INTEGRATED PEST MANAGEMENT APPROACHES FOR MALI

A Report Submitted to:

Bureau for Africa
U.S. Agency for International Development
Washington, DC

by

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September 23, 1993

ACKNOWLEDGMENT

The writer wishes to thank Dr. Walter I. Knausenberger of the United States Agency for International Development (USAID)-Africa Bureau, Washington for his efforts to organize this mission and his technical review, and for providing helpful documentation. The invaluable contribution of the different persons contacted in Mali, particularly the support of Dr. Omar Niangado, Director General of IER, and the technical review of Dr. Patricia C. Matteson are deeply appreciated.

PREFACE

The current mission was initiated in April 1993 with the selection of Dr. Moussa M. Diawara, a native of Mali, under the "African Fellowship Program" organized by USAID-Africa Bureau. Dr. Diawara was at the time a Postdoctoral Scientist at The University of California Riverside, but had accepted an offer from The University of Southern Colorado as Assistant Professor of Biology before he could begin the African Fellowship.

The USAID Africa Bureau decided to hire Dr. Diawara as a consultant because of his broad pest management academic background, his extensive previous professional experience in developing countries and his distinguished publication record. M. M. Diawara received his B.S. in Agriculture in Mali where he served as Director of a fruit and vegetable research center for 3 years before coming to the United States, where he completed an M.S. in Weed Science and a Ph.D. in Entomology. Beside his current research program in host plant resistance, various aspects of plant/insect interactions and biodiversity, plant toxins/food safety, and environmental health studies, Dr. Diawara teaches Environmental Conservation, Science Information Systems, General Entomology, Medical and Veterinary Entomology, and Botany at the University of Southern Colorado in Pueblo, Colorado (USA).

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INTRODUCTION

The environmental degradation and other major problems associated with the heavy reliance on synthetic pesticides for agricultural crop pests control (Kennedy et al. 1987; Miller 1992) dictate the necessity to develop sustainable integrated pest management (IPM) systems. This is a more critical issue in developing countries for two major reasons: 1) the hazards to human and animal health and the environmental impact associated with pesticide use are of greater concern due to farmers' limited understanding of pesticidal effects, and 2) most farmers produce on subsistence scale and have very limited resources for protection and medical care (CILSS 1992).

IPM research initiatives became more encouraged in Mali and the other West African countries members of the "Comité Permanent Inter-états de Lutte contre la Secheresse dans le Sahel" (CILSS) with the creation of the USAID-funded IPM project ("Projet CISS-Lutte Integrée") in 1978. This project was initiated in response to solicitation by the Sahelian countries members of the CILSS, created in response to the 1968-1973 severe drought and subsequent famine in the Sahel, to find immediate and long-term solutions to agricultural and environmental problems in the region. Despite the premature termination of the project in 1987, significant progress has been made in IPM research in Mali (CILSS 1987, 1992).

This progress, which was the result of activities of the 1978 USAID funded IPM project, national research and development efforts through Institut d'Economie Rurale (IER) and related extension services, and the IER/International Sorghum/Millet (INTSORMIL) collaborative research support programs (CRSP), can be summarized around one key element: an increased awareness for the need of an integrated approach to pest control. There was a shift from pesticide testing as major pest control systems funded by chemical companies to the study of the biology and population dynamics of the major pests as first steps toward the development of IPM systems (CILSS 1987). Economic threshold notions were introduced and some IPM systems were developed for a number of crops including rice, maize, sorghum, cowpea, and millet (CILSS 1987).

Other major accomplishments of IPM initiatives in Mali include the development of greater coordination between IER and existing extension services, an increase in extension activities with the creation of new extension services, and the training of several research specialists through the 1978 IPM project and recently the IER/INTSORMIL-CRSP. Aslo, collaboration with the ICRISAT Mali station has been very productive. All of these have resulted in a major recent restructuration of IER (MAEE-IER 1992a,b; USAID 1992).

Dr. Diawara's one-month consultancy requirements were to:

A. **Assess current status of IPM-related activities** at the key research and development, extension and rural development agencies in Mali, with the object of helping to stimulate new directions in IPM program implementation in Mali, and foster mechanisms of collaboration between U.S. and Mali professional IPM scientists, practitioners, and institutions;

B. Review, promulgate and explain the draft report on the study "Socio-economic Analysis of Farmers in Mali: Opportunities for Success in IPM" (funded by USAID/AFR/ARTS/ FARA) done in Mali September-December 1992; contacting key collaborating parties in Mali, including USAID mission staff;

C. Explore collaborative proposal on low-input sustainable pest management systems in Mali prepared jointly by Dr. L. Coop and Dr. M. M. Diawara in connection with the R&D/SCI programs in Science and Technology Cooperation (PSTC) grants program;

D. Review ARTS/FARA draft paper "Creating IPM research capability: the sahelian experience" with co-author Dr. (Mme) Ba-Diallo at the Institut du Sahel, UCTR/PV, Bamako, and become familiar with the pest management coordination activities being carried out under the AFR/SWA PADRES (Programs for Applied Development Research in the Sahel) project at INSAH; and

E. Review with USAID/Mali its past investment in pest and pesticide management programs, and explore possibilities of building on these investments through its existing portfolio or though new programming.

