

Report of the External Advisory Committee

**GLO/91/013 ECOLOGICALLY SUSTAINABLE CASSAVA
PLANT PROTECTION IN SOUTH AMERICA AND AFRICA (PROFISMA)**

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Acknowledgement

The members of the EAC wish to thank CIAT and its PROFISMA participants for their gracious hospitality and willingness to engage in frank, open and sometimes exhausting discussions. The EAC was provided with excellent resources, and always felt that it was sincerely welcomed into CIAT's laboratories.

List of Acronyms

- ACMV, African Cassava Mosaic Virus
- BRU, Biotechnology Resource Unit
- CD-ROM, Compact Disc-Read Only Memory
- CGIAR, Consultative Group for International Agricultural Research
- CGM, Cassava Green Mite
- CIAL, Committe Local Para Investigacion Agricola
- CIAT, Centro Internacional de Agricultura Tropica, Columbia
- CNPMF, Centro Nacional de Pesquisa de Mandioca e Fruticultura, Crus das Almas, Brazil
- COPAL, Comité Pesquisa Agricola Local
- CVMV, Cassava Vein Mosaic Virus
- EAC, External Advisory Committee
- ELISA, Enzyme Linked Immunosorbent Assay
- EMBRAPA, Empresa Brasileira de Pesquisa Agropecuria, Brazil
- ESCaPP, Ecologically Sustainable Cassava Plant Protection
- FPR, Farmer Participatory Research
- GIS, Geographic Information System
- IICA, Inter-American Institute for Tropical Agriculture, Costa Rica
- PCR, Polymerase Chain Reaction
- PROFISMA, Protecao Fitossanitaria Sustentavel de Mandioca (Sustainable Cassava Plant Protection)
- RAPD, Random Amplified Polymorphic DNA
- RFLP, Restriction Fragment Length Polymorphism
- UNDP-OPS, United Nations Development Programme, Office for Project Services

I. INTRODUCTION

This report is the third in a series of reviews of the UNDP Project GLO/91/013 "Ecologically Sustainable Cassava Plant Protection in South America and Africa". The African component of the project is known by the acronym ESCaPP and the South American component as PROFISMA. Introductions to the two previous reports dated 26 September, 1994 (PROFISMA) and 28 February, 1995 (ESCaPP) summarized the worldwide importance of cassava, the quests, objectives, phases and participants of the project, and the terms of reference for the EAC.

The South American component of GLO/91/013 is carried out in two locations, CNPMF, the research station in Bahia of the Brazilian federal government's agricultural research service (EMBRAPA) (see the 26 September, 1994 report), and at CIAT in Columbia, the subject of this review.

The EAC spent four full days evaluating the CIAT component of PROFISMA, including a half-day field trip. In the following review the EAC's impressions of the key aspects of various components of the project are described. Twelve specific recommendations are formulated in bold face throughout the report; other suggestions may be embodied in the text.

II. REVIEW OF RESEARCH

A. Comments From Project Administrators

In his introductory remarks to the EAC, the Director of CIAT stressed the significance of a recent CGIAR review of root and tuber research in which cassava stood out in its importance as a food crop, and also posed the opportunity for collaborative research to yield substantial benefits. A reorganization of the CIAT research structure, described by the Deputy Director should facilitate the type of synergistic activity that can occur when an interdisciplinary team is unleashed to address a major problem. The CIAT Coordinator explained CIAT's specific

objectives under PROFISMA in working with EMBRAPA to improve cassava pest management in northeastern Brazil, but pointed out that CIAT's core program in cassava research provides a huge resource that facilitates the conduct of PROFISMA. Examples of the value of this resource were seen repeatedly throughout the mission. In view of the EAC's call for benefit/cost studies that could predict the future pay-off of GLO/91/013 (27 September, 1994 report, Recommendation 21), the EAC noted with interest the Deputy Director's mention of a 1995 CIAT publication entitled "Global Cassava Sector Constraints and Estimated Future R & D Benefits".

Recommendation 1. The EAC recommends that the PROFISMA team at CIAT bring this report to the attention of their collaborators in South America and Africa, that they take the lead in adapting the contents of the report (and the data base underlying it) to specifically address GLO/91/013, and that the results of this adaptation be given to future EAC's and to UNDP-OPS to assist them in evaluating the worth of the project.

