cycle for CVMV symptoms.

In Araripina, many of the breeding trials of Dr. Wania Fukuda (CNPMF) became contaminated with CVMV by the second planting cycle. The source of these breeding trials is true cassava seed. CVMV is not seed transmitted and this is another source of evidence that CVMV is being transmitted in the field. The activity to identify the vector will continue into 1995.

Table 5.3.1. Collection of potential *Trichoderma* spp. biocontrol agents.

Sample Site	Agroecological zone[1]	No. of isolates	No. of different isolates[2]
Brazil			
Belém	6A	11	6
Guariabo	6A	12	7
Manaus	6A	35	22
Colombia			
Buga	7A	25	5
Bajo Calima	6A	13	
Calarca	7J	28	9
Carimagua	2,6E	14	10
Circasia	2J/7J	15	9
Maria La Baja	7C	61	
Montenegro	2J/7J	15	6
Palmira	4C	38	25
Sincelejo	7C	5	3
Villavicencio	6A	13	11
Ecuador			
Sto Domingo de los Colorados	7A	28	
Venezuela			
Monagas	5A	7	
TOTAL		317	110

[1] A: Lowland tropical
C: Lowland semihot isothermic
E: Lowland hot isothermic
J: Highland tropical
2: Soils with permanent depth restrictions.
4: Soils with seasonal moisture restriction (annual flooding or drainage problems).
5: Soils with permanent moisture and/or salinity restriction.
6: Soils with acidity restrictions.
7: Soils without restrictions.

[2] Based on macro observations: texture, growth, pattern of colony, colour at PDA and malt-extract agar.

Table 5.3.2. Effect of six isolates of *Trichoderma* spp. on survival time of cassava cuttings.

Trial	SURVIVAL TIME (DAYS)[1]								No. OF TRIALS	
	1	2	3	4	6	8	9	10	Control	No control
Isolate No.	CMC 40	CMC 40	CMC 40	MCOL 1684	MBRA 12	MBRA 451	SM 643-17	CM 7397-1		
Control	13 a[2]	42 a	19 a	24 a	24 a	14 a	28 a	25 a		
P. parasitica	8 bc	27 bc	12 c	5 c	12 b	4 d	9 c	16 bc		
11 TSM-4	-	-	-	-	-	8 b	-	-	1	0
14 PDA-4	12 ab	36 ab	13 bc	10 b	11 b	-	17 b	-	5	1
16 PDA-1	-	-	-	-	-	7 bc	-	-	1	0
19 TSM-3A	13 a	28 bc	15 b	-	13 b	-	-	13 c	2	3
26 TSM-2	12 a	29 b	-	-	16 b	-	-	-	2	1
48 TSM-1	-	-	-	-	-	7 b	-	-	1	0
C.V. (%)	14.1	18.9	10.9	11.9	26.7	19.6	16.9	14. 9		

[1]Survival time = mean no. days after introduction of pathogen that plantlets did not show symptoms.
[2]Means within columns followed by the same letter do not differ by DMRT, (α=0.05).

Table 5.3.3 Efficacy of two isolates of*Trichoderma* spp. for field control of *Diplodia manihotis*.

Clone/ isolate		Germination (%)	Plants infected by *D. manihotis* (%)		Weak sprouts	Plants w/ dead buds (%)	Defoliated plants (%)
Clone	Isolate	29 dap[1]	39 dap	106 dap	29 dap	29 dap	106 dap
HMC-1	14 PDA-4	92a	0 a	0 a	2.1 a	6.3 a	8.3 a
HMC-1	19 TSM-3A	94a	0 a	0 a	2.1 a	2.1 a	2.1 a
HMC-1	Control	65 b	13 b	10 b	23 b	8.3 a	2.1 a
CM 7397-1	14 PDA-4	74 b	4.9 ab	13 b	16 b	4.9 ab	0.7 a
CM 7397-1	19 TSM-3A	99 a	0.7 a	0.7 a	0.7 a	0 a	11 b
CM 7397-1	Control	83 b	4.2 ab	3.5 ab	9.0 ab	5.6 b	4.2 a
CM 7310-1	14 PDA-4	89 a	4.2 a	4.2 a	4.2 a	4.2 a	5.2 a
CM 7310-1	19 TSM-3A	91 a	4.2 a	4.2 a	5.2 a	2.1 a	1.0 a
CM 7310-1	Control	57 b	18 a	17 a	28 b	9.4 a	1.0 a

1 dap: Days after planting.

2 Means within columns followed by the same letter do not differ by Duncan's Multiple Range Test (α=0.05).

Table 5.3.4. Population of *Trichoderma* spp. in crop rotations.

Rotation	*Trichoderma* count (% of max. score)[1]	
	Cassava harvest	Rotation harvest
M-S-C	90 a[2]	57 ab
B-M-C	72 ab	0 c
F-C	70 ab	21 bc
S-S-C	70 ab	14 bc
B-S-C	63 ab	67 ab
M-B-C	50 abc	20 bc
M-M-C	37 bcd	61 ab
S-M-C	35 bcd	57 abc
S-B-C	13 cd	0 c
C-C (87-92)	12 cd	0 c
C-C (89-92)	8 cd	95 a
SU-C	6 d	69 ab
B-B-C	5 d	26 bc
CR-C	5 d	26 bc
C.V. (%)	37.6	55.9
Soil Humidity (%)	12.7	6.2

[1] Mean of percentage of total no. of colony forming units on *Trichoderma* semi-specific medium, number of CFU/g soil, and percentage of dishes (TSM and PDA) with *Trichoderma* spp.

[2] Means within columns followed by the same letter do not differ by Tukey's Studentized Range Test, α=0.05.

Table 5.3.5. Populations of *Trichoderma* spp. in soil collected from fields of varying crop rotations.

CROP ROTATION	HARVEST[1]	
	CASSAVA	ROTATION
B-M-C	9.8×10^3	0
M-S-C	8.3×10^3	4.3×10^3
M-B-C	5.9×10^3	0.5×10^3
S-S-C	4.7×10^3	0.1×10^3
F-C	4.6×10^3	0.3×10^3
B-S-C	3.6×10^3	2.4×10^3
M-M-C	3.2×10^3	4.2×10^3
S-M-C	1.6×10^3	1.7×10^3
C-C (87-92)	0.9×10^3	0
C-C (89-92)	0.9×10^3	4.5×10^3
S-B-C	0.4×10^3	1.7×10^3
SU-C	0.2×10^3	2.9×10^3
CR-C	0.1×10^3	1.0×10^3
B-B-C	0	1.9×10^3

[1] Number of colony forming units/g of soil.

Table 5.3.6. Effect of *Trichoderma* spp. on germination of cassava clone CM 3306-4.

CLONE/STRAIN	GERMINATION (%)		
	23 dap[1]	37 dap	66 dap
CM 3306-4, storaged			
Control	75 a[2]	96 a	100 a
14 PDA -4	88 a	88 a	96 a
19 TSM -3A	54 a	88 a	96 a
26 TSM -2	63 a	83 a	96 a
CM 3306-4, fresh			
Control	33 b	54 b	96 a
14 PDA -4	25 b	50 b	88 a
19 TSM -3A	29 b	54 b	79 a
26 TSM -2	25 b	54 b	88 a

[1] Days after planting.

[2] Means within columns followed by the same letter do not differ by DMRT, α=0.05.

Table 5.3.7. Effect of *Trichoderma* spp. on growth of cassava clone CM 3306-4.

	LEAVES AND STEMS		ROOTS	
Clone/strain	Fresh wt. (g)	Dry wt. (g)	Fresh wt. (g)	Dry wt. (g)
CM 3306-4, storaged				
Control	9.5 a[1]	2.7 a	4.1 b	0.8 a
14 PDA -4	8.6 a	2.8 a	4.6 b	1.0 a
19 TSM -3A	7.8 a	2.9 a	7.4 a	0.9 a
26 TSM -2	11.6 a	4.2 a	5.4 b	1.0 a
CM 3306-4, fresh				
Control	11.7 a	3.4 b	5.3 a	0.6 a
14 PDA -4	9.7 a	3.1 b	4.3 a	1.2 a
19 TSM -3A	10.3 a	3.8 b	5.0 a	0.9 a
26 TSM -2	9.5 a	2.5 b	4.5 a	0.7 a

[1] Means within columns followed by the same letter do not differ by DMRT, α=0.05.

Table 5.3.8 Effect of root rot pathogens from Ecuador and Colombia on germination and necrosis of three cassava clones.

	Diplodia manihotis				*Fusarium oxysporum*			
	COLOMBIA		ECUADOR		COLOMBIA		ECUADOR	
Clone	GER	NEC	GER	NEC	GER	NEC	GER	NEC
MCL 1505	45	71	0	100	90	48	20	95
MCL 1684	80	74	10	98	40	90	0	100
CM 3306-4	30	70	0	100	40	70	0	100

GER= percent germination, NEC= percent necrotic tissue.

6 Strategic Research at CNPMF

6.1 Agronomy

Effect of cover crops and weeds on cassava yield

To study effects of weeds on cassava yield, an experiment was planted at Cruz das Almas in July, 1993, and harvested in July, 1994. Average yield of root and aerial parts are shown in Figure 6.1.1. Keeping the cassava crop weed-free for 30 or 60 days after germination did not increase root yield (Table 6.1.1). Yield was not affected by weed competition during 30 days after germination, i.e., 40 - 45 days after planting. Thus, weed control was not necessary during that period suggesting that, at Cruz das Almas, it is not necessary to keep the crop weed-free throughout the cycle. It appears the critical period for weed interference begins 30 days after germination and lasts for 3 to 4 additional months. On-farm trials at Itaberaba and Piritiba, Bahia, were planted in March/April, 1994 to study effects of weeds on cassava yield. Harvest is expected in January, 1995.

Occurrence of weeeds in cassava fields was studied in trials planted in March/May, 1994 at Cruz das Almas, Itaberaba and Piritiba. Common weeds in those ecosystems are listed in Table 6.1.2. At Cruz das Almas, common weeds were *Richardia brasiliensis*, *Acanthosperum australe*, *Cyperus rotundus*, *Eleusine indica*, *Blainvillea rhomboidea*, *Borreria alata*, *Digitaria horizontalis*, *Rhynchelitrum roseum*, *Brachiaria decumbens*, *Croton lobatus*, *Commelina benghalensis*. At Itaberaba, common weeds in cassava fields were *Blainvillea rhomboidea*, *Portulaca oleracea*, *Diodia teres*, *Acanthospermum hispidum*, *Mitracarpus hirtu*, *Mollugo verticillata*, and a weed species to be identified. Common weeds in cassava fields in Piritiba were *Richardia brasiliensis*, *Solanum erianthum*, *Setaria vulpiseta*, *Eupatorium laevigatum*, *Eupatorium ballataefolium*, and an unknown species.

To study effects of cover crops on cassava yield, on-farm trials were carried out at Cruz das Almas, Itaberaba and Piritiba (Bahia), and in Feira Nova (Pernambuco), the last in cooperation with IPA. Harvest is expected in January, 1995.

Effects of cover crops on arthropod population dynamics have been studied in all three ecosystems where PROFISMA has research activities. It is expected to identify weeds and/or cover crops able to function either as shelter (refugia) or as source of food for natural enemies of cassava pests, thus increasing their population and, as a consequence, decreasing cassava pest incidence. All collected arthropods were sent for identification.

Effect of mulching on cassava yield

Bagana, a waste product of a species of palm named *carnauba*, was evaluated as mulch for cassava in semiarid regions at two locations: Russas and Acarau, Ceará. The trial conducted in Russas was lost to drought. At Acarau, increasing the amount of bagana in cassava fields increased root yield as well as weight of aerial parts (Table 6.1.3). Small increases in starch content were observed although these results are not conclusive. Differences in starch content from first to second harvest period may be explained by three hornworm infestations that occurred during the first crop cycle. It is important to mention that the use of *bagana* mulch controlled weed incidence, reducing weeding from 7 to 5 times. Additionally, *bagana* mulch promoted early development of the aerial part of cassava plants. Trials will be carried out in 1995 to confirm these data.

Table 6.1.1 Average yield of root and aerial parts of cassava at Cruz das Almas, Bahia, 1994.

	Treatment	Yield (tons/ha)* Root		Aerial part	
Weed control from germination					
1	For 30 days	3.73	de	5.17	ab
2	For 60 days	5.83	cde	8.57	ab
3	For 90 days	19.20	ab	13.73	ab
4	For 120 days	19.03	ab	18.40	a
5	For 150 days	23.67	a	15.20	a
Weed control starting 30 days after germination					
6	For 30 days	6.06	cde	7.87	ab
7	For 60 days	16.43	abc	9.87	ab
8	For 90 days	20.03	ab	16.03	a
9	For 120 days	17.17	abc	14.17	ab
Weed control starting 60 days after germination					
10	For 30 days	8.47	bcde	7.90	ab
11	For 60 days	15.10	abcd	11.20	ab
12	For 90 days	16.73	abc	13.17	ab
Weed control starting 90 days affter germination					
13	For 30 days	6.10	cde	7.63	ab
14	For 60 days	13.47	abcd	18.20	a
Weed control starting 120 days after germination					
15	For 30 days	6.57	cde	8.87	ab
Weed control throughout the crop cycle					
16		20.10	a	17.40	a
No weed control all over the crop cycle					
17		0.83	e	1.50	b

*Means followed by the same letter within each column do not differ by Tukey's test, $\alpha = 0.05$.

Table 6.1.2. Common weeds found in cassava fields located in Cruz das Almas, Piritiba, and Itaberaba, Bahia, 1994.

Code	Scientific name	Common name	Family
01	*Richardia brasiliensis*	Poaia branca	Rubiaceae
02	*Acanthospermum hispidum*	C. de carneiro	Compositae
03	*Portulaca oleracea*	Beldroega	Portulacaceae
04	Non identified	Plant C	
05	*Blainvillea rhomboidea*	Picão grande	Compositae
06	*Mollugo verticillata*	Molugo	Mulluginaceae
07	*Solanum erianthum*	Caiçara	Solanaceae
08	*Diodia teres*	Mata pasto	Rubiaceae
09	*Mitracarpus hirtu*	Poaia da praia	Rubiaceae
10	*Croton lobatus*	Café bravo	Euphorbiaceae
11	*Euphorbia prostrata*	Quebra pedra	Euphorbiaceae
12	*Setaria vulpiseta*	C. rabo de raposa	Graminae
13	*Eupatorium laevigatum*	Eupatorio	Compositae
14	*Eupatorium ballataefolium*	C. de coelho	Compositae
15	*Sida cordifolia*	Malva branca	Malvaceae
16	*Ageratum conyzoides*	Mentrasto	Compositae
17	*Passiflora cincinnata*	M. do mato	Passifloraceae
18	*Acanthospermum australe*	C. rasteiro	Compositae
19	*Cyperus rotundus*	Tiririca	Cyperaceae
20	*Eleusine indica*	C. pé-de-galinha	Graminae
21	*Digitaria horizontalis*	C. colchão	Gramineae
22	*Borreria alata*	Poaia-do-campo	Rubiaceae
23	*Commelina benghalensis* Commelinaceae	Trapoeraba	
24	*Rhynchelitrum roseum*	Capim-favorito	Gramineae
25	*Brachiaria decumbens*	Capim braquiária	Graminea

Table 6.1.3 Effect of bagana mulching on root yield, aerial part production, and starch content of cassava in Acaraú, Ceará, 1994.

Bagana (m3/ha)	Months to Harvest: 12	17	12	17	12	17
	Root yield (ton/ha)		Aerial yield (ton/ha)		Starch content (%)	
315	14.96	32.52	14.85	26.26	23.04	29.81
270	14.11	34.00	14.89	26.22	22.91	29.52
225	11.52	28.85	14.26	22.44	23.17	28.64
180	11.33	32.96	11.66	22.85	20.91	29.22
135	10.37	25.74	10.41	17.89	22.51	29.11
90	7.93	19.85	8.26	12.59	20.10	28.51
45	5.30	18.07	6.37	12.22	19.96	27.51
0	6.52	19.22	4.47	18.37	19.22	26.80

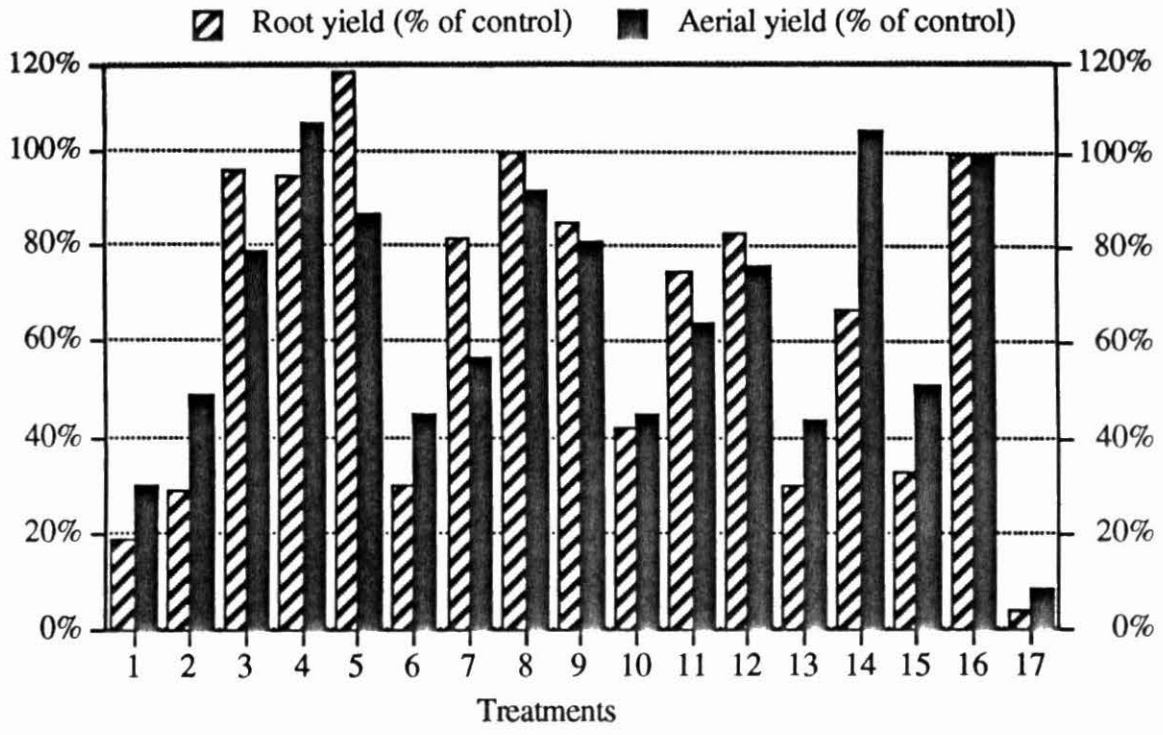


Figure 6.1.1 Cassava root yield and aerial biomass at harvest as affected by treatments listed in order in Table 6.1.1 and expressed as percent of the control treatment (weed control throughout the cropping cycle, treatment 16)

6.2 Acarology

Development of *Neozygites*

Strain selection and "in vivo" production. Isolates of *Neozygites* sp. (Zygomycetes: Entomophthorales) pathogenic to the cassava green mite (CGM) were collected from 24 sites located in Bahia, Sergipe, Alagoas, Pernambuco, Ceará, and Piauí (Fig. 6.2.1). Due to the possibility of contamination by local strains of the pathogen, the multiplication of the collected isolates has been performed at the Research Center for Semiarid Tropics (CPATSA)/EMBRAPA, located in Petrolina, State of Pernambuco, where there is no report on *Neozygites* occurrence. Multiplication of each isolate was initiated from a single mummy to reduce the possibility of contamination between collection sites thereby maintaining any population variability that may exist between collection sites.

Production of mummified CGM, due to *Neozygites* infection, under laboratory conditions is necessary to provide material for studies such as host/pathogen relationship. Mummified mites kept under high humidity conditions produce primary conidia which germinate and give rise to secondary conidia, also known as capilloconidia, that are used for bioassays. A method was developed to produce mummified CGM under controlled conditions. A mummified CGM is placed on a cassva leaf disk (1.7 cm diameter) and placed on a polyurethane foam pad inside water containing petri dishes, to avoid escape by mites. The petri dish is kept at 23 +/- 1 °C and 100% RH for 16 hours in the dark to promote fungal conidiation. Twenty five female CGM (approximately one day old) are then transferred to each leaf disk and kept for two days at 25 +/- 1 °C, 60 +/- 10% RH, 12 h. photophase; petri dishes are closed during the dark period. From the fourth to the seventh days of incubation the arenas are kept under continuous light. This technique yields 64% mummified CGM. For storage, mummies are placed in plastic vials, with a small amount of glycerol and kept at 4 °C. Methods for mass production of mummified CGM are currently under study.

Despite several attempts, *in vitro* production of *Neozygites* on Grace's medium and M199 modified medium, supplemented with bovine foetal serum was unsuccessful. Dr. Richard A. Humber (Insect Mycologist, USDA, US Plant, Soil and Nutrition Laboratory, Ithaca, NY) visited EMBRAPA/CNPMF, as a consultant, during the period of May 21 to 26, 1994.

In a joint activity between PROFISMA and the project Biological Control of the Cassava Green Mite, an EMBRAPA/CPATSA-IITA project founded by IFAD, evaluations of CGM population dynamics and infection by *Neozygites* were carried out weekly in nine cassava fields in Piritiba, Bahia from March to October, 1994. *Neozygites* natural occurrence and spread were evaluated every three days in two other cassava fields.

Epizootics were initiated on May 24, 1994. Twenty-three days later, infected CGM were observed in all nine cassava fields. Within one field it took 10 to 14 days for infected CGM to be found on all cassava plants. In six cassava fields, CGM infection reach 60% in 16 days. Infected CGM were initially observed in higher amounts on leaves located on the upper part of the cassava plant rather than on other leaves. CGM population decreased abruptly after high *Neozygites* incidence during June and July, 1994, when light rainfall occurred and a small number of CGM natural enemies was observed. This agrees with previous observations that *Neozygites* sp. is involved in reduction of CGM population in Piritiba.

Interaction of water stress and mite damage.

The effect of CGM on three cassava varieties under severe water stress was studied as a joint activity between PROFISMA and the project 'Development of Cassava Germplasma for Several Ecosystems and its Utilization Forms', funded by IFAD. The trial was planted on April 15, 1994, at the "Bebedouro" Experimental Station/CPATSA/EMBRAPA, Petrolina, Pernambuco. Planting material was obtained from evaluation trials of the EMBRAPA/CNPMF cassava germplasm bank at CPATSA. Three varieties were chosen; "Do Céu" and "Macaxeira Preta", due to their high performance, and the local variety "Engana Ladrão", as a check. Each plot contained 48 plants in a 1 x 1 m spacing. All plots were irrigated from planting up to June 6, 1994 to allow uniform germination. Since very low CGM populations were observed up to June, non-protected treatments were infested in late June by fixing a CGM-infested leaf on each cassava plant. The average number of CGM released per plant was 347.8. CGM population remained low until August when it began to increase, reaching high population density in late August/early September and causing severe plant defoliation in those plots without mite control. Defoliation occurred in both irrigated and non-irrigated plots showing a strong CGM effect on leaf area reduction. Visual diference was evident between irrigated and non-irrigated plots. Irrigated plants were taller and had higher number of leaves compared with non-irrigated plants.

Arthropod Population Dynamics

Studies of population dynamics of arthropods present on cassava plants have been carried out in 5 cassava fields: four at Piritiba and one at Itaberaba, Bahia. Biweekly evaluations at Piritiba showed that CGM numbers were higher on upper leaves compared with middle leaves. The highest CGM population was observed in March, 1994. Phytoseiids (eggs and adults) were found predominantly on middle leaves in all fields. The highest phytoseiid populations were detected late March/early April 1994 at Piritiba, and in March, 1994 at Itaberaba. *Amblyseius idaeus* was the most frequently observed phytoseiid mite. Whiteflies (eggs and nymphs) were observed from June to August in all fields.

Thrips incidence was very low.

Phytoseiid releases

Typhlodromalus tenuiscutus, introduced from CIAT, was quarantined at CNPMA and forwarded to CNPMF. *T. tenuiscutus* was released in two cassava fields in Piritiba. Due to the small number of mites available for release, 25 individuals were released per plant within each field. Surveys were performed every 15 days in areas where phytoseiid releases took place to monitor establishment.

Mass rearing of phytoseiid mites

Colonies of *T. tenuiscutus* were established at CNPMA, CNPMF and CPATSA (25 °C, 55% RH). There are currently six colonies of *T. tenuiscutus* at CNPMF producing about 2,000 mites/month. At CNPMF, *T. tenuiscutus* are fed CGM on cassava leaves.

Exportation of *Typhlodromalus manihoti* to Africa

In collaboration with IITA, 1800 individuals of *T. manihoti* were sent to the University of Amsterdam for quarantine and forwarding to IITA Biological Control Station at Benin.

Alternative food bases for *T. manihoti*

In collaboration with IITA, thirteen plant species were selected from a forest located at Cruz das Almas. Three plants of each species were sampled, and 3 samples (branches) were collected from each plant and brought to a laboratory. Samples were collected weekly during the first month of evaluation and monthly thereafter. Mites of the families Phytoseiidae, Tetranychidae, Tenuipalpidae and Tydeidea were found. Phytoseiid mites were found on all 13 plant species.

Phytoseiid population dynamics

Studies of population dynamics, also a cooperative activity with IITA, started May 27, 1994, on a 6 month old cassava field, cultivar "Cigana Preta", located at the EBDA experiment station. The field was divided into five 1,000 m^2 plots. Eggs, larvae, nymphs and adults (male and female) of phytoseiids were counted as well as insects such as whiteflies, lacebugs and others. Sex ratios were determined (Table 6.2.1). High populations of *T. manihoti* were found from the eleventh to the fifteenth leaves. Immature stages and males were found in higher numbers than females. CGM incidence was evaluted based on a zero to 3 rating in which 0 = no CGM infestation; 1 = < 25 individuals; 2 = > 25 and < 200 individuals; and 3 = > 200 individuals.

T. manihoti biology using whiteflies as alternative food

Cassava leaves, cassava leaves with whitefly eggs, and cassava leaves with whitefly nymphs were compared as food for female *T. manihoti*. Adult females survived longer when fed whitefly nymphs compared with other foods. Females fed whitefly nymphs laid more eggs than those fed either whitefly eggs or cassava leaves. Whitefly nymphs were

also the best food for *T. manihoti* based on rate of development to adult. Mites fed whitefly eggs were smaller and showed lower mobility compared with individuals fed whitefly nymphs.

Trichome-induced CGM mortality

Dead CGM were observed on leaves on a common weed, 'bamburral', *Solanum erianthum*. A laboratory test was done to determine if the trichomes present on the abaxial surface of the leaves of this weed affected CGM mobility. Another common weed without trichomes and cassava leaves were compared with leaves of bamburral. Only on bamburral were CGM observed adhered to the leaf and unable to leave the leaf surface. Further studies will look at the role of this plant in natural control of CGM.

Table 6.2.1. Sex ratio of adult *Typhlodromalus manihoti*..