DISCUSSION OF SPECIFIC CONSULTANCY WORK REQUIREMENTS

REQUIREMENT A:
Assess current status of IPM-related activities

The assessment of the status of IPM-related activities was focused on sorghum/millet and fruit and vegetable research programs at "Institut d'Economie Rurale" (IER) and related extension activities at two major extension and rural development agencies involved with farmer training and information in these areas: "Operation Haute Vallée du Niger" (OHVN) and "Project de Rehabilitation du Périmetre de Baguinéda" (PRB). These commodities were selected because of 1) the growing concern over pest problems on millet in Mali (SARSA 1993), 2) the need to increase awareness of the relative importance of fruit and vegetable crops in the Malian agriculture, and 3) the relatively short time of the consultancy (3 weeks in Mali).

Consultancy work was done through numerous discussion sessions with key researchers at IER, extension agents at OHVN and PRB, and several other research and development specialists in Mali (please see list of principal persons contacted), and by virtue of a thorough review of available documented work. The following is a brief review of the consultancy work for this requirement.

Current Status of IPM Research on Millet/Sorghum

In Mali, sorghum and millet were important parts of the USAID-funded IPM project of 1978. These constitute with corn the basic staple food crops in the country. Despite the premature ending of this project in 1987, it made a major impact on plant protection systems in the Sahel; the notion of IPM was introduced and there was an increased awareness of the dangers of heavy reliance on pesticides, and a very substantial body of professionals had been trained and returned to productive research, extension and/or administrative functions related to pest management in the Sahel (Matteson 1990). Specific IPM systems were developed for both sorghum and millet by 1987 (CILSS 1987) and subsequent increase in crop production was reported (Dembélé 1990).

For the past several years, representatives of extension services have regularily attended the national meetings where IER research results and future research programs are discussed. For instance, Mr. Noumoutié Diakité, the chief plant production and protection manager of the extension service OHVN, indicated to me that OHVN agents participate in the elaboration of IER research programs and their suggestions are taken into consideration. According to Mr. Diakité, a significant number of farmers in the OHVN zone follow the IPM recommendations advised by the extension agents. Verification and demonstration of research results are done via "actions pilotes" at village level by scientists from both IER and the "Service National de Protection des Végétaux" (SNPV), created in 1987 for emergency pesticide applications to suppress grasshopper infestations. The USAID funded project "Division de Recherche sur les Systèmes de Production Rurales" (DRSPR/IER) also significantly contributed to IPM implementation in Mali. My discussions with the different research team leaders indicated to me that IER scientists have developed strong ties with the regional International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) center at Samanko, near Bamako and are very open to collaborative initiatives with researchers around the world.

The current status of IPM research in sorghum/millet can be summarized as follows (ICRISAT 1985; Doumbia and Bonzi 1985-86; FAO 1991; INTSORMIL 1991; Doumbia 1992; CILSS 1992; ICRISAT 1992; Touré 1993; ROCARM 1993; Bal 1993; National reports; Personal communications of various IPM and extension specialists):

***Striga* spp. management**

Several species of the parasitic weed *Striga* spp. remain a major constraint to millet, sorghum, and corn production in Mali and across West Africa, causing an average 40% yield loss per year (Marou 1986). The most troublesome species is *S. hermonthica.* The old West African crop association production systems (e.g. cereal/broadleaf crop) proved to be the best *Striga* management tool (Khade 1982; ICRISAT 1986; Dembélé and Konaté 1993). Crop rotation, good soil fertility management, and following production systems also resulted in improved *Striga* control. There are no reported resistant sorghum, millet, or corn varieties.

Preliminary studies by Dr. Dembélé found that some local sorghum genotypes seem very promising; the most important of these is the landrace 'Seguetana' (Personal communication from Dr. Dembélé).

Major millet insect pests

***Psalydolitta* blister beetles** (Coleoptera: Meloidae): these are currently the major pests of millet in Mali and across the West African Sahel. The most important species are *P. vestita* and *P. fusca*. Adults of both species feed on the flowers and prevent grain formation. There are no reported resistant varieties though adults showed a relative non-preference for bristled millet varieties when exposed to both bristled and non-bristled varieties (Doumbia and Bonzi 1985). Farmers use a number of traditional control methods including smoke of burning tires to repel adults, fire to attract adults, and hand capture of adults. Chemical control is the only effective control method known. This is provided by SNPV with the help of international donors. Immatures of *Psalydolitta* species are, however, natural enemies of grasshoppers, currently the second most important group of millet insect pests (and in some years, the most important).

