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AGENCY FOR INTERNATIONAL DEVELOPMENT

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10. ESTIMATED COSTS ($000 OR EQUIVALENT $1 =)

A. FUNDING SOURCE	FIRST FY B. FX	C. L/C	D. TOTAL	LIFE OF PROJECT E. FX	F. L/C	G. TOTAL
AID APPROPRIATED TOTAL	1,000		1,000	1,000		1,000
(GRANT) S&T/AGR Funds	(1,000)	( )	(1,000)	(1,000)	( )	(1,000)
(LOAN)	( )	( )	( )	( )	( )	( )
OTHER U.S. 1. Mission/Bureau						
OTHER U.S. 2. (Ant. buy-in)	0		0	600		600
HOST COUNTRY						
OTHER DONOR(S)						
TOTALS	1,000		1,000	1,000		1,600

11. PROPOSED BUDGET APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	D. LOAN	E. 1ST FY 84 F. GRANT	G. LOAN	H. 2ND FY 85 I. GRANT	J. LOAN	K. 3RD FY 86 L. GRANT	M. LOAN
(1) ARDN	121	080		1,000		–	–	–	–
(2)									
(3)									
(4)									
TOTALS									

A. APPROPRIATION	N. 4TH FY ___ O. GRANT	P. LOAN	Q. 5TH FY ___ R. GRANT	S. LOAN	LIFE OF PROJECT T. GRANT	U. LOAN
(1) S&T ARDN	–	–	–	–	1,000	
(2) BIM ARDN					600	
(3)						
(4)						
TOTALS			–		1,600	

12. IN-DEPTH EVALUATION SCHEDULE: MM 07 YY 87

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1 (1 = NO, 2 = YES)

14. ORIGINATING OFFICE CLEARANCE

SIGNATURE

TITLE: Anson R. Bertrand, Director, S&T/AGR

DATE SIGNED: MM DD YY

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CROP NEMATODE RESEARCH AND CONTROL
936-4149
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CROP NEMATODE RESEARCH AND CONTROL

936-4149

Project Paper

I. Project Summary

A. Recommendation

S&T/AGR recommends that a $1.6 million cooperative agreement be authorized to implement the Crop Nematode Research and Control Project. The project will be implemented over a three-year period by a qualified university.

B. Summary Description

1. Goal, Purpose and Beneficiaries

The goal of the project is to increase the supply of agricultural products by reducing losses caused by crop nematodes. The prevention of these losses will benefit farmers initially, and the entire population in the long run.

The purpose of the project is to strengthen the regional, institutional and individual capability in crop protection and to help establish efficacious pest management systems with emphasis on crop nematodes.

2. Background and Project Activities

The objectives of A.I.D.'s food and agricultural policy are to enable developing countries to become self-reliant in food, assure food security, and achieve economic growth. Increased food availability and improved food consumption are related sub-objectives. One element in the Agency strategy is the identification of productivity-constraints which span major regions of the world. Pest management is identified in the A.I.D. strategy as a possible common theme area. The best land is already in production and cultivation of unsuitable lands results in excessive erosion and depletion of natural resources. Therefore, one of the best approaches to increasing crop yields is to use land already in production and reduce crop losses. The significance of the latter comes into focus when it is recognized that pests cause approximately 30% crop losses when not properly controlled. Nematodes are one of the more serious groups of crop pests causing average crop losses exceeding 5%. Localized losses are much higher and developing countries are bearing the brunt of the burden.

Most farmers in these countries do not even recognize the cause of their crop losses from nematodes. Since there is little knowledge and few organized programs for crop protection, most farmers simply tolerate these pests and rely on natural forces to control them. An enormous potential exists for improving this situation. Extensive technology for reducing crop losses by nematodes is available which could be adapted for use in developing countries. Research and field trials are needed to address local problems and to supplement the available information.

The science of nematology has been introduced only recently in many parts of the developing world. A.I.D.'s Pest Management Root-Knot Nematode Project, through cooperative efforts with an international network of nematologists, has encouraged research in this field. Many newly trained nematologists are now initiating research programs within their respective countries. Unfortunately, in spite of recent progress, research efforts in developing countries often lack depth due to the overwhelming nature of the problem, poor facilities, and lack of experienced nematologists.

This project is designed to provide a focus for the current nematode research being carried out in LDCs and to expand and improve the research efforts. The S&T funded portion of the project will finance most of the dollar costs of the project thru a Cooperative Agreement (C.A.) with a U.S. university. Under this C.A. the university will develop or strengthen linkages among LDC institutions engaged in nematode research and provide technical support for selected new LDC research programs in three or four geographic regions.

In addition to the support provided through the C.A., we anticipate that local currency costs for expanded research programs in the LDC institutions will be supported through several mechanisms. The six participating International Agricultural Research Centers will provide facilities, personnel and services for their related programs. The participating host country institutions will also provide facilities, personnel, and services but in some cases they may need extra budgetary support to develop or strengthen their nematode research. This is where LDC governments and A.I.D. Missions can contribute to the project. Since the needed budget support will be largely local currency, we anticipate that A.I.D. Missions may contribute counterpart funds from PL 480 or CIP accounts or may build support for the participating local research institution into bilateral agricultural projects. The U.S. university, under the C.A., will work with interested LDC research organizations to help them identify needs and prepare application for support, but we anticipate that mission or host government contributions will be made directly to the LDC organization, not to the U.S. university.

An institution that coordinates and stimulates a global nematology research program can provide a valuable service. The proposed project has been designed to address the situation described above and will encompass research, training and technology transfer. The design of these components will be based on the experience of the successful root-knot nematode project supported by A.I.D. at North Carolina State University.

a. Research

The research will be conducted in collaboration with six of the International Agriculture Research Centers as well as LDC institutions and nematologists. Where possible, one of the objectives will be for the institutions to develop the capability to conduct research independently. The research will include the following activities:

- Screening for resistant cultivars using the extensive live nematode collection assembled and maintained at North Carolina State University against which to screen plant lines and cultivars of important crop species for resistance to the major species and races of root-knot nematodes.

- Identification of nematode problems involving important crops in representative countries will be conducted in cooperation with nematologists in the network. Emphasis will be placed on problems in A.I.D. recipient countries but it can be anticipated that many problems will not be so localized that only a single country will be involved. If nematode control recommendations are known they will be passed on to agricultural and extension officials in the affected areas and the USAID Missions will be apprised as to the nature, extent and potential economic significance of the problem. If there are ongoing A.I.D. sponsored agricultural research and/or production projects in the affected countries assistance will be provided by the project, subject to mission concurrence, in modifying or redirecting an appropriate portion of project funding to conduct any needed in-country research. In other cases attempts will be made to identify needed funding sources for local nematode research network collaboration with the U.S. based nematode project staff. In such cases the project will assist the collaborator in the drafting of research plans and funding proposals for presentation to appropriate donor agencies.

- Evaluation of control methods will be conducted in selected countries in cooperation with LDC institutions and investigators.

- Crop loss assessments will be a part of the field trials to evaluate control methods.

- Implementation and evaluation of management strategies on farmer plots will be conducted utilizing the control methods that are most promising. These will also be done in cooperation with the LDC scientists.

b. Training

The project will organize and sponsor in-country and/or regional workshops as the need presents itself. In-depth short courses that emphasize new nematode identification techniques, management strategies sampling and survey methods, statistical analysis of data, and/or computer operation will be offered at the grantee university.

Since many aspects of nematology will require intensive individual training, project personnel also expect to conduct one-on-one training with selected research network collaborators. Funds for these scientists to receive training in nematology are expected to derive from local A.I.D. training budgets or as part of the training components of local A.I.D. funded agricultural research and/or production projects. Also other multilateral and bilateral donor programs have training funds available which can be tapped. To the extent possible, the short course training to be done in the U.S. will be widely publicized (at least nine months in advance) so that potential participants and/or their sponsors will have ample time to identify, request and obtain needed travel monies. The training courses per-se will be offered free of charge. The cooperator will attempt to obtain inexpensive on-campus room and board accomodations so that the total cost per student can be minimized.

c. Technology Transfer

The project will function as a resource center and information base. In this capacity it will locate, maintain and provide pertinent scientific literature to cooperators in developing countries. The project will provide technical support and information on nematode problems to missions upon request and linkage will be established with other A.I.D. crop protection programs.

In addition to providing literature, the project will also offer other kinds of technical assistance: e.g., advice on designing and equiping nematology laboratories, introduction to new research techniques, assistance in research project design and data storage and analysis.

It is recognized that the knowledge gained from research is not of maximum value unless it reaches the farmer. Therefore, one of the final products will be leaflets, pamphlets, etc. These will contain the results of the research and other pertinent material that will provide practical information for LDC specialists to use in preparing extension-type bulletins geared toward the farm level.

C. Summary Financial Plan ($ 000)

FINANCIAL PLAN PROJECTED COSTS
(U.S. $ 000)

Proj. Element	U.S. Univ.	S&T/AGR	Missions		IARCs	LDC's	Total
			Field Trials	Work-shops	Coop. Res.	Coop. Res.	
Personnel		467	15		70	80	632
Consultants	45						45
Travel & Per Diem		90	5	440	25	25	585
Equip & Supplies		90	20		55	35	200
Office Space	30						30
Greenhouse Space	120				25	45	190
Utilities	40						40
Library	10						10
Computers	10						10
Office Equip.	6				5	5	16
Vehicles	15				15	15	45
Soil Analysis	6						6
Lab. Space	60				10	15	85
Maintenance	30						30
Other Direct Costs			80	40	35	20	175
Overhead/Fringe Ben.		353					353
Total	372	1,000	120	480	240	240	2,452

D. Summary Findings

S&T/AGR has reviewed all aspects of the proposed Crop Nematode Research and Development project and finds that it is technically, institutionally, financially, socially and environmentally sound and technical annexes for detail). S&T/AGR also finds that the project is consistent with the objective set forth in the S&T and A.I.D. policy guidance.

During the development stage of the project, representative missions were contacted to determine their interest in the crop nematode research and control project The following missions and ROCAP indicated a desire to participate in various phases of the project: Bangladesh, India, Monrovia, Thailand, Cameroon, Guatamela, Bolivia, Jamaica, Senegal, Costa Rica, Indonesia, Paraguay, the Philippines, Dominican Republic, Sri Lanka, Kenya, Ecuador, Barbados and Peru. In addition, six of the International Agriculture Research Centers (CIMMYT, ICRISAT, AVRDC, CIP, IITA and CIAT) were advised of the project and all expressed a desire to collaborate with it. Through informal contacts it has been determined that investigators in the following 16 countries are interested in collaborating in the project: Costa Rica, Jamaica, Ecuador, Peru, Brazil, Ivory Coast, Senegal, Uganda, Kenya, Korea, Indonesia, Bangladesh, Taiwan, Jordan, Morocco and India. Six of the potential cooperators are already conducting research on crop-rotation schemes and have published results in this area of crop management.

The project was reviewed with regional bureau representatives and the suggested changes were incorporated into the final document. Based on these consultations, S&T/AGR believes that all major issues have been resolved and the project is an appropriate global initiative which complements mission activities and should be approved.

II. Project Background and Rationale

Crop losses caused by pests are a major constraint to agricultural production worldwide. These losses are especially serious in the developing countries. Nematodes (wormlike invertebrates) are among the most serious plant pests, with relatively little being known about them in the LDCs. Root-knot nematodes (Meloidogyne spp.) are found worldwide and cause major problems; with minimal training their damage is easily recognized. In 1975, A.I.D. approved the Pest Management Root-knot Nematode project (931-0614) with North Carolina State University (NCSU) to conduct a global study of these pests. This project was scheduled for termination in 1983, but the review in that year clearly indicated the project had been very successful and for maximum value should be modified to include other crop nematodes and extended for an additional period of time. Contacts made while developing the PID revealed there is strong interest in the project by the missions, the IARCs and LDC scientists. Information contained in the reports of the prior project, cables from missions and IARCs in response to an S&T/AGR quary as to possible future interest in collaboration with a nematode research network, personal visits and the last project evaluation formed the technical basis for the design of the project.

A. Agriculture in Developing Countries

Despite the efforts of the U.S. Government and other national and international agencies, the basic requirements for survival, i.e. food, clothing and shelter, remain the paramount issues throughout the developing countries of the world. Agriculture is the most important segment of the economy in the LDCs, with more than half of the labor force directly employed by agriculture and a significant portion of the remainder employed by agricultural business (food processing plants, textile plants, etc.). An objective examination of the economy in the developing world reveals some disturbing trends in agricultural production. With few exceptions the LDCs are deficient in the production of basic foods and income from export crops has decreased. These changes are due to a number of factors. Almost without exception the LDCs have experienced rapid increases in population so even where there has been an increase in agricultural production it has not kept pace with population growth. Even when adequate volumes of food are available, the quality and variety are such that nutritional problems often exist. Another problem is the shift in population that has occurred with many persons migrating to the urban areas hoping to improve their life, but becoming dependent for food on the persons remaining on the farms. Many towns and cities developed in areas with adequate fertile land to provide most of the agricultural products needed for the population. Often as the urban population has increased, farm land has been lost to residences, roads, factories, etc. As a result agricultural production is greatly reduced yet the need is greated. The remaining land is more intensively farmed and this in turn has led to an increase in frequency and severity of crop pest problems, including nematodes. Yet another factor is the changes in climate and changes in land character that has occurred. In addition, millions of hectares of productive land have been lost to desert encroachment, over-grazing of land and soil erosion.

Most of the farmers in the developing countries practice subsistence or traditional agriculture, characterized by mixed cropping and livestock systems, local often unimproved crop varieties, little or no artifical fertilizers, pesticides, or other similar inputs, and minimum tillage. A significant portion of the small farmers are situated in climatic zones that are less than optimal for good yields. A majority of the harvest is consumed by the residents and domestic animals on the farm where produced. The challenge facing the agricultural sector is to increase the yields and earnings of small farmers who have limited access to capital and technology. Since the best land is already in cultivation and expansion into unsuitable lands results in excessive erosion and depletion of natural resources, the best approach to increasing crop yields is to use land already in production more efficiently and to reduce crop losses. The significance of the latter comes into focus when it is recognized that pests cause approximately 30% crop losses when not properly controlled.

