THE INTERNATIONAL MELOIDOGYNE PROJECT: A MODEL FOR INTERNATIONAL COLLABORATIVE RESEARCH

J. N. Sasser and C. C. Carter

Principal investigator, IMP, and research Assisstant, North Carolina State University,, respectively.

Abstract

Sasser J.N. and Carter C.C The international Meloidogyne project : A model for international collaborative research. Arab Jour. of Pl. Prot. 1 : 48-50.

In summary, the International *Meloidogyne* Project has accomplished several of its objectives. These include. 1) the promotion of awareness concerning the importance of root-knot nematodes in developing nations; 2) survey of the distribution, frequency and relative importance of *Meloidogyne* species and races infesting agricultural soils; 3) the discovery and description of several new species; 4) the discovery of new and more reliable characters for identification; 5) clarification of phyletic relationships on the basis of cytogenetic and biochemical characteristics; 6) the elucidation of ecological factors affecting survival, distribution, and pathogenicity, and 7) the enhancement of research capabilities in developing nations through conferences, publications, and field and laboratory training sessions. These accomplishments, along with increased communication and cooperation among nematologists throughout the world, are bringing the ultimate goal of increased food production in developing countries closer and closer to reality.

PREFACE:

At least three requirements are prerequisite to the development of an international collaborative research project. These include the choice of a widespread, significantly important problem on which to work; the existence of qualified research staff; and the development of close ties with cooperating research personnel in other countries. The International *Meloidogyne* Project (IMP) has successfully met each of these requirements. Root-knot nematodes, the research subject, pose a considerable obstacle to optimum agricultural production in nearly all regions of the world. When the IMP was established in 1975, the organizing staff at North Carolina State University already had an extensive history of nematode research, especially root-knot nematode research, and had established contacts with foreign nematologists through conferences and trips abroad. In addition to meeting these basic prerequisites, several other factors have contributed to the success of the International *Meloidogyne* Project: 1) funding has been steady for a significant period of time; 2) root-knot nematode damage is easily identifiable even in countries where the problem has not received attention in the past; and 3) the Project was established at a time when the necessary resources, in terms of knowledge, personnel, and expertise, were available for application to the problem of root-knot nematodes. To emphasize the various qualities just described, a brief overview of the International *Meloidogyne* Project's research is presented.

AN OVERVIEW OF THE PROJECT

One of the most important pests limiting agricultural productivity is the root-knot nematode *Meloidogyne* species. Almost all of the plants that account for the majority of the world's food supply are susceptible to infection. In areas where root-knot nematodes are not controlled, average crop yield losses are likely to be in the neighborhood of 25%, with damage in individual fields ranging as high as 60%.

Because root-knot nematodes occur throughout most of the world, infect all major crop plants, and cause substantial reduction in crop yield and quality, scientists at North Carolina State University decided to initiate a worldwide investigation of the problem. In July of 1975, a grant from the United States Agency for International Development made this endeavor possible and led to the formation of the International *Meloidogyne* Project headquartered at North Carolina State University (NCSU) in Raleigh.

The rationale for Project formation was based on four major premises: 1) the recognition of root-knot nematodes as major world pathogens of food and fiber crops, 2) the necessity of an international approach ot the problem, 3) the availability of a network of trained research personnel, and 4) the relevance of this area of research to North Carolina agriculture. The departments of plant pathology, genetics, atatistics, and soil science at NCSU, as well as the N.C. Agronomic Division cooperate in Project research. Scientists and support staff from these departments work with scientists overseas through regional conferences, personal visits to their home countries and other contacts. These cooperative efforts are mutually advantageous, and the success of the Project is dependent upon the combined efforts of all involved. From this broad academic and geographic base, the Project approaches the problem of world hunger through the study of root-knot nematodes, *Meloidogyne* species.

Because root-knot nematodes limit agricultural production to some degree in all countries, the International *Meloidogyne* Project has enlisted the assistance of more than 100 nematologists associated with universities and research institutes around the world and has grouped them into 8 geographical regions. Regional conferences are conducted periodically in each of these regions for the purpose of planning research objectives and approaches. Seven major areas of research have been emphasized: the North Carolina differential host test, *Meloidogyne* morphology, reproductive characters and cytogenetics, biochemistry, ecology, management, and technology transfer.

