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INTERNATIONAL MELOIDOGYNE PROJECT

IMP

Contract No. AID/ta-c-1234

PROCEEDINGS OF THE RESEARCH PLANNING CONFERENCE

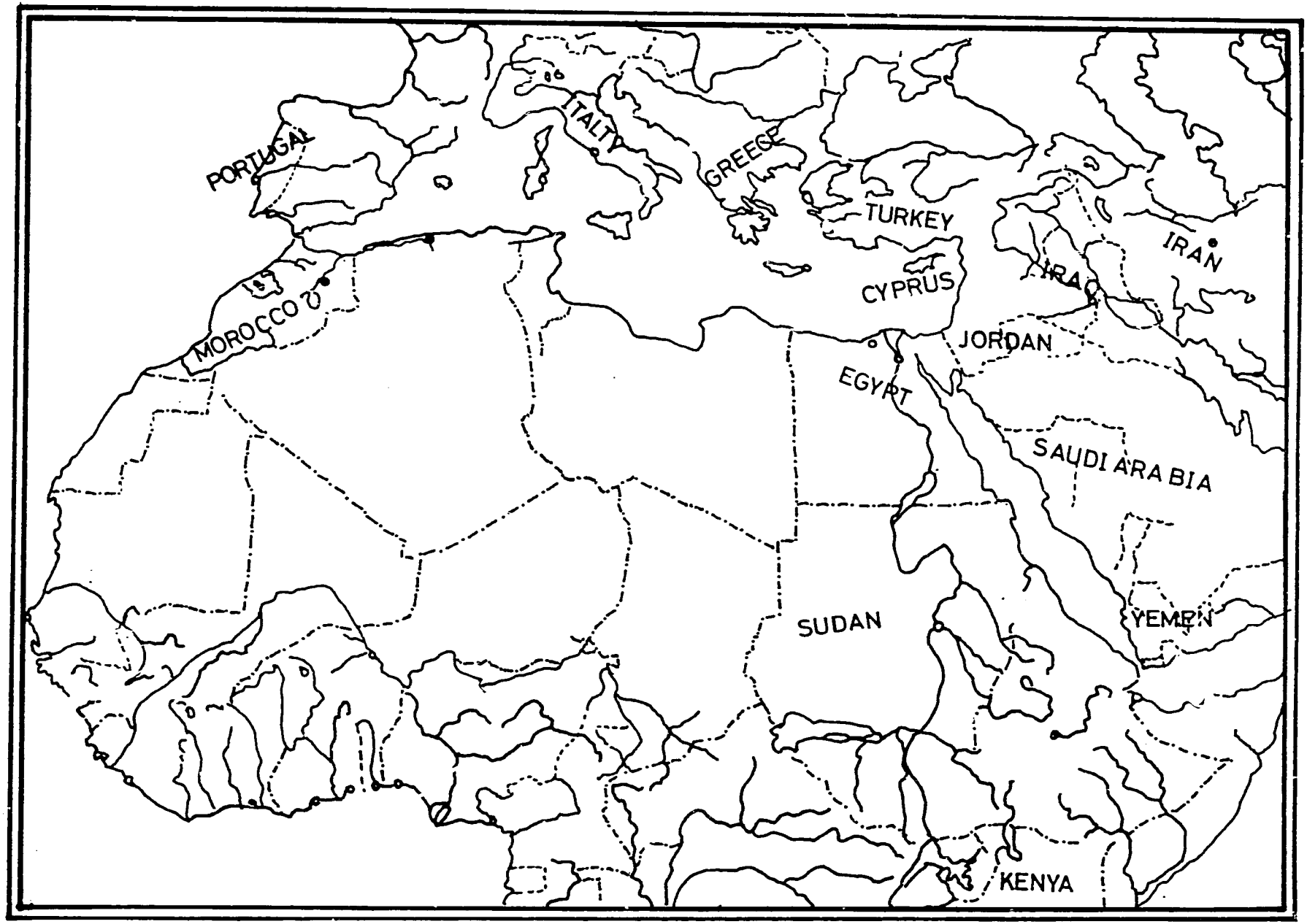
ON

ROOT-KNOT NEMATODES, *MELOIDOGYNE* SPP.

JAN. 29 - FEB. 2, 1978

NEMATOLOGY RESEARCH CENTER - FACULTY OF AGRICULTURE

CAIRO UNIVERSITY GIZA - EGYPT.



INTERNATIONAL MELOIDOGYNE PROJECT REGION VII PARTICIPATING COUNTRIES .

CONTENTS

I. Preface 1

II. Overview of the project - Pricipal goals and objectives and implementation schedule.
Dr. J. N. Sasser 3

III. Reports by cooperating scientists on the state of knowledge concerning root-knot nematodes in their countries. 10

1. Report on the state of knowledge concerning root-knot nematodes in Portugal.
Maria Susana N. de A. Santos. 10

2. The root-knot nematode, Meloidogyne, in Jordan.
W. I. Abu-Gharbieh. 16

3. The problem of the root-knot nematodes in Greece.
C. N. Koliopanos. 20

4. IMP: Technical research report - Region V.
B. W. Ngundo 24

5. Status of root-knot nematodes, Meloidogyne spp. in Iran.
C. Abivardi. 26

6. The current status of root-knot nematodes in Northern Egypt.
I. K. A. Ibrahim 36

7. Status of root-knot nematode problems and research in Turkey.
H. S. Yüksel 38

8. Report on the status of root-knot nematodes Meloidogyne sp. in Iraq.
Z. A. Stephan. 42

9. Report on root-knot nematodes in Cyprus.
J. Philis. 43

10. Root-knot nematodes in the Sudan.
A. M. Yassin. 46

11. Status of root-knot nematodes, Meloidogyne spp., in the Yemen Arabic Republic.
R. A. Sikora 50

12. The root-knot nematode in Saudi Arabia.
M. F. M. Eissa. 57

13. A note about Meloidogyne problems in Morocco.
M. Ammati. 60

14. State of knowledge concerning root-knot nematodes in Iran.
H. Mojtahedi. 66

IV. Invited lectures

1. Effect of soil environment on root-knot activity and distribution.
S. D. Van Gundy. 68

2. Root-knot nematoes in Italy.
F. Lamberti. 74

V. Guidelines for conducting differential host tests for Meloidogyne species. 78

VI. List of project research personnel and consultants 84

PREFACE

The International Meloidogyne Project (IMP) intiated by Dr. J. N. Sasser, Professor of Nematology, and his colleagues of North Carolina State University was established to cover six regions around the world in the tropical climates. These regions are Central America, South America, West Africa, East Africa and Southeast Asia. The project is an international effort to advance knowledge about an important group of plant-parasitic nematodes towards increasing yield of food crops in developing countries.

Dr. B. A. Oteifa, Professor of Nematology and Head of the Zoology and Nematology Department, Faculty of Agriculture, Cairo University, Egypt, in 1976 proposed a new extension program in the Near East Region. A regional research planning conference was held through January 29 to February 2, 1978 at the Nematology Research Centre, Cairo University, Giza, Egypt (NRCE) in cooperation with North Carolina State University, Raleigh, N.C. (NCSU). Fourteen countries from the region were represented by scientists and nematologists from universities, institutes and research centres. These countries were Cyprus, Egypt, Greece, Iran, Iraq, Italy, Jordan, Kenya, Moracco, Portugal, Saudi Arabia, Sudan, Turkey and Yemen.

The conference as headed by Dr. J. N. Sasser (NCSU), principal investigator of the IMP and Dr. D. M. Elgindi (NRCE), regional investigator, discussed the economical, ecological and control aspects of the root-knot nematodes in each of the participating countries. Dr. Sasser and Dr. Triantaphyllou reviewed the main goals of the project and research activities in North Carolina and other coordinating regional laboratories. In addition to country representatives, Dr. S. D. Van Gundy, Professor of Nematology and Head of the Nematology Department, University of California, Riverside, California, U.S.A. and Dr. F. Lamberti, Professor of Nematology, Laboratorio di Nematologia Agraria, Bari,

Scientists participating in the Research Planning Conference of the International Meloidogyne Project (IMP) held at the Nematology Research Centre, Cairo University, Giza, Egypt, Jan. 29-Feb. 2, 1978.

Italy; attended the conference and reviewed several scientific approaches to the genus Meloidogyne, and contributed to the research planning discussions. At the end of the conference, the representatives outlined the research work they can carry out in their countries with the objectives and goals of the project.

An excursion to the Nubaria Seed Company and the Egyptian Vineyards and Distilleries Company "Gianaclis", was arranged during the conference period. In Nubaria farms the participants examined some fields of broad bean and peas infested with root-knot nematodes. A fruitful discussion dealing with nematode problems and their control in seed production was conducted with Mr. H. Shabana, the Company President and with some directors. In Gianaclis Company some vineyards were examined for nematode infections. After that, Mr. A. Tawfik, the General Director invited the group to visit and to have a look on the processes of wine production in the company's factory.

Deep thanks are extended to all who participated and to every person tried and helped to make everything go easy and convenient.

Prof. Dr. D. M. ELGINDI

Regional Investigator

Conference participants at Gianaclis Company vineyards examining some grape-vines infected with plant-parasitic nematodes.

II. OVERVIEW OF THE PROJECT - PRINCIPAL GOALS AND OBJECTIVES AND IMPLEMENTATION SCHEDULE

J. N. Sasser

One of the major obstacles to the production of adequate supplies of food in developing nations is the damage caused by plant-parasitic nematodes, especially the "root-knot group", Meloidogyne spp. The most effective management practice for control of these pests, especially for developing nations, is through the use of certain cultural practices, including crop rotation, the use of available resistant crop cultivars, and development of other resistant cultivars. Crop rotation sequences capable of reducing soil populations of the root-knot nematode below the economic injury threshold can be developed. It will be necessary, however, to test the resistance and/or susceptibility of the economic crop plants grown in the regions covered by this project to the nematode species present. Furthermore, to develop resistant crop cultivars, it will be necessary to discover sources of resistant germ plasm and to determine the extent of pathogenic variation in the nematode. With this knowledge, effective crop rotation programs can be designed and resistant or tolerant cultivars developed on a regional basis. This proposal is to initiate research on the root-knot nematodes at a U. S. university and to link the research with international and national research institutions for the purpose of gaining information on the biology of these pests that will enable developing countries to cope with crop diseases caused by this group of nematodes.

PRINCIPAL GOALS:

1. To increase production of economic food crops in developing nations.
2. To upgrade crop protection capabilities of developing nations.
3. To advance knowledge about one of the world's most important group of plant-parasitic nematodes.

OBJECTIVES:

1. To determine the species and biotypes of the root-knot nematodes present within each of the six geographical regions.

2. To determine the susceptibility and/or resistance of the currently grown basic food crops in each of the regions to the root-knot nematodes which are present.

3. To establish a bank of information on cultivars which display resistance to any or all of the species of root-knot nematodes which have been identified in the six proposed regions of study (Central America, South America, Brazil, West Africa, East Africa and Southeast Asia).

WHY WAS ROOT-KNOT SELECTED:

The root-knot nematodes (*Meloidogyne* spp.) were selected because of their overall importance throughout the world as limiting factor in food production. Their world-wide distribution, extensive host ranges and involvement with fungi, bacteria and viruses in disease complexes, rank them high on the list of disease agents affecting the world's food supply. Collectively, the various species of root-knot nematodes attack nearly every crop that is grown including both annuals and perennials. Not only are crop yields greatly affected, but quality is also reduced, especially for root crops such as potato, yams, yuca and peanuts.

PROJECT IMPLEMENTATION SCHEDULE:

PHASE I: Organization of the "Research Center" at North Carolina State University, Raleigh, N.C., and establishment of Regional Laboratories (Fig. 1).

The team of principal researchers, cooperators, and consultants and their respective locations is as follows:

A. North Carolina State University, Raleigh, N.C.

Dr. J. N. Sasser, Nematologist, Department of Plant Pathology, Principal Investigator.

Dr. A. C. Triantaphyllou, Nematologist-Geneticist, Dept. of Genetics, Cooperator.

Dr. Hedwig Hirschmann Triantaphyllou, Nematologist-Taxonomist, Dept. of Plant Pathology, Cooperator.

Dr. James G. Baldwin, Nematologist-Morphologist, Dept. of Plant Pathology.

Dr. James L. Starr, Nematologist-Physiologist, Dept. of Plant Pathology.

Dr. L. A. Nelson, Statistician, Dept. of Experimental Statistics, Consultant.

B. Regional Investigators:

Central America, Mexico and the Caribbean (Region I)

Dr. Rodrigo Tarte,
Universidade de Panama, Facultad de Agronomia,
Panama, R. de Panama.

South America (Region II)

Dr. Rodolfo Barriga,
Department of Plant Pathology, ICA - Tibaitata,
Apartado Aereo 151123, Bogota, Colombia.

Brazil (Region III) not funded by project

Dr. Romero Marinao de Moura,
Universidade Federal Rural de Pernambuco, Escola Superior de Agricultura, Dois Irmaos, Recife, Pernambuco, Brazil.

West Africa (Region IV)

Dr. Fields E. Caveness,
International Institute of Tropical Agriculture,
Oyo Road, P.M.B. 5320, Ibadan, Nigeria.

East Africa (Region V)

Dr. Benjamin W. Ngundo,
East Africa Agriculture & Forestry Res. Org.,
P. O. Box 30148, Nairobi, Kenya.

Southeast Asia (Region VI)

Dr. Cesar P. Madamba,
Nematologist, Department of Zoology, University of the Philippines College, Laguna, Philippines.

Near East (Region VII)

Dr. Dawood M. Elgindi,
Nematology Research Centre, Faculty of Agriculture,
Cairo University, Giza, Egypt.

PHASE II: Conference at Raleigh

The regional investigators have been invited to spend this week with us for the purpose of discussing the onerall goals and objectives of the international *Meloidogyne* project. Their reports concerning root-knot nematode research in their regions will be of much help in our deliberations. Also attending the conference, in addition to local faculty participating in the project, are six consultants who have been asked to review certain basic aspects of the genus. We feel certain that from the discussions to follow, much will be gained in helping us to decide on research priorties and emphasis.

PHASE III: Regional Research Planning Conferences

Following this one-week conference in Raleigh, a regional research conference will be held in each of the six regions. Participants from the various countries will first give a summary of the state of knowledge concerning the root-knot nematodes in their countries. Each country will then outline research they can do in keeping with the objectives and goals of the international project. Special consideration will be given to research methodology relating to the genus *Meloidogyne* including collecting and maintaining inoculum, inoculation techniques, species identification, methods of evaluating for resistance, and interpretation of research results.

PHASE IV:

Research will begin within each region upon the completion of the planning conference in Raleigh and the regional research conference in the 7 regions. Specific activities will include:

1) Collection of nematode populations.
2) Identification of species and/or variants in the field collections.

3) Differential host tests to detect pathogenic variation.
4) Host susceptibility and/or resistance studies of major food crops in the region.
5) Utilization of crop response information in the development and implementation of effective rotation schemes for control of root-knot nematodes in each region.
6) Collection of information on environmental factors which may influence development of new pathogenic races and/or species.
7) Identification and utilization of resistant germ plasm.

Research at North Carolina State University on the genus Meloidogyne is ongoing, but will be expanded and intensified. Specific activities will include:

1) Detailed morphological and taxonomic studies, including descriptions of new species. Emphasis will be to find new and more reliable characters to support species identification and to distinguish between new pathotypes of the nematode.
2) Differential hosts tests of populations from the United States and areas not covered by the 6 regions to detect pathogenic variation.
3) A detailed study of the variants encountered.
4) Cytogenetic studies involving comparisons of populations with regard to chromosome numbers, mode of reproduction, sexuality, and the genetic basis of their ability to reproduce on resistant crops.
5) Biochemical investigations of general protein patterns and specific enzyme systems.

SUMMARY:

These cooperative research efforts involving a network of scientists, and institutions representing major geographical regions of the developing world, should enable us to better understand the biological behavior of one of the world's major crop pests. Such behavior is influenced not only by the genetic and biochemical makeup of the organism, but by pressures imposed by

various environmental influences. The more we know about the nematode and these environmental influences on disease development the more likely we will be able to provide conditions favorable to the host plant and less favorable or unfavorable to the nematode (Fig. 1). The thrust of this research proposal is to provide this information.