Date	Female (F)	Male (M)	Immature (I)	F + M	SR (%) F/M	SR (%) F/I
05/27	1	0	0	1	0	0
06/10	21	8	37	29	72	36
06/27	139	54	149	193	72	48
07/12	40	24	28	64	62	59
07/27	23	14	30	37	62	43
08/09	73	32	56	105	69	57
08/29	94	30	65	124	76	59
09/13	163	80	124	243	67	57
10/06	30	17	5	47	64	86
10/20	32	14	9	46	69	78
11/03	19	6	12	25	76	61

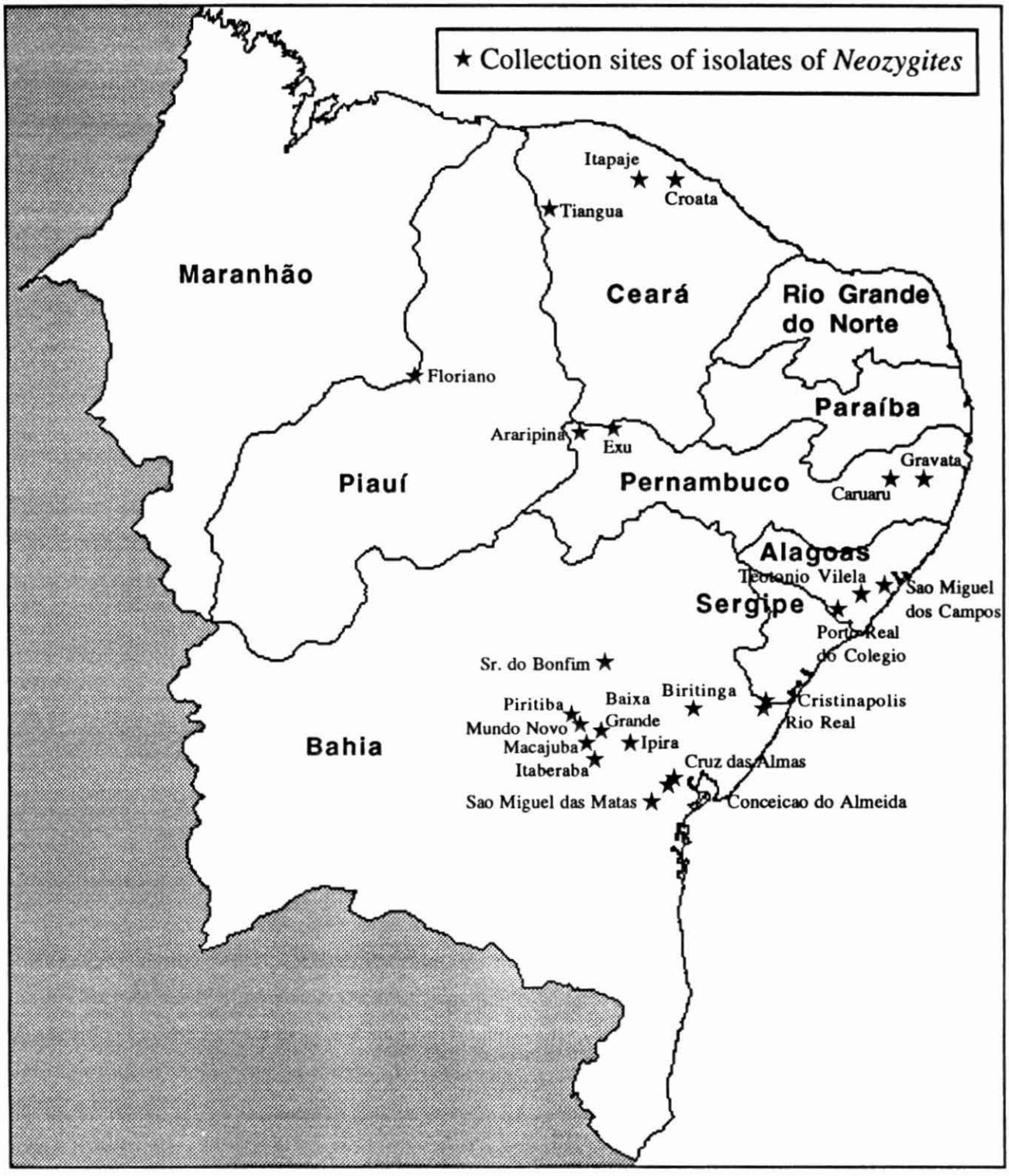


Figure 6.2.1 Collection sites of isolates of the mite fungal pathogen *Neozygites* sp. in states of northeastern Brazil.

6.3 Entomology

Arthropod pest incidence and yield loss assessment in northeastern Brazil

On-farm trials were carried out in Cruz das Almas and São Miguel das Matas, Bahia, to identify cassava pests, and to establish their period of incidence and associated yield reduction.. The effect of fertilizer application on pest incidence and damage was also studied. The most common pests at Cruz das Almas were CGM, lace bug (*Vatiga illudens*), CM, shoot flies (*Silba pendula, Lonchaea chalybea*) and gall midges (*Iatrophobia brasiliensis*), all of them at low incidence, and the cassava hornworm (*Erinnys ello*) at very low incidence. At São Miguel das Matas, CGM and whiteflies (*Aleurothrixus aepim*) were found in high incidence while lacebugs, shoot flies and gall midges were found at lower incidence. Fertilizer application increased shoot dry matter, root yield, flour production and starch content as shown in Tables 6.3.1 -6.3.4.

Two on-farm trials at Aracati and Pacajus, Ceará were planted in March/April, 1994. Treatments consisted of selective exclusion of pests as follows: CGM only, whiteflies only, hornworm only, all pests (no pest control) and pest free (chemical control). Either a biocontrol agent (*Cladosporium* sp.) or pesticides were applied to control specific pests. High populations of whiteflies and lacebugs, and a moderate infestation of CGM occurred at the Pacajus site. At Aracati, pest infestation was lower except for CGM.

At São Miguel das Matas, a trial was carried out to evaluate response of 37 cassava genotypes to whiteflies, CGM and lacebugs compared with the local variety "Corrente". Evaluations were performed every 15 days based on a 0 to 5 rating for whiteflies and lacebugs, and a 1 to 5 rating for CGM. Harvest was 12 months after planting and the following parameters were evaluated: shoot fresh weight (upper third of shoot), shoot dry weight (upper third of shoot), root yield, flour production and starch content. The most promising genotypes for root yield were "Aipim Bravo", MMex 59, and clones 128/8, 189/11, 192/13, and 194/16. The most promising genotypes in terms of flour production were "Olho de Porco", "Aipim Canário", "Cigana Preta" and "Maria Pau".

Mass production of *Baculovirus erinnyis* for control of *E. ello*

The cassava hornworm baculovirus (*B. erinnyis*) has been used as an efficient biocontrol agent in several cassava growing areas. Distribution to cassava growers has been carried out by CNPMF. Mass rearing of *B. erinnyis* at CNPMF was not possible during 1994 due to low hornworm incidence on cassava fields. Growers' requests were satisfied by sending small amounts of infected caterpillars from CNPMF stock, as well as providing information on how to apply correctly the biocontrol agent. CNPMF supplied *B. erinnyis* to cassava growers of Bahia, Paraiba, Pernambuco, Rio Grande do Norte, Maranhão, Espírito Santo, Mato Grosso and Brasilia.

Arthropods associated with weeds

Biweekly evaluations resulted in collection of 55 weed species from cassava fields; 25 species have been identified (Table 6.3.5). Mites of the sub-order Oribata and the families **Acaridae, Ascidae, Erythraeidae,** Phytoseiidae, Saproglyphidae, Tenuipalpidae, Tetranychidae and Tydeidae were found on 41 of 55 species collected. Insects such as Coleoptera (Alleculidae, Coccinellidae, Curculionidae), Diptera (Drosophilidae), Hemiptera/Sub-orders Heteroptera and Homoptera (Cicadellidae, Coccoidea, Lygaeidae, Margarodidae, Membracidae, Nabidae, Pentatomidae, Reduviidae, Tingidae), Hymenoptera (Calchididae, Ichneumonidae), Lepidoptera (Pyralidae), Psocoptera and Thysanoptera were found on 38 of 55 species collected.

Biological control of the cassava mealybug, *Phenacoccus herreni*

Exploration for *P. herreni* and natural enemies in northeastern Brazil. In anticipation of introduction of exotic parasitoids for biocontrol of the cassava mealybug (CM), surveys were carried out to establish pest distribution and damage to cassava plants in all nine states of northeastern Brazil. Thirty randomly-selected cassava plants in each field were rated based on a 1 to 5 scale (1 = no visible symptoms; 2 = initial deformation of emerging leaves, normal development of stem within the bud; 3 = deformation of the majority of leaves, normal stem development and internodes within the bud; 4 = bud completely deformed, shortened internodes, stem spiraled, if flowering occurs, peduncle is greatly shortened; and 5 = dead bud or buds, no plant development). Eighty cassava fields were evaluated from March to April, 1994 (Figure 6.3.1). Although surveys were conducted during the rainy season, CM was present in 4 of 9 states and 16% of evaluated fields were infested (Fig. 5). Damage ranged from 1.03 to 3.03 and infection varied from 3 to 80% (Table 7). The communities of Feira Nova and Lagoa de Itaenga, Pernambuco, and Cruz das Almas and Itaberaba, Bahia, were selected for release of parasitoids, based on location and CM incidence.

CM natural enemies were surveyed simultaneously with damage evaluations. In CM-infested cassava fields, 15 to 30 buds were collected and packed in vials containing vermiculite. As parasitoids and predators emerged, they were preserved in 70% alcohol for identification. All insects found on 30 randomly-selected cassava buds were collected, independent of CM occurrence. Natural enemies identified to date are listed in Table 8.

Surveys for natural enemies in South America enabled the identification of several parasitoides and predators of CM. At Cruz das Almas in May, 1994, CM were found infected by an Entomophthorales fungus identified as *Neozygites fumosa* (Speare). High mortality of CM due to the pathogen was observed during May and June. In August, five cassava fields were surveyed in Cruz das Almas and two in Feira Nova and Lagoa de

Itaenga, Pernambuco. Infected CM were found in three fields in Cruz das Almas; infection was 31.0, 9.3 and 64.6% while no infection was observed in the remaining fields. Although *N. fumosa* has been reported as an efficient natural enemy of several mealybug species, nothing is known about its effect on *P. herreni* in northeastern Brazil. This is the first report on *P. herreni* infected by *Neozygites fumosa* in northeastern Brazil.

Introduction, production and release of parasitoids for control of CM. *Epidinocarsis diversicornis*, *Aenasius vexans* and *Acerophagus coccois* were introduced from CIAT, passed quarantine at CNPMA and sent to CNPMF where they have been increased. Colonies were sent to the Pernambuco State Organizatiion for Agricultural Research (IPA), Recife, Pernambuco for rearing and release.

Pre-release surveys focussed on CM distribution and incidence to select sites for parasitoid releases. Pre-release surveys will estimate CM populations as a basis for impact assessment of introduced parasitoids and will determine species composition of infested cassava fields, also for impact assessment.

Post-release surveys will continue to determine establishment and spread of parasitoids, as well as to study population dynamics of both pest and natural enemies. Surveys are performed monthly. Cassava tips are selected at random and scored for CM damage. Ten CM-infested cassava tips are collected and adult CM and natural enemies are counted. Samples are placed in paper bags and kept under laboratory conditions for two to three weeks. Bags are then opened and numbers of predators and parasitoids determined and specimens sent for identification. Three months after the first evaluation, samples are collected from sites 100, 300, and 1000 m from the release point.

E. diversicornis was released in cassava fields located in Cruz das Almas, Bahia, and in Feira Nova, Pernambuco (Table 9). Recently (November, 1994) a colony of *A. coccois* was established at CNPMF. In December, 1994, 1,700 individuals of *A. coccois* were released in a cassava field at Itaberaba. Arrangements have been made to introduce *A. vexans* from CIAT during early 1995.

Occurrence of ectoparasitoides (Hymenoptera: Chalcidoidea) on the cassava gall midge *Iatrophobia brasiliensis* (Diptera: Cecidomyidae)

Three Chalcidoidea wasp species were found on larvae of the cassava gall midge, *Iatrophobia brasiliensis*, in cassava fields at Cruz das Almas, São Felix and São Miguel das Matas, Bahia. Cassava leaves with galls were collected in heavily infested fields and incubated under laboratory conditions until gall midges or parasitoids emerged. *I. brasiliensis*, *Dimeromicrus* sp. (Torymidae), *Aprostocetus* sp. (Eulophidae) and *Tetrastichus* sp. (Eulophidae) developed from galls.

Dissected galls typically contained one gall midge larva. Some galls contained eggs of

several parasitoids but, in all cases, only one developing ectoparasitoid larva was observed. Average parasitism was 69% at São Miguel das Matas, cultivar Corrente, 57% at São Felix, cultivar Cidade Rica, and 86% at Cruz das Almas, cultivar Cigana Preta.

Gall midge is not considered a major cassava pest and appears to be controlled, at least partially, by native Chalcidoidea species. In this sense, care should be taken to avoid pesticide use for control of other cassava pests to prevent resurgence of secondary pests such as *I. brasiliensis*.

Table 6.3.1. Shoot (upper third) dry matter yield for cv. Corrente, with and without chemical fertilizer. São Miguel das Matas, BA, 1994.

	Dry matter yield (tons/ha)							
Treatments	Without fertilizer				With fertilizer			
Months after planting:	4	8	12	(% loss)	4	8	12	(% loss)
Whitefly infestation	2.80	7.17	8.42	**(-11)**	4.87	6.83	28.08	**(-57)**
CGM infestation	2.73	9.17	5.93	**(22)**	4.53	6.00	10.42	**(42)**
All pests present	3.13	9.75	6.05	**(20)**	5.50	6.17	13.83	**(22)**
Control (no pests)	4.12	11.92	7.58		5.00	7.58	17.83	

Table 6.3.2. Cassava root yield for cv. Corrente, with and without chemical fertilizer. São Miguel das Matas, BA, 1994.

	Root yield (tons/ha)							
Treatments	Without fertilizer				With fertilizer			
Months after planting:	4	8	12	(% loss)	4	8	12	(% loss)
Whitefly infestation	1.02	7.21	14.84	**(44)**	3.13	13.32	33.32	**(-2)**
CGM infestation	1.25	7.70	14.21	**(46)**	2.85	9.09	24.89	**(24)**
All pests present	1.41	6.03	15.14	**(43)**	2.84	9.44	25.90	**(21)**
Control (no pests)	1.90	14.01	26.56		2.36	13.66	32.66	

Table 6.3.3. Cassava flour production for cv. Corrente, with and without chemical fertilizer, harvested 12 months after planting. São Miguel das Matas, BA, 1994.

	Flour yield (tons/ha)			
Treatments	Without fertilizer	(%loss)	With fertilizer	(%loss)
Whitefly infestation	23.82	**(4)**	25.83	**(7)**
CGM infestation	23.76	**(4)**	27.16	**(2)**
All pests present	24.84	**(0)**	25.00	**(10)**
Control (no pests)	24.80		27.83	

Table 6.3.4. Cassava starch yield for cv. Corrente, with and without chemical fertilizer, harvested 12 months after planting. São Miguel das Matas, BA, 1994.

	Starch yield (tons/ha)			
Treatments	Without fertilizer	(%loss)	With fertilizer	(%loss)
Whitefly infestation	4.44	**(47)**	10.83	**(-3)**
CGM infestation	4.36	**(48)**	8.09	**(23)**
All pests present	4.72	**(44)**	8.57	**(19)**
Control (no pests)	8.37		10.52	

Table 6.3.5 Arthropods associated with weed species present in cassava fields in Itaberaba and Piritiba, Bahia.

INSECTS (Order)	MITES (Family)	WEED SPECIES	
		Species	Family
Thysanoptera, Homoptera	Phytoseiidae, Tetranychidae	*Acanthospermum hispidum* D. C.	Asteraceae*
Homoptera	Tenuipalpidae	*Amphilophium vanthieri* D. C.	Bignoniaceae
Thysanoptera, Homoptera	Tenuipalpidae, Saproglyphidae, Tetranychidae, Acaridae	*Borreria verticillata* (L.) G.F.W. Meyer	Rubiaceae
Homoptera	Saproglyphidae, Phytoseiidae	*Capparis ico* Esch.	Capparidaceae
Thysanoptera, Lepidoptera, Homoptera	Tetranychidae, suborder Oribata	*Cassia excelsa* Schard.	Caesalpiniaceae
Thysanoptera, Homoptera	Tydeidae, Acaridae, Tenuipalpidae, Phytoseiidae	*Cassia rotundifolia* Pers.	Caesalpiniaceae
Thysanoptera, Heteroptera	Phytoseiidae,Tenuipalpidae, Acaridae	*Centratherumn punctatum* Cass.	Asteraceae*
Thysanoptera, Homoptera	Tenuipalpidae, Acaridae, Tetranychidae	*Centrolobium robusta* Mart.	Fabaceae
Thysanoptera, Homoptera	Phytoseiidae, Tenuipalpidae, Tetranychidae	*Diodia teres* Waet.	Rubiaceae
Thysanoptera		*Eupatorium sp.*	Asteraceae*
		Eupatorium ballotaefolium H.B.K.	Asteraceae*
Thysanoptera, Homoptera	Tetranychidae, Phytoseiidae, Tenuipalpidae	*Galinsoga parviflora* Cav.	Asteraceae*
Thysanoptera, Heteroptera		*Herissantia crispa* (L.)	Malvaceae
Thysanoptera	Tenuipalpidae	*Lantana lilacina* Desf.	Verbenaceae
Thysanoptera		*Melochia tomentosa* L.	Sterculiaceae
		Mitracarpus hirtus (L.)	Rubiaceae
Thysanoptera, Homoptera, Lepidoptera	Tetranychidae, Phytoseiidae, Tenuipalpidae, Ascidae	*Passiflora cincinnata* Mast.	Passifloracea
Heteroptera	Tetranychidae, Tenuipalpidae, Saproglyphidae	*Polygala violacea* Aubl.	Polygalaceae
Thysanoptera, Homoptera, Heteroptera	Phytoseiidae, Tetranychidae, Sub-ordem Oribata	*Richardia grandiflora* (Cham & SCW.) Schult & Schult	Rubiaceae
Thysanoptera, Lepidoptera		*Sida rhombifolia* (L.)	Malvaceae
	Phytoseiidae, Tetranychidae	*Sida spinosa L.*	Malvaceae
Thysanoptera, Heteroptera, Homoptera, Lepidoptera, Coleoptera	Phytoseiidae, Tetranychidae, Tenuipalpidae, Acaridae, Saproglyphidae	*Solanum erianthum* D. Don.	Solanaceae
Thysanoptera		*Stylosantes viscosa* S.W.	Fabaceae
Thysanoptera, Heteroptera	Phytoseiidae, Tetranychidae, Tydeidae	*Trigonia fasciculata Aubl.*	Trigoniaceae
	Sub-ordem Oribata	*Waltheria indica L.*	Sterculiaceae

*Compositae

Table 6.3.6 Damage by cassava mealybug, *P. herreni*, in northeastern Brazil, 1994.

Site	State	Mean Damage Score (1 - 5)	% Infestation
Feira Nova	PE	3.03	80.0
Lagoa de Itaenga	PE	2,43	73.3
Goiana*	PE		
Pombos*	PE		
Petrolina*	PE		
Feira de Santana	BA	1.16	17.0
São Gonçalo	BA	1.63	30.0
Capim Grosso	BA	1.53	43.3
Cruz das Almas	BA	1.77	70.0
Itaberaba	BA	1.73	66.6
Juá	CE	1.03	3.3
Croatá**	CE		
Mamanguape**	PB		

*Not evaluated
**Insufficient infestation

Table 6.3.7 Preliminary evaluation of natural enemies of cassava mealybug, *Phenacoccus herreni*, in northeastern Brazil.

PREDATORS	STATE*
Coleoptera: Coccinelidae	
Hyperaspis notata (Mulsant)	BA, PE
Hyperaspis sp.	BA, PE
Nephus sp.	BA, PE
Diomus sp.	BA, PE
Coleoptera: Staphylinidae	
sp 1	BA
Coleoptera: Fam. 1	
sp 1	BA
Diptera: Syrphidae	
Ocyptamus spp.	BA, PE
Diptera: Cecydomiidae	
Kalopidlosis coccidarium	PE
Hemiptera: Reduviidae	
Zellus sp.	BA, PE
Neuroptera: Chrysopidae	
Chrysopa sp.	BA, PE
PARASITOIDS	LOCAL
Hymenoptera: Encyrtidae	
Anagyrus sp.	PE
Hymenoptera: Fam. 1	
sp 1	BA

*PB and CE insufficient infestation.

Table 6.3.8 Production and release of *Epidinocarsis diversicornis*, 1994.

SITE	No. received at CNPMA	Adults		Retained for rearing	Parasitoids released	Release Date (1994)
		Live	Dead			
Cruz das Almas, BA	121	120	01	120	---	06/22
	400	280	120	100	180	07/28
					125	08/02
					250	08/16
					100	08/18
					200	09/16
					500	09/19
					650	09/22
					150	09/23
					200	10/07
					200	10/24
					225	11/07
					100	11/08
Total, Bahia	521	400	121	220	3220	
Feira Nova, PE*	350	350	---	40	310	08/24
					150	08/14
Total, Pernambuco					460	
TOTAL	871	750	121	260	3680	

*Partial data

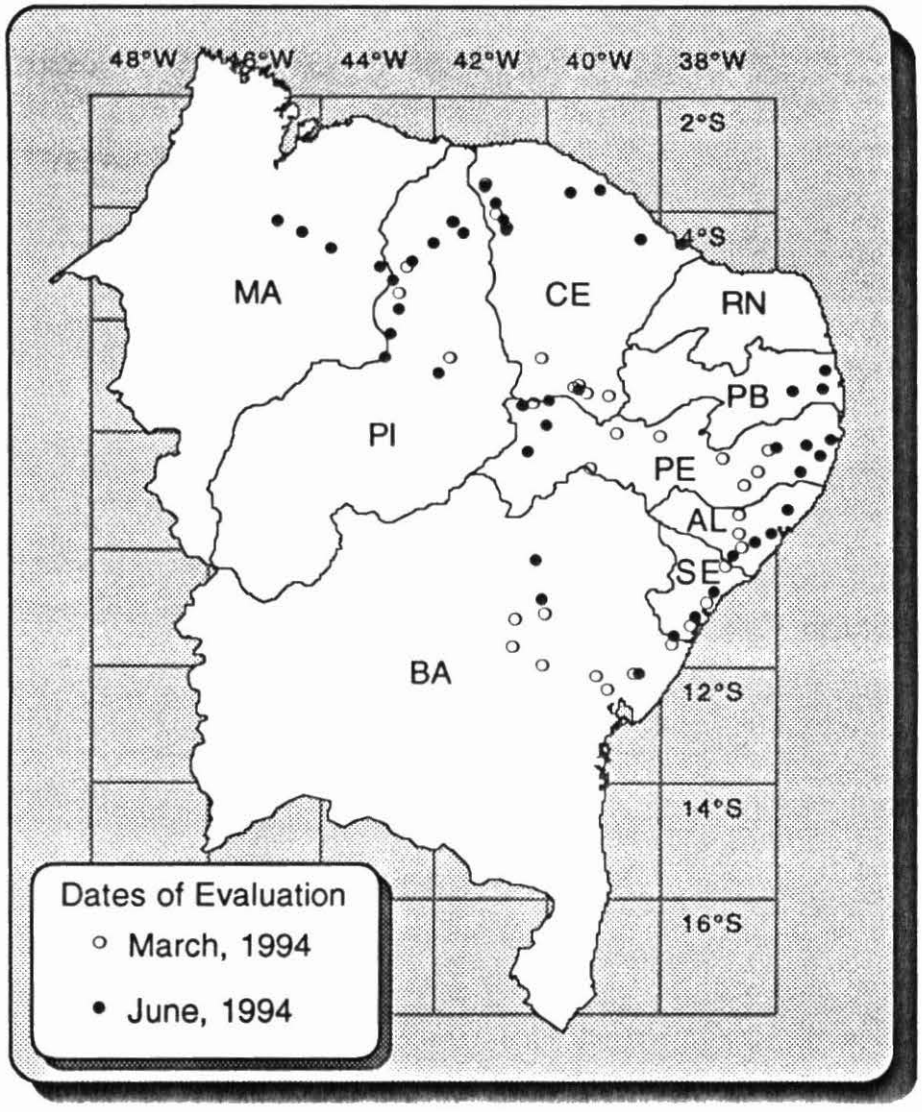


Figure 6.3.1 Sampled sites during survey for the cassava mealybug, 1994.

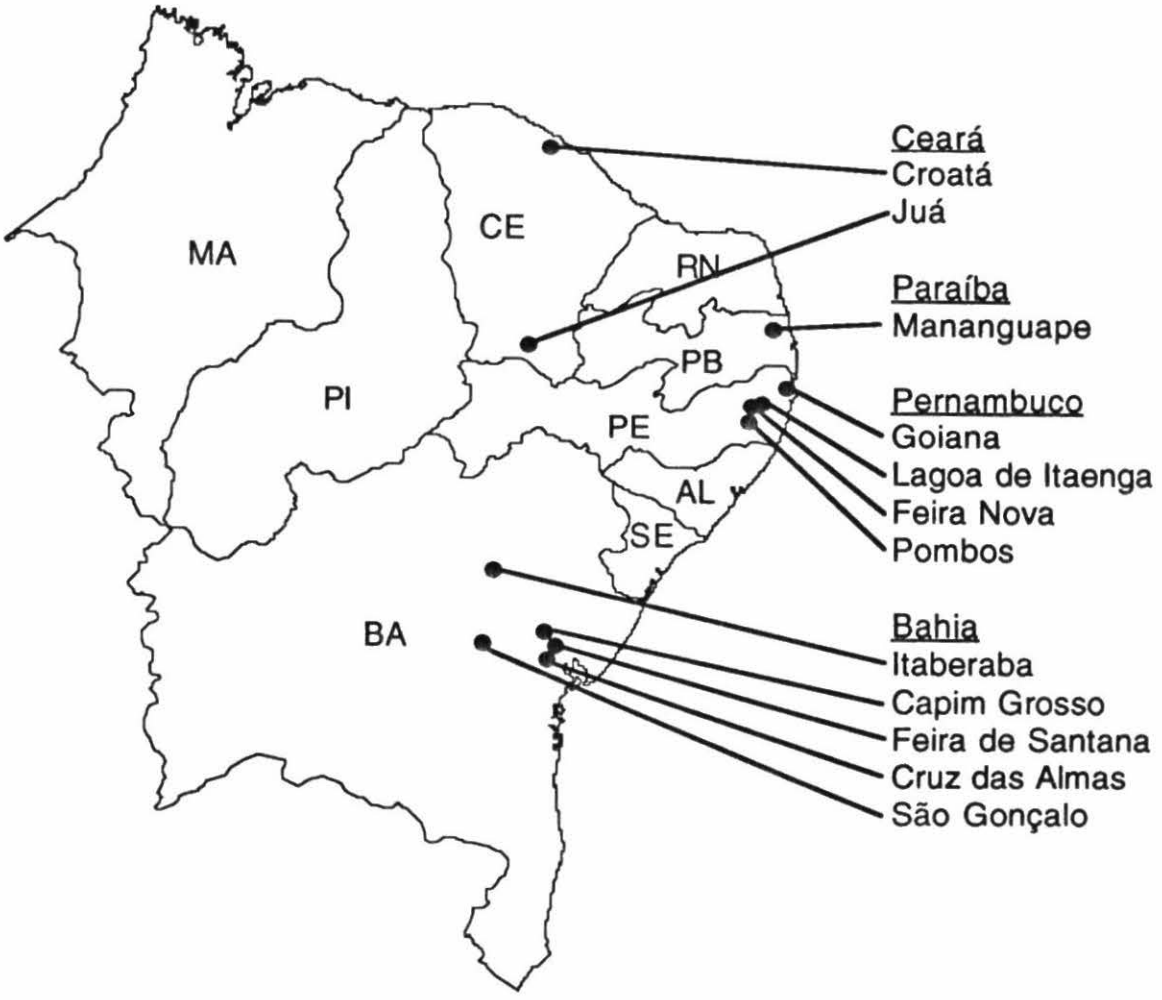


Figure 6.3.2 Occurrence of the cassava mealybug in northeastern Brazil, March and June, 1994.

