PN-AAW-414

Technical Information Bulletin 8

Parasitic Nematodes of Potatoes

Parviz Jatala

Nematode larvae (50x)

INTERNATIONAL POTATO CENTER (CIP)

Lima, Peru
1986

Technical Information Bulletin 8

Parasitic Nematodes of Potatoes

Parviz Jatala

International Potato Center
P.O. Box 5969
Lima, Peru

Tel. 366920
Telex 25672 PE
Cable CIPAPA-Lima

CIP authorizes non-commercial reproduction of this bulletin

Parasitic Nematodes of Potatoes

Objectives. Study of this bulletin should enable you to:

- describe nematodes in general and potato nematodes in particular,
- list the distribution of important potato nematodes,
- describe symptoms and damage of the most important potato nematodes,
- explain morphology and biology of a typical potato nematode,
- specify factors influencing severity of nematode infestation,
- explain how to monitor nematode infestations,
- discuss prevention and control.

Study materials

- Plants, particularly potato plants, with nematode damage.
- Illustrations of potato infecting nematodes and their damage.

Practicals

- Observe and discuss nematode damage, dissemination and nematode management in the field.

Questionnaire

1 What are nematodes?

2 Can you see nematodes with the unaided eye?

3 Where do nematodes live?

4 What harm does the majority of nematodes do?

5 How many species are important in potato?

6 What major symptoms do nematodes cause in potatoes?

7 How can you identify nematodes?

8 What is the shape and size of potato nematodes?

9 What is a main characteristic of plant-parasitic nematodes?

10 Describe a generalized life cycle of potato-parasitic nematodes.

11 Based on feeding habits, how can plant nematodes generally be grouped?

12 What are the most significant factors influencing nematode severity?

13 How does moisture influence nematode populations?

14 How can nematode infestation be monitored?

15 What effect has field infestation on potato seed production?

16 What are the principal methods of prevention and control?

17 What are the limitations of crop rotation for nematode control?

18 How may fallow and plowing affect nematode populations?

19 What is the principle of sanitation?

20 Discuss advantages and disadvantages of chemical control.

21 Describe the principle of integrated control or nematode management.

CIP authorizes non-commercial reproduction of this bulletin

Parasitic Nematodes of Potatoes

1 Importance of nematodes
2 Species, distribution
3 Symptoms, damage
4 Morphology
5 Biology
6 Soil factors affecting nematodes
7 Monitoring nematode infestation
8 Prevention and control
9 Additional study

Nematodes are unsegmented thread or round-worms of microscopic size. Their habitats are mainly soil and water. Thousands of species have no pathological importance but several species cause damage to potatoes.

1 IMPORTANCE OF NEMATODES

Nematodes are one of the most important groups of organisms that inhabit the soil about the roots of plants and frequently play a vital part in plant growth and production. *Threadworms* and *roundworms* are often used as common descriptive names for nematode parasites of vertebrates while *eelworms* is applied to freeliving and plant parasitic nematode species.

The several species of nematodes that damage potatoes may cause yield reduction of as much as 20 %. Besides direct yield losses some nematodes affect tuber quality. Infected tubers are unmarketable and undesirable for human consumption. If used as seed, infected tubers may be an inoculum source and spread the nematodes. Eggs of some species remain viable in soil for many years. Some nematodes are virus vectors, others interact with pathogenic agents to cause disease complexes. They can also affect the resistance of plants to other pathogens.

2 SPECIES, DISTRIBUTION

More than 40 nematode species infect potatoes but only a few are of major importance. Most of these damage-causing nematodes are distributed throughout the world and have a relatively wide host range.