Grasshoppers (Orthoptera: Acrididae). The wide range of grasshopper species reported to destroy millet in Mali and across the Sahel include *Kraussaria angulifera, K. amabile, Oedaleus senegalensis, Hieroglyphus daganensis,* and *Cataloipus cymbiferus* (COPR 1982). As for *Psalydolita* species, insecticide treatments provided by the SNPV is the only effective control method used.

It appears from this review the key to millet IPM in Mali is how to capitalize on the *Psalydolitta*/grasshopper species interactions (please see requirement C).

Major millet disease pathogens

Plant pathogens were not reported as major threats to millet production in recent years in Mali. However, based on past results (CILSS 1987; Mbahaisra 1993), the downy mildew due to *Sclerospora graminicola* caused

yield losses of 3-21%. The smut caused by *Tolyposporium penicillariae* and ergot caused by *Claviceps fusiformis* were also reported as occasional millet diseases.

Major sorghum insect pests

A number of insect species, primarily a complex of panicle-feeding sucking bugs (Hemiptera), have been reported as sorghum pests; the most important species include *Eurystylus marginatus* (Miridae), *Creontiades pallidus* (Miridae), several *Spilostethus* spp. (Lygaeidae), *Diploxis floweri*, (Pentatomidae), *Aganoscelis versicolor* (Pentatomidae), *Aspavia armigera* (Pentatomidae), *Mirperus jaculus* (Alydidae), *Cletus* sp. (Coreidae), and *Dysdercus völkerri* (Pyrrhocoridae).

After the end of the 1978-1987 IPM project, the IER IPM researchers and breeders, in collaboration with the USAID-funded INTSORMIL-CRSP project, initiated an intensive breeding program for insect resistance in sorghum, backed with a technological program to improve grain quality. Screening of over 89 sorghum varieties from the national germplasm collection with ICRISAT and from Texas A&M University for insect resistance, followed by further testing of the more promising lines, resulted in the identification of resistance sources to some of these important sorghum pest insects. The local landrace 'Malisor' 84-7 was among the most resistant genotypes to *Eurystylus marginatus*. This program can only be encouraged.

Major sorghum diseases

Though very few IPM studies have been conducted in this direction in Mali, the major disease occurrence zones have been identified as first step of the initiation of an IPM program based on development of resistant genotypes. The only IER plant pathologist just recently departed for Ph.D. training in the United States, which suggests a serious shortfall in available expertise in this area at present.

According to Drs. Dembélé and Doumbia, one problem with breeding sorghum for resistance to *Striga* and/or insects in Mali is the fact that the crop is grown for human consumption and not for beer production; therefore, the local populations prefer varieties with vitreous (or glassy) grains which have a texture more suitable for the Malian cuisine. Unfortunately, all promising sorghum germplasm that might be potential sources for resistance have grains with non-vitreous texture. One way to overcome this problem is to initiate an extensive breeding program with vitreous and non-vitreous grain sorghum varieties once the resistance sources have been identified and characterized.

Stored-grain pests

There is very limited available literature on stored grain pests in Mali. According to Dr. Alain Ratnadas, Principal Entomologist at the Regional ICRISAT Center of Bamako, no major pest problems were noticed in Mali in 1990, but some losses to *Rhizopertha dominica* (Coleoptera: Bostrichidae) were recorded in 1992. ICRISAT research efforts are directed at the identification of resistant genotypes using regular screening tests.

Current Status of IPM Research on Fruit and Vegetable Crops

Truck farming is one of the most important agricultural activities in Mali. Though this is an old activity in Mali, initiation of IPM research in fruit and vegetable crops is relatively recent and is primarily documented with studies by Dr. B. Diarra who described the biology of several species of fruit flies (Diptera: Trypetidae) (Diarra 1985). Several annual reports of the old IER "Section de Recherche sur les Cultures Fruitières et Maraîchères" (SRFM) described insect control activities which consisted primarily of insecticidal sprays to reduce sporadic pest insect infestations (SRFM 1988).