6.4 Quarantine of natural enemies of cassava pests

CM-infested cassava samples were collected at Capim Grosso/Jacobina, Bahia, and brought to CNPMA, in Jaguariuna, São Paulo, where CM has been reared according to a specific methodology developed for that purpose. CGM colonies have also been established in EMBRAPA/CNPMA according to the technique developed under the EMBRAPA/IITA agreement.

Starting February, 1994, the phytoseiid *Typhlodromalus tenuiscutus*, and the CM parasitoids *Epidinocarsis diversicornis* and *Acerophagus coccois*, were introduced from CIAT, quarantined at CNPMA and sent to CNPMF (Table 10). No contaminants were found in *T. tenuiscutus* introductions. Two primary parasitoids, *Timberlakia europaeus* and *Zaplaticerus* sp (Hymenoptera: Encyrtidae) were found in *E. diversiconis* introductions. Contaminants, four *Chartocerus* sp. females (probably Encyrtidae hyperparasitoids) were also present in *A. coccois* introductions. All contaminants were destroyed.

Table 6.4.1 Introduction, quarantine and transfer of natural enemies of cassava pests from EMBRAPA/CNPMA, 1994.

Species	No. recieved from CIAT	Date	No. sent to CNPMF	Date
T. tenuiscutus	201	02/02	350	
	03/28			
	750	03/03	520	
	04/04			
	1,481	08/19	550	
	06/13			
	150	07/05		
	300	08/04		
	400	10/21		
E. diversicornis	106	03/16	422	
	06/22			
	400	07/05		
	400	07/27		
	350	08/23		
	318	09/21		
A. coccois	220	10/13	700	
	11/30			
	2,000	12/13		

6.5 Effect of biocontrol agents on non target organisms

Monitoring phytoseiid releases

CGM has been frequently found associated with *Passiflora cincinnata* Mast., a common weed of cassava fields in Itaberaba and Piritiba. *P. cincinnata* may be an alternative host for CGM thus playing a role in integrated management of this pest. All CGM found on another common weed, *Hyptis suaveolens*, were dead. All CGM individuals placed on *H. suaveolens* were attached to trichomes present on the lower (abaxial) leaf surface, suggesting that this weed may be involved on decreasing CGM populations in cassava fields.

Monitoring *Cladosporium* sp

CGM, mealybug, lacebugs, and whiteflies were inoculated with *Cladosporium* sp. isolated from infected whiteflies, by spraying an inoculum suspension containing 300,000 conidia/ml. After inoculation, pests were transferred to cassava leaf disks and placed inside plastic vials with moist filter paper. Vials were sealed and kept at 25 °C, 75% RH. Whiteflies and cassava mealybugs were infected when evaluated five days after inoculation. Neither CGM nor lace bugs were infected.

6.6 Plant Pathology and Virology

Root rot survey, cultural and genetic control

Root rot disease symptoms may be observed in cuttings, on young and on old plants as well. *Fusarium* sp. or *Phytophthora* sp. were isolated from about 90% of infected material collected in area where root rot is a problem. In some cassava growing areas of Alagoas, both pathogens were isolated from the same sample. *Phytophthora* sp. was isolated more often than *Fusarium* sp. from cassava samples showing root rot symptoms collected in Pernambuco, and in cassava growing areas of Goiana and Itambé. *Fusarium* sp. was isolated in higher frequency than *Phytophthora* sp. from cassava samples collected in growing areas of Feira Nova and Santo Antão, Pernambuco; pathogens such as *Diplodia* sp. and *Scytalidium* sp. were also isolated from root rot infected samples collected in Feira Nova and Santo Antão. *Scytalidium* sp. was also isolated in high frequency from infected samples collected in the municipalities of Areia and Remigio, Paraiba. *Fusarium* sp. was the predominantly pathogen from infected samples collected in cassava growing areas of Sergipe and Ceará.

In northeastern Brazil, cassava root rot is caused by *Fusarium* sp., *Phytophthora* sp., *Scytalidium* sp. and *Diplodia* sp. *Fusarium* and *Phytophthora* are the most common pathogens. In some regions of Alagoas, root rot may be caused by an association of *Fusarium* and *Phytophthora*.

Surveys carried out in Sergipe, Alagoas, Pernambuco and Paraíba, showed that root rot occurs in about 50% of cassava fields in regions where annual rainfall is around 1,200 mm. Thus, root rot

is a very serious disease in the majority of the cassava growing areas of northeastern Brazil, reducing root yield by about 30%.

The effect of intercropping on root rot was studied in two on-farm trials established in June, 1994, in Taquarana, Alagoas and Remigio, Paraiba where root rot occurs naturally. Pigeon pea (*Cajanus cajan*) and jack bean (*Canavalia ensiformes*) were planted as intercrops. Soil physical characteristics at Taquarana are shown in Tables 6.6.1 and 6.6.2; water potential and soil humidity relationships are shown in Figs. 6.6.1. The trials were planted on slopes of 40% to 50% to study the effects of intercrops on soil erosion. Changes of soil characteristics due to the intercrops will also be studied.

On-farm trials located at Taquarana, Alagoas and Areia, Paraíba showed that using disease-free propagative material of tolerant varieties, such as 'Osso Duro', and planting them on ridges in a vertical position, constitute the most promising control measures for root rots.

Cultural and genetic control of cassava witches' broom disease (CWB)

CWB is caused by a mycoplasma-like organism (MLO) which occurs predominantly in Serra da Ibiapa, Ceará, in an area of about 5,000 ha, causing yield reduction of around 30%. To study environmental effects on CWB incidence, three trials were established at Guaraciaba do Norte, Ubajara and Tianguá (Ceará). CWB incidence was higher at Guaraciaba do Norte compared with Ubajara and Tianguá. Symptom expression was very weak in plants originated from infected propagative material planted at Ubajara and Tianguá, suggesting a strong environmental effect on CWB development.

Preliminary results suggest that an as yet unidentified insect may act as a vector in disease dissemination. Shown that some plant species, such as maidenhair and dodder, may support pathogen development and act as alternate hosts.

Virology

CVMV. The great majority of cassava fields located in semiarid zones of northeastern Brazil are affected by cassava vein mosaic virus (CVMV). In other cassava growing zones in the northeast, such as Cariri and Litoral, Ceará, even though CVMV incidence is high, symptom expression is weak. In the Recôncavo Baiano Region, Bahia, infected cassava plants express symptoms during the dry season but those symptoms completely disappear during the raining season. Yield loss to CVMV is being assessed at Petrolina, Pernambuco in cooperationwith CPATSA.

Purification, characterization and rapid diagnosis of cassava vein mosaic virus (CVMV). New attempts to purify CVMV were carried out during 1994 following the methodology shown in Fig. 6. Partially purified virus preparations were analyzed by spectrophotometer (220 to 340 nm) to evaluate virus purity and concentration. A high protein concentration peak was detected at A280.

Partially purified virus preparations were submitted to polyacrilamida gel electrophoresis containing sodium dodecyl sulfate (SDS) for protein analysis. Virus preparation was then diluted

1:2, v:v, in Tris-HCl buffer, 0.05 M, pH 6.8, containing SDS, 2%; dithiothreitol, 0.1 M; bromophenol blue, 0.15; and glycerol, 10%, boiled for 3 minutes and centrifuged for 2 minutes. Electrophoresis, 140 V and 95 mA, was performed under room temperature for approximately 2 hours. Bovine albumin (PM = 66 kDa), egg albumin (PM = 45 kDa), glyceraldehyde-3-phosphate dehydrogenase (PM = 36 kDa), carbonic anhydrase (PM = 29 kDa), trypsinogen (PM = 24 kDa), trypsin inhibitor (PM = 20.1 kDa) and lactic albumin (PM = 14.2 kDa) were used as standards for protein molecular weight estimates. After staining with blue coomassie, two protein bands, molecular weights 66.5 and 44.5 kDa, were detected (Fig. 6.6.2).

To obtain CVMV-specific antiserum, the 44.5 kDa molecular weight band was removed from the polyacrilamida gel, cut into small pieces, macerated and kept in Tris buffer, 0.02 M, pH 8.2 for 24 hours to elude the protein. Eluded protein, emulsified with Freud incomplet adjuvant (1:1, v:v), was injected into New Zealand rabbits. Two injections were performed at weekly intervals; a third injection, followed by a booster, will be performed. Blood will be taken 10 days after the last injection and antiserum will be tested using a double diffusion technique.

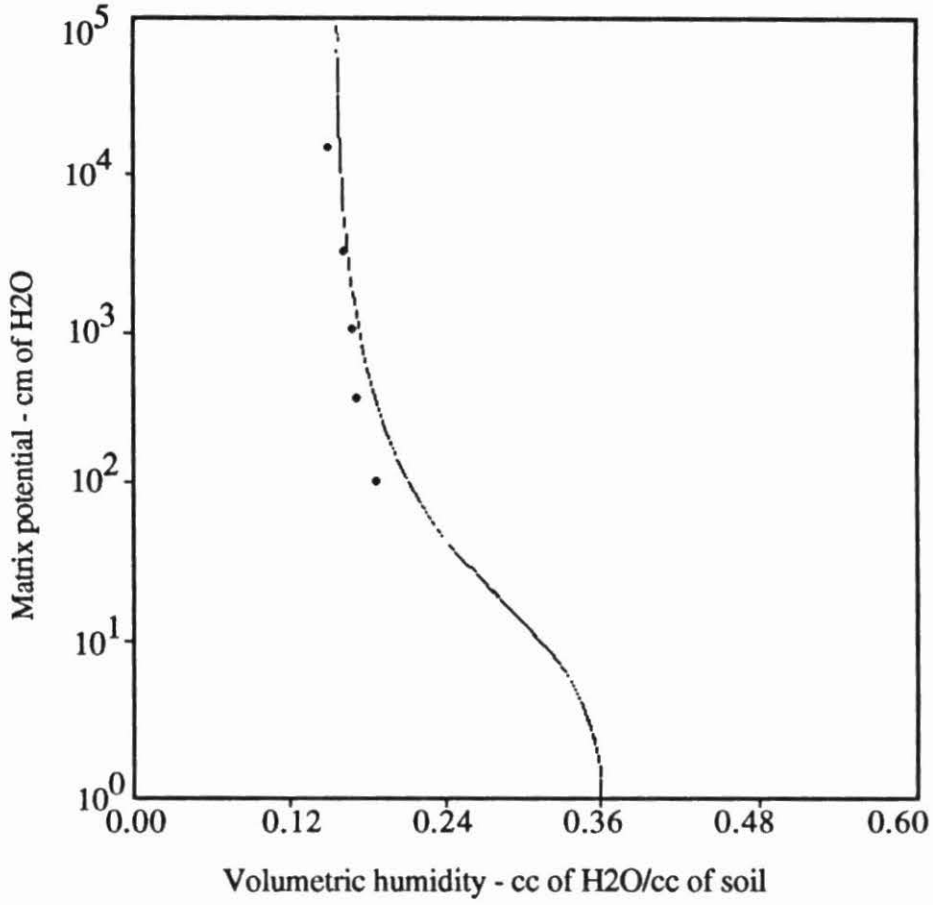
As stated in the 1993 PROFISMA Annual Report, the antiserum obtained at that time contained high concentrations of host plant antigens. Several dilutions of that antiserum were tested, using the double diffusion technique, during 1994. Results showed no specific reaction with host plant protein when antigen dilution 1:8 was used but, reaction was observed with extract of CVMV infected cassava plants. It was also observed that reaction occurs only with extract obtained from young cassava leaves showing CVMV symptoms.

Table 6.6.1 Soil porosity of several horizons at Taquarana, Alagoas, 1994.

Soil horizon	Bulk density (g/cm3)	Particle density (g/cm3)	Porosity (%)	Macropore (%)	Micropore (%)
Ap(0-23cm)	1.44	2.44	41.5	14.3	27.2
AB(23-48cm)	1.43	2.38	41.9	12.8	29.1
BW_1(48-88cm)	1.39	2.41	41.4	10.8	30.6
BW_2(+ 88cm)	1.35	2.45	42.9	10.5	32.4

Table 6.6.2 Textural classification of soil collected at Taquarana, Alagoas, 1994.

Soil Horizon	Sand type					Total		
	Very coarse	Coarse	Medium	Fine	Very fine	Sand	Silt	Clay
Ap(0-23cm)	5	4	34	-	21	64	19	17
AB(23-48cm)	4	2	27	-	17	50	22	28
BW_1(48-88cm)	4	4	21	-	14	43	31	26
BW_2(+ 88cm)	8	2	23	8	16	57	29	14



Soil horizon	Water potential/soil humidity relationship
Ap (0 - 23 cm)	$\varnothing = 0.1545 + \frac{0.2055}{\left[1+ (0.1125 \times h)^{1.5034}\right] 0.3348}$
AB (23 - 48 cm)	$\varnothing = 0.7861 + \frac{0.2039}{\left[1+ (0.1169 \times h)^{1.5015}\right] 0.3340}$
Bw1 (48 - 88 cm)	$\varnothing = 0.2044 + \frac{0.1956}{\left[1+ (0.1166 \times h)^{1.4966}\right] 0.3318}$
Bw2 (>88 cm)	$\varnothing = 0.1724 + \frac{0.2276}{\left[1+ (0.0342 \times h)^{1.5457}\right] 0.3530}$

Figure 6.6.1 Water potential x soil humidity relation by soil horizon at Taquarana, Alagoas, 1994. The curve of horizon Ap is presented and the coefficients for the remaining horizons measured.

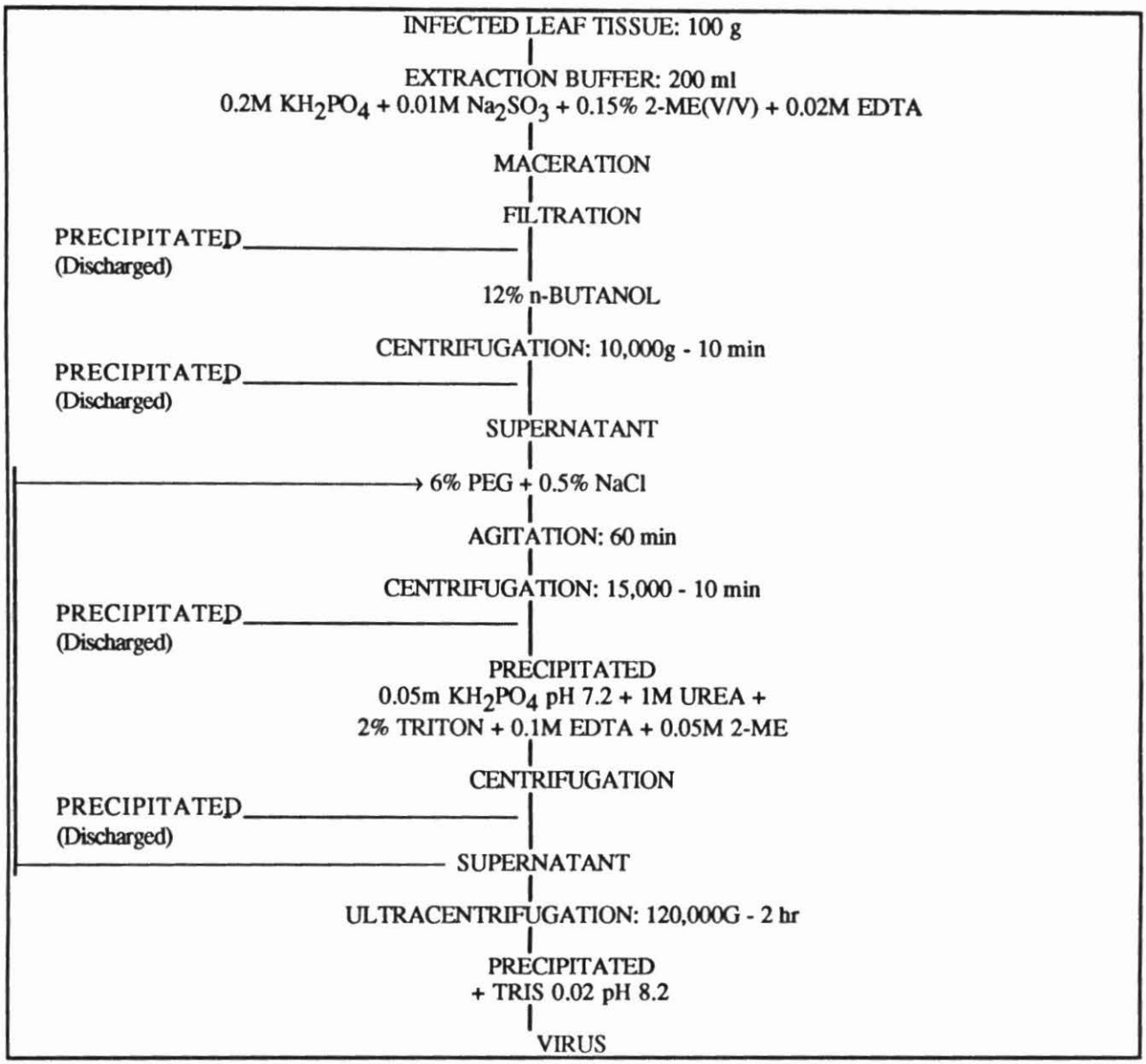


Figure 6.6.2. Purification sequence of cassava vein mosaic virus (CVMV) from infected leaves, Fortaleza, Ceará, 1994.

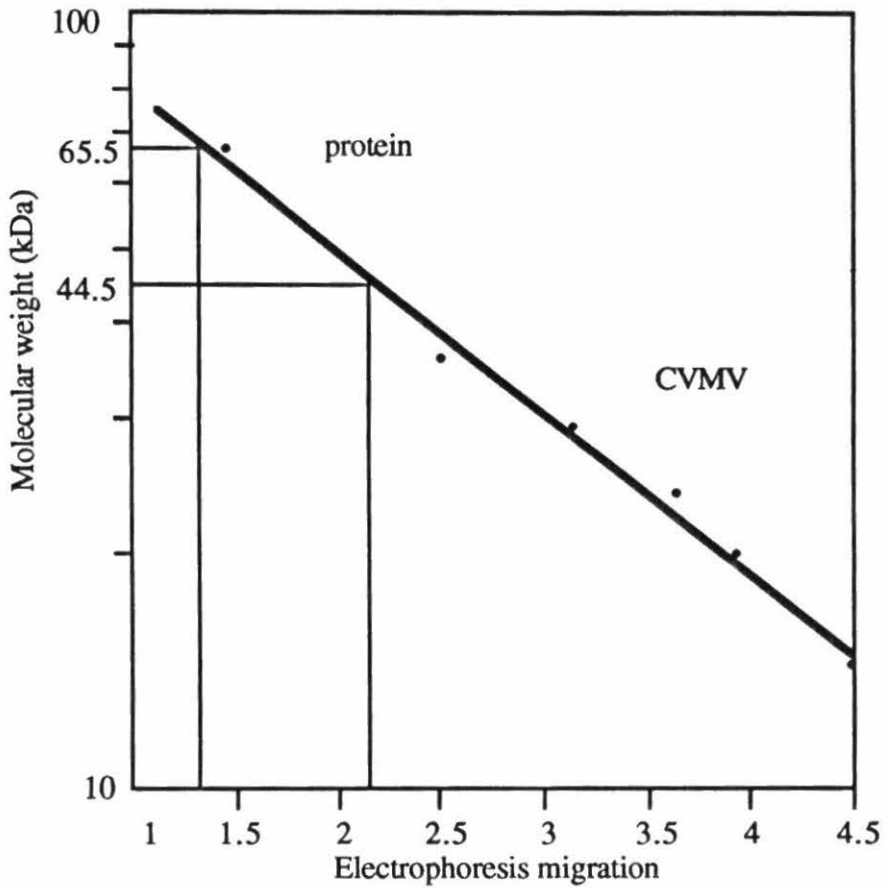


Figure 6.6.3 Polyacrilamide gel electrophoresis with sodium dodecyl sulfate, of a preparation from cassava plants infected with CVMV, Fortaleza, 1994

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LIST OF ACRONYMS

CIAT ..... Centro Internacional de Agricultura Tropical
CNPMA..... Centro Nacional de Pesquisa de Monitoramento e Avaliação de Impacto Ambiental
CNPMF..... Centro Nacional de Pesquisa de Mandioca e Fruticultura Tropical
CNPq..... Conselho Nacional de Desenvolvimento Científico e Tecnológico
CPATC..... Centro de Pesquisa Agropecuária dos Tabuleiros Costeiros
CPATSA..... Centro de Pesquiasa Agropecu[aria do Trópico Semi-Árido
EBDA ..... Empresa Baiana de Desenvolvineto Agrícola
EMATER-CE..... Empresa de Assistência Técnica e Extensão Rural do Ceará
EMATER-PB..... Empresa de Assistência Técnica e Extensão Rural da Paraiba
EMATER-PE..... Empresa de Assistência Técnica e Extensão Rural do Pernambuco
EMBRAPA ..... Empresa Brasileira de Pesquisa Agropecuária
EMDAGRO..... Empresa de Desenvolvimento Agropecuário de Sergipe
EMEPA ..... Empresa Estadual de Pesquisa Agropecuária de Paraíba S/A
EPACE..... Empresa de Pesquisa Agrpecuária do Ceará
ESCaPP..... Ecologically Sustainable Cassava Plant Protection
IFAD ..... International Fund for Agricultural Development
IICA..... Instituto Interamericano de Cooperacion para la Agricultura
IITA ..... International Institute of Tropical Agriculture
IPA ..... Empresa Pernambucana de Pesquisa Agropecuária
PROFISMA ..... Proteção Fitossanitária Sustentável da Mandioca na América Latina e África
UFAL ..... Universidad Federal de Alagoas
UFC..... Universidade Federal do Ceará

PUBLICATIONS

Bento, J. M. S.; Delalibera, I.; Moraes, G. J. de; Bellotti, A. C.; Lapointe, S. L. Distribuição da cochonilha da mandioca *Phenacoccus herreni* Cox & Williams (Homoptera:Pseudococcidae) no Nordeste do Brasil. Congresso Brasileiro de Mandioca, 8., Salvador-BA, 1994. Resumos, Salvador, SBM, 1994. p. 91.

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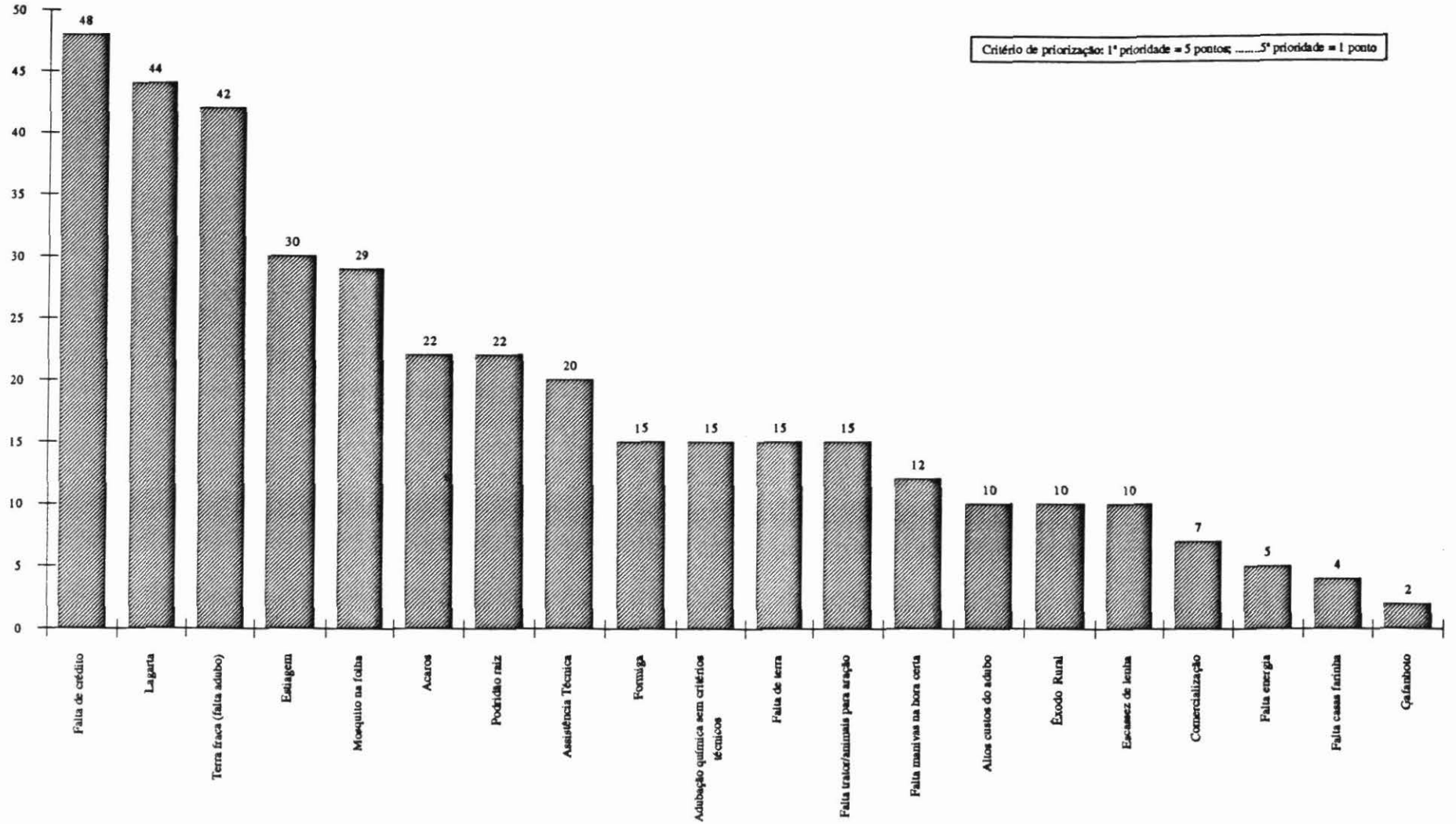
Noronha, A. C. S.; Moraes, G. J.; Ciociola, A. I. Biologia de *Amblyseius limonicus* Garman & McGregor s.l. em variedades de mandioca. Anais da Sociedade Entomológica do Brasil (in press).

Queiroz, G. M. de; Gonçalves, J. A.; Cavalcante, M. L. S. Uso de bagana de carnaúba com cobertura morta na cultura da mandioca. Congresso Brasileiro de Mandioca, 8., Salvador-BA, 1994. Resumos, Salvador, SBM, 1994. p. 38.

