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FINAL REPORT

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Project Title:

Research on Integrated Crop Protection Systems with Emphasis on the Root-knot Nematodes (Meloidogyne spp.) Affecting Economic Food Crops in Developing Nations

Contract No. AID/ta-c-1234

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Major Accomplishments

A. Organization of network and communication

The International *Meloidogyne* Project is organized into 8 major geographical regions as follows: Region I, Mexico, Central America and the Caribbean, 10 countries (15 cooperators); Region II, South America, 8 countries (15 cooperators); Region III, Brazil, 1 country (9 cooperators); Region IV, West Africa, 4 countries (17 cooperators); Region V, East and South Africa, 7 countries (9 cooperators); Region IV, Southeast Asia, 13 countries (25 cooperators); Region VII, Mid-East, 17 countries (23 cooperators); and Region VIII, India (this region has not been activated yet).

In addition to the 61 developing countries (103 cooperators), the following additional countries, including the United States, have provided *Meloidogyne* population samples for IMP ecological surveys: Australia, Belize, Bulgaria, Canada, China, El Salvador, Guatamela, Liberia, the Netherlands, Senegal, West Germany, Western Samoa, and Zaire. These countries receive no funds from the project, but can receive the IMP publications and participate in the overall objectives of the project.

There is frequent communication between the principal investigator and all cooperators. A directory of all personnel associated with the project is being prepared and will be made available to cooperators in all regions. This publication will facilitate and encourage correspondence between personnel within a region and between regions.

B. Characterization of Meloidogyne populations from the various geographical regions including the U.S., Canada, and Europe

1. Frequency of species encountered and their relative importance

Our team of scientists have now received more than 1500 living populations of Meloidogyne species from cooperators overseas and in the United States. About 65% have been identified to species and races. The frequency of species identified thus far is shown in Table 1.

Table 1. Frequency of Meloidogyne spp. identified from 1016 populations received from cooperators

Meloidogyne spp.	Number studied	Percent of total
M. incognita	522	51.4
M. javanica	310	30.5
M. hapla	86	8.4
M. arenaria	78	7.7
M. exigua	7	0.7
Others[a/]	13	1.3

[a/] M. megatyla, M. microtyla, M. naasi, M. graminicola, M. oryzae, M. chitwoodi, M. carolinensis, M. platani, M. nataliei, M. ardenensis, M. enterolobii.

The finding that about 98% of the root-knot nematode populations identified from agricultural soils comprise only four species is encouraging since it simplifies procedures for plant breeding and indicates that there is a worldwide market for seed of resistant cultivars. Crop plants with multiple resistance to M. incognita and M. javanica would provide resistance to 82% of the root-knot nematode populations encountered in the tropical and subtropical regions of the world. The low percentages shown for the cool climate species, M. hapla and M. naasi, are undoubtedly influenced by the fact

that most collections were made from warm climates. Furthermore, a very large percentage of collections from temperate and tropical regions came from cultivated fields that apparently are inhabited primarily by M. incognita, M. javanica, M. hapla, and M. arenaria, all of which have numerous crop plants as hosts. M. exigua has been collected only from coffee in Central and South America.

The approximately 46 remaining species appear to be highly host-specific, and apart from the original description, little additional information is available concerning their biology or distribution. It is possible, but not likely, that some of these species could become economically important in the future.

2. Occurrence of host races and their significance

The most important species on a world basis is unquestionably M. incognita. Scientists associated with the International Meloidogyne Project have long recognized that there is physiological variation within the M. incognita group. For example, some populations attack cotton or the resistant tobacco NC 95, while others do not. The differential host tests of about 300 populations of this species revealed a pattern of response to cotton and tobacco indicating at least four host races (Table 2). These appear to be biologically distinct races, since the gall and egg-mass ratings on the differential hosts indicated either susceptibility or complete resistance, intermediate reactions were rare. The consistency of host response for the four races; their widespread occurrence, especially races 1, 2 and 3; and the number of populations involved indicate that these are stable taxons. The four races are as yet morphologically indistinguishable and have no apparent cytological differences.

All have 41-46 chromosomes, the approximate number determined for this species by Dr. Triantaphyllou.