Principal nematode pests of the cultivated potatoes in the world

Scientific name	Common name	Climatological distribution*			
Globodera pallida	Potato cyst nematode		C	s	T
Globodera rostochiensis	Golden nematode or Potato cyst nematode		C	s	T
Meloidogyne spp.	Root-knot nematodes	H	C	S	T
Nacobbus aberrans	False root-knot nematode	h	C		T
Pratylenchus spp.	Root-lesion nematodes	h	C	s	T
Ditylenchus destructor	Potato rot nematode				T
Ditylenchus dipsaci	Stem nematode		c		T
Longidorus spp.	Needle nematodes		c		t
Paratrichodorus spp.	Stubby root nematodes		c		t
Trichodorus spp.	Stubby root nematodes		c		t
Xiphinema spp.	Dagger nematodes	h	c	s	t

*H = hot tropical; C = cool tropical; S = subtropical; T = temperate. Capital letters indicate greater importance and small letters less importance.

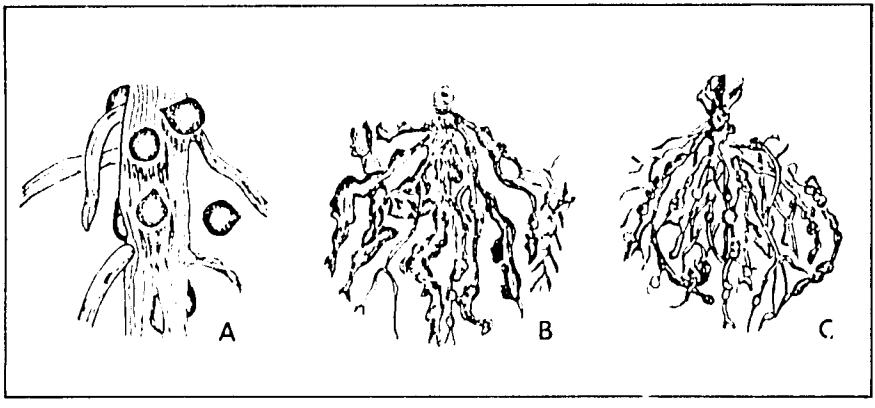
3 SYMPTOMS, DAMAGE

All potato nematodes feed on roots and/or tubers. Infected plants exhibit above-ground symptoms similar to those caused by root injury, fertilizer deficiency and lack of vigor with reduced efficiency to withstand drought. Below-ground symptoms of nematode damage and in most cases are typical for each nematode genus and aid in identifying the pests:

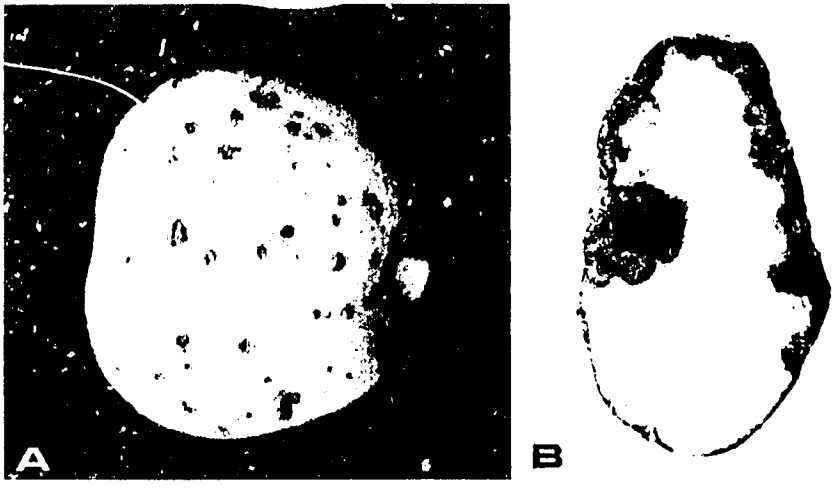
- Small (less than 1 mm), round, white, yellow females, or brown cysts represent maturing or mature females of *Globodera* species.
- Irregular root galls, usually combined with tuber deformations, are typical for *Meloidogyne* species.
- Chain-like root galls are formed by *Nacobbus aberrans*. They may be confused with symptoms caused by *Meloidogyne*.
- Necrotic lesions on roots and tubers may indicate presence of *Pratylenchus* species.
- Tuber tissue destruction that can best be described as dry, corky rot, is caused by *Ditylenchus destructor*.
- Stubby roots are induced by *Trichodorus* and *Paratrichodorus* species.