Priorização de Problemas através de Diagnósticos Participativos - Estado da Bahia (n = 25 comunidades; 472 produtores)



Fonte: Profisma/94

Diagnósticos Participativos no Estado da Bahia (n = 26 comunidades; 472 produtores)

Diagnósticos participativos PRIORIZAÇÃO DOS PROBLEMAS PELOS PRODUTORES ESTADO DA BAHIA																									Índice de Prioridade # comunidades x pontuação 1 prioridade = 5 pontos 2 prioridade = 4 pontos 3 prioridade = 3 pontos 4 prioridade = 2 pontos 5 prioridade = 1 ponto 6, 7 prioridade = *
Região	Itaberaba						Feira de Santana					Alagoinhas							Cruz das Almas							
Município	Piritiba	Mundo Novo	Piritiba	Itaberaba	Itaberaba	Piritiba	Anguera	São Gonçalo dos Campos	Irará	Conceição de Feira	Conceição de Feira	Apora	Crisópolis	Inhambupe	Sátiro Dias	Catú	Esplanada	Esplanada	Cruz das Almas	Cruz das Almas	São Felipe	Sapeaçu	São Miguel	Amargosa	Amargosa	
Comunidade	Caldeirão	Umbuzeiro	Sumaré	Guaribas	T. Branca	França	Umbuzeiro	Canto Escuro	Bento Simões	Candeal	11 mil Virgens	Chapada	Buriti	Roberto Santos	Arraial Santana	Varões	Campo Vigário	São José	Cadete	Poções	Gentepeo	Tapera	Barra	Palmeiras	Barbados	
# participantes homens	7	13	13	12	13	19	1	11	21	35	9	16	17	23	13	3	18	17	13	4	8	5	17	6	15	329
mulheres	5			5		4	12	7	3	32	22	4			21	5	1		2	3		2	7	1	7	143
Total	12	13	13	17	13	23	13	18	24	67	31	20	17	23	34	8	19	17	15	7	8	7	24	7	22	472
PRAGAS																										
Lagarta				5	3			4			3		1	4	2	1	2	1	1		4	4				44
Gafanhoto																					4					2
Mosquito na folha			2														3	3	1		4		1	1	4	20
Acaros								4			3	2	2		1	4						4				22
Formiga											3		3	3							4	4	5	5		16
DOENÇAS																										
Podridão raiz								4				1			4	2	4	4	1							22
OUTROS																										
Terra fraca (falta adubo)			4				2	4	3		4					3	1	2	2	2	2	1				42
Adub. química s/ critérios técnicos							3					3	4	2	3											16
Altos custos do adubo																						2		3	3	10
Estiagem	1		1	1	1	3													3						2	30
Falta de terra	5			4		5	4														1			2		16
Falta de crédito		1	3	3		1	1	1	4	2	1			1						4		3	2			48
Assistência Técnica	4	4			5	2		3	1														4		5	20
Falta manivas na hora certa	3			2						1																12
Falta trator/animais para aração	2	3			4	4					2															16
Êxodo Rural					2				5	4										3						10
Falta casas farinha								2																		4
Falta energia																									1	5
Comercialização									2	3																7
Escassez de lenha																				1	3			4		10

Fonte: Proflama/94

ANÁLISE DOS PROBLEMAS PRIORIZADOS PELOS PRODUTORES DURANTE OS DIAGNÓSTICOS PARTICIPATIVOS
ESTADO: BAHIA (25 comunidades e 462 produtores)

Problemas relacionados com doenças

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Necros na raiz • Plantio intensivo • Mono cultivo • Variedades Susceptíveis • Alta temperatura do solo • Má qualidade da semente • Solos fracos • Idade da planta • Ferimentos na raiz na capina • Período chuvoso • Presenca de verme no solo • Terra doente • Terra molhada	**Podridão da Raiz**	• Diminui produção • Maniva Fraca • Perda de folhas • Pouca produção de farinha • Seca a planta • Não produz farinha	• Rotação de culturas • Antecipar a colheita para 6 a 8 meses de idade • Mudar de semente • Mudar de local • Descanso na terra (pousío)	• Feijão e milho plantados no lugar deram bons • Aproveita uma parte da produção • A vezes funciona • Controla podridão • Alguns terrenos apodrecem novamente	• Mudar semente • Mudar área • Análise de solo • Mudar adubo • Rotação de culturas • Testar espaçamentos • Descansar a terra • Mudar forma de plantio	

Problemas relacionados com pragas

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Chuva após estiagem • Borboleta • Gafanhoto • Desaparecimento de pássaros • Desmatamento • Plantio intensivo • Alta temperatura	**Lagarta (Mandarová)**	• Prejuízo nos tratos culturais • Baixa produção • Semente não presta • Atraza a raiz • Prejudica o crescimento • Raiz cheia de água • Caída das folhas • Mata a planta	• Isca para urubú(matar animal) • Pulverização inseticida • Quebra olho da planta • Rezar • Cavar valetas • Cortar maniva perto do solo • Armadilha luminosa • Colocar cruz no plantio	• Urubú controla • Diminuição infestação (50%) • A vezes funciona • Rezar, pouco funciona • Valeta impede pouco • Produz brotes novos • A vezes funciona • A vezes funciona	• Aquisição inseticida • Veneno menos tóxico • Análise terra • Novas variedades	
• Chuvas • Estiagem • Uso de uma só variedade • Falta matéria orgânica nos solos • Tempo frio • Plantio intensivo • Altas temperaturas • Elevada umidade	**Mosca Branca**	• Raiz não cresce • Atrofia a planta • Maniva fica preta • Baixa produção • Queima folha • Maniva não presta • Folha escurece • Baixa produtividade • Apodrecimento de raiz • Alto custo de mão-de-obra • Problemas de saúde no trabalhador (alergias)	• Não tem solução • Variedades resistentes(Olho de Pomba, Jacaré, Perú, São José, Cidade Rica, Maria Pau) • Nada foi feito	• Com tempo desaparece • Ataque contínuo • Variedades tolerantes	• Controle biológico • Assistência Técnica intensiva • Controle químico • Variedades resistentes • Mudar adubos usados • Análise do terreno	
• Inverno frio e chuvoso • Idade da planta • Piolho no olho da planta • Frieza no solo • Estiagem prolongada	**Ácaros**	• Clorose nas plantas • Baixa produção • Atrofia e mata planta • Queima olho da planta • Semente não presta • Raiz com água • Atraza raiz	• Uso inseticidas • Deixar de usar essa semente • Queimar incenso no plantio • Quebra mandioca e joga fora • Corta maniva perto do solo • Limpeza da roça • Quebra olho da planta	• Melhora a semente • Diminui o ataque • Melhora condições da planta • Continua prejuízo	• Uso formicidas • Recursos p/ comprar produtos	
• Efeito climático • Venenos sem efeito • Falta recursos para combater • Resistencia das formigas aos venenos	**Formiga**	• Baixo rendimento • Retarda o crescimento • Raiz com água • Semente não presta	• Uso formicida pó • Uso formicida grão • Acmirex + farinha + casca laranja • Folidol+água • Fogo	• No começo o pó funciona • Grãos funcionam • Produtos são caros • Controla parcialmente • Funciona	• Usar formicidas mais eficientes	

Problemas relacionados com sistema de produção (solos, variedades,mecanizacão)

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Falta de manejo adequado (rotação de culturas, pousio) • Características próprias do solo • Ausencia de mecanização • Exploração intensiva do solo • Altos preços dos adubos • Solos arenosos • Falta de interesse • Adubação errada	**Terras Fracas (Falta de Adubo)**	• Baixa produtividade • Altos custos de produção • Apodrece a raiz • Planta não desenvolve • Esgotamento do solo	• Uso de adubo orgânico • Adubo dentro da cova • Adubo na cova e espalhado • Queima a terra • Usa cinzas de carvão	• Aumenta rendimentos • Bons resultados • Adubo espalhado é melhor	• Redistribuição de terras (reforma agrária) • Manejo adequado do solo • Assistência técnica sistemática • Adubação • Mecanização • Práticas conservacionistas (pousío) • Análise dos solos para fazer adubação correta • Subsidiar preços dos adubos • Instalar laboratorio regional de análise de solos • Baixar taxas de juros • Asociação fornecer insumos e produtor pagar com produto	
• Muito desmatamento • Desequilíbrio ecológico • Queimadas frequentes • Ausência de mananciais hídricos • Vontade divina	**Estiagem**	• Baixa produção • Redução da área plantada • Falta maniva p/ plantio • Falta ingressos (fome) • Desemprego • Pobreza • Degeneração das pastagens Desnutrição e morte dos animais	• Forma de plantio • Posição da maniva no solo • Uso de fileiras duplas • Plantio de cultivos de sequeiro (palma, sisal, algaroba) • Pedidos oficiais as autoridades para construção de açudes, barragens	• negativo • negativo • maior produção de mandioca • menor número de capinas • negativo	• Reflorestamento • Construção de açudes e barragens • Instalar sistemas de irrigação • Instalar campos demonstrativos com cultivares adaptados • Manter os frentes de serviços	• Testar variedades mais precoces de mandioca • Conhecer variedades resistentes a seca adaptadas a região

Problemas relacionados com sistema de produção (solos, variedades,mecanizacão) - continuação

• Falta financiamento bancário • Falta política agrícola adequada • Falta assistencia técnica sistematizada • Altos custos de arrendamento de equipamentos	**Falta de trator e animais para preparo da terra**	• Redução da área plantada • Baixa produção • Fome • Êxodo rural • Desemprego • Aumento preços • Baixa produtividade • Custos produção maiores • Atrazo nos tratos culturais e operações do cultivo Baixa retenção de umidade	• Alugel de equipamentos (arado e grade de discos) • uso tração animal	• melhor desenvolvimento cultivo • maior produtividade • menor número de capinas • Inviávelalugar dado o custo • nenhum resultado	• Compra comunitária de máquinas agrícolas • Uso de máquinas existentes nas prefeituras • linha de crédito especial para compra de trator e tração animal
• Estiagem • Colheita anticipada	**Falta de manivas na hora certa**	• Baixa produção • Redução da área plantada • Poucas variedades disponíveis	• Plantio de manivas na margem do riacho		• Aquisição de manivas em outras regiões • Reservar área para produção de maniva-semente

Outros problemas

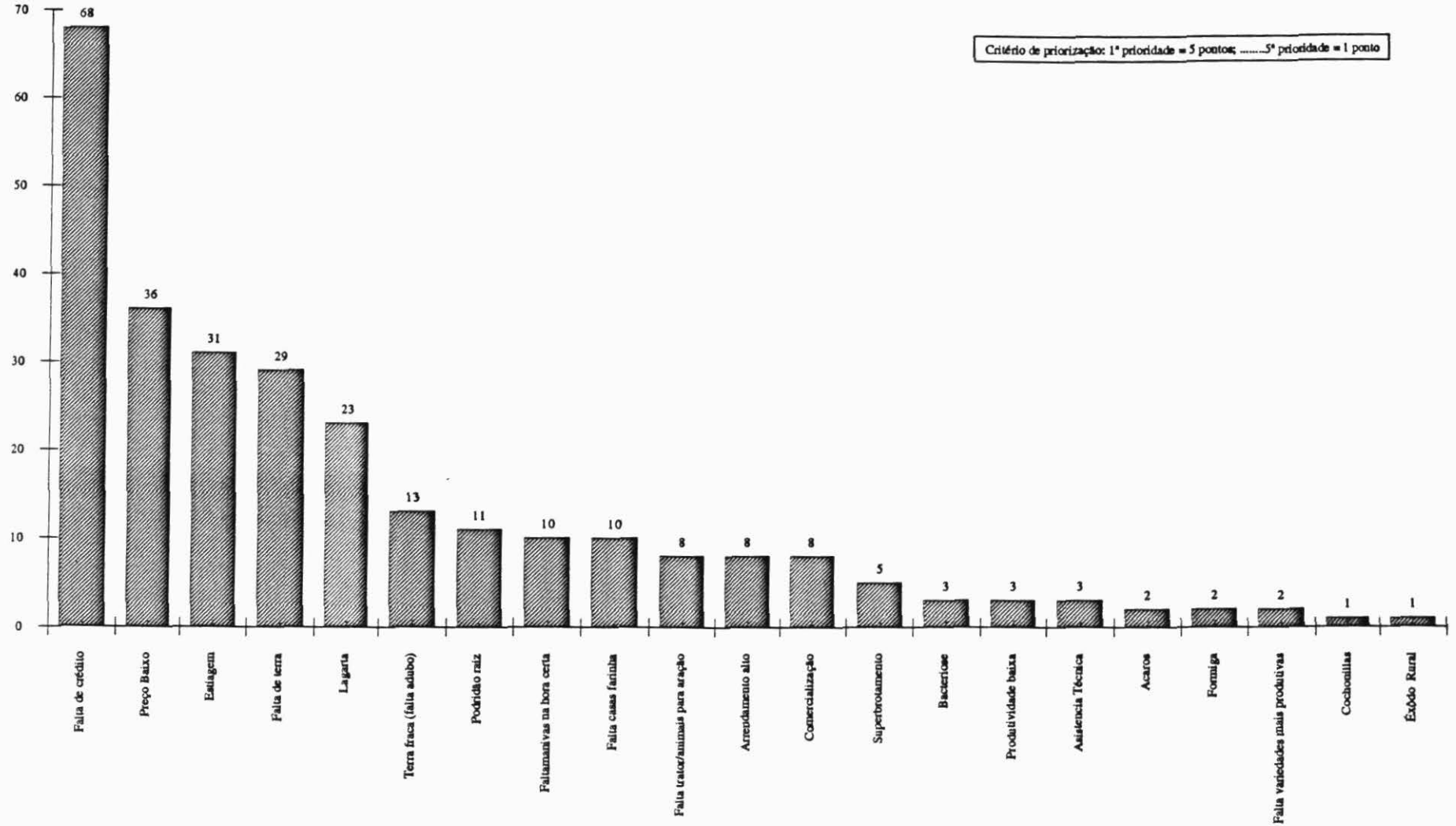
CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Falta política agrícola adequada • Falta de empenho dos produtores	**Falta assistência técnica**	• Redução da produção • Baixa produtividade			• Presença sistemática de um técnico na comunidade • Instalação de campos demonstrativos com técnicas mas adequadas ao cultrivo de mndioca	
• Altas taxas de juros • Falta de apoio governamental • Falta de crédito na hora adequada • Fiscalização ineficiente • Exigência de avalistas	**Falta de crédito**	• Atraso no plantio • Êxodo rural • Redução da área plantada • Desemprego • Falta de atenção nas etapas do cultivo • Fome • Descapitalização do produtor			• Redução de taxas de juros • Dispensa de avalistas • Linhas de crédito específicas para cada produtor • Estabelecer sistema de crédito equivalencia-produto"	
• Falta de emprego • Estiagem • Falta de terra • Diminuição da produção	**Êxodo Rural**					
• Latifundio	**Falta de Terra**	• Êxodo Rural	• Arrendamento	• Negativos (renda produzida não cobre a despesa)	• Reforma AGrária	
• Falta preços justos	**Comercialização**	• Descapitalização do produtor • Pobreza • Fome Baixa Produção			• Criar cooperativas	

Diagnósticos Participativos no Estado do Ceará (n = 20 comunidades; 549 produtores)

Diagnósticos participativos PRIORIZAÇÃO DOS PROBLEMAS PELOS PRODUTORES ESTADO DE CEARA																					Indice de Prioridade # comunidades x pontoação 1 prioridade = 5 pontos 2 prioridade = 4 pontos 3 prioridade = 3 pontos 4 prioridade = 2 pontos 5 prioridade = 1 ponto 6, 7 prioridade = *
Região	Acaraú							Itapipoca						Iblapaba				Sertão do Araripe			
Município	Acaraú	Acaraú	Acaraú	Acaraú	Acaraú	Bela Cruz	Acaraú	Cruz	Cruz	Itapipoca	Tururú	Tururú	Marco	Ubajara	Tianguá	Ubajara	Tianguá	Santana do Cariri	Santana do Cariri	Santana do Cariri	
Comunidade	Mucuna	Lagoa Grande	Imácega	Vila Moura	Capão	Lagoa do Mato	Caueseú	Cajueirinho	Solidão	Macaco	Lagoa do Inácio	Carnaúba	São Pedro	Tucúns	Valparaíso	Nova Veneza	Bom Jesús	Serra da Canafistula	Serra do Cruzeiro	Serra do São Gonçalo	
# participantes homens	21	20	28	27	30	15	53	15	39	18	29	41	16	11	25	22	15	15	14	10	464
mulheres	9			2	15	1	28			5	2	5	6	3	3		5	1			85
Total	30	20	28	29	45	16	81	15	39	23	31	46	22	14	28	22	20	16	14	10	549
PRAGAS																					
Lagarta	5	4	2	1	*	*		4	3	3	4	5	*								23
Gafanhoto				*						*											
Mosquito na folha						*									*						
Ácaros								5	5					*							2
Cochonillas				5	*																1
Formiga		*		*	*				4	*		*									2
DOENÇAS																					
Podridão raiz	4	5		4	*	*				5	5	*	3	5		*					11
Superbrotamento														3	*	4					5
Bacteriose			3																		3
OUTROS																					
Terra fraca (falta adubo)		3	5	*	1	2				*		*	*	*		*					13
Falta conservação solos																					
Preço Baixo						1		1	1	2	3	4	*	*		*	5	3	2	2	36
Estiagem					*					*		1		1	1	5	3	2	3	1	31
Produtividade baixa																				3	3
Falta de terra	2	*		3	3	3					1	3	2				2				29
Falta de crédito	1	1	1	2	4	5		2	2	1	2	2	1	4	2	1	1	4	4		68
Assistência Técnica													5							4	3
Falta variedades mais produtivas										4		*									2
Falta manivas na hora certa					*	*						*	4	2	5	3					10
Falta trator/animais para aração					2					*						2					8
Êxodo Rural					5							*				*	*				1
Falta casas farinha						*												1	1		10
Arrendamento alto	3		4	*		*		3				*									8
Comercialização		2				4							*		4						8

Fonte: Profisma/94

Priorização de Problemas através de Diagnósticos Participativos - Estado do Ceará (n = 20 comunidades; 549 produtores)



Fonte: Profisma/94

ANÁLISE DOS PROBLEMAS PRIORIZADOS PELOS PRODUTORES DURANTE OS DIAGNÓSTICOS PARTICIPATIVOS
ESTADO: CEARÁ (20 comunidades e 549 produtores)

Problemas relacionados com doenças

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Que vem do chão (solo infestado) • Terreno brejado (mal drenado) • Colheita fora de época • Orelha de Pau(fungo superior) • Maniva doente • Terrenos onde tem a presencá da planta "cipó seco" • Muita chuva • Colheita tardia • Seca		• Diminui o rendimento • Seca o olho • Amerela a folha • Seca o tronco • Não se aproveita a raiz • Prejuízo financeiro	• Colher as raízes antes do tempo (mais cedo) • Amontoar terra junto a planta • Pousio da área por dois anos • Troca de variedades • Plantio em outras áreas • Reza • Plantío em terras arenosas	• Diminui a produção de raiz (cauza prejuízo) • Resultado negativo • Adoeceu novamente • Sem resultados • As vezes funciona • Sem resultados • Diminuição da podridão de raízes	• Tratamento do solo ou plantio em áreas não infestadas pelos patógenos • Adubar a terra • Plantar variedades resistentes • Não plantar onde tem orelha de pau (fungo superior) • Selecionar o terreno antes do plantío • Rotação de culturas • Assisténcia técnica efetiva para decobrir o que está ocorrendo • Tratamento das manivas • Apoio da pesquisa	
• Fraqueza do solo • Fungo		• Semente não presta • Diminui a produção	• Arrancar a roça	• Prejuízo		
• Plantio em terras fracas • Falta de pesquisa • Inverno fraco(Estiagem) • Uso de manivas com baixas reservas e doentes • Altas temperaturas • Falta de assistencia técnica		• Redução da produção(70%) • Falta farinha para alimentação • Aumento nos preços da farinha • Redução da oferta de sementes • Raiz não desenvolve • Baixa qualidade da farinha	• Erradicação plantas doentes • Queima plantas doentes • Retiradas dos galhos doentes • Teste de variedades resistentes(EMBRAPA /EMATERCE/Produtores) • Plantio de manivas sadias • Desinfecção do fação	• Positivo • Positivo • Positivo • Em andamento • Ruim • Positivo	• Cobrar apoio da pesquisa • Tratamento de manivas • Seleção e plantío de manivas sadías • Buscar apoio do Governo • Queimar plantas doentes • Fazer calagem	

Problemas relacionados com pragas

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Falta de chuva (veranicos) • Produtor não está prevenido para o ataque (não tem inseticida) • Falta de pulverização • Estiagem • Tempo • Falta de assisténcia técnica • Aparecimento da borboleta • Umidade alta e calor		• Diminui produção (rendimento) • Maniva não presta para plantar • Come as folhas e diminui 50% do rendimento • Mandioca não cresce • Farinha de baixa qualidade • Prejudica produção raiz • Prejudica a maniva	• Aplicaram veneno (específico) • • Cavou uma vala no chão em volta do plantio (início da infestação) • Reza • Poda drástica dos ramos • Pulverizaram folidol e azodrim • Querozene com água e sabão • Cata manval • Ainda sem solução	• Matou na hora (controlou a praga) • Pulverizou a tempo e solucionou • Resultado regular (diminuiu a infestação) • A reza matou a praga (crença popular) • Aumenta a produção • Acaba com a praga • Matou as lagartas • Controle total • Problema novo	• Pulverização com inseticidas específicos • Reunir em campo para comprar inseticidas • Mais assistência técnica • Adiquirir pulverizadores e inseticidas • Combatir a praga na hora certa • Meios de controle mais econômicos • Crédito rural subsidiado para combater a praga	
• Falta de recursos		• Redução da produção	• Nada foi testado		• Crédito rural subsidiado	
• Falta de recursos		• Redução da produção	• Aplicação de formicidas	• Controla a praga		
• Variação da temperatura		• Baixa produção	• Aplicação de inseticidas	• Bom controle	• Pulverização das plantas atacadas	

Problemas relacionados com sistema de produção (solos, variedades,mecanizacão)

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Plantio intensivo • Queimadas • Falta de adubação • Desmatamento • Altos preços dos adubos • Solos esgotados		• Baixa produção • Plantas não desenvolvem • Maniva não germina • Renda baixa • Desestímulo ao plantio	• Adubação orgânica • Uso de bagana de carnaúba • Uso de adubo de minhocas	• Aumento da produção • Melhorou lucro • Triplicou produção	• Compra de adubos na própria comunidade • Financiamento para compra de adubos	
• Período de seca • Clima do Nordeste (semi-árido) • Desmatamento • Falta de mananciais		• Plantio não produz (produtividade reduzida) • Trabalho perdido (safra frustada) • Falta ração p/ os animais (restos de culturas) • Fome • Flta de manivas • Empobrecimento • Poucas opções de trabalho • Colheita mais trabalhosa • Aumentam ataques de pragas (acaros) e doenças (Superbrotamento e podridão) • Dificuldade de trabalho de beneficiamento de farinha e goma • Êxodo rural • Produto de qualidade ruim	• Aguar com um balde (irrigação manual) • Construção de poços • Dedicar a atividades extrativistas • Trabalhar alugado • Plantio de cajueiro (resistente a seca) • Plantio em áreas úmidas • Atraso colheita para não perder a semente • Construção de barreiros e cisternas	• Ficou verde e vigorosaa (as plantas desenvolveram com água) • Resultados positivos • Positivo • Aumenta renda familiar • Positivo • Bom resultado(Preserva maniva para próximo plantio) • Bom resultado • Ajuda no verão se abastecido com carros pipa	• Irrigação • Barrar o rio Mundaú (fazer uma barragem) • Aumenta r área de produção • Canalização da agua Jaburú • Lutar por crédito para compra e armazenamento de zafra • Lutar por financiamento para compra de equipamentos de irrigação	

Problemas relacionados com sistema de produção (solos, variedades,mecanizacão) - continuação

• Falta de recursos • Desorganização dos produtores • Baixa produção • Cultivo pequenas áreas	• Aumento de mão-de-obra • Baixa produção	• Aluguel de implementos	• Melhor desenvolvimento das plantas	• Recursos para aquisição e aluguel • Cobrança de projeto junto a Secretaria de Agricultura
• Colheita antes de tempo • Estiagem • Doenças e pragas • Uso de manivas não seleccionadas • Antecipação da colheita • Escasez de recurssos financeiros • Desinteresse pelo armazenamento	• Fica sem plantar • Preço da maniva semente muito alto • Redução do plantío • Baixa produtividade • Não ha produção • Aumenta fome • Aumenta sujeição do produtor junto ao patrão • Lavoura s mais susceptíveis a pragas e doenças	• Pedir maniva semente a quem tem • Roubar de outros campos • Cortar manivas novas • Testou variedades para saber qual é melhor • Distribuição de manivas pelo Governo Estadual-1991-92 (c.v. Bujá Preta e Cruvela) • Compra pela comunidade de 40m^3 de manivas • Armazenamento de maniva debaixo de uma árvore • Instalação de bancos de manivas	• Plantio desuniforme • Maniva sem prévia seleção • Melhora boa na produção Aumento area cultivada • Ruim (devido a seca) • Bom (plantío de pequena área coletiva) • Bom (Aproveitamento de 80% da maniva) • Bom (garante semente para próximo plantío)	• Armazenar maniva para o próximo plantio • Mais informações técnicas sobrte variedades • Seleção de manivas boas para o plantio • Deixar uma parte da roça para arrancar na hora de plantar • Ampliar roçado comunitário • Ampliar área com apoio financeiro • Distribuição de semente pelo governo • Arrendar áreas úmidas na região para plantío de mandioca • Implantação de campos de multiplicação de manivas

Outros problemas

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Falta de interesse do governo • Frequente transferência dos técnicos		• Desinformação dos agricultores para combater as pragas e doenças • Falta de apoio na comercialização	• Abaixos assinados reclamando as diretorias da EMATERCE • Construção de casa de farinha comunitária	• Nenhum resultado até o momento • Positivos	• Exigir do Governo • Treinamento dos produtores rurais visando suprir as necessidades de técnicos da EMATERCE	
• Depois da correção alta (correção plena) • Pequeno não tem condições de pagar (falta garantias) • Não tem terra • Juros que niguém aguenta (juros altos) • Governo não libera financiamento para agricultor • Política agrícola indefinida • Desvalorização do produto • Falta de melhor conciência do produtor pela ação comunitaria • Estiagem • Falta de manivas		• Trabalha sozinho porque não pode pagar trabalhador • Não compra sementes (maniva) • Não pode aumentar plantio (área reduzida) • Aumenta a pobreza do produtor (descapitalização) • Não tem acesso a nada • Falta recurso para trabalhar • Passa fome • Trabalha para outros • Produz pouco • Não dá para comercializar • Não mata lagarta e formigas • Venda antecipada da produção ao atracessador	• Trabalhou com o banco, quando os juros baixos • Crédito através da associação (associação repassando os recursos) Trabalhar (produtores) com recursos próprios • Mutirão; roçado comunitário • Projeto para aquisição de sementes • Projeto pelo FNE para criação de cooperativa • Venda antecipada da produção • Instalação de fábrica de raspas de mandioca • Instalação de bodega comunitária	• Bons resultados (tinham produção e tinham o que render) • Tiveram resultados (lucros) • Baixa produção (não produziram bem, tiveram que vender tudo e tomou dinheiro emprestado para pagar as despesas) • Redução das despessas • Não se obteve resultados até o momento • Em fase de implantação Lucro reduzido • Faltou matéria prima • Está funcionando	• Financiamentos com os juros baixos direcionados ao pequeno produtor • Volatr a financiar pelo Banco do Brasil • Créditos pelo sistema "equivalência-produto" • Financiamento p[illegible] armazenar a pro[illegible]ção • União do grupo para conseguir financiamento • Registro de associação para fortalecer e pleitear condições de reinvindicar • Trabalhar em mutirão • Pressionar recursos junto ao Governo Estadual • Maior organização • Apoiar a cooperativa local • Aumentar área plantada • Reivindicar projetos de irrigação • Lutar por política agrícola definida	

Outros problemas (continuação)