Table 2. Host races of *Meloidogyne incognita*

Race Designation	Differential Hosts[a] Cotton	Tobacco	Percent of 334 populations studied
1	-	-	70.3
2	-	+	12.3
3	+	-	14.9
4	+	+	2.5

[a] Cotton, Deltapine 16; Tobacco, NC 95.

There are two host races of *M. arenaria*. One severely infects and reproduces on peanut, causing serious crop losses in Virginia, North Carolina, Georgia, Florida, Alabama and Texas. It attacks the fibrous roots, and also causes galls and other malformations on the pegs and pods, greatly reducing quality. In our collections, however, most populations of *M. arenaria* fail to infect and reproduce on peanut. No morphological or cytological differences between the two populations have been observed. For the present, we have designated them races 1 and 2, with race 1 being pathogenic on peanut.

We have not found distinct host races of *M. javanica* or *M. hapla*. A few populations of *M. javanica* parasitize California Wonder pepper, but most do not. Other species have not been studied sufficiently to determine the existence of races, although some variability has been reported. Differential host responses to the various *Meloidogyne* species and races are summarized in Table 3.

Table 3. Summary of differential host responses to the various Meloidogyne species and races

Species	Number Populations Studied	Number Countries	Number Populations Pathogenic to each differential host					
			Cot.	Tob.	Pep.	W'melon	P'nut	Tom
M. incognita								
Race 1	370	54	1	0	358	367	0	370
Race 2	64	27	0	61	52	63	0	64
Race 3	79	21	77	0	77	79	0	79
Race 4	10	6	10	10	10	10	0	10
M. javanica	312	57	0	308	31	298	5	312
M. hapla	86	22	0	72	75	1	82	86
M. arenaria								
Race 1	14	5	0	7	11	13	14	14
Race 2	65	23	1	64	25	63	0	65

The question of races will need to be considered in any control program, including crop rotation and use of resistant cultivars. The definite evidence developed by the work of the Project of the existence of "races" within what are now regarded as species of Meloidogyne opens an entirely new field of research. Past reports of susceptibility and resistance can no longer be regarded as dependable, and any future research on this subject will be incomplete if it does not specify the races involved. The question of relationship of crop plant resistance to different races of any given species is entirely open. Much of the future work of the Project will be on this subject. In addition, importance of host races has been extensively publicized and will influence the research and thinking of numerous nematologists.

3. Morphology

Although members of the genus Meloidogyne have been studied extensively over the years with respect to their morphology, most

of them are still insufficiently defined taxonomically, based on present-day standards of species description. There are now approximately 52 different species of root-knot nematodes that differ considerably in their host preferences. We, therefore, need to identify precisely the species or races of these nematodes in order to use the appropriate schemes for their control. It is very difficult, however, to identify the various root-knot nematode species by their morphology, because they are so similar, and because their morphological characteristics are difficult to see in the light microscope. A number of morphological and morphometric characters in females, males and second-stage juveniles have been used by various investigators to distinguish the Meloidogyne species with the light microscope. The one character most frequently used for identification isthe perineal pattern of the female. The patterns of individuals and populations within species vary but basic species characteristics are quite stable. These characteristics do not change significantly over an extended period of culturing. Many of the other characters of the various life stages proved to be too variable to be readily usable in identification. Therefore, we have been searching for more distinctive morphological characters that might be useful in distinguishing between species and, if possible, races of root-knot nematodes. In addition to the light microscope (LM), we have been using the scanning electron microscope (SEM) in these morphological studies, because we can obtain a higher magnification and a 3-dimensional image of external morphological structures.

Our detailed comparative morphological studies by light and scanning electron microscopy demonstrated clearly the existence of

morphological differences between the four more economically important species, Meloidogyne incognita, M. javanica, M. hapla and M. arenaria. Two less important species, M. megatyla and M. microtyla, have also been studied. The external morphology of second-stage juveniles, males and females was examined, and differences between species were found in all three life stages. In addition, a technique was developed that allowed the removal of the female stylet for examination with the SEM. Stylets from one population each of the four economically important species were compared, and differences were found between species. The same populations that were used in the SEM comparisons were examined by light microscopy. Morphological differences in the male head and the female stylet that were demonstrated with the SEM were also apparent in the LM. Results of these studies should make species identification practical by light microscopy alone.