Efforts are currently underway toward the definition of IPM-based research programs for fruit and vegetable pests management. Following reorganization of IER (MAEE 1992a,b), the old SRFM along with the other commodity specific "sections" of research were replaced by the research stations across the country. Each station has a research team working on the commodities of interest in the different parts of the country. The consultant

attended the first workshop on fruit and vegetable pest management organized by the Director of the Baguineda Research Station. The major objective of this workshop was to establish a network to coordinate fruit and vegetable research and extension activities in Mali. Mr. Noussourou, the pest management specialist of the Baguineda station, made a tremendous effort to identify several pest insects of fruit and vegetable crops. The key insect pests of fruits and vegetables can be summarized as follows (Diarra 1985; Dembélé 1992; MAEE 1992a,b; Noussourou 1992; Noussourou et al. 1993; Noussourou and Coulibaly 1993; Personal communications of various IPM and extension specialists):

Tomato

The wihitefly ***Bemisia tabaci*** (Homoptera: Aleyrodidae). This insect is currently the most important pest of tomato in Mali. Insect feeding transmits the tomato yellow leaf curl virus (TYLCV), which easily kills the plant. According to Mr. Noussourou and Mr. Avitabelier (FAO Principal Technical Advisor), who travel across the country to survey pest infestations on fruit and vegetable crops, many farmers in Mali did not harvest any tomatoes in Mali 1992/93 due to *B. tabaci.* The Assistant Director of PRB and the Director of the Extension Department of OHVN confirmed this observation. The consultant also visited with the Director of the farm production unit of the only fresh tomato transformation industry in the country; the factory's tomato production was significant reduced in 1993 due to losses to *B. tabaci.* IER just received some TYLCV-resistant wild germplasm sources from France. However, the Baguineda station IPM unit and the station Director, Dr. D. Dembélé, expressed the need for both financial and technical assistance to initiate a good breeding program for host plant resistance.

In Mali, there are currently no recommended control methods against *B. tabaci.* The writer has experience in design and use of various bioassay techniques to detect insect resistance in plants and has developed insect-resistant plant breeding lines in collaboration with Dr. C. F. Quiros at the University of California, Davis Department of Vegetable Crops. The writer would be willing to provide assistance in development of TYLCV-resistant tomato breeding lines in Mali to control *B. tabaci.* The plant

introductions from France should first be tested in an initial screening program for *B. tabaci* resistance. Genotypes with high levels of resistance should be crossed with local varieties and the F1 hybrids should then be tested. The more promising hybrids should be backcrossed to the desired parents in an attempt to determine the genetics of the resistance in order to transfer the resistance mechanism. The Baguineda station already has a plant breeder, Dr. B. Cissé, who could be a big asset to the breeding program for host plant resistance. The writer would work with both the station IPM unit and the breeding team to design and use appropriate bioassay techniques to identify and characterize sources of insect resistance.

There have been worldwide whitefly outbreaks in recent years; consequently, a number of scientists have been working on whitefly IPM for vegetable crops. These include

1. Dr. Thomas Perring, Department of Entomology, University of California, Riverside, California 92521 (USA)
2. Dr. Lance Osborne, University of Florida, 2807 Binion Road, Apopka, Florida 32703 (USA)
3. Dr. K. V. Raman, Chief Entomologist, International Potato Center (CIP), Apartado 5969, Lima, Peru
4. Dr. Judy Brown, Department of Plant Sciences, University of Arizona, Tucson, Arizona 85721 (USA)
5. IPM specialists of the USAID-funded PVO Development Initiatives project (677-0051) in Tchad (B.P. 1170, N'Djamena-Tchad) have also been studying the management of whitefly in vegetable crops; IER fruit and vegetable IPM researchers should inquire about findings of these studies.

Several Lepidoptera (Noctuidae) larvae: *Heliothis armigera, Spodoptera littoralis, and Trichoplusia ni.* These feed on both leaves and fruits and cause serious crop losses.

Several grasshopper species (Orthoptera: several families) feed on the leaves.

Okra

Aphis gossypii (Homoptera: Aphididae). This insect, an aphid of global importance, has several natural enemies, farmers do not know them and cannot manipulate the biological control agents.
Mylabris **spp.** (Coleoptera: Mylabridae). A beetle which feeds on leaves.
Several grasshopper species (Orthoptera: several families) feed on leaves.

Onion and shallot

Thrips tabaci (Thysanoptera: Thripidae). Farmers confound damage by this insect with a disease manifestation or senescing leaf characteristic.

Green beans

Mylabris **spp.** (Coleoptera: Mylabridae). This beetle feeds on the leaves and flower.

Several grasshopper species (Orthoptera: several families) feed on the leaves.

Cabbage

The caterpillars of ***Plutella xylostella*** (Lepidoptera: Plutellidae), ***Hellula undalis*** (Lepidoptera: Pyralidae), and the aphid ***Brevicoryne brassicae*** (Homoptera: Aphididae) all feed on leaves and head.

Several grasshopper species (Orthoptera: several families) feed on the leaves.

Mango

Fruit flies *Pardalaspis punctata, Pardalaspis cosyra, Pardalaspis sp., Pterandrus sp., Dacus ciliatus, Dacus vertebralus, Dacus sp., Ceratitis capitata* (Diptera: Trypetidae). The female of this insect punctures the fruit with its

ovipositor to lay eggs; larvae develop by feeding on the fruit, causing important economic damage.

