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CROP PROTECTION IN SENEGAL, NIGER, MALI, GHANA, NIGERIA, KENYA, TANZANIA AND ETHIOPIA

A MULTI-DISCIPLINARY STUDY TEAM REPORT

by

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CONTENTS

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First, we would like to thank all the personnel of the Agency for International Development, both in Washington, D. C. and in the countries visited who were involved in one way or another with our visit. The manner in which we were received in each country and the many courtesies extended by local AID staff members was of tremendous help to us in our efforts to gain some insight concerning the status of crop protection in these countries.

The study team also wishes to thank local country officials and scientists who were enthusiastic in their efforts to help us get a true picture of the needs for each country. The cooperation received from personnel associated with the various institutes and organizations, especially IRAT, ORSTOM, and IITA, who were especially helpful, is also appreciated.

We are also much indebted to Dr. Peter Haskell, Director of the Center for Overseas Research, Dr. R. K. Cunningham, Director of the Overseas Development Administration, both with headquarters in London, and Dr. G. Mathys, Director European Plant Protection Organization (EPPO), Paris, for arranging meetings with scientists of these and related organizations who have had considerable experience in the African countries visited.

Finally, we wish to thank the Administrations of our own local universities for affording us time off to make this study for AID.

I. Summary and Recommendations

Present losses to pests in African countries visited are consistently large, at times catastrophic, and were deemed intolerable and a serious handicap to country development. Therefore the developmental needs justify intensive and coordinated efforts made at an international level in research, training and extension in the various disciplines of plant protection. Certainly AID could and should play a strong role in this effort. Most research efforts currently underway are in the field of production but advances in plant protection must proceed simultaneously. Without such program development, increases possible from better crop varieties and improved cultural practices may be negated. The countries visited varied rather widely in plant protection capability, but there is a need for a very positive approach to programming country needs on a priority basis. More gains would result in crop production through effective plant protection programs than through additional production research in many instances. Many of these countries do not have the capability to attack their food crop protection problems at this time thus these recommendations are made to accelerate capability in this area. The ultimate goal, of course, is to raise their capability, not only to solve problems themselves but to provide their own training on a self-perpetuating basis. The following specific recommendations should greatly enhance the likelihood of attaining this goal:

1. Training: Each country visited needs more trained personnel so that they can take care of their plant protection problems themselves. Each should have a core of scientists trained at an advanced level, i.e., M.S. and Ph.D., to provide leadership in crop protection programs. There is also a great need for personnel trained at a technical level (e.g., B.S. degree or near equivalent) to help with various programs involved in crop protection, including extension. Significant training may also be conducted in the form of "workshops", short courses, seminars and should be taught, insofar as possible, by local scientists from universities, institutes and ministries. Clearly assistance would be desirable by outside scientists to help organize and participate in the training sessions. Short and long term consultantships for specific research problems would be extremely useful.

The Study Team spent some time at several, although not all of the universities in the various countries visited. Plant protection personnel were relatively few. In most departments, for example, there were only one or two entomologists on the staff. As an illustration, taxonomists are needed, not just for teaching programs but to build reference and eventually research collections. Taxonomic efforts could be centered initially on collection and identification of pest

species. Teaching responsibilities were heavy as a result of so few staff with little time for research. Additional staff to share the teaching load would permit the time for badly needed research and improve teaching capability particularly in applied courses. This will be increasingly important as the countries approach capability to train and support sufficient numbers of scientists to meet in-country needs. It is recommended that AID thoroughly study the need for additional plant protection personnel in universities including ability to support them, and increase the provision for advanced training for promising students where circumstances warrant assistance.

2. Pest Management Programs: Practical programs of total pest management or crop protection integrated completely with improved production systems should be the ultimate goal. Research programs dedicated to development of pest management strategies should be undertaken immediately but should stress initially the solution of pest problems. An efficient approach to problem solution and development of research information leading eventually to pest management might be the formation of regional research facilities based upon the three major ecological zones. The basic framework for the regional approach exists in Eastern Africa although Ethiopia does not operate within the present parameters.

3. Pesticide Management: All countries visited need help in managing pesticides in all aspects--e.g., registration, labeling, and residue analysis. The UC/AID Project should provide help and expertise in setting up committees or some other structure in the various ministries for formulating necessary procedures and advice on legislation to accomplish these highly desirable objectives. Pesticide monitoring systems should be established either on a country or regional basis so residues in or on crops and soils do not become a problem of the future.

4. Entomology: There is much to be learned about specific pest problems particularly on biology, ecology, phenology, population dynamics and levels constituting economic thresholds. This type of information is known for pests of a few major cash crops. It is possible that more is known than was apparent to the study team; if so, the information is scattered and not readily available in the brief study period available. Several suggested activities seem to be immediately important.

A. Research on host plant interrelationships and on nonchemical control methods should be increased throughout countries visited.

B. An early undertaking should be to assay losses caused by insect pests. On a few crops this is known but often the losses are attributable to a complex rather than to individual species. It is suggested that an entomologist make a more complete analysis of existing knowledge and potential research value. Several resident scientists or those who have worked in Africa previously would be particularly helpful initially.

C. AID should continue to supply help in the case of migratory locusts as in the past. Any new developments in survey or control technology should be brought to the attention of program participants. The entire problem of non-migratory grasshoppers with emphasis on losses needs evaluation. This should be coordinated with other international agencies.

D. An evaluation of the termite problem should be made. In this evaluation we urge attention be given to impact to loss of organic matter in soil attributable to termites. Activity here should be coordinated with any program planned by other agencies. COPR, ICIPE and perhaps others may already have programs underway.

E. Losses to insects attacking stored products, especially grain, are serious in all areas of Africa visited. Although the study team did not have expertise in this field, it appeared that reasonably effective methods are known but a serious gap in extension of available protection methods existed. The study team noted with satisfaction the existence of a unified effort by several international organizations (including USAID) entitled, "Group for Assistance on Storage of Grains in Africa" (GASGA). In addition to centralizing effort, the consortium is studying training, technique application and constraints on extension. This effort clearly warrants continuing participation and support.

F. Over the years there have been inputs in biological control in Central Africa particularly, it appeared, through the Commonwealth Institute of Biological Control and O.I.L.B. A great deal remains to be done, however, particularly of a semi-basic research nature in identifying and evaluating beneficial species present and in determining the potential of importing exotic beneficial species. Particular attention could be given to basic food crops initially as more is known about population regulating species on the important cash crops. This might be best attempted on a regional basis. It seemed, for example, to the Study Team that certain insects

reported on citrus as pests might warrant beneficial insect importation. Some of these beneficial species are already available in insectaries.

G. The line of entomologists actively participating in research and teaching is generally thin and in a few countries virtually non-existent. Likewise, interchange of available research progress, techniques and results could be improved. It appeared to the Study Team that improved interaction is clearly desirable. One avenue to improvement would be the formation of an Interafrican Entomological Society. Annual meetings and publication of an edited journal could provide a flow of information and boost pride in the profession.

5. Plant Diseases: While there have been good surveys of fungal and bacterial diseases of plants in Africa, little has been done on identification of the plant viruses. More support should be given to investigation of plant viruses in Africa, particularly identification. Different viruses require different methods of control and it is necessary to know which virus is causing a disease in order to make recommendations for controlling it. The possibility should be explored of placing a USAID supported plant virologist who should be permitted latitude in movement to work in the plant virology laboratory at IITA, primarily on identification of viruses on a regional basis and description of any new viruses found.

In the millet and sorghum areas of Senegal, Mali, Niger, and the northern parts of Ghana and Nigeria, frequently a third or more of the crop is lost from diseases (principally smuts and downy mildew). Production of these two crops has not been sufficient to feed the population over much of the area for the past few years. Although USAID is supporting research on these crops at Zaria in Nigeria, additional support is needed to hasten the development of resistant varieties and to put into practice some of the known disease control measures over this vast area.

The West Africa Rice Development Association (WARDA) is just getting started on its program to increase rice production. It seems that blast, Pyricularia oryzae, will be important in reducing yields in many areas and support for research on this disease is warranted. Control will depend on the development and use of resistant varieties, cultural practices and sanitation to reduce the intensity of the disease and, if needed, chemical control. Pathologists should work in cooperation with plant breeders and agronomists. This work could probably best be coordinated through WARDA.

Disease losses are heavy on fruits, vegetables and pulse crops. Support for disease control should be given to any major effort to increase production of these crops.

6. Nematology: The most urgent need in nematology in all countries visited is to train or upgrade indigenous personnel in the basics of nematode diseases and their control. The level of training needed initially can best be given through well organized workshops of short duration (2 weeks) on a regional basis with 18 to 24 students. Emphasis should be on symptomatology, techniques for sampling soil and plant tissue for nematodes, extraction techniques, recognition of parasitic genera, and testing for resistance. Control methods such as rotation and cultural practices, use of resistant varieties, clean planting stock and chemicals would be covered. Instructors would have available slides, movies, and much hand-out carry home material for the students. Local personnel, where available, should contribute by lecturing or assisting in laboratory sessions but someone from the U.S. with AID assistance should be in charge. Considerable funds should be available for laboratory supplies and hand-out materials. Much can be accomplished in a short time by this approach.

Through these workshops, outstanding students who wish to pursue nematology as a career could be identified and recommended for degree programs (MS primarily) in selected academic institutions.

7. Weed Science: Surveys and studies should be established to determine the level of weed competition and set priorities on the problems. Those problems for which there are immediate solutions should be attacked first. Basic weed control practices such as the use of weed free seed, cultivation, rotation, mulch, host plant tolerance, and cover crops that are basic to good agriculture production should be developed in a total production system. The use of herbicides should be included where economical.

8. Bird Control: Highest priority must be given to the development of appropriate control mechanisms for bird control. The present chemical control is both costly and environmentally unacceptable and in most cases is not making a major impact on the bird populations. Multilateral programs of research and education represents the only reasonable approach to the development of an effective bird control program.

9. Extension: Extension services within Ministries of Agriculture or their equivalent should be upgraded to teach and extend research findings after adapting it to local areas. Outstanding persons, especially graduating students, should be encouraged to go into and continue in extension. Training programs should be initiated for selected farmers that will provide extension through visual demonstration at the local level. Applied research that is adaptable to extension

programs should be encouraged. A mechanism whereby the flow of information from research to extension and thence to grower should be developed. Extension can sometimes be assisted by chemical industries in the promotion of agricultural chemical use through demonstration plots if properly designed.

10. Quarantines: FAO and others provide expertise and help in this area. However, this help is not adequate to developing country needs. USAID could help train personnel in plant pest identification by supporting workshops, training programs and grants at institutions of higher learning. General training in inspection and quarantine procedures can be obtained from the USDA training center at Battle Creek, Michigan. Developing countries should be encouraged to cooperate, then there would be less need to set up a complete quarantine station in each country for introducing new germ plasm. One station in Senegal, Niger, or Mali, for example, could be used for the introduction of germ plasm for all the countries in that ecological zone. Similarly the quarantine station in Nigeria could serve other countries in the heavy rainfall area.

11. Salaries: The salary differential between the universities and ministries is a serious handicap. This is a problem best resolved by the governments concerned. Possibly USAID could assist in equalizing the salary differential, but a permanent solution will only come by an improvement in the overall economy.

12. Library Facilities: Improved libraries to include current technological and scientific publications are needed where those in positions in research, teaching and extension can have access to technical agricultural developments. US/AID should continue plans to provide assistance in library development.

13. International Agency Coordination: The study team strongly recommends that international agencies with significant plant protection inputs into Central Africa thoroughly coordinate activities whenever feasible. This is already attempted in a number of cases but it appeared to the study team that coordination could be strengthened for long range as well as for immediate planning.

II. Introduction:

This report reflects the findings of a multidisciplinary pest management study team to eight African countries during the period October 9 - December 1, 1972. It is one of several such studies conducted for the United States Agency for International Development by the University of California at Berkeley under Contract No. AID/CSD-3296.

In each country visited the study team attempted to identify major pest problems (insects, plant diseases, nematodes or weeds) through consultation with local country and mission officials, and scientists working at various universities, institutions or Ministries. When possible, field trips were scheduled for the purpose of viewing pest problems on growing crops or in storage houses. Our conclusions regarding the major pest problems and current level of employment of pest management practices were based primarily on these discussions and observations. Information was also recorded on 1) pesticide uses and management, 2) status of plant quarantine, 3) the Agricultural Extension Service, 4) facilities and 5) manpower resources.

The length of time spent in each country varied depending somewhat on size, local country interest and ongoing programs. It is recognized that more time would have been necessary to examine all aspects of plant protection in depth. It is felt, however, that through the excellent cooperation received from personnel in each country visited, that this report reflects a useful analysis of the situation as it existed. Hopefully, it can serve as a meaningful guide to USAID in formulating programs to help developing nations solve their pest problems, which are currently a major deterrent to the production of adequate supplies of food, feed, fiber and oil crops for the populace in many parts of Africa.

III. Acronyms Used in this Report:

COPR = Centre for Overseas Pest Research (London)
CRI = Crops Research Institute (Ghana)
CRIN = Cocoa Research Institute of Nigeria (Nigeria)
CSIR = Council for Scientific and Industrial Research (Ghana)
EAAFRO = East African Agriculture & Forestry Research Organization (Nairobi)
EAPCO = East African Pesticides Control Organization (East African Community)
EPPO = European and Mediterranean Plant Protection Organization (Paris)
IAR = Institute Agricultural Research (Ethiopia)
ICIPE = The International Center of Insect Physiology and Ecology (Nairobi)
IFAC = Institut Francais de Recherches Fruitieres Outre-Mer (France)
IFCC = Institut Francais du Cafe, du Cacao et autres plantes stimulantes (France)
IITA = International Institute of Tropical Agriculture (Ibadan)
IRAT = Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres (France)
IRCT = Institut de Recherches du Cotton et des Textiles Exotiques (France)
OAU = Organization of African Unity
OCLALAV = Organization Commune de Lutte Antiacridienne et. De Lutte Antiaviaire (Senegal)
ODA = Overseas Development Administration (London)
OICMA = International African Migratory Locust Organization
OILB/SROP = Organization International de Lutte Biologique/Section Regionale Ouest Palearctique
OPAM = Office des Produits Agricoles du Mali (Mali)
ORSTOM = Office de la Recherche Scientifique et Technique Outre-Mer (France)
TPRI = Tropical Pesticides Research Institute (Tanzania)
WACRI = West African Cocoa Research Institute (Ghana)
WARDA = West Africa Rice Development Association

IV. Countries Visited and Ecological Zones:

Countries visited in order of visit included Senegal, Niger, Mali, Ghana, Nigeria, Kenya, Tanzania and Ethiopia.