Nematodes are one of the more serious groups of crop pests causing losses as high as 80% where infestations are high. Infestations of nematodes become high usually as a result of more intensified agricultural practices coupled to an emphasis on monocultures. Since it s economically impractical to eradicate nematodes it is necessary to "manage" their population levels. This in turn can be accomplished by the use of chemical nematicides, introducton of new and resistant plant varieties or by introducing new crop rotational schemes which help maintain nematode populations at economically acceptable levels.

B. Crop Nematode Management and Research Requirements

In most developing countries, little is known about crop losses due to nematodes; frequently their damage is not even recognized. However, sufficient information is available to state without reservation that they are a serious agricultural problem and, if recognized, measures can be taken to minimize their impact.

Surveys conducted by the NCSU Root-knot Nematode project have provided excellent data on the crop losses due to this genus in a representative sample of the developing countries. From this study it is obvious that the damage by members of this genus are enormous. Worldwide, crop losses due to root-knot nematodes average 5% for the susceptible crops, but localized losses are much higher and developing countries are experiencing the most serious damage. Developing countries suffer a disproportionate share of crop losses due to nematodes mainly due to the fact that their role in crop losses is poorly understood and measures to ameliorate their negative impact are rarely taken. Several other genera are very destructive crop pathogens, but are more geographically localized than Meloidogyne (root-knot nematodes). For example, the cyst nematodes Globodera and Heterodera are important pests of the potato, sugar beet, soybean, and cereal crops, to name a few, and Radopholus species are important on banana, pepper and other crops; Scutellonema cavenessi is becoming an economically limiting pest of peanut; and Rhadinaphelenchus cocophilus represents a serious threat to oil and coconut palms. Where management strategies are known and utilized, total estimated crop losses due to all nematode species average only 2 to 3.5%. In heavily infested fields in developing countries where the problem is barely recognized, losses from some nematode species may often be total.

The management strategies for reducing crop damage from nematodes include planting resistant cultivars, crop rotation schemes, and the use of nematicides. As a result of the NCSU Root-knot Nematode project, the technology is available to identify and manage root-knot problems rapidly. Much work remains to be done with other genera, however, so surveys will be required to delineate problems with nematodes such as Globodera, Heterodera, Radopholus, Scutellonema, Rhadinaphelenchus and others. It has been determined by NCSU that approximately 95% of the damage by root-knot nematodes to agricultural crops is caused by four species, Meloidogyne incognita, M. javanica, M. arenaria and M. hapla. With this concept established, NCSU assembled and maintained an extensive live root-knot nematode collection and used it to screen plant lines and cultivars of important crop species for resistance to the major species and races.

It has been determined by NCSU that approximately 95% of the damage by root-knot nematodes to agricultural crops is caused by four species, Meloidogyne incognita, M. javanica, M. arenaria, and M. hapla. With this concept established, NCSU assembled and maintained an extensive live root-knot nematode collection and used it to screen plant lines and cultivars of important crop species for resistance to the major species and races.

In cooperation with its LDC nematode collaborator network the project will conduct a worldwide survey for economically important new nematode genera. A set of selection criteria will be developed prior to actual undertaking of this worldwide survey which will provide reasonable assurance that most major nematode problems will be identified in a preliminary manner on most of the important cash and subsistence crops. Items to be considered in setting up the survey criteria include:

--Nematode populations (qualitative and quantitative).

--Intensively cultivated land vs. long-term fallow land in same soil zone and agroecological area.

--Comparisons of nematode populations related to selected crops in areas of intensive monoculture vs. areas where traditional rotational practices have been observed.

--Priority screening of areas where crop producion is low but cannot be explained on the basis of soil moisture, soil fertility or from other crop pest problems.

A special effort will be made to collaborate with the various CRSP programs and all ongoing A.I.D. country and regional agricultural research/production projects. It is anticipated that substantial savings in sample collection costs can be made by such collaborative efforts. Collaborative relationships have been established with the International Agriculture Research Centers (IARCs) for them to send plant material to Raleigh, N.C., for screening. To date several thousand cultivars have been screened for resistance but even more remain to be processed. The following IARCs have been actively participating in this activity and have indicated interest in continuing: CIMMYT, ICRISAT, AVRDC, CIP, IITA and CIAT. Germplasm from all of the above centers will continue to be sent to the U.S. cooperator and their individual resistance to specified levels of the four major species of Meloidogyne will be measured. As appropriate, live collections of other nematode genera will be established at the U.S. facility and will be included in the resistance screening effort.

Since developing countries often do not have adequate facilities and/or sufficient current scientific information to facilitate the identification of all nematode species and races, the provision of a nematode identification and advisory service will be useful until permanent services can become established throughout these countries. In the interim the project will send a team of investigators to assess specific nematode problems as a technical assistance effort. Species will be identified, extent of damage estimated, and management options recommended in accordance with the types of crops locally grown and the resources available for the region in question. This technical assistance will always be coordinated with the respective missions and will be restricted to A.I.D. recipient countries.

In addition to evaluation of nematode problems in LDCs, the project will conduct research on various nematode management options. Investigations into the effectiveness of chemical and biological controls as affected by methods, rate, and time of application will be conducted within selected LDCs. Also cultural practices, including crop rotation, destruction of crop refuse, and production of clean planting stock will be emphasized since these kinds of measures are particularly well suited for use in developing countries.

The project will work with the private sector in the various countries in selecting and obtaining pesticides for evaluation. Cropping systems research will be conducted to establish optimal management schemes for the reduction of losses due to plant-parasitic nematodes. Particular attention needs to be given to methods which have low resource demands, and long term benefits, for deployment in developing countries. Crop rotation has proven to be an effective management strategy in controlling losses due to plant-parasitic nematodes, and is suitable to the constraints of LDC's. Other tactics, such as biological control methods, may also prove to be effective low-input long-term management options.

An extensive network of scientists engaging in nematological research has become established over the past nine years. Over 100 scientists from more than 60 countries have collaborated on nematode surveys and research problems. Due to this network, rapid strides have been made in understanding the ecological factors affecting Meloidogyne distribution. Scientists in this network also reseaech other plant-parasitic nematodes, and could benefit greatly by increased collaboration. An expanded network is proposed in which scientists share their findings by means of a periodic newsletter and at special workshops.

Table 1

Examples of current ongoing nematode research activity in LDC's with which the existing project has strong ties and which can serve as a basis for a Nematode Research Network are as follows:

Country*	Professional m/y of ongoing	Technician m/y effort	Institutional Facilities includes: greenhouse, field tests, equipment and travel costs $ 000
Ecuador	.3	.15	11
Nigeria	2.0	3.0	9
Egypt	.65	.3	36
Malawi	1.5	1.5	29
Philippines	.2	2.7	37
Sri Lanka	.5	1.35	16
Korea	.8	.5	18
Thailand	.45	.5	4
Jordan	.4	.3	12
Morocco	1.75	1.0	11
India	.4	-	5

*Does not include IARCs.

As basic information on nematode biology and crop protection is produced, emphasis will gradually shift to the evaluation under field conditions of various combinations of locally available pest management options. The project will not actually conduct any of this research at the U.S. university, but will guide and advise such research within selected countries where there is an interest. Integrated crop protection systems will include combinations of resistant cultivars, crop rotations, nematicides, biological control agents, and sanitary and cultural practices. Care will be taken to ensure that nematode species, population densities and crop yields are accurately monitored in field trials under the various combinations of management strategies.

One of the greatest obstacles to effective nematode management in developing countries is the lack of trained personnel and adequate facilities. Refresher training for developing country scientists is important since most of the technical information acquired during advanced education becomes obsolete within four to seven years after graduation. By this means current technology is rapidly extended; e.g. knowledge of operation of nematode extraction equipment and survey techniques, taxonomic techniques for accurate species identification, experimental design of nemoticide tests and crop rotation experiments, and data analysis, to name a few.

C. Rationale for Global Project

Nematodes, particularly root-knot nematodes, are a serious problem throughout the tropical and subtropical regions of the world. Very little research was devoted to nematodes in the LDC's until the start of A.I.D.'s Pest Management Root-Knot Nematode project with NCSU. Consequently, the potential for reducing losses from this pest are comparatively high provided a critical mass of knowledge, human resources and institutional capability are developed the lack of intensive, collaborative studies on nematodes of more local and regional importance is a void that needs to be filled. Since LDCs largely occupy tropical climates with many unique crops and pest-nematode species, these problems have not been studied extensively in developed-country universities. As a result of this kind of research, land once thought to be depleted and nonproductive can become more fruitful with effective nematode control.

Lack of communication among plant protection personnel has delayed the exchange of information and implementation of crop protection programs especially in the developing countries. All too often nematode problems have been ignored by crop protection researchers and agronomists. This has led to a disproportionate emphasis on other aspects of crop protection and a false impression that all economically feasible crop protection interventions had been made, when indeed that had not! NCSU has developed a global network of nematologists who are now exchanging technical information. It is important that this network be maintained and expanded and placed on a permanent footing.

A global approach to nematode research will also take advantage of the following factors:

-- No one of the developing countries has sufficient nematologists to conduct research on all the nematode problems of his country. As there are many problems that are common to the countries, different nematode problems can be addressed in different countries and the results of the research exchanged. Pests do not recognize national boundaries. Because of the regional commonality of many nematode problems and cropping systems, different problems can be addressed in different countries and the results of the research exchanged. In addition, a global, nematode-oriented project can introduce stability and continuity into national programs, since the benefits derived from any one national program will be greatly magnified by the inter-country transfer and exchange of information, technology and technical expertise.

-- Global and regional cooperation, properly focused, can direct the needed attention and expertise on problems that are widespread and can assure that priority items receive their share of emphasis. As a result, limited research resources will not be dissipated by too much effort being expended on relatively unimportant local problems.

D. Advantages of U.S. University Cooperation

This project will be housed at a U.S. university that can serve as a nematology information base and resource center. The selected university must have a department with a broad, well-established nematology program and extensive international experience. The university selected should have the following qualifications.

-- A department with a long history of research on nematodes.

-- A nematology staff that can cover a wide spectrum of related subtopics, e.g. morphology, genetics, biochemistry, taxonomy, nematode-disease interactions, ecology, and control strategies.

-- A department with a record of successful international programs and working relationships with a number of International Agriculture Research Centers.

-- An extensive, live root-knot nematode collection to screen for resistant crop germplasm.

-- An extensive literature base on nematodes.

-- Access to a sizeable library and interlibrary loan services to augment the project information base.

-- A scanning electron microscope to use in identification and/or conformation of unusual nematode species.

-- Adequate greenhouse facilities available for total dedication to the project.

E. Relationship of Project and A.I.D. Policies and Priorities

1. Relationship to A.I.D. Policies

The objective of A.I.D.'s food and agriculture policy are to enable LDCs to become self-reliant in food, assure food security, and achieve economic growth. Increased food availability and improved nutrition are the related sub-objectives. One element in the Agency strategy is the identification of productivity-constraints which span major regions of the world. Institutions dealing with activities in the problem areas will be encouraged to initiate and implement collaborative networks. Pest management is identified in the A.I.D. strategy as a possible common theme area. Crop nematodes are one of the most serious groups of crop pests causing losses as high as 80% where infestations are high. In addition, they are widely distributed through the developing countries so they are a common problem over wide geographic areas.

2. Relationship to A.I.D. Priorities

Crop protection, by the most cost-effective and environmentally acceptable means, has been identified as one of the agriculture research priority areas. Genetic resistance, biological control, cultural practices including crop rotation, and judicious use of chemicals are among the methods to be explored. Management of nematode populations by means of varietal selection, modified cropping practices and pesticide treatments must always be considered in the light of overall pest management for the target crops of concern. Therefore, any research which is done should be interpolated into the larger integrated pest management system. To assume that this will happen, the project will always coordinate it's research with other crop protection specialists and agronomists working on the same crop and with the same agroecological zones. Special efforts will be made to coordinate nematode research activities with other S&T/AGR, regional bureau and mission funded agricultural research/production/demonstration projects. Of special importance is the close and frequent exchange of ideas, information and philosophy with any S&T/AGR regional crop protection networking activities and the two ongoing sister projects underway at S&T/AGR, namely: a) the CICP Pest Management and Related Environmental Protection Project, and b) the Oregon State University International Plant Protection Center Weed Project.

3. Relationship to S&T Policies

In order to utilize personnel and resources more effectively, the S&T policy is to identify constraints that are common to several countries and to establish a common theme research network. Common theme research networks involve several major components, i.e. coordinated focusing of effort by several agencies on the common theme and an A.I.D. ribbon project to provide linkage and coordination among the agencies in the network and technical backstopping for the projects.
This project meets the criteria of this policy as it follows-up on an international network of nematologists that is already well established; it addresses as a common theme a group of pests, crop nematodes, that cause major crop loss worldwide; and six IARCs, 11 missions, 16 LDC institutions in 16 countries have expressed interest in cooperating with the project.

III. Project Description

A. Goal, Purpose, and Beneficiaries

The goal of the project is to increase the supply of agricultural products by reducing losses caused by crop nematodes. The immediate value will be to improve the living standard of the farmers.

The purpose of the project is to strengthen the regional, institutional and individual capacity in crop protection and to help establish efficacious pest management systems with emphasis on crop nematodes.

Due to its professional and institution-building character, the project will have direct and indirect beneficiaries. The nematologists and plant pathologists in the network and the institutions that cooperate in the project will have an increased technical capability in nematology and crop protection and the ability to deliver it at the national level. National institutions and private sector businesses associated with agricultural production will also benefit from the availability of an expanded pool of expertise to call on, as well as from participation in the training activities and field trials planned for the project.

Even more important than these direct benefits will be the long-term indirect benefits of the project. The entire agricultural sector will benefit from increased productivity and income as a result of reduced crop losses. Also, the general welfare of the LDC populations will be improved because of the increase in quantity and quality of food and other agricultural commodities.

B. Location of Project Activities

The headquarters for the project will be a U.S. university with demonstrated competence in conducting international research programs. The university must have a College of Agriculture and a Department of Plant Pathology with sufficient professional depth to support an international program. The Department should have international experience in crop nematology research and a staff of nematologists qualified to conduct research and provide technical support in the agriculturally important genera of nematodes.
The principal investigator should be an internationally recognized nematologist with demonstrated ability to manage large, complex, diversified research and training programs. He/she should have demonstrated ability to organize, coordinate and motivate international networks of scientists. The university will provide office, greenhouse and laboratory space to conduct the research described in the project. In addition, the grantee will have the capability to screen crop germplasm for resistance to representative species and races of Meloidogyne, as well as other genera which, based on a worldwide survey, are judged to be of economic significance.