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Concentração de terra nas grandes propriedades • Ricos não dão terra para o trabalhador • Pequeno tem pouca terra • Plantio de cajú (monocultura) • Região de pequena propriedade • Terras fracas e ocupadas • Arrendamentos caros • Falta dinheiro para comprar terra		• Fica devendo ao patrão • O pobre não tem onde trabalhar (não pode produzir) • Se retirada do lugar a procura de outras atividades • Falta de condições de trabalho • Não tem produção • Passa fome • Trabalhar de aluguel • Arrendamento muito caro • Empobrecimento • Redução da área plantada • Saúde precaria • Prejuízo na educação, lazer e moradia Exploração intensiva de pequenas áreas	• Plantaram na mesma terra (áreas pequenas e esgotadas) • Arrendaram terras (dos grandes e médios proprietários) Procurar outro meio de vida (trabalhar fora do campo) • Trabalhar com arrendamentos altos) • Solicitação a paroquia de uma área de 10 ha	• Deu resultado no início, hoje não dá (aluguel alto) • Não compensa se a terra não for fértil). Aumentam as despesas • Diminui a produção • Abandono da terra (êxodo rural) • Doação de área de 10 ha através da paroquia	• Reforma agrária • Financiamento para comprar terras • Financiamento para comprar adubos para aumentar a produtividade • Arrendamento de terras sem exploração • Compra de área comunitária para trabalhar • Melhor aproveitamento das terras da comunidade • Cuidar melhor das próprias terras	
• Todo mundo tem o produto (exceto de oferta) • Falta dinheiro para as necessidades familiares • Ausência de preço mínimo • Falta de uma cooperativa • Muita farinha no mercado • Não dá para pagar • Falta financiamento para armazenar a produção • Não pode guardar quando produz muito (falta de armazéns) • Descapitalização do produtor Ação dos intermediários		• Compra caro (entre safra) • Vende a o atravessador • Perde a produção porque não pode colher • Faz farinha de meia • Vende barato para cobrir despesas • Atravessador compra do jeito que quer • Pior condição de vida • Passar fome • Quando faz farinha já está devendo • Falta dinheiro para pagar o trabalhador • Levar para feira e não vender ao atravessador Pedir dinheiro emprestado	• Armazenou para vender mais tarde • Fez financiamento em banco para pagar as despesas e guardou (armazenou) a produção • Construiram campo de raspas de mandioca • Organização de cooperativa • Vender em outro município • Fazer raspas de mandioca • Criação de suínos para consumo de mandioca	• Vendeu a produção mais tarde por preço bom • Lucro melhor • Ainda não funcionou • Em fase de organização • Lucro mínimo • Melhorou lucro • Positivo; alternativa de renda	• Voltar o financiamento para guardar a produção e vender quando o preço melhorar na entre-safra • Garantia do preço mínimo • Industrializar (produzir raspa) • Organizar cooperativas	

Outros problemas (continuação)

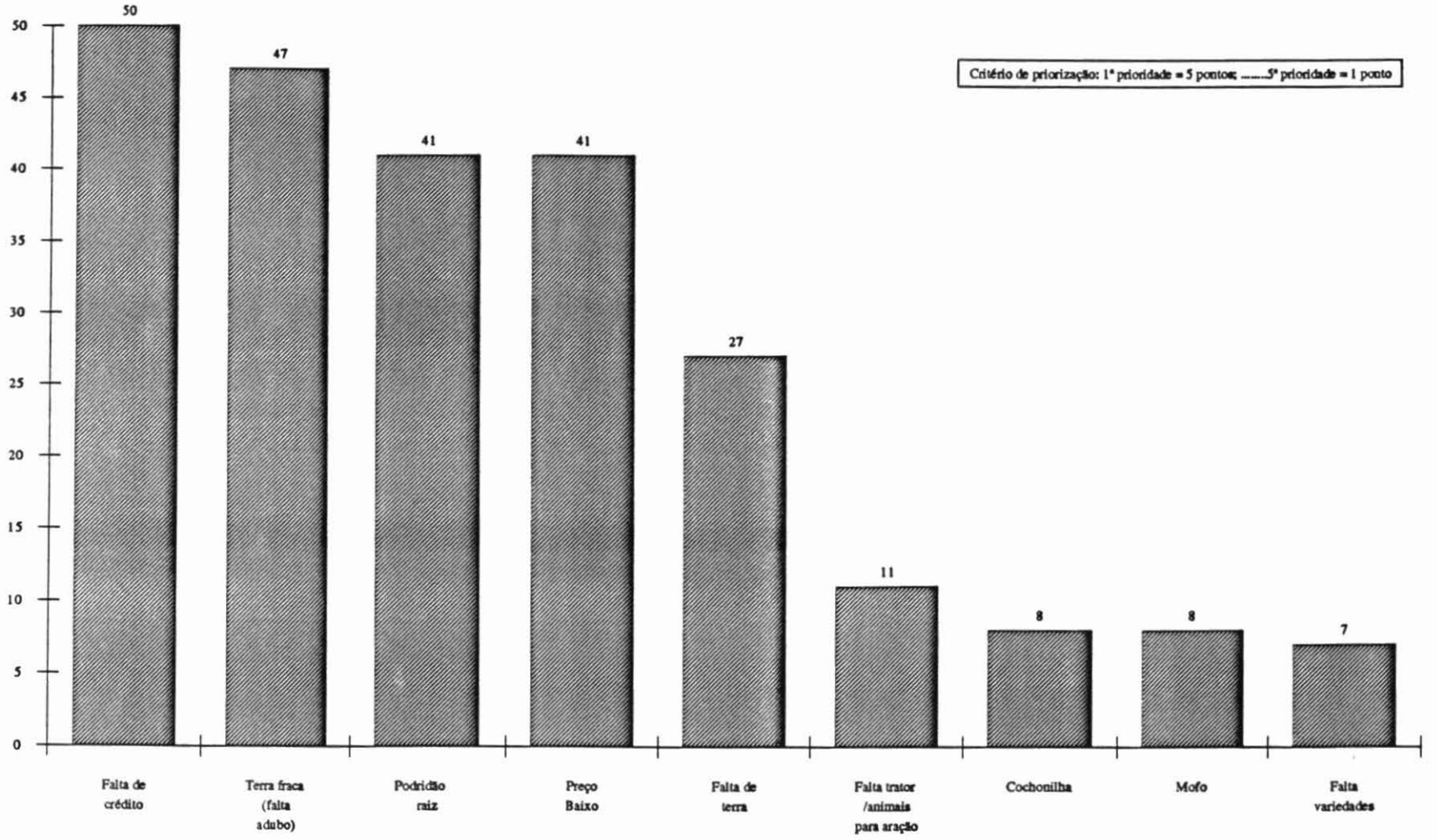
• Falta de transporte • Farinha é alimento desprestigiado	• Sofre necessidade e não vender o produto • Lucros mínimos • Desânimo para produzir mais • Produto é vendido barato para comprar outros artigos caros			
• Mão de obra cara • Custo de vida alto	• Redução no lucro • Redução no trabalho	• Uso de mão de obra familiar • Trabalho no mutirão	• Reduz os custos de produção • Plantio exitoso	• Melhorar preço do produto • Reduzir a ação dos intermediários • Incentivo ao mutirão
• Custo elevado	• Perdem dinheiro • Vendem o produto fora da época • Vendem a raíz • Faltam farinha e goma • Pago renda muito alto (6:1) • Vendem o produto fora da época	• Solicitaram casa de farinha dos políticos	• Aguardam resultados	

Diagnósticos Participativos no Estado da Pernambuco (n = 19 comunidades; 377 produtores)

Diagnósticos participativos PRIORIZAÇÃO DOS PROBLEMAS PELOS PRODUTORES ESTADO DE PERNAMBUCO																			Indice de Prioridade # comunidades x pontuação 1 prioridade = 5 pontos 2 prioridade = 4 pontos 3 prioridade = 3 pontos 4 prioridade = 2 pontos 5 prioridade = 1 ponto 6, 7 prioridade = *
Região	**Agreste Meridional**								**Mata Sul**				**Sertão do Araripe**			**Mata Norte**			
Município	Lajedo	Caetés	Caetés	São João	Jupi	São Bento do Una	Cupira	Paranatama	Pombos	Belo Jardim	Glória de Goitá	Vitoria de Santo Antão	Araripina	Ouricuri	Ipubi	Condado	João Alfredo	Sítio Agostinho	Sítio Baroncos
Comunidade	Pau Ferro	Queimada Grande	Barriguda	Tiririca	Mulungú	Tatu	Riacho do Veríssimo	Ihodaguina	Pé de Serra	Batinga	Gameleira	Campina Nova	Serra da Boa Vista	Lagoa Comprida	Serrolandia	Engenho Patrimônio	Sítio Camará	São Agostinho	Sítio Baroncos
# participantes homens	16	23	14	6	10	14	13	9	10	14	16	13	7	24	38	21	13	23	19
mulheres	4		2	4	10	4	2	1	1	5	6	2	2	9	3		7	10	2
Total	20	23	16	10	20	18	15	10	11	19	22	15	9	33	41	21	20	33	21
PRAGAS																			
Lagarta	*		*					*		*	*	*	*	4	*	5			
Gafanhoto											*								
Cupim												5							
Mosquito na folha																		4	*
Formiga		4						5		*	*	*			*				
Cochonilha									2			2							
DOENÇAS																			
Podridão da raiz				4			4		1	4	1	1			*	1	1	1	1
Mofo											*	*					2		2
Macheio												3							
Bacteriose		3																	
OUTROS																			
Terra fraca (falta adubo)	4	1	1	1	2	1		1	3	1	*	4	3			4			5
Falta conservação solos																			*
Preço Baixo	3	*	*	2	3	3		4	*	3	4		2	3	3	2	4	3	4
Estiagem	5		*		*				4				4		*			*	
Produtividade baixa	6																		
Falta de terra	2		4	3	1	4	1	3	*	*					4			5	
Falta de crédito	1	2	2				2	2		*	2		1	1	1		3	2	3
Falta transporte		*			*														
Falta equipamentos			3										*						
Falta defensivos			*																
Asistencia Técnica			*																
Falta variedades			*				3						*	2				*	*
Falta organização produtores					4														
Falta trator/animais para aração						2				2	3				*				
Êxodo Rural										5		*			*				
Falta casas farinha															2				
Arrendamento alto																4	4		
Comercialização																*			

Fonte: Profisma/94

Priorização de Problemas através de Diagnósticos Participativos - Estado de Pernambuco (n = 19 comunidades; 377 produtores)



Fonte: Profisma/94

ANÁLISE DOS PROBLEMAS PRIORIZADOS PELOS PRODUTORES DURANTE OS DIAGNÓSTICOS PARTICIPATIVOS ESTADO: PERNAMBUCO (19 comunidades e 377 produtores)

Problemas relacionados com doenças

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Terra muito quente • Muita chuva • Microbio existente na terra • Terra muito instrumada • Terra fraca • Maniva doente • Causa desconhecida • Plantio sucessivo na mesma área • Tapuru no tronco (?) • Mofo branco (?0		• Perda da roça • Falta de maniva • Prejuízo econômico • Diminuição da área plantada • Amarelamento da planta • Raíz apodrece • Não podem mais plantar na mesma área • Aumenta o replantío • Morte da planta	• Trocar variedade • Parou de plantar mandioca e plantou outro cultivo(feijão, milho, batata) • Rotação da cultura com Cana e Inhame • Eliminação e queima dos restos culturais das plantas afetadas • Descansar a terra • Colocou cinza e cal • Colocou enxofre • Não plantou maniva doente • Uso de novas variedades • Colocar cinza da casa de farinha • Plantar em terreno de barro ligado • Uso de adubo quimico e calcario • Aração e gradagem	• Foi pior • Foi melhor; plantou milho e teve lucro • Diminui ataque • Positivo (não apareceu a doença) • Aumento da produção • Não deu resultado • Não deu resultado • Nãi deu resultado • Melhorou 80% • Positivo (adoeceu menos) • Positivo (adoeceu menos) • Negativo (adoeceu) • Negativo (doença atacou)	• Mudar a lavoura • Preparar a terra com calcario, arar, usar adubo e veneno • Presença de entidades para ajudar a resolver o problema • Usar manivas sadias • Arrancar e quemar as plantas doentes • Descansar a terra • Identificar um remedio químico ou veneno para acabar com a doença • Conseguir areas maiores para facilitar a rotação da cultura	
• Causa desconhecida		• Menos produção	• Uso de defensivos	• Dimunui ataque	• Governo liberar defensivos	
• Micróbio que ataca a planta criando um mofo entre a raíz e o caule da planta		• A planta morre • Não produz • Prejuízo • A planta mucha de baixo para cima e morre • Redução na área plantada	• Plantou maniva com miolo branco • Tratamento das manivas com querozene e agua • Uso de estrume de gado	• A doença foi controlada • A doença aumentou • A doença aumentou		

Problemas relacionados com pragas

• Microbio da terra • Uso de manivas doentes	• Perda da maniva • Baixo rendimento • Perde a cor • Diminuição da área plantada	• Uso de formicida • Qebrou o olho da mandioca • Rotação da lavoura	• Deu bom resultado • Não deu resultado • Diminuição do microbio	• Usar veneno • Rotação da lavoura
• Falta de veneno • Problema da terra • Falta dinheiro para comprar venenos	• Baixa produção • Maniva não presta	• Nenhuma	• Nenhum	• Uso de venenos
• Maniva não presta • Inverno fraco • Micróbio da terra • Ninguem sabe a causa aparece por épocas	• Maniva não serve para nada • A raíz não engrossa	• Não têm jeito • Parar de plantar	• Não têm resultados	• Mudar a lavoura
• Devido ao tempo • Inverno fraco • Epoca fría e chuvosa	• Amarelecimento das folhas • Perdas no rendimento • Maniva não serve para plantío • Atraza o crecimento • Suga a sevia da planta	• Aplicação de veneno •	• Resultado positivo; matou o mosquito e não houve reinfestação	• EMATER-PE indicar solução através de seus técnicos
• Mudanças no clima • terra fraca • Falta de dinheiro para combater • Pouco inverno	• Roça com menos de 90 dias acaba • Roça com mais de 90 dias só produz 40% do total • Prejuízo econômico • Miséria • Fome	• Aplicação de veneno • Catação manual (386 lagartas em 1.936 m^2) • Usar maniçpba com fumo • Usar sabão em pó • Usar agua sanitária • Usar alcool com fumo e sabão • Folisuper	• Resultado positivo; matou o mosquito e não houve reinfestação • Controle da praga • Em parte combate • Em parte combate • Em parte combate • Em parte combate • Em parte combate	• EMATER-PE indicar solução através de seus técnicos • usar defensívos

Problemas relacionados com sistema de produção (solos, variedades,mecanizacão, etc)

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Não tem recursos financeiros para comprar adubos • Exploração intensiva das mesmas terras • Erosão • Falta de adubo orgânico • Preços altos dos adubos • Falta de terra • Falta de assistência técnica		• Pouca produção • Raízes sem peso • Plantas fracas • Fome • Exodo rural	• Aplicar adubo nas terras mais fracas • Uso de esterme de curral • Descanso do solo por um ano • Uso de sulfato de amonio • Comprou para pagar com a safra • Algumas áreas foram adubadas com projeto do Governo	• Boas lavouras nas terras adubadas • Melhorou a produção 70% • Maior produção • Maior produção • Foi positivo até que apareceu a indexação e a inflação alta. • Foi bom mais não teve condição de continuar por falta de dinheiro	• Financiamento com juros baixos • Financiamento pelo governo com pagamento em produto(equivalencia produto) • Deixar descansar a terra • Arrendar outras terras para deixar descansar as próprias	
• Falta de recursos financeiros • Trâmites burocráticos • Seca de 1993 (faltou pasto para os animais e foram vendidos) • Preço alto do aluguel • Falta de tratores no municipio		• Deixa de plantar • Menor produção • Plantar com a enxada • Demora mais tempo para plantar • A terra fica mais dura	• Plantio mais tarde • Plantio sem aração e gradagem • Usar tração animal • Usar a enxada	• Produziu menos • maior mão de obra e menor produção • A lavoura deu melhor • Com enxada foi mais cansativo porem não precisou esperar pelo trator e não gastou dinheiro	• Financiamento com juros baixos para compra de trator e animais • Que existissem pelo menos 1 ou 2 tratores em cada comunidade para atender aos agricultores • A comunidade organizar uma especie de cooperativa para os agricultores pagarem as horas-máquina na época da colheita com produto ou com dinheiro	
• Não guardam sementes de um ano para outro • Pouca área para plantar como reserva • Muita distancia das áreas onde existe disponibilidade de sementes • Falta de transporte • Seca		• Planta pouco • Planta fora da época • Baixa produção • Baixo lucro • Fome • Diminuição da área	• Guardar maniva • Usar manivas de áreas distantes • Obter semente com os vizinhos • Comprar maniva fora	• Falha muito (perda da roça) • Aumenta os custos • • A semente sendo boa compensa • Prejuízo	• Programas de distribuição de sementes por orgãos públicos	
• Problema climático da região		• Diminuição da área plantada			• Plantar no início do inverno • Introdução de novas variedades	

Outros problemas

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Juros altos • Falta de crédito adaptado a realidade do pequeno produtor • Preços baixos da fainha • O dinheiro financiado é pouco, demora a liberação e o preço do produto não compensa • Diminuição da área plantada • Falta organização do produtor • Desinteresse do banco em emprestar ao pequeno • Falta de vontade do Governo		• Planta manos • Falta de tratos culturais ao cultivo • Produtor trabalha sozinho e não pode contratar mão de obra • Exodo rural • Hipoteca da terra • Venda de bens para pagamento do empréstimo • Endevidamento alto (falencia) • Fome • Miséria • Em vez de producir fica recebendo cesta • Não pode alugar trator • Não pode usar adubos • Toma empréstimo a particular e no fim fica até sem semente • Vai trabalhar para os outros	• Plantar menos com recursos próprios • Empréstimo bancario • Tentar negociar com banco uma forma de financiamento • Vender na folha • Vender parte da roça • Arrancar antes do tempo • Venda de animais	• Pouca produção (só para consumo próprio) • Negativo porque vende-se o que tem para pagar ao banco • Negativo • Grande prejuízo • Grande prejuízo • Grande prejuízo • Prejuízo	• Financiamento sem juros • Financiamento com juros baixos e prazos maiores • Financiamento com equivalencia produto • Garantía de preços mínimos • Liberação mais rápida dos financiamentos • Intermediação dos financiamentos pela EMATER-PE • Financiamento na sede do município • Organização dos produtores para cobrar empréstimos a juros baixos • Chamar o prefeito e os vereadores e exigir deles uma solução	
• Terras muito caras • Falta de recursos para compra de terras • Divisão da terra por heranças (familias com muitos filhos) • Ciclo vegetativo largo • Concentração da terra em mãos de poucos • Compra de terras pelos fazendeiros para plantar capim • Governo não ajuda • Os pequenos venderam as terras porque a mandioca não tinha preço		• Deixa de plantar • Fome • Prejuízo económico • Pouca produção • Exodo rural • Marginalização • Grande divisão da terra • Trabalho todo ano no mesmo local • Trabalho perdido porque lucro fica com o dono da terra • As áreas são grandes o que torna difícil a compra pelo pequeno	• Plantar em terra arrendada • Plantar em fileira dupla	• Pouca renda (produção é dividida com o dono da terra) e ainda tem que plantar capim) • Produção aumentou	• Financiamento com juros baixos para compra de terra • Reforma agraria • Arrendamento de terra • Apesar da pouca terra, crédito para comprar adubos e presença do técnico para dizer as necessidades do solo • Financiamento do Governo para comprar terras e pagar com o produto • Organizar os grupos de produtores para pedir terras ao Governo o condições para comprar	

Outros problemas (continuação)

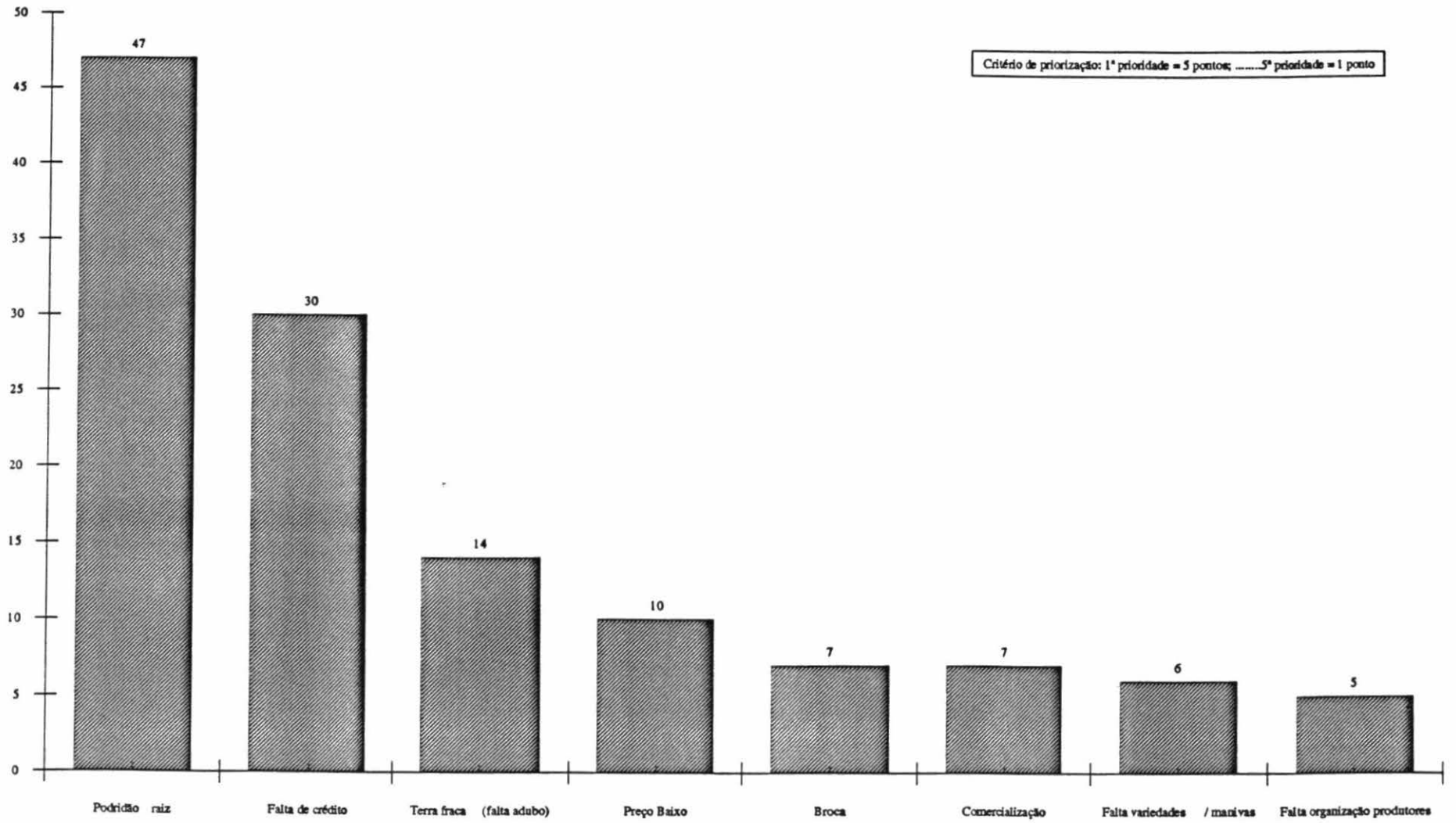
• Excesso de produção • Falta de garantia de preços mínimos • Competencia com farinha de outras regiões • Colheita coincide com a de outras regiões • Falta de uma cooperativa ou grupo organizado • Farinha é produto de pobre • Má qualidade do produto • Presença dos atravessadores	• Fome • Prejuízo financeiro • Retarda a colheita • Miseria • O produtor deixa a produção na roça; não zela mais porque não compensa • A safra diminui	• Deixar a mandioca no campo e colher só quando melhorar o preço • O agricultor vender sua produção direto ao consumidor • Não tentarem nada • Vender barato • Guarda a farinha • Guarda a goma para vender o inverno	• Rendimentos baixos; pouca renda • Maior lucro • Prejuízo • Prejuízo • Não deu resultado; o preço ficou o mesmo • O preço da goma subiu	• Financiamento do governo com pagamento em equivalente produto • Diversificar produção • Garantia de preços mínimos para farinha • Governo comprar a farinha a preços justos • Criarem uma Cooperativa • Não trazer mandioca de fora • Diversificação de culturas • Melhorar a qualidade da farinha • Um plano para mudar os produtos além da farinha
• Falta de recursos financeiros	• Diminui o lucro	• Pagou frete	• Pouco lucro	• Financiamento com juros baixos
• Falta de conscientização do grupo	• Falta de produção • Prejuízo financeiro	• Aproveitar os sub-produtos da mandioca	• Negativo (não houve adesão)	• Tentar conscientização de todo o grupo
• Falta de técnicos na área	• Pouca produção	• Procura a EMATER-PE	• Nenhum (EMATER-PE não oferece condições de trabalho ao técnico local)	
• Falta poço de grande porte • Agricultor não tem condições de ir a buscar agua • Não tem reservatório suficiente para acumular agua	• Paralização da produção de farinha • Renda maior na batata do que na mandioca • Prejuízo nos sub-produtos	• Reivindicaram ás autoridades	• Nenhum	• Poço profundo • A união do povo para buscar soluções
• Porque não têm condições de comprar nem uma prensa • Poucos agricultores têm casa de farinha • Falta incentivo • Vende raiz	• Termina vendendo a mandioca barata • Paga alta renda por usar casas de farinha • 3/4 da produção de raiz saem para fora • Falta emprego	• Construiram casa de farinha comunitária • Fabricam farinha nas casas dos outros pagando renda de 2 sacos por tarefa • Vendem a raiz	• Fazem a farinha • Pagam aluguel caro (8 por 1) • Prejuízo	• Financiamento do Governo para construção de casas de farinha para o povo

Diagnósticos Participativos no Estado da Paraíba (n = 10 comunidades; 274 produtores)

DIAGNÓSTICOS PARTICIPATIVOS Priorização de problemas pelos produtores Estado da Paraíba											Indice de Prioridade # comunidades x pontoação 1 prioridade = 5 pontos 2 prioridade = 4 pontos 3 prioridade = 3 pontos 4 prioridade = 2 pontos 5 prioridade = 1 ponto 6, 7 prioridade = *
Região	Areia-Alagoa Grande						Guarabira				
Município	Lagoa Grande	Lagoa Nova	Areia	Alagoa Grande	Areia	Alagoa Nova	Salgado São Félix	Salgado São Félix	Araçgí	Araçagí	
Comunidade	Engenho Mares	Gravatá	Casa de Pedra	Quitéria	Engenho Cipó	Gameleira	Abunã	Souza	São Vicente	Piabas	
# Participantes homens	33	14	13	41	23	19	26	28	27	17	241
mulheres		8	5	3	12			5			33
total	33	22	18	44	35	19	26	33	27	17	274
PRAGAS											
Lagarta		•								•	
Cupim		5									1
Tananjuá		•				•				•	
Broca			3					2			7
Formiga			•			2					4
DOENÇAS											
Podridão raiz	1	2	1	1	1	1	1	1	2	2	47
Queima olho planta							4				2
OUTROS											
Terra fraca (falta adubo)	5		2		2	5	3	5	•		14
Falta conservação solos											
Preço Baixo	3		•	4	3	•			•	4	10
Estiagem						•					
Produtividade baixa										•	
Falta de terra		•		2		•			•		4
Falta de crédito	2	•	5	3	4	3	2	3	1	1	30
Falta transporte					•	4	5		•		3
Assistência Técnica	4								•	•	2
Maniva doente		•				•					
Falta variedades/maniva		3		5	•			4	•		6
Falta organização produtores					4				3		5
Falta trator/animais para aração									5	3	3
Êxodo Rural		4	4		5						5
Falta casas farinha									•		
Arrendamento alto										•	
Comercialização		1			•				4		7

Fonte: Profisma/94

Priorização de Problemas através de Diagnósticos Participativos - Estado da Paraíba (n = 10 comunidades; 274 produtores)



