PEST ADVISORY LEAFLET NO. 09

Plant Protection Service
Secretariat of the Pacific Community

Revised March 2005

ROOT-KNOT NEMATODES

ROOT-KNOT NEMATODES (*Meloidogyne* spp.) are amongst the most economically important nematode pests in the Pacific. They are ranked amongst the most important parasites in the tropics. There are many species and races of the root-knot nematode the world over but the three most common species found in most Pacific Island countries and territories (PICT) are *Meloidogyne incognita* (southern root-knot nematode), *M. javanica* (Javanese root-knot nematode) and *M. arenaria* (peanut root-knot nematode).

Root-knot nematodes have a very wide host range. This makes them very difficult to control because they can always survive and reproduce on other host crops including weeds. Some of the most susceptible crops in the PICTs are listed under the Host List section.

SYMPTOMS

Galls or knots on the roots and tubers are distinctive below-ground symptoms of a root-knot nematode infected crop. These should not be confused with root nodules produced by leguminous plants. The galls or knots are distinguished as swellings from within the root whilst nodules are swellings sticking onto the root and can be easily flicked off the root. The galls, however, vary in size and shape depending on the infective species and the host.

On some plants, such as tomato (*Lycopersicon esculentum*), kava (*Piper methysticum*), noni (*Morinda citrifolia*), parsley (*Petroselinum crispum*) and papaya (*Carica papaya*), the swellings are very clear (see Figure 1); but on others, including bananas (*Musa* spp.), sweet potato (*Ipomoea batatas*) and taro (*Colocasia esculentum*), they are less noticeable. Crops belonging to the grass family (Graminaceae), for example, rice (*Oryza sativa*), maize (*Zea mays*) and sugarcane (*Saccharum officinarum*), also have very small galls. Galls are best seen if roots are washed free of soil and examined in water.

Above-ground symptoms are similar to those caused by nutrient deficiency, water stress or some soil-borne diseases. These include stunting or poor growth, yellowing or chlorosis, excessive wilting, reduced yield and premature death of plants (see Figure 2). Heavily diseased plants do not respond to water or fertilisers. This is because the nematodes have severely damaged the conducting tissues of the plant at the roots.

Root-knot nematodes are present in many soils, but severe infection seems to be limited to soils that are sandy and free-draining. Symptoms may occur in patches, or throughout infected crops.

EFFECT OF ROOT-KNOT NEMATODES

Infection causes poor root development, resulting in reduced nutrient and water uptake and weak support for the plant. Food produced by the plant goes

Figure 1: Root-knot nematode infections of A) pawpaw, B) parsley and C) noni.

Figure 2: Noni (*Morinda citrifolia*) heavily infested with root-knot nematode.

to the nematode galls instead of the leaves and fruits. Root-knot infections encourage fungal and bacterial diseases. Crop yields are reduced, and harvested produce is of poor quality.

For export produce like ginger rhizomes, nematodes often cause shrinking in storage, thereby reducing storage life and quality of the produce.

NEMATODE BIOLOGY

Root-knot nematodes can only live as parasites of plants. Microscopic, eel-shaped larval nematodes hatch from eggs left in the soil from earlier infections; they enter and feed on growing plant roots. Larvae then stop in one place within the roots and grow into pear-shaped females that produce hundreds of eggs (Figure 3). Eggs are either buried inside gall tissues or stand out in small groups that can barely be seen on the surface of the galls. Males do not cause disease symptoms.
The life cycle from egg to mature adult takes about one month. Several to many generations are possible during the life of the crop, and millions of nematodes can be associated with a mature plant. Nematodes may remain in the soil for 6 months or more after an infected crop has been harvested. Usually, they decrease rapidly in number in the absence of a host plant — that is, if land is left fallow.

CONTROL

In general, root-knot nematodes have a very wide host range. They have been found to infect more than 2000 plants worldwide. Because of this they are amongst the most difficult plant parasitic nematodes to control. Each species has specific or preferred hosts; however, it is not uncommon for a plant to be infected with more than one root-knot species. Identification of species therefore is essential for effective nematode management.

Root-knot disease can become severe when the natural balance of soil micro-organisms is upset by such practices as mono-cropping, short rotations and repeated growing of susceptible crops without any fallow periods.

Preventative control
Awareness of how root-knot nematodes spread to new areas is very important because this will help growers prevent their spread and will save on costly control methods.