Six International Agriculture Research Centers (IARCs), CIMMYT, ICRISAT, AVRDC, CIP, IITA, and CIAT have been actively participating in the root-knot nematode project and have indicated a desire to continue participation in the expanded project. All will select cultivars for screening for resistance to root-knot nematodes and other genera of nematodes found to be of importance to the production of one or more crops. In addition, others will cooperate in conducting various crop nematode management field trials as described in III, D, 2.

In addition, 15 national institutions have indicated to the existing nematode project an interest in active participation in a research network. These are as follows:

COUNTRY	PARTICIPATING INSTITUTION (S)
Jamaica	Plant Protection Division Ministry of Agriculture
Ecuador	INIAP, Estacion Sta. Catalina
Brazil	Instituto de Ciencias Bio. Universidade de Brasilia
Ivory Coast	ORSTROM-Adiopodoume
Uganda	Kawanda Research Station
Kenya	Ministry of Agriculture National Agriculture Lab.
Korea	Kyunpook Nat'l. University
Indonesia	Segunung Research Station
Bangladesh	Bangladesh Agr. Res. Inst.
Morocco	Inst. of Agronomique et Veteranaire
India	Univ. of Agr. Sciences
Panama	Instituto de Investigacion Agropecuaria de Panama
Jordan	University of Jordan
Costa Rica	Universidad de Costa Rica
Philippines	University of Philippines at Los Banos

An active cropping system research program involving the new nematode project and selected researchers in seven LDCs will be mounted as soon as possible after initation of the new project. These are:

Jordan - a root-knot nematode program involving at least one man-year effort on tomatoes, peppers, cucumbers and egg plant in the Jordan Valley. In addition, to crop rotation research, chemical and biological control techniques will be evaluated. This work will be done with the collaboration of Dr. Walid Abu Gharbieth who is a nematologist at the University of Jordan. The new nematode project will actively assist Dr. Gharbieth in development of a project proposal for mission funding. It is anticipated that local currencies available within the A.I.D.-Funded Jordan Valley Agricultural Project can be used to fund this research activity.

Senegal - An ectoparasite nematode Suctellonema caveness is causing major yeild decreases on peanuts. Yield increases up to 86% have been shown on plots treated with nematicides. While it is unlikely that chemical control of nematodes in West Africa will be cost-effective, new crop rotation schemes are expected to yield smaller but significant yield increases.

Dr. Larry Duncan of OSTROM is interested in a collaborative effort involving at least one scientist-year. Funding for this activity is reportedly available from USAID/Dakar if the necessary research proposals can be prepared in a timely matter.

Costa Rica - Ing. Luis A. Salazar of the Universidad de Costa Rica is interested in a collaborative effort involving at least one scientist-year of effort. Since Costa Rica has local currency funds (PL-480) there should be no serious impedement to developing the needed in-country funding.

Columbia - CIAT has an active ongoing collaborative program with the current nematode project. Bean varieties are screened in the U.S. and based on these tests plant breeders at CIAT are developing new crosses showing increased nematode resistance. This program can be expanded to include field trials wherein new crop rotational schemes are evaluated.

Peru - The existing project conducts advanced screening on resistant potatoe varieties so that the outresearch program of CIP can "fine-tune" its outresearch distribution of potatoe varieties based on existance or absence of specific root-knot nematode species. This program collaboration can easily be expanded to include at least one man-year of collaborative research including cropping systems management and testing of chemical control measures.

India - A three way effort involving ICRISAT, the Peanut CRSP and the new nematode project with funding provided by ICRISAY/CRSP can easily be negotiated. This effort would involve at least one man-year effort.

Philppines - Mission funding will be requested for a jointly devised one-man year effort.

The criterion for a truly joint "one on one" interaction will be the willingness of LDC investigators to "jointly" publish research results. All five of the above specific efforts are expected to result in such joint publications - either in the research networking newsletter to be published by the new project or as a publication in a recognized scientific journal.

C. Project Components

1 Introduction

Research, training and technology transfer have been selected as the major components of the crop nematode research and control project. The close interaction of these three components make it possible for the project to achieve a high degree of cost effectiveness by sharing many inputs among the components.

The most important of these inputs will be a team of nematode specialists and technical support personnel at a major U.S. university who will form the core of the information and resource center on nematology. The team will coordinate all project activities, carry out research, serve as instructors for training activities and provide technical assistance. The composition of the team should reflect each of the major research areas to be covered by the nematode research and control project.

The basic team will include:

-- A world-renowned nematode specialist who will serve as principal investigator with the overall responsibility for coordinating project implementation.

-- A nematologist who will coordinate, assist with planning guide & help analyze cropping systems and biocontrol research for nematode managment in each of the six major regions of the world.

-- A nematologist to screen cultivars of major world food crops for resistance to root-knot nematodes and to transfer this technology gradually to developing country scientists.

-- A technology transfer specialist to make nematode management information readily available for research and training purposes.

The basic nematology team will operate out of a major U.S. university and work closely with selected LDC national institutes or universities, USAID missions, and several IARC's. Cropping systems research will be carried out in considerable detail in at least seven countries with the cooperation of an in-country coordinator. These countries are listed in Section III B.

2. Research

a. Description

The aim of this project's research is to transform current information about nematode biology into practical applications for managment of these pests in the field. Methods particularly appropriate for use in developing countries will be emphasized. Such methods include the use of resistant cultivars, biocontrol with emphasis on the fungus *Paecilomyces lilacinus*, and cropping systems that effectively and economically reduce nematode populations in

farmers' fields. Some work will be devoted to management of nematode populations with nematicides, but because these chemicals are often expensive, not readily available, and inconvenient to apply, considerable discretion will be used in selection and use of nematicides in developing countries. The potential environmental impact of any new nematicide use will be evaluated in conjunction with S&T/AGR and its Pest Management and Related Environmental Protection Project. Their use will only be considered as part of an overall integrated control program.

Research on the managment of nematodes will be strengthened by the fact that much of the work will actually be conducted within selected developing countries. Thus, specific management strategies can be developed for each of the major geographical regions represented by this study. Linkages with IARC's and the USAID Missions that are willing to buy into the project will facilitate these overseas endeavors. The following six IARC's have indicated a desire to participate in the project: CIMMYT, Centro Internacional de Mejoramiento de Maiz y Trigo in Mexico; CIP, Centro Internacional de la Papa in Peru; CIAT, Centro Internacional de Agricultura Tropical in Colombia; ICRISAT, International Crops Research Institute for the Semi-Arid Tropics in India; IITA, International Institute of Tropical Agriculture in Nigeria; and AVRDC, Asian Vegetable Research and Development center in Taiwan. The two major areas of research to be emphasized, screening of germplasm of major food crops for resistance to nematodes, and cropping systems research, are outlined below and the expected outputs appear in Table 2.

Crop Nematode Research Network

The Crop Nematode Research and Control Project (CNRCP) will involve intimate cooperation among the project-based university, A.I.D. missions, IARCs, and LDC institutions in each of the three areas of research emphasis. (Figure 1) In screening for resistance, the project-based university will receive germplasm from IARCs, and once evaluation is complete, the material will be returned to the IARCs and incorporated into ongoing breeding programs. Cultivars developed from the nematode-resistant lines will be re-evaluated for resistance either at the project-based university or at the IARC, depending on the state of project development. Once IARC personnel receive the range of nematode cultures and are instructed in the screening process, all further screening will be conducted by the IARCs themselves. As resistant cultivars are developed, they will be made known to LDC institutions and A.I.D. missions through the Network of Nematologists' Newsletter, which is to be published by the project-based university. Use of these cultivars will also be encouraged as they are incorporated into the various management studies conducted by the CNRCP in conjunction with A.I.D. missions. Through these studies which will include on-farm testing, farmers will be introduced to the new cultivars.

Cropping systems research will also involve the entire CNRCP network. As particular nematode problems come to the attention of A.I.D. Missions, the missions will enlist the assistance of the CNRCP resource center and information base. Project representatives will then study the problem and strive to develop management strategies in conjunction with pertinent LDC institutions or IARCs and the affected growers.

The research network will be further linked together through the process of technology transfer. A newsletter to be published quarterly or bi-annually will bring all members of the network up to date on the various aspects of progress in the LDCs toward nematode management. The newsletter will be received by A.I.D. missions, IARCS, and LDC institutions and help prevent unnecessary duplication of research efforts. In addition, CNRCP scientists will work closely with LDC institutions in guiding the development of native-language, extension-type publications geared toward LDC farmers.

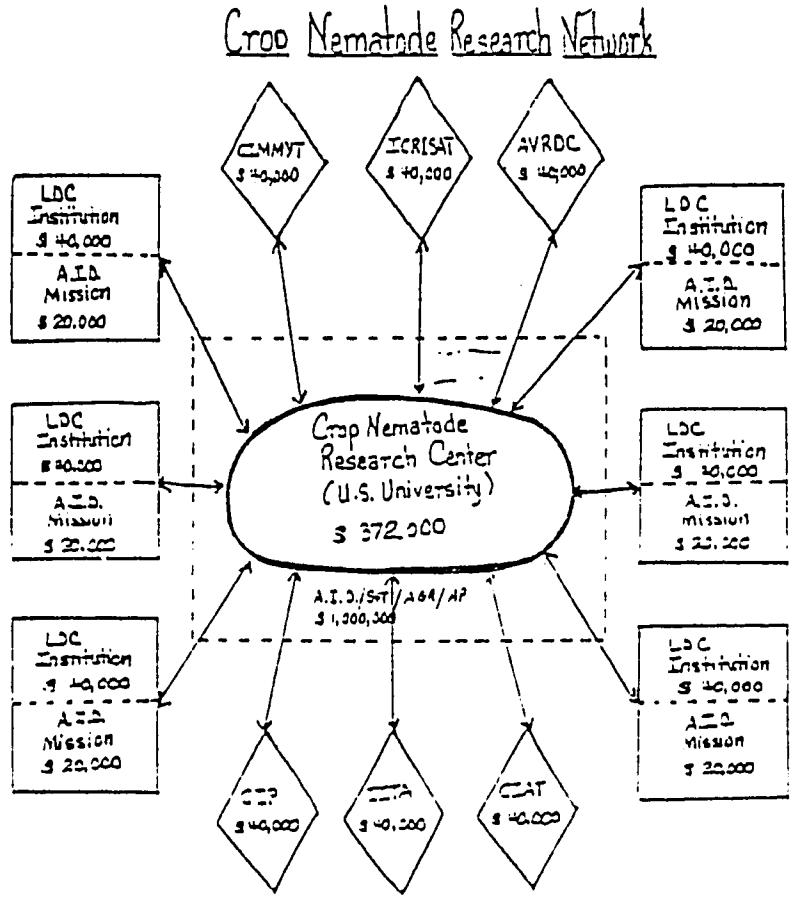

Figure 1. Estimated Level of Collaborative Effort in the Proposed Crop Nematode Research and Control Project.

1) Screening for Resistance

To date, the root-knot nematode project has screened accessions, provided by selected IARC scientists, for resistance to all host races of the four major species of Meloidogyne. This service was the first of its kind in that large quantitites of crop germplasm had never before been screened simultaneously against the major Meloidogyne species and races infecting agricultural crops. This work is proving extremely useful in the development of highly resistant crop germplasm and will be continued by the crop nematode research and control project for at least two years after initiation of the project. During the third year, the research technology for conducting this screening will be transferred to interested IARC's and to some of the better equipped nematology research centers within developing countries.

a) Objectives

-- Identify germplasm of major crop plants that is resistant to many or all eight of the common root-knot nematode species and races.

-- Evaluate resistance of major crop plants to other nematode genera as appropriate.

-- Establish populations of the eight common root-knot species and races at selected IARC's (perhaps CIP, CIAT, CIMMYT, ICRISAT, ITTA, AVRDC) and at other strategic nematology centers in developing countries (selected institutions from Table 1, depending on their interest, support, and technical capability).

Table 2. Summary of Research Components

Activity	Outputs
1. Screening crop germplasm for resistance	-- 1500 accessions screened for resistance to all eight major species and races of Meloidogyne -- 200 accessions screened for resistance varieties to other economically important nematodes -- 100 of the most resistant accessions tested in field trials -- 8 IARC's and/or nematology labs with the technical ability to screen their own germplasm to the 8 major species and races of Meloidogyne
2. Identification of nematode problems involving important crops	--Increased yield due to use of appropriate management techniques --Assessment of crop losses due to specific nematodes
3. Evaluation of cropping systems	-- 24 rotations tested in each of 4 to 6 regions -- 30 cooperators instructed in experimental design and data analysis -- 10 biocontrol studies -- Implementation of integrated managment strategies on farmer's plots

b) Approach

The project will develop Memoranda of Agreement with the previously mentioned IARC's for the screening of approximately 1500 crop lines or varieties for resistance to the eight major species and races of root-knot nematodes. The extensive live nematode collection assembled and maintained at North Carolina State University (NCSU) will be used in screening plant lines and cultivars for resistance.

Transfer of the screening-for-resistance technology will be accomplished by training at the project-based university. Representatives from the interested institutions, preferably ones who will be actively involved in the screening process, will travel to the U.S. for hands-on instruction. Trainees will probably need at least two to four weeks to become exposed to all aspects of the screening process. In addition to becoming skilled in screening, the trainees will be taught how to maintain healthy nematode cultures indefinitely. This skill is prerequisite to the establishment of independent screening services. By the third year of the project, six to eight new laboratories with root-knot nematode screening capabilities should be present in major geographical regions.

2) Identification and Assessment of Nematode Problems Involving Important Crops

As a resource center and information base, the project will lend its expertise to the accurate identification of nematodes infecting major agricultural crops. Management strategies will be furnished to deal with those infections that are detected in early stages. However, in most cases, the crop is likely to be fairly well established before the problem is noticed. In such cases, recommendations for management will be applicable only to subsequent crops. However, the infected crops can furnish important crop loss data.

a) Objectives

-- Identify the most important nematode problems of agricultural crops in developing countries.
-- Estimate crop losses due to specific plant-parasitic nematodes.
-- Compare losses with those assessed by farmers.

b) Approach

Through contacts with A.I.D. Missions, the project will work intensively on the nematode problems of seven specific geographic areas. A specialist will visit problem sites, sample for nematode populations, identify or assist in identification of pest species, and work with in-country cooperators in designing effective management strategies for future crops. Attempts will be made to address as many different kinds of economically important nematode pests as possible, especially Radopholus similis, Scutellonema, Cavenessi, Globodera spp., Heterodera spp., Rhadinaphelenchus cocophilus, and Meloidogyne spp.