Fonte: Profisma/94

ANÁLISE DOS PROBLEMAS PRIORIZADOS PELOS PRODUTORES DURANTE OS DIAGNÓSTICOS PARTICIPATIVOS
ESTADO: Paraíba (10 comunidades e 274 produtores)
Problemas relacionados com doenças

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Solos doentes • Solos encharcados • Excesso de chuvas • Plantio sempre na mesma área • Terreno argiloso • Ano bom de inverno • Micróbio na terra • Maniva contaminada • Falta de conhecimento técnico • Terras quentes X chuvas	**Podridão da Raiz**	• Baixa produção • Colheita precoce • Desistímulo ao plantio da cultura • Prejuízo financeiro (grande) • Maniva doente (contaminada) • Farinha ruim • Solo doente e prejuízo financeiro • Perda do plantio • Amarelamento das folhas • Raiz fofa • Baixa quailidade dos subpprodutos (a farinha é amarela) • Seca as manivas	• Plantio de outras variedades no mesmo local • Mudança de plantio • Mudança de área • Trocar a maniva • Colheita antecipada • Descanso da terra • Rotação de culturas • Não plantar no começo do inverno • Deixar de plantar • Plantio em leirões	• Negativo Bom (diminui a podridão) • Diminui a incidência • Aumenta a produção • Continua apodrecendo • Nada • Bom (diminui a podridão) • Diminui a produção • Diminui a podridão • Maior produção • Nenhum • Não teve rendimentos • Diminui a produção • Melhorou a produção • Diminui a podridão • Diminui a mão-de-obra • Diminui a podridão	• Plantar outras variedades resistentes • Assistência técnica • Rotação de cultura • Tratamento da maniva • Análise de solo • Mudança de área • Plantar outras sementes • Remédio para combater • Interesse por parte dos produtores • Estudo técnico (pesquisa)	• Apoio do governo para dá assistência técnica

Problemas relacionados com pragas

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Solos com muitas raízes • Solos fracos • Tipo de solos	**Cupim**	• Plantas nascem com dificuldades (sementes não brotam normalmente) • Roem (comem) as estacas • Baixa produção • Maniva amarelada • Morte das plantas			• Crédito subsidiado pelo Governo (para poder comprar insumos e combater a praga) • Assitência técnica específica para o problema por parte dos órgãos do setor	
• Em tempo frio	**Ácaros**	• Morre quando é nova • Pouca produção (70% de perca)	• A quebra do olho	• Quando nova não tem produção • Pouca produção	• Remédio para combater • Outra variedade resistente	
• Proximidade das chuvas • Presença de formigueiros • Veneno fraco • Cheiro da folha atrai a formiga	**Formiga**	• Diminui o crecimento das plantas • Baixa a produção • Baixo rendimento • Atraso na cultura • Não cria raiz • Desfolhamento	• Uso de veneno (mirex ganulado) • Uso de manipueira no formigueiro • Enterrar um sapo cururu no formigueiro • Aplicação de isca no formigueiro	• No início diminui a incidência • Acabou (repeliu) as formigas • Nenhum • A formiga caminha 3 dias e depois desaparece	• Orientação técnica • Recursos (crédito rural) compatível com as condições do produtor • Equipamento específico para o combate • Veneno mais forte	
• Presença do inseto • Falta de orientação técnica • Época invernosa	**Percevejo de Renda**	• Queda da produção • Morte da raiz • Deixa de plantar • Mucha as folhas • Atrasa o desenvolvimento da planta			• Assistência técnica • Variedades resistentes • Pulverização • Mudança de área	

Problemas relacionados com sistema de produção (solos, variedades,mecanização)

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Erosão • Forma de plantio • Assistência técnica • Plantio todo ano na mesma área • Falta de adubo orgânico • Uso do solo constantemente • Queima • Plantio no sentido das águas • Falta de preparo da terra • Solo fraco	**Terras Fracas (Falta de Adubo)**	• Prejuízo na produção • Diminui a produção • Diminui o lucro • Desistímulo ao plantio • Cultura não se desenvolve • Erosão • Perda de tempo	• Terras em repouso • Mudança de área c/ queima • Uso de adubo orgânico • Evitar a queima • Incorporação de restos de culturas • Análise de solo	• Melhorou a produção • Produz 1 a 2 anos no máximo • Aumento da produção • Melhorou a produção • Aumento da produção • Aumento da produção • Aumento da produção	• Adubar a terra • Deixar a terra em repouso • Colocar adubo químico e orgânico • Trator para virar a terra • Análise do solo • Rotação da terra	
• Falta de recursos financeiros • Falta de política agrícola do Governo para o pequeno produtor • Falta de interesse da comunidade • Falta de recursos	**Falta de trator e animais p/ preparo da terra**	• Baixa produção • Redução da área • Vende a produção ao atravessador • Pagam fretes caros • Prejuízo financeiro	• Solicitado a Prefeitura Municipal • Paga aluguel (frete pago) • Contato com a EMATER local para pedir informações sobre a Procera	• Atendido • Negativo (não atendido) • Prejuízo no lucro • Negativo. Impossibilidade, tendo em vista não ser área de assentamento	• Apoio dos poderes públicos • Melhor distribuição de máquinas pela Prefeitura (atendimento ao peq. produtor) • Adquirir animais para transportar a mandioca da área para casa de farinha • Conseguir um trator • Aquisição de um transporte (caminhão) pela Associação junto aos órgãos competentes	
• Não dispõe de alternativas de variedades • Inverno irregular • Pragas e doenças • Colheita antecipada (obter maniva para plantio, mas se perde por falta de chuva)	**Falta de manivas na hora certa**	• Baixa produção • Não tem produção • Diminui área de plantio • Não tem lucro	• Aquisição em outros municípios • Retardar a colheita (arrancar quando o inverno chegar)	• Aumentou a área • Bom (conseguiram a semente) • Bom (conseguiram a semente)	• Mudanças das variedades existentes • Instalação de unidades de pesquisa coletiva • Análise da terra e variedade e plantio de campos de multiplicação de sementes • Unidade coletiva de produção manivas semente • Aumenta a área de plantio • Adquirir manivas em outras áreas, através da associação com a EMATER • Multiplicação das manivas (sementes sadias)	

Outros problemas

CAUSAS	PROBLEMAS	CONSEQUÊNCIAS	SOLUÇÕES TESTADAS PELOS PRODUTORES	RESULTADOS OBTIDOS	SUGESTÕES DOS PRODUTORES	OPÇÕES DE PARTICIPAÇÃO DOS PRODUTORES EM PESQUISA AGRÍCOLA E EXPERIMENTAÇÃO
• Não direcinada para cultura da mandioca • Falta de condições da empresa • Falta do apoio do governo	**Falta de Assitência Técnica**	• Baixa produção	• Ampliação de algumas práticas tecnologicas • Solicitação de cursos e treinamentos a EMATER	• Ótimas • Insuficientes	• Adubação • Rotação de áreas • Análise de terra	
• Juros altos • Falta de política agrícola • Falta de empréstimo • Descapitalização dos produtores • Falta de comercialização • Burocracia • Falta de confiança na linha de crédito (governo) • Banco não fianancia para pequenos produtores sem avalista • Insegurança do produtor em contrair empréstimos • Deixa de plantar • Diminui a área de plantio • Falta de reinvidicação junto ao governo • Crédito fora de época	**Falta de Crédito**	• Diminuição de área • Redução da produção • Diminui o lucro • Falta de alimento para a população • Prejuízo • Falta de trabalho • Atraso no desenvolvimento • Não tem produção • Diminui a mão de obra • Liberação de recursos fora de tempo (quando tem) • Rotação de culturas (plantam outras culturas) • Passam necessidades • Diminui o poder de compra	• Financiamento do PROCERAR • Trabalho comunitário (mutirão para tratos culturais) • Venda de bens para custeiar a produção • Trabalho alugado • Proposta de crédito ao governo • Zero • Buscaram orientação junto a Agentes Financeiros, sobre as condições dos financiamentos	• Empréstimo bancário • Produçao garantida • Negativo (prejuízo) • Negativo (prejuízo) • Zero • Nenhum • Zero • Negativo. Impossibilidade de contrair o fianciamento • Aumento de área • Aumento de produção	• Procurar os agentes financeiros, procurar INCRA, EMATER e outras autoridades • Prejuízo devido os encargos • Crédito rural (juros compatíveis) • Recursos do FPM (Agricultura) • Mutirão • Associativismo (cooperativa) • Política agrícola voltada ao pequeno produtor • Solicitar ajuda do vizinho • Juros diferenciados para o pequeno produtor • Elaboração de projetos	
• Falta de um líder • Falta de união • Falta de associação	**Falta de Organização dos Produtores**	• Falta de benefícios para a comunidade			• Associar-se a cooperativas atuantes • Criação de Associação comunitária • Mutirão	
• Reforma agrária indefinida lotes das áreas pequenas	**Falta de Terra**	• Baixa produção	• Plantio em terrenos de outros	• Aumento da produção	• Se organizar e procurar os orgãos competentes • Arrendar outras áreas	• Plano agrícola compatível com o pequeno produtor

Outros problemas (continuação)

• Muita oferta • Importação da farinha • Atravessador • Falta de garantia de mínimos (preços compensadores) • Baixo consumo de produto: compra de outros produtos similares • Qualidade do Produto	**Comercialização**	• Prejuízos econômicos • Desistímulo ao plantio • Redução da área • Diminui a produção • Perda do trabalho (Não cobre os custos da produção) • Falta de armazenamento • Comercialização do produto	• Armazenamento, não arraquio • Armazenamento (silos insuficientes)	• Melhor preço, bom resultado • Maior lucro	• Transporta a produção para outros centros consumidores • Instalação de industria de raspa, armazenamento • Garantia de preços mínimos (preços compensadores) • Evitar o atravessador • Criação de cooperativas para receber e comercializar a produção, assegurando, assim, os preços	• Garantia de preços mínimos (preços compensados)
• Êxodo rural • Desinteresse dos jovens pela agricultura • Falta de recurso financeiro • Baixa remuneração • Aposentadoria	**Falta Mão de Obra**	• Limita a área do plantio • Baixa produção • Impossibilita em parte os tratos culturais • Terras sem produção • Falta de estímulo para o plantio	• Mutirão • Plantio comunitário • Mão-de-obra familiar • Trabalhar alugado em outro lugar, para conseguir recursos e pagar trabalhador • Vender bens (animais de criação para conseguir pagar trabalhadores)	• Aumento de área • Bom • Aumento de área • Plantio limitado • Baixa produção • Bom (conseguiram recursos e pagaram trabalhadores) • Ruim	• Aquisição de recursos para melhor remuneração • Crédito a juros baixos • Crédito subsidiado (o produtor poderia pagar trabalhadores, evitando o deslocamento dos mesmos para outras regiões) • Trabalhos comunitários	

Table 4.2.2 PROFISMA's monitoring and evaluation system.

Factor	Data Base	Diagnosis		Intensive follow-up to technology testing	Training	Adoption
		Extensive	Intensive			
Population	a. Communities. b. Producers that participate in tecnology testing. c. Producers that do not participate in tecnology testing.	Communities	Farmers	Subsample of intensive diagnosis survey.	Researchers and producers	Year 3 & 4, same sample as intensive diagnostic survey.
Objectives	a. Basic information about activities and project beneficiaries b. Create subsamples for extrapolation with results from surveys & intensive follow-up.	a. Prioritize areas and quantify problems b. Information about traditional production and protection practices c. Identification of farmer collaborators	a)Characterize production & marketing systems b)Quantify principal constraints to production. c)Cost/benefit analysis. d)Determine damage severity & frequency	Determine short-term adoption of tecnology.	Determine efficiency of training program in implementing ecologically sound production practices.	Determine efficiency of the project to achieve expected results abd benefits
Areas	Secondary data: areas production productivity soils climate major constraints	Major constraints Most affected areas Traditional protection practices Potential farmer collaborators	Characterization of production & marketing systems Cultural practices Cost/benefit estimated for new technologies. Severity & incidence of losses determined	No. farmers participating. No. farmers adopting new practices No. components validated. No. components adopted. No. farmers adopting components over time.	No. trained technicians No. trained farmers No. demonstrative areas. No. training events	-Technical, social, economic, environmental and institutional impact
Method	Collection of secondary information	Participatory group surveys at communities level, representative sample	Farmer surveys, representative sample.	Periodic visits to subsamples selected from data base.	Survey of subsample selected from data base.	- Comparative analysis of data assembled in Intensive Survey and Follow-up Study -Assessment by external consultant

Table 4.2.1 PROFISMA's framework of socioeconomic activities.

PHASE	ACTIVITY	OBJECTIVES	METHODS	LEVEL	PARTICIPANTS	EXPECTED RESULTS
I DIAGNOSIS	**Extensive Diagnostic Survey**	To identify: 1. target areas 2. problems/needs 3. traditional practices 4. potential collaborators	1. Semi-structured group interviews 2. Communities selected for cassava importance (pre-stratified) 3. Identification and ranking of problems 4. Cause/effect analysis of top problems	Community	1. Multidisciplinary teams of researchers and extensionists from state institutions 2. Project personnel 3. Farmers	1. Selection of potential project pilot sites 2. Identification of problem priorities from farmers perception 3. Potential farmers collaborators.
	Intensive Diagnostic Survey	1. Quantification & validation of cassava constraints & priorities identified in extensive surveys 2. Characterization of production, processing, market & utilization system 3. Evaluation (socio-economic screening) of already existing best-option technological components 3. Creation of ex-ante baseline data for Monitoring & Evaluation studies	1. Structured questionnaire 2. Sample includes pilot sites, collaborator, & non-collaborator farmers in "similar" communities (control)	Farmer households including men and women	1. Multidisciplinary teams of researchers and extensionists from state institutions 2. Project personnel 3. Farmers	1. Cost/benefit analsys of cassava production system at farm level 2. Detailed knowledge of traditional cassava production & protection. 3. Qantification of: a. pest & disease damage b. cost/benefit analysis c. frequency 4. Farmers interested in technology valdation & adaptation activities
	Analysis of technology gaps	Interdisciplinary analysis of available data and in-house technologies to define "gap" or opportunities between needs (demand) & possible technology components (supply).	1. Interdisciplinary meetings to analyze extensive & intensive surveys & define demand. 2. Comparison of needs with existing technology	Research centre	1. Multidisciplinary teams of researchers and extensionists from state institutions 2. Project personnel 3. Farmers	Definition of porfolio of technology options for prioritized needs
	Development of a monitoring and evaluation system (M&E)	Compilation, analysis, packaging, feedback and dissemiation to relevant audiences of project activities, results and benefits.	1. Project annual technical reports 2. State institutions annual reports	1. Research centre 2. State institutions 3. Farmers groups	1. Multidisciplinary teams of researchers and extensionists from state institutions 2. Project personnel 3. Farmers	Relevant audiences timely informed of project results and benefits
II FARMER PARTICIPATORY RESEARCH ACTIVITIES (FPR)	**Implementation of FPR activities with porfolio of technology options developed by PROFISMA.**	1. Generate, validate and adapt technological components at farm level 2. Select appropriate technological options	Farmer participatory research	Selected farmers	1. Multidisciplinary teams of researchers and extensionists from state institutions 2. Project personnel 3. Farmers	Testing, selection, adaptation and adoption of technological components
	Socio-economic validation of experimental technologies.	1. Soco-economic validation of technology components. 2. Cost/Benefit analysis of technology options	1. Cost/benefit analysis 2. Ex-ante analysis 3. Partial budgets	Research centre	1. Researchers 2. Extension workers	Technology options appropriate for cassava production systems in project target areas
III ADOPTION & IMPACT	**-Base-line study(Intensive survey) -Follow-up study(last year of the project)**	1. Characterization of social, economic, institutional and environmental impact due to project activities and results	1. Critical analysis of data assembled during intensive survey and follow-up study 2. Neutral assessment by external consultant at the end of the project	- Farmer households -Research centre -State institutions	1.Multidisciplinary teams of researchers and extensionists from State institutions 2. Project personnel 3. Farmers	Assessment of project implementation according to proposed objectives

Appendix II

Development of the fungal pathogen *Neozygites* for biological control of the cassava green mite in Latin America and Africa.

An international workshop held at Cruz das Almas, Bahia, Brazil
7-11 November, 1994.

Contributing sponsors:
The Cassava Biotechnology Network, CIAT, Cali, Colombia
ESCaPP, Cotonou, Benin
PROFISMA, Cruz das Almas, Bahia, Brazil
EMBRAPA/CNPMF

Report to the Cassava Biotechnology Network on a workshop held at Cruz das Almas, Bahia, Brazil, 7 - 11 November, 1994: "Development of the fungal pathogen *Neozygites* for biological control of the cassava green mite in Latin America and Africa." Prepared by S. Lapointe, 25/11/94.

TABLE OF CONTENTS

I. Introduction

The United Nations Development Programme (UNDP) provided funding for Global Project GLO/91/013 "Ecologically Sustainable Cassava Plant Protection in South America and Africa: An Environmentally Sound Approach" beginning in 1993, projected through 1997. The project is divided into two components, one for Africa (ESCaPP, Ecologically Sustainable Cassava Plant Protection) and one for Latin America (PROFISMA, Proteção Fitossanitária Sustentâvel de Mandioca) with emphasis on northeastern Brazil. The African component has activities in Benin, Nigeria, Ghana and Cameroon and is coordinated by IITA (International Institute for Tropical Agriculture) through its biological control center in Cotonou, Benin. The Latin American component is coordinated jointly by CIAT (Centro Internacional de Agricultura Tropical) in Cali, Colombia and by EMBRAPA (Empresa Brasileira de Pesquisa Agropecuaria) through its national research center CNPMF (Centro Nacional de Pesquisa de Mandioca e Fruticultura Tropical) located at Cruz das Almas, Bahia.

The overall goal of the project is to contribute to the welfare of poor and landless farmers within the target areas through increased productivity of cassava based on appropriate crop production systems. The project's main focus is development and implementation of biological, genetic and cultural control of the major pests, diseases and weed species accomplished to the extent possible through the participation of farmers and extension agents in the adaptive research and validation stages.

A major pest of cassava on both continents is the cassava green mite (CGM), *Mononychellus tanajoa*. CGM causes speckling and chlorosis of the leaves; severe infestations can cause leaf drop. CGM is primarily a dry season pest; damage is often confused with drought symptoms. Yield reduction due to CGM in Brazil can be as high as 40%.

CGM was discovered after accidental introduction into Africa during the early 1970's. Based on the successful model of the cassava mealybug classical biological control program, emphasis has been placed on indentification and importation of natural enemies from Brazil and what is believed to be the center of diversity of CGM, northern South America. These natural enemies consist of phytoseiid predatory mites and a fungal pathogen, *Neozygites* sp. or spp. While *Neozygites* exists in Africa as well as Brazil, it is thought that Brazilian strains may be more adapted to CGM given the longer period of coexistence of the host and pathogen. Therefore, the ESCaPP and PROFISMA projects anticipate releases of Brazilian strains of *Neozygites* into Africa in the near future.

The PROFISMA/ESCaPP projects emphasize implementation and farmer impact. Therefore, some of the basic constraints to utilization of *Neozygites* require strategic research that are beyond the present scope of the ESCaPP and PROFISMA projects in terms of resources and expertise. To define and prioritize these constraints, a workshop was convened by PROFISMA/ESCaPP at EMBRAPA's national research center for cassava and fruit crops (CNPMF), Cruz das Almas, Bahia, Brazil, with the support of the Cassava Biotechnology Network (CBN), coordinated by Dr. Ann Marie Thro (CIAT). The workshop focussed on reviewing current knowledge, identifying constraints amenable to resolution through research, and prioritizing those constraints with a view towards developing a project proposal outline, and determining the appropriate sites, laboratories, research stations, etc. for execution.

II. Workshop schedule

Monday, 7 November, 1994. Participants arrived to Cruz das Almas. List of participants appears in Appendix I. A preliminary meeting was held in the

afternoon to set the agenda for the remainder of the week.

Tuesday, 8 November. Presentations by G. Moraes, G. Oduor, I. Delalibera, J. S. Yaninek, D. Roberts, S. Keller, M. Sabelis (see appendix II)

Wednesday, 9 November. Presentations by R. Cuero, S. Lapointe, L. Smith (see appendix II). Constraints to utilization of *Neozgites* that were identified by each speaker was assembled and presented to participants for discussion and comments.

Thursday, 10 November. SL presented work breakdown structure as a means to organize and prioritize various activites identified as important. A breakdown structure for project activities was worked out for each major area, beginning with characterization. See below. For each Basic Research Area, the following were ennumerated and discussed: Goal, Purpose, Expected Results and Specific Activities associated with each Expected Result. These were collated, printed and distributed to participants. Participants were then asked to identify those areas where they felt capable of making a contribution or undertaking research activities for discussion on the following day.

Friday, 11 November. Work breakdown structures for each Basic Research Area were presented to the group and participants identified those specific activities they were interested in conducting. Interested participants were asked to give rough budget estimates. The workshop was concluded at noon.

III. Workshop results

The work breakdown structures are presented in the next section of this report. Here, I will try to summarize the group's consensus concerning priorities and the importance of the specific activities while acknowledging any bias as the result of imperfect memory or my opinions. Five Basic Research areas were identified with a number of expected results and specific activities within each area, as follows:

I. CHARACTERIZATION
II. IN VIVO PRODUCTION
III. IN VITRO PRODUCTION
IV. BIOLOGY OF HOST-PATHOGEN INTERACTIONS
V. EPIZOOTIOLOGY

The Basic Research areas are presented in rough order of priority in that it was agreed that the most urgent area to address is characterization of the fungus through traditional morphological and cytological means as well as genetic characterization through the use of molecular genetics. The need to identify species, if they exist, or infraspecific strains or isolates is critical for the planned

releases of Brazilian isolates in Africa to distinguish introduced from indigenous *Neozygites* and to assess impact of releases on CGM. The work presented by Siegfried Keller showed that insufficient material from Africa and Brazil has been examined for morphological and cytological characters. However, based on the few specimens studied to date, the best determination available is that there is one species of *Neozygites* affecting CGM, namely, *N. floridana*. Arrangements were made to provide SK with additional specimens for further study. Genetic analyses may turn up additional characters that will be essential for separating ifraspecific taxa.

In vivo production is being done currently by PROFISMA and efforts to improve and optimize production of inoculum through the various activites delineated below will continue within the resources available to the project. This will require consideration by the project coordination at CIAT and EMBRAPA to organize activities within the currently available budget.

In vitro production is important to a number of subsequent activities that will require larger quantities of fungus of a given genotype. While PCR can be attempted from single infected mites, the possibility of multiple infections cannot be avoided, thereby reducing the precision of results. This problem can be minimized by running PCR on field-collected infected mites from a range of locations. Nonetheless, genetic characterization will be simplified if cultures of protoplasts can be maintained originated from individual hyphae. A number of methods were discussed to improve chance of success for culturing *Neozygites* on artificial media or on hosts other than CGM. While an analytical approach was outlined to evaluate the nutritional requirements of the fungus, this may be tedious, costly and slow. It was suggested to try immediately to amend media currently used with CGM and/or cassava leaf homogenate, and with chitosan. The potential for chitosan for in vitro production and as a potential delivery system was presented by Raul Cuero (see Appendix V). There appear to be several options that should be tried immediately to solve the bottleneck of in vitro production. These should receive higher priority than more exhaustive approaches, e.g., chemical analysis of mite hemolymph.

Basic Research Area IV, Biology of Host-pathogen Interactions, includes a number of unstudied aspects of the basic biology of *Neozygites*, its interactions with its mite host, and potential tritrophic interactions (host plant/mite host/fungus). Currently, the survival stage of the fungus is unknown. This would be valuable information for designing methods for long term storage, for assessing inoculum potential in the field and understanding how the fungus survives between outbreaks, and as a potential taxonomic character.

Characterization of the infection process would require considerable additional resources and would need to be carried out in a specialized laboratory such as BTI although light microscopic observations of germination and host invasion can be started at CNPMF and CNPMA.

Melanization has been observed in some infected mites and, on occasion, occurs in significant proportions of infected mites. This may be a host defense mechanism and may significantly reduce the yield of conidia from mummies. First efforts should be directed to verifying the phenomenon and determining the importance of melanization on in vivo production and, potentially, field epizootics.

Observations made by Ítalo Delalibera indicate that the mating behavior of male CGM may contribute to transmission of *Neozygites*. This and other aspects of mite behavior and movement would be easy to document and may provide insights into the epizootiology of *Neozygites*.

The area of tritrophic interactions was addressed by Maurice Sabelis. Collaboration between MS and the Entomology section of CIAT's Cassava Program (Anthony Bellotti) may result in external funding to study the effect of cassava variety on mite behavior and disease transmission.

Under epizootiology, monitoring of field populations of CGM and *Neozygites* will be carried out by PROFISMA and ESCaPP. Experimental releases already planned for Benin will be carried out by ESCaPP with the participation of MS. Modeling will depend on data generated by field surveys for data on abiotic conditions, distribution, etc. MS has a grant proposal pending in this area.

IV. Work breakdown structure for activites to develop *Neozygites* for biological control of the Cassava Green Mite in Latin America & Africa.

PROFISMA/ESCaPP project goal: To increase the productivity of cassava in Africa and NE Brazil.

Neozygites project goal: To develop and implement the mite pathogen *Neozygites* as a biological control agent of the cassava green mite.

I. CHARACTERIZATION

Activity goal: Selection of promising *Neozygites* isolates for release in Brazil, introduction into Africa and further experimentation.

Purpose: Genotypic, phenotypic and geographic characterization of *Neozygites* species and isolates.

Expected result 1: Genotypic characterization of isolates

Activities:

1.1.1 Develop methods for obtaining DNA from protoplasts, conidia, hyphal bodies, and/or in vitro cultures.

1.1.2 RAPD analysis.

1.1.3 RFLP analysis.

1.1.4 Develop strain-specific probes.

1.1.5 Chromosome number and size determination.

Expected result 2: Map of geographic distribution of *Neozygites* isolates associated with CGM in Africa & Latin America.

Activities:

1.2.1 Surveys to collect *Neozygites* isolates from CGM and other mite hosts from cassava and other host plants, geographic information, climatic data, and severity of mite damage and infection of CGM with *Neozygites*..

1.2.2 Curation of isolates.

1.2.3 Development of a geo-referenced database.

Expected result 3: Phenotypic characterization of *Neozygites* spp. and strains.

Activities:

1.3.1 Virulence assays.

1.3.2 Host specificity trials.

1.3.3 Determine response to abiotic factors (RH, temperature, UV light).

1.3.4 Morphological and cytological descriptions.

1.3.5 Testing viability of *Neozygites* under storage.

1.3.6 Isozyme analysis.

1.3.7 O_2 uptake and lipid analysis.

II. IN VIVO PRODUCTION

Activity goal: In vivo production of *Neozygites*.

Purpose: Maintenance and propagation of *Neozygites* for experimental purposes.

Expected result 1: Optimization of production system

Activities:

2.1.1 Determine ideal CGM density to receive the fungus.

2.1.2 Determine developmental stage and inoculum size for releases.

2.1.3 Determine optimal release technique.

2.1.4 Determine optimum time and method to harvest infected mites.

Expected result 2: Quality control protocol

Activities:

2.2.1 Bioassays to determine fungal viability and virulence.

2.2.2 Bioassays to assure mite quality.

2.2.3 Procedures for identifying and verifying isolates.

2.2.4 Procedures for screening contaminants.

Expected result 3: Methods for storage and shipments of mummies

Activities:

2.3.1 Evaluate effect of temperature and humidity on mummies.

2.3.2 Develop appropriate packaging techniques.

Expected result 4: Inexpensive production in factitious hosts

Activities:

2.4.1 Screen possible factitious hosts and host food.

2.4.2 Evaluate chitosan to increase infection rate.

III. IN VITRO PRODUCTION

Activity goal: In vitro production of *Neozygites*.