In general, there were three major ecological zones included in this study, although variations occur within each of the three zones. The Sudanian Zone, roughly including Senegal, Niger, Mali, Northern Nigeria and Northern Ghana, is characterized as hot with short rainy seasons and occasional droughts (the last few years have had less than normal rains). Southern Nigeria and Ghana are in the Guinean Zone where hot, humid tropical conditions prevail with tropical rain forests the predominant vegetation. Ethiopia, Kenya and the small portion of Northern Tanzania visited (Arusha area) are characterized by high elevations with pleasant climates and both a long and a short rainy season. These countries are in the Eastern Ecological Zone.

V. Conferences in London and Paris:

The study team was unusually fortunate to have arrangements for an afternoon in Great Britain and the following day in France with scientists long involved in overseas work in Africa. The meeting in London was arranged and chaired by Dr. Peter Haskell, Director of the Centre for Overseas Pest Research. In addition to COPR personnel, representatives from the Overseas Development Administration (ODA) including Director Cunningham, plus several outstanding, experienced scientists from other research and teaching units joined the meeting. The following day, prior to departure for Africa, a similar meeting in Paris was arranged by Dr. G. Mathys, EPPO Director. French organizations represented at this meeting included scientists from IRAT, IFAC, IRCT, IFCC, OILB/SROP, and ORSTOM.

These scientists provided information on the function of their various organizations in research and training of personnel in Africa with particular reference to the areas the study team were to visit. Based upon their years of experience, they identified some of the gaps in research, extension, and training. They also indicated personnel in Africa who could be of help to us and provided information on the general plant protection situation currently prevailing. At both London and Paris the groups indicated that, in general, cooperation between international agencies could be greatly improved as compared with when each international agency tends to go it alone.

The study team found the counsel offered at these two stops to be accurate and of great help during our study.

VI. General Observations

A. Entomology

1. Insect Pest Problems & Potential for Pest Management

It seems likely that most major pest species have been identified although in some countries visited much remains to be done. In most areas and on most crops the complex of insects found is incompletely understood and the potential of secondary pests needs study. As new crops are introduced, careful studies to determine the damage potential of insects are essential.

Virtually all agricultural crops are faced with a complex of serious pest problems and losses on crops are high, certainly beyond tolerable levels. Because of location in relation to the equator in the countries visited in Central Africa, there is virtually no slack crop production period or pest population cycles caused by seasons (winter and summer) as in temperate regions. Seasonal changes are primarily the result of wet and dry periods of the year. In the wet tropical areas of coastal Nigeria and Ghana, for example, there is less seasonal fluctuations in cropping and pest problems than in the more northerly area. In the latter, the dry season which is pronounced and prolonged interrupts cropping systems and insect population buildup as few hosts are available over the dry period.

There are several factors which favor development of pest management in the countries visited. With the possible exceptions of a few crops such as cocoa and coffee, the relatively small amounts of insecticide used have not resulted in massive upsets of beneficial fauna as is the case in so many areas of the world. Also in most areas the farms are small, diversified and somewhat isolated which may result in some ecosystem stability. To date, consumers are not so sophisticated as to demand produce free of insect damage or presence. An adequate food supply at low cost is more important than produce appearance thus putting a reduced demand for insecticide use. Likewise the subsistence farmer cannot afford fertilizers and insecticides despite his need. This places a premium upon non-chemical methods of pest management--e.g. crop rotation, host-free periods, host plant resistance, and crop residue destruction.

There is some attention being given to integrated control or pest management, but with the exception of a few people, mostly in international centers, e.g. IITA

and cocoa research institutes, little is done. Dr. D. A. Taylor at the University of Ibadan is certainly a leading advocate and is performing research to this end.

There is great need for research on non-chemical methods of pest control. Time of planting, for example, is promising for sorghum midge and several other pests, stalk destruction to reduce carryover of the stem borer species so damaging and common on millet, sorghum, maize, and other crops. There is host-plant resistance studies at IITA and at Zaria by Dr Stan King and Dr Dean Barry plus in a few other places. In general, however, new varieties being developed, e.g. by IRAT, have no entomologist checking them on a continuing basis for increased (or decreased) susceptibility to pests like stem borers and shoot-flies.

2. Losses to Insects and Other Arthropods

Very few cases of losses caused by insects have been quantified, but it is apparent that losses are beyond tolerable levels on most crops in virtually all areas visited. Losses may be total in cases of mass invasion of migratory locusts, mainly the African migratory locust and desert locust, and only constant monitoring and application of prompt-control measures by various organizations prevent occasional widespread devastation from occurring. Yields of cowpeas, an important food crop, can be increased several times with timely insecticide applications. Losses to irrigated cotton are consistently at least 30% in the absence of timely insecticide applications. Most estimated losses are much higher. A complex of termites are noted as pests of many crops, the amount of damage being largely unknown, but perhaps equally or even more serious is the destruction of soil organic matter estimated to be as much as 10 tons per hectare per year in Ghana. An unidentified "spike" or earworm has caused 20-30% losses in millet production in Niger for the last three years.

Stored product insects are extremely serious in all areas visited. Bruchids on stored beans and peanuts cause a 50% weight loss in 8 months in Niger. In some dry areas losses in storage at the farm level in traditional small storage conditions are considered acceptable; losses are greater in more humid areas. In commercial storage losses are consistently high. It should be noted that cereals stored for consumption in the off-production season may be heavily infested but because of the general food shortages there is no differential in price between infested and non-infested stock. Thus there is inadequate incentive to maintain clean stored products.

3. Insecticide Use and Problems

Clearly crop production could be substantially increased if insecticides were applied properly. In Mali, Senegal, and Niger little is used with exception of some seed dressing, some on stored products and some subsidized use of cash crops such as cotton. In other countries a like situation prevails except on major cash crops on plantations such as cocoa, coffee, and rice. Farmers producing at the subsistence level simply cannot afford insecticides, fertilizers, etc. at the present time (or in the foreseeable future). Many do not deal in money to any extent, but only barter and trade the commodity for their necessities.

Because little insecticide is used, pesticide resistance is not a serious problem. An exception occurs in the case of the cocoa capsid resistance to lindane, suspected resistance in a few areas in the case of Tribolium castaneum to lindane and malathion on stored products, and aldrin resistance in white grubs on sugar cane in Tanzania. It is suspected in a few other cases but not confirmed in any reasonable way.

There is no monitoring of population levels of insects at the farmer level in determination of need for pesticide application. Only in very few cases on major cash crops are approximate economic thresholds of pest populations necessitating treatment established.

The organochlorine insecticides are normally the chemicals of choice where insecticides are applied. Heavy reliance is placed upon BHC. On cotton Endrin, DDT and often Endrin + DDT are the insecticides most commonly applied. There are no discernible effects on the environment from use of these compounds, presumably due to relatively small total amounts applied. Stem borers are a serious problem throughout Africa and DDT is the insecticide of choice. The general feeling throughout countries visited is that there is a need for compounds such as the organochlorines because of their relatively long residual on the crop, their comparative safety in handling, and because they are less expensive. However, many workers expressed concern about the future use of such insecticides, particularly in Kenya because of possible effects on wildlife and thus the tourist industry. The U.N. Environmental Center will be located in Kenya and locally approved use of chemicals like DDT might cause undesirable publicity. A few locations, like IITA, are working with shorter-lived organophosphorous and carbamate insecticides; in fact, their use is suggested in quite a number of areas.

In very few cases have pest problems changed radically or have pest complexes been altered from widespread and repeated applications of insecticides. In Ethiopia one comment was made that bollworms on cotton were more serious and was believed to be because of excessive use of pesticides. There was a feeling in a few areas that increased use of fertilizer, e.g. on rice, was resulting in increased insect problems. On the other hand, plantings the study team observed were rather isolated and stem borer problems were not severe. In Senegal, the experiment station director stated that they thought they had insect and disease problems in reasonable control but increased irrigation and better agronomic practices was forcing them to resume plant protection research. We suspect this applied mainly to experiment station plantings, however.

Some research on biological control has been done by the French and British, but certainly more is needed, although it continues at a low level. The French, for example, were going to import stem borer parasites. Other importations of exotic biological control species have been made but a great deal more semi-basic research is needed to identify what is present and what might be useful to import. It is our feeling that this is particularly important on the basic food crops as much more attention has been given to the important cash crops. The French said they were going to increase input here, however. For example, they said (Senegal) that there is fairly effective biological control on millet midge if planted at the proper time but that there were no indigenous parasites on sorghum midge.

4. General Insect Pests.

There are many insect pests which are common to the areas of Africa visited. Stem borers, for example, are serious pests throughout, but as species vary somewhat on host plants attacked, they are considered under crops in the discussion of individual countries. There are insect pest complexes, however, which can be discussed best in this general section.

a. Migratory locusts. The ages-old problem of massed swarms of migratory locusts leaving devastation throughout their flight pattern from remote breeding sites is well recognized. This is an international problem as the swarms cross country boundaries in flights often of many hundreds of miles. The two predominant species involved are the historically notorious desert locust, Schistocerca gregaria, and the African migratory locust, Locusta migratoria. Through a rather sophisticated system of population

prediction, of scouting the breeding sites, swarm monitoring and treatment when needed, damage from migratory locusts has been greatly reduced and in many cases negated. This is truly an international effort. International organizations are coordinating efforts and provide expertise to local ministries and locust control centers. This overall operation in countries visited must be rated highly and should retain continued priority for AID involvement particularly when serious outbreaks occur and as new techniques of swarm monitoring and control are developed.

b. Grasshoppers. Numerous grasshopper species were evident in large populations throughout African areas visited. The variegated locust, Zonocerus variegatus, was particularly evident in western Africa. Abundant evidence of feeding was observed even in our limited site inspections. Feeding was common on foliage and fruit but is noted as being particularly damaging to seedling crops with plant death common. Little is known apparently regarding population abundance and economic damage.

c. Termites. Extremely heavy populations of termites were evident in all areas visited, ranging from dry to rain forest environments. Many termite genera and species are represented in Africa. Virtually all crop plants are affected to an unknown degree ranging from a general plant weakening and introduction of plant pathogens to plant destruction. Some species form mounds above ground which cause problems in agricultural fields and are aesthetically displeasing in urban areas. It was estimated in Ghana that termites destroy as much as 10 tons of organic matter in the soil per hectare per year. The total damage attributable to termites is not quantified. Loss in organic matter may be serious, particularly in high rainfall areas through accelerating soil depletion and erosion and perhaps forcing farmers to abandon cleared land for crop production earlier than would be necessary in their absence. Research on termite problems is indicated but potential inputs by AID should be coordinated with that being done by ICIPE and with COPR which has some plans for ecological studies in both agricultural and urban areas including population prediction.

B. Plant Pathology

Losses from plant diseases were heavy in all countries visited. Programs for controlling these diseases varied greatly among the countries. In Senegal, Niger, and Mali

there were no African plant pathologists. One French plant pathologist was recently stationed in Senegal and plant pathologists from France make periodic visits to the French speaking countries. Ghana, Nigeria, and Kenya have a few plant pathologists. Their efforts are mainly devoted to research on the cash crops (primarily cocoa and coffee) and to teaching. Ethiopia has two Ph.D.'s in plant pathology, one is teaching at the College of Agriculture and the other is Director of Research. Thus while some countries have made a start in training native personnel in plant pathology, the priorities for their services seem to have been placed on cash crops and teaching, with little effort being devoted to controlling diseases on food crops.

One disquieting note is the reluctance detected in some countries to share information on pest control of cash crops with other countries that may be their competitors in the world market. In the East African Community, for example, scientists or directors of research stations could not discuss their research with other scientists without prior approval from some higher administrative officer. A freer flow of information among countries would result in more efficient utilization of limited resources by reducing duplication of efforts and by more effective planning of experiments based on information obtained in more than one country.

In some of the countries visited there was an interest in trying to grow vegetables, fruits or floral crops for export, primarily to the European market. Diseases are particularly abundant on these crops and may be expected to flourish when acreages of these crops are planted. Successful production of these crops will necessitate a sound program of disease control.

C. Nematology

African countries visited have serious nematode problems that need attention as part of an overall pest management program. For the most part, there is less knowledge concerning the role of nematodes in crop production than that which is available for insects and plant diseases. Plant-pathogenic nematodes are by nature debilitating organisms, rarely killing plants outright. Because of their subtle nature, they often go unrecognized, or the damage they cause is attributed to other causes. In several countries visited, specific nematode problems have not been identified or correlated with crop losses and consequently little attention is being given to this group of organisms. The group at Dakar, working at the ORSTOM laboratory, are doing an excellent job but they can only do so much. The nematologist in Ghana has been on the job for only a few months and his facilities and other resources for work are very meager. The International

Institute of Tropical Agriculture at Ibadan has a very competent nematologist and the program there holds considerable promise. At the Universities in Nigeria the nematologists are just getting programs underway and need additional resources for effective work. In Kenya the nematologists have made a good start in identifying some of the problems, but again, personnel is limited and in some cases just getting started. In Tanzania and Ethiopia, there are no trained nematologists. The same holds for Niger and Mali although the nematologists working with ORSTOM at Dakar have contacts and responsibilities for these countries.

In general the needs are great in most countries visited for additional scientists trained in nematology. Even a recognition of the problems is dependent upon a person trained for survey and diagnostic work. Once this is done, then information on control already available from other parts of the world can be put to use. Such information includes the use of clean planting stock, resistant varieties and crop rotation schemes where applicable. Furthermore, trained scientists are urgently needed to initiate long and short term research projects designed to gain information on local problems essential to development of effective control measures.

D. Weed Science

Agriculture in the countries visited is primarily subsistence with few monetary inputs, or improved methods and with little capital return. Weeds are one of the major deterrent factors in expanding agricultural production. Any program such as weed control or increasing fertility levels must be integrated into a total system. At present there is abundant rural labor to handle most weed problems in a subsistence agriculture economy. However, this picture could change or be changed by increasing the number of hectares each farmer is to handle. Controlling weeds by hand limits the number of hectares he can till and if this number is to be increased from the current 1-3 hectares to even 5-10 hectares improved weed control practices are necessary. Cultural practices such as cultivation using animal power is one of the first steps. The use of chemical energy (herbicides) for weed control can perhaps be considered in the early critical stages (up to 1 month after emergence of the crop) to allow a farmer to till or seed a larger area.