3) Evaluation of Cropping Systems

a) Objectives

-- To determine the quantitative relationship between plant-parasitic nematode population levels and crop yields for important food crops in selected LDC's.

-- To determine the quantitative relationship of end-of-season population densities to preplant nematode densities for selected nematode-host combinations.

-- To determine economic constraints associated with various cropping systems for management of nematode problems.

b) Approach

Efficient analysis of crop rotation schemes begins with an evaluation of quantitative host-parasite relationships. Host-parasite relationships will be quantified on important food crops in representative countries. These relationships will be used to model the relative efficacy of long-term crop rotations under different managment schemes. Computer simulation of all possible rotation sequences will allow the selection of optimal strategies, for each country, under varying types of nematode-pest pressure. Selected management strategies for various nematode-hazard levels will be provided in native-language pamphlets through cooperators in each LDC. This information will enable LDC growers to implement effective, low-cost crop management strategies for a stable, long-term reduction of losses due to plant-parasitic nematodes. Responsibility for various stages of the cropping systems research will be divided among CNRCP staff and LDC cooperators (Table 3).

Table 3 Responsibilities for Implementation of Cropping Systems Research

ACTIVITY	CNRCP STAFF	LDC COOPERATOR
1. Identify nematode problems	X	X
2. Select sites for research		X
3. Establish plot boundaries, initial nematode assay	X	X
4. Plant crops on selected sites		X
5. Maintain research plots		X
6. Harvest, measure yield per plot		X
7. Final nematode assay	X	X
8. Analyze data, interpret results	X	
9. Select optimum systems for LDC's	X	X
10. Write pamphlets describing cropping	X	X
11. Disseminate information to LDC growers		X

Cooperative Research: Cropping systems research will be done with the assistance of selected LDC cooperating scientists. Sixteen potential cooperators have been identified, from representative countries. These cooperators have expressed an interest in conducting cropping systems research, as outlined in this proposal. Seven of the potential cooperators are already conducting research on crop-rotation schemes, and have published results in this area of crop management. (Table 4) Potential cooperators are located at LDC research institutions, and international research facilities.

LDC cooperators will be requested to identify important food crops, and suitable cultivars of these crops, for each of their regions. Nematode pests of these crops will be identified from previous research, and where necessary, surveys will be conducted. Selected crops must be economically important to the region, and culturally acceptable to LDC growers. LDC cooperators will also be requested to locate nematode-infested sites, suitable for conducting the cropping systems research. Many of the potential cooperators have already identified sites, through previous studies.

Table 4

Examples of current ongoing nematode research activity in LDC's with which the existing project has strong ties and which can serve as a basis for a Nematode Research Network are as follows:

Country*	Professional m/y of ongoing	Technician m/y effort	Institutional Facilities includes: greenhouse, field tests, equipment and travel costs $ 000
Ecuador	.3	.15	11
Nigeria	2.0	3.0	9
Egypt	.65	.3	36
Malawi	1.5	1.5	29
Philippines	.2	2.7	37
Sri Lanka	.5	1.35	16
Korea	.8	.5	18
Thailand	.45	.5	4
Jordan	.4	.3	12
Morocco	1.75	1.0	11
India	.4	-	5

*Does not include IARCs.

As basic information on nematode biology and crop protection is produced, emphasis will gradually shift to the evaluation under field conditions of various combinations of locally available pest management options. The project will not actually conduct any of this research at the U.S. university, but will guide and advise such research within selected countries where there is an interest. Integrated crop protection systems will include combinations of resistant cultivars, crop rotations, nematicides, biological control agents, and sanitary and cultural practices. Care will be taken to ensure that nematode species, population densities and crop yields are accurately monitored in field trials under the various combinations of management strategies.

Responsibility for maintaining the research plots, and collecting data, will be with the LDC scientists. Each cooperator will work with local growers and staff from the sponsoring institute to implement the cropping systems research. It is anticipated that support will be provided, in one or more of the following ways: a) Use of PL 480 local currencies, b) modification of regional and/or mission funded agricultural research/production products, c) in-kind support from IARCs and national institutions, and d) grants from other donors. In many cases, the cropping systems research will be an extension of work that is already on-going by the selected cooperators. Crop Nematode Research and Control Project (CNRCP) staff will provide advice, and detailed, uniform research methods to be implemented in each region. Duplication of effort will be avoided, and the uniformity of research plans will allow for the application of systems modeling techniques by CNRCP staff.

The final phase of cooperative effort will be in the transfer of cropping systems information to local LDC growers. Pamphlets will be prepared in native languages, detailing optimal crop rotation and management alternatives under varying levels of nematode pressure. Cooperators will assist in the preparation and dissemination of these pamphlets.

Data Collection: Cropping systems will be evaluated for rotations of 4 to 6 economically important crops, in each region. Cooperators already studying crop rotations have included an average of 8 crops in their work. Each crop will be planted at 4 to 6 nematode-infested sites. The number of crops at each site will depend on grower practices and the size of the site. The area allotted for each crop will be divided into 100 research plots, each measuring 24 m^2 (approx. 6-m by 4-rows).

On-site research will be conducted with a minimum of disruption to normal grower practices. The research plots will be marked, but a grower or researcher need not be aware of plot boundaries, while managing the crop. Initial nematode densities (P_i), final nematode densities (P_f), and yield (Y), will be measured in each plot. Assessment of P_i will be done immediately before planting, when the plots are marked, and P_f will be assessed at the end of the growing season, when yield is measured. Additionally, the soil at each site will be analyzed, and records kept on management practices, irrigation, and fertilization. These variables will be used as covariates in the analysis of quantitative host-parasite relationships, to remove site-to-site variation. Research designs may include the application of specific managment tools, such as nematicides or biological control methods, depending on the interests of the cooperator, and economic viability of the application for the specific LDC.

Plots will be sampled prior to planting because crop yield is typically a function of preplant nematode density (Fig. 2). Likewise, final nematode density can be expressed as a function of preplant density, for each host crop (Fig. 3). As an example system, a rotation of potato, tomato, and pepper will be studied in Peru, with the cooperation of S. A. Raymundo at the International Potato Center (CIP). Sites heavily infested with Meloidogyne incognita have been selected and are currently under study as part of an integrated pest management project. Experimental test plots will be established at these sites (Fig. 4) and the yield-loss-population curves will be derived for each of the three crops. Other crops, such as maize or marigolds will be included in the system as nonhost alternatives. It is anticipated that each crop will have distinctive crop-loss and reproductive rate curves (Fig. 4). Each site will be maintained for at least three years. A varying number of growing seasons will be included in these three years, depending on the site location, climate, and existing cropping systems. Potato, pepper, and tomato would be allocated to sites randomly, in the first growing season. In the second season, crops would be assigned to sites, so that specific rotations could be studied. Sequences would include no rotation, for each of the crops, as well as all possible two season combinations. This process of assigning rotation sequences in a logical pattern would continue over all growing seasons in the three years.

The overall design may be complicated, but the grower/researcher responsible for each site would only have to plant a specific crop, and manage it as usual. Only three variables, P_i, P_f and yield, need to be assessed, and the site is ready for the next crop. In this manner with CNRCP staff coordination, all the data necessary to simulate nematode-host relationships in long-term cropping systems can be collected in each region. These data will be analyzed by

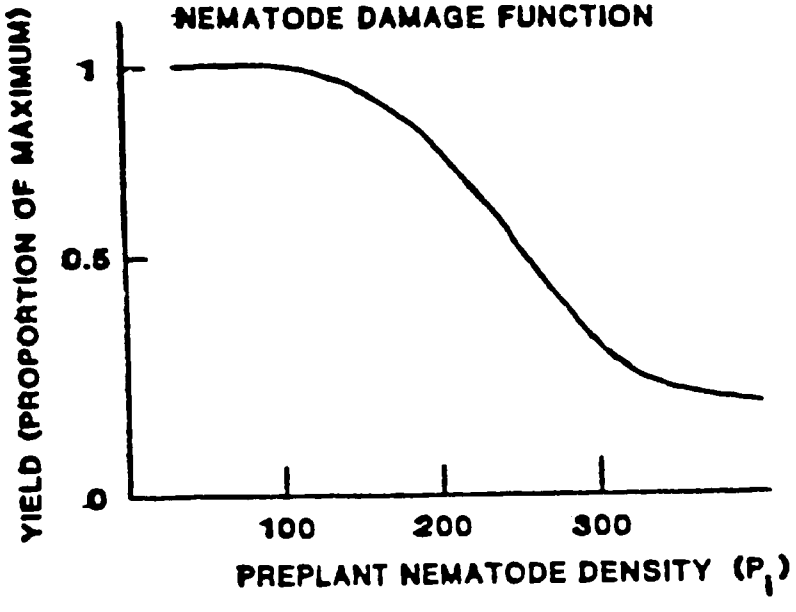

Fig. 2. Typical quantitative relationship between crop yield, and preplant nematode density (P_1). Relationship will be estimated for selected crops by regressing yield on preplant nematode densisty data from each plot.

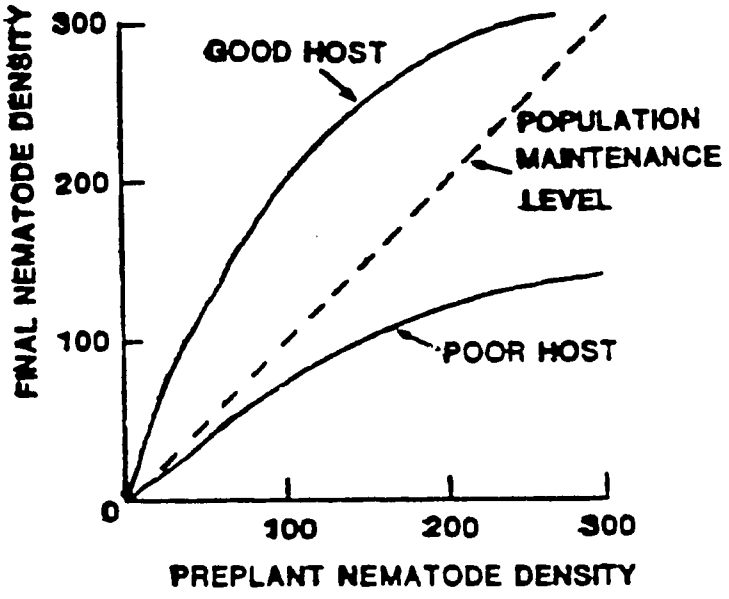

Fig. 3. Typical nematode reproductive curves. Maintenance level is described as a reproductive rate at which the final nematode density is the same as the preplant density. A good host is one on which the final density is greater than the preplant density, whereas a poor host results in a decline of the population. Reproductive curves will be estimated for selected crop-nematode combinations by regressing final nematode counts on preplant counts from each plot. It is anticipated that good hosts, poor hosts, and nonhost plants will be included in the cropping systems.

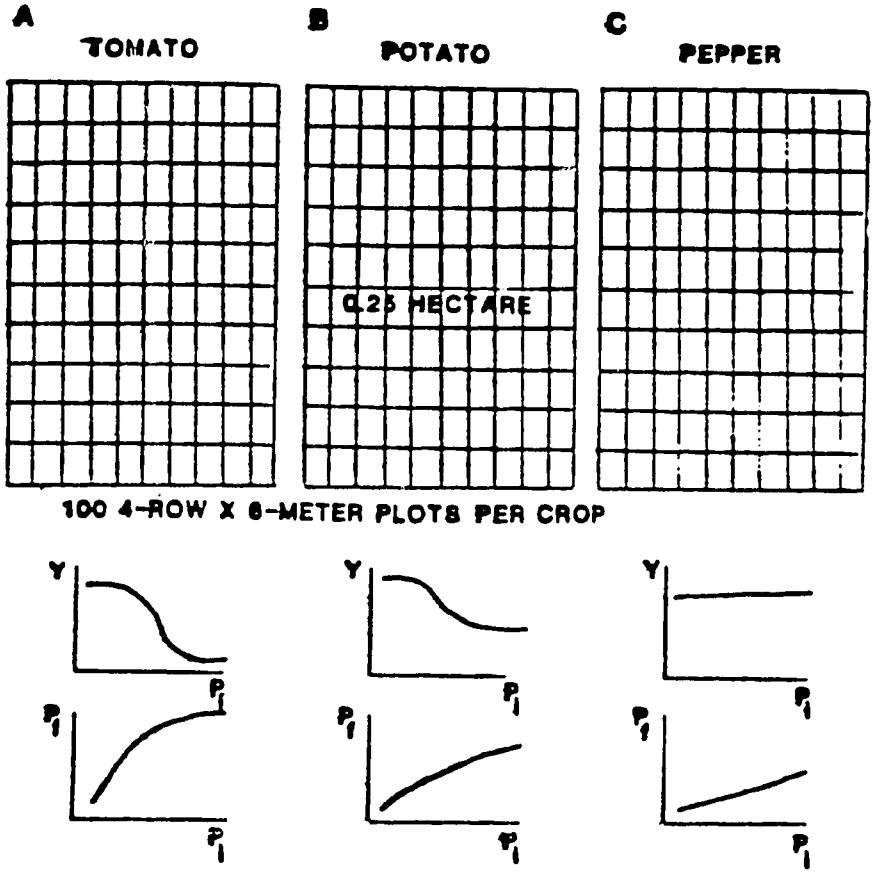

Fig. 4. Proposed cropping-systems-research plot plan for a tomato-potato-pepper rotation plan in Peru. Approximately 0.25 hectares would be required for each crop, with that area divided into 100 plots for the assessment of nematode population levels and crop yields. Nematode population density would be assessed at preplant and at harvest. Other than the individual harvesting of each plot, standard grower practices could be followed in this plan. The data would be used to derive the quantitative relationships shown beneath the plot grids for each crop, including yield (Y) versus initial population density (P_i), and final population density (P_f) versus P_i, for a susceptible crop (tomato), a moderately resistant crop (potato), and a resistant cultivar (pepper).