Purpose: Provide pure *Neozygites* for genetic characterization and release.

Expected result 1: Production of pure *Neozygites*

Activities:

3.1.1 Evaluate existing media and methods.

3.1.2 Amend media with CGM and cassava homogenate/extracts.

3.1.3 Optimizing production.

Expected result 2: Elucidate nutritional and environmental requirements

Activities:

3.2.1 Evaluate nutrient requirements (sugars, amino acids, vitamins, salts).

3.2.2 Evaluate environmental requirements (temperature, O_2, osmolality, pH).

3.2.3 Evaluate chitosan for growth stimulation.

Expected result 3: Chemical composition of host hemolymph

Activities:

3.3.1 Analysis of proteins, sugars, salts, vitamins.

Expected result 6: Description of the formation and germination of resting spores

Activities:

4.6.1 Study biotic and abiotic conditions necessary to induce resting spore formation and germination

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V. EPIZOOTIOLOGY

Activity goal: Understand the epizootiology of *Neozygites* in CGM

Purpose: To determine effects of biotic and abiotic factors on population dynamics and spread of *Neozygites* and CGM

Expected result 1: Description of the seasonal and geographical conditions favorable for infection by *Neozygites*

Activities:

5.1.1 Monitor field populations of CGM in relation to abiotic factors, cultural practices, distribution and density of inoculum, and other biological control agents.

Expected result 2: Reduction of CGM by releasing *Neozygites*

Activities:

5.2.1 Experimental releases

5.2.2 Follow-up monitoring

5.2.3 Evaluation of spread

5.2.4 Impact assessment

Expected result 3: Generation and validation of hypotheses generated by population models

Activities:

5.3.1 Model disease spread in relation to distribution of the host.

5.3.2 Model metapopulation dynamics.

5.3.3 Valid with field data.

5.3.4 Use model predictions to design experiments.

5.3.5 Expand model to include interactions with other biological control agents.

IV. BIOLOGY OF HOST-PATHOGEN INTERACTIONS

Activity goal: Generate basic knowledge on biology of host-pathogen interactions.

Purpose: To elucidate relevant aspects of the life cycle of the pathogen and its interaction with the host.

Expected result 1: Identification of the survival stage of *Neozygites* and its location.

Activities:

4.1.1 Assay soil, plant parts, etc. for infectivity to CGM.

4.1.2 Determine whether fungus morphology changes seasonally.

4.1.3 Test for dormant fungal structures.

Expected result 2: Infection process characterized.

Activities:

4.2.1 SEM & light microscopic observations of germination and invasion.

4.2.2 Determine physical and chemical processes in hosts and non-hosts.

Expected result 3: Characterization of melanization in infected mites.

Activities:

4.3.1 Chemical and physical verification of melanization.

4.3.2 Measure the effect of melanization on fungus and host.

4.3.3 Effect of temperature, host age, host plant characteristics and geographic strain of fungus and mite on melanization.

4.3.4 Biochemical analysis of melanization process.

Expected result 4: Behavioral characterization of infected mites.

Activities:

4.4.1 Monitor movement and dispersal of infected mites on plants.

4.4.2 Observe behavior of potential hosts and other vectors with respect to infection.

Expected result 5: Description of tritrophic interactions on *Neozygites* germination and transmission.

Activities:

4.5.1 Study the effect of plant variety on the probability of mite contact with capilloconidia.

4.5.2 Study the effect of plant variety on the germination of capilloconidia.

V. Budget estimates for specific activities as identified in the work breakdown structure.

Activ.	Researchers/yrs	CM	RC	RH	DR	SK	MS	AB	ED	Other	Total
1.1.1 - 1.1.3	CM/4yrs, RH/yr, J.Tohmé?	50		30							80
1.1.4	DR/1yr				25						25
1.1.5	CM/1.5yrs	20									20
1.2.1 - 1.2.3	Profisma, ESCaPP										
1.3.1	Profisma, ESCaPP, MS?										
1.3.2	Profisma, ESCaPP										
1.3.3	CM/4yrs	55									55
1.3.4	CM/4 yrs, SK/4yrs	"				10					10
1.3.5	Profisma										
1.3.6	CM/4yrs	"									
1.3.7	CM/4yrs	"									
2.1.1 - 2.3.2	Profisma										
2.4.1 2.4.2	RC/4yrs, Profisma		440								440
3.1.1 3.1.2	RC/4 yrs, Profisma, ESCaPP, RH		"								
3.2.1 3.2.2	RC/4 yrs, RH, CM	15	"								15
3.2.3	RC/4 yrs		"								
3.3.1	DR/4 yrs				400						400
4.1.1 - 4.1.3	Profisma, GM										
4.2.1 4.2.2	DR/4yrs, CM/2yrs	10			400						410
4.3.1	DR&GM/1yr				10						10
4.3.2	Profisma, GM										
4.3.3	pending										
4.3.4	DR & GM/2yrs				100						100
4.4.1	Profisma										
4.4.2	ED/2yrs								60		60
4.5.1 4.5.2	MS, AB/4 yrs						160	200			360
4.6.1	GM, RC/4yrs		40								40
5.1.1	Profisma										
5.1.1 - 5.2.3	ESCaPP, MS, McCoy/4yrs									80	80
5.2.1	CM/4 yrs	45									45
5.2.4	ESCaPP, MS										
5.3.1 - 5.3.5	ESCaPP, MS/4yrs						130				130
	Subtotals	195	480	30	935	10	290	200	60	80	2280

Appendix I: List of Participants

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Appendix II: Notes on individual presentations.

(Note: These are my personal notes and are, as such, incomplete. I include them for the benefit of the participants. Errors are mine alone. SLL.)

1. Presentation by Dr. Gilberto Moraes

First report of *Neozygites* in Brazil was made in 1981 from infected *Tetranychus evansi* on tomatoes. Approximately ten species of arthropods have been inoculated with *Neozygites*, but none were infected. There was no germination of the fungus nor infection. Hence, the fungus is believed to be very specific. This complements work carried out by Italo Delalibera that shows no infection of other mite species. Some invasion was observed on *Tetranychus urticae*; however, there was no propagation in the heomocoel of infected mites.

MS: What species was *T. urticae* reared on? Host plant may affect mite/pathogen interaction. GM: I believe it was beans. SLL: Thesis by J. M. Alvarez showed infection by *N.* on *T. urticae* reared on cassava in Colombia. The difference in infectivity of *N.* to *T. urticae* may be due different pathogens or to different rearing conditions experienced by the mites.

SK: Why do mummies not sporulate? Have dissections been done?

GM: CGM with resting spores may dislodge from leaf more easily.

2. Presentation by George Oduor

Importance of darkness. Sporulation commences at onset of darkness and peaks at end of dark period. Temperature also siginificant. Germination of primary conidia decreases with increasing temperature to 33°C (0). Effect of temperature on gemination of capilloconidia - gemination decreased at low (13) and high (33) temperatures compared with 28, 18 and 23°C. Capilliconidia are

able to germinate at low humidity and high temperature to an extent, whereas primary conidia cannot. Time to 50% mortality: Effect of temperature: increasing temperature shortens period between infection and death; Humidity had no effect as process is internal; Photoperiod had no effect. Viability of primary conidia: Increasing temperature reduces survival; low humidity eliminates viability; light//dark no effect.

SLL: Since a factorial design was used, interpretation of interactions may be most interesting in looking at fungus behavior in different ecosystems.

Effect of inoculum size on mortality of CGM. Pathogenicity to different stages of CGM: all stages mumified, immature stages took longer to die (range 58 - 77 h); adults took less time to mummify. Mortality coincides with scotophase (best time for sporulation).

Viability of *N.* in cadavers drops to zero after 6 months at room temperature but can be maintained at 4°C (5% RH over glycerol) for >16 months.

3. Presentation by Ítalo Delalibera

Aspects of utilization of *N.* that need to be determined: Ideal CGM density on plants to receive the fungus; Developmental stage of the fungus to be released; Size of inoculum for releases; Release technique; Length of time between fungus release and harvest (no. of cycles); Harvesting process; Storage technique; Definition of the melanization phenomenon.

4. Presentation by Steve Yaninek

Priorities: Specificty testing of isolates. Virulence assay - are Brazilian isolates hotter than African? Strain characterization/identification - how to differentiate introduced from native isolates. In vivo production. Experimental releases. Impact evaluation.

MS: Is there a trade-off between virulence and spore production that might affect epidemiology?

5. Presentation by Don Roberts*

Hirsutella is a member of the group subject to use as a bioinsecticide E.g., *Zoophthora* on *Empoasca fabae* on beans in central beans. Dried down hyphae - flakes - used as inoculum to start epizootics. Regarding genetic characterization, isozyme analysis can characterize isolates to an extent, but not as good as other methods. RT has done PCR on *Metarhizium* spp. and *Beauveria bassiana*. It is fairly easy to find three primers that would provide differentiation of all isolates. From PCR, have developed specific probes to

identify any *Metarhizium* spp., but strain-specific probes are more difficult. Should be able to extract DNA from CGM mummies. May have to work with more than one mite, making it impossible to detect double infections. Protease is critical in penetration of cuticle (mostly protein). Nothing known for *Neozygites*. At BTI have sequenced a protease and are attempting to modify and observe effect on substrate specificity. It would be interesting to know how to induce resting spores for storage.
*See additional notes provided by Don in Appendix III.

6. Presentation by Siegfried Keller

Twelve species of *Neozygites* have been described. Morphological characters include: Protoplasts (present or unknown (either not present or undescribed)), hyphal bodies (spherical or rod-shaped); resting spores (ellipsoidal or spherical); germ conidia (capilloconidia, similar to primary, unknown). These characters result in three groups. Case of *N. floridana*: rod-shaped hyphal bodies germinate with single germ tube, penetrate host. Sexual cycle: four-nucleate hyphal bodies multiply by binary fission and then pair, form bridge (genetic exchange?), producing cytospore Thick cell wall formed, resting spore. Germination of resting spore produces germ conidium at top of thick germ tube that produces the infection. Rhizoids are produced by resting spores that attach mite to the leaf in some species. May be a taxonomic character.

Samples of *N.* from Brazil have been characterized for length and diameter of the hyphal bodies and the ratio (L/D), the presence of secondary conidia resembling primary conidia, capillary tube size, and number of nuclei in hyphal bodies (3 in 27% and 4 in 74% for Benin. Benin material matched descriptions of *N. floridana*. Brazilian material has slightly larger primary conidia. Hard to determine. Prefers to consider strains as one species that cannot be separated by morphological or cytological methods. Genetic methods may provide further characters. It is important to note that these comparisons are based on very few specimens (5 for Benin, 2 for Brazil) and would need more material to examine. Genetic characterization would most likely be necessary for strain separation. Bottomline: *N. floridana* is our best identification available to date.

7. Presentation by Maurice Sabelis

Mite population dynamics. The damage caused by phtyophagous mites on a per capita basis is small and the colonizing population is small. Thus, several generations of population growth are required to achieve overexploitation of the host plant. The system of plant/phytophagous mites/predatory mites is

characterized by overexploitation of the host plant by the phytophagous mite and overexploitation of the phytophagous mite population by predators. Therefore, there is very little chance of stability on a local scale. Persistence is only possible at a meta-population scale.

Assumptions for model:

Predation is constant and maximal

Prey population grows exponentially in the absence of predators

Predator population grows exponentially

Population is without age structure

Predators do not disperse until prey are wiped out

Constant environmental conditions

Insights from model: Small differences in timing of predator invasion result in large differences in prey population and therefore host plant damage. Natural selection will favor plant genotpes coding for traits that promote effectiveness of natural enemies.

Possibilities for cheating:

Other herbivore may utilize shelter, food, etc.

Organisms other than herbivores and predators may take advantage of plant effects

Plants without characters may take advanatage of neighboring protected plants

Indirect plant defense promotes effectiveness of natural enemies by

1. Provision of shelter to mites on plants

Predatory mites often found in acarodomatia, phytophagous mites only occasionally. Phytophagous mites would not be selected for entering domatia as their encounter rate with natural enemies would increase. Acarodomatia are selected for only if provided scarcely. On cassava, growing tips are often inhabited by predators (as the case of *T. aripo*). No special structure known. Transmission of disease between predators could endanger this theory.

2. Providing alternative food (Pollen, Extrafloral nectaries, Plant exudates (from phloem & xylem) used by various nat enemies), Parenchym tissue. Plants should not provide food of too high quality otherwise predator may switch.

3. Facilitating foraging (Dispersal, take-off, passive transport by air currents, landing)

Searching (for spider mite patch; for colonies within a patch; for spider mite in a colony; for a suitable site for take-off).

Can enemies smell spider mites?

With Phtyoselulus persimilis, infested leaves were preferred.

Spider mites alone, webbing, infested leaf plus spider mites, as odor sources produced no response. Spider mite faeces, v. small response. Only damaged leaf w/o spider mites approached attractiveness of full system (damaged, infested leaf).

Compounds identified. Four components, each attractive independently. Host plant does not produce volatiles if artificially damaged; induction by spider mite required.

Systemic nature of ellicitor within plant demonstrated; Plant actively involved in producing signal, probably with a spider mite ellicitor.

Response to airborne signal : contamination or communication?

Conclusions

- Plants betray the presence of phytophagous miteoes to predatory mites by conveying information of a volatice nature (synomones)
- This is inducible between plants (communication).
- The response of predatory mites is prey-specific.
- *T. limonicus, N. californicus, N. anonymus* had positive response to CGM on cassava. Other species not.
- Phytoseiid mites locate plants infested by phtyophagous mites by means of olfaction.
- They can distinguish between spp. of phytophagous mites feeding on the same host plant.

SLL: Are similar interactions to be expected between fungi and mite hosts?

LS: Nematode entrapping fungi respond to presence of nematodes.

SK: Flies infected with entomophthorales are attractive to other flies.

DR: Scarabs avoid soil infested with entomopathogen.

8. Presentation by Raul Cuero

How to make *N.* a good biocontrol agent? By increasing efficacy. Discrecancy between requirements of the fungus and the mite. Have to amplify "window" of opportunity for the fungus, therefore must look at microclimatic conditions. Dew point or water potential as measures of microclimate are essential to determine conditions actually experienced by the fungus.

Chitinaceous (chitin, chitosan) natural polymers are easy to produce. Chitosan produced by deacetylation of chitin to chitosan. By applying chitosan, can stimulate germination when abiotic conditions are not appropriate.

Proposal: Evaluate in vivo application of *N.* as single biocontrol agent or in

combination with predators. Study host range, alternative host plants.

SLL: Is this approach appropriate for small-scale cassava production in northeast Brazil as it requires exogenous application?

GO: This appears to be a non-specific technique that could act against natural enemies and other non-target organisms.

MS: Could chitonase break down specificity of the fungus? If so, it could be a contribution to mass rearing of the fungus on (currently) non-hosts.

Appendix III. Notes provided by Don Roberts

The arthropod pathogenic fungi are uniquely adapted to directly penetrate the heavy-walled exocuticle of their hosts. An understanding of the sequence of events involved in the invasion of cassava green mite cuticle by *Neozygites* sp. is fundamental to understanding the limitations and key points for selecting and improving fungal strains. Such details are currently being explored at Boyce Thompson Institute and elsewhere with another important group of entomopathogenic fungi, viz. the fungi imperfecti (Deuteromycetes), primarily *Metarhizium* and *Beauveria*. We propose, to the extent possible, to utilize similar technology to assist in making wise decisions in the expected release and augmentation programs in Africa and South America with *Neozygites* sp. pathogenic to cassava green mite.

Cuticular invasion is, from the aspect of the fungus, a very ordered event. *Neozygites* presents some fascinating problems, primarily because there is so little current knowledge on this group—particularly in the area of infection processes and disease development. The infectious unit is expected to be capilloconidia produced from primary spores. For experimental purposes, other isolates of *Neozygites* (not from cassava green mite) have been grown in liquid medium as protoplasts, and these protoplasts produced capilloconidia when spread on agar (solid) media. Capilloconidia, of course, are also produced on dead infected hosts. The steps in the invasion process normally involve: attachment of the conidium to the host; recognition by the conidium of the host; germination of the conidium; production of invasion structures (normally appressoria); production of cuticle-dissolving enzymes; penetration of host cuticle; utilization of mechanisms to avoid (usually via specialized outer layers of the fungus hyphal bodies or protoplasts) or production of metabolites which immobilize the phagocytic phase of the host immune system; in some cases, production of toxins; ramification of hyphae throughout the host; host death; penetration from the inside to the outside of the host; and finally production of conidia on the host.

Attachment

The attachment of *Neozygites* capilloconidia to their hosts is assumed to be by the adhesive spot found at the tip of the conidium. The chemical nature of this adhesive material is not known for any of the Entomophthorales. Accordingly, some studies with histochemical stains and enzymes will be utilized to broadly characterize the adhesive material. Of particular interest is whether there is any host recognition associated with this initial adhesion. Accordingly, the ability of the capilloconidia to attach to smooth and rough, hydrophilic and hydrophobic substances such as plastic and glass, as well as the cuticles of non-host mites and insects, will be examined to evaluate the role of this trait in host specificity.

Germination and Differentiation

Once the conidium is attached to its host, it must recognize the host and germinate. Physical and chemical factors may be involved. In the case of *Metarhizium anisopliae*, a smooth hydrophobic surface with a minute level of nitrogenous nutrient is adequate for germination and production of infection structures. Germinating fungal conidia frequently produce significant amounts of mucus, which apparently aids in attachment to host and nutrient substrates during germination. Such mucus materials will be sought in scanning electron micrography (SEM) of hosts in the process of being attacked by the fungus; and, after an in vitro germination system has been developed, by direct staining and exclusion dyes. In vitro germination studies will include the use of chemicals obtained by solvent washes (alkanes and chloroform/methanol) of mite cuticles. Such chemicals may inhibit germination, but based on older literature of other fungi are more likely to stimulate germination. Various sources of carbon and nitrogen will also be utilized in the germination studies. Non-hosts will be included in this phase of the study. Their examination following exposure to capilloconidia will indicate whether the failure to be infected comes at the attachment, recognition, germination, penetration, or later development stages.

Penetration

After germination, some fungal isolates of low virulence grow extensively over the host cuticle without penetration. Virulent isolates of *Metarhizium* and *Beauveria* have little of this "errant" growth, but rather almost immediately penetrate the host. Penetration can be accomplished without specialized invasion structures, but it is more common for the germ tube from the conidium to produce an appressorium from which the fungus gain purchase to invade the host. We have found that the production of cuticle-dissolving enzymes is closely associated with the differentiation of the fungus to make appressoria. Currently, it is not known if the capilloconidia of *Neozygites*

produce appressoria. This is easily determined, as we have done previously with another entomophthorales fungus, *Zoophthora radicans*, by direct observation. Host mites will be exposed to capilloconidia and observed by SEM and by direct light microscopic observation using epifluorescence, and by staining the fungi on the host with fluorescent dyes such as Uvitex or Calcofluor. The scanning electron and light microscopic studies will afford knowledge on the preferred invasion site of the fungus into its host, viz. intersegmental membranes or heavier structures. Exuvia and cuticular ghosts of hosts will be used in this phase of the work. Ghosts are prepared by boiling hosts in SDS to remove all soluble components, leaving only the cuticle. Exposure of ghosts to capilloconidia will reveal the importance of physical structures, such as cuticular protuberances, on the attachment, germination, and invasion of cuticle. Histochemical tests, particularly MNA peptides released during cuticle penetration will be detected by use of a chelating agent, such as fast blue B, to give color and indicate enzymatic action during penetration of host cuticle. Plastic replicas of mite cuticle also may be formed to investigate the importance of surface structure to the fungus in invading its host. Of particular interest, considering the novel chemical aspects of cassava, will be to examine the effects of extracts of cassava leaves on the invasion processes of *Neozygites*.

Enzymes Involved in Penetration

As mentioned previously, enzyme activity will be detected in place with histochemical methods. We have examined extensively the wide range of proteases produced by *Metarhizium anisopliae* during invasion of insect cuticle. Similar enzymes probably exist in *Neozygites*, and as with *Metarhizium*, their manipulation may be useful in understanding the invasion process and the genes themselves are expected to be useful in enhancing virulence of these and other pathogens. Accordingly, if in vitro cultures which can be induced to differentiate invasion structures become available, such studies similar to those conducted by us with *Metarhizium* and, more recently, with *Beauveria*, will be carried out. This will provide both basic knowledge and tools for evaluating and improving fungal isolates. Powerful tools are now available to quickly characterize small amounts of enzymes. For example, the enzymes in isoelectric gels can be characterized with enzyme overlay membranes with substrates for chymotrypsin- or trypsin-like genes, exopeptidases, chitinases, lipases and other enzymes. Also substrate specificity for enzymes can be examined in the same way without the necessity of purifying large amounts of a specific enzyme.

Toxins

Toxin production will be examined if strong cultures of the fungus become

available. The test animal for contact and feeding assays will be the cassava green mite, but for injection studies it will have to be a larger arachnid or insect.

Appendix IV. Notes provided by Chris Lomer

(The following notes were sent by Dr. Chris Lomer (Insect Pathologist, IITA) who was unable to attend the workshop).

Epizootiology, CGM and *Neozygites*

There are essentially four factors interacting to drive fungus outbreaks epizootics in the field. Host mite susceptibility; pathogen genotype; pathogen inoculum availability and micro climatic factors. The first two are best considered together. The essential point is that we must first know what the fungus is currently doing to mite populations in Brazil and in Africa, then look at which factors can be manipulated.

Current status

As far as I understand it, in Benin we have surveys showing the incidence of African isolate of *Neozygites* and *Hirsutella* which lead us to suppose that both fungi are fairly widespread, but as yet we have no detailed ideas on the impact that either have on the mite in the field. This would be best accomplished by some preliminary life table studies in the field, preferably with measurement of micro climate variables. In Brazil I think you are a bit further ahead with his type of study. So you may already have some ideas on what is driving fungus epizootics there.

Host mite susceptibility/pathogen genotype

These two factors need to be considered together - obviously a mite resistant to one fungus strain may well be susceptible to a different one. The essential point is that we need some basic measure of the 'virulence' (big debates about the use and meaning of this word in pathology) between the pathogen and its host both in Brazil and Africa. IF there are differences here, then there is a good case for swapping isolates around from one continent to another.

Inoculum availability

In order for epizootics to occur, the fungus inoculum must be available - either in a dormant or resting spore stage (but ready to germinate), or recycling in the host (or an alternative host), or arriving from elsewhere. If it can be shown that epizootics are inoculum-limited, then there are good prospects for introducing fungus in one form or another. (This was what Sam Elliott was proposing to look at - the way the pathogen survives between outbreaks.)

Micro climatic factors

Obviously, these are the least manipulable of the factors involved, unless

different cassava varieties or soils influence micro climate in some way, such as a closed canopy raising humidity. If epizootics in Africa are limited by low humidity, there are few prospects for successful intervention. However, we do notice that during Harmattan, we get a lot of outbreaks of Entomophthoralean fungi, particularly *Entomophaga* on *Zonocerus*. Whether this is due to spores being transported/protected with dust, or the ups and downs in humidity leading to condensation, we just don't know. The point is that there can often be a few surprises when you go into the details.

Other interactions

Other possible interactions which need to be considered if the answers don't turn out to be obvious: some fungus strains may be no different in virulence, but have more resistant resting spores, faster germination, or lower humidity requirement. Reduced solar radiation or heat for any reason may improve spore survival, and this may be strain-dependent. Conversely, too much moisture can cause deterioration of spores.

Summary

To summarize, we need to find out whether the fungus/mite situation is different in Africa and Brazil. If the fungus is doing more to control the mite in Brazil than Africa, then we need to know whether this is because of an interaction between the host and the pathogen (which we might be able to do something about) or whether there is a climatic/micro-climatic effect (which would be hard to do anything about).

Appendix V. Notes provided by Raul Cuero

(The following notes were extracted from a draft proposal developed by R. Cuero[1], R. Humber[2], F. Gilstrap[3], G. McIlveen[3] & C. McCoy[4]. [1]Prairie View A&M University; [2]USDA-ARS-Plant Protection Research, Ithaca, New York; [3]Texas A&M University, Entomology Dept.; [4]University of Florida, IFAS, Florida)

Use of the pathogenic fungus Neozygites is an ideal approach to be implemented as an alternative and/or complementary to biocontrol of the CGM. The role of what may be a complex of poorly circumscribed Neozygites species (Zygomycetes: Entomophorales) as pathogens of mites affecting cassava and other crops in Brazil, Colombia and elsewhere is clearly established (Muma, 1969; Nemoto and Aoki, 1975; Branderburg and Kennedy, 1982; Smitley et al., 1986; Alvarez et al., 1991; and Dick et al., 1992). Pathogenic strains of Neozygites isolated from CGM are host-specific (R. Humber personal communication). Therefore, it is very important to determine how to distinguish the Neozygites species (Humber et al., 1981). Three species of Neozygites, N. floridiana, N.

tetranychi, and N. adjaria have been described from tetranychid mites (Humber et al., 1981). The USDA-ARS Collection of Entomopathogenic Fungal Cultures (ARSEF; Ithaca, NY) currently includes two strains of Neozygites isolated from mites, both of these were isolated with relative ease after using only small number of infected mites as source of inoculum. These strains represent, to the best of our knowledge, the only germplasm of any Neozygites species currently available in axenic cultures. During a recent trip to Brazil, Dr. R.A. Humber, the ARSEF curator, who isolated these Neozygites cultures, demonstrated the techniques for isolation further Neozygites cultures to Dr. Delalibera (EMBRAPA-CNPMFT, Cruz das Almas, Bahia). Therefore, it is anticipated that this effort should result in the isolation of a considerable number of strains of Neozygites from CGM and other mites affecting cassava.

Phytoseiid mites may be the most important nontarget beneficial invertebrate operating in cassava plantations for which non-target effects of Neozygites and any other fungal mite biocontrol agents must be studied. Fortunately, it has long been observed that phytoseiid mite predators operating in populations of tetranychid mite prey species are refractory to species of Neozygites and other fungal genera that may be causing mortality among their tetranychid prey. A number of hypotheses for this differential effect have been offered; these range from non-adherence of conidia to phytoseiid mite, to more fastidious grooming habits of phytoseiids than of tetranychids,, to potential differences in cuticular chemistry that might prevent the successful infections of phytoseiid mites (R. Humber, personal communication).

Usually, both the pest CGM and the pathogenic fungus Neozygites require different moisture conditions for maximum growth. Thus the CGM is more prevalent during dry season, and Neozygites, like most fungi, require high moistures for germination, conidiation, reproduction, colonization and infection. Therefore, it is important to develop a reliable delivery system for the biocontrol agents, which ensures continuous growth of Neozygites in the field, and consequently efficient biocontrol of CGM. The delivery system should function independent from the dynamic of the CGM population, and drastic changes of weather conditions during field growth of cassava plants. The main criteria for selecting the delivery system are: a) it should be able to be used in combination with the other biocontrol methods without reducing the efficacy of them, b) it should give both physical and nutritional protection to the pathogenic fungus, Neozygites, c) it should not affect the development of the cassava plant, d) it should be of natural origin, e) it should be able to offset deficiencies of the other biocontrol methods, f) it should be cost-effective, g) it should be able to

easily be found or produced in cassava-growing countries, and h) it should be environmentally sound.