A major problem in the identification of Meloidogyne is the variability existing between populations of the same species. Different populations may exhibit different host reaction, have different chromosome numbers, and even different modes of reproduction. Meloidogyne hapla and M. incognita, e.g. have been shown to be composed of two cytological races (A and B) each, based on chromosome number, and, in the case of M. hapla, also mode of reproduction. We compared six populations of M. hapla morphologically with the SEM including three populations of M. hapla race A with 15, 16, 17 chromosomes, and two populations of race B with 45 chromosomes and one with 48 chromosomes. Observations on second-stage juveniles, males, female heads and female stylets showed that the two races were morphologically

different in all the important characteristics of the life stages, except in the female stylet. Within race A of M. hapla, each of the chromosomal forms differed, but all three populations of M. hapla race B were similar to each other.

These SEM and LM studies have given us new insights into the external and internal morphology of the root-knot nematodes and have demonstrated the value of the SEM as a tool in the taxonomy of this difficult group.

4. Cytogenetic studies

Approximately 300 of the populations received have been examined cytogenetically (Table 4). These studies have revealed that several chromosomal forms of different degrees of polyploidy within Meloidogyne incognita, M. hapla and M. arenaria, while all populations of M. javanica examined belong to a single polyploid form with a somatic chromosome number of 42 to 48. These findings show that cytological information, particularly chromosome numbers, as well as chromosome morphology and behavior, can assist in identification of most common species. A feature of great value for species identification is the peculiar behavior of the prophase chromosomes during maturation of the oocytes of M. incognita. It involves a characteristic clumping of the prometaphase chromosomes which prolongs considerably the duration of this stage. This feature easily differentiates M. incognita from all other species of Meloidogyne studied thus far.

Table 4. Major chromosomal forms and mode of reproduction detected in different populations of *Meloidogyne incognita*, *M. javanica*, *M. hapla* and *M. arenaria*

Species	Number of populations studied	Chromosome number	Mode of Reproduction
M. incognita	244	2N = 41-46	Mitotic parthenogenesis
	6	2N = 32-36	" "
M. javanica	125	2N = 43-48	" "
M. hapla	45	N = 14-17	Facultative
	1	N = 34	Meiotic parthenogenesis
	5	2N = 30-32	Mitotic parthenogenesis
	10	3N = 43-48	" "
M. arenaria	6	2N = 36	" "
	61	2N = 51-56	" "

Electron microscopic (EM) comparison of several forms of root-knot nematodes has revealed that synaptonemal complexes are present in pachytene nuclei of amphimictic and meiotically parthenogenetic forms, but are absent on mitotically parthenogenetic forms. This observation demonstrated that no chiasmata and, therefore, no gene recombinations take place in mitotic species. Many other ultra-structural aspects of gametogenesis of these nematodes have been elucidated, such as the occurrence of recombination nodules, cylindrical granular complexes, etc. Specialized regions along the synaptonemal complexes (decondensed chromatin regions) constitute 5% of the length of the karyotype and may represent the location of the sex-determining chromatin. The karyotype of meiotic *M. hapla* has been analyzed by three dimensional reconstruction of synaptonemal complexes from EM serial sections.

The evolutionary trend of the genus Meloidogyne is believed to be in the direction from amphimixis to parthenogenesis. In the faculative meiotic parthenogenetic Race A studied here, normal spermatoza are produced although males are not essential for the preservation of this species. In the presence of males, cross-fertilization with females does occur, resulting in genetic variability. This ability of the M. hapla female to reproduce by either of two opposing systems, depending on the presence or absence of males, implies a developmental function not usually attributed to sperm. In fact, in Race A, the maturation division of the oocyte is delayed for a period of time if there are no sperm present. In the event of sperm penetration, the divisions proceed rapidly. The sperm in the mitotic Race B plays no role in the reproductive mechanism of the female. Yet, the ultrastructural morphology of the sperm of the two different reproductive races is identical.