In plantation areas (coffee, cocoa, and cotton) extensive use of herbicides is being made with good success. Here there is capital input as well as capital return that will allow for improved methods. As more industry and urbanization develops and the need for increased agricultural production by fewer people becomes necessary weed control programs will

become more important in food and feed crops. However, large scale mechanized programs and the widespread use of herbicides for weed control does not seem feasible with the availability of current rural labor and with no industry to use the labor if it is removed from agriculture. Current agricultural programs must be set up to use labor under the existing conditions in these areas.

In certain areas if the current production practices of mixed cropping is changed and more mechanical clearing is done, the damage produced by soil erosion in open land will necessitate the use of herbicides which do not disturb the soil.

The two major weed problems observed in the countries visited were nutsedge, Cyperus esculentus and Cyperus rotundus, and witchweed, Striga hermontheca, and other species. There are many broadleaved species that infest the cropped area, however, these are controlled by hand. Hand labor while reducing the population and perhaps reducing competition have not been successful in effectively controlling nutsedge or Striga.

More complete surveys of the weed problem in most areas and cropping patterns are necessary with a consideration of species that are predominant problems in each ecological zone or cropping system and the competitive nature of the populations. It would be most important to know the level of population of nutsedge and Striga that will actually produce yield reductions. The information that is available on weed competition from other parts of the world may not be applicable in the tropical areas because of differences in weed species and growing conditions. It is important in the development of a weed control program to establish the level of population that will be economically competitive.

It is felt that the first consideration for the control of Striga in millet, sorghum, and cowpeas in the areas of subsistence agriculture should be host plant tolerance. Again it is necessary to establish what levels of infestation are competitive. The use of trap crops, rotational systems should also be considered. However, in many areas which are semi-arid and millet and sorghum are the major crops there is at present little opportunity to make minor changes in cropping patterns to combat Striga.

Studies on the ecological shifts in weed populations as cropping systems or rotations change or in current continuous mixed cropping programs are needed to establish what future problems and control programs will entail. If herbicides are brought into these programs there will be shifts in weed populations similar to what has happened in other areas using

herbicides continuously for several years. While ecological shifts have not occurred widely under current production practices some are apparent. The shift a year or so after the slash and burn procedure from primarily a broadleaf infestation to a grass problem primarily guinea-fowl or itch grass, Rottoboellia exaltata, was evident.

The use of herbicides through equatorial Africa is very small. As indicated earlier, use is primarily limited to plantation type crops. Residues of herbicides on crops, in soil and water are not a problem. Research to provide information for the future would be valuable for that time that extensive shifts in cropping systems promoted extensive use of herbicides.

There is no work on the integrated systems from the standpoint of the problem of weeds serving as a host for other pests. It is felt that pest management must be a package program tied closely to total production systems.

Research on weed control at the experiment stations visited is quite limited. There are no trained weed scientists in the countries visited except at IITA in Nigeria and at one station in Ethiopia. However, at present it is more important that the production type agronomists or crop specialists be concerned with weed problems as it involves a complete cropping pattern. There were programs at the experiment stations (IRAT, IITA) where herbicides were being evaluated. It is felt that presently it is more important to find a place for proven chemicals in current and changing cropping systems than to evaluate new chemicals.

E. Bird Depredation

Toward the Savannah part of central Africa, bird depredation represents the most serious plant protection problem. This includes an area of approximately 20% of Africa and the seriousness of the problem is intensified by the drought and general lack of available food. The main problem is associated with Quelea, however as new crops are introduced and developed other birds are becoming of increasing importance. Of particular seriousness is to the food crops such as millet, sorghum, rice and wheat. At present the most serious economic loss is of millet and sorghum. Estimates of annual devastation range from complete losses in certain valleys of Senegal to millions of dollars of losses in Sudan. It is generally agreed that it will be impossible to implement many of the programs associated with the "green revolution" until bird depredation can be brought under control.

(Information in above paragraph provided by Dr. G. E. Guyer)

VII. Country-Specific Observations

A. Senegal

1. Entomology

The study team itinerary provided only one day in Senegal. The time available was spent at OCLALAV and IRAT, both French Missions. The crops and crop pests are quite similar to those found in Niger, Mali, and Northern Nigeria and specific discussion will be left for these areas. There is no French entomologist at this time in Senegal, but the arrival of one is anticipated in the near future.

There were several comments of entomological interest. Improved agronomic practices and increasing irrigation have shown potential production increases of 2 to 3 times. With higher yields, insect and disease problems are more serious. Comparatively small amounts of pesticides are used, most being applied to rice apparently for stem borer control. There are many species of stored product insect pests, including the Khapra beetle, Trogoderma granarium. Insecticide resistance has been noted in the case of Tribolium casteneum to lindane and malathion and in seed bruchids to lindane. Some research in biological control has been done and they expect to increase work on stem borers of rice, millet and sorghum. If millet is planted at the proper time, parasite activity on millet midge is quite good but there seems to be no indigenous parasites of the sorghum midge.

2. Plant Pathology

On millet and sorghum, the smuts are of major importance and cause heavy losses. Covered smut of millet, Tolyposporium penicillariae, and covered smut of sorghum, Sphacelotheca sorghi, are the most important species. Long smut of sorghum, Tolyposporium ehrenbergii, head smut of sorghum, Sphacelotheca reiliánum, and loose smut of sorghum, Sphacelotheca cruenta, are also commonly observed. Seed treatment for control is not widely practiced by farmers. Downy mildew, Sclerospora graminicolum, is also a serious problem on millet. A program of breeding for resistance to these diseases is under way at the Bambey station. Disease problems of lesser importance include head molds (several weakly parasitic or saprophytic fungi); rusts, Puccinia purpurea and P. penniseti; anthracnose, Colletotrichum graminicolum; ergot, Sphacelia sorghi, and various leaf spots, Cercospora, Gleocercospora, Ramulispora, Ascochyta, and Pyricularia. These diseases can be severe on certain varieties, but the commonly grown types appear to have resistance or tolerance. Release of new varieties with high susceptibility to one or more of these lesser diseases should be avoided. On rice, blast caused by Pyricularia oryzae, is of primary importance. Fungicidal control tests and a

search for resistant varieties are in progress. Helminthosporium oryzae is of lesser importance and Rhynchosporium oryzae is of minor importance. On peanuts, the virus disease "rosette" is important but losses are reduced by the use of the resistant variety "69101". The Cercospora leafspots are usually not severe enough to warrant fungicidal applications. Aspergillus niger causes a seedling blight and also attacks plants about 50 days after planting, causing appreciable damage. Macrophomina phaseoli is also of some importance on peanuts.

3. Plant Nematology

Investigations concerning plant pathogenic nematodes are carried out by nematologists employed by the Office of Overseas Scientific and Technical Research (ORSTOM), a French organization with headquarters in Paris. In Dakar, several nematologists are working under the direction of Dr. Michel Luc, Head of the Nematology Section.

ORSTOM also has a nematology laboratory at Abidjan, Ivory Coast. Because of the activities of the ORSTOM organization in Ivory Coast for almost 20 years and Senegal for 2 years, considerable information is available concerning nematode disease problems in these two countries. Furthermore, nematologists employed by ORSTOM have made surveys in other parts of Africa, namely Madagascar, The Canary Islands, Upper Volta, The Central African Republic, Congo (Brazzaville), Dahomey, Togoland, Mauritania and Gambia. From these studies, ORSTOM nematologists concluded that the root-knot nematode, Meloidogyne spp., is the most important plant parasitic nematode in Africa. ORSTOM nematologists also work cooperatively with other organizations in nematode control problems. These include IRAT (Institut de Recherche d'agronomie Tropical) at Bambey, Senegal; IAO in Camberene (near Dakar); IRCT (Institute de Recherche pour le Coton et les fibres exotiques) in Dahomey; and with IFAC (Institute Francais de Recherches Fruitieres Outre-mer) in Mali.

Specifically for Senegal, the most important nematode disease on vegetable crops is root-knot caused mainly by M. javanica and M. incognita. M. arenaria occurs but the population present does not attack peanut, the most important export crop. Pratylenchus spp. is important on rice, sorghum, millet and maize. Other nematode genera causing varying degrees of damage include Heterodera, Tylenchorhynchus, Hoplolaimus, Xiphinema, and Hirschmanniella. There are no trained native nematologists in Senegal.

4. Weed Science

The major weed problems that are not being handled by hand labor are Striga and Cyperus. Several broadleaf weeds

appear to be problems, among these are the following genera; Commelina, Cenchrus, Cordorus, Crotalaria, and Digitaria. Striga is associated with the millet and sorghum generally grown in subsistence agriculture while the Cyperus is associated with those areas of higher moisture. The broadleaf weed problems generally seem to be scattered throughout the area. There is no information on the competition from weeds nor the general levels of infestation.

The IRAT research station at Bambey is conducting research trials on the screening of new herbicides. The migration of herbicides into the soil in these areas is high and degradation is relatively slow. Improved fertility practices in certain areas has merely complicated the weed problem by producing improved weed growth. In general hand labor is sufficient to handle most weed problems, however, there are situations where labor is not in the right place at the right time. This is particularly true in the first two or three weeks after emergence of the crop. Herbicide use in Senegal has been estimated by the researchers at the IRAT Station as about 1200 kilos per year. Because of the problem of slow degradation, some testing is being done for residual carryover. It was pointed out that fertilization depressed the growth of Striga.

B. Niger

1. Entomology

This is a hot, dry, land-locked country with grass and shrubs in the south grading quickly into the Sahara environment over the central and northern portion. Nearly all agriculture is of a subsistence nature with limited irrigation along the Niger River and in a few oases. Major subsistence crops are millet and where more rainfall occurs millet is largely replaced by sorghum. Cowpeas and ground nuts are produced widely, often interplanted with millet and sorghum. It was generally felt that there was a good potential for a greatly increased livestock industry. Cash crops are largely in irrigated areas and consist largely of cotton and rice with the latter replacing cotton to some extent. Irrigation potential appears limited, however, and in the foreseeable future, it is difficult to envision an intensive agricultural cropping system.

a. Major insect pests of millet. Although there are a number of insect pests which affect millet production, stem borers are considered the most serious. A complex of species exist, three of which are consistently serious. Of these Busscola fusca is considered the most damaging but also very serious are Sesamia sp. and

Coniesta ignefusalis (=Hambochia sp.). In addition there are seed-feeding hemipterous species plus more which are not generally considered to be as consistently serious as stem borers. An unidentified "spike" or "ear" worm caused estimated losses of about 20 to 30% the last three years.

In the economic structure of subsistence agriculture such as the millet producing area of Niger, there can be little use of insecticides without heavy or total subsidy. Careful attention should obviously be given to the development of varieties which are resistant to stem borers. Sufficient information has been developed at the IRAT stations to indicate the existence of significant differences in varietal susceptibility to stem borer attack. Breeding programs should include an entomologist skilled in such evaluation.

b. Major insect pests of sorghum. The same species of stem borers which cause serious damage to millet are equally important in production of sorghum.

The sorghum midge, Contarinia sorghicola, is a major pest, but losses can be minimized by planting uniformly and early. Late plantings are attacked more severely. In 1966 losses caused by the sorghum midge were several tons per hectare in some instances on late sorghum. Several times on visits with scientists, none of whom were entomologists, a millet midge was mentioned but it was not clear to the study team whether this is the same species as the sorghum midge.

The sorghum shoot fly, Atherigora varia soccata, may at times be a major pest, particularly where sorghum is planted so maturity is reached over a prolonged period. The attacks are particularly serious on experiment stations where plant breeding require a number of planting dates.

c. Major pests of cowpeas. Production is reduced markedly without use of insecticides. Three insecticide treatments, one at flowering and two later applications made at a ten-day interval, will increase yield two to four times. Major pests listed were thrips, aphids and particularly a complex of true bugs which attack and abort buds, blooms, and pods. Other similar areas do not include thrips but add leaf and pod feeding lepidopterous larvae, weevils and leaf beetles. Cowpeas are attacked very seriously in storage by bruchids.

d. Rice. Still comparatively a small crop, rice is expected to at least double in acreage soon. Insect problems are not considered serious at this time but as production becomes more intensive, particularly if double cropped, damage is expected to increase. Currently there are some problems with stem borers, probably Chilo agamemnon and to a lesser extent Sesamia sp. The stalk-eyed fly of genus Diopsis at this time is only a minor problem, but is a major pest in neighboring countries. Some losses are caused by seed-feeding bugs, e.g. Dysdercus, Leptocorisa and stink bugs like Nezara viridula.

e. Groundnuts. The problems of most concern on groundnuts apparently are aflatoxin and storage problems. A number of insect pests attack this crop but none were considered to be particularly major except Aphis craccivora which is a vector of groundnut rosette virus disease and a very serious problem of bruchids attacking the groundnuts in storage. The virus problem is less severe in dry zones as exist in Niger than in the zones producing groundnuts where more rainfall is received. It was not clear to the study team whether this was because of effect on aphid populations and/or on the virus reservoir.

f. Cotton. There are approximately 50,000 hectares of cotton in Niger of which perhaps 10% is treated with insecticides. It was estimated that yields would double with proper use of insecticides. As no entomologist was available for discussions, it was not possible to identify major pest problems, although Heliothis armigera and cotton stainers were mentioned as consistent problems. A more complete discussion was held in Mali where the environment and pest problems are quite similar.

g. Stored product pests. Many of the notorious stored product pests found throughout the world exist throughout Africa. Genera called to our attention in this country include Tribolium, Sitotroga, Trogoderma, Cryptolestes, Oryzaephilus, and the bruchids Caryedon serratus (on peanuts) and Callosobruchus sp. (on cowpeas). Farmers store their products on the farm. In general, scientists feel that traditional storage techniques on the farm sustain losses but levels are acceptable. Bruchids attacking peanuts and cowpeas in storage cause extremely serious losses; it is estimated, for example, that a 50% loss in weight of cowpeas often occurs in a period of eight months. A recommended stored product treatment is to store or place the infested

product in plastic bags, add carbon tetrachloride and seal the top. Phostoxin is used to some extent in commercial storage. A grain protectant is needed, however, as products are subject to reinfestation immediately following fumigation. The residual activity of malathion, which is used widely worldwide as a protectant, is considered to be too short in this climate.

h. Insecticides. Importation of pesticides is a government monopoly; there is no agribusiness dealing in chemicals. There is neither manufacturing nor formulating of pesticides practiced in Niger. Little insecticide is used in practice. Virtually none is applied to the subsistence food crops, including cowpeas despite heavy, consistent losses to pests. Approximately 10% of the 50,000 hectares of cotton receive insecticides even though it was estimated yields could be doubled with approved use of insecticides. Some seed treatment is practiced, particularly on cotton.