Longidorus and *Xiphinema* species do not cause characteristic symptoms on potatoes. Presence of these virus vectors may be detected by specific virus symptoms.

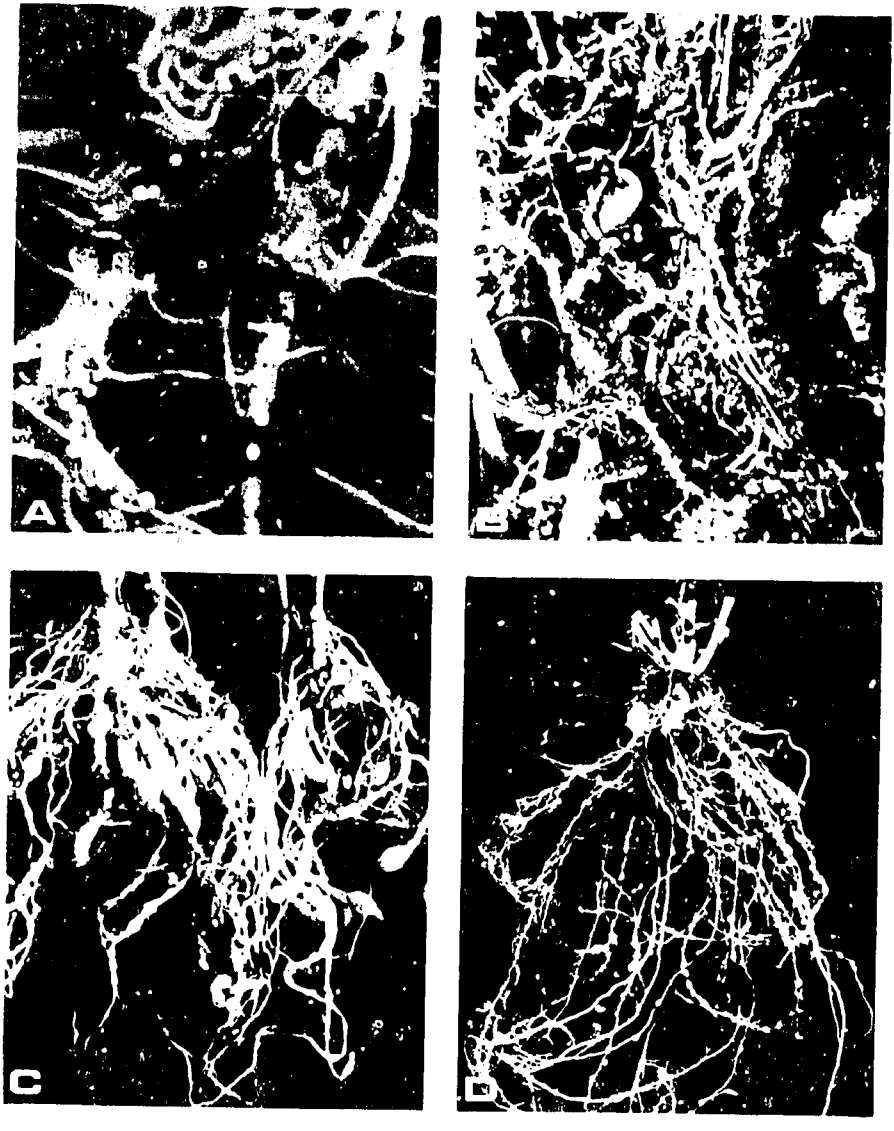
Nematodes are virtually invisible to the unaided eye. Trained persons using special equipment are needed to identify nematodes. It is advisable to send both roots of infected plants and samples of surrounding soil to specialized laboratories for nematode identification.



Small (less than 1 mm), round, white or yellow females, or brown cysts represent maturing or mature females of *Globodera pallida* and *G. rostochiensis* (A). Irregular root galls are typical for *Meloidogyne* species (B). Chain-like root galls are formed by *Nacobbus aberrans* (C).



Necrotic lesions may indicate presence of *Pratylenchus* species (A). Tuber tissue destruction that can best be described as dry, corky rot, is caused by *Ditylenchus destructor* (B).