The cytogenetic and EM studies have demonstrated that the most successful species or races of root-knot nematodes in agricultural soils are those which combine mitotic type of parthenogenesis with polyploidy. Such forms, normally, would not be expected to be successful under natural conditions. Apparently, the systems and cultural practices we employ on agricultural lands around the world have helped these nematodes become major crop pests.

5. Biochemistry

A "micro" system has been developed that permits the electrophoretic analysis of very small samples of proteins. This has enhanced our ability to study the proteins and enzyme systems produced by Meloidogyne species. Several enzyme systems,

including non-specific esterases, RNases, peroxidases, and β-glycosidases, have been examined using this system. Although differences in the isozyme profiles of esterases and RNases among different Meloidogyne species are evident, considerable variation within species was also evident. Studies with peroxidases indicate that much of the peroxidase activity associated with adult females is of host origin; probably ingested by the nematode during the feeding process. This phenomenon may be responsible, in part, for the variation in the isozyme profiles of esterases and RNases. Other studies provide evidence for the presence of β-galactosidase and β-glucosidase activities within the nematode, with β-galactosidase activity being predominant. A portion of this glycosidase activity is undoubtedly of host origin, but the evidence also indicates the presence of enzyme activity of nematode origin. These studies have increased our knowledge of the capacity of Meloidogyne species to produce enzymes that may be involved in pathogenesis. Additionally, these studies have indicated new areas of investigation which will lead to a better understanding of the complex host-pathogen associations that exist with root-knot nematodes.

C. Ecological studies

An important objective of the International Meloidogyne Project has been to gain some insight concerning those ecological factors which influence survival and pathogenicity of root-knot nematodes. The established network of cooperators has recorded pertinent information with reference to host location, elevation, severity of damage, other organisms associated with the disease, cropping history of fields for the 24 months preceding the collection of

the sample, agronomic practices used, weather data and other information for each population sample sent to project headquarters. In addition, 300 grams of soil collected from the rhizosphere of the infected plant have been forwarded to project headquarters for physical and chemical analysis. All of this information has been analyzed in order to determine the existence of relationships between the geographic distribution of root-knot nematodes and various ecological and climatic variables.

Preliminary results of the ecological studies have been published recently. Some important trends have become apparent and are summarized below.

The average temperature of the coldest month of the year is apparently the principal factor limiting the occurrence of M. incognita, M. javanica, and probably M. arenaria. These species have not been received from areas in which the average temperature for the coldest month is below 3°C. M. hapla, on the other hand, is much more cold tolerant and has been known to survive in climates which average monthly temperatures of as low as -15°C. Average annual temperatures of about 24-27°C may limit the occurrence of M. hapla in warm parts of the world.

The majority of Meloidogyne population samples have been received from areas with 1000 to 1500 mm of annual precipitation. Though most populations have come from areas with well-distributed rainfall, significant numbers of some species have been found to occur in areas with as many as 4 or 5 dry months (< 10mm rain/month) per year. About 25% of M. javanica and 8% of M. incognita populations have been received from such areas.

As far as soil characteristics are concerned, very few Meloidogyne populations have been collected from soils with more than 40% clay or 50% silt. This distribution pattern is thought to occur because these small particles reduce soil pore space and, presumably, limit nematode dispersal through the soil. A positive correlation between high soil pH and the occurrence of M. incognita and M. javanica has been found, but this relationship is believed to reflect the prevalence of these two species in dry climates since areas with low rainfall tend to have a relatively high soil pH.

D. Breeding for resistance

During the first seven years of the project, several useful and productive associations have been initiated with the international centers. Of these institutes, only Centro Internacional de la Papa (CIP) and International Institute of Tropical Agriculture (IITA) have nematologists on their staff; in both cases, these individuals are playing major roles in the project. Dr. Fields Caveness, nematologist with IITA, is serving as regional investigator for Region IV, West Africa; Dr. Parviz Jatala of CIP is coordinating the work of the several cooperators in Peru. The project has been instrumental in providing advisory services to two other institutes, Centro Internacional de Agricultura Tropical (CIAT) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Dr. J. L. Starr, Research Associate with the IMP at Raleigh, served as a consultant nematologist on a short-term basis (8 months) with ICRISAT in India examining nematode problems of sorghum, pearl millet, pigeon pea, chickpea, and groundnut. Dr. R. M. Riedel, Associate Professor

at Ohio State University, spent four months with CIAT in Colombia examining nematode problems of cassava, field beans, forage crops, maize and rice.