Most of the insecticides applied for crop protection are chlorinated hydrocarbons. BHC is widely used and the standard on cotton is a mixture of DDT-endrin. Some Thiodan is applied to cowpeas. Heptachlor or aldrin are most commonly used for seed treatment. Based upon the facts that resistance is not reported and the comparatively small quantities are applied, it seems highly unlikely that undesirable environmental effects have occurred.

i. Trained personnel in entomology. Plant protection needs intensive research and extension involvement of entomologists on all crops and in all phases of production and storage. The study team did not meet a single trained entomologist, native or foreign, resident in Niger. A trained cadre of native entomologists is badly needed to provide the continuity necessary in research and extension which cannot be provided by the occasional short-term inputs by scientists from a developed country. Most of the serious pests are identified but much remains to be learned about pest biology, ecology and populations resulting in economic losses. The excellent IRAT research centers are devoted largely to variety development, agronomic practices, etc. but valuable inputs should be made by plant protection personnel at these stations in evaluation of resistant or more tolerant varieties, management practices devoted to reducing pest damage, biological control assessment, plus much more.

2. Plant Pathology

The pathogens that attack millets and sorghum in Niger are in general the same as for Senegal. A large percentage of the millet and sorghum seed is treated before planting so that the smuts cause less damage in Niger than in Senegal. Downy mildew is the most important disease. The diseases on peanuts are also about the same as in Senegal. Rice culture is just beginning and no important disease losses have been reported on this crop. Gummosis, caused by Phytophthora citrophthora, and tristeza caused by a virus are the most important diseases of citrus. An important collar rot and root rot of mangos in nurseries is caused by Macrophomina phaseoli. Fusarium wilt, rust, and leaf spots have been reported on cowpeas but the extent of damage is not known.

3. Plant Nematology

The importance of nematodes in crop production in Niger is not known. There are no nematologists in Niger and no surveys have been made to determine the presence of nematodes. Root knot, caused by Meloidogyne spp., was observed by the study team in home garden plots on egg-plant and tomato.

4. Weed Science

The same general problems exist as was indicated in Senegal. Millet is the most important crop and therefore Striga is the most important weed pest in Niger in that it infests most of the millet acreage. There has been some testing of chemicals done at the IRAT Station, however, nothing at any great depth. It was pointed out that the Striga seed will exist in the soil for 5 to 6 years. Striga also infests cowpea which is another important crop associated in the areas where millet is grown. Therefore, a rotation of millet and cowpea is not successful in the reduction of Striga infestation. Striga will produce approximately 50% yield reduction of millet and nearly complete loss on cowpeas. In lower areas where more moisture is available sorghum becomes a major crop and it too is infested with Striga. In general there are no possibilities of quarantine in that Striga is widely distributed throughout the country. It is especially prevalent on sandy and intermediate soils. There is some interest in Niger in producing sugarcane and here again Striga would be a problem. Striga does not appear to be a particular problem on heavy soils; greater than 30% clay.

As in Senegal, in many of the areas of higher moisture, particularly the valleys, Cyperus is an important problem. Any place that rice is grown Cyperus is a major problem. Echinochloa spp. was also prevalent. Hand labor was the major means of weed control with little or no emphasis on herbicides.

In a visit to Western Niger in an oasis area it was pointed out that cassava produced suppression of nutsedge. It was pointed out at the IRAT Research Station in TARNA that plowing or tillage to a depth of 2-3 inches increased sorghum yields 20 to 30%. It was also pointed out that closer spacing would give twice the number of plants presently grown with doubled yields. The species of Striga was S. gesnerioides. It was noted in Western Niger in sorghum that had heavy applications of urea nitrogen there was less Striga than those with no urea. Further, there was more Striga in the recent years which were dry than when the valleys were flooded. In general it appears that host plant resistance or tolerance would be a possible answer to the Striga problem in much of the millet and sorghum producing area. There is very little opportunity under the current system for trap crops since there are relatively few acres of crops such as cotton and the current rotations involve only millet and cowpeas which are both hosts for Striga.

The present agricultural system cannot support the use of pesticide chemicals in that there is no significant capital output from subsistence agriculture. Another possible answer to the Striga problem is fast growing, early harvested sorghum that will be harvested before Striga becomes a serious problem.

There is a need for more effective weed control for one month or so after planting to allow a farmer to handle or plant more acreage than he is currently growing. The competition for labor in the early period is a problem.

Extension of all practices is a problem and there is a lack of trained personnel and funds to support the programs. It is felt that the extension effort is accepted fastest when a commercial crop is involved.

C. Mali

1. Entomology

The general environmental situation in Mali is roughly similar to that in Niger, grading from grass and shrubs in the south to the Sahara desert environment in central and northern portions. Likewise agricultural crops and

production systems are quite similar. Plant protection problems accordingly are similar as well. As in Niger, an apparent potential for a greatly expanded livestock industry warrants evaluation.

a. Pests of millet and sorghum. As nearly as could be determined, insect pests affecting millet and sorghum production are similar to those occurring in Niger. Stem borers are considered to be the most serious complex of pests. The sorghum midge is a serious pest when crop maturity is late. At the IRAT research station, problems with small grasshoppers and millipedes were mentioned as causing significant damage and that research on problems such as this is needed. They are expecting a myriopod specialist to be sent from France to study identification and problems caused by millipede species.

b. Cowpea and peanut pests. As the complex of insects pests are similar to those discussed earlier in the section on Niger nothing is added here.

c. Cotton pests. Insect pests of cotton were mentioned only briefly in the section on Niger as an informative discussion with IRCT workers in Mali covered both countries well. There are about 80-100,000 hectares of dry-land cotton grown in Mali but irrigated acreage of this crop is being replaced by rice. Cotton production on dry-land amounts to about 800 kg. of seed cotton per hectare. In general, hirsute cottons are produced because of jassid (leafhopper) resistance. The major leaf-feeding pest of cotton is Cosmophila sp., likely C. flava. There are a number of insects which attack the fruiting forms, all of which can cause serious damage on late maturing cotton. These include Diparopsis watersi, Heliothis armigera, Earias insulana, E. biplaga, Argyroploca leucotreta, and Pectinophora gossypiella. The feeding of Dysdercus superstitiosus can be serious in causing bud and small boll shedding and in older bolls causes lint staining and introduced fungal rots. Heltopeltis is most serious in the more humid areas. Research on virus and bacterial diseases of insects is not conducted in Mali but is by colleagues in the Ivory Coast. Cotton seed is treated prior to farmer purchase with heptachlor plus a mercurial compound. Four to five applications of endrin plus DDT are recommended at 15-day intervals, although the recommendation is not practiced on much of the acreage. It was estimated that the average cotton loss is about 30% in the absence of insecticides. Some research has been performed on gossypol-free cotton and upon frego-bract cotton varieties. Preliminary research is underway

on biological control including the introduction of Trichogramma egg parasites from Mexico. Some upsets believed to be caused by insecticidal impact on beneficial insects has resulted in increases in Earias populations.

d. Rice pests. Rice has been replacing cotton on irrigated land. Seed is treated prior to planting. Farmers have problems with stem borers but the magnitude of the problem is incompletely known.

e. Citrus. A crop of considerable importance, but the study team got comparatively little information on pest importance. A mealybug, perhaps Planococcus citri, was considered a pest as were species of scale insects. Parathion plus oil is the only effective insecticide on the scales with the method of application available, but little is used because of expense and worker injury. Aphids were noted as occasional pests. Interestingly, the very damaging fruit-piercing moths in neighboring countries were not mentioned here.

f. Stored product pests. The insects attacking stored products and the protection methods employed are similar to those discussed in Niger. Seed in warehouses, especially in sacks, is protected by Phostoxin. One fumigation will usually suffice but the storage is subject to reinfestation readily and sometimes a second treatment is necessary. Tribolium sp. are the most consistently damaging pests with Sitotroga cerealla considered to be the second most serious. However the Khapra beetle, Trogoderma granarium is by far the most serious when it becomes abundant. Loss in storage on the farm is not considered to be high, estimated to amount to about $5 million dollars loss over the country. Some farmers dust their stored seed (normally in stacks not threshed) with lindane.

g. Insecticides. Insecticide importation, application, and total amounts applied is quite similar to the situation in Niger. Likewise, importation is a government monopoly and there is no agribusiness dealing in pesticides. Treatment of seed prior to planting is encouraged. Small packages of cotton seed, for example, are treated with heptachlor and mercurial fungicide by the controlling monopoly prior to becoming available to farmers. Other seed treatment is left to the growers. Approximately 5% of the millet and sorghum seed is thus treated. Rice seed is also treated to an unknown extent. Each year a program of treatment is prepared

and demonstration farms in different areas are selected for application of protection techniques. When unanticipated problems arise, special information is prepared for distribution.

h. Trained personnel in entomology. The situation regarding trained entomologists in Mali is about the same as exists in Niger; that is, a cadre of native entomologists is badly needed to provide continuity in research and extension. The occasional short-term inputs by scientists from foreign countries is grossly inadequate. An agricultural school exists in Mali which provides some post-high school training, but this provides training primarily in aspects of production other than professionals for crop protection.

2. Plant Pathology

Diseases of millet and sorghum in Mali are the same as those listed for Senegal. Only about 5% of the acreage is planted with treated seed so that losses from smut are heavy. Downy mildew is also important. Diseases of peanuts are about the same as those of Senegal also. The most important disease of cotton is angular leaf spot and black arm caused by the bacterium Xanthomonas malvacearum. An anthracnose, caused by Colletotrichum, causes considerable damage to kenaf or "dah", Hibiscus sp. Gummosis is very important on citrus and whole orchards of mangos are dying from an unknown cause.

3. Plant Nematology

The situation in Mali is about the same as that for Niger. No surveys or studies have been made to determine the importance of nematodes. The director of the Citrus Research Station, Bamako, said that root knot was so serious on vegetable crops planted between rows of citrus trees, that the practice had to be discontinued. Root knot was also reported to be a problem with the continuous culture of Kenaf.

4. Weed Science

In Mali the major agricultural production is millet and cattle. Labor is limiting in millet production where land is available. Again, Striga is a major problem. As in Senegal and Niger there is nothing known about the degree of weed competition nor the level of particular species infestation. Broadleaf weeds do not seem to be a problem throughout the area as they are handled or controlled by hand labor. A list of weeds in addition to Striga and Cyperus generally thought to be important in Mali are as

follows: Commelina condensata, Mariscus spp., Eleusine indica, Paspalum scrobiculatum, Phyllantus spp., Rottboellia exaltata, Aspilia helianthoides, Ageratum conyzoides, Oldenlandia herbacea, and Stylosanthes gracilis. A small amount of testing of herbicides is being carried out by the group at IFAC. This related primarily to weed problems in cotton.

D. Ghana

1. Entomology

The study team encountered a warm, humid tropical climate in Southern Ghana. Northern Ghana is quite similar to Niger and Mali, and pest problems also are similar although this portion of the country was not visited. Observations will be restricted largely to Southern Ghana as cropping systems and pest problems are different from those studied previously.

a. Millet and sorghum pests. Major pest problems are similar to those occurring in Niger and Mali, but in addition the shoot fly, Atherigora varia soccata, is occasionally a serious pest.

b. Maize pests. Although some maize is grown in Senegal, Niger and Mali, it is a major food crop in Ghana where moisture is adequate for good production. The stem borers which are pests on millet and sorghum also seriously attack maize. On a few of the larger farms, guthion is applied with two applications giving good protection. At times aphid populations, Rhopalosiphum maidis, are considered serious. A weevil, Sitophilus oryzae, may infest maize grain in the field and become very serious upon being transported with the seed into storage. The entomologist at CSIR evaluates varieties, primarily on advanced development lines, for borer resistance.

c. Cocoa pests. Cocoa is the most important export crop in Ghana. Production on some plantations can be sophisticated or the crop may be harvested in a virtual rainforest situation. Plant protection is quite sophisticated in many instances and the Cocoa Research Institute provides up-to-date information to the industry. Considerable quantities of insecticides are applied to this crop and BHC is sold to the farmers at subsidy rates for capsid control. A large number of insects are considered pests of cocoa but only the most important are listed here. Probably the most serious pests are two species of mirids. The black cocoa capsid

(mirid), Distantiella theobroma, and brown cocoa capsid, Sahlbergella singularis, adults and nymphs feed on pods, pod stalks and small branches. Their feeding causes lesions and introduces fungi which results in a branch die-back. Losses may be total to nil, but the average loss is high. BHC provides good protection but resistance has developed in some areas. Sevin has provided acceptable capsid mortality as a substitute but secondary effects have occurred. Baygon is a promising substitute at present. A stink bug, Bathycoelia sp., has caused damage to developing buds recently and may become a serious pest. Several mealybug species are serious pests, the most abundant species being Planococcus citri, P. njalensis and Ferrisiana virgata. High populations may reduce yield but a far more serious injury is transmission of the swollen shoot viruses. Ants may be a factor in providing some biological control of the capsids, but also provide protection of the mealybug, presumably from parasite and predator activity. Occasionally a cocoa psyllid, Mesohomotoma tessmanni, is a major pest, primarily in the dry season, killing the buds which may eventually end in defoliation through failure of leaf replacement. Some research is being done on pest management with particular reference to pest population monitoring of capsids.

d. Oil palm pests. Grown in the high rainfall area, a number of insects attack it. The rhinoceros beetle, Oryctes spp., is a major pest and the leaf miner, Coelaenomenodera elaidis, has many parasites but is an occasional pest of an apparent cyclic nature.

e. Cowpea pests. Like previous areas, cowpea production is increased greatly with insecticide use. A number of insects are particularly damaging to bloom set and pod retention. A more complete listing of pests is left for the Nigeria discussion, but Maruca testulalis, Euchrysops malathoma and a number of bloom, pod, and seed feeding bugs were mentioned as most serious. Grown primarily by small farmers, guthion and toxaphene + DDT is recommended. A few farmers follow the recommendation.