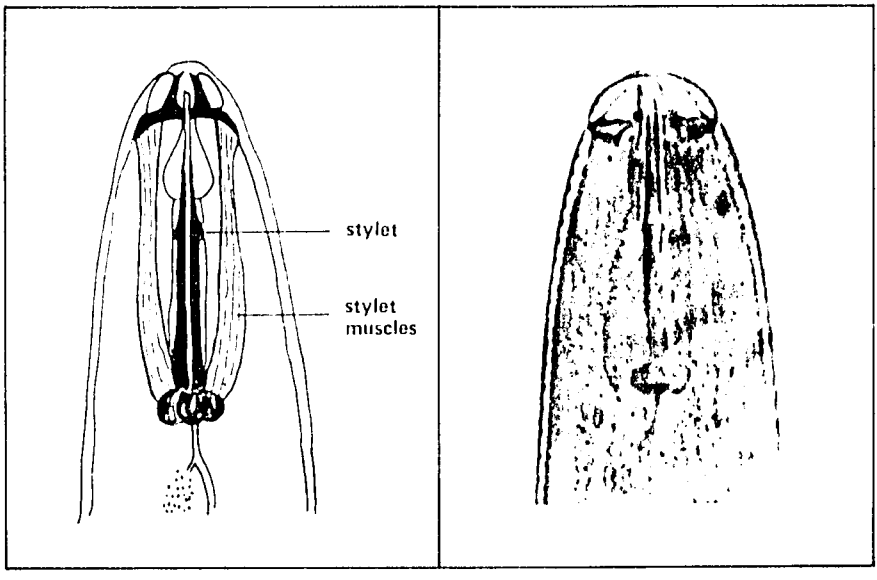
Below-ground symptoms of nematode damage in most cases are typical for each nematode genus and aid in identifying the pests: Small (less than 1 mm), round, white or yellow females, or brown cysts represent maturing or mature females of *Globodera pallida* (A) and *G. rostochiensis* (B). Irregular root galls are typical for *Meloidogyne* species (C). Chain-like root galls are formed by *Nacobbus aberrans* (D).

4 MORPHOLOGY

Nematodes, unsegmented thread or roundworms, have cylindrical bodies which may become fusiform or sac-like in shape upon maturity. Nematodes parasitizing potatoes range from 0.5 to 4 mm in length. They vary in width from 0.05 to 0.25 mm (50 - 250 μm). The nematode body is generally considered to be bilaterally symmetrical.

In general nematodes lack coloration and appear more or less transparent. There is no circulatory or respiratory system. Sexes are usually separate. In some genera pronounced sexual dimorphism occurs. The females of these genera enlarge to become a reproductive sac, whereas the male remains slender and worm-like. This is the case for sedentary parasites.

The main characteristic of plant-parasitic nematodes is the presence of a spear or stylet in the mouth region which is used for feeding. However, not all the nematodes having a stylet are plant parasites.



The spear or stylet in the mouth region is used for feeding.