B. Farmer Participatory Research

Farmer participatory research (FPR) is a major part of PROFISMA. The EAC had been somewhat perturbed that such research had not been implemented at the time of its first South American review in 1994. It is now evident to the EAC that the program was on track and on time in 1994. FPR has now been implemented on a wide scale in northeastern Brazil, using as its basis a successful enterprise already established by CIAT in Columbia.

Under PROFISMA the participatory diagnosis phase of the program involved 51 trainees in six states and nine institutions. Seventy four communities with 1662 farmers (20% of them women) participated. In the technology testing phase, 40 extension/liaison persons received additional training, and four states and six institutions are currently involved. The basis for implementation of research within a farming community is a COPAL comprising four leading farmers. Nineteen COPALs have been established, and each is conducting a technology testing

experiment. Each COPAL selects its own research topic, but the research is conducted in a scientifically sound manner involving adequate controls, replication and randomization. This is accomplished with the aid of trained extension workers in collaborating institutions and the involvement of state or PROFISMA scientists.

A travel advisory from the U.S. Embassy prevented the EAC from entering the dangerous area in Columbia where FPR is being practiced on cassava. We were instead taken to a CIAL, the Columbian equivalent of a COPAL, where a small group of farmers has banded together on their own initiative, to attempt to solve a problem misdiagnosed as being caused by root-knot nematodes*. This problem is extremely severe in the major blackberry production area northeast of Cali.

With the assistance of an extension worker, the growers have devised an un-replicated, controlled experiment testing extracts of four plant species as botanical pesticides. It is a good idea, and clearly demonstrates the eagerness of resource-poor farmers to conduct research that will help in solving their pressing problems. Of interest was that we were joined on our visit by a lead farmer from another village who sought out the extension worker for assistance in forming a much larger CIAL in his village.

Despite the laudable initiative shown by the farmers, they have been unable, to date, to attract a scientist to work with their CIAL. This is a major departure from the PROFISMA model. Before conducting an experiment with botanical pesticides, a scientist would certainly have obtained a correct diagnosis, consulted the literature, and probably advised a different line

*While the EAC was at CIAT a junior scientist there correctly identified the causal agent as a type of scale insect.

of research. The EAC was reassured to learn that COPALs formed under PROFISMA always have a scientist available to them.

While there may be a very occasional feeling among PROFISMA staff that investment in farmer participatory research takes resources and time from "real" science, the movement seems to have general approval. If the grass roots initiative that the EAC observed is as widespread throughout the world as we were told, this really is a movement. The collective voice of the specific farmers that we visited high in a mountainous valley is now reaching politicians' ears further down the valley. Their message to the politicians is "stop giving us chickens; we want help in doing research to save a more valuable, perennial crop".

The EAC feels that FPR may have much more than local significance. It may actually be an effective way to foster the development of the scientific and technological culture so urgently needed as a basis for increasing the prosperity of agrarian-based developing nations. In any case, FPR certainly eliminates the technology transfer problems of the past, and PROFISMA is to be commended for embarking on and apparently succeeding in this venture.

Recommendation 2. Because of the success of FPR under PROFISMA, and the CIAT-based capability that has facilitated its implementation far sooner than if it had been started from scratch, the EAC recommends that UNDP-OPS and the leaders of GLO/91/013 explore means by which the expertise and experience now resident in PROFISMA could be used to aid ESCaPP in fulfilling its mission in Africa.

C. Strategic Research in Entomology

A great deal of research has been done and is ongoing at CIAT on insect pests of cassava. While much of this research is part of CIAT's core program, a significant amount is being conducted under PROFISMA or pertains directly to it.