Root-Knot Nematode Germplasm Collection

Project research would be impossible were it not for the nematode germplasm collection established and maintained at North Carolina State University. This collection is the result of extensive sampling by Project cooperators throughout the world. Root-knot nematode egg masses are collected from infected plants and sent in saline solution to the Project Center. There, they are used to inoculate seedlings of «Rut-

gers» tomato, a highly susceptible host of root-knot nematodes. The nematode population increases rapidly on this host and can be maintained indefinitely by periodic inoculation of new «Rutgers» seedlings with root-knot nematode eggs.

North Carolina Differential Host Test

Each population of nematode received is subjected to the North Carolina differential host test (2). This test involves the inoculation of six standard host plants: cotton cv. "Deltapine 61," tobacco cv. "NC 95," pepper cv. "California Wonder," waltermelon cv. "Charleston Grey," peanut cv. "Florunner," and tomato cv. "Rutgers." On the basis of host susceptibility (indicated by +) or resistance (indicated by −), pure populations of the four major species--*M. incognita*, *M. javanica*, *M. arenaria*, and *M. Hapla*--can be easily distinguished. Susceptibility and resistance are based on the average egg mass and root gall indices of three replications of the host test.

The four major species account for more than 9% of the root-knot nematodes received from agricultural soils. Therefore, most pure sample populations encountered by the Project can be reliably identified by means of the North California differential host test. Work completed so far has led to the recognition of multiple host races for *M. incognita* and *M. arenaria*.

Morphology

Identification techniques, other than the North California differential host test, are necessary to detect and verify mixed populations and/or rare species. For this reason, much taxonomic research on *Meloidogyne* species is focused on distinctive morphological characters (1). Such characters include: the perineal pattern--which is an external, fingerprint-like series of markings in the anal region of the adult female; male head shape; and stylet morphology.

Under a scanning electron microscope, minute morphological details can be thoroughly examined. However, scanning electron microscopes are expensive, and most nematologists do not have acces to one. Therefore, in practical terms, only those features also visible under a light microscope will prove useful in the routine process of nematode identification.

Reproductive and Cytological Characters

Reproductive and Cytogenetic characters are also being studied for use in root-knot nematode identification. Mode of reproduction and chromosome number show much promise as identifying characters (4). Some species reproduce only by cross-fertilization; other species reproduce by parthenogenesis, that is without fertilization (mitotic parthenogenesis). Still other species can reproduce with or without fertilization (facultative, meiotic parthenogenesis).

Races of some of the more common *Meloidogyne* species have been identifield on the basis of chromosome number and mode of reproduction. These races are called cytogenetic races and are designated by letters such as «A» or «B», instead of by numbers, in order to distinguish them from host races.

Biochemistry

Biochemical differences among species, that is, in protein and enzyme content, are also being investigated. Major bands of esterase activity have been found to be noticeably different among the four major species (1). Other distinct isozyme patterns are being studied and show much promise for use as identifying characters.

Ecology

In addition to taxonomic research, the project also conducts ecological studies. Once nematode populations are identifield at the Project Center in Raleigh, the soil samples and ecological data which accompany each sample are analyzed. This information is then used to characterize the geographical distribution of *Meloidogyne* species by host range, temperature, precipitation, soil characteristics, and other ecological characters.

Preliminary findings (3) indicate that *M. incognita*, *M. javanica*, and *M. arenaria* inhabit areas with average annual temperature of less than 15° C. In areas of low rainfall, *M. incognita* and *M. javanica* appear to be prevalent species. In general, root-knot nematode most frequently occur in soils less than 10% clay, less than 30% silt, and at least 60% sand. Basically, however, root-knot nematodes can occur anywhere host plants grow.

Management

The current emphasis in IMP research is management of root-knot nematodes. Earlier studies concerning general biology and identification of *Meloidogyne* species have proven to be valuable prerequisites for research into management practices. Research efforts are concentrating on five aspects of root-knot nematode management: host resistance, cropping systems, chemical control, biological control, and integrated crop protection systems.

Host resistance. Much of the screening and evaluation of cultivars for resistance is being done in cooperation with International Agriculture Research Centers (IARC's) and the Asian Vegetable Research and Development Center (AVRDC). Crops screened at these centers include potato, Chinese cabbage, tomato, pigeon pea, chickpea, cowpea, bean, maize, and wheat. Individual cooperators are also involved in screening for resistance. Some crops being studied include: cowpea in Nigeria; tomato in Nepal; and tomato, eggplant. bean, pepper, lettuce, cucumber, cabbage and radish in the Philippines.