5 BIOLOGY

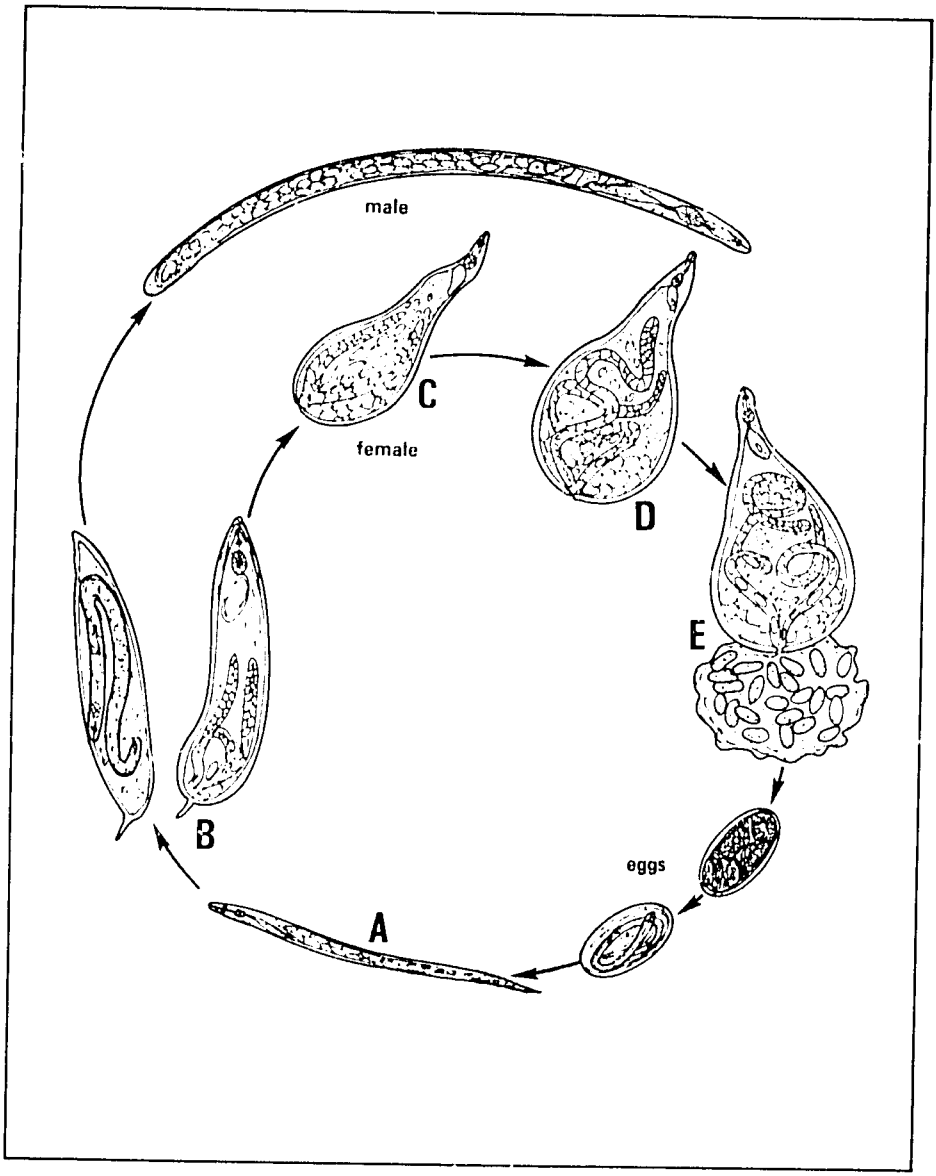
Potato-parasitic nematodes spend at least part of their life cycle in the soil. Since nematodes are basically aquatic animals, a film of moisture around them is absolutely necessary for survival. The generalized life cycle of potato-parasitic nematodes is simple. Females lay eggs that hatch into young nematodes called juveniles, which are much like adults in structure and appearance. During their growth and development larvae undergo a series of four molts. The period of growth between molts is called a larval stage. Some nematodes undergo the first molts while the larva is still within the egg shell.

Sex ratios are variable but for most cases it is about equal male and female. In a few species, however, males do not exist and in other species they are rare. In such cases female gonads produce both egg cells and sperm cells.

Based on feeding habits, plant nematodes are generally grouped into three categories:

- Ectoparasites that normally do not penetrate tissue (*Londigorus, Xiphinema* spp.).
- Semi-endoparasites that normally feed with the front part of the body buried in a plant root.
- Endoparasites that enter a plant root completely and feed for at least part of their life cycle with their entire body inside the root plant tissue. This is the common feeding habit for the most important potato nematodes such as *Globodera, Meloidogyne, Nacobbus, Ditylenchus* and *Pratylenchus* species.

Further subdivision in each of the three feeding habits include migratory and sedentary parasitism. As the name indicates, migratory parasites migrate freely in the roots while the sedentary parasites enter the roots and become sedentary after locating a suitable feeding site.