CNRCP staff, and returned to the cooperators as optimized cropping systems for various growing conditions and nematode hazard levels.

Although the above example refers specifically to Meloidogyne, similar studies can be designed for management of Radopholus similis, Heterodera spp., Globodera spp., Scutellonema cavenessi, Rhadinaphelenchus cocophilus, and other nematodes of more localized importance. The design for such experiments will depend largely on the specific details of the problem: whether the affected crop is annual or perennial, which crops are available, and which cropping practices are locally accepted. Because of the number of variables, the design for such cropping system experiments will be developed for each particular situation.

Data Analysis: Plant-parasitic nematodes have very clustered spatial distributions, within fields. Where a site is divided into relatively small, contiguous plots, there will be large variations among the plots in nematode population densities. Some plots will have very few nematodes, whereas others, which are located on cluster centers, will have very large population densities. The cropping systems research design will take advantage of this clustered spatial distribution and the fact that crop losses due to plant-parasitic nematodes are strongly related to initial population densities. The broad range of densities among plots at each site will allow CNRCP staff to quantify yield loss-P_i relationships, with replication across sites and growing seasons. Where necessary, multiple species yield-loss curves will be derived.

The quantitative relationship of P_f to P_i will be determined by regression techniques for each crop, with replication across sites and growing seasons. Again, the variation of population densities among plots at each site will provide comprehensive information on how P_f will vary as a function of P_i, for each crop (Fig. 4). This relationship is the key to link subsequent growing seasons together in a simulation of cropping systems. P_f can be calculated for a given crop and P_i combination. P_f from the first season then becomes the P_i value for the next crop, and this process continues through an entire cropping sequence. Quantitative crop-loss relationships will be used to determine yield, and eventual crop value, for each P_i along the sequence. The final step is to simulate

rotation/managment sequences by "hooking together" all possible combinations through the crop-loss functions and reproductive-rate curves derived from experimental data (Fig. 5). In this manner, a computer can rapidly evaluate the net results of thousands of different crop rotation alternatives and select promising systems for further evaluation. Economic contraints or cultural desirability will be incorporated into the linear programming models to allow the selection of practical alternatives for implementation by LDC growers.

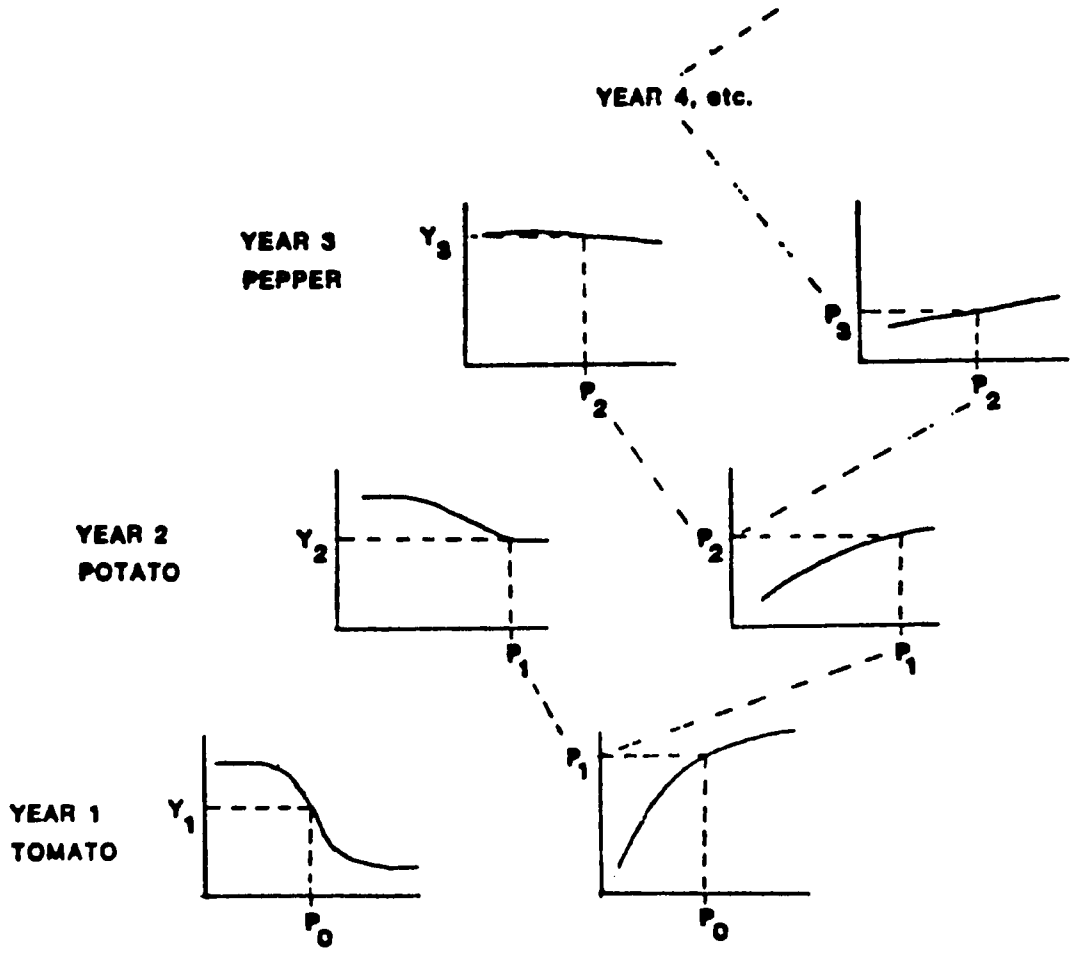

Fig. 5. After quantitative relationships have been derived for crop-nematode combinations, cropping sequences can be simulated and optimized. An initial nematode density (P_0) is selected, and used to predict a yield value (Y_1) and final nematode density (P_1) for the first crop. The final nematode density of the first crop (P_1) is then used to predict a yield value (Y_2) and final density for the next crop. This process continues until a selected cropping sequence is evaluated. Linear programming techniques will be used on a computerized data base in evaluation of all possible cropping sequences simultaneously and selection of the best. An additional economic constraint will be included in the linear programming process as a function in the form; $V_1Y_1 + V_2Y_2 +)V_3Y_3...$, where "V" represents the relative value of a given crop, and "Y" is the yield under the selected management sequence.

c) Implementation

Research activities will begin as soon as contacts are established with the appropriate organizations. Screening for resistant varieties will begin after extension of the existing Memoranda of Agreement with IARC's. Nematode surveys for other species will begin immediately in cooperation with network nematologists. Identification and management services will be available for the A.I.D. Missions immediately.

Screening will be carried out continuously the first two years of the project, with the second year being largely devoted to the training for foreign cooperators. The third year will provide a trial period in which any problems the cooperators may experience with the screening process can be solved.

Data analysis and cropping system simulation will begin after the first year of research. All analyses will be done by CNRCP staff. Data from the second year of the program will be used to revise and adjust models for year-to-year variation. Two years of research may include as many as 6 growing seasons in most LDC climates. After two years of research, data anlysis will be completed, and preparation of LDC pamphlets will begin. Data from the third year of research will be used to validate and increase the accuracy of the quantitative host-parasite models.

Cascading levels of complexity are inherent in the cropping systems research design. Research design and data analysis, which are quite complex, will be done by CNRCP staff at the U.S. University. Cooperating LDC scientists will be involved in the design stage, and will participate in data analysis, to the extent of their interest and abilities. The cooperative effort will provide additional training to LDC scientists in the techniques of cropping systems research.

Another level of complexity is involved in the selection of research sites, data collection, and coordination of management efforts with growers and research staff. Primary cooperators will be responsible for these activities, and will provide advice and consultation to growers on appropriate cropping practices. It is anticipated that research sites will also serve as demonstration farms, showing the advantages of crop rotation and advanced management techniques in the control of losses due to plant-parasitic nematodes. This will increase the interest of nearby growers and begin the technology transfer process.

The simplest level of complexity is reached in the duties of growers, or site managers. Their responsibility will be to manage the crop, as indicated by the cooperating LDC scientist. Except at harvest, the grower will have little concern for the actual research plots. Even where additional management techniques are applied, such as the use of nematicides or biological control methods, the applications will be done as a one-time preplant operation. The selected growers will gain from interaction with LDC cooperating scientists during the experiment. Techniques for assaying nematode populations, and for the application of specific nematode control measures will be demonstrated by CNRCP staff, on-site.

The final phase of technology transfer will be accomplished through native-language pamphlets, describing the best cropping system alternatives for reduction of losses due to plant-parasitic nematodes. Specific crop rotations will be recommended, taking into account the cultural desirability of certain crops. Writing the pamphlets will be a cooperative effort with CNRCP staff and LDC scientists. A selection of cropping-systems alternatives will be presented for differing nematode-hazard levels, with an explanation of the advantages of specific crop combinations.

It is anticipated that nematode research stimulated by this project will be continued beyond the three-year term of the project. Once the research designs are implemented and computer programs for data analysis are completed, cropping systems can be evaluated quickly and efficiently through the international network of scientists promoted by this project. New data will be transferred into existing programs for crop-rotation simulation, and optimization. As new crops and cultivars become available, as crop values change, and as the cultural desirability of certain crops shift, recommended cropping systems will be updated. The technique for such updating will be provided by the project.

d) Inputs

The project will fund personnel costs of the principal investigator, a senior nematode-management specialist, a screening-for-resistance specialist, two technicians to help carry out the screening, a technology-transfer specialist and a secretary.

3. Training Component

a) Description

One of the greatest obstacles to effective nematode management in developing countries is the lack of trained personnel. There is a severe shortage of both junior level (M.S. degree) and senior level (Ph.D.) nematologists in many countries. In countries where shortages are less severe, the scientists are often without access to current scientific literature and/or stimulating professional exchange with other nematologists. Without these educational stimuli, scientists can rapidly become out of date.

To address this problem, two types of training will be implemented. The first will be short-term specialty training (two weeks to three months) at the project center offered on two different levels: one for research technicians and one for scientists who already have degrees. The second aspect of training will be to hold conferences and workshops for specific purposes.

1) Short-term specialty training

This will basically be refresher training. LDC scientists who already have degrees will be given the opportunity to spend two weeks to three months at the project-based university learning improved nematode identification approaches, research methods, and management strategies.

2) Conferences and workshops

The project will organize and publicize conferences or workshops pertaining to specific aspects of nematode management. Some topics that might be anticipated include screening for resistance, proper use of nematicides, production of nematode-free planting stock, conducting nematode surveys, and recognition of nematode problems.

b) Implementation

The project's principal investigator will serve as the project's training coordinator. The entire project staff, however, will participate in organizing training activities, preparing training materials, and conducting training sessions. The A.I.D. Missions will function as liaisons between the project and the targeted audience and/or students.

c) Inputs

Core technical staff to conduct these workshops will be provided by the project. This staff will be supplemented by volunteer services of workshop attendees who are members of the research network. Meeting sites will be furnished gratis by various collaborating IARCs. Travel and per diem for participants will be solicited from USAID Mission training funds and adequate lead time will be provided between announcements of availability of training and actual conduct of the same so that missions and governments ill be able to program training monies in advance. These workshops will be conducted as specialized short-term training courses and will also serve as a research networking activity. By combining both networking and training in the same package it is anticipated that the funding base for travel can be considerably leveraged. A third function of the workshops will be to serve as regional congresses on nematology.

Table 5. Summary of Training Components

Activity	Outputs
1. Short-term specialty training	-- 10 scientists with refresher training.
	-- 15 research technicians with improved nematology skills
2. Conferences & workshops	-- 4 Workshops on techniques in screening for resistance, conducting surveys and recognition of nematode problems
	-- 4 Workshops on proper use of nematicides and on production of nematode-free planting stock

3. Technology Transfer

a) Description

One of the ultimate objectives of this project is the production of quality nematology services in developing countries.

Training will do much to achieve this goal, but other types of assistance are also necessary, such as guidance in the planning of new laboratories and in the selection of new equipment. Access to current scientific literature is also an important asset.

Table 6. Summary Technology Transfer

Activity	Outputs
1. Nematode laboratory advisory service	-- 8 nematode laboratories set up
2. Information base/resource center	-- 10 sets of guidelines for preparation of extension bulletins published
	-- hundreds of reprints and books supplied
3. Nematologists' Network	-- Newsletter published quarterly

1) Nematode laboratory advisory service

Nematode identification services are not readily available throughout developing countries. As these services become feasible, A.I.D. Missions may enlist the assistance of the nematode research and control project in planning new laboratories or selecting appropriate equipment. Guidance could also be given in the carrying out of surveys and development of sound research projects, but these topics are covered in the research component.

2) Information base/resource center

One of the most useful roles of the project will be that of a clearinghouse for information. Network collaborators, A.I.D. Missions and projects, IARCs and other interested parties will be able to obtain information on nematode problems from the project. Publicity for this availability of information will mainly be accomplished through the research network and newsletter but an effort will also be made to publicize the availability through scientific organizations dealing with crop protection, other A.I.D. financed newsletters (e.g. those of the Consortium for International Crop Protection and the International Plant Protection Center). Also, the information project will closely associate itself with the S&T/AGR funded A.I.D. Agricultural Information Exchange Service (AGIES) project at the National Agricultural Library and its satellite A.I.D. Pesticides Information Service (AIDPEST) project. Information output will be in two formats - that of interest only to nematode specialists and that of interest to crop protection professionals and agronomists in general.

3) Nematologists' Network

In an effort to maintain and expand the international network of nematologists formed by the root-knot nematode project, a newsletter will be published quarterly. A priority task, immediately after initiation of the project, will be to obtain the necessary clearances from the Communications Review Board. All members of the network will have an opportunity to submit brief research articles to and receive copies of this publication. The newsletter will bring nematologists throughout the world up to date on research being conducted by their peers.

b. Implementation

The principal investigator and the crop management specialist will coordinate the assistance in setting up new nematode laboratories. The principal investigator and the technology transfer specialist will coordinate the information base/resource center and network newsletter. Screening tests for the worldwide nematode survey will be provided by the project. Collection of samples will be done mainly by research network collaborators. Shipment to the U.S. will be provided by mission pouch service. Packaging and labelling for soil samples will be provided by the project.

c. Inputs

The staff requirements for this component are the same as discussed elsewhere. Funds for books, reprints, laboratory facilities and laboratory equipment will be drawn from A.I.D. Mission and regional bureau projects, from other bilateral and multilateral donor agricultural projects, from IARCs and from local currency funds. The newsletter will be underwritten from core funding to the U.S. university. Screening tests for the worldwide nematode survey will be provided by the project. Collection of samples will be done mainly by research network collaborators. Shipment to the U.S. will be provided by mission pouch service. Packaging and labelling for soil samples will be provided by the project.