Though the biology of these flies has been described, the two control methods were tested were not successful:
1. use of yellow plates containing soap water or vinegar to attract the fly and
2. insecticides.

As for *B. tabaci*, in Mali there are no research-based IPM recommendations for any of the vegetable or fruit pest insects. Farmers use hand destruction and/or spray any pesticides they come across. Many farmers spray fungicides or even herbicides against insect pests. According to Mr. Noussourou, IPM specialist of the Baguineda station, some farmers in the OHVN zones of Kati and Bamako crush dry tobacco leaves on their wet garden plants to control pest insects.

The consultant discussed with Mr. Noussourou the initiation of research trials designed to test cultural control methods such as early or delayed planting dates, use of botanical insecticides such as neem, and screening of local and introduced varieties for identification and characterization of resistant genotypes. Fruit bagging approach may provide short-term solutions to the mango fruit fly infestations; this has successfully been used for high-value fruits in Asia (Matteson 1991). The station of Baguineda's IPM team expressed their limited experience in development and use of appropriate sampling techniques; the consultant will send sampling information directly to Mr. Noussourou and would be willing to assist in conducting experiments in the area of economic pest management. The consultant conducted collaborative research with Dr. John T. Trumble (Department of Entomology, University of California, Riverside, California 92521), who has extensive experience in economic entomology. Trumble and Alvarado-Rodriguez (1993) described the development and economic evaluation of integrated pest management systems for fresh market tomato. Dr. John T. Trumble would be a good advisor for scientists in Mali should the country move toward large scale production of fruits and vegetable crops.

A literature review of research conducted in other countries where the same pests have been reported as problems should help initiate research programs in Mali. Groot and Djibo (1993) found that farmers in Niger sometimes know the majority of their garden pests, but ignore the biology of these pests and generally believe that the best control method is use of pesticides.

Pesticide Management

This is a subject of major concern. Studies conducted by the Malian Public Health Department and financed by USAID revealed a slight decrease in the concentration of cholinesterase in farm "brigades" exposed to pesticides in the OHVN zone of Nara (MSPAS 1990). Cholinesterase is the enzyme that hydrolyses acetylcholine, a neurotransmitter, to choline and acetic acid and also other acylcholines to choline and carboxylic acids in the body. Decrease in cholinesterase titer can result in nerve and muscle fatigue. The study also found that more than 40% of these "brigades" do not wear spray masks. The effects of pesticides on non-target organisms, their biomagnification in the food chain, and other environmental impacts associated with pesticide use yet have to be determined.

The consultant's visit with Mr. Issa Konda, Director of the Malian Society of Chemical Products (SMPC), the primary company providing farmers in Mali with fungicides, indicated that this service would be willing to support research programs with pesticide management objectives. The Director of Ciba-Geigy, the major insecticide and herbicide supplier in Mali, also expressed some interest in helping support pesticide management research programs with "clearly defined objectives". The consultant discussed with Mr. D. Bilodeau, Project Manager of the USAID Development of the Haute Vallée project, the USAID Bamako Bureau pesticide management program.

REQUIREMENT B:

Review, promulgate and explain the draft report on the study "Opportunities for Success in IPM" (funded by USAID/AFR/ARTS/FARA) done in Mali September-December 1992; contacting key collaborating parties in Mali, including USAID mission staff

The consultant reviewed the first draft of the study AFR/ARTS/FARA-funded "Opportunities for Success in IPM" report. Upon arrival in Bamako, the consultant announced the report during his first visit with the AID mission staff in Mali and explained the mission objectives. The relevance of the study "Opportunities for Success in IPM" was discussed with a number of people at the major agricultural research and development institution in Mali, the "Institut d'Economie Rurale" (IER). These included Dr. O. Niangado, the "Directeur Général", Dr. A. Diarra, weed management specialist, Dr. Y. O. Doumbia, IPM specialist.

The consultant also reviewed the report "Understanding Farmers' Responses to Pest Management Initiatives: an Illustration from Mali" by Dr. D. Koenig, which was a summary paper also based on the same survey. The final version of the "Opportunities for Success in IPM" report was also reviewed by the consultant after his return from Mali; comments and suggestions were sent to Dr. Knausenberger at USAID Africa Bureau. The consultant is willing to work closely with USAID Africa Bureau to determine how the report can best be used for the benefits of IPM research and implementation in Mali.