The EAC visited a busy entomology laboratory where a team of researchers is investigating the biology of many insect pests and their control with insect parasitoids and fungal and viral pathogens. Work is also well underway on host resistance to several insect pests, a subject not in PROFISMA's original objectives, but one that could well be incorporated into a renewed project. Seven major arthropod pests of cassava have been identified by CIAT for intensive research in Latin America. These include: mealybugs, mites, whiteflies, lace bugs, thrips, hornworms, and burrowing bugs. The latter are not a problem in Brazil. Work will soon be initiated on leaf-cutter ants, which have been identified as major pests of cassava in northeastern Brazil, where farmers use insecticides to control them. *Phenacoccus manihoti* which occurs in very restricted areas in its native South America is the only serious mealy bug pest present in Africa. In contrast *P. herreni* is the only major mealy bug pest in South America. Research on insect parasitoids of *P. herreni* has been supported by PROFISMA, and plans are underway to release three species in Brazil in the near future. Ongoing work on this subject should be included in any request for extension of PROFISMA because of its importance to sustainable pest management of cassava.

Of interest to the EAC was an entry in the 1994 PROFISMA annual report on the discovery in 1994 of the fungus, *Neozygites fumosa*, in mealy bugs in northeastern Brazil. Follow-up studies indicated that *N. fumosa* infected up to 60% of mealybugs in several populations, and also infected whiteflies in the laboratory. It may prove useful as a supplement or fall-back organism in case of failure or inadequate control of mealy bugs and whiteflies by parasitoids in Latin America and Africa. CIAT staff were unaware of this finding, and the EAC assumes the same is true of ESCaPP.

Recommendation 3. To evaluate the potential of *N. fumosa* as a biological control agent, studies on its biology and pathogenicity should be initiated under PROFISMA, and the results of this research widely disseminated.

None of the five species of whiteflies that feed on cassava world wide is considered to be a serious problem South America. One of these, *Bemesia tabaci*, feeds on cassava in Africa where it is the vector of ACMV, but the Latin American race(s) does not feed on cassava.

A crisis appears to be emerging in that rapidly increasing populations of *B. tabaci*-like whiteflies which feed on cassava have been found in the past year in Ecuador, northeastern Brazil and elsewhere in South America. It is assumed that this is the very devastating silverleaf race of *B. tabaci* (or a new species, *B. argentifolia*, depending on which taxonomist one consults) which has paralyzed agriculture in the southwestern U.S.A. This race multiplies to massive numbers, and kills plants outright. Sooty mold and virus vectoring are additional serious adverse effects. Even if ACMV is not introduced into South America (which could occur any time), the new strain of *B. tabaci* could become an efficient vector of the native CVMV.

Recommendation 4. Specimens from outbreak populations *B. tabaci* should be submitted to expert laboratories in North America for confirmation of the tentative identification of the silverleaf race/species. Biological control methods under development in North America including use of entomopathogenic fungi, one of which is now registered for commercial use, should be examined by PROFISMA. Population studies of the new race are needed in South America, and for studies on cassava, PROFISMA is properly positioned to play a central role.

The EAC was surprised to learn of a recent publication by CIAT on a root-infesting mealy bug, *Pseudococcus mandio*, that is a pest of cassava in Paraguay and Argentina. In turn, the CIAT team was surprised at the EAC's knowledge of another root-infesting mealybug, *Stictococcus* sp., disclosed by ESCaPP diagnostic surveys to be a major, previously-unrecognized pest of cassava in the semihumid rain forest zone of Cameroon. Despite the potential importance of these insects, neither the researchers in Africa nor in South America

knew of each other's activities or findings. On inquiry, the EAC learned that the EAC's 28 February 1995 report on ESCaPP, containing information on the African mealy bug, had not yet been circulated to PROFISMA workers.

Recommendation 5. The EAC recommends that its reports be circulated with dispatch by UNDP-OPS to all lead laboratories and national collaborators in GLO/91/013.

Recommendation 6. PROFISMA and ESCaPP should ensure and encourage direct, timely and frequent communication, particularly between individual researchers in GLO/91/013, so that discoveries and knowledge are shared and progress is facilitated.

Cassava hornworms migrate considerable distances, and therefore frequently appear in plant-defoliating numbers without a full complement of natural enemies. Faced with loss of their crop, farmers sometimes spray synthetic insecticides for rapid control of hornworms. PROFISMA staff are producing small numbers of larvae infected with granulosis virus (baculovirus). These are distributed to farmers who request a storable product for control of the pests. The farmer can amplify this stock and store it at 6°C until the next outbreak. PROFISMA should continue this commendable service in the short run, but they should also seek means by which virus production and dissemination can be taken over by cottage-level industries, possibly through the involvement of COPALS.