IV. Cost Estimate and Financial Plan

The proposed budget for the project is $2.45 million of which S&T/AGR's contribution will total $1.0 million (41%), the missions $0.6 million (22%), the IARC's $0.24 million (11%), and the LDC Cooperators $0.24 million (11%), and the U.S. university .372 (15%). Table 7 contains a summary of the project budget.

The total A.I.D./S&T/AGR funds for the project were committed in FY 84 to cover activities over the implementation period of three years from September 1984 through September 1987.

Firm commitments from IARCS as to their type and share of commitment will be negotiated immediately after the project is initiated. Also, immediate efforts will be undertaken in cooperation with regional bureaus to obtain USAID Mission cooperation in local project redirection in Senegal, the Philippines and Jordan for collaborative projects. PL-480 money will be solicited in Costa Rica and the Bean/Cowpea and Peanut CRSPs will be asked to provide staffing, facilities and equipment for projects in Columbia (CIAT) and India (ICRISAT) respectively.

TABLE 7

FINANCIAL PLAN PROJECTED COSTS
(U.S. $ 000)

Proj. Element	U.S. Univ.	S&T/AGR	Missions		IARCs	LDC's	Total
			Field Trials	Work-shops	Coop. Res.	Coop. Res.	
Personnel		467	15		70	80	632
Consultants	45						45
Travel & Per Diem		90	5	440	25	25	585
Equip & Supplies		90	20		55	35	200
Office Space	30						30
Greenhouse Space	120				25	45	190
Utilities	40						40
Library	10						10
Computers	10						10
Office Equip.	6				5	5	16
Vehicles	15				15	15	45
Soil Analysis	6						6
Lab. Space	60				10	15	85
Maintenance	30						30
Other Direct Costs			80	40	35	20	175
Overhead/Fringe Ben.		353					353
Total	372	1,000	120	480	240	240	2,452

V Implementation Plan

The schedule of major events as they are currently planned is contained in Table 8. This schedule reflects the judgement of the S&T/AGR staff and considers the contacts that must be established in developing a project of this type. Regular monitoring of the project will assure early recognition of unanticipated problems and areas where modifications are needed. This will be particularly important in the early stages of the project. Toward this end, project staff will prepare regular progress reports covering activities and accomplishments, factors affecting implementation, financial status, etc. and, based on these, activities will be planned for the next reporting period. Annually, the project staff will prepare new work plans which will become the basis for amending the implemenation plan.

TABLE 8
SCHEDULE OF EVENTS

	Sept Dec 1984	Jan Jun 1985	July Dec 1985	Jan Jun 1986	July Dec 1986	Jan Jun 1987	July Sept 1987
PREPARE ANNUAL WORK PLAN	C	----------	C	----------	C		
SCREENING FOR RESISTANCE							
1. Develop agreements with IARC's		S	------	C			
2. Conduct screening tests	S	----------	----------	----------	----------	C	
3. Train LDC cooperators and IARC technicians to conduct screening tests			S	----------	----------	----------	C
4. Initiate screening at IARC's and in LDC's (for Meloidogyne only)					S	----------	C
5. Develop screening procedures for other important nematode genera			S	----------	----------	C	
CROPPING SYSTEMS							
1. Visit missions & LDC cooperators	S	----------	----------	----------	----------	----------	C
2. Assist potential collaborators in obtaining funding			S	----------	----------	C	
3. Select sites for field trials			S	----------	----------	C	
4. Conduct field trials				S	----------	----------	C
INFORMATION BASE & RESOURCE CENTER							
1. Expand existing data base	S	----------	----------	----------	----------	----------	C
2. Develop data base index	S	----------	----------	----------	----------	----------	C
3. Provide information on request	S	----------	----------	----------	----------	----------	C
4. Coordinate with S&T/AGR and AIDPEST	S	----------	----------	----------	----------	----------	C
5. Consultation on nematode problems	S	----------	----------	----------	----------	----------	C
6. Consultation on nematode advisory services			S	----------	----------	----------	C
TECHNOLOGY TRANSFER INCLUDING SPECIALIZED TRAINING							
1. Conduct conference/workshops			S	----------	----------	----------	C
2. Expand network of nematologists	S	----------	----------	----------	----------	----------	C
3. Publish newsletters				S	----------	----------	C
4. Guide development of extension pamphlets					S	----------	C
5. Short-term specialty training			S	----------	----------	----------	C

TABLE 7 (Continued)
SCHEDULE OF EVENTS

	Sept Dec 1984	Jan Jun 1985	July Dec 1985	Jan Jun 1986	July Dec 1986	Jan Jun 1987	July Sept 1987
REPORTS							
1. Copies of newsletters, manuals, pamphlets, etc.	S----------	----------	----------	----------	----------	----------	----------C
2. Annual Report			C----------	----------	C		
3. Final Report	----------	----------	----------	----------	----------	----------	----------C
EVALUATION							
1. Program Review			C				
2. Program Review					C		
3. Program Review						C	

VI. Monitoring Plan

The project will be administered by S&T/AGR. The project manager will establish liaison with the grantee and communicate with the principal investigator frequently. The grantee will visit or be visited by S&T/AGR personnel every six months. Annual progress reports will be submitted to S&T/AGR. Copies of all newsletters, pamphlets, manuscripts will be sent to the project manager. The grantee will purchase and maintain word processing equipment which can transfer data directly by telephone and modem to S&T/AGR Wang and/or IBM-PC computer disks. Also the grantee will install telecopy equipment which is compatable with that currently owned by S&T/AGR.

VII Evaluation Arrangement

Two formal evaluations will be conducted during critical stages of project implementation, one by the S&T/AGR Staff and the other by outside consultants.

A - 10 and 22 - month Evaluations

At approximately the 10th and 22nd month of project implementation, S&T/AGR will conduct a management review to determine if detailed project plans are adequate to achieve project objectives. The review will cover specific implementation plans and will develop recommendations for possible changes in project direction.

B - Final Evaluation

A final evaluation will be conducted toward the end of the project. It will be carried out by an outside consulting team selected by S&T/FA and will focus on an assessment of the overall success of the project. The team will consider all facets of the project. The final evaluation report will include:

- overall assessment of the success in meeting original objectives.
- estimation of the value of project accomplishments.
- identification of principal factors leading to project successes and failures.
- assessment of the probability that project accomplishments will be sustained.
- recommendations regarding future development of similar A.I.D. projects.

ANNEX I

PID Approval Message

The Agricultural Sector Council approved the Crop Nematode Research Control PID when it met on June 12, 1984.

AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Project Title & Number: CROP NEMATODE RESEARCH AND CONTROL 936-4149

Life of Project:
From FY 84 to FY 87
Total U.S. Funding $1,000,000
Date Prepared: February 1984

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: To increase the supply of agricultural products by reducing losses caused by crop nematodes.	Measures of Goal Achievement: Increase yields of target crops. Improved quality of products. Increased farmer incomes.	National census figures. Data from appropriate national ministries.	Assumptions for achieving goal targets: Countries will remain stable politically so that major disruptions of agricultural production and essential inputs will not occur. Mission and bureau support will materalize. Nematologists in network will actively participate in project. Research results will be extended to and adopted by farmers.
Project Purpose: To strengthen the regional, institutional and individual capacity in crop protection and to help establish efficacious pest management systems with emphasis on crop nematodes.	Conditions that will indicate purpose has been achieved: End of project status. 1. Additional Regional and national institutions are engaged in crop nematode research. 2. Participating institutions and private sector groups have adopted improved crop management systems. 3. Technicians in participating institutions involved in crop nematode research and control are better trained.	Annual reports of institutions. Review of publications produced by project collaborators.	Assumptions for achieving purpose: Network scientists will implement productive research. Practical training material will be produced and extended to farmers. Farmers will adopt improved control systems.

AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project
From FY 84 to FY 87
Total U.S. Funding $1,000,000
Date Prepared: February 1984

Project Title & Number: CROP NEMATODE RESEARCH AND CONTROL 936-4149

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Outputs:	Magnitude of Outputs:		Assumptions for achieving outputs:
A. Research			
1. Crop germplasm selections screened.	Seventeen hundred screened.	Project reports.	IARC's will continue to provide crop samples.
2. Nematode problems evaluated.	Twenty-five evaluated.	Project reports.	Network nematologists, national institutions, farmers and missions will cooperate.
3. Nematode management trials completed.	Sixteen completed.	Project reports.	Same as above.
B. Training			
1. Conferences/workshops.	Eight conferences held, 240 participants.	Reports.	Missions / regions will support.
2. Field Demonstrations of Nematode Control Techniques.	Thirty held, 30 locations & 600 participants.	Reports.	Mission, network nematologists & private sector farmers will support & cooperate.
3. LDC scientists trained.	Fifteen trained.	Reports.	Missions will support.

AID 1020-25 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 84 to FY 87
Total U.S. Funding $1,000,000
Date Prepared: February 1984

Project Title & Number: CROP NEMATODE RESEARCH AND CONTROL 936-4149

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Outputs:	Magnitude of Outputs:		Assumptions for achieving outputs:
C. Technology Transfer			
1. Leaflets, pamphlets, etc. published.	Thirty publications reproduced in fifteen countries.	Reports, samples.	Network nematologists will cooperate, national ministries will support.
2. Manuals, manuscripts, etc. published.	Ten published.	Reports, samples.	Same as above.
3. Laboratories set up.	Eight upgraded.	Reports.	Missions and national ministries will support network nematologists will cooperate.
4. Response to requests for technical services.	Sixty-five responses. (Assumed number of requests generated within nematode research network)	Reports.	Missions, network nematologists will participate.

AID 1020-25 (1-78)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 84 to FY 87
Total U.S. Funding $1,000,000
Date Prepared February 1984

Project Title & Number: CROP NEMATODE RESEARCH AND CONTROL 936-4149

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Inputs:	Implementation Target (Type and Quantity)		Assumptions for providing inputs
A.I.D. S&T/AGR Contributions ($000) Personnel 467 Equipment and supplies 90 Travel and per diem 90 Overhead 353 IARCs Personnel 70 Travel and per diem 25 Research facilities/labs 10 Equipment and supplies 55 Greenhouse space 25 Office equipment 5 Vehicles 15 Other direct costs 35 LDC Contributions Personnel 80 Travel and per diem 25 Equipment and supplies 35 Greenhouse space 45 Office equipment 5 Vehicles 15 Research facilities/labs 15 Other direct costs 20	Personnel, laboratory facilities, and equipment utilized in accordance with time schedule shown in Table 8 of Implementation Plan.	S&T accounting reports	Cooperative agreement is negotiated in timely manner along with adequate funding.

AID 1020-29 (1-78)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project
From FY 84 to FY 87
Total U.S. Funding $1,000,000
Date Prepared February 1984

Project Title & Number: CROP NEMATODE RESEARCH AND CONTROL 936-4149

NARRATIVE SUMMARY		OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Inputs:		Implementation Target (Type and Quantity)		Assumptions for providing inputs
A.I.D. Missions ($000)				
Field Trials				
Personnel	15			
Travel and per diem	5			
Equipment and supplies	20			
Other Direct Costs	80			
Workshops				
Travel and per diem	440			
Other Direct Costs	40			
U.S. University				
Consultants	45			
Laboratory space	60			
Office space	30			
Greenhouse space	120			
Utilities	40			
Library	10			
Computers	10			
Office equipment	6			
Vehicles	15			
Soil Analysis	6			
Maintenance	30			

Technical Analysis

A. Introduction

The crop nematode research and control project is intended to increase the knowledge about this group of serious plant pests, to improve the ability of LDC nematologists to conduct research, to conduct field trials to evaluate crop nematode management systems and to initiate programs for training farmers in nematode control methods. The approach to this broad objective is focused on three components: research, training and technology transfer. The following discussion is intended to provide a general perspective of these components.

B. Research

1. Overview

Nematodes, particularly root-knot nematodes, are a serious problem throughout the tropical and sub-tropical regions of the world. Although this group of pests has been studied extensively in the developed countries and a variety of control methods developed, there are many unresolved problems. Much less information is available about nematodes in LDC's than in the developed countries, so the research needs are proportionally greater. The AID Pest Management Root-Knot Nematode Project with North Carolina State University yielded a wealth of information on the genus Meloidogyne, but additional research in LDCs is needed on this genus and even more on other genera. In designing the research phase of the project, it was decided to follow-up on the root-knot nematode research and to conduct studies on other species that were causing serious crop losses.

2. Screening for Nematode Resistance

The search for nematode resistance in crop germ plasm is not a new one, even in developing countries. However, screening programs in LDC's have been limited by many factors. One is the use of locally obtained nematode populations. Field populations used in screening may contain several genera, species, and even races. It is unlikely that resistance can be found to such mixtures, and if it were, no one would really know the exact nematode mixture for which resistance had been found.

A second factor limiting LDC screening programs again pertains to the nematode populations used. Even if a pure, single-species population is used, it often is not maintained for future use or reference. Thus when host races are discovered, as has been the case with Meloidogyne spp., it is not possible to go back and identify more precisely the population used in the past.

Thirdly, because LDC screening programs rely solely on local nematode populations, major agricultural crops cannot be screened for resistance to all of the four major Meloidogyne species and their races. ~~Since~~ these major species and races of Meloidogyne are responsible for about 95% of all root-knot nematode damage to agricultural crops, knowledge of crop resistance to these particular nematodes is essential. Effective cropping systems cannot be designed without this information.

~~For the above reasons~~, the AID Pest Management Root-Knot Nematode Project has screened thousands of crop germ plasm accessions for resistance to the four major Meloidogyne species and their races. These accessions have included bean, chickpea, pigeon pea, tomato, potato, Chinese cabbage, wheat, barley, maize and cowpea. Seeds of these crops were provided by plant breeders located at the various International Agriculture Research Centers. The Crop Nematode Research and Control Project will continue this effort for about two more years. At the end of this period, the emphasis will already have shifted to the instruction of LDC scientists and technicians in screening procedures. At the completion of this three-year project, selected IARC's and other strategic nematology centers in developing countries will have received pure cultures of the necessary nematode populations, as well as hands-on training in the performance of screening procedures.