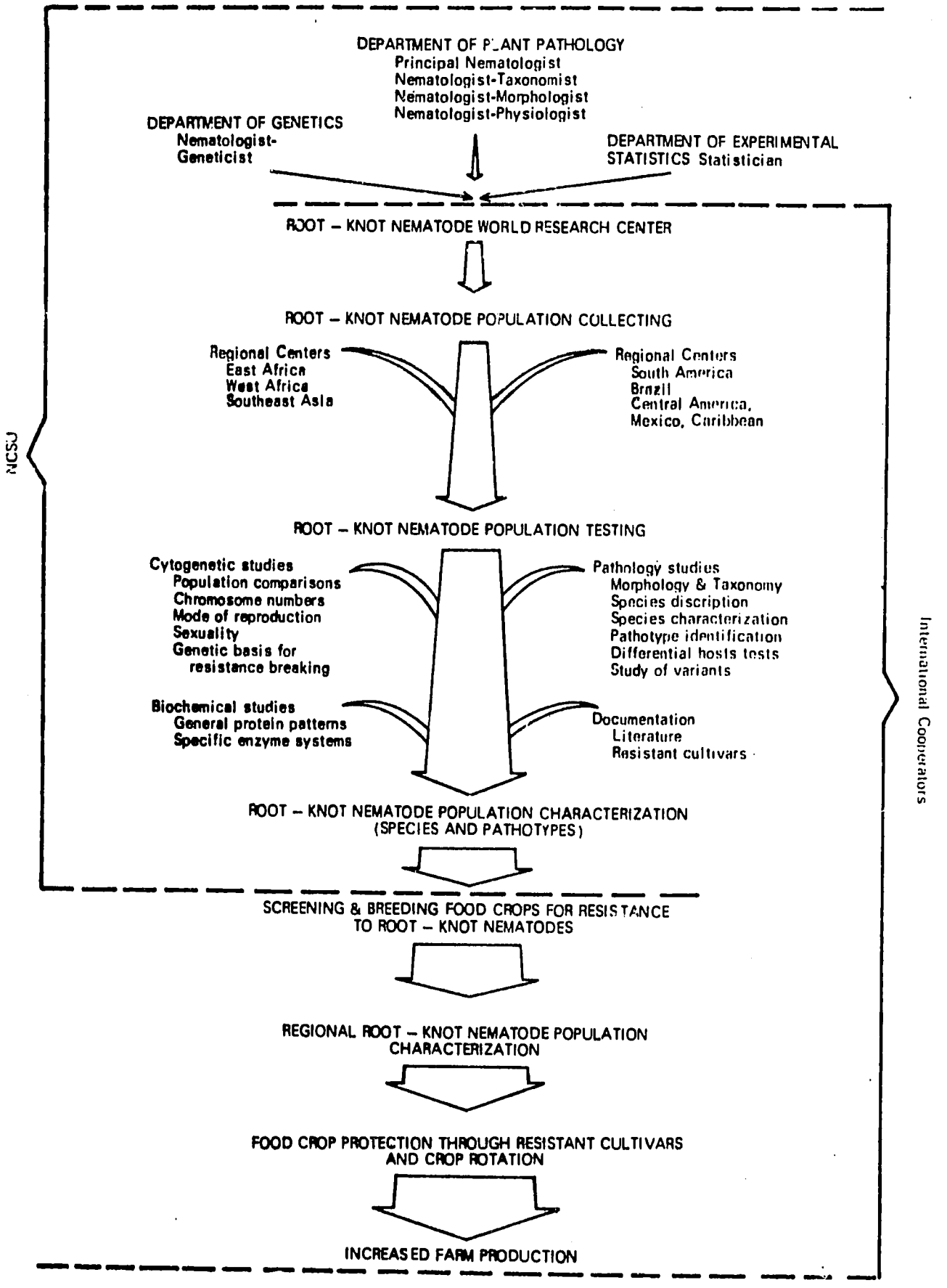


Fig. 5. Schematic representation of ongoing *Meloidogyne* research and program cooperators.

1. Report on the state of knowledge concerning root-knot nematodes in Portugal. — Maria Susana N. de Santos.

Short history of nematology in Portugal

Root-knot nematodes, Meloidogyne spp., were the first plant parasitic species observed in Portugal and these were recorded by Moraes in 1882. Since then several other accounts of "root-knot" and other nematodes were published. The research work has been mainly of a preliminary nature: surveys and species identification. During the past ten years some progress has been made including work on extraction techniques, numerical taxonomy, population dynamics, host-parasite relationships and control.

At the present time there are three research laboratories and only seven nematologists in Portugal.

Studies of root-knot nematodes in Portugal

This report does not refer to Açores and Madeira because there is very little knowledge on root-knot in those islands.

The portuguese climate has mediterranean and atlantic influences.

The major crops of Portugal include grape, tomato, olive, apple, corn, wheat and oat. Other crops are legumes, vegetables, tobacco and citrus.

a) Survey b) Species identification

To date there are only about forty publications dealing with Meloidogyne from Pôrtugal. In some of these publications Meloidogyne species was not identified and before 1962 the reports referred to root-knot as Heterodera marioni.

There are only ten hosts recorded for Meloidogyne up to 1962: grape (Vitis vinefera L.), tomato (Lycopersicon esculentum Mill.), potato (Solanum tuberosum L.), red pepper Capsicum annuum L.), Begonia sempervirens Link et Otto, Ornithogalum sp., Scorpiurus sp., Thalictrum angustifolium L., Clematis orientalis L. and tobacco (Nicotiana tavacum L.).

Since 1962 infestations have been seen on several other plants. Table 1 shows the hosts and host range, from pot tests, recorded for Meloidogyne sp., M. incognita, M. javanica and M. hapla.

c) Control

There are few data on the extent and type of crop losses caused by Meloidogyne spp. Lima (1962) and Macara (1971) refer that the parasite has caused severe infestations, respectively, in peach and olive.

Little experimental work on the control of Meloidogyne spp. in Portugal has been published.

d) Biology and e) Pathogenicity

Since 1970 research in Portugal has included:

1) Studies on development of root-knot nematodes in tomato.
2) Histopathology of tomato plants infected by Meloidogyne spp.
3) Studies on pathogenicity of Meloidogyne incognita and M. javanica in Vitis spp. The research that has been done is published in a report of limited circulation (Reis, 1970).

The IMP objectives and the current work being done in Portugal

The first meeting of the portuguese nematologists was held in December 1977. The nematology program includes research on the genus Meloidogyne. Specific activities include:

1) Collection of nematode populations and identification of species.
2) Host susceptibility and plant response to root-knot nematodes at the cellular level. Studies on the interactions between tissue cultures and root-knot nematodes. It is hoped that research on the genus Meloidogyne will be expanded. Other activities will possibly include.
3) Cytogenetic studies and biochemical investigations of general protein patterns.

It seems that the current work being done in Portugal fit in very well with the IMP objectives.

Table 1. List of host plants in Portugal in which naturally infection of *Meloidogyne* is known to occur and host range from pot tests, of some populations.

HOSTS OF *MELOIDOGYNE* SP.		HOST RANGE
Onion	*Allium cepa* L.	
Celery	*Apium dulce* Mill.	
Peanut	*Arachis hypogaea* L.	
	Begonia sempervirens Link et Otto	
Beetroot	*Beta vulgaris* L.	
Sugarbeet	*Beta vulgaris* L.	
Sugarbeet	*Beta vulgaris* L. and *Galinsoga parviflora* Cav.	*Impatiens holstii* Engl. et Warb. and *Lycopersicon esculentum* Mill.
Red pepper	*Capsicum annuum* L.	
	Clematis orientalis L.	
Melon	*Cucumis melo* L.	
Thorn apple	*Datura stramonium* L.	
Carrot	*Daucus carota* L.	
Carnation	*Dianthus caryophyllus* L.	
	Dichondra repens Forst.	
Straberry	*Fragaria* sp.	
Fig	*Ficus carica* L.	
	Kalanchoe peltata Baill.	
Tomato	*Lycopersicon esculentum* Mill.	
Apple	*Malus domestica* Borkh.	
Tobacco	*Nicotiana tabacum* L.	
Olive	*Olea europaea* L.	

TABLE 1 (continued)

HOSTS OF *MELOIDOGYNE* SP.		HOST RANGE
	Ornithogalum sp.	
Kidney bean	*Phaseolus vulgaris* L.	
Peach	*Prunus persica* (L.) Batsch	
	Scorpiurus sp.	
Egg-plant	*Solanum melongena* L.	
Black nightshade	*Solanum nigrum* L.	
Potato	*Solanum tuberosum* L.	
	Thalictrum angustifolium L.	
	Trifolium resupinatum suaveolens (Willd) Dinsm.	*Lycopersicon esculentum* Mill.
		Impatiens holstii Engl. et Warb.
Broad bean	*Vicia faba* L.	*Impatiens holstii* Engl. et Warb.
	Vinca difformis Pourret	
	Vinca major L.	
Grape	*Vitis vinifera* L.	
Grape	*Vitis vinifera* L.	*Impatiens holstii* Engl. et Warb.
	Vitis spp.	

HOSTS OF *MELOIDOGYNE HAPLA*		HOST RANGE
Alfalfa	*Medicago sativa* L.	*Daucus carota* L.
	Polypodium spp.	
Rose	*Rosa* sp.	

TABLE 1 (continued)

HOSTS OF *MELOIDOGYNE INCOGNITA*		HOST RANGE
	Begonia sp.	
Fodder beet	*Beta vulgaris* L.	
Carrot	*Daucus carota* L.	*Impatiens holstii* Engl. et Warb.
Tomato	*Lycopersicon esculentum* Mill.	*Coleus* sp.
		Impatiens holstii Engl. et Warb.
Alfalfa	*Medicago sativa* L.	*Impatiens holstii* Engl. et Warb.
		Lycopersicon esculentum Mill.
Kidney bean	*Phaseolus vulgaris* L.	
Peach	*Prunus persica* L. Batsch	

HOSTS OF *MELOIDOGYNE JAVANICA*		HOST RANGE
Melon	*Cucumis melo* L.	
Tomato	*Lycopersicon esculentum* Mill.	
Grape	*Vitis vinifera* L.	*Coleus* sp.
		Impatiens holstii Engl. et Warb.
		Lycopersicon esculentum Mill.

References

Lampreia, M. Antónia B. 1977. Nódulos radiculares da beterraba causados por Meloidogyne sp. In Doenças e pragas da beterraba sacarina reconhecidas em Portugal. I.N.I.A. Oeiras: 83-87.

Lima, M.B. 1962. Introdução ao estudo dos nemátodos de Portugal Continental. Relatório final do Curso de Engenheiro Agrónomo. Universidade Técnica de Lisboa. 141 pp.

Macara, A.M. 1963. Aspectos sobre a importância dos nemátodos de interesse agrícola em Portugal e no Ultramar português. Agros, 46: 367-384.

Macara, A.M. 1971. Importância agrícla dos nemátodos Meloidogyne spp. no espaço português. Bolm Agron. Agran, 9: 3-15.

Reis, L.G.L. 1970. Patogenicidade de Meloidogyne incognita e Meloidogyne javanica em Vitis. Relatório final do Curso de Engenheiro Agrónomo. Universidade Técnica de Lisboa. 158 pp.

Santos, M. Susana N. de A. Root-knot nematodes in Portugal. (In preparation).

2. The root-knot nematode, Meloidogyne, in Jordan.

W. I. Abu-Gharbieh.

Introduction

Even though agricultural production constitutes only 13% of the national income, 60% of Jordan's population depend directly or indirectly on agriculture.

Crops are grown in the uplands under rain-fed conditions or under irrigation in the Jordan Rift Valley (Ghors) and along several vallies descending from the eastern or western mountains. Several other projects along the periphery of the eastern desert are irrigated by ground water.

Past experience has shown that crops grown in the rain-fed areas do not harbour the root-knot nematode that fails to get established. Therefore, amphasis will be given to the problem of the root-knot nematodes in the irrigated areas of the Jordanian Ghors.

Vegetable growing comprises the corner stone of agricultural production in the Ghor areas. In 1977, 164 thousand dunums ($1000m^2$) were under cultivation in the irrigated areas of the various Ghors. 60, 28 and 12% of the total area was planted to vegetables, cereals and fruit trees, respectively. Tomatoes alone occupied 25% of the total area.

The Jordan Rift Valley is characterized by warm humid winters and hot dry summers, with average monthly temperatures of 15 - 20°C and 25 - 30°C, respectively.

Under extensive and intensive cultivation in the Ghor areas, several problems have arisen. The mean production per unit area of tomatoes, for example, equals to about one-half of the world's mean. This is an alarming fact. Of course it is attributed to several reasons, one of which is undoubtedly due to root-knot nematodes.

In the 1950's the root-knot nematode problem in the Jordan Rift Valley was minor, for large additional virgin lands were put to cultivation. By 1970 practically all soils

of these areas became infested. Many lands were abandaned for several years or planted to cereals to cope with the devastating effects of the soil-borne root-knot nematode and fusarium wilt of tomatoes. Other farmers adopted the late planting of tomato (November) to avoid the heavy hits of these disease causal agents.

Survey

In a report published in 1970, Abu-Gharbieh and Hammou processed over 500 soil and root samples collected from 45 crop species from the various locations of Jordan. About 20% of thesamples harboured the root-knot nematode. (Annual Report, Dept.Agr. Res. and Extension, 1970).

From these and many other samples, M. javanica and M. incognita were identified, but the former is predominant.

Resistant Varieties

Abu-Gharbieh and Hammou tested 14 tomato varieties to Meloidogyne spp., ten of which were immune or highly resistant. The authors also tested the same root-knot nematode on 6 strawberry varieties, but all these varieties failed to harbour the nematode (Annual Report, Dept. Agr. Res. and Extension, 1971).

In 1977, Abu-Gharbieh tested over 100 tomato cultivars under greenhouse conditions for resistance to M. incognita and M.javanica. Fourteen cultivars exhibited high level of resistance to both species of the root-knot nematode (In Press, PDR).

Chemical Control

In 1971 and 1972 seasons, four dosages of Nemagon EC 75% were used as preplant treatments in two tomato fields in the Central Jordan Valley. 1.5 and 2 ml/m^2 proved very effective against the root-knot nemabode. (Plant Protec. Studies, Jordan (1972) 1: 49-53). In another experiment, Nemagon was used 15 days before and after tomato planting, at 1.5 ml/m^2,

but differences in time of application were insignificant (Ann. Report, Dept. Agr. Res. and Extension, 1972).

In the 1974/1975 season, three field experiments were conducted in the Central Jordan Valley to control the root-knot nematode, M. javanica on tomato (Unpublished).

It was concluded from the first experiment that: eighty days before planting, DBCP soil fumigation wt any of the rates used (1.0, 1.5 and 2.0 ml/m^2) significantly increased tomato yield over the non-fumigated control. Soil fumigation 45 or 15 days before planting, however, did not statistically increase yield. These results were obtained inspite the fact that the fumigations closer to the planting date g gave better results both in suppressing nematode population levels in the soil and less galling of the roots. Such results may suggest that, under the conditions of late fumigation and DBCP concentrations used, tomato plants were adversely affected.

The second experiment showed that: fifteen days before planting, an overall soil application of DBCP, at the rates 1.0, 1.5 and 2.0 ml/m^2, significantly reduced tomato yield as compared with the non-treated control. Yields obtained from plots treated by either row or with irrigation water, at all rates, were less than but statistically insignificant from, the non-fumigated. These results suggested that DBCP soil fumigation, under the conditions of the experiment, adversely affected tomato yield. On the other hand, applications of the nematicide overall or in rows (at all rates) showed favourable reduction of root galling, as compared with the non-treated controls. However, application of DBCP with irrigation water reduced root galling only slightly. At the lower dosages (1.0 and 1.5 ml/m^2), overall application of the nematicide, gave significantly larger and healthier foliage than all other treatments.

It was concluded from the third experiment that soil fumigation with D-D mixture, Nemagon EC and Fumazon EC at the rates 37.5, 1.5 and 1.5 ml/m^2, respectively was effective

against the root-knot nematode. The same respective nematicides (at the rates 25, 1 and 1.5 ml/m^2) and Nemagon Gr. and Basamid Gr. (at 15 and 40 gm/m^2) were moderately effective. Nemagon Gr., both levels of Vydate Gr. and Basamid Gr. (at the rates 10 gm, 12 gm, 6gm and 25 gm/m^2), however, were nearly ineffective and not different from the non- treated control. Though insignificant in yield increase, the nematicides less effective against the nematode, Basamid Gr. at 25 gm/m^2 and Nemagon Gr. at 10 and 15 gm/m^2, gave better yields than the more effective treatments. Treatments with Vydate Gr. at both levels, not only were ineffective against the nematode, but it seemed to have reduced the yield below the non-treated.

Ecology

In the Jordan Valley, a study was conducted on the population dynamics and effect of M. incognita on different plantings of tomato. A susceptible tomato cultivar was planted on six dates at 15 day intervals, starting September 15. Seedlings planted in Sept. and Oct. were infected in the seedling stage, even though only low populations of the nematode larvae were present in the soil. Seedlings planted in Nov; and Dec., however, were not infected in the seedling stage and no nematode larvae were recovered from the soil. the nematode resumed its activity at the beginning of the spring in March and early April and continued progressively until termination of the experiment on June 1. At the termination of the experiment roots of plants in all plantings were galled but severity of galling and the effect on plant vigour and thriftiness decreased as date of planting was delayed (Abu-Gharbieh 1975. Dirasat 2: 61-68).

In another experiment in the Jordan Valley, experimental plots received: Nemagon EC 75% pre-plant soil fumigation (75 or 15 days); dry summer hoeing (15 and / or 45 days before tomato planting on September 15) and removal of the infected root systems of the previous crop from the soil. Soil fumigation on

both dates, similarly reduced the nematode population and root galling, and produced more thrifty-looking tomato plants. Under the conditions of the experiment, neither dry summer hoeing nor removal of root refuse of the previous crop gave satisfactory results (To be published in J. Nematology).

. . . .

3. The problem of the root-knot nematodes in Greece. — C. N. Koliopanos.

Introduction

Undoubtedly the most devastating nematodes to the greek crops are the root-knot nematodes(Meloidogyne spp.).

The majority of the samples, dispatched by the farmers to the various clinic phytopathological laboratories of Greece, are found to be infested by root-knot nematodes.

The first report on this nematode is that by Isaakides in 1935. He found galls of Meloidogyne spp. on tomatoes, okra, potatoes, tobacco, lettuce, almond trees, apricot trees, dahlia and eggplants. He considered the infestation to be caused by Heterodera marioni.

During the next years several other investigators, such as Ayoutantis, Pelekassis, Triantaphyllou, Hirschmann, Kyrou, Koliopanos, Kourtzipaschalaki, etc., have found root-knot nematodes on many other host-plants at various locations in Greece.