Development stages of root-knot nematode *Meloidogyne* sp.: second-stage larvae hatch from eggs and penetrate roots (A), larvae develop and sexes are differentiated (B), final molt (C), fully frown female (D), egg-laying female (E). First larval stage develops within egg shell.

6 SOIL FACTORS AFFECTING NEMATODES

Because nematodes are soil-borne, principal factors affecting their soil environment would directly and indirectly influence their severity. Most significant factors are:

- temperature,
- moisture,
- soil texture,
- aeration,
- soil chemistry.

Temperature. Temperature affects such nematode activities as hatching, reproduction, development and survival that would determine the establishment and parasitism. Temperature requirements vary with nematode species. Optimum temperature range for most plant nematodes is 15 to 30 °C.

Moisture. Fluctuation of soil moisture due to rainfall or irrigation is the chief factor influencing nematode population dynamics. Excess moisture results in a lack of oxygen and increase of anaerobic microorganism toxins. Lack of soil moisture and desiccation lead to inactivity and eventually death, unless there are special adaptation for survival as in the case of *Globodera* and *Nacobbus.*

Cysts of *Globodera* withstand desiccation and the eggs inside may survive for 20 years or more. Cysts are the main means of dissemination of *Globodera* species. Eggs, larvae and adults of *Nacobbus* and some other parasitic nematodes withstand desiccation and survive for long periods until favorable conditions stimulate their re-activity.

Soil texture. Speed of nematode activity and movement in soil to reach the host are related to soil porosity, soil particle size, thickness of the water film present, and relative activity of the nematode. Soil texture influences structure, a property of the soil concerned with the geometry of pore space. Therefore, a fine textured clay soil may impede root growth and penetration because of narrow pore spaces. It also can inhibit nematodes which require a minimum pore diameter of 0.02 mm for their movement in soil.

Aeration. Poor soil aeration decreases nematode survival and population density. This is particularly true for nematode survival in irrigated agricultural soils because oxygen supply drops to low levels during periods of flood irrigation.

Soil chemistry. Salinity, pH, organic matter, fertilizer, and biocides affect hatching and activity of nematodes.

Soil chemicals influence parasites either through the plants or other organisms, or directly. For example, nitrogenous compounds added to soil or their degradation products influence microorganisms and causes decrease of *Pratylenchus penetrans* populations. Similarly, application of sodium nitrate ($NaNO_3$) and ammonium nitrate (NH_4NO_3) to soil reduces hatching, penetration and development of cyst nematodes.

Other factors that influence plant growth also affect nematodes. In addition, plant resistance and weeds that harbor nematodes are directly related to nematode population increase and severity of damage.

7 MONITORING NEMATODE INFESTATION

High nematode population densities may seriously restrict potato production. Seed production in infested fields is not advisable because seed tubers themselves or soil clinging to tubers may be a means for nematode dissemination. Some legal regulations may permit certain levels of soil infestation by some nematodes. In general, however, infested fields must be excluded from seed production.

Direct field observation of roots and tubers during the growing season helps in estimating nematode presence or severity of damage. The best monitoring method is to sample soil and plant material prior to planting, during the growing season, and after harvest. Soil and plant material should be analyzed by experienced and competent nematologists or laboratories for nematode identification.

8 PREVENTION AND CONTROL

Several measures for preventing and controlling potato nematodes may be effective depending on local conditions.

Prevention and quarantine. Regulatory control of nematodes involves enforcement of quarantine to prevent introduction and spread of a particular plant nematode into areas known to be free of that species. This is only effective when the nature of the specific nematode is known and the regulations are enforced. Despite failures and shortcomings, regulatory action has undoubtedly reduced spread of some potato parasitic nematodes.

Crop rotation. Certain criteria are required for crop rotation to be effective. The nematode population density must be high enough to be potentially damaging, or to actually damage the primary crop. Knowledge of the nematode host range is essential. Nematode population density must be appreciably reduced by crop rotation so that the primary crop can be economically produced and the rotational crop must be adaptable and marketable. This method of control is therefore restricted to the parasites with limited host range such as *Globodera* species.