D. Biological Control of the Cassava Green Mite

An amazing amount of research is being conducted at CIAT on biological control of the CGM. This research is backed up by excellent laboratory resources and an enthusiastic research team supported substantially by PROFISMA. The successful introduction of three species of predaceous mites into Africa is a major achievement for this laboratory.

Included in the present work are studies on characterization of 22 species of potential predators of the CGM, development of new rearing methods, evaluation of the ability of

predaceous mites to utilize alternative food sources (including members of their own species), and the use of molecular techniques in combination with classical methods in taxonomic studies. A data base has also been organized to record the locations of all collections of predator and prey species of mites in South America and to correlate them with the climatic data available from the nearest weather stations. Using this data base, field explorations funded by PROFISMA are aggressively searching for mite predators in South America that are adapted to the climatic conditions in northeastern Brazil, and in Africa where the three established predators are not effective.

Much of the progress is made possible by four outstanding young scientists who are currently employed under PROFISMA as Research Assistants or Technicians. Three made formal presentations to the Committee. One who is already an accomplished taxonomist is being trained under PROFISMA to complement an overworked senior Brazilian. She was challenged by the EAC to explain what mite taxonomy had to do with the welfare of resource-poor farmers. Her reply demonstrated that she well understood the critical role that taxonomy plays in selecting the best adapted species, and possibly races, to ensure the success of biological control. An intensive visit to the acarology laboratory made it clear to the EAC that the other young researchers have a similar understanding of the role of PROFISMA and their place in it.

The EAC was particularly interested in *Neozygites* nr. *floridana*, a fungal pathogen of the CGM. This fungus occurs in epizootic proportions in northeastern Brazil under certain conditions, particularly high humidity. It occurs in Columbia as well, but physiological observations indicate that the Brazilian and Columbian fungi are different. A third pathotype occurs at low levels in Africa. Since the African pathotype is only weakly virulent, there is considerable interest in introducing one or both of the South American pathotypes into Africa. A PCR-based method for identifying pathotypes is being developed in conjunction with CIAT biotechnology staff. Success in this endeavor is a mandatory antecedent to African release, since this will allow tracking of spread and impact of authentic South American pathotypes. Although

the nucleic acid-level studies might be construed as too basic in nature, they are being pursued for practical ends, and PROFISMA is commended for their commitment and progress in this area. They should move ahead with *Neozygites* from several localities as soon as possible to verify the dependability of their methodology.

E. Pathogens of Cassava

A resurgence of interest and efforts on the study of cassava root rots and their control strategies has occurred under the leadership of a plant pathologist who has recently returned to CIAT after completing Ph.D. studies in the U.S.A. The approach that her team is taking toward elucidation of pathogen diversity and specificity is encouraged, since this will lead to the establishment of a broad spectrum of test strains in selection and breeding for resistant varieties.

Genetic diversity of the biocontrol agent, *Trichoderma*, should also be studied to determine if there is specificity to particular root rots. It has been noted that there is intraspecific morphological variability among the causal fungal pathogens.

The root rot team is also investigating the possibility that bacterial rot of cassava roots is caused by a pathogenic bacterium, rather than a secondary colonizer. This is being addressed by classical experiments to test Koch's postulates.

Excellent results have been obtained by the virology research team in the molecular characterization of the CVMV genome. This genome has been completely sequenced, and based on the results, PCR primers have been synthesized that are now being used to detect the virus and to investigate the identity of its insect vector(s). This work also demonstrates the effective utilization of modern molecular techniques in the solution of a practical problem. The elucidation of the vector of CVMV will be important in the selection of an appropriate management strategy. The PCR method which was developed for researchers at EMBRAPA is, therefore, a significant step in searching for the vector. The proposal to develop an ELISA

method for detection of CVMV which will be applicable in the field, will make the task much easier. Such a technique will also lead to the rapid assessment of the impact of CVMV on cassava yields, a task not yet accomplished by any method.