3. Identification of Nematode Problems

Accurate nematode identification is the primary prerequisite for effective management of these pests. The distinction between inocuous and plant-parasitic forms is only rarely a sufficient basis for selection of a management approach. Management strategies, such as cropping systems, which are most applicable to LDC agricultural crops, require accurate and precise nematode identification.

Nearly every crop plant is susceptible to infection by nematodes. Some nematode species, or races, infect a wide range of hosts while others are known to infect only a single host. The variation in host specificity has a significant impact on selection of rotation crops. The feasibility of using biological control agents also depends on the identity of the nematode pest.

Nematode advisory services in LDC's are not very accessible or, in some cases, very well equipped. Therefore, problems may be encountered in dealing with unusual, or particularly difficult, nematode problems. As a resource center and information base, the CNRCP plans to make its expertise available in the diagnosis and management of nematodes on important agricultural crops. Assistance of this nature will focus on economically important crop/nematode interactions of significance to the geographical region in which it occurs. Such work will ~~probably~~ entail nematode sample surveys of agricultural soils.

4. Evaluation of Cropping Systems

LDC growers need to be able to implement effective, low-cost crop management strategies for a stable, long-term reduction of losses due to plant-parasitic nematodes. For this reason, strategies involving crop rotation, biological control agents, production of disease-free planting stock, and other cultural and sanitary practices need to be investigated. Use of nematicides is often impractical in LDC's because the chemicals are expensive, potentially dangerous, and not readily available. In nematode management research studies, however, nematicides serve a valuable function by demonstrating the extent to which crop yield can be improved by successful nematode management.

Effective analysis of crop rotation schemes begins with an evaluation of quantitative host-parasite relationships. For this reason, the size and composition of nematode populations must be monitored closely before, throughout, and after the growing season. The number of crops to be studied at each site will depend on grower practices, local availability and the size of the site. Selected crops must be economically important to the region and culturally acceptable to LDC growers. Another aim is to conduct on-site research with a minimum of disruption to normal grower practices. These stipulations are made to enhance the local adoption of proposed cropping systems. Also, it is hoped that research sites which serve as demonstration farms will thereby spark the interest of nearby growers.

5. Conducting Crop-Loss Assessments

Crop-loss assessment is one of the more neglected areas in LDC nematode management. Most estimates that have been made available to date are primarily subjective. Also, in such cases where estimates have been provided, there has been little attempt to identify thoroughly and precisely all of the plant-parasitic nematodes contributing to crop loss. The usefulness of crop-loss estimates due to nematodes has also been decreased by the simultaneous occurrence of many other disease organisms and insect pests.

Assessment of crop losses has been chosen as a target area by the CNRCP not only because an obvious need for it exists but also because it is easily integrated with the two previous sections: identification of nematode problems (Section 3) and evaluation of cropping systems (Section 4). As the CNRCP serves in its capacity as a worldwide nematode advisory service, serious nematode/crop problems will be brought to its attention. In this way, many opportunities will arise for the gathering of crop-loss data. This information, along with results of management experiments involving the same crops and nematodes, will provide solid and reliable data for estimation of losses due to plant-parasitic nematodes. This data will be valuable due to the scarcity of reliable crop-loss information in LDC's. It will also contribute substantially to the development and evaluation of effective cropping systems.

6. Implementation and Evaluation of Management Strategies on Farm Plots

Evaluation of cropping systems (Section 4) on research stations alone will not be sufficient to address the nematode problems of LDC's. Although research plots on experiment stations will be used as demonstration plots, more direct contact with the farmers is necessary. For this reason, the strategy outlined in Section 4 will also be implemented in selected growers' fields.

This approach will make it clear to farmers that significant increases in crop yields can be obtained through nematode management. By becoming familiar with the signs of nematode damage, knowing where to turn for expert identification services, and understanding the basis for management strategies, the farmer will develop an appreciation of the problem as well as confidence in his ability to master it. Emphasis necessarily will be placed on inexpensive and locally available management options.

7. Development of the Research Capability of Collaborating Institutions

Part of the rationale for this objective is given under Section 2 -- Screening for Nematode Resistance. Practically all major efforts by LDC's to screen crop germ plasm for resistance to root-knot nematodes involve some cooperation by the AID Root-Knot Nematode Pest Management Project. To alleviate this dependence, the CNRCP plans to transfer the screening technology to major IARC's and other appropriate and strategically placed LDC institutions.

Aside from the screening-for-resistance capability, one of the drawbacks that faces LDC scientists is the lack of access to current scientific information. For this reason, CNRCP's service as a resource center and information base will be extremely valuable. Reprints, books, and

articles, especially on specific topics that these scientists may have difficulty tracking down, may be obtained through CNRCP. Such access to research findings on similar crop/pest interactions or the latest taxonomic breakthroughs can substantially improve LDC efforts in the field of nematology.

Also in connection with the identification of nematode problem areas (Section 3), the CNRCP will be conducting nematode sample surveys and performing identifications with the cooperation of local LDC agricultural specialists, technicians, and/or growers. This experience will serve to strengthen existing nematode advisory services and/or instill the determination to initiate such services which are badly needed in many LDCs.

8. Research Linkages

The CNRCP is committed to serving LDC's in a wide range of geographical areas. To concentrate studies in one or two locations would be to limit unnecessarily the usefulness of this project. By selection of ~~four to six~~ geographical areas in which to conduct cooperative studies, nematode identification and management research can be carried out in a range of climatic and environmental conditions. Because this diversity is being allowed for, practically all LDC's will potentially benefit from the research results. For example, management studies will be able to involve a wider range of crops for rotations and the effectiveness of biological control agents can be analyzed under varying ecological settings. Most LDC scientists will be able to glean information from these studies that will apply to his or her country.

Optimum effectiveness of the CNRCP will depend on the extent to which AID mission bureaus "buy-in" to the resource center/information base services that will be offered. Willingness to cooperate in the screening-for -resistance program has already been expressed by several IARC's including CIP, CIAT, CIMMYT, IITA, ICRISAT, and AVRDC.

Several research institutions in developing countries have indicated a desire for cooperative studies with CNRCP. These include the Universidad de Costa Rica, the Jamaican Ministry of Agriculture's Plant Protection Division, INIAP (Ecuador), Universidade de Brasilia, ORSTROM (Ivory Coast and Senegal), Uganda's Kawanda Research Station, the Kenyan National Agriculture Laboratory, Korea's Kyunpook National University, Indonesia's Segunung Research Station, the Bangladesh Agricultural Research Institute, the University of Jordan, Morocco's Institute de Agronomique et

Veteranaire, and India's University of Agricultural Sciences. Due to the abundance of interest expressed and to the geographical diversity of these institutions, CNRCP is in a good position to select suitable research sites in ~~four to six different regions of the world.~~

9. Research Outputs

One of the major goals of CNRCP is timely dissemination of information. For this reason, a newsletter will be issued quarterly ~~to [illegible]~~ so all cooperating scientists can be brought up to date on each other's research progress. When necessary, assistance will be given in analyzing and interpreting data.

Emphasis will also be placed on publication of research findings in refereed journals so the scientific credibility of the work will be enhanced. Scientific publications will also serve to document the progress of the project. As findings accumulate and begin to point to practical management strategies, research outputs will also take the form of native-language, extension-type bulletins for use in the education of LDC agriculture specialists and farmers. This aspect of information dissemination will be largely the responsibility of in-country scientists who will benefit from CNRCP guidance in development of bulletins and financial assistance in their publication.

C. Training

Though LDC's are beginning to produce sizeable numbers of agricultural specialists, well-trained nematologists are relatively scarce. To help close this gap, CNRCP plans to direct training for many levels of agriculturalists: advanced degree scientists, student technicians, and growers. The ultimate goal of this effort is the production of a core of indigenous personnel with sufficient knowledge concerning the science of nematology that they are able to recognize, address and alleviate their country's problems in this realm. In working toward this goal, CNRCP will stress refresher training for scientists and intensive training for technicians in the form of workshops, individual training in special skills for agricultural personnel, and field demonstrations for farmers.

1. Workshops

Within seven years of the time a scientist completes graduate education, most of the technical information learned is obsolete. This problem is especially true in LDC's where scientists often do not have access to current professional literature on a regular basis. To alleviate this

problem, CNRCP plans to conduct conferences and workshops on aspects of nematode management that specifically need to be updated. Some topics that are anticipated include screening for resistance, proper use of nematicides, production of nematode-free planting stock, design of nematode surveys, and recognition of nematode infections.

2. Individual Training

Some training must necessarily be intensive with abundant "hands-on" experience. Because workshops cannot always offer the individual attention sometimes needed, CNRCP will provide two-week to three month specialty training at the project-based university. Topics more suited to this training approach may include current nematode taxonomy, research methods, data analysis, and management strategies.

3. Field Demonstrations

The topic of field demonstrations has been addressed under Sections B.4 and B.6. These demonstrations are designed to benefit all levels of agriculturalists from administrators to researchers to farmers.

D. Technology Transfer

Although technology transfer has been emphasized under the topics of research guidance and professional training, the term is used here to specify the project's functions as a resource center and information base. In pursuing its goal of transferring professional capability in nematology to LDC's, CNRCP recognizes the need for transfer of information, guidance and materials.

1. Data Base Development

The comprehensive nature of CNRCP activities will dictate the collection and analysis of an enormous quantity of data. Nearly every conceivable aspect of international nematology will be covered in the project approach. All of this information will be of value and must be made available to cooperating LDC scientists. To accomplish this goal in an orderly manner, computerized database-management techniques will be used to coordinate information storage and retrieval for each component of the CNRCP. Databases will be maintained for the germ-plasm screening efforts so that scientists in any part of the world will have immediate access to the resistance status of tested cultivars. Data from cropping-systems research will also be analyzed and placed in an appropriately keyed

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database so that LDC pest management personnel can retrieve information related to nematode problems in their areas. Other research data such as morphological, biochemical and cytogenetic results related to the taxonomy and identification of nematode pest species will be organized and managed for use by cooperating scientists. This information will be invaluable for the identification of specific nematode problems in LDC's.

2. Research Guidance

Until recently, nematology research conducted in LDC's was carried out with little or no collaboration among neighboring countries. Much work was duplicated or overlapping, and works that might have been complementary were not compatible because of differences in the methods used. By providing a newsletter abstracting current nematology research in LDC's, CNRCP will foster more cooperation and less duplication. Guidance in research methods also promises to lead to some standardization in approach.

Guidance in the area of screening for resistance has already been addressed in Section B.2. This effort will be a direct example of capacity transfer in that a core of indigenous personnel will be trained to take over the screening for Meloidogyne resistance that was formerly performed by AID's Root-Knot Nematode Pest Management Project.

3. Design of Nematology Laboratories and Equipment Selection

In LDC's, the few currently established nematode advisory services need bolstering, and additional services are in demand. Because LDC's have limited resources to expand in this research area, CNRCP plans to offer advice on the design of laboratories and the selection of the most essential equipment. In this way, the limited funds available can be put to the best use.

4. Periodic Dissemination of Information

The quality of nematological research in LDC's can be improved and the interest of the scientists spurred by improved dissemination of information about research problems, approaches, and solutions. A newsletter published quarterly or biannually by CNRCP will serve this purpose. In addition to covering general LDC research in nematology, the progress of CNRCP's collaborative studies with IARC's and other research institutions in LDC's will be covered.

5. Technical Publications

Technology transfer through research guidance and training efforts requires reinforcement by means of technical publications. Only a fraction of this requirement will be met by CNRCP's periodic newsletter. Topics to be covered by workshops and individual training sessions, such as standardization of taxonomic approaches, research methods, screening procedures, and nematode survey design, will leave a more lasting impression if supplemented with written guidelines. Technical publications of this kind will be prepared as CNRCP feels they are warranted.

6. Development of International Liaison Organization for Nematologists

Many international nematology organizations already exist, but few focus on nematology in LDC's particularly the problems of tropical nematology. Also because of stringent rules for manuscript acceptance, many LDC scientists rarely publish their findings outside their own countries.

A global network of scientists has already been established by AID's Root-Knot Nematode Pest Management Project. CNRCP plans to strengthen and expand this network in its capacity as a resource center/information base. The distribution of the newsletter mentioned in Section C.4 will assist in this effort. While a new "nematology society" will not be formed as such, LDC scientists engaged in nematology projects will be made aware of research being conducted in other countries and have access to research publications. Inter-country cooperation will be promoted as a result.

Financial Analysis

~~The~~ cooperating LDC institutions have ~~yet to be~~ identified. Their financial and administrative soundness will be taken into account following the grantee selection and the subsequent selection of cooperating research partners. However, it is obviously in the interest of A.I.D. to fund activities in countries and institutions where there is sufficient financial commitment for such efforts.

What can be stated with clarity is that there is substantial interest in nematode-related problems in LDCs as represented by estimated total LDC research budget outlays currently running between $750,000 and $1,000,000 per year. Additionally, the International Agriculture Research Centers (IARC) carry on nematode research. CIP in Peru has the single largest IARC nematode program, which in addition to its center-based expenditures and efforts, allocated over $36,000 during the last four years to pay for potato germ-plasm screening for resistance to nematodes and for biological control research services performed by North Carolina State University.

Such relationships illustrate the complementary efforts that the proposed project will foster. The grantee recipient that implements this cooperative agreement will also facilitate and coordinate the activities and efforts of joint concern for very broad based interests in nematode research throughout over 60 countries and an estimated network of institutions that should approach 100. Such a network is critical for national level research programs to be able to take advantage of the research findings of each other and those of the IARCs. Therefore, it is expected that specific project support, i.e. investments, will be made with institutions that are financially viable and administratively sound.

Economic Analysis

A. Introduction

Pest problems in LDCs annually cause economic crop losses estimated to average as high as 30 percent of crop values. Pests affect agricultural potential both by causing production losses and necessitating that energy and resources be diverted to their control instead of other productive alternative uses. Mean crop-yield losses directly attributable to a single genus of nematodes (Meloidogyne spp., root-knot nematodes) range from 11% in Southeast Asia to 25% in West Africa and 15% for Latin America and the Caribbean. Single crop-yield losses directly attributable to Meloidogyne are as high as 46% of the tomatoes produced in West Africa and 24% of the common beans grown in South America. Total crop failure due to nematodes is commonly reported where infestations are highest.