Existing species

More than 85 host-plants have been reported from the whole country to be infected by various species of Meloidogyne. The identified species are the following :

1. Meloidogyne acrita (reported by Kyrou as M. incognita acrita)
2. M. arenaria (reported by Hirschmann et al., Koliopanos et al. and Kyrou)

3. M. artiellia (reported by Kyrou)
4. M. exigua (reported by Koliopanos et al.)
5. M. hapla (reported by Hirschmann et al., and Kyrou)
6. M. incognita (reported by Hirschmann et al., Kalyviotis-Gazelas, Koliopanos et al., and Kyrou)
7. M. javanica (reported by Buchelos et al., Hirschmann et al., Koliopanos et al. and Kyrou)
8. M. thamesi (reported by Koliopanos et al., and Kyrou as M. arenaria thamesi).

The most prevailing species, according to the number of different host-plants reported on, are considered to be M. incognita on 26 hosts, M. javanica on 25 hosts, and M. arenaria on 22 hosts. The rest of the species have been reported on 6 hosts (M. thamesi), on 5 hosts (M. acrita), on wheat (M. artiellia), on peach trees (M. exigua) and on cyclamen (M. hapla).

A great number of hosts has been reported to be infected by root-knot nematodes but without the identification of their species (bad condition of nematode specimens, lack of key publications, etc.).

After personal observations I should say that some other species of Meloidogyne may exist in Greece and several host-plants too, e.g. on pome granate trees at Peloponnesus I found a Meloidogyne species which is probably new one; also the roots of Echeveria sp. were heavily infected by a root-knot species which resembles a little to M. acronea.

Distribution

There is no evidence that the environmental factors (temperature and rain), as well as tha altitude and latitude influence the distribution of any particular species to any particular region. The three most common species have been found everywhere.

Of course an extensive survey is needed for all the country to demonstrate any particular distribution or geographic isolation of the various species of Meloidogyne.

Economic importance

Among the various infected host-plants by root-knot nematodes the mostly damaged ones are the following.

- crops in the greenhouses, such as cucumbers, tomatoes, egg-plants, several flowers etc.
- nurseries of various plants.
- vegetable crops, such as tomatoes, okra, lettuce, eggplants, carrots, cabbage, potatoes, etc.
- field grown flowers, such as carnation, hyacinth, dahlia, roses, etc.
- industrial crops, such as tobacco, cotton, sugar beets, etc.
- arboreal crops, such as peach, apricot, almond, olive trees, etc.

It is very difficult to assess the loss of yield due to the root-knot nematodes alone, but there is no doubt that some million dollars per year are consumed by Meloidogyne spp.

Control and Research

Until 1960 there was no great interest for the crop damage caused by nematodes merely because nematodes were known only by very few people.

Since that time several seminars and post-graduate courses have been held at Benaki Phytopathological Institute or elsewhere in the country concerning phytopathology, entomology, nematology and other disciplines. More than 300 agronomists have attended those seminars and courses.

To-day there is no agronomist in the whole country who is not familiar with the nematological problems in general.

On the other hand the growers do not consider seriously the nematode menace. In order to protect their crops from the pests, they apply quite successfully the crop rotation system in the areas where it is feasible, very seldom the fallow system, the trap-cropping system and the use of organic fertilizers as a means of nematode reduction.

In certain crops, such as tobacco, cereals, cotton, etc., they cut the stalks after harvest, and the root system of the

plants is then turned out. Thus the root-knot nematodes and many others are reduced through the drying action of wind and sun. The top and roots of certain crops used also for fuel, and thus a great number of nematodes is diminished.

The use of nematicides has been increased during the last 7 years particularly in the greenhouses, nurseries and certain arboreal crops (mainly citrus trees).

A limited survey on Meloidogyne has been done in Greece.

Also few experiments have been conducted regarding the control of root-knot nematodes in the field or in the greenhouses.

Nothing has been done in the area of resistant varieties to Meloidogyne or other related subjects.

Future work

The existing scientific staff working with nematodes is very limited in Greece. In the Ministry of Agriculture there are only 4 agronomists, two doctors in plant pathology with good knowledge in nematology, and two trained in nematology for several years. In the University College of Agriculture there is one nematologist with Ph. D. in nematology and one agronomist trained in nematology for 3 years.

The chemical companies give help to the farmers concerning the use of nematicides against nematodes.

The nematological problems are numerous and nematologists need to work hard.

The following schedule can be drawn for the future:

- An extensive survey all around the country to find the existing species and their geographic distribution.
- Search for resistant natural host-plants to the root-knot nematodes, mainly wild hosts.
- Propagation of the existing species for further studies.
- Experimental work on their control on certain crops with nematicides particularly new ones.
- Genetic studies on various populations.

Literature

Hirschmann, H. et al. 1966. Annls Inst. Phytopath. Benaki, N.S., 7: 144-156.

Isaakides, C.A. 1935. Annls Inst. Phytopath. Benaki, 1(2): 1 - 12.

Koliopanos, C.N. et al. 1969. Annls Inst.Phytopath. Benaki, N.S., 9: 30-32.

Koliopanos, C.N. et al. 1973. Annls Inst. Phytopath. Benaki, N.S., 10: 301-306.

Kyrou, N.C. 1963. Pl. Dis. Reptr 47: 916.

Kyrou, N.C. 1973. Geoponika 212: 155-157.

Kyrou, N.C. 1975. Geoponika 223: 87-89.

Kyrou, N.C. 1975. Geoponika 225: 238-241.

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4. IMP: Technical research report - Region V, East Africa, March - June, 1977. — B. W. Ngundo.

The host range studies described in the February 1976-77 Technical Report, was continued. All plants were used except Sweet Potato (All Gold) which was discarded due to a virus infection.

Sixteen days after planting, one egg mass from Meloidogyne incognita and M. hapla was inoculated into each of the nine plants (Table 2). M. javanica was not inoculated until 70 days after planting as nematode species was not available.

Roots were checked for nematode (M. incognita, M. hapla and M. javanica) attack after 30 days inoculation. Results are given in Table 2.

Only one plant, Corn, did not correspond with the previous (February 1976-77) report for plants inoculated with M. incognita. Three plants, pepper, strawbery and sweet potato inoculated with M. javanica did not correspond with the

Table . Response of plant species to attack by *Meloidogyne* spp.

Meloidogyne species		Differential hosts[a]								
		Tobacco	Cotton	Pepper	Water-melon	Peanut	Corn	Straw-berry	Sweet potato	Tomato
M. incognita:	(NC)[b]	-	±	+	+	-	+	-	±	+
	(K)[c]	+	-	-	+	-	-	-	-	+
	(K)[d]	+	-	-	+	-	+	-	-	+
M. javanica:	(NC)[b]	+	-	-	+	-	+	-	-	+
	(K)[c]	+	-	+	+	-	+	-	-	+
	(K)[d]	+	-	-	+	-	+	+	+	+
M. hapla:	(NC)[b]	+	-	+	-	+	-	+	+	+
	(K)[c]	+	-	+	-	-	+	+	-	-
	(K)[d]	+	-	+	-	-	-	+	-	-

[a]Plant varieties include Tobacco, N.C.95; Cotton, DeltaPine 16; Pepper, California Wonder; Watermelon, Charleston Gray; Peanut, Florrunner; Corn, Minn A401; Strawberry, Allbritton; Sweet Potato, Puerto Rico; Tomato, Rutgers.

[b]Results of the tests carried out in North Carolina.

[c]First results of the tests carried out in Kenya.

[d]Second results of the tests carried out in Kenya.

previous report. Similarly, one plant, corn, inoculated with M. hapla did not correspond with the previous report. Only two plants, cotton and watermelon corresponded with results of the tests carried out in North Carolina. Due to this inconsistency, the experiment will have to be repeated. This time 10,000 eggs of each nematode species will be used per plant per pot; and 40 days after planting and 90 days after inoculation will be allowed to correspond with the North Carolina experiment.

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5. Status of root-knot nematodes, Meloidogyne spp., in Iran.

Cyrus Abivardi.

IRAN: The land of extremes and potentials

1- Extremes:

Iran's total land area is approximately 1,640,000 square kilometers, an area nearly as large as Italy, Spain, France and British Isles combined, with a population of about 36,000,000. It is a land of extremes and potentials. Altitudes range from 15 meters below the sea level on the shores of the Caspian Sea to 5,774 meters at the summit of Mt. Damavand, which is higher than any peak west of the Hindukush in Eurasia. Great differences in altitudes, have resulted in considerable temperature changes ranging from a mean January temperature of 20°C along the Sea of Oman to minus 2°C northwest of Iran. Alternatively, extreme temperatures of 53°C in the Persian Gulf region to minus 38°C in the northwest have been recorded. The forests of the western Caspian receive an annual rainfall up to 2,400 mm, whereas the desert of Dasht-e-Lut may receive none for many seasons (6), (Fig. 1).

2- Potentials:

Such wide climatic variations allow the cultivation of wide range of economic plants normally grown in cold, subtropical and tropical regions of the world. In relation to the size

of Country, however, precipitation and water recources limit the area of cultivated lands to less than 20 million hectars, of which only some three million hectars can be irrigated. This, in turn, emphasizes the vital need for increase in productivity of the agricultural lands to balance the nutritional requirements of our growing population. Therefore, the principal goals of the International Meloidogyne Project, properly fit with the needs and potenials of the Iranian agriculture, and the aims of our government in agricultural development of Iran.

The root-knot nematodes: History, research and concluding remarks

1- History

As might be expected, the wheat nematode (Anguina tritici) and the root-knot nematodes (Meloidogyne spp.) were the first plant-parasitic nematodes observed in Iran. The former has been taught in entomological courses as the "wheat worm", since 1950; whereas, the latter was observed for the first time in 1956 by Scharif, unpublished, from Ghasr-e-Shirin from the Province of Kermanshahan (5).

An important event in the development of Plant Nematology, in Iran occurred in 1963, when Dr. M. Omidvar joined the Ministry of Agriculture as the first nematologist of the country. This date should be marked as the beginning of Plant Nematology in Iran. Since then, the nematology courses were included in the B.S. programs of the agricultural colleges in Tahran and Pahlavi Universities for the students majoring in Plant Protection. Instruction of nematology helped the students to get aquainted with plant-parasitic nematodes, and consequently resulted in orientation of interested students towards this science. Several preliminary surveys were made by some undergraduate students to determine the nematode fauna of Iran, from which at least three surveys included the root-knot nematodes (13).

Growth of interests in this field encouraged some students to pursue their studies in Plant Nematology, so that the number of nematologists with doctorate training has recently reached to six persons.

2- Research:

Nematological research in Iran began on an organized basis in 1964, when the first directed research was planned by Dr. M. Omidvar (Nematologist, Plant Pests and Diseases Research Institute, Ministry of Agriculture) and the Tobacco Monopoly Organization, to establish a 5-year project on plant-parasitic nematodes of tobacco plantations in Guilan Province. The major part of this project was focused to the root-knot problems including identification of different species, evaluation of cultural methods of control and testing commercial nematicides for their nematicidal effects under natural conditions. According to the results, three root-knot nematode species (M. hapla, M. incognita and M. arenaria) were determined. A 3- year fallow; and also rotation of tobacco with broadbean or barley reduced the nematode population (15).

The second directed research on theroot-knot nematodes was started in 1965; as a part of the Regional Pulse Improvement Project (RPIP) sponsored by U.S. Department of Agriculture as a joint agreement with the Ministry of Agriculture and the Plant Organization of Iran. According to Omidvar (14), three species of the root-knot nematodes (M. hapla, M. incognita and M. javanica) were isolated from pulse crops growing in Varamin at the vicinity of Tehran. Studies on rotation, resistant cultivars, survival, fallow, and possible use of Tagetes sp. were also included in the proposal. According to the investigator, further works were required for recommendation of the appropriate means of control. Studies of Okhovat and his co-investigators (8, 9, 10, 11, 12) during 1970-1974 that included numerous data on evaluation of different cultivars of pulse crops for their resistance, nematicidal trials, rotation and studies on the host range of undetermined species of the root-knot nematodes, did not show uniform results. Lack of statistical analysis in some of the trials, the presence of ununiform results and low population of the nematodes in their experimental plots, suggest the need for additional investigations on this

project. Similar results are noticed in the 1975 experiments conducted by Rassoulian (16).

Excluding these two projects, the research on root-knot nematodes has constituted almost a minor part of activities of the Iranian nematologists. Therefore, due to the limited number of nematologists, gradual growth in their present number, educational responsibilities, the scope of untouched nematological problems, and limitations in finding and funding the trained technicians, few reports are available on the root-knot nematodes in Iran (2,3,4,5,7,13). Consequently, the status of Meloidogyne species, like other plant-parasitic nematodes, is not clearly understood. According to the available reports, mentioned earlier, a root-knot nematode was first reported in 1965 (5). Other reports have been mainly dealing with distribution, and hosts of the genus (2,4,5,13). There are also few reports on identified species (2,3,4,5,7,13), and their control (3,7,13), (Fig. 1 and Table 1).

Although the root-knot nematodes are essentially hot-weather organisms, they are not confined to the tropical and subtropical region of Iran. They have been found to be fairly common on plants growing in the open fields in cold areas of the northwest of Iran (13). Therefore, it is believed to be widespread all over the country with variations in types of species and extent of injury.

3- Concluding remarks:

Our present knowledge indicates that at least four species of the root-knot nematodes (M. hapla, M. incognita, M. arenaria and M. javanica) are present in Iran, on a wide range of economic plants and weeds listed in Table 1. As a genus, it has been reported from the following regions in nine Provinces:

Name of the Province	Infested regions
1- Boushehr	Borazjan, Boushehr.
2- Central	Karaj, Tehran, Varamin.
3- Guilan	Ahmad-Gorgab, Astaneh, Bandar Pahlavi, Behshahr, Ghazian, Lahijan, Rasht, Roodsar.

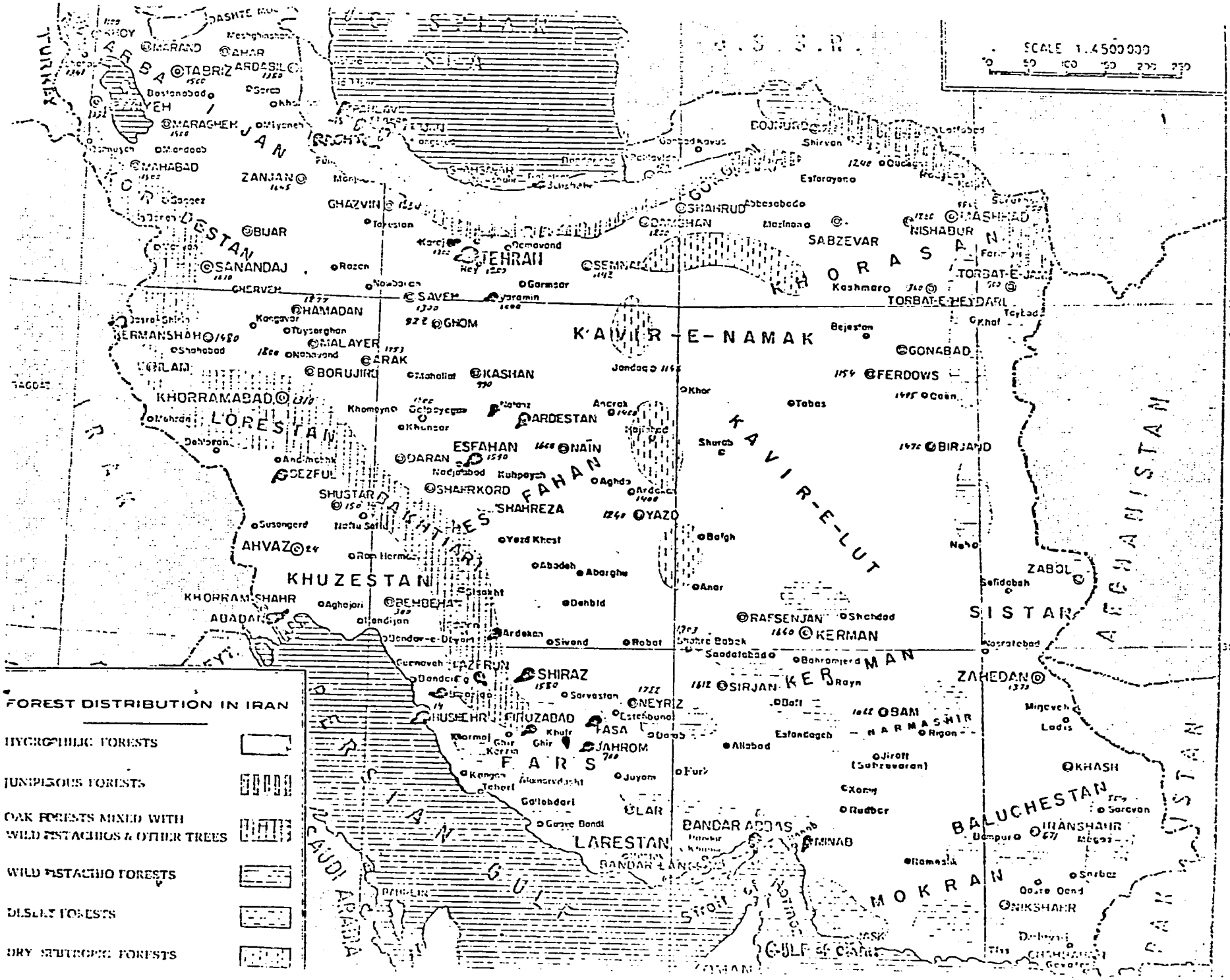
Name of the Province	Infested regions
4- Fars	Ardekan, Fassa, Firooz-Abad, Jahrom, Kazeroon, Khafr, Shiraz.
5- Hormozgan	Bandar Abbas, Minab.
6- Isfahan	Ardestan, Badroo, Barkhar, Isfahan, Khoor-o-Biabanak, Lenjanat, Mourche-Khort, Natanz.
7- Kermanshahan	Ghase-e-Shirin.
8- Khuzestan	Dezful, Abadan.
9- Kohkiluyeh	Mamasani.