More recently, the IMP has cooperated with International Agriculture Research Centers in screening germ plasm of important crops for resistance to Meloidogyne species. Evaluations have already been performed on potato germplasm (Solanum spp.) from the International Potato Center (CIP) and on tomato and Chinese cabbage (Brassica pekinensis (Lour.) Rupr.) cultivars from the Asian Vegetable Research and Development Center (AVRDC). Current work includes the screening of 27 lines of pigeon pea (Cajanus cajan (L.) Millsp.) and 50 lines of chickpea (Cicer arietinum L.) for the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India; bean (Phaseolus spp.) and the tropical forage legume Desmodium ovalifolium (Prain) Wall. for the International Center for Tropical Agriculture (CIAT), Colombia; and wheat (Triticum aestivum L.), barley (Hordeum vulgare L.), and corn (Zea mays L.) cultivars for the International Center for Maize and Wheat Improvement (CIMMYT), Mexico. These evaluations are an important step in a direct approach to development and utilization of resistant germ plasm for incorporation into commerical crop cultivars.

E. Cropping systems research

Cropping systems can be defined as the yearly sequence and spatial arrangement of crops, or the alternation of crops and fallow, on a given farm in addition to the management of resources based on available technology. Regional conferences conducted by the IMP sponsor guest lecturers knowledgeable in this area of research, and Project cooperators then have an opportunity to

participate in group discussions led by the expert. In this way, cooperators are encouraged to conduct research on management of root-knot nematodes through use of various cropping systems. Systems such as bush fallow, in-situ mulch, alley cropping, and inter cropping which are adapted to tropical conditions are currently being studied in order that they can best be adapted for management of root-knot nematodes. Appropriate crop rotations, cultural practices, and sanitation are components of such systems. Current plans to boost this aspect of research include the hiring of a full-time professional to give guidance and assistance to overseas cooperators interested in conducting cropping system studies. Because of the nature of this research, the actual studies must be conducted in the general area where they are likely to be employed.

F. Biological control

Research on the biological control of root-knot nematodes is being conducted in Peru and at the Project Center at North Carolina State University. The control agent being investigated is the fungus Paecilomyces lilacinus which occurs naturally in many soils. However, an isolate particularly pathogenic to root-knot nematodes has been isolated from soils in the Andes mountains by Dr. Parviz Jatala of the International Potato Center.

Research on the fungus has proven it to be harmless to other animals and plants, easily cultured under laboratory conditions, and able to survive at least a year when introduced into certain fields. Additional tests on the fungus' effectiveness as a bio-control agent are being conducted under a wide range of conditions. Similar research is being encouraged in many countries cooperating with the IMP.

G. Technology transfer

Through the process of technology transfer, current research has already begun to focus on development of management strategies for root-knot nematodes. Results of taxonomic, ecological, and control research completed at IMP headquarters are being made available to Project cooperators in developing countries so they can develop management strategies suited to their particular agricultural situations. The publication of books, journal articles, slide sets, posters, and conference proceedings are all part of this effort. Regional conferences and field and laboratory training sessions keep research personnel abreast of the work being conducted by other cooperators throughout the Project.

1. Enhancement of Cooperators' Problem-Solving Capabilities

The experience and expertise of the nearly 100 cooperators associated with the International Meloidogyne Project varies tremendously. Some cooperators have Ph.D. degrees in nematology while others have Masters degrees with little formal training in nematology. Nearly all of the cooperators are located at institutions in areas with limited access to current literature, scientific equipment, and other working nematologists. Through the resources of the IMP, their access to these items has been increased. Important reference texts, subscriptions to professional journals, and copies of all the various publications of the project have been provided free to the cooperators. Access to the current literature is necessary if cooperators are to stay abreast of new developments in the science of plant nematology and are to improve their own capabilities.