Fallow and plowing. Controlling nematodes by leaving fields fallowed or plowed is related to crop rotation. Desiccation, heat, and starvation reduce nematode populations. The disadvantages include absence of income and possible increase of soil erosion.

Sanitation. This is particularly important to prevent introduction of nematode infested plant material in areas where the nematode is not present. Avoid tuber production in infested areas and prevent nematode transport through contaminated soil, farm machinery, and tools. Nematodes may be carried on soil adhering to resistant tubers.

Physical control. Heat treatment of soil and hot water treatment of plants, electricity, radiation, and ultrasonics are used to physically control nematodes. However, these methods are effective only when used on a small scale such as in greenhouses and nurseries.

Resistance. Resistant varieties offer a promising method to control nematodes. Breeding programs involve development of lines resistant to a particular nematode and the released variety may be susceptible to other races of the same nematode. This control method has possibilities in combination with crop rotation and other controls.

Chemical control. Chemical control of nematodes is dependent upon bringing the toxic chemicals, termed *nematicides* into contact with the parasitic nematodes in concentrations high enough to kill them. Although this means of control is effective and widely used, working with chemicals is often difficult and hazardous for unskilled personnel. Chemicals must be applied correctly and under suitable environmental conditions.

Based on their action in soil, nematicides are either fumigants or non-fumigants. The fumigants volitalize and become gases that move through soil. They are highly phytotoxic and must be applied two weeks to one month before planting. Fumigants that effectively control potato nematodes are DD, Super DD, Telone, and Vorlex.

The non-fumigant nematicides are either organic phosphates or carbamate compounds. These materials are usually in granular formulations and can be applied at the time of planting potatoes. They are applied in a 10 to 15 cm band in the seed furrow directly over potatoes. Soil temperature and moisture should be suitable for planting. Mocap and Nemacur are organic phosphates and Aldicarb, Carbofuran and Oxamyl are carbamates that have been used for control of potato nematodes.

Integrated control or nematode management. Although all control methods have merits, continuous application of only one method is not desirable. In practice, integration or combining different control measures is necessary to keep nematode population densities below damaging levels and to prevent their establishment in new areas. A well-known integration of methods that can control *Globodera* spp. includes a 2-year rotation combining soil fumigation, cultivation of resistant and susceptible varieties in a systematic program.

The key components of nematode management are:

- extensive survey to determine nematode presence and distribution;
- soil fumigation to reduce population;
- use of resistant varieties to prevent nematode population density increase;
- use of crop rotation;
- use of clean machinery and farm tools;
- use of seed tubers free of nematodes;
- prohibition of potato seed production in known infested or exposed land.

Control measures may be complemented by use of trap crops (*Crotalaria* sp. for *Meloidogyne*), green and organic manuring, flooding, antagonistic plants (*Tagetes* sp. for *Pratylenchus*) and the use of biological control agents such as fungi, bacteria and predators.

9 ADDITIONAL STUDY

Franco, J. 1981. Potato cyst nematodes; *Globodera* spp. Technical Information Bulletin 9. International Potato Center, Lima, Peru. 21 pp.

International Potato Center. 1978. Developments in the control of nematode pests of potato II. Planning Conference Report 16. International Potato Center, Lima, Peru. 193 pp.

Jenkins, W.R., and D.P. Taylor. 1967. Plant Nematology. Reinhold Publishing Corporation, New York, Amsterdam, London. 270 pp.

Mai, W.F. et al. 1980. Nematodes. pp. 93-101. In: Hooker, W.J. (ed.). Compendium of potato diseases. American Phytopathological Society, St. Paul, Minnesota. 125 pp.

Wallace, H.R. 1973. Nematode ecology and plant disease. Edward Arnold Publishers Limited, 25 Hill Street, London. 228 pp.

Webster, J.M. (ed.) 1972. Economic Nematology. Academic Press, London, New York. 563 pp.

Technical Information Bulletin Coordinator: Rainer Zachmann

Processed and printed by the Training and Communications Department, CIP, Lima, Peru
February 1986
Copies printed: 2000