Although the root-knot nematodes are quite prevalent in warm climates with potentials of economic injury, control measures have not been thoroughly investigated to establish the economic level of injury for any crop.

According to my observations in the southern Iran, the nematode does not occur in a uniform pattern in the adjacent farms with similar soil types. In other word, some farms are heavily infested, whereas the neighboring farms with the same crop have remained uninfested. Since this is noticed in egg-plants and tomato plantations, it seems that the source of transplants may be the reason for this ununiformity. Therefore, studies on the infestation of seedbeds and their correlations with ununiform distribution of this nematode deserve special attention. This, if positive, can be an answer to the economic control of the nematode infestations in crops initially growing in the seedbeds.

Due to the high cost of soil fumigation in Iran, as compared with the net income of many field crops, special emphasis should be made on finding alternative methods of control, where the chemical control is not economic.

Since, the anthelmintic plants (specially Artemisia cina and Artemisia absithium) are widely distributed in Iran, the possibility of their application in the nematode control should be investigated further (1,3). My previous studies showed that the extracts of both plants were highly toxic to a root-knot



in major infested areas of Iran.

nematode (M. incognita). Investigations on practical aspects of their nematicidal activities may throw light to the economic aspects of the nematode control. Amendments of the infested soils with the plant residues, and evaluation of the nematicidal activities of the root exudates of the anthelmintic plants growing in the infested soil should be included in the experiments. Other methods of control also should be evaluated for their feasibility.

Parallel studies should be made for determination of the nematode species and their importance in different localities. The tropical and subtropical regions, the economic plants, and the establishment of the role of the root-knot nematodes in the infested areas should be given special priorities.

Due to the lack of trained technicians, establishment of special training programs will save a lot of time of the nematologists presently spent for routine works, and will accelerate the progress of the project.

Table 1.The list of plants infested with the root-knot nematodes, Meloidogyne spp., in Iran.

No.	Name	No.	Name
1	Tomatoes	13	Sugarbeet
2	Tobacco	14	Table beet
3	Dogwood	15	Dill
4	Eggplants	16	Coriander
5	Petunia	17	Parsley
6	Cucumber	18	Carrots
7	Melon	19	Judastree
8	Watermelon	20	Mungbean
9	Squash	21	Bean
10	Musk melon	22	Chickpeas
11	Goose	23	Broadbeans
12	Spinach	24	Peas

Table 1. Continued.

No.	Name	No.	Name
25	Lentils	45	Pomegranate
26	Cowpeas	46	Mulberry
27	Alfalfa	47	Purslane
28	Okra	48	Basil
29	Red pepper	49	*Setaria verticilata*
30	Garden cress	50	Potatoes
31	Radish	51	Pistachio
32	Cabbage	52	Geranium
33	Sunflower	53	Kenaf
34	Pickly lettuce	54	Grape
35	Onion	55	Silk tree
36	Garden leek	56	Peach
37	*Amarnthus blitoides*	57	Willow
38	*A. retroflexus*	58	Daisy
39	Common mallow	59	Almonds
40	Holly hock	60	Pine
41	Hemp	61	Celery
42	Snapdragon	62	Tea
43	Bird's meat	63	Citrus
44	Silk vine		

Summary

Iran is a land of extremes with great potentials for food production. There is a vital need for increase in productivity of agricultural lands to balance the nutritional requirements of the growing population. The principal goals of the International *Meloidogyne* Project, fit with the needs, potentials, and the government programs.

Plant Nematology was started late in Iran (1963), and its progress has been relatively slow in this country. Therefore, literature pertaining to the root-knot nematodes are limited to

few sporadic reports. Although two projects were mainly focused on the root-knot nematodes of tobacco and pulse crops, still many questions have remained unclear.

Our present information indicates that at least four Meloidogyne species (M. hapla, M. incognita, M. arenaria and M. javanica) are present in Iran. They have been isolated from many economic crops growing in different climatic conditions.

The present status of the nematode species, the economic level of injury, appropriate methods of control, and the nematode distribution should be thoroughly investigated. Economic plants of tropical and subtropical regions should be given special priorities. Technician training programs should be established to accelerate the progress of the project.

Literature cited

1. Abivardi, C. 1969. A study of anthelmintic natural plant products, exhibiting nematicidal activity to plant-parasitic nematodes. Dissertation Abstracts Vol. XXIX, November 11, 1969.
2. Abivardi, C., K. Izadpanah, M. Sharafeh and A. Saffarian 1970. Plant-parasitic nematodes associated with citrus decline in southern Iran. Plant Dis. Reptr 54: 339-342.
3. Abivardi, C. 1971. Studies on the effects of nine Iranian anthelmintic plant extracts on the root-knot nematode Meloidogyne incognita. Phytopath. Z. 71: 300-308.
4. Abivardi, C. and M. Sharafeh 1973. A preliminary report on the occurrence of some unreported plant-parasitic nematodes in southern Iran. Z. Pflkrankh. PflSchutz 80: 612-614.
5. Barooti, S. 1974. Prevalence and host range of root-knot nematode Meloidogyne incognita in Esfahan area. Iran J. Plant Path. 10: 78-85. In Persian (with English summary).
6. Firouz, E. 1974. Environment Iran. A publication of the National Society for the Conservation of Natural Resources and Human Environment. Offset Press Inc., Tehran. 51 pp.

7. Hojtahedi, H. and S. Barooti 1976. The chemical control of root-knot nematodes in Isfahan. Iran J. Plant Path. 12: 45-46.

8. Okhovat, M., Gh. R. Rasoulian and M. Chalangari 1970. Studies on root-knot nematode, Meloidogyne sp., in Varamin and Karaj. Regional Pulse Improvement Project (RPIP). Annual Report: 144-154. (In Persian).

9. Okhovat, M., Gh. R. Rasoulian and M. Chalangari 1971. Studies on root-knot nematode, Meloidogyne sp., in Varamin and Karaj. Annual Report (RPIP): 225-232.

10. Okhovat, M. and Gh. R. Rasoulian 1972. Studies on root-knot nematode, Meloidogyne sp., in Varamin and Karaj. Annual Report (RPIP): 245-248.

11. Okhovat, M. and Gh. R. Rasoulian 1973. Studies on root-knot nematode, Meloidogyne sp., in Varamin and Karaj. Annual Report (RPIP): 209- 213.

12. Okhovat, M. and G. H. Mesbahi-Mohammadi 1974. Progress Report: Section — Plant Diseases. Annual Report (RPIP): 125-194.

13. Omidvar, M. 1968. Plant-parasitic nematodes behavior, biology, systematics and their control. Minist. Agric., Plant Pests and Dis. Res. Inst. Tehran, Iran. 196pp.

14. Omidvar, M. 1969. Parasitic nematodes of pulse crops and methods of their control. Annual Report (RPIP): 97-99.

15. Omidvar, M. 1969. A report on a 5-year project on plant-parasitic nematodes of tobacco plantations in Guilan. Proc. 2nd Plant Med. Cong. September 13-16, Tehran. pp. 58-78.

16. Rasoulian, Gh. R. 1969. Study on the resistance of pulse crops on root-knot nematodes. Proc. 2nd Plant Med. Cong., September 13-16, Tehran. pp. 249-256. In Persian (with English summary).

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6. The current status of root-knot nematodes in Northern Egypt.

I. K. A. Ibrahim.

In the past 12 years, the problem of plant parasitic nematodes in the agriculture of northern Egypt (NE) has become increasingly recognized. The plant nematodes already present in NE appear to be of great importance specially in light soils and the reclaimed sandy areas of the Western Desert (Ibrahim et al. 1976, Oteifa and Tarjan 1965). Certain species such as root-knot, reniform, spiral, lesion and citrus nematodes are potentially very injurious to most economic plants. The root-knot nematodes (RKN) are perhaps the most widely recognized nematode pests in most agricultural areas of NE (Ibrahim et al. 1972, 1973, 1976; Ibrahim and El-Saedy 1976).

In 1957 the first post-graduate program in plant nematology was intiated in the College of Agriculture, Alexandria University. In the present time, there are 12 trained nematologists (3 Ph.D., 4 M.S., 5 research associates) working mainly on the RKN and chemical control of nematode pests.

Studies on plant parasitic nematodes conducted in Alexandria University showed that RKN were usually among the important pests of economic plant crops in NE. Presently, about 5 species of RKN are known to occur in NE. These species include: Meloidogyne arenaria, M. graminis, M. hapla, M. incognita, M. incognita acrita, and M. javanica. M. javanica and M. incognita were numerous in most cultivated soils and on many agricultural plants. M. arenaria and M. graminis were less common and mainly found on peanuts and rice, respectively. On the other hand, the occurrence of M. hapla was very low.

Survey studies indicated that RKN were present in 34-86% of the collected rhizosphere soil samples and this ratio depends on the host crop and the location. These nematodes were detected in about 83% of the soil samples which collected from corn and rice fields in 8 governorates in NE, with an average number of 524 larvae per 100 ml soil. They were found in 34% of cotton soil samples collected from 4 governorates in NE, with an average number of 342 larvae per 100 ml soil.

Probably M. javanica is the most prevalent species of the RKN and is followed by M. incognita. Examples of some host plants of M. javanica are: alfalfa, almond, apple, banana, bean, carrot, clover, corn, cotton, grape, pea, peach, peanut, rice, rose, soybean, squash, tomato and watermelon. M. incognita occurred on almond, corn, cotton, eggplant, pepper, rice, soybean, sugarcane and tomato.

We have been studing the occurrence, pathogenicity, life cycle and histopathology of M. javanica and M. incognita on some host plants such as corn, cotton, peanut, rice and soybean. To date, the current research on RKN also involves studies of species and biotypes of RKN and their relationships to economic host plants in NE. We believe that IMP (NCSU) and USDA - Nematology Division will be of great help and assistance to the current Meloidogyne research being done in Alexandria University.

Literature cited

1. Ibrahim, I.K.A., I.A. Ibrahim and M.A. Rezk. 1972. Pathogenicity of certain parasitic nematodes on rice. Alex. J. Agric. Res. 20: 175 - 181.

2. Ibrahim, I.K.A., I.A. Ibrahim and S.I. Masseoud. 1972. Induction of galling and lateral roots on five varieties of soybeans by Meloidogyne javanica and M. incognita. Plant Dis. Reptr 56: 882 - 884.

3. Ibrahim, I.A., I.K.A. Ibrahim and M.A. Rezk. 1973. Host-parasite relationship of Meloidogyne incognita (Kofoid et White) Chit. on rice. Nematologia Mediterranea 1: 7-14.

4. Ibrahim, I.K.A., M.A. Rezk and M.A. El-Saedy. 1976. Occurrence and distribution of plant parasitic nematodes in northern Egypt. Alex. J. Agric. Res. 24: 93 - 101.

5. Ibrahim, I.K.A. and M.A. El-Saedy. 1976. Pathogenicity of Meloidogyne javanica and certain fungi on peanuts. Alex. J. Agric. Res. 24: 411 - 415.

6. Oteifa, B.A. and A.C. Tarjan. 1965. Potentially important plant-parasitic nematodes present in established orchards of newly reclaimed sandy areas of U.A.R. Plant Dis. Reptr 49: 596 - 597.

7. Status of root-knot nematode problems and research in Turkey. — Hasan S. Yüksel.

In Turkey some researches have been done on various aspects of nematology, such as biology, taxonomy, chemical control, etc. In our country, root-knot nematode is one of the most important problems as in the whole world. Chemical control, distribution of root-knot nematodes and their relationship with soil borne fungal diseases have been investigated.

Many parts of Turkey offer different ecological niches and diversified agriculture, so accordingly, surveys of the Meloidogyne species were made in five climatically different regions.

1- Black Sea Region:

This region has low altitude and a well distributed high rainfall. On the east coast of Samsun tea plants, hazel-nuts, corn, various kinds of vegetables, strawberries, pears, cherries, and plums are grown. Hazel-nuts, tea plants and corn are the most important cash crops. Surveys were made especially on the main crops and also on the others. Meloidogyne incognita and a setaria root-knot nematode were found on the cultivated plants and on some weeds. They were about equally abundant on the cultivated plants while not on the weeds. Setaria lutescens (Graminae) was highly infected by the last species but not by M. incognita. Hazel-nuts, tea plants and corn seemed to be very resistant to M. incognita and to the other species. Tomatoes, cucumber, beans, squash, tobacco, egg-plant, pepper were found very susceptible to them while cabbage was not very good host.

In the provinces at the west of Samsun cereals, corn, rice, vegetables, peaches, figs and pears are grown. Rainfall is high but not well distributed. In addition to the two previously mentioned species in the east coast, herein Meloidogyne thamesi was found on celerly. Cereals, corn, rice and pears were resistant while peaches and cabbage were moderately susceptible. Figs, plums, tobacco and vegetables were very susceptible to M. incognita and to the undescribed species. M. thamesi was very

rare. M. incognita and the other species were frequently found together, reproducing in the roots of the same plants. The mixed populations were very common in most of the plants.

2- Marmara Region:

This region has much rainfall but its distribution is not very good in summer. In Sakarya, Kocaeli, Istanbul, Tekirdağ, Çanakkale, Balikesir, Bursa and Bilecik provinces, various cultivated plants such as peaches, olive, cherries, apples, vine, walnut, tomatoes, egg-plants, pepper, melon, water-melon, sugar-beet, potatoes, tobacco, cereals and corn are grown. In most of the provinces Meloidogyne arenaria and M. incognita were equally and widely distributed. In Isanbul and Kocaeli, M. arenaria was more common. Meloidogyne acrita, M. hapla and M. javanica were also highly abundant. This region contains abundantly about all the Meloidogyne species, found in Turkey. In some provinces, as Tekirdag, Heterodera schachtii and M. incognita together attacked sugar-beet very badly. Peaches were susceptible to M. incognita. Tomatoes and egg-plants seemed equally susceptible to M. hapla, M. arenaria, M. incognita and M. javanica, while olives, corn, cereals, potatoes and cherries were resistant to these species.

3- Agean Region:

In this region summer is dry and hot, winter is rainy. Snow does not stay long. Vine, tobacco, olive, figs, cotton and mandarin are the main crops of this region. Fruits, vegetables and cereals are also economically important crops. Tobacco, peaches and sugar-beet were susceptible to M. incognita and M. javanica. Some vegetables such as tomatoes, egg-plants and okra were susceptible to M. incognita, M. javanica and M. acrita and they were mostly found together, reproducing in the same plant roots. In Gediz Valley, Sultana vineyards were badly infested by M. incognita. Spinach was not a good host. The most spreaded root-knot nematodes, M. incognita followed by M. acrita and M. javanica, in order, were recorded in Izmir, Manisa, Aydin, Muğla and Denizli. M. hapla was present on begonias only in the ornamental plant research station in Izmir. M. arenaria was detected

in the vineyard at Menemen vineyard research station. Possibly the last two species could be foreign originated. Some varieties of cotton are grown in large scale in this region, although Meloidogyne spp. were not found except within a limited area in Aydin province. This species was considered under M. acrita group. Mandarin was very resistant to Meloidogyne spp., only few plants were found to be slightly infested by M. incognita in Azmir province. In this region more than 2/3 of the 138 populations studied were M. incognita (94 M. incognita and variants); 26 were M. acrita; 12 were M. javanica; 1 was M. hapla and 1 was M. arenaria.

4- Mediterrenean Sea Region:

In Antalya, Mersin, Adana and Hatay provinces citrus, mulberry, cotton, sesame, banana, many kinds of vegetables and fruits are grown. Cotton is one of the most important cash crops. It was resistant to all Meloidogyne species occurring in this area. In general, it is one of the susceptible plants could be infected by two, sometimes by three Meloidogyne species. Some vegetables were susceptible to M. incognita, M. javanica and M. acrita, while radish, a pepper variety, spinach, leek, cabbage, water-melon, carrot and lettuce were not. Figs, mul-berry and celery were susceptible to M. incognita. Olives, apricots, oranges and strawberry were resistant to all known Meloidogyne species of this area. M. hapla only infected radish. Bananas were susceptible especially to M. javanica and somewhat to M. acrita. Host differences were recorded between southern and northern M. incognita, where it infects pepper badly in the northern part of Turkey while the same variety was highly resistant to the same nematode species in the south. I think these should be different variants of M. incognita.

5- Microclimate Regions:

Central part of Turkey is at intermediate altitude, has small rainfall, summer is dry, winter is cold and snowy. Eastern region is at high altitude (about 1500 - 2300 m). Winter is very cold, summer is short and cool. This part of Turkey has the

heaviest snow. Both localities have microclimate plains where subtropical plants are grown. In the eastern and central microclimate regions M. hapla and M. incognita were found respectively.

According to this study the distribution of Meloidogyne spp. are influenced by the locality, and population density depends upon soil texture and host plants. M. incognita was dominant at all regions. In Marmara region, the most recorded root-knot nematode was M. incognita followed by M. arenaria. In dry regions, such as south and west of Turkey M. acrita poulations come after M. incognita. Meloidogyne acrita, M. incognita, M. javanica and M. thamesi are probably indigenous at all the localities. Some of the M. hapla and M. arenaria could be foreign originated.