f. Banana and Plantain pests. There seems to be no consistently serious pests, but in certain areas a root borer, Cosmopolites sordidus bores into the tree base and roots. The base of the tree may be sprayed, but a cultural control of splitting apart and drying affected trees is more often practiced.

g. Cassava pests. A major food crop, it is virtually 100 per cent infected with a virus transmitted by the whitefly, Bemisia tabaci. The virus is accepted and losses are not quantified. Occasionally the very common grasshopper, Zonocerus variegatus, may be sufficiently abundant to cause defoliation.

h. Coffee pests. Three pests are considered to be consistently serious. The coffee berry borer, Stephanoderes hampei, is apparently the most damaging, but the shothole borer, Xyleborus compactus, and the defoliator, Epicampoptera glauca, are also very damaging.

i. Tomato and eggplant pests. Of several pests, Heliothis armigera on the fruit and Prodenia (=Spodoptera) litura as a defoliator are most often damaging. Few farmers apply insecticides for their control. Attacking eggplant also, the fruit borer, Leucinodes arbonalis, is very difficult to control with chemicals and the flea beetle, Podagrica spp., can reach damaging populations.

j. Yam pests. Yam is an important food crop. Of several pests, the white grubs of Heteroligus meles mainly but also of H. appius, Prionoryctes rufopiceus and P. canaliculus attack tubers in fields and in storage. Seedling roots may be dipped in aldrin prior to planting.

k. Sugar cane pests. Stem borers are the most serious and a complex of species is involved. Sesamia spp., Busseola fusca, Eldana saccharina, and Coniesta ignefusalis are all very damaging. Little chemical controls are attempted. Other insects can be pests; for example, termite species can cause minor losses in attacking the roots and stalks.

l. Rice pests. The most consistently damaging of the stem borer species is Chilo agamemnon although attack by Sesamia spp. is common. A few pentatomids and other Hemiptera may attack seed. The larvae or maggots of the stalk-eyed flies, Diopsis thoracica and D. apicalis, are major pests through boring into the rice stems causing "dead heart".

m. Cotton pests. Several bollworms are major pests in Ghana and Nigeria. The false codling moth, Argyroploce leucotreta; spiny bollworms, Earias insulana and E. biplaga; the red bollworm, Diparopsis watersi; and in some areas the pink bollworm, Pectinophora gossypiella, all cause serious losses. In addition, three hemipteran species cause serious losses to terminal growth, bud and small boll abortion and in the case of Dysdercus,

lint staining in older bolls also. Species involved are Helopeltis schoutedeni, Campylomma spp. and Dysdercus superstitiosus. As in most cotton production areas, many other insect species attack this crop but the above are considered consistently major pests. Little insecticide is applied apparently even though the Cotton Board provides some supervision and scouting with an area to follow resulting recommendations. The Board provides chemicals at subsidy rates.

n. Stored product pests. Stored product pests are very serious in Ghana and most species of stored product insect pests reported earlier are found here except for Khapra beetle. EDB is the fumigant most widely employed. EDB is available in encapsulated form. For example, capsules are available in a size to provide precise fumigation for contents of a single plastic bag. Sevin sprays are used on the exterior of fabric bags. If the product is to be stored for long periods, it is placed in a plastic bag and the top tied after breaking capsule and the plastic bag is then placed in a burlap bag. It is very critical that seed moisture is low prior to bagging. Improved techniques are needed for storage in big granaries. According to the Chief Crop Production Officer, Dr. Baffoe, losses remain serious as further education is needed to get people to adopt the effective practices developed. Losses were estimated at the Stored Products Research Station to be about 20 per cent of stored cereal grains, including maize, cowpeas, and beans. It was pointed out that there was no price differential between clean and infested seed. FAO ran residue studies following EDB fumigation and found no bromine remaining.

o. Trained personnel in entomology. There are a few experienced entomologists resident in Ghana and despite their good training and motivation, many more are needed. In addition, there are two universities with a Faculty of Agriculture. The study team impression is that there is only one entomologist on each faculty. In general, with the heavy teaching load in the universities, little time remains for research, particularly in the applied field. Insufficient students are coming out with specialization in entomology and few employment opportunities existed. Library facilities are poor, particularly for research reference. Photocopies can be obtained from countries like England, but the time lag is serious. The study team had the definite impression that more trained, experienced people and facilities are desperately needed in view of the great number and variety of pest problems. One scientist

from the Commonwealth Institute of Biological Control (Dr. G. Scheibelreiter), working on stem borer parasites and their ecology, was located at the Crops Research Institute at Kumasi. Unfortunately he was finishing his research and would soon depart Ghana. As in countries visited previously, there are no extension specialists trained specifically in entomology.

p. Insecticides. Problems and use of insecticides are similar to those occurring in Nigeria where the situation is discussed more fully.

2. Plant Pathology

On cocoa, the virus disease "swollen shoot" is most important. One million infected trees are destroyed annually in the control program. Annual losses due to black pod, Phytophthora palmivora, is estimated at 19% of the crop. A new disease caused by the necrosis virus (related serologically to the tomato black-ring virus) has been found in a few areas. A destructive disease of coconuts called "Cape St. Paul Wilt" appears to be similar to the lethal yellowing disease of coconuts found in the Caribbean area. Blast, Pyricularia, causes heavy losses in rice. Helminthosporium is moderately important and Cercospora and Rhynchosporium cause minor losses. Rosette of peanuts causes an estimated 5% loss of the crop each year. Cercospora leaf spots, Macrophomina phaseoli and Sclerotium rolfsii, cause diseases of lesser importance. Virtually 100% of the cassava plants are infected with cassava mosaic. A rot of the cassava tubers by Fomes lignosum causes minor losses. True yams, Dioscorea, suffer from two diseases--a mosaic and a leaf blight. The causal agents of these two diseases have not yet been identified. The "sigatoka" disease of banana, caused by Cercospora, is very severe. The most important diseases of corn are rusts; Puccinia polysora and some P. sorghi; leaf spots, Helminthosporium tursicum and H. maydis; and maize streak, a virus disease. Citrus suffers from two virus diseases, tristeza and "greening", and from gummosis caused by Phytophthora. Angular leaf spot and black arm of cotton, caused by Xanthomonas, is the most important disease of cotton. Cotton leaf curl, a virus disease, is also fairly common. Coffee rust, Hemileia vastatrix, is not very important because mostly resistant "robusta" type coffee is grown. Coffee berry disease hasn't been observed. Oil palm suffers from a common seedling disease caused by Pythium, a fruit rot of unidentified cause, and Cercospora leaf spot. The most important disease of rubber is white rot of the tree caused by Fomes lignosum. Tobacco suffers from virus diseases, tobacco mosaic virus, leaf curl, and probably others; black shank, Phytophthora; and Cercospora leaf spot.

Tomatoes and peppers are also heavily infected with viruses. In addition, leaf diseases, Cladosporium fulvum and to a lesser degree Phytophthora infestans, completely defoliate tomato plants by the time harvesting begins.

3. Plant Nematology

There are two nematologists in Ghana; one located at the Crops Research Institute, Kumasi and one located at the University of Science and Technology, Kumasi.

Meloidogyne spp. are the most important plant pathogenic nematodes in Ghana when all crops are considered. The main species are M. incognita and M. javanica. Radopholus similis is important on banana. D-D and Nemagon granules are the only nematicides available.

4. Weed Science

In Ghana the major place for weed research is CSIR, Council for Scientific and Industrial Research. Within this group there is a weed committee that meets regularly to discuss and outline weed programs. However, there is very little being done in that there are not enough trained people.

The research coordinated by the research control committee of CSIR deals primarily with the toxic effect of herbicides in soil, plants and people and secondly with the effect on ecological balance. The weed control committee includes agents from industry who are selling chemicals. In general the proceedings to date have revolved around chemical application but now there is a move to biological control possibilities. The chemical companies sell directly to the user, however, the big user is the government through the research institutes. There is no registration of chemicals, however, the committee does submit a list of chemicals recommended for crops.

In certain crops such as cocoa, herbicides are being used for weed control, however, in most crops herbicides are not being considered in view of the cost. Paraquat is being used in the cocoa plantations and can be a valuable asset to management, however, herbicides are not generally recommended as a general practice in upkeep and maintenance in cocoa. Generally shading in matured cocoa will handle the weed problem. The cost of herbicides is an additional burden and there needs to be a labor reduction if herbicides are going to be used successfully.

At the Crops Research Institute (CRI) at Kumasi there is no one directly concerned with weed control, however some testing of herbicides is being done. In certain areas there is some use of herbicides by the larger farmers on maize. The primary weeds are Amaranthus spp., Portulaca oleracea, and Euphorbia hinta. There are no grass weed problems in maize. Cyperus is a serious problem and is being spread rapidly due to cultivation. In the northern part of Ghana, Striga is also a problem in maize. It was pointed out here also that nitrogen fertilization reduced the damage from Striga.

In general there is no information concerning the loss produced by weeds nor the levels of infestation of the various species. The evaluations on herbicides are very limited. A problem that appears to be developing in certain areas where intensive agriculture is being practiced is Rottboellia exalta commonly called Buffalo grass. This appears to be infesting areas after the slash and burn program.

In general, weeds are associated with an ecological area. Cyperus is not a problem in the Forest Belt but is in the transition zone to the North. In Ghana there are a few knapsack sprayers being used for application of herbicides. These are primarily in the cash-crop areas and there is little possibility of use at the peasant farmer level in view of current cost. The mixed cropping programs in the Forest Belt present a problem from the standpoint of herbicide use. Also the fact that much of the planted area does not involve row planting makes herbicide application difficult.

E. Nigeria

1. Entomology

The study team visited Southern Nigeria only where the agricultural crops, production systems and major pest species are very similar to those of Southern Ghana. A trip to Northern Nigeria was canceled because of bad weather. This was unfortunate not only for missing Nigerian and University officials in that area, but an entomologist, Dr. Dean Barry, is conducting research primarily upon host plant resistance to pest attack at Zaria. According to Dr. Barry, most of the major insect pests found in Northern Nigeria are also found in Mali, Niger, and Northern Ghana.

In addition nearly all the major crops and pests in Southern Nigeria were discussed previously in the Ghanian section. Consequently, only a few additions are made here. For details the reader is referred to Research Bulletin 269 entitled "Insect Pests of Nigerian Crops" (Research Division, College of Agricultural and Life Sciences, Univ. of Wisconsin, Feb. 1968). A list with biological notes is included in this Bulletin distinguishing major pests and those frequently encountered but believed to be of minor significance on virtually all crops in Nigeria.

a. Cucurbit pests. Cucurbits are not a major crop in any of the countries visited. Wherever they are produced, however, fruit flies of the family Trypetidae have been mentioned as major pests. Species involved in other countries are not known by the study team, but those occurring in Nigeria are Dacus bivitattus and D. brevistylus. According to scientists at IITA losses average at least 20% of the crop on melons.

b. Cocoa. Research at the Cocoa Research Institute of Nigeria (CRIN) is sophisticated and productive. Pest problems were identified in the section on cocoa in Ghana. Preliminary research is under way on pest management. The cocoa capsids, for example, frequently occur in pockets and through population monitoring, it may be possible to identify economic levels in these pockets and apply chemicals accordingly. Usually a total of 3 or 4 sprays have been found necessary for optimum crop protection. Research workers are convinced, however, that secondary pest populations can surge following pesticide treatment. Accordingly, increasing attention is being paid to the effect of insecticides on the beneficial insect complex, including pollinators, as well as upon pest species.

c. Cowpea and bean pests. A more complete discussion on cowpea and bean pests was held in Nigeria than in Ghana, thus the majority of major pests are discussed in this portion. Losses to pests reduce yields very heavily without insecticidal protection as was the case in previous countries visited. Most of the major pests in various ways destroy flowers, pods or developing seed. A complex of four coreid bugs cause major losses. These are Anoplocnemis curvipes, Riptortus dentipes, Acauthomyia spp. and Mirperus jaculus. Maruca testulalis and Laspyresia ptychora are serious problems with the latter species sometimes causing 25 to 30% loss in yield. Weevil, Apion varium, larvae feed in developing pods on the seed and the leaf beetle, Ootheca mutabilis, destroys foliage and new growth and is reported to be a vector of cowpea yellow mosaic virus.

d. Insecticides. The insecticide situation is roughly comparable in Nigeria and Ghana. At the present time there are no regulations pertaining to labeling, registration or standardization of insecticides. Often insecticides are purchased in small amounts taken from unmarked drums. Containers are frequently contaminated. BHC is used for many pests because it is readily available and supported by the cocoa industry. Residues are watched closely on cocoa. The study team was not aware of monitoring on other crops. Some thought is being given to regulation of insecticides and it is possible USAID, FAO or other international units can be of help here.

e. Trained personnel in entomology. Resources and trained manpower are advancing in Nigeria, although far short of meeting minimal needs. Universities need augmentation for teaching and to increase research effort, particularly in fundamental entomology. The Institutes of Research and Training, of which there are several (Moor Plantation, cocoa, oil palm, rubber, etc.), provide a strong basis which if augmented have a wonderful opportunity for problem-orientated research. The Cocoa Research Institute is already well known for its research. The University of Wisconsin and Nigerian Government have an AID sponsored contract at the University of Ife for teaching and administration although research still lags. Another similar arrangement exists in Northern Nigeria with Kansas State University. At these centers of learning Nigerians are being trained to take over eventually. Trainees have been sent to other countries for graduate studies. The University of Ibadan has a strong program under the outstanding leadership of Dr. T. A. Taylor, but with only two other entomologists additional staff would strengthen the teaching program and provide more time for research which, of course, adds strength to teaching.

The International Institute of Tropical Agriculture at Ibadan is already involved in productive research even though their physical plant is not yet complete. Three research entomologists with interests ranging from host plant resistance to insecticide evaluation are playing a strong role in research, and, importantly, in interaction with entomologists in Nigeria and neighboring countries. The overall aim of this institute is to improve quality and quantity of food in lowland humid tropics. The study team was greatly impressed with the staff, facilities, motivation and objectives of IITA.