Like any other plant parasitic nematode, they can not move over long distances but need assistance to do so. The main mode of transfer is through infected planting material. They can also be transferred through infected soil sticking onto farm implements and on footwear. Growers should be aware how nematodes spread and should take every precaution when moving plant material and soil from infected areas to clean areas.

Recommended control methods
To achieve good root-knot nematode management, as many as possible of

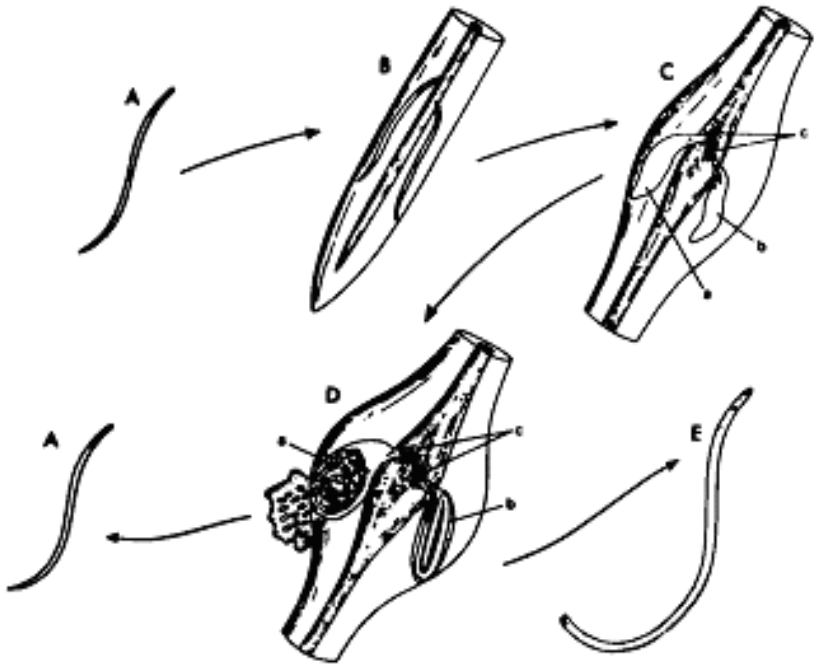

Figure 3: Life cycle of a *Meloidogyne* species (schematic). A. Pre-parasitic 2nd stage larva. B. Two larvae that have entered a root, become stationary and started to feed. C. Gall formation and development of larvae (a, b) and specialised 'giant cells' of root where nematodes feed (c). D. Gall with mature female and egg mass (a), male (b) and giant cells (c). E. Male free in soil.

the following practices should be followed.

Seedbed sanitation
Avoid making seedbeds near fields where susceptible crops have been growing for several years.

The beds should be prepared by turning the soil several times to kill the nematodes by exposing them on the soil surface to get hot and dry. Hot water treatment is another option (Figure 4).

Nematodes (and some pathogenic fungi) may be controlled if soil is covered with a thin (50 microns) layer of polythene in direct sunlight for 4–6 weeks.

Nematode-free planting material
Planting material infected with nematodes must not be used. Infections in vegetatively propagated crops such as banana, ginger, potato and yam are recognised by swollen or cracked surfaces on corms, rhizomes, roots or tubers.

Hot water treatment can kill nematodes in infected planting material. For example, ginger is treated by immersing the rhizomes in water at 51°C for 10 minutes. Caution, however, is necessary in the application of hot water treatment because the planting material could die if the treatment temperature is higher or the rhizomes are left for longer periods.

Land management and cultural practices
Methods that make the soil less favourable for nematode growth and reproduction reduce their numbers or prevent them from increasing. Clean fallows or weed fallows will starve the nematodes to death (although some weed species are susceptible).

Crop rotation is one of the most effective ways of managing nematodes. To be most effective, non-host crops, poor hosts or those with resistance or tolerance to root-knot nematodes should alternate with a susceptible crop. A possible crop rotation would be: susceptible > poor host > poor host > non-host or resistant host > susceptible.


Figure 4. Hot-water treatment of seedbeds.

As with seedbeds, thorough land preparation helps in nematode control. Nematodes uncovered when crop residues are turned up will die in the sun, reducing infection of later plantings.

Field sanitation is very important. Plant residue and ratoon should be all removed from the field straight after harvesting to deprive the nematodes of food supply.