REQUIREMENT C:

Explore collaborative proposal on low-input sustainable pest management systems in Mali prepared jointly by Dr. L. Coop and Dr. M. M. Diawara in connection with the R&D/SCI programs in Science and Technology Cooperation (PSTC) grants program

The proposal on low-input sustainable pest management systems in Mali "Management of *Psalydolitta* spp. as millet pests and natural enemies of grasshoppers" was prepared jointly by Dr. L. Coop (Oregon State University) and the consultant in collaboration with IER scientists. The *Psalydolitta* blister beetles (Coleoptera: Meloidae) are natural enemies of important species of grasshoppers, but also cause major losses to pearl millet, *Pennisetum glaucum*, the principal subsistence food crop in the Sahelian regions of Mali and other West African

countries. Evaluation of land-race millets indicated that use of bristled varieties could significantly reduce damage by *Psalydolitta* (Zethner and Laurence 1988; Doumbia and Bonzi 1985). The proposal will examine the economic and ecological benefits of major *Psalydolitta* species and develop on-farm host plant resistance screening techniques in order to establish the foundations of a sustainable pest management systems that are economically justifiable, socially acceptable, and ecologically and environmentally sound.

The consultant discussed with Dr. Niangado, the Director of IER, the relevance of the proposal. Following recommendations of Dr. Niangado who was very enthusiastic about the project, the consultant visited several times with Dr. Doumbia, the IER IPM specialist, to talk about the details of the research proposal and to determine the role of key participants. Dr. Doumbia promised his full collaboration for the execution of the proposal should the project be funded. The IER leaders and research scientists realize the importance of the blister beetle problem and understand that this project could have significant implication on agricultural productions in Mali. It is the consultant's hope that USAID Africa Bureau will make every effort for the realization of this project.

REQUIREMENT D:
Review ARTS/FARA draft paper "Creating IPM research capability: the sahelian experience" with co-author Dr. (Mme) Ba-Diallo at the Institut du Sahel, UCTR/PV, Bamako, and become familiar with the pest management coordination activities being carried out under the AFR/SWA PADRES (Programs for Applied Development Research in the Sahel) project at INSAH

The consultant reviewed the paper "Creating IPM research capability: the Sahelian case" by Matteson, Ba-Diallo, Pierrard, and Knausenberger with co-author Dr. (Mme) Ba-Diallo at the Institut du Sahel, UCTR/PV, Bamako. Comments and suggestions of the revision were sent to Dr. Knausenberger at USAID Africa Bureau. The consultant also discussed with Dr. (Mme) Ba-Diallo the pest management coordination activities being carried out under the AFR/SWA PADRES project at INSAH. Dr. (Mme) Ba-Diallo provided consultant with sample issues of several publications. These include various extension information bulletins prepared for farmers' education, proceedings of symposiums organized by the CILSS, and an international refereed scientific

journal Nuisibles-Pests-Pragas. Despite the progress being made by Sahelian researchers, IPM implementation is a concern in agricultural production systems in Mali. INSAH publications could play a major role in dissemination of research results in the Sahel and should continue to receive financial support from potential donors.

REQUIREMENT E:
Review with USAID/Mali its past investment in pest and pesticide management programs, and explore possibilities of building on these investments through its existing portfolio or though new programming.

Circumstances did not allow the consultant the opportunity to fully address this aspect of the expectations. It is recommended that this be followed up at a later date.

FINDINGS / RECOMMENDATIONS

1. **The Malian Government needs to consider fruit and vegetable crops as priority commodities and somehow allocate more resource to research and development in this area in the long term strategic plan for agronomic research in Mali.** The USAID Strengthening Research Planning and Research on Commodities (SPARC) project, created for the restructuring of IER with partial financial assistance of the World Bank, has elements of IPM components and is having significant influence on agricultural production in Mali in particular and the Sahel in general (USAID 1992). Unfortunately, the SPARC project overlooked the importance of fruit and vegetable crops in the overall economic growth of Mali. It might be understandable why the report would give priority to cereal crops and cotton research and development programs at first look. However, with the collapse of the peanut market following the *Aflatoxin* controversy and the fragility of the tobacco industry because of health problems associated with cigarette smoking, fruit and vegetable crops will soon be the second most important export commodities in Mali next to cotton. This adds to their importance in the diet of an important segment of rural and urban populations across the country. Sometimes, fruits and vegetables are the only food available during summer in some rural areas in Mali.

2. **Direct IPM research efforts toward the development of multiple pest resistant sorghum and millet genotypes.** Host plant resistance is already a major part of IER IPM research programs. It is, however, advisable to coordinate weed science, plant pathology and entomological, and plant breeding research programs; millet and/or sorghum genotypes identified and characterized for resistance to *Striga* should be included in breeding for disease and insect resistance programs, and vice versa. Because of the importance of plant resistance in IPM systems, such programs should easily get support of international collaborators such as INTSORMIL-CRSP, the Food and Agriculture Organization (FAO) of the United Nations, ICRISAT, or the Semi-Arid Food Grain Research and Development (SAFGRAD).

3. **Establish host plant resistance as basis for IPM systems** to avoid dependence on synthetic pesticides in IPM, keep production costs within farmer reach, and reduce the health hazards and environmental degradation associated

with pesticide use. While farmers may have difficulty distinguishing beneficial insects from pest insects (Matteson 1992), use of resistant plant varieties does not require any challenging knowledge. Host plant resistance would be a viable IPM component in Mali because the country has a national certified seed production service, a FAO-funded certified seed project, and a seed research laboratory.