2. Plant Pathology

Most of the plant disease problems of Nigeria are similar to those of Ghana. Swollen shoot of cacao is not quite as severe as in Ghana, but black pod is more serious, reaching 100% loss in unsprayed plots in the wetter areas. Coffee rust and coffee berry disease cause significant losses of "arabica" coffee but are much less severe on "robusta' types. Diseases of rice, maize, cotton, rubber, oil palm, tobacco, peanuts, banana, and citrus are about the same as found in Ghana. According to Dr. Stanley King, the diseases of sorghum and millet in northern Nigeria are about the same as those of Senegal, Mali, and Niger, with smuts and downy mildew as the most serious problems. More work has been done on diseases of pulse crops in Nigeria than at other locations visited. Significant losses occur in cowpeas from leaf spots, Cercospora cruenta and C. canenscens; anthracnose, Colletotrichum lindemuthanium; viruses mostly unidentified; bacterial pustule, Xanthomonas vignicola; and seedling diseases. Important disease problems occur on other legumes also. Cassava is generally infected with mosaic. In addition a bacterial disease, Xanthomonas manihotis, has been found in various parts of Nigeria which may impede the distribution of improved lines from IITA to other African countries. Tomatoes and peppers are generally heavily infected with viruses and suspected virus diseases occur in yams, sweet potatoes, and okra.

3. Plant Nematology

The importance of nematodes in crop production in Nigeria is better understood than in most countries visited. Studies conducted there by Dr. Fields E. Caveness indicate the presence of over 100 parasitic species. Root-knot nematodes, Meloidogyne incognita, M. javanica and M. arenaria are the important species. Lesion nematodes, Pratylenchus spp., can cause as much as 25% reduction in yield of maize. Scutellonema bradys is a serious pest on yams. Many other nematodes are causing damage to specific crops such as Heterodera saccharii on sugar cane, Aphelenchoides besseyi on rice, and Radopholus similis on banana.

Nematodes are serious factors in the production of many of Nigeria's important crops. Agricultural agencies are now recognizing the importance of these pests and are taking them into consideration in their various programs. For example, the International Institute of Tropical Agriculture (IITA) has a full-time nematologist on their staff who works as a member of the team in looking for host resistance and other forms of control. The University of

Ibadan has two full time nematologists and the University of Ife, a new university started in 1963, has one full time nematologist. Moor Plantation, the Federal research station near Ibadan, also has a nematologist.

4. Weed Science

Dr. Keith Moody of IITA is conducting research in the area of weed control. His studies indicate that the greatest limitations in farm size is weeds and that 70 to 80% of the time is spent in weeding. Much of the weeding is done poorly and too late or after 60 or 70% of the damage is done. Competition studies being carried on at IITA indicate that the first three or four weeks are most critical from the standpoint of weed competition. There are a few chemicals used in plantation crops such as coffee and cocoa but are not in general use in agriculture, due to cost. In Nigeria, there are for example only three distributors for atrazine and so availability of chemicals is limited.

There is rapid soil breakdown of herbicides. Absorption is low because of the low content of organic matter and clay and the breakdown is rapid because of high microbial activity.

One of the major problems in rice and maize in Nigeria is Rottboellia eratata. It was pointed out in Nigeria that weeds such as Panicum and Rottboellia may carry stem borers. Weeds will serve as a host for viruses and diseases of maize.

There are no labeling or regulations for registration. In Nigeria following the slash and burn program, broadleafs are the first to establish and then the population shifts to grasses under continuous slashing.

Dr. Moody has indexed many of the common weeds that are a problem in Nigeria. The general weed species present in Western Africa are indicated in a book by J. K. Egunjobi, "Some Common Weeds of Western Nigeria". Aquatic weeds are not a problem in the big lakes because of constant water turnover but they are a problem in small ponds.

F. Kenya

1. Entomology

The different environment in East Africa presented some crops not encountered earlier and accordingly some new

pests. A Pest Handbook entitled "The Recognition and Control of the More Important Pests of Agriculture in Kenya" by P. E. Wheatly and T. J. Crowe, published by the Republic of Kenya provides detailed information on major pests of the important crops. Only a few major crops are mentioned here.

a. Coffee pests. The coffee leaf miner, Leucoptera meyricki and L. coffeina, are the most consistently important pests. It is thought they are more abundant following application of certain chemicals. The Antestia bug, Antestiopsis spp., can have serious effects on buds, berries, and growth with populations as low as one or two per tree. Coffee thrips, Diarthrothrips coffae, and coffee lace bug, Habrochila ghesquierei, can be serious particularly in hot, dry weather. The Kenya mealybug, Planococcus kenyae, is usually not a problem unless ants are allowed to become abundant.

b. Tea pests. There are no consistently serious pests and thus an attempt is made to use as little insecticide as possible. Occasionally the black tea thrips, Heliothrips haemorrhoidalis, will cause sufficient leaf damage to require insecticides. Spot spraying is occasionally needed for the red crevice mite, Brevipalpus phoenicis. The giant looper is occasionally a pest and is believed to be worse following insecticide application, particularly when parathion was applied.

c. Cotton pests. The most serious pests are those which attack fruiting forms. The American bollworm, Heliothis armigera, the spiny bollworms, Earias insulana and E. biplaga, and pink bollworm, Pectinophora gossypiella, are all very damaging, the pink bollworm being extremely important if host-free periods are not observed. Cotton stainers, Dysdercus spp., is a serious pest over most of Kenya. Lygus vosseleri is damaging primarily in Western Kenya. Cotton jassids, Empoasca spp., would be serious pests but resistant, hirsute varieties of cotton are grown. Helopeltis schoutedeni is not a consistent pest but causes very severe damage in Western Province in some years.

d. Cucurbit pests. Melon flies of genus Dacus commonly destroy the entire crop unless protective measures are taken. Epilachna chrysomelina is a serious defoliator at times.

e. Maize, sorghum and millet. The stem borers, Busseola fusca and Chilo orichalcociliellus, are serious pests on all three crops. Outbreaks of the armyworm,

Spodoptera exempta, are feared on all grass-like crops, including cereal crops--rice and wheat. The American bollworm, Heliothis armigera, is a common pest of maize. On sorghum the shoot fly, Atherigona indica, is considered serious but exact level of losses are unknown.

f. Rice pests. The white rice borer, Maliarpha separatella, and stalk eyed fly, Diopsis thoracia, are stem boring pests. The rice hispid, Trichispa sericea, destroys foliage in nursery rice.

g. Pyrethrum pests The thrips, Thrips nigropilosus, at times requires treatment on large plantings but small acreages seldom receive applications of chemicals. Aphids and spider mites increase in the dry season but seldom warrant chemical application.

h. Coconut pests. There are several sporadic pests of coconut but only the rhinocerus beetle, Oryctes monoceros, is consistently serious. Control by tree destruction is enforced by legislation

i. Stored product pests. Stored product insects are serious in Kenya as in other countries visited. No detailed discussions on stored product pests were held. The most common species causing problems are the maize weevil, Sitophilus zeamais: rice weevil, S. oryzae; Angoumois grain moth, Sitrotroga cerealla; red flour beetle, Tribolium castaneum; warehouse moth, Cadra cautella; bean bruchid, Acanthoscelides obtectus; and cowpea bruchid, Callosobruchus spp. Sanitation and chemical control recommendations are available but the extent they are used is not known. One estimate of losses in storage was at least 20% and probably much higher if protection is not used.

j. Insecticides. A vigorous agribusiness promotes pesticide use and a wide range of insecticides are recommended. The organochlorine insecticides are frequently applied and there is some concern about their future availability. There is a growing concern about DDT contamination in the environment. At the present time there is no legislation to control importation, labeling, and registration of pesticides but preliminary work to this end is starting. On coffee, for example, the research station approves and recommends and the chemical industry sells the product. The amount of pesticide used in Kenya is unknown, but coffee and cotton receive the largest amount often through repeated treatments each production season.

k. Trained personnel in entomology. The University in Nairobi has a very small but active teaching program in entomology. It was the study team's understanding that the University should become self-sufficient in training manpower reasonably soon. Libraries are deficient in research resources and feel help is needed especially in this facet. There is insufficient research personnel in entomology, particularly in the applied field, to develop answers to the many problems. Nevertheless, a cadre of excellent scientists exist upon which to build soundly for the future. In addition there are well-trained people in industry who can be of assistance. The International Center of Insect Physiology and Ecology (ICIPE) with Professor Odhiambo as leader, is devoted entirely to fundamental research and application of basic principles to insect problems. Supported largely by scientific societies and international organizations, it is staffed by local and visiting scientists. In addition it can be and is of significant assistance to the University training program. The Coffee Research Foundation performs research and is recruiting for an entomologist to work on ecology and economic thresholds for coffee pests. This has been brought about partially by a move towards pest management and observed upsets following applications of certain insecticides. Additional entomological input is needed in the Ministry of Agriculture. EAAFRO has wide responsibilities for quarantines, harbors, and railroads, but forms another nucleus for research on forest and agricultural problems. There is a need here for more resident native entomologists to provide greater continuity of research as much of it now is done by foreign scientists.

2. Plant Pathology

The coffee berry disease, Colletotrichum coffeanum, is the most important plant disease in Kenya. In 1967 an estimated 30% of the crop was lost from this disease and a total loss of the crop occurred on many farms. Coffee rust, Hemileia vastatrix, is also a problem. There are no major disease problems on tea, although Armillaria mellea and Phomopsis cause some damage. Also, there are no important disease problems on pyrethrum. The angular leaf spot and blackarm disease, Xanthomonas, is fairly important on cotton and Verticillium wilt occurs on this crop. The most important pathogens on maize are viruses, maize streak and strains of sugar cane mosaic virus; leaf spots, Helminthosporium tursicum and H. maydis; and rust, Puccinia sorghi. Stalk rots also cause some damage. On wheat, rusts, Puccinia graminis tritici, P. recondita, and P. glumarum; and leaf blotches, Septoria tritici and S. nodorum, are important problems. On beans, rust, Uromyces appendiculatus, anthracnose, and viruses are important

diseases. On potatoes, viruses, late blight, Phytophthora infestans, and bacterial wilt, Pseudomonas solanacearum, cause heavy losses. An important disease of sugar cane is smut, Ustilago scitaminea. Viruses and a bacterial disease also cause losses. Blast is a serious disease of rice. A damaging virus disease (rice yellow mottle) was recently described from Kenya. Bacterial wilt, bacterial canker, late blight, and viruses limit production of tomatoes. Cassava mosaic is also prevalent where this crop is grown.

3. Plant Nematology

Kenya is making some progress in delineating its important nematode problems. Dr. D. P. Taylor, a staff member of East African Agriculture and Forestry Research Organization (EAAFRO), Nairobi, Kenya, is engaged in research and training. Meloidogyne species, M. javanica and M. incognita, are important on practically all crops. M. hapla is serious on Pyrethrum. Aphelenchoides besseyi is the major nematode pest on rice. Banana has a number of nematode genera attacking it; namely, Meloidogyne, Pratylenchus, Helicotylenchus and Radopholus similis. Another nematologist, Dr. Isaiah N. Njoroge, is employed by the Ministry of Agriculture, National Agricultural Laboratories, Nairobi. He is concerned with diagnosis of nematode disease problems and research on the root-knot nematode, M. hapla, on Pyrethrum. There are no nematologists in Uganda or Tanzania.

4. Weed Science

The weed problems in East Africa are well outlined in the book, "East African Weeds and Their Control", by G. W. Ivens.

The cropping patterns in Kenya, Uganda and Tanzania are quite similar in that coffee, cotton and tea are cash commodities in all three countries. Maize is the most important subsistence crop in Kenya and where maize is grown on a large scale, there is some small use of herbicides, namely atrazine and 2,4-D. Small growers have not begun to use herbicides as yet. In general the small holders are carrying out hand-weeding practices and the estates are using herbicides such as paraquat for effective control particularly in coffee and tea plantations. At the present there seems to be indiscriminate use of pesticides and there is no mechanism for recommendations. There is currently legislation being considered for registration, however it is not in effect at the present time.

In much of the plantation crop areas mainly sugar cane, coffee, tea and pineapple, Digataria scaralum is a major problem. This perennial infests much of the acreage with no practical means of control. Also in sugar cane Rottabellia and Cyperus are problems. The other major problem in Kenya in addition to Digataria is Cynodon dactylon (stargrass). These perennial grasses are serious throughout the plantation areas. In the East Rift area broadleafs are a problem, and the dry period allows for some control of perennial grasses.

Seasonal availability of hand labor is a problem. There has been some testing of herbicides, however, the cost of herbicides in comparison limits the use of these materials. The availability of herbicides is good if the grower can afford them, however, cash availability is a limiting factor. All of the herbicides are sprayed by hand. In the wheat growing areas of Kenya the phenoxy compound, 2,4-D, is being used.

G. Tanzania

1. Entomology

Only a portion of one day was available to the study team in Tanzania. This was spent at the Tropical Pesticides Research Institute which is a regional laboratory for Tanzania, Kenya and Uganda. Most of the pest problems discussed were considered in the section on Kenya. It was noted that cotton produces only about 300 pounds of seed cotton per acre without insecticides but yields up to 2,000 pounds are produced with chemical protection. Sometimes as many as 6 to 7 applications of insecticide, normally DDT, are applied to this crop and mite populations may increase as a result. It was indicated to us that research on cotton insect problems was strongly needed.

Some equipment for residue analysis is located at this laboratory, but a skilled analyst is needed in the program. If a large program is to be undertaken, however, additional modern equipment will be necessary. The Ministry needs trained entomologists badly.

Pest population surges are believed to occur on coffee in Tanzania following insecticide application, particularly with DDT. Coffee berry moths and looper were examples used. There is field evidence that white grubs on sugar cane have developed a 200X level of resistance to aldrin. Where aldrin has not been used for some time, resistance levels have declined.

2. Plant Pathology - (No information)

3. Plant Nematology - (No information)

4. Weed Science

The Tropical Pesticide Research Institute is the only organization in the African countries visited doing fundamental herbicide work. Their recommendations are published by the Ministries and include evaluation of both the laboratory, greenhouse and field experiments with herbicides. They also collaborate with the Ministries in demonstration trials throughout the East African community. The herbicide section in EAAFRO has been operating for 10 years and is now the strongest section. They are mainly concerned about herbicides in the environment and the resultant residue problems. It is felt that this regional evaluation of herbicides as is done at the Pesticide Research Institute is an advisable practice.