Weeds are very important in maintaining and increasing root-knot nematode populations, unfortunately a little data have been obtained on the susceptibility of weeds in my country. Extensive surveys are necessary on weeds from the stand point of controlling Meloidogyne species. In some parts of Turkey most of the major crops have been surveyed but not completed.

Many chemical control works have been done on Meloidogyne spp. Usually the yield increased about 50% by the application of nematicides. According to the experimental results, in cabbage and tobacco growing areas, better results were obtained by exposing the root systems og these plants to wind and sun immediately after harvest and then by applying nematicides.

Some resistant varieties of vines, tomatoes and peaches were introduced from abroad and tested to M. javanica and M. incognita in Agean region. Only a vine cultivar was found highly resistant but the others were moderately resistant to these two species.

Disease complexes in cotton involving root-knot nematode (M. acrita) and cotton wilt disease (Verticillium dahlia) were

studied. A similar study has been going on banana, "The relationship between Fusarium wilt (Fusarium oxysporium) and M. javanica and Helicotylenchus muticinctus". Cotton wilt disease and root-knot nematode exist together, the destruction was much greater than when Virticillium dahlia occurs alone.

In the southern part of Turkey, especially in winter, tomatoes, cucumbers and peppers are grown in green-houses throughout the year except in August. In green-houses root-knot nematodes are important problem. Due to the recommendations obtained from the results of experiments, most of the growers raise their seedlings in fumigated seed beds or in clean soil and also dig green-house soil two times during the very hot days of August. This manipulation keeps the nematode population under economic destructive level. In addition to this integrated control method, nematicide application drops the nematode population level too low. But from the side of economic view it is not necessary. The growers easily accepted these integrated control recommendations because of its additive effect of yield and income.

In my contry, the efforts spended using our own possibilities to keep the root-knot nematodes under control still not satisfactory in suppressing their challenge to us and it keeps its important place as a pest and spreading year after year.

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8. Report on the status of root-knot nematodes Meloidogyne sp. in Iraq. — Zuhair A. Stephan.

Most of the economic crops have been surveyed for the last 10 years. These include citrus, tobacco, wheat, sugar cane, grape vines and tomatoes. Iraq as a subtropical country, its weather conditions are very favorable to the activity and survival of nematodes. The first nematology survey published by Al-Adhami (1955), reported only one species Meloidogyne javanica attacking 42 host plants. Al-Rawi (1974) identified Meloidogyne thamesi

from the roots of cucumber. Stephan (1968 - present) conducted a general survey to study the different species of Meloidogyne and their host range in Iraq. Two more species were reported, Meloidogyne arenaria and M. incognita. More over 29 new host plants were infected by the different species of the root-knot nematodes for the first time. This study also revealed that Meloidogyne javanica is the most widely distributed in Iraq, with a broad host range. This species was found to be one of the most destructive diseases on tomatoes, egg plants and tobacco. Recently, this species cause a severe damage to date palm tree at Um Qassir area in Basrah Province.

Research studies included chemical control of root-knot nematodes, citrus root nematodes and sugar-cane nematodes. Results concerning the use of nematicides against root-knot nematodes showed that, Ethylen dibromide and D - D mixture were very effective. DBCP, Nemacur and Furadan ranked next in effectiveness against this nematode on tomatoes and tobacco crops.

In Iraq, there are few trained nematologists (1 Ph.D., 2 M.Sc. and 3 B.Sc.). The major problems that can be considered on root-knot nematode are on vegetables, tobacco, sugar beet and date palm trees.

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9. Report on root-knot nematodes in Cyprus. — J. Philis.

Root-knot nematodes are considered as serious pests for Cyprus Agriculture. They are spreaded all over the island attacking many crops all the year round except in winter when soil temperatures are insufficient for nematode activity. The nematodes can be found in areas of intensive cropping regardless of soil type.

Soil and root samples collected occasionally from various places in the island revealed that Meloidogyne javanica is the most frequently occuring root-knot nematode. Attack by this

nematode was found to cause serious yield losses on tomato, eggplant, watermelon, okra, cucumber, beans, squash, tobacco, bananas, peaches and vines. Other species reported to have been found in Cyprus are M. arenaria and M. incognita.

Work carried out:

Experiments conducted since 1967 aiming at testing the effectiveness of several nematicides applied prior to planting showed that certain chemicals can control the nematode and increase yields.

The nematicide D-D at the rate of 385 liters/ha controlled the nematode M. javanica. in the soil and increased yield of eggplants (Solanum melongena) by 100 per cent over the untreated; The same nematicide at 165 liters/ha was not effective. Also, experiments for the control of M. javanica on tomato have shown that the nematicides EDB, D-D, Di-trapex and Terracur at the rates of 84, 375, 375 liters and 18 kg a.i./ha, respectively, resulted in remarkable yield increases. However, nematode population in soil and roots at the end of the growing season was not appreciably affected as compared to the untreated control. This indicates that the effect of nematicides is more pronounced in the early stages of plant growth. A trial conducted for the control of the root-knot nematode (M. javanica) on a newly established banana plantation has shown that DBCP (as Nemagon) applied as a drench in May and November at the rate of 67 liters a.i./ ha (per year) resulted in good nematode control and a 16 per cent increase in yield in the second year of application.

Also, work carried out for selecting high yielding tomato cultivars resistant to M. javanica have shown that the cultivars VFN-8, 70T82 and 72T51 planted in late spring in nematode-infested soil produced fruit commercially acceptable while nematode development on these cultivars was largely prevented. Nematode invasion and reproduction on the resistant plants was not, however, fully prevented. This, most probably, indicates the presence of resistance-breaking biotypes in the species. The yield performance of VFN-8 in non-fumigated soil compared favourably with that of Pearson in fumigated soil.

Major problems:

Considering the serious crop losses caused by root-knot nematodes in Cyprus and the need to solve problems usually prevailing to small land-owners, the following questions should draw most of our attention:

I. Rapid build-up of nematode populations after harvest, in soil treated prior planting.

II. Identification of species using keys other than those describing the perineal pattern.

III. Determination of biotypes.

IV. Use of nematode-resistant varieties in a wider range of crops. (Eggplant, okra, potato, beans, cucurbits, tobacco).

V. Natural control: (a) crop rotation, (b) fallow and (c) cultural practices.

VI. Use of granular nematicides, mostly of systemic action. Testing the efficiency of systemic nematicides in liquid form which could be applied safely as sprays at the b beginning of the growing season.

Important crops attacked by root-knot nematodes in Cyprus.

Crop	Area under cultivation (hectares)		Value of crop (1000's C)	
	1973	1976	1973	1976
Tomatoes	1.694	1.196	1.913	1.623
Egg plants	163	135	176	145
Watermelons	1.155	857	806	747
Other melons	612	339	446	342
Okra	75	102	136	138
Cucumbers	747	531	1.110	963
French beans	n.a.	763	292	222
Squashes	269	216	376	261
Vines (irrigated)	3.265	3.265	1.300	1.350
Tobacco	408	188	23	46
Bananas	88	136	374	495
Potatoes	8.841	8.433	4.992	18.072
Peaches	711	728	311	217
	18.028	16.886	12.255	24.621

1 C = 1.39 Sterling, n.a. = Not available.

References:

Philis, J. 1971. Control of root-knot and spiral nematodes on bananas in Cyprus. Pl. Dis. Reptr 55: 707 - 710.

Philis, J. 1971. Control of root-knot nematode (Meloidogyne javanica (Treub.) Chitw.) on eggplant by preplanting treatments. Phytopathologia Mediterranea 10: 117 - 119.

Philis, J. 1974. Chemical control of the root-knot nematode Meloidogyne javanica Treub. on tomato. Agric. Res. Inst. Cyprus, Technical paper, 4: 9p.

Philis, J. 1976. A list of plant parasitic nematodes in Cyprus. Nematologia Mediterranea 4: 171 - 174.

Philis, J. 1977. Resistance of tomato cultivars to the root-knot nematode Meloidogyne javanica in Cyprus. Nematologia Mediterranea 5: 39 - 44.

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10. Root-knot nematodes in the Sudan. — A. M. Yassin.

Species and distribution

Root-knot nematodes are among the most important tropical parasites. These are widely occurring in river silt along the Nile bank and also in light alluvial soils, e.g. of western and southern Sudan; but not under the Gezira heavy clay. They can infest many crop and weed plants but those severely affected are vegetables and tobacco. A total of 3 species are thus far identified, Meloidogyne arenaria, M. incognita and M. javanica, but the most economically important are the last two (Yassin, 1974). While M. javanica can inflict heavy damage, especially in tomato and tobacco, in the northern sector, M. incognita is more prevalent in the south, both on tomato and egg plant.

Economic importance

It is difficult to assess damage due to root-knot invasion under the existing system of peasant farming along the Nile bank. On the other hand, up to 70 - 100% of the tobacco and tomato plants in pilot farms around Zalingei, western Sudan, might be completely

devastated by M. javanica. Likewise, in southern Sudan, e.g. around the canning factory in Wau District, M. incognita is a limiting factor in the production of vegetables to supply the factory. In fact it was responsible for the failure of pilot experiments in the locality.

Possible control

The majority of investigations were undertaken on M. javanica in tomato, since it is the most important pest in this very popular and widely grown vegetable crop. The main lines along which control can be achieved are :-

(a) Cultivation of tomato under heavy clay: This is the most practicable means of control whenever possible.

(b) Use of resistant tomato lines: Extensive breeding work has been undertaken in tomato against the root-knot nematodes in many countries throughout the world, e.g. the USA, France, Italy, Holland and India. All of the 11 imported varieties tested by the author at the GRS were found to be highly resistant to the local race of M. javanica, but resistance of many of them degraded after 2 - 3 seasons of test (Table 1); perhaps due to the occurrence of various pathogenic races of M. javanica in the locality. Work is in progress to include other varieties e.g. from India.

(c) Crop rotation: This is very difficult to devise due to the polyphagous habit of the nematode.

(d) Chemical control: Several nematicides were found very effective in increasing tomato fruit yield and reducing M. javanica infestation according to tests undertaken by the author at a site at Wad Medani river bank during several seasons (Table 2). Nevertheless, such chemicals are expensive and rather hazardous to use under our existing peasant farming.

(e) Cultural practices: Deep ploughing, dry fallow, flooding of soil and organic amendments, as conventional cultural practices, can be useful.

Future lines of research

Not more than a few nematologists are at present engaged

Table 1. Performance of various tomato varieties towards the local race of *M. javanica* (Wad Medani).

The figures refer to mean root-knot index, 0 = No infestation; 1 - 3, 4 - 6 & 7 - 9 = mild, moderate and severe infestation respectively.

	1972/73	1973/74	1975/76
VFN - 8 (USA)	0	0	0
VFN - BUSH (USA)	0	1	2
Motubo (France)	0	0	3
Rossol (France)	0	0	4
Tiersol (France)	0	0	5
MON-144 (USA)	-	0	5
Romano NR (Holland)	-	-	5
Ronita (Italy)	0	0	6
Marsol (France)	0	0	6
GBN - 144 (USA)	-	0	7§
Anahu (USA)	0	-	-
Local (Gezira)	9§	9§	-

- = Not tested.

§ = Root function largely impaired, often wilted plants.

Table 2. Effect of selected nematicides against the local race of *Meloidogyne javanica* from the Gezira on the local variety of tomato.

	Treatments (1)	Mean yield (kg/plant)	Mean plant size in cm. (rad. x ht)	Root galling
1970-71	Terracur	0.66***	25 x 75	4.4**
	Methomyl 5% G	0.41**	27 x 72	2.5**
	DBCP	0.51**	21 x 68	6.3*
	Dazomet	0.39**	23 x 66	5.6*
	Thionazin	0.22	24 x 69	6.9
	Methomyl 90% wp	0.19	25 x 66	7.5
	Control	0.23	21 x 62	7.9
	S.E.	0.089		
1971-72 (Average of 2 plots)	Metham sodium	0.69**	21 x 55*	3.0**
	D - D	0.60*	19 x 44	2.5**
	Terracur	0.60*	21 x 53	3.0**
	DBCP	0.57*	18 x 47	4.0**
	Oxamyl	0.67**	18 x 48	5.6
	Methomyl 5% G	0.65**	19 x 51	5.0*
	Prophos	0.60*	18 x 45	5.0*
	Control	0.32	18 x 47	6.0
	S.E.	0.074		
1972-73	Metham sodium	0.33***	22 x 56**	1.0**
	Prophos	0.11**	15 x 38**	1.5**
	DBCP	0.15**	11 x 31	2.5*
	D - D	0.09**	13 x 35**	2.5*
	Methomyl 5% G	0.08**	8 x 25	2.0*
	Oxamyl	0.09	14 x 34*	2.6
	Terracur	0.06	12 x 32	2.8
	Control	0.04	9 x 27	2.8
	S.E.	0.028		

*, **, *** P = 0.05, 0.01 and 0.001 respectively,

(1) for dosage see the test.

nematological investigations throughout the country. It is therefore necessary that nematology research be supported by the supply of more funds, better transport, better equipments and the appointment of qualified staff. This is in order to tackle many of the yet untouched nematology problems, especially those of root-knot:

(1) Integrated control:
   (a) Rotation: Test of local crops or crop varieties for resistance to *M. javanica*.
   (b) Resistant test lines: Expansion of present tests to include other more recent lines and undertake routine and yearly tests.
   (c) Chemical: Extended use of modern nematicides.

(2) Mode of persistence of root-knot nematodes.

(3) Ecological behaviour, e.g. of *M. javanica* in relation to soil type: heavy clay viz. light river silt.

(4) Possible occurrence of biotypes.

References:

Yassin, A.M. (1974). Root-knot nematodes in the Sudan and their control. Nematologia Mediterranea 2: 103 - 112.

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11. Status of root-knot nematodes, *Meloidogyne* spp., in the Yemen Arabic Republic. — R. A. Sikora.

Introduction

The Yemen Arabic Republic covers an area of 135.000 Km^2 and is inhabited by 5 million people; 80 to 85 percent directly or indirectly concerned with agriculture. Approximately 88 percent of the total area in agricultural use is devoted to cerial production, mainly sorghum, millet, barley, wheat and maize, in their order of importance. The remaining 12 percent, is planted

to a wide variety of crops the most important being: legumes, cotton, vegetables, grapes, stone fruits, tobacco, coffee, potato, sesame, citrus, banana, sugarcane, catha and peanut (1, 2). The country can be divided into the following geographical zones: coastal plain, southern-western uplands, terraces, upland high plateaux, and the eastern uplands. the major soil types and crops grown in the five zones and the meteorological conditions existing in the areas are given in figures 1 and 2.

Nematology

There is a serious shortage of trained personnel in plant protection, particularly in nematology. Information therefore, on the presence and distribution of root-knot nematodes in the country is, for the most part, nonexistent. Experts working for various international agencies have conducted surveys for plant diseases and have reported the presence of root-knot nematodes on a number of crops (4, 5). An extensive survey covering all 5 zones was conducted in 1977 for the West German Agency for Technical Cooperation (GTZ). The information which follows has been taken largely from that survey (3).

Root-knot in Yemen

Species of Meloidogyne were found in 33 of the 110 fields sampled (Table 1). The isolates were identified using standard techniques in the Institut für Pflanzenkrankheiten in Bonn. A select number of populations and related ecological data were sent to the International Meloidogyne Project in North Carolina. Of the 33 root-knot populations examined the most common proved to be M. incognita (60%), followed by M. javanica (35%). Meloidogyne arenaria and M. hapla were not found in the samples taken. Root-knot larvae were found in a number of samples (5%) where galling was not observed e.g. coffee, apple and cotton.