4. The national millet germplasm collection of Mali held in Cinzana consists of nearly 100 landraces. **This collection should be screened for resistance to *Psalydolita*** and other major pests of millet. The more promising genotypes should be included in the national germplasm improvement programs. It is recommended that this receives great attention in the development of candidate IPM systems for millet pest control; the writer would be willing to participate in the development of a breeding program for resistance should USAID or another international organization decide to fund such programs. **Information on international germplasm network (for use in plant resistance programs) can be obtained through the International Board of Plant Genetic Resources (IBPGR),** FAO, Rome, Italy or directly with ICRISAT.

5. **The regional ICRISAT center should get involved in *Psalydolita* management and in screening for pest resistance programs requiring mass rearing of the target insect species** for artificial field infestations.

6. Development of pest resistant plant genotypes, however, requires team efforts. **There is an inadequate number of scientists at IER and a acute need for more IPM specialists.** At the moment, the only IER Pathologist is not in the country. Also, the research stations created following the restructuring of IER need IPM teams. The only IPM specialists are at the Sotuba/Bamako station. The consultant discussed with Mr. Manlafi Keïta, the training officer of the Bamako USAID mission, ways to fund an MS program in Entomology for Mr. Noussourou, the IPM specialist of the Baguineda station. Recently, the consultant sent to the Director of IER application forms for the African fellowship program, organized by the USAID Africa Bureau to bring African scientists to the US for short training in IPM and other related fields.

7. **Initiate research programs designed to test botanical pesticides such as neem and other local botanical products used traditionally for seed treatment by farmers in Mali** as alternatives to synthetic pesticides to supplement host plant resistance. The neem tree is very common in West Africa (Belayneh 1991; Hodges and Beatty 1992); compounds from this plant and other botanical chemicals have shown potential as ecologically and environmentally sound alternatives to synthetic pesticides (USAID 1990; Belayneh 1991). Preliminary studies conducted in Mali on pesticidal effects of neem were very encouraging (AFGRO 1989); this report is available through Dr. W. I. Knausenberger at USAID Africa Bureau, Washington. Mr. Noumoutié Diakité, the OHVN chief plant protection manager has a complete file on traditional seed treatment products used in the past by farmers in Mali; the consultant has a copy of this file. Should a botanical pesticide research program be initiated in Mali, this would need be backed with tests designed to assess their hazards to human health and their effects on other nontarget organisms.

8. **Biological control research programs such as testing of the fungus *Bauvaria baciana* against grasshoppers under the USAID-funded African Emergency Locust/Grasshopper Assistance (AELGA) project should continue to receive support** in order to find alternatives to synthetic pesticides in grasshopper management. Reports received from Mr. Bilodeau of the Bamako USAID mission indicate that 40% (5 of 12) of insecticides used in the OHVN zone are for grasshopper control only.

9. **The extension agency "Projet de Rehabilitation du Périmetre de Baguineda" (PRB) should find ways financially support some of the fruit and vegetable research programs.** Mr. S. Keïta, the Assistant Director of PRB indicated that this sort of research program will be considered for their coming annual budget.

10. **Increased coordination in research of the IER IPM unit with activities of the "Service National de Protection des Végétaux" (SNPV) should result in improved IPM implementation.** For instance, IER scientists could concentrate on basic and applied research while SNPV agents would primarily be concerned with the management of "actions pilotes" at village levels for demonstration and

verification of research results, and at the same time continue to supervise emergency pesticide applications through farm "brigades".

11. **Continuous emphasis should be placed upon implementation of "farmer first approach" in the development of IPM research programs** (Matteson 1993). Research programs should be elaborated on the basis of farmers' needs and should take into account farmers' personal experience This approach is also suggested for the OHVN zone in the study "Opportunity for success in IPM" conducted in late 1992 in Mali by a USAID survey team (SARSA 1993; please see requirement B). The extension agencies and the SNPV's networks of "action pilotes" should play a major role in achieving this goal by asking farmer advice during their direct contacts.

12. **The chemical companies and other suppliers of pesticides operating in Mali should be involved in pesticide management programs** through adequate labeling, distributor training, farmer sensitization campaigns, and other forms of judicious use and safety-related activities. **Pesticide risk assessment studies should possibly be financed by these chemical companies and conducted by independent scientists hired by IER or the Public Health Department.** This would insure that pesticide use does not result in great hazards to human and animal health in developing countries, where the governments do not have the appropriate research funds to study the potential harmful effects of these chemicals. Pesticide regulations should strictly be enforced by the local governments.