H. Ethiopia

1. Entomology

The entomologist and weed scientist on the study team had to return to the United States before the Ethiopian study was completed. Most, but not all, major pest problems were found to be similar to those occurring in Kenya. Detailed information on pest problems is available in the Crop Pest Handbook by T. J. Crowe and Shitaye Gebre Medhin entitled "A Guide to the Recognition and Control of the Most Important Pests of Field and Plantation Crops in Ethiopia" published by the Institute of Agricultural Research, June 1972.

a. Coffee pests. About 50% of the export value of agricultural crops is attributable to coffee. Only the antestia bug, Antestiopsis spp., is listed as a consistent pest. There are occasional problems with a fruit fly.

b. Cotton pests. Cotton pests occurring in Ethiopia were covered sufficiently in the section on cotton for Kenya. The jassid, Empoasca lybica, is a pest in all Ethiopian production areas, but insecticides applied for control of other pests normally are effective on the jassid also. Presumably cotton varieties resistant to jassid are not grown in this country. The cotton leafworm, Spodoptera littoralis, is a major defoliating pest of cotton. According to the Director of the Institute of Agricultural Research, Dr. Dagnatchew, as many as 6 to 10 insecticide applications may be made. At times control results may still be poor, indicating a need

for field monitoring by trained personnel. He indicated that Heliothis armigera populations may increase more than normal as effect on beneficial insects from the Spodoptera control attempts.

c. Teff. This is an important seed crop for food and there are few major pests attacking it. All pest species are leaf feeders and are generally only serious in outbreak situations. The three species are Plusia acuta, Spodoptera exempta and S. exigua. Major outbreaks of the armyworm, S. exempta, are especially feared.

d. Citrus pests. There are many insect pests which affect citrus production. Included are a large number of scale species and the Mediterranean fruit fly, Ceratitus capitata. In some areas the fruit-piercing moths may cause almost complete loss of thin-skinned citrus fruit. Losses may be total on tangerine but less serious on lemons and grapefruit. The FAO entomologist, Mr. Terry Crowe, is working with entomologists outside Ethiopia on biological control of some of the most serious scale pests.

As most other crops have major pests in common with those discussed in Kenya and are listed again in the Handbook mentioned, they are not repeated again. It was interesting to note, however, that Spodoptera littoralis is a sporadic but much feared pest on many crops. This was not the situation in Kenya based on our limited observations.

e. Stored Product Pests. The situation with stored product insects in Ethiopia is similar to other areas visited, but little time or information was available to the study team to pursue this aspect in detail. It was noted, however, that a team of scientists from the U.K. (FFHC/CA Stored Product Project) was involved in research and extension problems relating to stored products. The team was working on damage assessment and surveys. Improved means of storage were being investigated, including storage in plastic bags. Evaluation of seed protection with products like lindane and malathion was under investigation. They have been involved in teaching and training in methods improvement. The final report of this team was in preparation but not available to the study team at this date.

f. Insecticides. Time did not permit a thorough investigation of the status of the insecticide situation. There is agribusiness in Ethiopia but no organizations were visited. As was the case in other countries, there

is no legislation pertaining to labeling, registration and other aspects of insecticide importation and use.

g. Trained personnel in entomology. The Institute of Agricultural Research with five main field stations is the major research resource but there is no entomologist employed. One is currently training in the United States (Univ. of Arizona). According to our information, there is a single entomologist in the Ministry of Agriculture. The entomologist was not able to visit the College of Agriculture in the University, and the entomological training and teaching staff, if any, was not evaluated. Mr. Terry Crowe, FAO entomologist, plays an active role in entomological research. Very obviously, trained entomologists are badly needed in the various governmental organizations in Ethiopia.

2. Plant Pathology

Many of the plant disease problems of Ethiopia are similar to those of Kenya. Coffee berry disease has recently been found and is severe in localized areas. Coffee rust is also important. Stem rust of wheat is a major problem with leaf and stripe rust occurring to a lesser extent. Septoria causes heavy losses in wheat, primarily S. tritici. Bunt, Tilletia foetida, also occurs in cooler areas. Barley scald, Rhynchosporium secalis, causes heavy losses. Leaf rust, stem rust, and Helminthosporium diseases are also quite prevalent on barley. Rust, primarily Puccinia sorghi with some P. polysora, and leaf spots, primarily Helminthosporium, occur on corn and are severe on some varieties but most of the varieties grown seem to have tolerance to these diseases.

On sorghum, rust is a major problem and the smuts are generally present. Leaf diseases, anthracnose, bacterial stripe, and bacterial streak, and ergot may become severe in localized areas or on certain varieties. Teff, Eragrostis tef, is an important crop. Rust, Uromyces eragrostidis, and head smudge, Helminthosporium miyadei, may become very severe in localized areas, but disease losses on teff are generally light. Angular leaf spot and black arm are generally severe on susceptible varieties of cotton and a small amount of Verticillium wilt has been noticed. Sugar cane suffers from smut and virus diseases. There are serious diseases of beans. Rust, Uromyces phaseoli, anthracnose, Colletotrichum lindemuthianum and virus diseases, mostly unidentified, are the most important. Two bacterial diseases, halo blight, Pseudomonas phaseolicola, and common blight, Xanthomonas

phaseoli, are also common. Chocolate spot, Botrytis fabae, and rust, Uromyces fabae, are the most prevalent diseases on broad bean. Sclerotium rolfsii is the most important pathogen of chickpea and causes heavy damage. Peppers are generally attacked by powdery mildew, Leveillula taurica, and by viruses. The principal diseases of potato are late blight, Phytophthora infestans, powdery mildew, and viruses. Bacterial wilt, Pseudomonas solanacearum, has also been observed on this crop. Late blight and viruses are also important on tomatoes and in addition Septoria leaf spot completely defoliates the plants during the rainy season. Phyllody, probably caused by a mycoplasma-like organism, has completely ruined some fields of sesame. In addition Cercospora leaf spot and bacterial blight may cause heavy defoliation. A new disease of enset, Ensete ventricosum, caused by Xanthomonas musacearum has wiped out this crop in certain areas. The bacterium also attacks bananas and produces symptoms similar to those of the moko disease.

3. Plant Nematology

Virtually nothing is known concerning nematode disease problems in Ethiopia. The principal plant pathologist, Dr. Dagnatchew, indicated that the root-knot nematode, Meloidogyne spp., was quite prevalent throughout Ethiopia but indicated that no surveys had been made and that the extent of damage is unknown. While visiting the agricultural research station at Jimma, severe root-knot symptoms were observed on soybean, tomato and pyrethrum. Also, severe root-knot was found on tobacco at Melka Werer, another research station of the Institute of Agricultural Research (IAR). There are no trained nematologists in Ethiopia.

4. Weed Science

It was pointed out in Ethiopia that from a farmer's point of view, weeds are the most important problems in agricultural production. Cyperus is a major problem in Ethiopia particularly in the irrigated areas. There is some herbicide research being conducted at the Melka Werer Station, primarily in the cotton and citrus areas. Striga is a problem in the northern part of Ethiopia in the sorghum growing area. In the coffee plantation areas Digataria scaralum is a problem as was indicated in Kenya. Water hyacinth is a problem in the canals and irrigation water throughout much of Ethiopia and this problem should receive some attention in the near future because of the nature of spread.

It was pointed out in Ethiopia that weeds produce 30 to 35% yield losses. Labor costs are low and hand weeding will be a continued method of weed control. There is some herbicidal evaluation on the research stations. It appears that there is some possibility of using herbicides in the early stages of growth followed by hand weeding later in the season if herbicides are available. This would allow for an increase in commercial scale operations in certain crops. As was pointed out earlier it appears that while the use of hand labor is important and labor is abundant there is a critical need for weed control in the first 3 or 4 weeks after emergence.

VIII. Management of Pesticides

In virtually all countries a real problem exists in management of pesticides. There is no legislation regulating labeling, quality, registration for use and residue monitoring. Often, for example, pesticides for sale are taken from large containers and put in smaller, unlabeled and occasionally contaminated containers. Only few facilities exist with a limited ability to determine residues and these are very small, understaffed and equipment used is generally inadequate by modern standards. In a few cases, residues have been determined by international laboratories for exported crops, but in many cases before pesticides are recommended by Ministries the chemical company producing the pesticide provides information on residue levels. In general, the need for management of pesticides is recognized in the various Ministries and some plans are underway for legislation governing pesticide use. For example, the East African Pesticides Control Organization (EAPCO) was established in 1971, to promote the safe and effective use of pesticides in East Africa. Its establishment will be the outcome of more than 20 years of unremitting efforts by East African Government Scientists and the Pesticide Chemicals Association of East Africa. Although there is no enforceable control over labeling and quality of pesticides sold and used in East Africa, the Pesticide Chemicals Association has, over the past twelve years, exercised voluntary restrictions on the sale of pesticides rejected by government research stations.

IX. Plant Quarantine

At a convention sponsored by FAO in 1954 the Interafrican Phytosanitary Council was formed to deal specifically with plant quarantine problems in Africa. This Council now operates under the auspices of the Organization of African Unity (OAU) and meets every two years to coordinate legislation and discuss other problems related to plant quarantine. The Council sponsored a publication, "A Memorandum for Phytosanitary Procedure in Africa", which gives general information on plant quarantine services and lists important plant pests that might be introduced

into Africa or into new areas of Africa. In 1967, the Heads of African States and Governments approved the "Phytosanitary Convention for Africa" and most, if not all, countries of the OAU have now ratified this Convention. The Scientific Secretary of the Interafrican Phytosanitary Council is Dr. Paul G. Addoh, B. P. 4170, Yaounde, Cameroon. The Scientific, Technical, and Research Commission of the OAU (P.M.B. 2359, Lagos, Nigeria) has recently published a 445 page "Handbook for Phytosanitary Inspectors in Africa", which gives the organization of plant protection in Africa as well as general principles and specific techniques involved in inspection, sampling, and identification in plant quarantine work.

There seems to be two main areas to be concerned with in preventing the introduction of new plant pests into a country. One is the inspection of personal effects of persons entering the country from abroad and inspections of plant commodities intended for commercial use at ports of entry. The other area is a quarantine system to prevent pests from being brought in with live plant material intended for growing in the country. Presumably the African countries have alerted their customs inspectors about the dangers of bringing in new pests on plant materials and most if not all countries seem to have some form of inspection of commodities at ports of entry. We were not able to evaluate the efficacy of these inspections. If more inspectors are needed, which seems probable, these could be trained at Moor Plantation in Nigeria or at the school run by the United States Department of Agriculture in Battle Creek, Michigan, to train foreigners in customs and quarantine inspection.

Quarantine facilities and technical training of personnel for allowing the introduction of useful planting stocks without introducing new pests varied greatly among the countries visited. In Senegal and Niger this program is just beginning. The French scientists (IRAT) in these countries indicated that they took precautions to prevent the entry of new pests on any plant materials they brought in and that they needed to get permission from someone in the Ministry of Agriculture to bring in the plant material. This seemed to be merely paper work since there are no facilities or trained technical personnel to make a detailed examination of the material. In Mali a man (Mr. Kane) who had had a few months of training in France in dealing with all types of plant pests was handling the plant quarantine work as part of his responsibilities.

In Ghana there is a man devoting full time to plant quarantine work and in addition Mr. E. A. Addison, plant pathologist at the Kumasi Research Station, makes laboratory examinations of some materials and grows out cultures, particularly from seeds, for identification.

Nigeria has set up a plant quarantine service that seems to be progressing well. Also, details of the program of post-entry plant quarantine services in Nigeria has been provided for us by Dr. George H. Berg, Project Manager of the Post-entry Plant Quarantine Station and Training Center. Details are as follows:

1. On October 6, 1970, a Plan of Operation was signed for the establishment of a Post-entry Plant Quarantine Station and Training Centre at Moor Plantation, Ibadan, Nigeria. Work on the establishment of the Project was initiated shortly thereafter, with the field operations scheduled to be concluded on 30 November 1975. This Project was established with assistance from the United Nations Development Programme, with the Government Cooperating Agency being the Nigerian Federal Department of Agricultural Research and the Food and Agriculture Organization of the United Nations being the Participating and Executing Agency.

2. The purpose of this Project is to assist the Government of Nigeria in the re-establishment of the post-entry plant quarantine station at Ibadan and the training of plant quarantine personnel. In particular the project will:

a) Establish an approved post-entry plant quarantine station at Ibadan;

b) Service plant propagating material that is subject to post-entry plant quarantine requirements and destined for Nigeria;

c) Service plant propagating material that is subject to post-entry plant quarantine requirements and destined for neighboring English-speaking countries;

d) Strengthen existing Federal Plant Quarantine Services and coordinate their activities with those of the Post-entry Station;

e) Train plant quarantine personnel of the Federal Plant Quarantine Service in national level courses;

f) Carry out on-the-job training of plant quarantine personnel;

g) Train plant quarantine personnel of the neighboring, English-speaking countries.

3. At the present time, as only very limited facilities are available for providing post-entry plant quarantine services, these activities are almost at a standstill. However, construction of the required facilities are now in progress and if all goes as planned, by the end of 1973 the Post-entry Plant Quarantine

Station will be operational and space for processing plant propagating material will consist of 14 closed quarantine glasshouses (28 units), two controlled environment rooms, two large propagating glasshouses (4 units) and two or more screenhouses.

4. By the end of 1975, it is envisaged that 30 or more closed quarantine glasshouses (60 or more units), 4 controlled environment rooms, two large propagating glasshouses (4 units) and four screenhouses will be in use.

5. In addition, seed health testing will be incorporated as part of the post-entry plant quarantine complex, although these will be primarily for routine examination of admissible material, as well as for verification of the presence of seed borne diseases under certain circumstances. At a later stage of the Project, meristem culture will also be incorporated as one of the Station's activities.

6. During 1972, one National Plant Quarantine Course was presented, as well as one International Plant Quarantine Course (five countries represented). During 1973, there will be two National Plant Quarantine Courses presented. During the first half of 1974, the Second International Plant Quarantine Course will take place. These courses deal with all phases of plant quarantine work including post-entry.

The East African Community has excellent plant quarantine facilities at Muguga, Kenya. The East African Standing Technical Committee on Plant Import and Export put out in July 1972 its seventh "Non-legal" draft of regulations governing the import of all kinds of plant materials. The facilities include a number of small greenhouses for growing plants in isolation before release. Ethiopia is just getting started in setting up a plant quarantine service. There are some inspectors for export and import of commodities but no facilities for detailed examination of imported plant materials. J. M. Thresh was brought in to study the situation and make recommendations for the quarantine program.