Cropping systems. Cropping systems research helps pinpoint crops or other plants which prevent increases in *Meloidogyne* populations. These plants can then be incorporated into cropping sequences or crop rotation schemes. Cropping sequences for each region are analyzed to determine those which most effectively control root-knot nematodes and therebey increase yields.

Chemical control. Investigations into chemical control include tests for nematicide efficacy, and determination of application rates. In developing countries, however, nematicides often cannot be incorporated into control programs. The chemicals may be too expensive or application equipment may not be available. Even so, nematicide tests can serve a very useful purpose by demonstrating to farmers the benefits to be derived from effective nematode control.

Biological control. Research into biological control of root-knot nematodes is being conducted at the International Potato Center (CIP) in Peru, at the Project Center at North California State University, and in several other developing countries. The fungus *Paecilomyces lilacinus* occurs naturally in many soils. However, a particularly pathogenic isolate from soils in the Andes mountains has been found to control *Meloidogyne* populations; The fungus penetrates the nematode eggs, thus destroying the embryo and preventing hatch. Under experimental conditions, introduced fungal inoculum has persisted in the soil in spite of fungicide and nematicide applications. Additional tests on its performance are being conducted under a wide range of conditions.

Integrated crop protection systems. The eventual goal of root-knot nematode management studies is increased crop production, particularly food crop production, and develop-

ment of integrated crop protection systems is step in this direction. These systems will utilize the best combinations of resistant cultivars, crop rotation, nematicides, biological agents, and sanitary and cultural practices. In this way, a broader spectrum of pests can be managed simultaneously.

Technology Transfer

Through the process of technology transfer, current research has already begun to focus on development of management strategies for root-knot nematodes. Basic information on *Meloidogyne* biology, ecology, and methodology is 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, conference proceedings, journal articles, slide sets, and posters are all part of this effort. Research personnel are kept up to date by means of conferences and field and laboratory training sessions. As a result of the project's investigations, nematode research capabilities in developing countries are continually advancing.

الملخص

ان مشروع الميلويدوغاين *(Meloidogyne)* العالمي قد حقق العديد من اهدافه والتي منها (١) نشر الوعي بما يتعلق باهمية ديدان تعقد الجذور في البلدان النامية، (٢) مسح توزيع، كثافة والاهمية النسبية لانواع الميلويدوغاين وسلالتها الموجودة في التربة الزراعية، (٣) اكتشاف ووصف عدة انواع جديدة، (٤) اكتشاف صفات جديدة يمكن الاعتماد عليها في تحديد الانواع والسلالات، (٥) توضيح علاقات القربى على اساس صفات الخلايا الوراثية (cytogenetics) والبيوكيميائية، (٦) معرفة العوامل البيئية التي تؤثر على لقاء وتوزيع وامكانية احداث المرض و (٧) تنمية امكانيات البحث العلمي في البلدان النامية بواسطة المؤتمرات والمنشورات العلمية بالاضافة الى دورات تدريبية في الحقل والمختبر. هذه الانجازات بالاضافة الى زيادة التعاون بين الباحثين في حقل النيماتولوجيا في جميع انحاء العالم سيقرب من الوصول الى الهدف الاساسي وهو زيادة الانتاج الغذائي في البلدان النامية.

References

1. 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. A Cooperative Publication of The Departments of Plant Pathology and Genetics, North Carolina State University, and The United States Agency for International Development. Raleigh, N.C. 48 pp.
2. Taylor, A. L. and J. N. Sasser. 1978. Biology, identification and control of root-knot nematodes (*Meloidogyne* species). A Cooperative Publication of The Department of Plant Pathology, North Carolina State University, and The United States Agency for International Development. Raleigh, N.C. 111 pp.
3. 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. A Cooperative Publication of The Department of Plant Pathology, North Carolina State University, and The United States Agency for International Development. Raleigh, N.C. (In press).
4. Triantaphyllou, A. C. 1979. Cytogenetics of root-knot nematodes, pp. 85-109 **In** Root-knot Nematodes (*Meloidogyne* species) Systematics, Biology and Control, eds. Lamberti and Taylor. Academic Press, New York. 477 pp.