In recent years, commercial producers have identified physiological factors that affect fungal survival and infectivity. Moisture, temperature, and nutrient availability are major factors affecting germination, sporulation, growth, infectivity, and rate of survival (Cuero et al., 1987; R.Humber, personal communication). Fungal metabolism is temperature-water activity-driven. These factors, over time, affect fungal pathogenicity and viability. Consequently, different type of microbial carriers have been developed that immobilize the fungus in an effort to maintain metabolism, growth, and even improve shipping and storage stability of the biocontrol agent. Several techniques have been employed for the delivery of biocontrol agents. For example, biocontrol organisms have been applied in liquids (Papavizas et al., 1982), in organic matter (Wells et al., 1972), and in vermiculite or in clays such as Pyrax (Maul et al., 1980; Fravel et al., 1983). Encapsulation of potential fungal biocontrol agents in an alginate-clay amtrix have been developed and effectively used (Fravel et al., 1985). Among the current list of carriers are attapulgite clays, polyacrylamide and alginate gels. Some of these formulations, especially those with gels, use sodium citrate as an activator. However, most of these formulations or carriers may not be cost-effective to be used in developing countries, and they do not provide all the biological demands (see above mentioned criteria) to a fastidious biological control agent such as Neozygites. Different bioasay methods have been developed using mites as a host (McCoy and Cough, 1978; McCoy, 1981); however, environmental conditions and continuos nutritional availability influence the efficay of the method. McCoy (1986) reported than less tha 80% relative humidity in moving air reduced survival of Hirsutella thompsonii significantly after 4 days compared to 100% R.H. with no air movement. He also reported that survival was improved by imcorporating ,olasses and soyflour as energy sources into wettable powder formulation.

Chitinaceous material such as chitosan (B-1,4 glucosamine residues) which is chemically derived by deacetylation of natural-occurring chitin, and their enzymes (chitinase/chitosanase) hydrolyze chitin/chitosan (Muzzarelli et al., 1988). Some proteins show chitinase activity, sometime in combination with lysozyme activity (Kombrink et al., 1988). Chitinase degrades the poly-N-acetylglucosamine chains that form chitin, a major compound of the cell wall of fungi and the exoskeleton of arthropods (eg., insects, acari), whereas lysozymes degrades the poly-(N-acetylmuramate-N-acetyl-glucosamine) chains that are part of the bacterial cell wall (van Scheltinga et al., 1993). This is an ideal material to

be used as delivery system for field application of Neozygites as biocontrol agent of CGM. This polymer is a good carbon and/or nitrogen source, has high moisture retention, is resistant to thermophilic conditions. Chitosan has successfully been used as delivery system with Rhizobium for legumes (Dean, 1992). Encapsulation of the biocontrol agent Trichoderma sp. in a mixture of chitosan with alginate-clay matrix protected the fungus helped it to maintain high population in corn under greenhouse conditions(Cuero, 1987, unpublished). Glucosamine sugar, which is the basic unit of chitosan, can also be used effectively to stimulate fungal sporulation (Cuero, 1992, unpub.). Maltose stimulates Neozygites sporulation (R. Humber, personal communication).

Similarly, chitosan enhanced fungal and bacterial survival in field corn (Cuero et al., 1991). Chitosan also induced phytoalexin precursors including free and bound phenolic compounds in peanuts (Cuero et al., 1992; Fajardo et al., 1994 in press). This induction of phenolic compounds by chitosan will enhance biocontrol capacity against CGM whenever chitosan is used as delivery system. Mites like many organisms are also susceptible to phenolic compounds and/or phytoalexins. The process of molting is universal among arthropods and the monolayered epidermis is the main player. The CGM like any other arthropod, has an exoskeleton with epidermal cells where chitin microfibrils make up the bulk of the endocuticular lamellae (see Figure 1). Chitin is synthesized as a chitin-protein complex concurrently during the intermolt phase immediately after acdysis. The arthropod cuticle (eg. procuticle) is made of chitin, a B 1-4 linked polymer of N-acetylglucosamine that is probably covalently bound with a protein that requires severe conditions for separation (Takiguchi et al., 1987). The procuticle is rigid and strong excepting in intersegmental regions where it is flexible, and provides the insect with not only protection from outside forces but also a stratum for muscle insertion (Retnakaran and Oberlander, 1993). Hormonal regulation of chitin synthesis in two insect cell lines has also been demonstrated (Spindler-Barth et al., 1989). Chitinolytic activity has also been observed in other molting animals (eg., Antarctic krill, Euphasia superba). Chitinolytic enzymes are directly involved in its growth process under a double aspect: first, as moult cycle related resorptive enzyme in the integument, and second, as digestive enzymes (Buchholz, 1983). Entomapathogenic fungi such as Metarhizium sp has shown chitinolytic enzyme activity. Chitinase is one of the hydrolytic enzymes secreted by the entomopathogenic phycomycete fungus M. anisopleae. Chitinase production among strains of M. anisopliae with different types of chitin as carbon source, in relation to variations in pathogenicity toward the locus Schistocerca greagria, has been demonstrated (Valadaras & Peberdy,

1983). Production of chitinase/chitosanase from phycomycetes fungi such as Mucor spp (Araki and Ito, 1975; Villagomez-Castro et al., 1993); and Saprolegnia sp (Gay et al., 1993) and other species (Allan and Hadwidger, 1979) has been reported. Barnicki-Garcia (1973; 1984; 1987; 1988) has extensively studied the presence of chitnaceous material in fungi including phycomycetes. Chitosanase induction in plants has also been reported (Hadwiger et al., 1981; Cuero et al., 1992; Cuero and Osuji, 1993). Chitinaceous material such as chitosan increased both chlorophyll production in tomato (Cuero et al., 1991), and storage protein in corn (Osuji and Cuero, 1992).

From the above mentioned reports and information, an ideal situation to biocontrol of the CGM would involve a combination of Neozygites, which is CGM specific pathogen, and which functions well at both higher and low mite densities, and with phytoseiid mite predators which are better at controlling mites at low densities. The use of a natural delivery system, such as chitosan, will ensure continuous high Neozygites population. It will also contribute to control the CGM by softening its exoskeleton.

Dissemination of new technology always involves training of personnel, distribution of didactic materials, and implementation of extension program. Therefore, dissemination of the CGM biocontrol technology will involve the same approach with participation of farmers from project collaborators in South America and Africa. The Texas A&M University system has developed a strong extension program, and also has extensive experience in implementing cooperative extension programs in developing countries, especially Latin America and Africa. Prairie View A&M developed an unique extension program approach for transferring research technology to farmers, which is the utilization of non-professionals or paraprofessionals change agents termed "Agricultural Program Aides". These individuals are employed at the local level based on their similarly situated small farm background, leadership skills, and ability to relate and communicate effectively with small low-income farm producers. An evaluation of this concept in Texas, showed a significant increase in the level in which farmers adopted new farm practices (Strickland and Soliman, 1976). A similar approach was conducted in Ghana (Africa) with similar results as was obtained in Prairie View A&M University, Texas (Kirkwood and McIlveen, 1975).

Therefore, we are herein proposing an interdisciplinary approach to CGM biological control involving a combination of the pathogenic fungus Neozygites with different biological delivery systems (eg. chitosan, mummified cadavers of mites) and other agents (eg., alginate-clay material, and/or glucosamine) . The

effect of Neozygites on control of CGM will be assessed alone or in combination with phytoseiids mite predators. The research will involve: 1) field assessment in cassava grown in South America and Africa. Biological control agents will be introduced at different stage of cassava development, and under different moisture conditions. Both population of Neozygites and phytoseiids mite will be determined; and 2) assessment of the biology of the Tetranychus, Mononychellus, and Oligonychus pest mites and compare by construction age-specific life tables. Simultaneously, effects of the different biocontrol agents and delivery systems will be assessed on the mite biology using life table analysis, and the mortality variables will be determined.

It is expected that this research will yield innovative control methods against CGM in cassava producer countries, and also to be used in other crops and pathogens in both developed and developing countries and will ultimately lead to higher production and quality, safer crop harvest and longer storage times.

Appendix III

PROFISMA workplans for 1995.

Workplan 2 **International Coordination** **CIAT** **Stephen Lapointe**

Objective	Activity	Expected Output, 1995	Assumptions
Coordination of Strategic Research areas at CIAT and CNPMF.	1. Periodic briefings at CIAT. 2. Periodic PROFISMA meetings at CNPMF.	1. Collaborative strategic research between CIAT & CNPMF staff. 2. Integration of CNPMF & PROFISMA staff.	1. Staff interest.
Coordination of PROFISMA interactions with ESCaPP (Africa).	1. Meeting with ESCaPP coordinator in Coperhagen, June; travel to UNDP, NY. 2. Travel to Cotonou, Benin. 3. Sharing of data bases.	1. Proposal for project extension or second phase. New project areas defined. 2. Coordination of production of training materials. 3. Merging of PROFISMA and ESCaPP data bases.	1. Interest in continued funding from UNDP. 2. Travel with B. Ospina.
Representation of PROFISMA to UNDP.	1. Preparation and presentation of annual technical report to UNDP. 2. Coordination of financial reporting from CNPMF to CIAT. 3. Receive External Advisory Committee.	1. Prompt and complete reporting resulting in timely disbursement and execution of budget. 2. Feedback on overall project activities to participants. 3. Successful external project review.	1. Collaboration from National Coordinator. 2. Collaboration from financial sector, CNPMF.
Information Management	1. Statistical analysis. 2. Data base archival data storage. 3. Creation of relational data base.	1. Experiments analyzed; feedback to researchers. 2. Data stored in digital form. 3. Structure determined for data base and interface.	
Publish project results.	1. Encourage & collaborate with project scientists in preparation of articles. 2. Participation in Internat'l Symp. on Plant-Inhabiting Mites, Denmark, June.	1. Publications in peer-reviewed journals. 2. Publications in Experimental & Applied Acarology.	1. Collaboration of CIAT, CNPMF & PROFISMA staff.

Workplan 3 **National Coordination** **CNPMF** **Aristoteles Matos**

Objective	Activity	Expected Output, 1995	Assumptions
Mechanisms for better institutional relations.	Elaborate agreements enabling fund transfer from EMBRAPA to collaborating institutions.	Timely development of activities in state institutions with adequate funding & collaboration of EMBRAPA	
Supervision of activities in CE, PB, PE, AL, SE and BA	Periodic visits to states conducting PROFISMA activities	Completion of collaborative trials and planning of new experiments	
Integration of additional Brazilian expertise in socioeconomics.	Identify and invite Brazilian University faculty to review PROFISMA workplan and their potential involvement	Improved capacity in Brazil for data collection and analysis	
Training in IPM for national coordinator	University of Illinois course on IPM	Improved overview of IPM for LDCs with emphasis on coordination.	Course is relevant to developing countries.
Project representation	National scientific meetings	Project promotion to a wider audience within Brazil	
Coordination of EMBRAPA activities with CIAT	Travel to Cali, Colombia	Present PROFISMA activities to CIAT and refine ongoing activities.	

Workplan 4.1 **Training** **CIAT, CNPMF** **Bernardo Ospina**

Objective	Activity	Expected Output	Assumptions
Train researchers & extensionists in planning technology testing activities with farmers, & farmers' evaluation of trials.	Two courses (11 days ea) for researchers & extensionists from CNPMF & counterpart institutions in Ceará, Bahia, Pernambuco & Paraíba. One course at Cruz das Almas with collaboration of CNPMF & EBDA, the other at Recife, Pernambuco with collaboration of IPA-PE & EMATER-PE.	1.Trained cadre of researchers & extensionists to do technology-testing with farmers. 2. First technology-testing trials set up by trainees & farmers. 3. First CIAL's (Local Committees for Agric. Research) at pilot sites in BA, CE, PA, & PE. 4. Farmers trained by trainees in particip. res.	1. Collaboration from CIAT's IPRA project with PROFISMA's funding 2. Collaboration from CNPMF, EBDA, IPA-PE & EMATER-PE, with PROFISMA's funding
Training/updating researchers & extensionists in cassava production & crop protection.	Refresher seminar for researchers & extensionists from CNPMF & BA, CE, PA & PE.	Cadre of researchers & extensionists trained in methods developed & results obtained as part of PROFISMA's activities	Participation of research staff from CIAT, CNPMF & other institutions as resource-persons.
Sustainable human resource development through Training of Trainers.	Formulation of a proposal for a Training of Trainers component complementary to PROFISMA's current training activities	1 Proposal formulated. 2 Funding sources sought.	Collaboration from CIAT's IPRA project, IIED-London & EScAPP-IITA.
Cooperation with CNPMF in project management.	Assistance to the CNPMF project coordinator & administrators in project implementation with emphasis on financial control & reporting.	1. Strengthend liaison & communication between CIAT & CNPMF. 2. Strengthened financial control & reporting methods.	

Workplan 4.2 Socioeconomics CIAT, CNPMF G. Henry, B. Ospina, J.H. Almeida

Objective	Activity	Expected Output	Assumptions
Socioeconomic characterization of project area.	Completion of extensive phase of the Interdisciplinary Diagnostic Survey.	1. Data from Diagnostic Surveys in BA, CE, PA & PE analyzed, published & distributed. 2. Identification of traditional farmer practices, farmers' perceptions of problems & key collaborators. 3. Study areas identified for intensive Interdisciplinary Diagnostic Survey.	Collaboration & participation of counterparts from Ceará, Bahia, Pernambuco & Paraiba.
	Intensive phase of the Interdisciplinary Diagnostic Survey.	Baseline socioeconomic database.	Collaboration & participation of counterparts in CE, BA, PE & PA.

Workplan 5.1 Acarology CIAT, PROFISMA Lincoln Smith

Objective	Activity	Expected Output	Assumptions
Classical biological control of CGM in northeast Brazil and Africa.	1. Analyze geographic phytoseiid distribution. 2. Collect populations of phytoseiids from dry environments 3. Ship predators to Brazil & Africa 4. Evaluate phytoseiid prey preference 5. Evaluate cassava varietal effects on phytoseiids 6. Test variety, mulch, intercropping, prey-refuge in field at Pivijay 7. Test release strategies in field at CIAT 8. Write taxonomic key to cassava phytoseiids. 9. Develop CD-ROM database for biocontrol, bibliography, cassava management, researcher directory	1. Geographic & climatic range of phytoseiids. 2. Establishment of cultures of predators at CIAT 3. Establishment of exotic phytoseiids in NE Brazil & Africa. 4 - 7. Determination of effects on CGM-predator population dynamics 8. Publication of a taxonomic key. 9. Print and distribute CD's to national programs in Latin America & Africa	Continued cooperation of PROFISMA, ESCaPP, CNPMA, University of Amsterdam for quarantine, rearing, and releases Collaboration with M. Bonierbale and M. El-Sharkawy Collaboration with G. de Moraes at CNPMA Collaboration with ESCaPP & scientists in Florida; additional funds.
Genetic characterization of *Neozygites* & phytoseiid strains.	1. Develop culture methods. 2. Collect isolates from Colombia, Ecuador, etc. 3. PCR analysis of isolates.	Sufficient quantities of pure DNA for analysis. Establish lab cultures Tests to identify strains	Methods to isolate sufficient pure DNA; collaboration of J. Tohmé
Develop PCR method to identify geographic strains of Phytoseiids	PCR analysis of phytoseiid strains	Tests for strain identification.	Collaboration with J. Tohmé & Marjorie Hoy (Florida)

Workplan 5.3a (continued) Control of root rots CIAT Fernando Correa

Objective	Activities	Expected Outputs	Assumptions
Improve efficiency of *Trichoderma* spp. strains to control *Phytophthora*-induced root rot.	1. Greenhouse trials to select *Trichoderma* strains to control *P. parasitica* under similar edaphic and climatic conditions of *Phytophthora*-endemic areas. 2. Greenhouse evaluation of elite strains using various delivery methods, application times, soil mixtures & cassava cvs. 3. Greenhouse evaluation of selected strains on two cassava clones to control *P. drechsleri*.	1. Six elite *Trichoderma* isolates to control a highly pathogenic strain of *P. parasitica* from Brazil. Elite isolates must show 80% control in at least 50% of trials. 2. Optimal delivery system for *Trichoderma*. 3. Preliminary results on efficiency of six *Trichoderma* isolates to control *P. drechsleri*.	CIAT pool personnel for propagation of rooted cuttings.
Development of integrated disease management implementation strategy through a pilot project.	1. On-farm evaluation of selected strains in three clones at Maria La Baja (Bolivar), an endemic *Phytophthora*-area. 2. Field day: Visits to growers at Maria La Baja; training extensionists in implementation of on-farm biocontrol practices.	1. Two *Trichoderma* strains exhibiting biocontrol of *Phytophthora* in a commercial cassava field. 2. Detailled information of cassava growers and extensionists concerning potential of delivery methods to introduce biocontrol agents.	Travel expenses to experimental site at Maria La Baja .
Selected strains of *Trichoderma* spp. to control *Diplodia manihotis*.	Field evaluation at CIAT of *Trichoderma* strains to control *D. manihotis*.	Selected *Trichoderma* isolates for control of *D. manihotis*.	Temporary labor to maintain field trials.
In vitro methods to select *Trichoderma* isolates & establish their mode of action.	Evaluation of 20 strains by inhibition of pathogens using cell-free culture filtration method in vitro.	Improved in vitro method to screen and evaluate *Trichoderma* isolates.	
Improved delivery method for *Trichoderma* in small-scale farms; Methods to produce & apply inoculum by stake treatment & soil augmentation.	Preparation of two benomyl-resistant strains and one on-farm trial at Maria La Baja.	Population dynamics of *Trichoderma* introduced in a cassava field.	Costs mencioned in objective B.
Characterization of beneficial isolates of *Trichoderma*.	Taxonomic characterization.	Five characterized elite biocontrol agents.	
Expand existing collection of *Trichoderma* isolates.	1. Isolation of *Trichoderma* from the rhizosphere of healthy plants in a root rot infected cassava field. 2. Identification of duplicate strains.	Strains to evaluate in greenhouse trials during 1995 & 1996.	Isolates collected in Brazil.

Workplan 5.2 **Entomology** **CIAT** **Anthony Bellotti**

Objective	Activities	Expected Outputs	Assumptions
Classical biological control of cassava mealybug in NE Brazil	1. Surveys of parasitoids and predators. 2. Maintenance of cultures of three parasitoids. 3. Shipment of parasitoids to Brazil. 4. Competition studies.	1. Identify important parasitoids & predators 2. Establish exotic parasitoids in Brazil 3. Select best species	Collaboration with PROFISMA & CNPMA
Biological control of cassava whiteflies	Determine natural enemy complex of cassava whiteflies through explorations in Colombia, Venezuela and Ecuador	Identification and distribution of key natural enemies	Collaboration with PROFISMA & CNPMA

Workplan 5.3a **Control of root rots** **CIAT** **Fernando Correa**

Objective	Activities	Expected Outputs	Assumptions
Biological control of root rots	Epidemiological study of *Phytophthora* & *Fusarium* survival in artifically-infested soils.	Definition of edaphoclimatic factors affecting pathogen development	Soil samples from regions that differ in pH, minor & main elements, OM, texture, & crop management.
Determination of relationship between inoculum quantity & incidence & severity of *Phytophthora* & *Fusarium* root rots.	1. Develop methods to produce & standardize inoculum: a. Separation of chlamydospores, sporangia & zoospores. b. Establish infection rates of propagules by inoculation of rooted cuttings & stakes. 2. Standarize *Fusarium* inoculation of stakes. 3. Cytology & histology of healthy & infected tissue.	1. Optimal production & inoculation conditions. 2. Information on host-pathogen interactions.	1. Vegetative material and statistical models to evaluate inoculation methods. 2. Availability of electronic & light microscopes.
Evaluation of genetic variability of *Fusarium* & *Phytophthora* spp. from Colombia & Brazil.	1. Glasshouse inoculation trials. 2. Laboratory comparison of strains using molecular techniques.	1. Characterization of strains according to aggressivity. 2. Molecular caracterization of biotypes.	1. *Phytophthora* & *Fusarium* strains from Colombia & Brazil. 2. Collaboration w/ CIAT Biotech Unit for microörganism production & conservation.

(continued...)

Workplan 5.3b Virology CIAT Lee Calvert

Objectives	Activities	Expected Outputs	Assumptions
Characterization and diagnosis of CVMV	1. Characterization a. Pathogen diversity b. Serology		
Development of control strategies for CVMV	Field Trials a. Yield loss assessment. b. Control strategies	Determine yield loss and assess impact of clean stake introductions.	Availability of in vitro CVMV-free planting material.
	Epidemiology a. Field movement b. Assay potential vector for CVMV	Determine if virus is moving under field conditions Identify vector of CVMV	PCR test transferred to CNPMF

Workplan 5.4 Crop Management CIAT Mabrouk El-Sharkawy

Objectives	Activities	Expected Outputs	Assumptions
Components for improved and integrated crop management systems for subhumid and seasonally dry ecosystems.	Characterization of long-term response of cassava to NPK levels in acid infertile soils. Characterization of long-term response of cassava to plant surface mulch and fertilizer application in poor sandy soils	Identification of managment practices to sustain productivity in infertile acid soils Identification of crop management practices to improve productivity in poor sandy soils	

Workplan 6.1 Agronomy CNPMF J. Eduardo Carvalho

Objectives	Activities	Expected Outputs	Assumptions
Improved crop management practices using cover crops	1. Evaluation of cover crops for soil & moisture conservation, weed control, & effect on yield. 2. Characterization of pest & natural enemy population dynamics in cassava with cover crops & varying weed management.	1. Selection of most efficient cover crop species. 2. Determination of effect of cover crops on biological control of CGM and other pests.	
Identify optimal weeding practices.	1. Determine most common weed species 2. Evaluate yeidl losses to weeds.	1. Identify the 5 most important weeds in cassava fields. 2. Define critical period of weed competition.	

Workplan 6.2a Acarology CNPMF Aloyseia Noronha

Objectives	Activities	Expected Outputs	Assumptions
Biological control of CGM through introduction of exotic phytoseiid mite predators	1. Surveys and population dynamics studies of arthropods on weeds in CE and PE. 2. Introduction, rearing, release and monitoring of phytoseiids from CIAT in BA, CE and PE. 3. Mass rearing of CGM 4. Taxonomic studies	1. Establishment of baseline data for impact analysis. 2. Establishment of phytoseiid colonies at CNPMF and in the field. 3. Maintanence of CGM colony at CNPMF. 4. Differentiation of native from introduced phtyoseiids.	

Workplan 6.2b Mite pathology CNPMF Ítalo Delalibera

Objectives	Activities	Expected Outputs	Assumptions
Selection of *Neozygites* isolates for biocontrol of CGM.	1. Collect & multiply isolates of *Neozygites* from NE Brazil. 2. Evaluate sporulation response of isolates to RH. 3. Evaluate viability of isolates under varying storage conditions.	1. Establishment of an isolate germplasm bank. 2. Selected isolates based on quantity & rate of conidia production at low RH. 3. Identify optimal storage conditions; information on mummy viability at ambient conditions.	Standardized isolate production at Petrolina. Mass production of mite mummies.
Small-scale production of *Neozygites* for lab studies and field releases.	1. CGM rearing & development of methods for production of mite mummies. 2. Evaluation of cuture media for isolation & production in vitro.	1. Method ofr mass production of *Neozygites* 2. Protoplast culture for genetic characterization studies.	
Develop methods for use of *Neozygites* for biocontrol of CGM.	Evaluation of inoculation techniques & pathogen dispersal in cassava fields at Piritiba, BA.	Reduction in CGM populations by timely application of *Neozygites* .	Mass production of mite mummies.
Determine effect of weeds and cover crops on indicence of *Neozygites*	Evaluation of population dynamics of CGM & infection on cassava under varying conditions of weed management & cover crops, Piritiba, BA.	Recommendation for sustainable management of CGM through appropriate weeding and cover crops.	
Generate basic knowledge on pathogen/host interactions.	1. Monitor dispersal & movement of infected CGM on plants. 2. Observation of behavior of potential hosts & other vectors.	1. Characterization of behavior of infected mites. 2. Determine occurrence of vectors or hosts & influence on pathogen dispersal.	
Evaluate effects of CGM and water stress on cassava varieties in the semi-arid.	Trial to evaluate variety x mite x irrigation effects at Petrolina, PE.	1. Isolate effects of drought and mite damage on root yield. 2. Characterize three cassava varieties for resistance to drought and CGM.	

Workplan 6.6b **Witches Broom** **CNPMF** **Chigeru Fukuda**

Objectives	Activities	Expected Outputs	Assumptions
Cultural control of Witches' broom	Participatory validation of cultural practices.	Recommended cultural practices.	
Genetic control	Participatory validation of resistant varieties.	Selected resistant varieties	

Workplan 6.6c **Virology** **CNPMF** **Celia Cámara**

Objectives	Activities	Expected Outputs	Assumptions
Characterization of CVMV and development of diagnostic tests	1. Purification a. Viral particle b. Genome c. Proteins 2. Rapid diagnostic tests a. Serological tests b. PCR-based test 3. Biological strain characterization	1. Methods for purification of virus, genome and particles. 2. a. Antiserum production and development of ELISA test b. PCR-based diagnosis 3. Determination of virus variability	
Development of control strategies for CVMV	1. Surveys of virus incidence to determine economic importance 2. Epidemiology a. Within-field movement b. Identification of vector	1. CVMV distribution. 2. a. Determine if virus moves within a field b. Identify or eliminate vector candidates	
Development of control strategies for Cassava Witches' Broom	Identification of vectors	Identify or eliminate vector candidates	

Workplan 6.3 **Entomology** **CNPMF** **Mauricio Bento**

Objectives	Activities	Expected Outputs	Assumptions
Biological control of cassava mealybug (CM) in NE Brazil through introduction of exotic parasitoids.	1. Importation & rearing of *E. diversicornis, A. coccois* & *A. vexans* at Cruz das Almas & Recife. 2. Quantification of biological impact in the field of the three parasitoids in BA & PE.	1. Mass rearing methods for the three parasitoid spp. for releases in NE Brazil. 2. Documentation of the impact of each species on CM populations, related plant damage, and root yield.	
Determine effect of weeds and cover crops on pest incidence and severity on cassava.	Population dynamics of arthropods on cassava with varying weed and legume covers.	Understanding of the effect of use of cover crops and weed management on pest and beneficial arthropod fauna.	

Workplan 6.4 **Quarantine** **CNPMA** **Gilberto Moraes**

Objectives	Activities	Expected Outputs	Assumptions
Safe introduction of natural enemies of cassava pests	Importation from CIAT of natural enemies. Establishment of colonies at CNPMA & CNPMF.	Permanent colonies of natural enemies of CGM & CM at CNPMF	

Workplan 6.5 **Environmental Imact** **CNPMF** **Ana Maria Eloy**

Objectives	Activities	Expected Outputs	Assumptions
Determine effect of biocontrol agents on non-target organisms	1. Laboratory trials to determine feeding behavior of biocontrol agents. 2. Glasshouse trials to study predator competitiveness 3. Determine effect of biocontrol agents on arthropods, plants and standard organisms.	Determine effect of biocontrol agents on the environment and non-target organisms	

Workplan 6.6a **Root Rot control** **CNPMF** **Aristoteles Matos**

Objectives	Activities	Expected Outputs	Assumptions
Biological control of root rot	1. Laboratory and glasshouse trials on effect of *Trichoderma* on root rot pathogens 2. In vitro studies on *Trichoderma* x pathogen interactions.	1. Selected *Trichoderma* isolates. 2. Determination of mechanism of action of *Trichoderma* against root rot pathogens	
Genetic control of root rot	1. On-farm trials to evaluate improved cassava genotypes for resistance. 2. Glasshouse and lab trials to evaluate resistance	Selection of cassava varieties resistant to root rot.	
Cultural control of root rot	Participatory trials to evaluate cultural practices for control of root rot	Recommendations for cultural practices.	