In Nigeria and Ghana, there were complaints, primarily from plant breeders, that the quarantines were either too strict or too inefficient and that prohibition or delays in bringing in needed plant materials was hindering their progress. The FAO Conference on the establishment of cooperative agricultural research programs between countries with similar ecological conditions in Africa, held in Nigeria, 1971, emphasized the need for freer movement of seeds between research organizations.

X. Agricultural Extension

A major bottleneck or "gap" in agricultural production and crop protection is extension. The plantation areas or those in

which government has vested interest as export commodities have many of the answers. An important concern is to get to the small or peasant farmers who are on a subsistence base. Extension is an important link in the improvement of peasant agriculture.

Extension functions in all countries are under the direction of the ministry of agriculture. It appears that these are considered "positions" without regard to what are the necessary functions to make extension work. There are a number of factors that make extension, as we know it in our land grant system, a viable unit. Among these factors is communication. Transportation and other lines of communications are difficult and in many areas non-existent. One extension agent placed in an area finds it very difficult to get to the farmers and it does require considerable effort and motivation to get the job done.

Perhaps a more feasible approach in the overall approach to extension is to train the more knowledgeable and progressive (model) farmers in each area or village or unit and depend on his getting the information to a small number of farmers in his area. Many of the persons being trained and going into extension do not have a farm background and are unable to relate to the problem. Further it is necessary to get government to recognize the benefits of extension on a comparable basis with research and teaching. In these countries extension "teaching" is the most important thing that can be done in the agricultural field. It is necessary to encourage the "bright, motivated" persons to go into extension. Further it appears that financing of extension is a problem in comparison to research.

In some areas it takes 10-20 years to extend information and this is too long. Immediate extension of simple basic agronomic principles is necessary and can not wait until all of the research answers are obtained. There is considerable good basic research going on but very little is being extended.

The training of a typical extension agent is limited and his knowledge of technical agriculture is lacking. Usually training consists of 1 year beyond a Junior-Senior high school level. Any training programs that are developed should include provision for "retraining" every 2 or 3 years. This should be done with agents under the current system and with the "farmer type agents" proposed earlier. Constant upgrading is necessary if the system is to advance.

There should be greater stress put on applied research on farms away from research stations. This would lead into more effective extension methods. This need here is to tie applied research in production agriculture to an extension demonstration system.

There is a need for good production agronomists (BS or MS level) throughout all countries. Consideration should be given to training indigenous persons in these areas. The needs in general are not for high level sophisticated research. For example, it was reported that 20-30% increase in yields can be obtained by simply plowing or tilling the soil before planting. This has been known for some time but not used to any extent. "Cooperative" tillage programs and other production practices to make greater use of animal power and equipment might be considered.

It was observed that extension effort and acceptance is faster if a commercial crop is involved. Again lack of trained personnel and funds are the major factors. Farmers, for example, might accept animal traction but neither money nor credit is available. There are certain sociological and traditional concerns that also slow change.

It is necessary to bring scientific information to bear on a scale that is meaningful and in keeping with the farmer's ability to use it. Change must be made gradual and a continuous low profile program through years is necessary. The extension of sociological aspects is as important as the economic aspects.

In some areas the extension looks good on paper but the need for facilities, transportation and to some extent personnel is apparent. There is less need for more people than there is for more contact with farmers. In no case were there plant protection people in extension in any area visited.

In the minimum package program in Ethiopia, it is an extension approach with innovations that will catch on. There is a concentration of extension in focal points with approaches that include 1) survey, 2) determination of what is feasible, 3) demonstrations, and 4) initiation of a sound extension program.

In summary, upgrading of extension programs is necessary by organizing training programs to improve technical knowledge, interest rural persons into coming into extension service, and develop action programs that revolve around socio-economic progress. It is important the level of skilled manpower be raised and with a motivation toward insuring farmers are kept abreast of modern scientific developments that are relevant to allowing for steady, continuous improvement in agriculture production.

XI. Appendix I. Itinerary including institutions and persons visited during the period October 9 - December 1, 1972

October 9: Team enroute to London

October 10: Afternoon--London: Centre for Overseas Pest Research (COPR)

Dr. Peter Haskell (Director)
Mr. C. Ashall
Dr. D. Hunter Jones
Mr. C. Lee
Mr. G. Popov
Mr. P. Walker
Mr. R. A. C. Williams

Overseas Development Administration (ODA)
Dr. R. K. Cunningham (Director)
Dr. D. W. Hall

Visitors
Dr. E. M. Thain -- TPI
Prof. M. J. Way -- Silwood
Dr. G. R. Conway -- Silwood
Mr. G. A. Matthews -- Silwood
Dr. T. W. Tinsley -- Invertebrate Virology
Mr. A. H. Strickland -- Plant Pathology Lab.
Dr. C. A. Butler -- Rothamsted

October 11: Paris (afternoon)

Those in Attendance	Title	Institute
MM. J. Breniere	Entomologist	IRAT
J. Brun	Phytopathologist	IFAC
P. Jan	Weed Specialist	IRAT
R. Lagiere	Phytopathologist	IRCT
E. M. Lavabre	Entomologist	IFCC
J. Le Gall	Entomologist	IRCT
E. Biliotti	Entomologist	OILB/SROP
F. Fournier		ORSTOM
G. Mathys	Director-General	EPPO

October 12: Morning--Paris, Bondy (ORSTOM)
Director: Dr. Pierre Segalen

October 13: Senegal, Dakar. Visit with AID personnel--Dr. David McAdams, Mr. John E. Osguthorpe and Dr. Ralph Edwards.
--Visit to OCLALAV--Director, Mr. Castel

--Visit to IRAT, Bambey by Hebert, Reynolds and Meggitt. Discussions with Ir. Jacques Deuse, Plant Protection Officer; Ir. Jean Claude Girard, Plant Pathologist; Ir. Jean Claude Mauboussin, Agronomist; and Dr. Sauger, Director
--Visit to ORSTOM by Sasser. Discussions with Drs. Michel Luc, Caspar Netscher, George Merny, R. Fortunes and Alain Perraud.

October 16: Niamey, Niger
--Visit with IRAT Director Jean Nabos
--Rice Experiment Station
--Sonipium--French Trial Farm

October 17: Zender, Niger
--Visited with Dr. B. Dean Barry, Entomologist, USDA Zaria, Nigeria; Dr. Stan King, Plant Pathologist, USDA, Zaria, Nigeria; Mr. Paul Gadbois, Min. Economic Rurale and J. Charoy, Director IRAT Station, Maradi.
--Visited Oasis at Myrriah with Ministry of Agr. official.
--Visited farmers fields of millet, sorghum, peanuts and cowpeas.
--Toured millet flour mill.

October 18: Maradi, Niger
--Tour of IRAT Station at Tarna with Director J. Charoy, Agronomist.

October 19: Traveled to Magadou to visit IRAT trial farm
--Traveled back to Maradi and visited Ministry of Agriculture nursery for production of citrus and mangos.

October 20: Flew back to Niamey

October 21: Niamey, Niger. Visited with Ambassador R. D. McClelland

October 23: Bamako, Mali
--Visited with Ambassador Blake
--Discussions with Bakary Coulibaly, Minister of Production; Mr. Kane, general biologist.

October 24: Bamako, Mali
--Discussions with officials of OPAM
--Discussions with scientists of IRCT, IRAT, IFAC, CFDT
--Lunch with Ambassador Blake
--Discussions with Mr. Jeanteur, Agronomist with IFAC
--Mr. E. Malm, Acting Director, OICMA and Dr. M. Husseiny, Entomologist and Project Manager.

October 25: Accra, Ghana
--Brief visit with Director of AID Ghana, Mr. North
--Visit with Dr. Joseph Goodwin

October 26: Accra, Ghana
--Visit with Mr. M. Dowuona, Chairman, CSIR
--Visit with Mr. Baffoe, Chief Crop Protection Officer, Ministry of Agr.
--Tour of Stored Products Research Station, Pokoase.
--Traveled to Tafo, Cocoa Research Institute. Held discussions with Director E. J. A. Asomaning; Dr. E. Owugu-Manu, Entomologist; and Dr. E. E. N. A. Bonaparte, Agronomist (weeds).
--Traveled to Bunso, then to Kumasi.

October 27: Kumasi, Ghana
--Discussions with the following scientists at the Crops Research Institute:
Mr. E. A. Addison, Plant Pathologist
Dr. O. B. Hemeng, Nematologist
Mrs. B. S. Hemeng, Plant Pathologist
Dr. M. Agyen-Sampong, Entomologist
Dr. G. Scheibelreiter, Entomologist
--Visited University of Science and Technology, Kumasi

October 28: Traveled back to Accra

October 29: Visited University of Ghana, Legon. Held discussions with
Dr. Paul Lamptey, Plant Virologist
Mr. Hector Morgan, Entomologist
Dr. K. A. Haizel, Weed Scientist
Dr. D. A. Acquaye, Soil Chemist
--Toured Agricultural Irrigation Research Station, Univ. of Ghana, Kpong, with Director E. J. A. Khan.

October 31: Ibadan, Nigeria
--Visited with Dr. John Nickel, Associate Director of IITA
--Discussions with Drs. S. K. Hahn
George Wilson
R. J. Williams
K. O. Rachie
W. K. Whitney
J. C. Moomaw
Keith Moody
Fields Caveness
B. T. Kang
--Tour of Institute research plots.

November 1: Ife, Nigeria
--Visited with
Dr. John Medler, Chief of Party, Univ. of Wisconsin team
Dr. Jolayami Olakunle Amosu, Nematologist
Dr. Adenuga, Entomologist
Dr. Jerry Frankowick, Plant Breeder
Dr. Jacob L. Ladipo, Plant Pathologist

November 2: Ibadan, Nigeria
--Visited Cocoa Research Institute of Nigeria (CRIN) and had discussions with
Dr. Opeke
Dr. Ashiraw, Agronomist
Dr. S. A. O. Adeyemis, Deputy Director, Entomologist
Dr. W. E. Equagie, Principal Entomologist
Dr. G. A. Filani, Senior Plant Pathologist
Dr. M. O. K. Adegbola, Principal Plant Pathologist
--Visited Moor Plantation
--Visited University of Ibadan. Discussions with:
Dr. O. F. Esuruoso, Acting Head (Pathologist)
Mrs. O. A. Egunjobi, Nematologist
Dr. R. A. Odihirin, Nematologist
Dr. J. K. Egunjobi, Ecologist and
Dr. R. M. Gilmer, Virologist, Visiting Professor from Geneva, N. Y.

November 3: Drove to Lagos

November 4: Visited with Dr. Russell O. Olson, Food and Agriculture Officer, USAID/Lagos, Nigeria

November 9: Nairobi, Kenya
--Discussions with Mr. Clinton, Twiga Chemical Co.; Dr. David R. Baldwin and A. H. Naik, Pfizer Lab.
--Visited with the following scientists at the National Laboratory, Research Division, Ministry of Agriculture: Dr. John Ondieki, Senior Plant Pathologist, Dr. Isaiah Ngumi Njoroge, Nematologist, Dr. G. W. Oloo, Entomologist

November 10: Kenya
--Visited Coffee Research Foundation, Ruiru. Discussions with Dr. S. K. Mulinge, Acting Deputy Director (Plant Pathologist) and Mr. H. W. Mitchell, Agronomist.
--Visited Kenya Canners (Del Monte Co.), Thiku. Mr. Dean W. Wheeler, Supervisor.

November 13: Arushu, Tanzania
--Visited TPRI, Dr. Materu, Director

November 14: Kenya
--Visited Windmill Fertilizer, Mr. Renze Dantuma, Marketing Manager
--Pyrethrum Extract Plant
--Pyrethrum Research Station, Malo. Mr. Enos Mwakhe

November 15:
--Tea Research Institute, Mr. D. H. Laycock, Director
--Brooke Bond Tea Co., Dr. K. F. Prebble

November 16: Muguga, Kenya
--Visited EAAFRO and held discussions with:
Dr. Leo Cole, Forest Entomologist
Mr. T. Jones, Forest Entomologist
Dr. J. Overman, Entomologist
Dr. K. Bock, Virologist
Dr. J. Guthrie, Virologist
Dr. D. P. Taylor, Nematologist
Dr. S. W. Braverman, In-Charge Plant Quarantine Station
--Visited ICIPE, Dr. Thomas R. Odhiambo

November 17: Nairobi, Kenya
--Discussions with Director of AID Mission, Mr. Charles James and Mr. Harold Jones, Food & Agriculture officer.
--Visited with officials of Ciba-Geigy (E.A.) Limited--Mr. Robert Knupfer and B. M. Oskam.

November 19: Addis Ababa, Ethiopia
--Discussions with Captain C. A. Temple and Dr. Terry J. Crowe, Entomologist

November 20:
--Visited with AID officials, Dr. Lane Holdcroft and Mr. Bob Sweet
--Toured facilities of FAO/SIDA Locust Project, Mr. R. D. MacCuaig, Insect Toxicologist
--FFHC/CA Stored Products Project, Dr. P. J. E. Bendell, Director
--Discussion with Director of IAR, Dr. Dagnatchew Yirgou.

November 21: Melka Werer, Ethiopia
--Visits with Mr. J. H. Saunders, Director; Mr. John Moore, Horticulturist, accompanied by C. A. Temple and T. J. Crowe

November 22: Jimma, Ethiopia
--Discussions with Dr. Samu--Negus Haile--Marian Mrs. Tsega Berecket, accompanied by C. A. Temple and T. J. Crowe

--Toured plant of Ethiopian Spice Co.

November 23: Visited Holetta Research Station, IAR
--Accompanied by C. A. Temple and T. J. Crowe

November 24: Visited the Chilalo Agricultural Development Unit (CADU)
--National Horticultural Center (IAR), Nazareth
--Discussions with Mr. L. Ohlander, Pulse Agronomist FAO and Mr. P. A. Goosens, Entomologist

November 27: Dire Dawa, Ethiopia
--Visited College of Agriculture. Discussions with Dr. Amare Getahun, Director of Research, Dr. Mengistu Huluka, Plant Pathologist and Dr. Tesema Megenasa, Entomologist. Accompanied by Captain C. A. Temple and Dr. Terry J. Crowe

November 28: Addis Ababa, Ethiopa
--Discussions with: Dr. W. H. Shitaye, Chief Plant Protection Section, Ministry of Agriculture and Mr. Alemayehu Wadageneh, General Director, Ministry of Agriculture