Recommendation 7. PROFISMA should aid the virology group in any way possible to hasten the development of an ELISA diagnostic method for CVMV.

F. Stake Quality

Stakes are the short sections of cassava stems that are cut after harvest and planted to propagate the crop vegetatively. Superior stakes will produce vigorous plants with high levels of tolerance to many pests. Although PROFISMA did not initially include agronomic studies, such work, particularly on stake quality, has been included primarily through the assistance of CIAT core staff with some PROFISMA funding. This work provides concrete steps to improve stakes at the farm level, and the work establishes that stake quality is directly related to yield. The central thrust has been to examine the effects of nutrients in the form of mulches and fertilizer applications. It is very clear that potassium is the key compound as it is repeatedly removed from fields in harvested roots. Since a farmer requires approximately 10% of the plants in a field to provide stakes for the next crop, these findings indicate that the 10% of the crop that will be used for stakes should receive a potassium supplement. Naturally occurring mulch plants could be used instead of an inorganic fertilizer because mulching was found to increase potassium in the soil.

Recommendation 8. Since improvement of stake quality is of high importance to future yield and is consistent with PROFISMA's applied objectives, the findings on stake quality improvement obtained through partial PROFISMA support, should be widely disseminated among PROFISMA and ESCaPP participants and applied whenever possible. This would be an excellent subject for FPR.

G. Biotechnology Research Unit

A visit to the BRU demonstrated to the EAC the capacity of CIAT to undertake and utilize modern molecular techniques in its mission to help the resource-poor farmer. Molecular marker-band genetic mapping of cassava is underway which can eventually be useful in molecular marker-assisted selection and breeding for resistance to important pests. A current project on mapping markers linked to resistance to whiteflies should eventually boost PROFISMA's capability to meet its goal of developing a sustainable pest management strategy for cassava.

H. Geographic Information Systems

Part of the core resources at CIAT is a state-of-the-art GIS facility. Among the demonstrations of the role that GIS could provide for GLO/91/013 the EAC was shown a GIS map plotting climatically and ecologically comparable areas in Africa and South America that could be used to select and validate sites for the collection of specifically adapted biological control agents. This work has been well used in the exploration for CGM predators. Another significant output was maps of the known and projected distributions in South America of several root diseases of cassava. These were generated four years ago in collaboration with a now retired plant pathologist. However, these maps have not been distributed to PROFISMA staff and their existence was unknown to PROFISMA.

Recommendation 8. PROFISMA should explore the GIS resources currently available to it at CIAT, and should consider how GIS can be used to facilitate and enhance future work.

I. Germplasm Research Unit

CIAT's core program maintains 5632 accessions of cassava in tissue-cultured clone banks and a further 4695 outplanted clones in the field. These are from 23 countries. An additional

bank of clones from 29 wild species of cassava are also maintained. Both endeavors are exemplary. Tissue-cultured plants are inspected every two weeks and recultured routinely. Accessions are assessed by morphological criteria, isozyme analysis and RFLP; duplicate accessions are discarded. Field plantings are in groups of six plants per clone and are renewed yearly.

The scientists running both the *in vitro* and *in vivo* operations stress that these are working collections. Possibly their most important use in relation to pest management is for host resistance. Numerous clones in the field were labelled according to their resistance traits. Although the use of host resistance was not originally in PROFISMA's objectives, the opportunity exists for the early incorporation of resistant varieties into an integrated sustainable pest management program.

Recommendation 9. The EAC recommends that PROFISMA, and possibly ESCaPP, incorporate the use of resistant germplasm currently available at CIAT into their applied research programs at the earliest possible opportunity.

III. PROJECT MANAGEMENT

A. Budget

The EAC met with CIAT research and financial administrators to review the overall PROFISMA budget. This budget is managed and disbursed by CIAT. The EAC is satisfied that expenditures are well justified and that the proposed budget for 1996 is reasonable. Given the vagaries of the national economies, as well as other variables, the project should end its first phase with a near zero balance.