The presence of root-knot in percent samples in the different geographical regions was as follows: coastal plains 57%, southern-western uplands 30%, terraces 10%, and upland high plateaux 3%. The highest levels of detection, and greatest crops losses were observed in the production areas located at low

FIGURE 1:

SOIL TYPES AND CROPS OF MAJOR AGRICULTURAL AREAS OF THE YEMEN ARABIC REPUBLIC

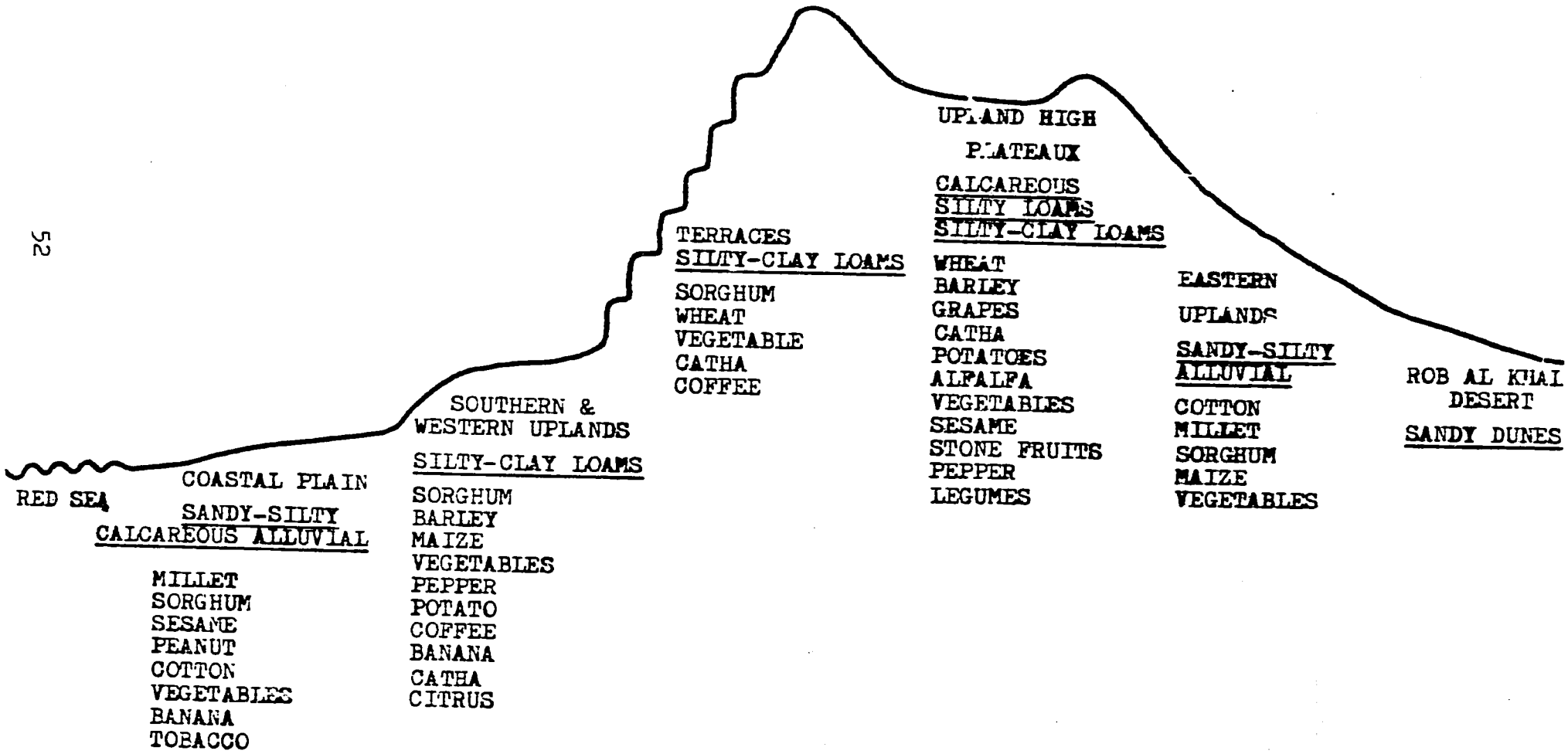

FIGURE 2:

ELEVATION, ANNUAL TEMPERATURE AND RAINFALL

IN THE YEMEN ARABIC REPUBLIC

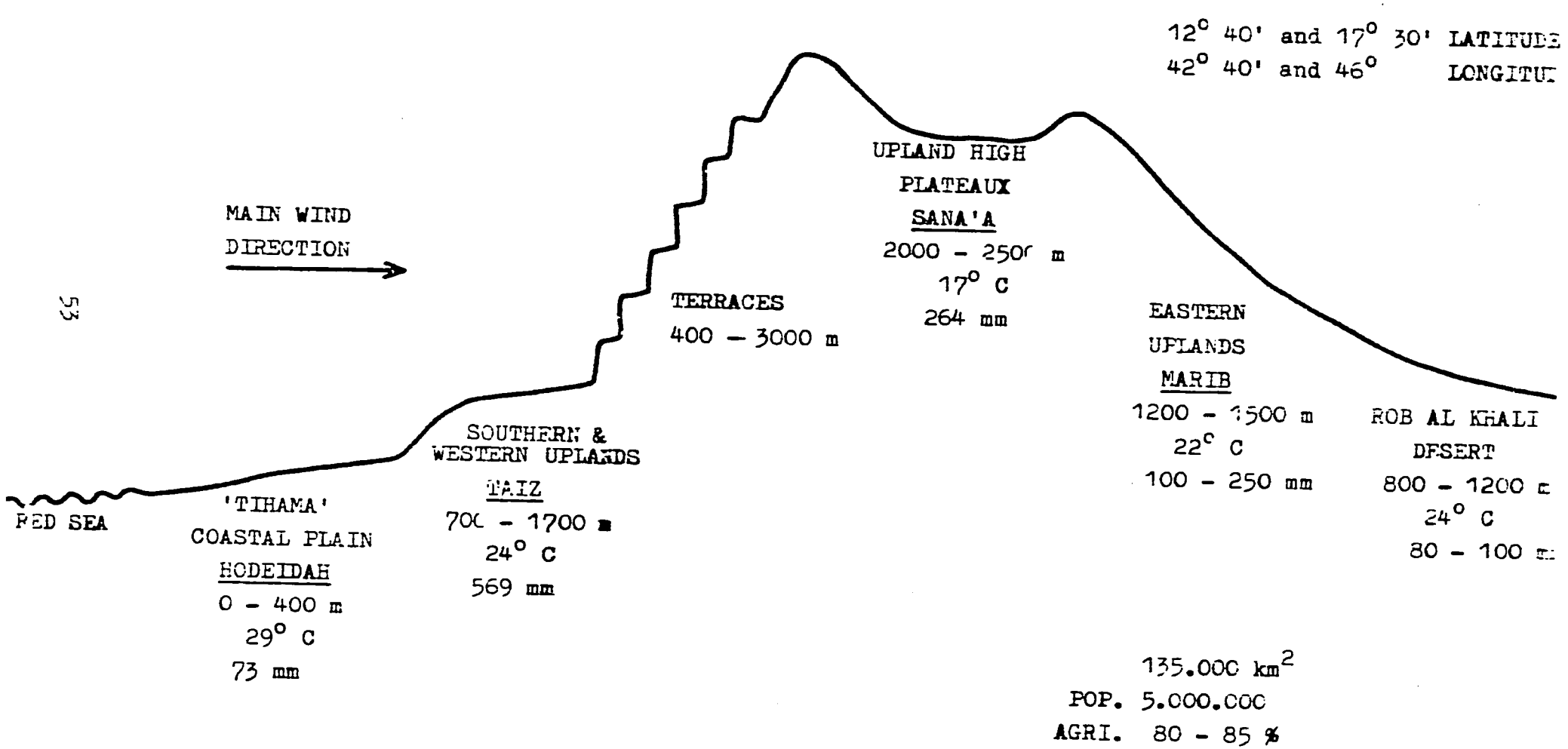

Table 1. Occurrence of plant-parasitic nematode genera and species from all 110 samples collected in Yemen.

Nematode	Frequency of occurrence	Percent of samples
Acrolaimus	1	0.9
Anguina tritici	1	0.9
Aphelenchoides	3	2.7
Aphelenchus	18	16.0
Criconemoides	5	4.5
Ditylenchus	2	1.8
Helicotylenchus	30	26.8
Hemicycliophora	4	3.6
Heterodera	3	2.7
Hoplolaimus	17	15.2
Longidorus	1	0.9
Meloidogyne	33	29.5
Paratylenchus	8	7.1
Pratylenchus	33	29.5
Psylenchus	1	0.9
Rotylenchulus reniformis	13	11.6
Scutellonema	3	2.7
Tetylenchus	1	0.9
Trichodorus	1	0.9
Tylenchorhynchus	33	29.5
Tylenchulus semipenetrans	12	10.7
Tylenchus	50	44.6
Xiphinema	3	2.7

elevations where high temperatures, sufficient rainfall, and multiple cropping in one year, favor root-knot build up.

Host range and economic importance

In table 2 the hosts known to be attacked by root-knot, as well as, the production area is presented. Severe damage has been observed on pepper, tometo, potato, squash, eggplant and banana. Tomato seed beds were often severely infested with both M. incognita and M. javanica; an important means of spread to adjacent uninfested fields. Overwatering, lack of sufficient fertilizers and other adverse factors in addition to severe M. incognita attack were responsible for heavy losses in banana production. There was a direct correlation between M. incognita population density and the presence of root-rotting fungi, notably Fusarium solani and Rhizoctonia sp. in the root system, in fields in an advanced state of decline.

Control

Nematode control is nonexistent mainly due to the lack of knowledge concerning the importance of root-knot nematodes to production. Present rotation systems which often include such non-host or poor host crops, as millet, sorghum and maize do give a certain amount of 'unintentional' control. In many cases, however, the practice of planting highly susceptible root-knot host plants in between the rows of these non-host crops has reduced its effectiveness in reducing the root-knot population. Nematicides are seldom seen on the market, and programs for the incorporation of resistant varieties into the production process have not yet been established.

Outlook

Root-knot nematodes will continue to be a problem until trained plant protection people are available. A Plant Protection Agency established in Sana'a by the West German Agency for Technical Cooperation together with the Yemen Ministry of Agriculture is presently training local agriculturalist for extension work in plant protection.

Table 2. Major crop plants, production area, and present *Meloidogyne* host status in the Arab Republic of Yemen.

Crop	Production area 1000 ha	Area in %	Host status
Cerials	1434	94.0	-
Legumes	40	2.0	-
Potato	4	0.3	+
Grapes	4	0.3	-
Dates	100000 Trees	-	-
Coffee	300000 Trees	-	+ 1/
Catha	8	0.6	-
Vegetables	8	0.6	+
Fruit	63	4.3	+ 1/
Tobacco	4	0.3	-
Cotton	12	12.0	+ 1/
Sesame	1	0.1	-
Banana	2	0.3	+
Eggplant	-	-	+
Squash	-	-	+

1/ Root-knot larvae detected, no galling observed.

References

1) Bartelink, A. 1974. Yemen Agricultural Handbook. Federal Agency for Economic Cooperation. Eschborn, Fed. Rep. of Germany, 75 pp.

2) Dequin, H.F.E. 1976. Arabische Republik Jemen. Riyadh, 251 pp.

3) Nienhaus, F. and R.A. Sikora 1977. Research Report I and II. Distribution and importance of plant parasitic nematodes and plant viruses in the Arabic Republic of Yemen. German Agency for Technical Cooperation, Eschborn, Fed. Rep. of Germany, 80 pp.

4) Vargas, L. 1974-75. Survey of plant diseases and recommendations in the field of plant pathology. UNDP/FAO Project Report Yemen 73/010. United Nations / Food and Agricultural Organization, Rome.

5) Watt, M.J. 1975. Technical Report UNDP/FAO Project Report Yemen 73/011. United Nations/Food and Agricultural Organization, Rome.

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12. The root-knot nematode in Saudi Arabia. — M.F.M. Eissa.

The cosmopolitan nematode pests of the genus Meloidogyne occur widely in S.A. They appear to be the most common nematode pests of the Kingdom. Root-knot diseases were reported in S.A. by Ayoub (1959), Natour (1963), Fatmi (1969), and Martin (1971). Since none of these investigators were trained nematologists, they did not identify the actual species, the species causing the observed symptoms.

My own observations suggest that the most species of economic plants are attacked by root-knot nematode in Saudi Arabia. Serious reduction in crop yield occur in vegetables, especially cucurbits, legumes and most solanaceous species. Grape-vines are also highly susceptible. Root-knot nematodes infect date-palm roots (without causing galls) and severely

attack peach and other stone-fruit trees and many ornamentals.

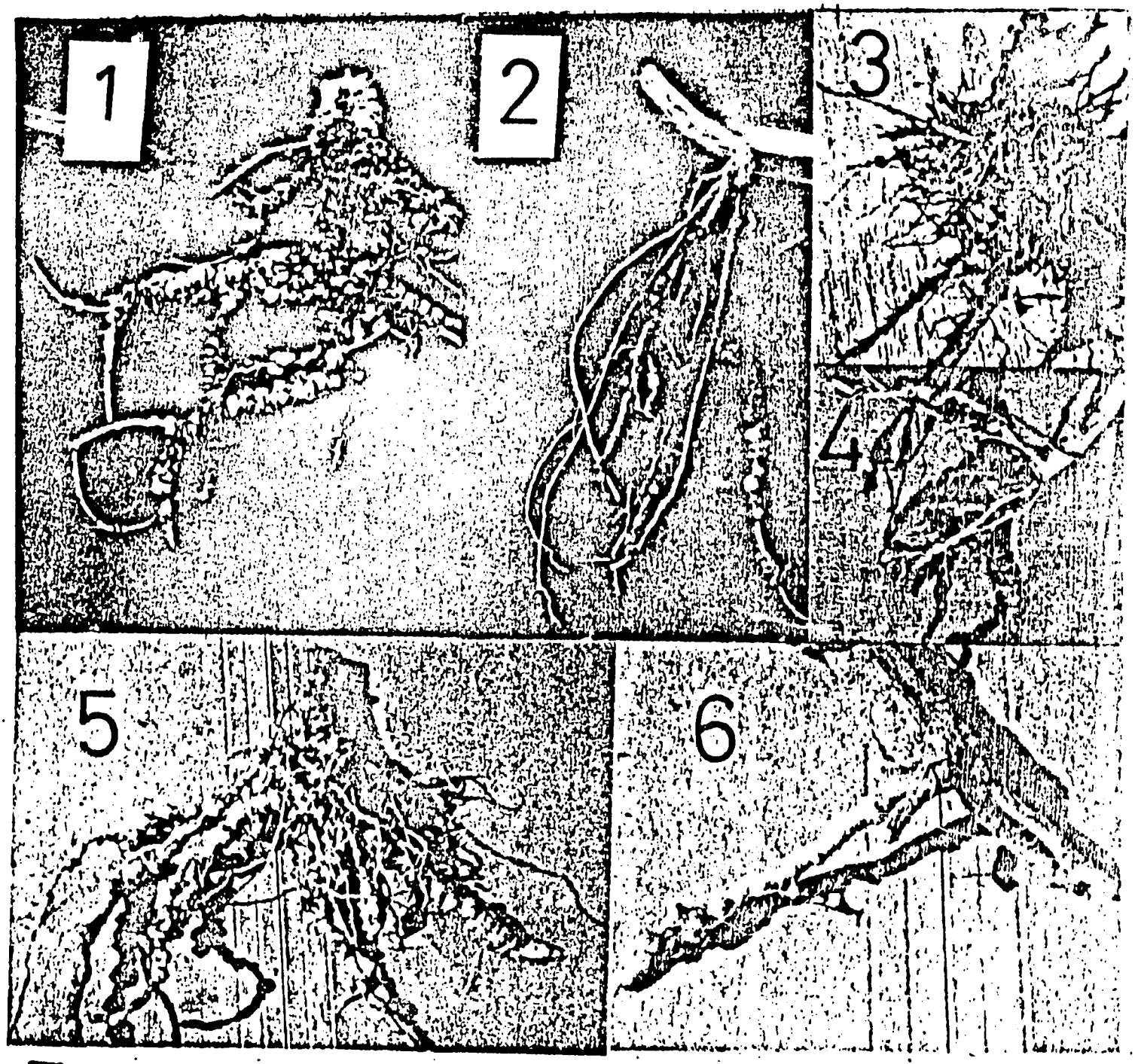
Soils in S.A. are mostly light and sandy, and favor reproduction of Meloidogyne species. The Environmental stresses associated with aridity and severe climatic conditions tend to increase the destruction caused by Meloidogyne infestations. The most Saudi soils are extremely low in organic matter; as a result, predators, microorganisms, and other natural enemies, of nematodes seldom are present in effective numbers.

Soil-plant water relationships affect both nematode populations and the degree of injury to plants caused by the pests. At higher altitudes, in the mountains in the western part of Daudi Arabia, crop gamage caused by root-knot nematodes tends to less severe because of higher rain fall and lower temperature. Maximum root-knot damage occurs in arid areas where crop production depends entirely upon irrigation. Excessive concentrations of soluble salts in irrigation water impose stresses on plants and thus increase the severity of nematode damage of those plants.

Inadequate water supply is the most important factor limiting agricultural production in Saudi Arabia and nearly all intensive farming depends upon irrigation water pumped from wells.

Farmers usually prefer to cultivate lands near the well inorder to avoid constructing drains and water channels to carry water for long distances. As a result, some lands remain under cultivation year after year. Under such traditional conditions good management practices, including proper crop rotation, are not practiced and nematode populations tend to reach high levels, endangering the production of the agricultural crops.

In short, plant-soil-water relationships need to be thoroughly studied in the irrigated desert agriculture practiced in Saudi Arabia. Evidence of the severe damage under S.A. arid conditions and nematode infested land, caused by nematodes is given by the photographs (Figures 1 - 7) showing symptoms of plant injury caused by the southern root-knot nematode, Meloidogyne incognita in some major Saudi crops.



Figures 1-7 shows root infestation with M.incognita on okra, beans, pepper, eggplant, tomato, squash and potato from Al-Kharj, Al Kharj, Dirab, Dirab, Qatif, Hofuf and Abha, respectively

Cultivars highly resistant to the root-knot nematodes would be the best hope of reducing crop losses if and when they are available. However, arid ecological conditions and other environmental stresses on growing plants, in addition to the newly produced "pathotypes" (Oostenbrink, 1971), may lessen inherited resistance of improved varieties; this is a subject that needs study in Saudi Arabia.

The multi-scientific-efforts of IMP personnel offers to us the hope of fruitful cooperative efforts on an International base for human welfare. Especially for countries where traditional agriculture still dominates, cooperation and technology may help avert the frightful starvation threatening the World's whole population in the next few decades.

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13. A note about Meloidogyne problems in Morocco. — M. Ammati.

Introduction

In Morocco, the agricultural income is mostly based on citrus and vegetable crops. Unfortunately, those crops are subject to serious diseases which is a problem for their intensification. Among the plant parasites, concerned, nematodes cause a great damage on vegetable crop areas. Some investigations were carried out about nematode surveys in many moraccan areas (Ritter and Scotto, 1976; Mc Donald, 1975). Other workers dealt with biological aspects of some nematodes such as Tylenchulus semipentrans (Vilardebo 1967), Heterodera rostochiensis (Schlüter 1975) and Ditylenchus dipsaci (Schlüter 1976, Schreiber 1977).