Cooperators have been provided with small items of scientific equipment which are difficult to obtain in their respective countries, but which are necessary for the efficient operation of their individual projects. Cooperators have had opportunities to interact directly with other cooperators within their respective regions and with personnel from the project center through attendance at Regional Conferences and personal visits. This allows the cooperators to obtain a better perspective of the total root-knot nematode problem within their region and to benefit from the experiences of their colleagues. Collectively, these services and opportunities, which have been provided through the resources of the project, have served to enhance the problem-solving capabilities of the country cooperators. In general, the cooperators have been pleased with the project, and some have indicated ways to improve its effectiveness.

2. Feedback of information to cooperators pertaining to nematode populations from their region

Each cooperator has forwarded to project headquarters, live cultures of from 5 to 20 populations of Meloidogyne collected from diverse hosts and habitats within their country. In addition, soil samples (approximately 300 gm) were collected from the rhizosphere of the host from which the nematode was collected, and forwarded to project headquarters. Scientists at the research center have identified these populations to species and races.

Identifications have been based on morphological, cytological, physiological (host response on 6 differentials) and, in a few cases, biochemical characteristics. The soil samples for each nematode collection has been analyzed both physically and chemically.

A data feedback sheet has been prepared for each sample, giving information on species identification, host response and soil analysis. These completed data sheets are returned to the cooperator to be compared with his own identification and host response and to be used in publishing results locally.

3. Conferences and training

In addition to the research and planning conferences (see Section 1) held periodically in each of the active project regions, training conferences are also an integral part of technology transfer within the International Meloidogyne Project. Training has involved individual cooperators on a one-on-one basis or small groups of cooperators in field and laboratory training sessions. Currently, an intensive, 3-week training conference for 60 or more cooperators is being planned for April of 1983. Professionals and experts in many pertinent areas of nematode biology and management will participate as lecturers and discussion moderators. This conference will be the project's most comprehensive training effort in its seven-year history. The proceedings from this gathering will be published as a two-volume textbook on nematode biology, methodology, and control, particularly as these subjects relate to root-knot nematodes.

4. Publications that have resulted from the International Meloidogyne Project

General

Anonymous. 1976. Atlas of Perineal Patterns of Certain Root-Knot Nematodes, Meloidogyne spp. Raleigh, NC. 14 pp.

Anonymous. 1976. Research on Integrated Crop Protection Systems with Emphasis on the Root-Knot Nematodes (Meloidogyne spp.) Affecting Economic Food Crops in Developing Nations. (Brochure describing International Meloidogyne Project, Raleigh, NC.) 14 pp.

Carter, C. C. and J. N. Sasser. 1982. Research on integrated crop protection systems with emphasis on the root-knot nematodes (Meloidogyne spp.) affecting economic food crops in developing nations. 25 pp.

Eisenback, J. D., H. Hirschmann, J. N. Sasser, and A. C. Triantaphyllou. 1981. A guide to the four most common species of root-knot nematodes (Meloidogyne species) with a pictorial key. 48 pp.

Sasser, J. N. and M. F. Kirby. 1979. Crop cultivars resistant to root-knot nematodes, Meloidogyne species, with information on seed sources. 24 pp.

Sasser, J. N., C. C. Carter, and A. L. Taylor. 1982. A guide to the development of a plant nematology program. 21 pp.

Taylor, A. L. and J. N. Sasser. 1978. Experimental and agronomic use of nematicides. 20 pp.

Taylor, A. L. and J. N. Sasser. 1978. Biology, identification and control of root-knot nematodes (Meloidogyne species). 111 pp. (Soon available in Spanish).

Taylor, A. L., J. N. Sasser, and L. A. Nelson. 1983. Relationship of climate and soil characteristics to geographical distribution of Meloidogyne species in agricultural soils. 72 pp.

IMP Conference Proceedings

Proceedings of the Research Planning Conference on Root-knot Nematodes, Meloidogyne spp. January 12-16, 1976. (Raleigh, N.C.) 106 pp.

Proceedings of Asian Regional Planning Conference on Root-knot Nematode Research, Region VI, February 16-20, 1976. (Los Banos, Philippines;)

Memorias de la Conferencia de Trabajo Sobre el Proyecto Internacional Meloidogyne, Regional II, Marzo 22-26 de 1976. (Palmira, Colombia.)

Proceedings of the Regional Planning Conference of the International Meloidogyne Project, Region I, April 26-30, 1976. (Panama.)