13. **Increase efforts to organize farmers in cooperatives to allow transport of their production toward commercial centers.** This is particularly important for fruit and vegetable growers because of the short shelf life of these products. Thus, Mali should develop an international onion market with neighboring Ivory Coast, where Mali onions are valued. This could have a positive impact on IPM implementation by motivating growers to increase production.

14. **Efforts should also be directed toward natural resource management and conservation** in line with the long term strategic IPM plan. Soil and water conservation, and restoration of the native vegetation through reforestation with native trees such as "Karité", "Néré", etc. can have IPM implications by improving

soil tilth, increasing biodiversity, and consequently favoring proliferation of pests' natural enemies.

15. **Access to literature by Malian scientists should be enhanced. Literature search is an important component of IPM research.** The following centers could be valuable reference sources for findings in IPM research:

a. Réseau Sahelien de Documentation (RESADOC) at the "Institut du Sahel", Bamako, Mali, and the "Unité de Coordination Technique de Recherche en Protection des Végétaux (UCTR/PV), also at INSAH, Bamako (Mme Dr. Daoulé Ba Diallo).
b. ICRISAT Sahelian Center Library, BP 12404, Niamey, Niger. Access to numerous databases PESTBANK, AGRIS, TROPAG, etc.).
c. Centre de Recherche Appliquée (CRA), N'Djamena, Tchad.
d. Department de Formation en Protection des Végétaux (DFPV), B.P. 12625, Niamey, Niger, Tel.: 73-21-81, FAX: 73-22-37, Telex: 5545 DFPV NI.
e. Bio-Integral Resource Center, P.O. Box 7414, Berkeley, California 94707, USA, Tel.: (510) 524-2567, FAX: (510) 524-1758.

The consultant, as an African, particularly a Malian committed to development, will continue to seek ways to promote new directions in IPM, make efforts to foster mechanisms of collaboration between U.S. and Mali scientists, and initiate collaborative research programs with scientists at IER. The consultant also proposes to establish contact with other scientists interested in pest management and environmental conservation in the Sahel, and encourage them to initiate collaborative research programs in Mali to improve IPM research and implementation.

ITINERARY

April 20:	Leave Riverside, California, 8:00 am
April 20:	Arrive Washington, D.C., 10:30 pm
April 21	With Dr. W. I. Knausenberger at USAID Washington, D.C. Bureau
April 22:	Leave Washington, D.C., 5:40 pm
April 23:	Arrive Bamako, 8:15 pm via Brussels
April 24:	Off: Studied reports
April 25:	Off: Studied reports
April 26:	Visit with USAID mission staff in Bamako, Mali
April 26-May 17:	Several visits with several key people in Mali, including a trip to the Cinzana station and to the ICRISAT center in Samanko to visit with researchers.
May 17:	Debriefing at the Bamako USAID mission
May 17:	Leave Bamako, 11:55 pm
May 18:	Arrive Washington, D.C. via Paris, 8:30 pm
May 19:	With Dr. W. I. Knausenberger at USAID Washington, D.C. Bureau
May 22:	Arrive Riverside, California 4:30 pm

PRINCIPAL PERSONS CONTACTED IN MALI

USAID Bamako Mission

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Ministère du Developpement Rural

Dr. Moussa D. Traoré, Directeur de Cabinet (Assistant Secretary of Agriculture)

Institut d'Economie Rurale (IER)

Dr. Oumar Niangadou, Director General

Mr. Lassine Dembélé, Assistant Director General

Dr. Yacouba O. Doumbia, entomologist, Director, Sotuba regional center

Dr. Timothy T. Schilling, coordinator, SPARK project

Dr. Mamadou Kanté, coordinator, horticultural crops program

Dr. Eli Dioné, coordinator, cereal crops program

Dr. Aboubacar Touré, plant breeder, Chief sub-program sorghum, Coordinator INTSORMIL-CRSP project

Dr. Bouréma Dembélé, weed scientist, Director Sotuba station

Dr. Samba Traoré, agronomist, Chief Cinzana station, Chief sub-program millet

Mr. Karim Traoré, millet breeder, Cinzana station

Dr. Daouda Dembéié, agronomist, Chief Baguineda station, Chief Sub-program vegetable crops

Mr. Moussa Noussourou, agronomist, IPM research manager, horticultural crops, Baguineda station

Mr. Siraba Dioné, Chief Seed Laboratory

Dr. Amadou Diarra, Weed Science specialist

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CILSS

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Project de Rehabilitation du Périmètre de Baguineda (PRB)

Mr. Seydou Keïta, Assistant Director General

Société Malienne des Conserves (SOMACO)

Mr. Sekou Bouaré, Chief, agricultural production

Société Malienne de Produits Chimiques (SMPC)

Mr. Issa Konda, President Director General

Ciba Geigy Technical Assistance Bureau

Mr. Lona Traoré, Director

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