Until 1976, no research was done on Meloidogyne under Moroccan conditions, because of lack of specialists, thus the plant pathology department at Hassan II Institute, has designed a part of activities to plant nematology research as well as teaching.

The first attempts on Meloidogyne started on September 1977. these studies deal with the nematode fauna associated with Autumn tomatoes (grown from July to December) and spring tomatoes (grown from Jan. to June), along the atlantic coast.

I will present here the first results obtained and the research program for the coming years.

Materials and methods:

1- Location and type of crops

Surveys have been done on 3 different sites, in the coastal area of Mohammadia. Observations concerned the Autumn tomatoes, grown with local techniques. Samples were taken at the end of the growing season in soils where nematode susceptible varieties (Exhibition, Eclaireur (VR) and Canari) were grown.

2- Type of sampling

Samples were taken in the rhizosphere of tomatoes by a handle shovel at 20 cm depth. Each sample contains soil and roots of the plant under which it was taken.

3- Processing details

Nematodes are extracted from soil and roots by a method derivative of those described by Caveness and Jensen (1965) and Dalmasso (1966). Nematodes extracted in 5 ml volumes of final suspension were identified and counted.

Results:

Extraction results are given in numbers of free living nematodes per 100 g of soil and numbers of endoparasitic forms per 1 g of roots. Those results are given in Tables 1 and 2.

Discussion

The results figured on table 1, concerning measurments relative to larvae total length and "a" value suggest species closed to M. javanica and M. incognita (Chitwood, 1949). Pattern observations confirm M. javanica, especially in station 1. This will be accurately confirmed by the biological test and the biochemical analysis.

Table 1. Measurements taken on *Meloidogyne* larvae.

Location	Total length, μ	"a" value	"c" value	Stylet length, μ
Station I	390-450	21.8-27.3	7.59-9.05	13.0-13.75
Station II	400-475	23.5-28.0	7.50-10.0	12.5-13.75
Station III	400-417.5	24.2-30.27	7.04-10.0	13.25-14.5

$$\text{"a"} = \frac{\text{Total length}}{\text{Maximum diameter}}$$

$$\text{"c"} = \frac{\text{Total length}}{\text{Tail length}}$$

For all the larvae observed, the rectum is not dilated.

Table 2. Average of nematode populations observed in the three stations experimented.

Genus	Station I		Station II		Station III	
	A[§]	Frequency %	A[§]	Frequency %	A[§]	Frequency %
1) Soil:						
Meloidogyne, 2nd stage larvae	779	87	199	62	8	73
Heterodera	0	0	24	8	0	0
Tylenchorhynchus	42	96	72	79	3	73
Helicotylenchus	0	0	0	0	3	45
Pratylenchus	9	4	0	0	4	9
Paratylenchus	32	25	31	8	2	18
Ditylenchus	0	0	0	0	1	80
Aphelenchus	17	58	41	93	3	63
Tylenchus	19	75	25	62	1	64
Free living nematodes	303	100	376	100	38	100
Other dorylaimoids	0	0	18	45	1	50
2) Roots						
Meloidogyne						
- 2nd stage larvae	530	50	249	27	10	30
- Other stages	43	25	40	4	0	0
- Females	35	20	34	9	0	0
- Eggs	2851	58	1357	27	400	50
- Males	5	4	3	2	0	0
Heterodera, 2nd stage larvae	43	8	55	2	0	0

§, A: Soil: number of nematodes / 100 g of soil,
Roots: number of nematodes / g of roots.

Each number in the table is the average of samples taken as follows: Station I: 24 samples, Station II: 44 samples, Station III: 12 samples.

70% of the eighty samples processed contain the genus Meloidogyne (Table 2). This shows their importance in the 3 observed stations.

The amount of inoculum inoculum in the soil and roots varies from station to station. This variation could be due to differences in thetype of soil and agricultural practices. Heavy infestations were observed in station I and II, where tomato is grown yearly with potatoes as intermediate crop. This aids to mutiplication and conservation of the inoculum in the soil (Webster, 1972).

In station III, the infestation level of Meloidogyne is lower, because of pretreatment with D-D, (Dichloropropane - dichloropropene). Severe damages due to Fusarium oxysporum f.sp. lycopersici and Verticillium dahliae were noticed.

Meloidogyne Research Projec. in view:

We suggest for the coming years a program that can be summarized as follows:

- Identification of Meloidogyne species under Moroccan conditions
- Geographical distribution and major host crops of Meloidogyne.
- Effect of environmental conditions, with emphasis on the Meloidogyne.
- Determination of the economic injury level in different situations in order to justify treatments.
- Study the effect of crop rotations.
- Investigation of the interaction between root-knot nematodes and Fusarium or Verticillium wilts.
- Introduction of the resistant varieties and their test under moroccan conditions.

Acknowledgements:

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References

Chitwood, B.G. 1949. Root-knot nematodes. Part I - A revision of the genus Meloidogyne Goëldi, 1887. Proc. helm. Soc. Wash. 16: 90-104.

Dalmasso, A. 1971. Les Nématodes des cultures. Journées d'études et d'information ACTA-FNGPC 1971: 759 - 787.

Mc Donald. 1975. Summary of details and results of a survey for plant parasitic nematodes, US/AID, University of Minnesota, Project in Morocco, 2pp.

Ritter, M. and C. Scotto La Massès 1976. Nematodes associés à quelques cultures d'Afrique du Nord. Poljopr. Znan. Smotra 39: 617.

Schlüter, K. 1976. The potato cyst eelworm Heterodera rostochiensis Woll. in Morocco: its distribution and economic importance. Z. PflKrankh. PflSchutz 83: 401-406.

Schlüter, K. 1972. Premières obsevations sur la pourriture latérale du collet de la betterave sucrière. "Al-Awamia" Revue de la Recherche Agronomique Marocaine 43: 95-107.

Schreiber, E.R. 1976. Recherche sur Ditylenchus dipsaci Race géante sur fève (Vicia faba L.) au Maroc. Direction de la Recherche Agronomique: 10 pp.

Vilardeba, A. 1963. Etude sur Tylenchulus semipenetrans Cobb au Maroc. "Al-Awamia". Revue de la Recherche Agronomique Marocaine: 8: 1-24.

Webster, J.M. 1972. Economic Nematology. Academic Press. London and New York, 563 pp.

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14. State of knowledge concerning root-knot nematodes in Iran.

Hassan Mojtahedi.

Knowledge about the Phytonematodes is relatively new to Iran. The first Iranian with training in nematology graduated from England and returned to Iran in 1963. He wrote the first persian text on nematodes in 1968, established an independent research department within Ministry of Agriculture in 1970, and offered the first formal nematology course in 1970. Today, fortunately, there are seven well trained nematologists in the country, five of them assigned with the universities and two with the Ministry of Agriculture. Formal nematology courses are now offered in two major universities, and nematological research papers appear occasionally in Iranian Journal of Plant Pathology.

The earliest report on the presence of root-knot nematode was recorded by Sharif (Sharif, 1956 cited by Barooti, 1974). He observed galled roots of tomato in Ghasr Shirin and hinted that the causal agent to be Heterodera marioni. From the same area I have received root samples to be infected with Meloidogyne javanica. Later, in 1968, Omidwar reported that three root-knot nematode species namely, M. arenaria, M. hapla and M. incognita are widely distributed in the country (Omidwar, 1968). This report however, has not been fully substantiated by others.

Though M. incognita has been found in Shiraz (Abivardi, 1971); Gilan (Kheiri, 1972) and Isfahan (Barooti, 1974), but the other two species have not been reported from elswhere except Gilan (Kheiri, 1972). Sturhan, doing an extensive survey in the country, noted that M. javanica is present in Moghan (unpublished record). I have found the same nematode from Kermanshah, Isfahan and Kerman. As can be seen, this latter species has been collected more often than the previous three species.

Although few studies have been conducted on the chemical control of root-knot nematodes (Omidwar, 1968; Omidwar et al.,

1973; and Mojtahedi et al., 1976) however, the knowledge on the occurrence, biology, population dynamics and ecology of these nematodes is scanty (Omidwar et al., 1973; Barooti, 1974).

The major problem challanging researchers in Iran is the fact that the researchwork itself is not fully appriciated and its place in common life is not felt. There are however, few specific and urgent problems to be solved namely: difficulty of access to the literature and lack of experience of most of researchworkers in the area of taxonomy of the nematodes. It is refreshing to learn that the cooperation with IMP will have definit impact on resolving part of these two aforementioned problems.

Literature cited:

Abivardi, C. 1971. Studies on the effect of nine Iranian anti-helmintic plant extracts on the root-knot nematode Meloidogyne incognita. Plantpath. Z. 71: 300-308.

Barooti, S. 1974. Prevalence and host range of root-knot nematode Meloidogyne incognita in Isfahan area. Iranian J. Plant Path. 10: 33.

Kheiri, A. 1972. Plant parasitic nematodes (Tylenchida) from Iran. Biol. Jb. Dodonaea 40: 224-239.

Mojtahedi, H. and S. Barooti 1976. The chemical control of root-knot nematode in Isfahan. Iranian J. Plant Path. 12: 45-46.

Omidwar, A.M. 1968. Plant parasitic nematodes. Minist. Agric., Tehran, 192 pp. (In persian).

Omidwar, A.M. and M. Moosavi 1972. Reports of the results from experiments carried out in population dynamics of nematode attacking tobacco plants in Ahmed Gorub. Field Station Rasht. Published by Iranian Tobacco Company.

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EFFECT OF SOIL ENVIRONMENT ON ROOT-KNOT ACTIVITY AND DISTRIBUTION

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The soil environment is a constantly changing habitat of physical and chemical factors. Since they are also interrelated, it is difficult to relate nematode distribution, population levels, pathogenicity, etc., to any one factor. In addition to the general effects of soil temperature; soil moisture, soil aeration, soil texture and soil solution are important factors which should be given consideration in the ecology of nematodes (Stolzy and Van Gundy, 1968).

Simply stated, soil can be thought of as a three-phase model: solid, liquid and gas. The solids may be inorganic or organic. The liquid usually contains a variety of ions and gases. The gas phase is inversely proportional to the liquid phase. The solid inorganic phase is made up of sand, silt and clay particles and these may be mixed in varing degrees. Most studies in the soil have been to isolate various segments of the system and study them separately. The pest management approach for the future should approach the soil environment from a holistic point of view.

Soil moisture is an important factor because nematodes are dependent upon water for most of their activities. In moist soils (40-60% of field capacity) nematodes are active and move through the soil cavities in water films. In dry soils nematodes become inactive and go into anhydrobiosis or they may eventually die due to desiccation. In extremely wet soils nematodes often become inactive and may die because of lack of oxygen. Therefore, it is extremely difficult to separate soil texture from soil moisture and soil aeration.

The distribution of Meloidogyne spp. in agricultural soils in California (Siddiqui et al., 1973) and East Africa (Whithead, 1969) have been surveyed in some detail. In California M. hapla is distributed throughout the agricultural areas but has a tendency to be more common in the cooler coastal areas. Meloidogyne incognita and M. javanica are more commonly found in the hot interior valleys, while M. naasi and M. thamesi are found in cooler coastal and northern areas of California primarily restricted to barley and potatoes, respectively. In Africa, M. hapla was found in many areas of East Africa; it only flourished at high altitudes (6000 ft. and above). Meloidogyne javanica and M. incognita were restricted to areas below 6500 ft. This general pattern is typical of numerous other observations on the world-wide distribution of root-knot nematodes.

There are numerous observations and reports suggesting an association between soil type and distribution of root-knot species or the severity of disease expression caused by various root-knot species. Sasser (1954) has reported that infestations of M. incognita, M. incognita acrita and M. hapla are more severe in sandy loam soils than in the heavy clay soils of Eastern Maryland. In California, the root-knot nematodes are a major problem on the coarse textured soils of warm interior Imperial, Coachella, and San Joaquin Valleys and a relatively minor problem in the non-irrigated coastal fine-textured soils. In Arizona, the heaviest infestations of M. incognita acrita occur on the coarse texture soils (O'Bannon and Reynolds, 1961). On the other hand, Whitehead (1969) the relative frequencies of M. javanica and M. incognita in East Africa were not correlated with soil texture. Even though there are variable and conflicting observations, it generally appears that the various species of root-knot nematodes occur in a wide-range of soil types but that the damage to crop plants is often accentuated on sandy soils or sandy patches within a given field. Damage, particularly in the field situation, may, in part, be related to moisture stress experienced by infested plants on sandy soils. Therefore, distribution of a species and damage by a species as related to soil texture may be quite different. In detailed laboratory studies (Wallace, 1969) particle size had a significant effect

on the numbers of larvae hatching from egg sacs; highest numbers in fine sand (150 - 250 u) and lowest numbers in coarse sand (500 - 1000 u). Reproduction rate was highest in the coarse sand and invasion of roots was highest in fine sand. The moisture distribution in pore space is also important and closely related to soil texture. In general, maximum hatch of M. javanica occurs when most of the pores are emptied of water and corresponds to a stage of the moisture characteristic which is sometimes called field capacity (Wallace, 1966b, 1968b). The effects of moisture are also closely associated with aeration. Wallace (1968a) found a linear relationship between rate of hatch of M. javanica and oxygen concentration over a range of 5% O_2 to 20% O_2. No hatch occurred in the absence of oxygen.

Exposures of embryonated eggs to anaerobic conditions for short periods (1 week) appear to be lethal presumably from buildup of lactic acid within egg shell. At low oxygen levels, metabolic and movement activity of larvae is reduced and the subsequent infection rate is reduced. Continued low oxygen levels around larvae and females within plant roots caused correspondingly reduced growth and reproduction (Van Gundy and Stolzy, 1961; Van Gundy, et al., 1967). The effect of O_2 on invasion, movement and hatch of M. hapla in organic soil appears to be modified by the level of CO_2 present. Wong and Mai (1973) found the activity was not adversely affected at 10% CO_2 but was at 30% CO_2. High suction potentials directly or indirectly because of increased aeration induce high metabolic activity in M. javanica larvae causing them to be using up body reserves faster and thereby reduce their survival time in soil (Van Gundy, et al., 1967).

Root-knot nematode survival in fallow soil is variable depending on soil conditions, climate and life stage (eggs or larvae) of the nematode when adverse conditions arise. Martin (1967) in Southern Rhodesia found that M. javanica was not eradicated in weed-free soils after 51 months even though there was a gradual decline in infectivity. A number of other workers have studied the decline of various species of Meloidogyne in

fallow soils and have found that one growing season and one winter season decreased infection by root-knot and eliminated serious damage in succeeding susceptible crops. In studies by Van Gundy, et al. (1967), they found that some root-knot larvae found niches in the soil that favored their survival and reduced their physiological aging. A factor which favored such survival was reduced aeration which may commonly occur in micro niches. Recent studies by Towson (1977) suggest that some root-knot larvae of M. javanica may survive best in soils with a soil moisture condition of 1.1 bars suction. These nematodes appeared to be in the survival state referred to as anhydrobiosis. Recent work in Senegal by Demeure (1976) suggests that Meloidogyne populations decrease rapidly in soil under clean fallow during the dry season but were not erradicated through one season particularly at the 20 - 40 cm depth. The persistance of the Meloidogyne populations was attributed to the survival of eggs and perhaps juveniles enclosed in gelatinous egg masses that tolerated the dry soil conditions. The horizontal and vertical movements of Meloidogyne javanica have been studied by Port (1976) in Senegal. He found that M. javanica larvae were able to move 75 cm vertically and 50 cm horizontally from tomato roots and penetrate in large numbers. Susceptible varieties exerted a greater attraction than a resistant variety. This may account for many examples of root-knot infections in surface soils apparently free of root-knot larvae.

Literature cited:

Bergeson, G.B. 1959. The influence of temperature on the survival of some species of the genus Meloidogyne, in the absence of a host. Nematologica 4: 344 - 354.

Demeure, Y. 1976. Persistance de l'infestation d'un sol par Meloidogyne sp. en saison seche au Senegal. Cah. ORSTOM, ser. Biol. Vol. XI (No. 3): 167 - 172.

Martin, G.C. 1967. Longevity of Meloidogyne javanica under conditions of bare fallow in Rhodesia. Rhod. Agric. J. 64: 112 - 114.

O'Bannon, J.H. and H.W. Reynolds 1961. Root-knot nematode damage and cotton yields in relation to certain soil properties. Soil Sci. 92: 384 - 386.

Port, J.C. 1976. Amplitude et cinetique des migrations du nematode Meloidogyne javanica sous l'influence d'un plant de tomate. Cah. ORSTOM, ser. Biol. Vol. XI (n° 3): 157-166.

Sasser, J.N. 1954. Identification and host-parasite relationships of certain root-knot nematodes (Meloidogyne sp.). Univ. Md; Agric. Exp. St. Bull. A - 77.

Siddiqui, I.A., S.A. Sher and A.M. French. 1973. Distribution of plant parasitic nematodes in California. Dept. Food and Agric., Sacramento, CA, 324 pp.

Stolzy, L.H. and S.D. Van Gundy. 1968. The soil as an environment for microflora and microfauna. Phytopathology 58: 889 - 899.

Towson, A.J. 1977. Survival of Meloidogyne javanica in a desiccated soil. Ph.D. Thesis. Univ. Hawaii. 63 pp.

Van Gundy, S.D., A.F. Bird and H.R. Wallace. 1967. Aging and starvation in larvae of Meloidogyne javanica and Tylenchulus semipenetrans. Phytopathology 57: 559 - 571.

Van Gundy, S.D. and L.H. Stolzy. 1961. Influence of soil oxygen concentrations on the development of Meloidogyne javanica. Science 134: 665 - 666.