The financial administration of PROFISMA continues to be cumbersome. CIAT receives all funds from UNDP and dispenses money periodically to EMBRAPA's account, so that large sums are not vulnerable to inflation in Brazil. Money for PROFISMA employees in

Brazil, however, is transformed to IICA in Costa Rica, which is the technical employer of these persons. Overhead is charged by all three agencies: 15% by CIAT on its in-house portion and 4% on funds administered for EMBRAPA; 9% by IICA on salary monies that it administers; and a further 5% by EMBRAPA on monies transferred to it. Much of CIAT's in-house overhead is spent in a manner that directly benefits PROFISMA. To by-pass IICA, CIAT is in the process of negotiating a special contract with EMBRAPA

Two problems with financial management identified in the EAC's mission to Brazil in 1994 have been solved. CIAT has exercised its option to purchase equipment for PROFISMA in EMBRAPA, circumventing stifling red tape associated with that institution. For example, a budgeted phase-contrast microscope for acarology research, that never materialized under EMBRAPA's administration, has found its way to Brazil under this arrangement. The purchase price is simply deducted from the funds to be transferred to EMBRAPA. The EAC was also pleased to learn that PROFISMA employees now have medical insurance through a private contract set up by IICA, again by-passing an EMBRAPA roadblock. Two thirds of the costs are paid by PROFISMA and one third by the employees.

This project has amply demonstrated that financial and operational planning for research on a crop with a long rotation are difficult, and require at least a year's lead time to muster resources. Therefore, PROFISMA must soon begin to consider its options for renewal.

Recommendation 9. UNDP should inform PROFISMA and ESCaPP at the earliest possible date if they are eligible for renewal, and should also inform them of UNDP's capacity for funding. If such information is not available by 1 January 1996, the participants in GLO/91/013 should consider pursuing alternative sources of funding if they desire to continue the work initiated under GLO/91/013.

B. Work Plan

The EAC reviewed every entry pertaining to CIAT in six pages of condensed tabular material (Appendix III, 1994 PROFISMA Annual Report). Pertinent comments are as follows.

1. *International Coordination.* Work on a cassava CD-ROM is going well. Coordination with ESCaPP could be better, particularly with regard to sharing of data bases. Attempts by project management to retrieve new data from PROFISMA-supported research done at EMBRAPA have not been successful. The list of publications in the 1994 annual report has omissions, but even so is unimpressive.

Recommendation 10. All data from PROFISMA and ESCaPP projects should be made available to project management and to other project participants in response to reasonable requests. UNDP-OPS should be prepared to back up this policy if necessary.

Recommendation 11. PROFISMA participants should strive for publication of their results in timely fashion in refereed journals. Significant results should not be hidden in obscure reports. Refereed scientific publications arising from FPR should be a particular goal, because such publications will make huge strides in validating this pioneering type of research.

2. *Training.* The formulation of a proposal for a Training of Trainers component is on hold because of the pressures of other activities. This component is not considered to be critical by the EAC
3. *Socioeconomics.* Unlike ESCaPP, PROFISMA has split its survey activities into two phases. Thus the intensive diagnostic survey is still in progress.

Recommendation 12. As also recommended to ESCaPP (28 February, 1995 report, Recommendation 1), early publication of survey data in appropriate forms should occur,

even if later publications must await an exhaustive analysis of the data. The information gained from these huge surveys is too important and too valuable to sit on.

4. *Acarology.* Collection of phytoseiid predators has been extended to Ecuador because of its biogeoclimatic similarity to target introduction zones. Evaluation of cassava varietal effects on phytoseiids will start in October; the project student was delayed in completing course work because of a University strike. Test variety work at Pivijay has been terminated because budget cuts resulted in lay-off of the person doing this work. Development of a PCR method of identifying strains of phytoseiids is on hold because of lack of funding.
5. *Entomology.* No comments
6. *Control of Root Rots.* This exhaustive plan was devised by technical staff in the absence of the principal scientist. With her return from studies abroad, the plan has changed markedly and is very much more focussed. Work on bacterial rots has been added.
7. *Virology.* Yield loss work on CVMV has proven to be impossible because of undetectable viral contamination of control plants. An ELISA test is clearly needed.
8. *Crop Management.* Most of this work is completed, is ready for technology transfer, and may be very suitable for COPAL's.