Proceedings of the Research Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region IV, June 7-11, 1976. (Ibadan, Nigeria.)

Proceedings of the Research Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region VII, Jan. 29-Feb. 2, 1978. (Giza, Egypt.)

Proceedings of the Second Asian Regional Conference on Root-Knot Nematodes, Meloidogyne spp., Region VI, February 13-17, 1978. (Bangkok, Thailand.)

Proceedings of the Second Research Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region IV, February 20-24, 1978 (Abidjan, Ivory Coast.)

Proceedings of the Second Regional Planning Conference of the International Meloidogyne Project, Region I, September 4-8, 1978. (San Jose, Costa Rica.)

Memorias de la II[a] Conferencia de Trabajo sobre el Proyecto Internacional Meloidogyne, Regional II, Septiembre 18-22 de 1978. (Lima, Peru.)

Proceedings of the Second Research Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region VII, November 26-30, 1979. (Athens, Greece.)

Proceedings of the Third Research Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region VI, July 20-24, 1981. (Jakarta, Indonesia.)

Proceedings of the Third Research Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Regions IV and V, November 16-20, 1981. (Ibadan, Nigeria.)

Proceedings of the Third Research and Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region I, January 11-15, 1982. (Panama City, Panama.)

Proceedings of the Third Research and Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region II, March 22-26, 1982. (Lima, Peru.)

Proceedings of the Third Research and Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region VII, September 13-17, 1982. (Coimbra, Portugal.)

Proceedings of the First Research and Planning Conference on Root-Knot Nematodes, Meloidogyne spp., Region III, October 25-29, 1982. (Brasilia, Brazil.)

Reports Resulting from Special Assignments

Starr, J. L. 1979. Plant-parasitic nematodes as pathogens of ICRISAT mandate crops. Mimeo. 28 pp.

Riedel, R. M. 1978. Final Report - Nematode Survey, CIAT, Colombia. Mimeo. 45 pp.

Journal Articles or Book Chapters

Al-Hazmi, A. S. and J. N. Sasser. 1982. Biology of Meloidogyne platani Hirschmann parasitic on sycamore, Platanus occidentalis. J. Nematol. 14:154-161.

Baldwin, J. G. and J. N. Sasser. 1978. Meloidogyne megatyla, n. sp. (Heteroderidae) a root-knot nematode from loblolly pine. J. Nematol. 11:47-56.

Bost, S. C. and A. C. Triantaphyllou. 1982. Genetic Basis of the Epidemiologic Effects of Resistance to Meloidogyne incognita in the Tomato Cultivar Small Fry. J. Nematol. (in press).

Eisenback, J. D. 1982. Description of the blueberry root-knot nematode, Meloidogyne carolinensis n. sp. J. Nematol. 14:303-317.

Eisenback, J. D. 1982. Morphological comparison of head shape and stylet morphology of second-stage juveniles of Meloidogyne species. J. Nematol. 14:339-343.

Eisenback, J. D. and H. Hirschmann. 1978. Morphological comparison of second-stage juveniles of Meloidogyne hapla, M. arenaria, M. incognita, and M. javanica by scanning electron microscopy. J. Nematol. 10:286 (Abstract).

Eisenback, J. D. and H. Hirschmann. 1979. Morphological comparison of second-stage juveniles of several Meloidogyne species (root-knot nematodes) by scanning electron microscopy. Proceedings of SEM, Inc. pp. 223-229.

Eisenback, J. D. and H. Hirschmann. 1979. Morphological comparison of second-stage juveniles of six populations of Meloidogyne hapla by SEM. J. Nematol. 11:5-16.

Eisenback, J. D. and H. Hirschmann. 1980. Morphological comparison of Meloidogyne males by scanning electron microscopy. J. Nematol. 12:23-32.

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Posters (45 x 60 cm)

Perineal Patterns of the Four Most Common Species of Root-Knot Nematodes (Meloidogyne Species)

Head Shape and Stylet Morphology of Males of the Four Most Common Species of Root-Knot Nematodes (Meloidogyne Species)

Life Cycle of Root-Knot Nematode (color)

Slide-Tape Set (In process of development)

An Overview of the International Meloidogyne Project