Wallace, H.R. 1968a. The influence of aeration on survival and hatch of Meloidogyne javanica. Nematologica 14: 223 - 230.

Wallace, H.R. 1968b. The influence of soil moisture on survival and hatch of Meloidogyne javanica. Nematologica 14: 231 - 242.

Wallace, H.R. 1969. The influence of nematode numbers and of soil particle size, nutrients and temperature on the reproduction of Meloidogyne javanica. Nematologica 15: 55 - 64.

Whitehead, A.G. 1969. The distribution of root-knot nematodes (Meloidogyne spp.) in tropical Africa. Nematologica 15: 315 - 333.

Wong, T.K. and W.F. Mai. 1973. *Meloidogyne hapla* in organic soil: effects of environment on hatch, movement, and root invasion. J. Nematol. 5: 130-138.

ROOT-KNOT NEMATODES IN ITALY

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Five species of the root-knot nematode Meloidogyne Goeldi have been found attacking cultivated plants in Italy.

The commonest species is M. incognita (Kofoid et White) Chitwood which is distributed through all the country and which causes remarkable crop losses on some fruit trees (as peach and olive) and on various vegetable, industrial and flower summer crops.

Among the most damaged cultures are undoubtedly tomato, cantaloupe and watermelon on which reduction in yields up to 50% have been observed. Attacks of these nematodes have caused in eggplant fields, in southern Italy, yield suppressions between 30 and 60%. Less destructive is M. incognita on pepper, never were observed crop losses higher than 15% with this species, probably because of the fact that the culture is planted early in March, when soil temperatures, below 15°C, are unfavourable to the development of the nematode. Complete destruction of oriental tobacco fields planted in late April or crop losses of over 80% of early May sown sugarbeet have been often encountered in heavily infested fields in southern Italy.

Other plants frequently attacked and severely affected are carnation, cucumber, celery, artichoke, carrot, garden beet, anemone and white clover.

Meloidogyne javanica (Treub) Chitwood is more widespread in the southern regions where attacks tomato, eggplant and carnation. A population of this nematode have been found damaging young citrus seedlings in a nursery bed in Sicily but it failed to reproduce on this host.

Meloidogyne arenaria (Neal) Chitwood and M. hapla Chitwood are rather rare. The first have been sometimes found on heavily galled roots of peach trees or on roots of tobacco and carnation

plants, while the second attacks mainly winter crops as carrot or potatoes. Damages caused by M. hapla have been often observed in plantations of actinidia in northern and southern Italy.

Finally, M. naasi Franklin resulted to be present in 17% of declining durum wheat fields sampled in southern Italy.

The wide polyphagy of the most important species of the root-knot nematode makes very difficult its control with cultural methods as rotations. The use of resistant varieties can be the most economical practices for the farmers. However, in many instances the available resistant varieties are not well accepted on the market. Therefore chemical control remains still a practical method to limit the damage caused by these destructive nematodes.

Fumigant nematicides containing 1,3 dichloropropene (1,3-D) as active ingredient are the most widely used and give excellent results when the soil to be treated is appropriately prepared.

Rates ranging from 200 to 300 l/ha of D-D or from 150 to 250 of Telone give usually economical control of root-knot nematodes on several annual crops. More difficult is the case in which perennials must be planted in infested soils, since an higher degree of control is required to avoid rapid reinfestation of plants which should give a profitable production for a number of years.

Doses as high as 2,000 l/ha of D-D have been sometimes applied in this situation and not always the results have been satisfactory.

Methyl bromide is a very efficient totipotent pesticide which gives excellent control of root-knot nematodes. However, it is rather expensive and sometimes arises problems of residues in edible parts of plants. Moreover, it cannot be used with some plants as Liliaceae and Caryophyllaceae which are very sensitive to bromine.

Bromine residues and phytoxicity problems can be encountered also in crops grown in soil treated with Ethylene dibromide (EDB). This chemical is as efficient as D-D in controlling the nematodes

and can substitute D-D when soil temperatures are too high for its application. EDB, in fact, is much less hydrolized than 1,3-D at high temperatures.

DBCP (1,2-dibromo-3-chloropropane) although effective in killing root-knot nematodes is very little used in preplanting treatments since better results can be achieved with less expensive nematicides as 1,3-D or EDB. Its dispersion in the soil requires abundant irrigations and it is greatly affected by the content of organic matter in the soil. As a curative treatment DBCP does not give, against Meloidogyne, economically acceptable results, since it would not penetrate the infested roots to kill the endoparasitic stages of the nematode.

Limiting factor of Dazomet are its persistant phytoxicity, for which a long interval is needed before treatment and planting, and the necessity of a high soil humidity to be effective. When applied in winter crops in suitable environmental conditions gives very satisfactory results.

The nematicidal activity of Metham is rather modest as unsatisfactory is, usually, the control of root-knot nematodes with application of thionazin.

Among the chemicals of more recent formulation the systemic aldicarb has proved in different situations to be effective against Meloidogyne spp. However, a large use of it might imply problems of residues, having two very persistent metabolites: sufoxyde and sulfone.

Much less persitent than aldicarb is carbofuran which, conversely, is also less effective against root-knot nematodes and can be toxic to some crops when used in alcaline soils.

Another carbamate oxime is oxamyl, actually more efficient in its liquid formulations than the granular. In fact, the granules applied to the soil rapidly decomposed in warmer climates, while the emulsion sprayed on leaves is basipetally translocated in the roots where can prevent nematode infestations for two to three weeks.

The granular formulation of the organo-phosphate phenamiphos gives outstanding control of Meloidogyne spp. The results with it obtained, usually, compete with those obtainable with soil fumigants. Its persistence is high also in warm climates.

Very little persistent is ethotrop, a non systemic nematicide which, when applied at optimal time to prevent root-invasion by the second stage juveniles of Meloidogyne performs satisfactorily.

Steam sterilization of the soil gives an excellent control of root-knot nematodes, however, it is costly, unpractical because of the equipment it requires, and can be efficiently adopted only on limited surfaces as green-houses or plots with very intensive high cash cultivations.

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GUIDELINES FOR CONDUCTING DIFFERENTIAL HOST TESTS

FOR MELOIDOGYNE SPECIES

I. Collecting Root-knot Nematode Populations

Field populations are intiated by collecting soil samples from a Meloidogyne infested field or collecting 30 egg masses from infected plants from different sections of the field. Root-knot susceptible tomatoes (3-week-old) are transplanted into infested soil or are inoculated with the egg masses for increasing the population for the host test.

II. Culturing of Nematode Populations

Root-knot nematodes are easily maintained and propagated on a susceptible tomato, Lycopersicon esculentum Mill., cultivar such as Rutgers. Populations usually need to be subcultured approximately every 2 to 3 months by inoculating new tomatoes with 15 egg masses each. Usually three plants for each population will suffice. Plastic-coated wire screen splash guards around each pot will help to reduce contamination. Pots should not be crowded on the bench. Tomato plants do best with abundant sunlight, daily watering and biweekly fertilizing with a water soluble complete fertilizer.

III. Preparation of Inoculum

A. Materials required:

1. Clorox (5.25% NaOCl) or similar strength commercial sodium hypochlorite solution.
2. 200-mesh and 500-mesh 3-inch Tyler sives, standard height and stainles steel.
   (Manufacturer) W.S. Tyler, Inc.
   Screening Division,
   Menton, Ohio U.S.A. 44060.
   Approximate cost: 500-mesh, $35.00; 200-mesh, $21.00.
3. 500 ml jar or similar container with large orifice and tight seal.

B. **Reference:**

Hussey, R.S. and K.R. Barker. 1973. A comparison of methods of collecting inocula of Meloidogyne spp., including a new technique. Plant Disease Reporter 57: 1025 - 1028.

C. **Procedure:**

1. Wash soil from galled roots of a plant harvested a minimum of 45 days after inoculation. If older plants are used, make sure roots are not in an advanced stage of deterioration. Eggs from roots of an older plant will be less uniform in development than if a younger plant is used.
2. Excise roots and wash well. Cleaner the root system, the easier it will be to collect the eggs by the sieving process. If root system is large, process only half at a time.
3. Prepare a 10% Clorox solution (0.525% sodium hypochlorite) by adding 20 ml of Clorox to 180 ml of tap water.
4. Place washed roots in jar, add 200 ml of the NaOCl solution and seal top. Vigorously shake jar manually for 4 minutes. Do not expose the eggs to the NaOCl solution any longer than 4 minutes.
5. After shaking, quickly pass the NaOCl solution through two sieves, a 200-mesh sieve nested in a 500-mesh sieve. Once original NaOCl solution has been sieved, fill jar containing the roots with water and set aside. After the NaOCl solution has passed through the sieves remove the 200-mesh sieve and hold the 500-mesh sieve (containing eggs) under a slow stream of cold tap water to remove residual NaOCl. Rinse eggs from 500-mesh sieve into a 2-liter flask.
6. Rinse the roots at least twice with water to remove additional eggs and collect eggs by sieving as described. If you intend to collect eggs of two Meloidogyne species, sterilize all equipment in very hot water between collections.

7. For determining the concentration of eggs per milliliter, remove three 1-ml samples, count the eggs, and use the average to represent the number of eggs per milliliter. Representative 1-ml samples are obtained best by blowing air through the pipette into the egg suspension for a few seconds prior to removing sample. Finally, adjusting the volume of water to make 1000 per ml will simplify the dispensing of eggs.

III. Differential Host Test

Seedlings of tomato (Rutgers), tobacco (NC95), pepper (California Wonder), peanuts (Florrunner), watermelon (Charleston Gray), cotton (DeltaPine 16) should be transplanted into 4" pots with 3 replications. Two additional replicates of tomato should be included for use in determining when the test should be terminated. Also, one or two noninoculated tomatoes planted in the sterilized soil will serve to check for any possible soil contamination with root-knot nematodes. Sterilized sandy loam soil mixed 1 : 1 with quartz sand (35 mesh) makes an excellent soil medium for the nematodes and plants. A soil mixture of this type is good for most nematode studies.

After determining the number of eggs per ml (see above), plants can be inoculated. Plants are to be inoculated at the time of transplanting with 10,000 eggs / pot. Eggs are added to a depression in the soil at the time of transplanting. Eggs can be dispensed easily and accurately by using a calibrated pipetter (10 ml volume) attached to a 2-liter flask. Since the flask is tilted back to fill the pipet head to designated volume, eggs are easily kept in suspension. Eggs are dispensed when flask is tilted forward.

CAUTION: KEEP WEEDS OUT OF THE POTS. Most weeds can be infected by one or more root-knot nematode species. Infected roots of weeds can easily be mistaken for roots of a differential host and result in a positive rating when rating should be negative.

IV. Termination of Test and Rating of Root System

Since temperature will have an effect on the development of the root-knot nematode, the duration of the test will vary slightly depending on the temperature at which test was conducted. Ratings for gall number and egg mass number should be made 50 days after inoculation if grown within a temperature range of 24° to 30° C.

If the temperature is significantly below this, the duration of the experiment should be lengthened to 55 days and if the temperature is significantly above 24° to 30° C, the duration of the experiment should be shortened to 45 days. Additional replicates of tomato, which could be sacrificed should be included. These could be examined to determine if time and temperature conditions have allowed maturation of the egg masses (light brown color). Root systems with a very light infection may be stained by incubating roots in an aqueous solution of Phloxine B (.15 gm/liter tap water) for 15 minutes to emphasise egg masses. Be sure galled roots are not responsible for any low ratings.

The egg mass and gall ratings should be made according to the following scale:

0 = 0, 1 = 1 - 2, 2 = 3 - 10, 3 = 11 - 30, 4 = 31 - 100, and 5 = greater than 100 galls or egg masses.

Since field populations are used in these experiments, it is possible that a mixture of *Meloidogyne* species may have been collected. If a mixed population was used it will be evident after conducting the host range study. Usually all of the plants will be infected. If this happens, egg masses must be collected from the appropriate hosts and put on tomato to build up population for retesting on the differential hosts.

After rating of root system, compare results with data on table below. If host reactions seem to be unusual, save root systems. From unusual hosts for that particular species (assuming a single root-knot nematode species is involved),

put galls in lactophenol for making perineal patterns later. Also, a composite of egg masses, 25-50, should be collected and put in moist sterilized soil in double plastic bags and stored in the incubator (14°C). Additional egg masses should be collected for inoculating 3 tomato plants (15 egg masses each).

VI. Usual Response of Differential Hosts to the Four Common Meloidogyne Species.

Meloidogyne species	Differential Hosts[1]					
	Tobacco	Cotton	Pepper	Watermelon	Peanut	Tomato
M. incognita	$\boxed{-}$[2] (+)[3]	$\boxed{+}$ (-)	+	+	-	+
M. javanica	+	-	$\boxed{-}$	+	-	+
M. hapla	+	-	+	$\boxed{-}$	$\boxed{+}$	+
M. arenaria	+	-	+	+	$\boxed{+}$ (-)	+

[1] Plant varieties include: Tobacco, NC95; Cotton, DeltaPine 16; Pepper, California Wonder; Watermelon, Charleston Gray; Peanut, Florrunner; Tomato, Rutgers.

[2] Indicates key differentials for that species.

[3] Some populations attack the differential host while others do not.

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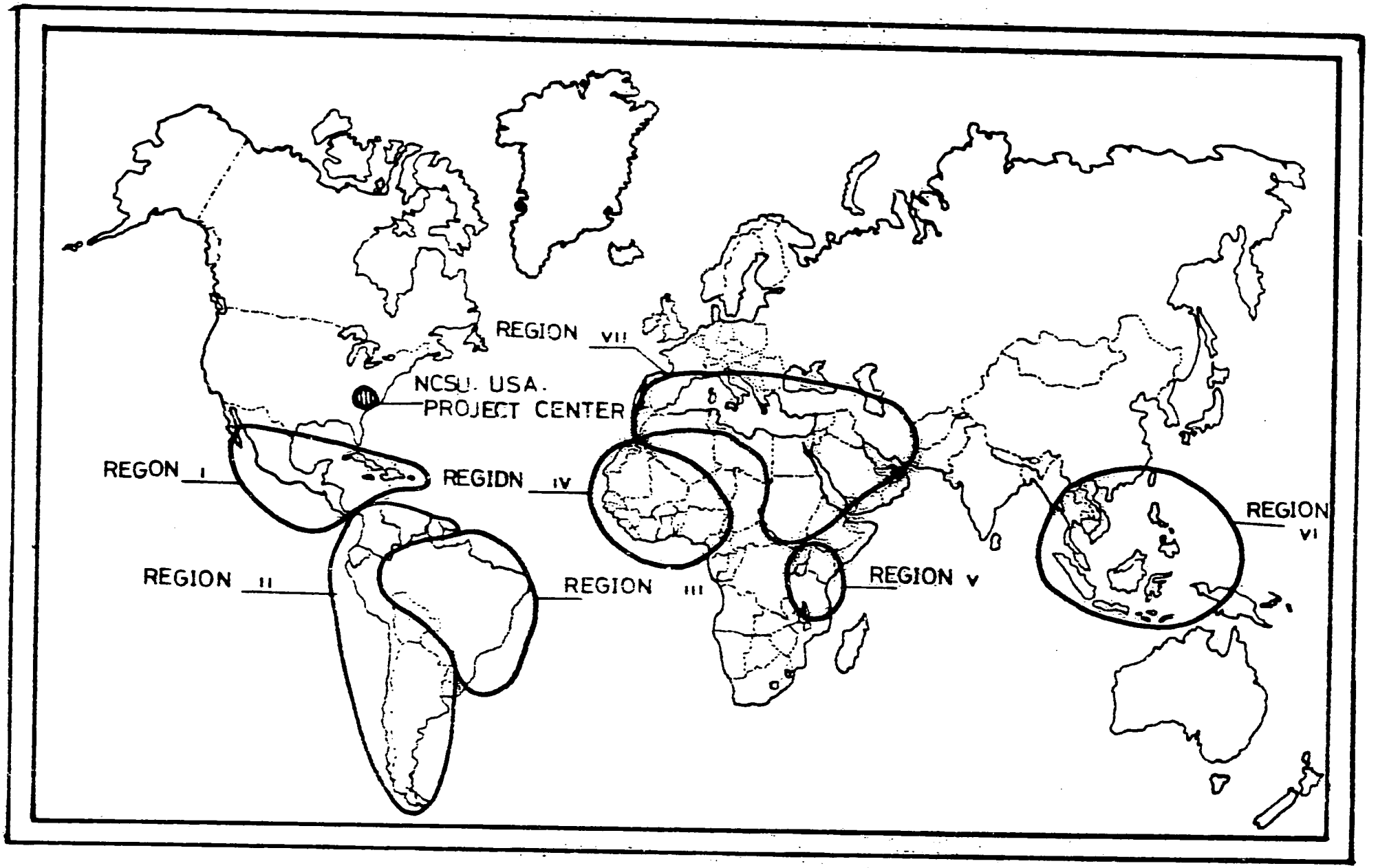

THE SEVEN INTERNATIONAL MELOIDOGYNE PROGRAM REGIONS

INTERNATIONAL MELOIDOGYNE PROJECT

CONTRACT AID NO. TA-C- 1234

C E R T I F I C A T E

The board of the Regional Planning Conference declars hereby

that From

has attended the lectures, presented report, taken part in discussions and made valuable contributions to the Regional Planning Conference on Root-knot Nematodes for the Near East, held in Cairo, Egypt, from January 29th to February 2nd, 1978.

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Signed and delivered on the 2nd day of February 1978, at Cairo, Egypt.

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