Field abandonment is often the only alternative many peasant farmers can turn to. In other areas the crops most optimally suited for local growing conditions are simply not cultivated where nematode infestation is reported. Thus the indirect effect of nematodes is also present in the loss of employment and revenues from crops that would otherwise be cultivated. In areas with high population densities, abandonment results in the bringing into cultivation of marginal lands which in turn leads to environmental degradation as a result of watershed cover removal and soil erosion.

Nematodes are one of the most important agricultural pests in terms of economic losses. The combined losses due to all species of nematodes are much higher than for Meloidogyne alone. Given already established and known methods of control for the temperate regions of the world, along with promising results from the limited amount of nematode research that has been performed in the tropics, it is apparent that adaptive research coupled with some additional basic research through cooperating LDC institutions will lead to significant gains in agricultural productivity.

The Crop Nematode Research and Control Project is designed to develop institutional and individual capacity to carry-out research and to develop nematode control systems for transference to local farmers. The economic analysis that follows expands upon the introductory comments regarding the economic importance of nematodes through examples of general impacts of nematode-caused problems and three country-specific examples of conservatively estimated losses for selected crops.

B. Background

The agriculture sector in most developing countries that AID works with is the primary source of employment and a major contributor to gross domestic product and exports. However, increases in agricultural production have not, in general, kept pace with population growth trends. Concurrently there have been increased pressures on the domestic resources and growing demands for basic food imports. These trends as well as other problems have depleted foreign exchange reserves. Indebtedness and debt service burdens have increased rendering domestic development capacity more problematical. Increases in agricultural productivity are promptly needed to improve both the financial situation and/or well-being of individual farmers and the aggregate well-being of LDC population.

The major thrusts of this project are research, information generation and practical control methods for decreasing nematode damage and increasing crop yields. Direct and quantifiable benefits cannot be established ahead of time. However, based on the successes of the earlier Pest Management Root-Knot Nematode Project (931-0614) which generated much in terms of basic research, we are now in the position to draw some useful inferences about project pay-off potential. Assuming that the project purpose is achieved and outputs attained, significant gains should be obtained in terms of reduced nematode damage on agriculture production and improved economic welfare.

C. Economic Costs of Nematode Problems

Estimates of selected crop losses due to Meloidogyne alone in three developing nations are based on country production statistics and information collected during the previous project from 75 scientists in 36 countries in the tropics. The three country examples, Bangladesh, Ecuador, and Senegal, also represent potential cooperator countries in that scientists in each have expressed interest in collaborating with the project.

Nematodes are economically important for three primary reasons: (1) production losses; (2) production costs incurred due to control efforts; and (3) macroeconomic and social costs associated with balance of payments and enviromental degradation problems. The relative importance of each factor depends upon the crop variety, nematode species, climate, soil type and condition, farming system, etc.

Nematode damage is often undiscernable due to its underground nature and therefore goes untreated by many farmers. Weeds as pests are easily recognized and farmers typically take actions to control them. The nature of the damage from nematodes also probably results in higher losses on limited-resource farms due to the fact that fewer inputs are directed to pest management than is the case with cash-crop farms.

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Data from 36 nations spanning Latin America and the Caribbean, Africa and Southeast Asia suggested that these countries in aggregate have estimated production losses due to Meloidogyne nematodes alone, of 28% of the potential bean production, 24% of the potential potato production, 22% of the potential yam production, 19% of the potential coffee production, 25% of the potential rice production and 29% of the potential tomato production. For Bangladesh, using 1981 sweet-potato-production statistics and the estimated average loss figures due to Meloidogyne, an estimated 47,700 metric tons of sweet potatoes were lost. As additional examples, an estimated 33,150 metric tons of pulse crops production were lost and 3,750 metric tons of peanuts. All of the above are nutritionally important as well as economically important. For example, in 1981, Bangladesh imported $440,000 worth of pulses and $1,100,000 worth of potatoes.

For Senegal, estimated crop losses due to Meloidogyne conservatively translate into 135,000 metric tons of peanuts which along with peanut oil are major export products. An estimated 7,700 metric tons of maize were lost while maize imports totaled $978,000. As a final example for Senegal, pulse crop losses in 1981 were approximately 5,720 metric tons in a year when $393,000 of pulses were imported.

For Ecuador, Meloidogyne attributable losses are estimted at 16,350 metric tons of potatoes, 13,260 metric tons of coffee, 13,870 metric tons of pulses and 239,000 metric tons of bananas. Bananas are the third largest crop export from Ecuador behind coffee and cocoa. Banana and coffee exports in 1978 totaled $453,009,000 while imports of pulse crops totaled $2,070,000. A very small percentage decrease in coffee or banana losses due to Meloidogyne would easily offset imports of pulses and several other crops.

D. Expected Benefits of the Project

Reduction of economic losses starts with adequate information on nematodes and crop relationships and with specific management practices that are practical and effective for dealing with nematodes. Such information is best generated by research institutions and through cooperative on-farm trials. This project builds on the earlier Pest Management Root-Knot Nematode Project and plans to establish these capabilities in from 4 to 6 cooperating institutions (along with the envisioned dissemination of information via publications and workshops.

The direct beneficiaries will be the institutions and individuals whose capabilities are enhanced. Once knowledge and practical control methods are transferred to them, farmers will also benefit from increased

production and/or net revenues. When a sufficient mass numbers of farmers have adopted these management techniques, through extension efforts and word-of-mouth, resulting increased agriculture production will generate broader social benefits.

The ground work has been accomplished by the previous nematode research project. It is now time to move into field testing in cooperation with farmers. Some basic technologies have been developed, while others should be readily transferable from temperate-zone agriculture.

The existing international network of nematologists (developed during the previous project) will be expanded and their activities will be better coordinated. Collaboration and coordination via workshops and the recipient university will lead to complementary research activities enabling consideration of other nematode species and more field trials under a variety of settings. A more efficient transfer of knowledge and experience among the scientists and extension personnel should also result from expansion of the network of nematologists and the establishment of an international liaison organization. Actions of the grantee university and the liaison organization should lead to more efficient publishing and dissemination of information on nematodes and methods of controlling them as a higher quantity and quality of information results from implementation.

The case for the project may be stated best in terms of scale economies; that is, once the information and methods of control are developed and the network is expanded, the transference of information to and from additional areas may be performed at very low additional costs. By building upon and expanding the existing international network of individuals, data bases and information systems will realize economies of scale by serving the same individuals plus additional ones representing the sum of national audiences for a fraction of the cost required to establish separate systems. Training provided or supported through the project will directly benefit the trained individuals by increasing their career opportunities.

Secondary benefits will accrue to LDC farmers and their societies as a whole when successful transfer of nematode control technology occurs. Some transfer will occur during the project period, but the most beneficial impacts of the project are not expected to occur within the project period. Instead, the project will build the institutional capacity, knowledge, skills and technologies that are necessary prerequisites for improved agriculture-sector performance.

E. Expected Returns to Project Investments

If we assume that the nematology research and training outputs generated by this project will be transferred to farmers through extension programs, then we can expect to observe quantifiable increases in farmer net returns. This assumption is considered to be valid since project activities are focused on concerns of regional importance and are designed to incorporate on-farm trials which have a good record for spreading effects once appropriate technologies have been identified.

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SOCIAL ANALYSIS

A. Introduction

The objectives of the Crop Nematode Research and Control Project are fourfold: (1) to increase the body of scientific knowledge about nematodes; (2) to improve the ability of LDC nematologists to conduct research; (3) to conduct field trials to evaluate crop nematode management systems; and (4) to initiate programs for training farmers in nematode control methods. To accomplish these objectives, the project proposes three inter-related activities: research, training and technology transfer. These aspects are outlined in detail in the technical analysis; in this section, factors affecting appropriateness of research agenda, diffusion, replicability and beneficiary participation are examined and recommendations made to assure maximum participation.

B. Appropriateness

Research, to be conducted in collaboration with the implementing American university, LDC institutions, and six of the international agricultural research centers (IARCs) will concentrate on screening for resistant cultivars, identification of nematode problems, evaluation of control methods, assessments of crop losses as part of the field trials, and implementation and evaluation of management strategies on farmer plots.

Pest control technology is not scale neutral; research funded under this project will focus on devising low cost pest management schemes for food crops which should be well within the financial reach of small farmers and which meet other socio-

economic criteria. Pest control methods will be tested on farmers fields, ensuring the involvement of the end users (farmers) in the evaluation of technologies.

To assure socio-economic appropriateness and hence adoption of the proposed technologies, it is strongly encouraged that IARC and national program collaborators work closely with farming systems or cropping systems research programs in their institutes in determining acceptability of alternative crops in rotations, labor requirements for such crops, consumer taste preferences, etc. By working with existing FSR programs, the collaborators would also ensure that a representative cross-section of the farmer population is included in on-farm trials (e.g. female headed households, larger and smaller land holders).

C. Diffusion

The grantee university will serve as a resource center providing information to cooperators in developing countries. The university is responsible for encouraging wide dissemination of research findings to IARC and LDC collaborators.

The project attempts to promote the transfer of technology in several ways: (1) to professional researchers via (a) workshops (both in-country and regional); (b) short courses offered at the grantee university, (c) international network activities (including technical publications) sponsored by the project; and (2) ultimately to farmers through leaflets, pamphlets and other publications prepared by project staff and distributed broadly to collaborators and other network participants in the hope that they will then be adapted to their

extension services.

D. Replicability

A very small number of species of nematodes account for a large percentage of nematode problems around the world. Although the cause of the problem is similar, the management techniques needed to solve the problem differs widely as a function of crops involved and resources at the disposal of the farmer. Hence there is a pressing need to adapt pest control management strategies to the LDC realities. The US university grantee is meant to develop an approach to problem-solving that is replicable throughout the world. Although the management strategy that is technically sound and socio-economically feasible differs from one area to the same, the approach is the same and hence highly replicable.

E. Beneficiaries

There are several levels of people who will benefit from project activities:

--LDC researchers who will participate in regional and/or in-country workshops, receive individual training and will expand their professional contacts through international networking activities;

--international agricultural research centers whose abilities to accomplish their mandates will be strengthened by project-sponsored workshops, training and networking;

--individual farmers selected for field trials and demonstrations who will benefit from individual extension agent attention.

Environmental Analysis

I. Project Description

Losses in agricultural production due to pest damage is a serious problem in developing countries. Crop nematodes are a group of pests that cause significant losses, but have received relatively little attention in these countries. Methods for reducing crop losses from nematodes are available and utilized in developed countries, but have not been developed for small farming systems in the tropics. Additional research and evaluation adapted to cropping systems in developing countries can produce information that would result in increased crop production.

This project will coordinate an effort to develop and extend an international capability in crop protection aimed at reducing crop nematode damage. The program will be based at a U.S. university with unique expertise in crop nematode research which will work with national and international research centers and LDC nematologists in conducting research and field demonstrations. Because of their global importance and to follow-up on the results of USAID funded research at North Carolina State University, the development of cropping systems and control methods and the selection of resistant cultivars to reduce root-knot nematode damage will be emphasized. However, nematodes of other genera will also be considered. The majority of the field evaluations will be carried out by cooperating scientists with assistance and supervision by the university staff. While some of the research will involve the use of nematocides, a totally integrated approach will be used including the use of resistant varieties, crop rotation and other physical and cultural control methods. In those cases where chemicals are used the research will be closely monitored and oriented toward determining their most effective use while minimizing any potential environmental damage. The project will also place heavy emphasis on screening crop germ plasm against important species and races of root-knot nematodes. In addition, training from the professional to the applicator level and technical assistance will be important components of the project.

The proposed S&T/AGR contributions to the project will be $1.0 million. In addition, it is anticipated that additional funds from A.I.D. bureaus and missions will be added. Project resources will be used primarily for personnel, travel and per diem, equipment and supplies. Small quantities of chemical nematocides will be procured, but only for use under controlled research conditions.

II. Discussion of Impacts

In that the project principally involves technical assistance, training, controlled research, document and information transfers, and other activities that generally have little or no direct effect on the physcial and natural environment, a categorical exclusion is justified in accordance with Environmental Procedures 22, CFR, Section 216.2(c)(2)(i), (ii), (iii), (v) and (xiv). With regard to pesticide use and procurement, procedures outlined in Section 216.3(b) are excluded as justified by Section 216.3(b) (2) (iii). Both mission and A.I.D. project monitoring personnel will ensure that the procedures outlined in Section 216.3(2)(iii) will be followed.

III. Recommendation

From the above discussion, it is determined that the project will not have a significant direct effect on the environment. A negative determination is recommended.

IV. Impact Identification and Evaluation Form

Impact Areas and Sub-Areas	Impact Identification Evaluation[1/]
A. LAND USE	
1. Changing the Character of the land through:	
a. Increasing the population	N
b. Extracting natural resources	N
c. Land Clearing	N
d. Changing soil character	L+
2. Altering Natural Defenses	M+
3. Foreclosing important uses	N
4. Jeopardizing man or his works	M+
5. Other factors: Reducing pesticide pollution and contamination	M+

[1/] The following symbols were used:

N = No environmental impact
L = Little environmental impact
M = Moderate environmental impact
H = High environmental impact
U = Unknown environmental impact
+ = Beneficial impact
- = Negative impact

B. WATER QUALITY

1. Physical state of water	N
2. Chemical and biological states	M+
3. Ecological balance	N
4. Other factors	N

C. ATMOSPHERIC

1. Air additives	N
2. Air pollution	N
3. Noise pollution	N
4. Other factors	N

D. NATURAL RESOURCES

1. Diversion, altered use of water	N
2. Irreversible, inefficient commitments	N
3. Other factors	N

E. CULTURAL

1. Altering physical symbols	N
2. Dilution of cultural traditions	N
3. Other factors	N

F. SOCIOECONOMIC

1. Changes in economic/employment patterns	M+
2. Changes in population	N
3. Changes in cultural patterns	N
4. Other factors	M

G. HEALTH

1. Changing a natural environment	N
2. Eliminating an ecosystem element	N
3. Other factors	
Reduce pesticide poisoning	M+

H. GENERAL

1. International impacts (cooperation in pest management)	M+
2. Controversial impacts	N
3. Larger program impacts	N
4. Other factors	N

I. OTHER POSSIBLE IMPACTS (Not listed above)

1. Introduction of new plant species	N
2. Agricultural chemicals	M+
3. Other factors	N

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