Good agronomic practices that give a rapid start and good crop growth will help overcome harmful effects of nematodes. Proper watering, drainage, fertility and weed control will be helpful.

Resistant or tolerant varieties
Very little research work has been done on crop resistance to root-knot nematodes in the PICT region. Nevertheless, many crops grown in the region can tolerate root-knot nematodes at certain levels of infection without significant yield loss. Crops such as cassava (*Manihot esculentus*) and taro (*Colocasia esculenta*) have been used successfully in crop rotation programmes for the control of nematodes in ginger in some island countries. Tomato variety Heatmaster has a very high resistance to root-knot nematode and is grown successfully in some PICTs.

Although sweet potato and yams are known hosts for root-knot nematodes, there are many varieties in the region with some tolerance to root-knot nematodes. Growers can observe their crop varieties and select the ones showing tolerance to the nematodes whilst avoiding the planting of those that are very susceptible.

Chemical control
Strict precautions must be taken whenever chemicals are used. It is essential that protective clothing is worn. It is important to consider the effects that these chemicals might have on the environment and water supply; this is especially important on atolls and also where affected crops requiring treatment are close to a water source. It is not appropriate for village gardeners to use nematicides but they could, perhaps, be used by licensed operators or under the close supervision of trained agricultural staff in crops grown commercially.

There are nematicides that kill soil nematodes before or at planting time. They are poisonous to man and animals so people using them must understand and follow the instructions on the pesticide labels. Good yields often follow nematicide applications, but nematode numbers at harvest can return to levels as high as, or higher than, those in untreated crops so additional control measures are needed when planting again on previously treated land.

Some of the nematicides that can be used to kill root-knot nematodes and other nematodes in the soil are:

- Dazomet (Basamid), a granular formulation that can be used for seedbed treatment. When incorporated in moist soil dazomet releases methyl isocyanate gas, which kills nematodes.
- Fenamiphos (Nemacur), another granular formulation that can be used before or at planting or in established crops.
- Oxamyl (Vydate) in a liquid formulation, which is supplied with an application gun that makes application into the soil safer.

Biological control

Natural enemies for the control of root-knot nematodes are now being developed as commercial products in many developed countries like USA, China, Great Britain and a few other European countries. Care, however, must be taken whenever these are considered for use in the PICTs not only because of their high market costs but also because they may not be viable in our local environmental and climatic conditions. It is preferable to explore those that are found in our own environment before considering commercialised ones. The bacterium *Pasteuria peretrans* is one such natural enemy that has been developed into a commercial biological nematicide for controlling root-knot nematodes. This bacterium is already present in some countries in the Pacific such as Samoa. The bacterium can be cultured easily in the field by planting root-knot infected tomato plants in the field where the bacterium is found. The root-knot infected roots of these tomato plants can then be harvested, dried and chopped into tiny pieces that can be worked into root-knot infected soil.

Common names	**Botanical name**
Eggplant	*Solanum melongena*
Tomato	*Lycopersicon esculentum*
Ginger	*Zingiber officinale*
Bele, aibika, island cabbage	*Abelmoschus esculentus*
Noni, nonu, nono, non,	*Morinda citrifolia*
Parsley	*Petroselinum crispum*
Carrot	*Daucus carota*
Kava, Ava, Yagona	*Piper methysticum*
Cucumber	*Cucumis sativus*
Bananas	*Musa* spp.
Lettuce	*Lactuca sativa*
Melon	*Citrullus* sp.
Okra	*Hibiscus esculentus*
Papaya	*Carica papaya*
Sweet potato	*Ipomoea batatas*
Yams	*Dioscorea* spp.
Tobacco	*Nicotiana tabacum*
Beans	*Phaseoulus* spp.
Black pepper	*Piper nigrum*
Cowpea	*Vigna sinensis*
Gourds	*Lagenaria siceraria*

Host list

The above list indicates some of the crops commonly grown in the PICTs that are susceptible hosts of root-knot nematodes. It is advisable that these crops are not grown one after another in the same field.

This third edition was written by S.R. Gowen, T.K. Ruabete and J.G.Wright. The photographs were supplied by T.K.Ruabete, Plant Protection Service, Secretariat of the Pacific Community and the schematic life cycle diagram by S.R.Gowen. This leaflet was originally prepared by M.F. Kirby.

Printed with financial assistance from the European Union, NZAid and AusAID.

Published by the Secretariat of the Pacific Community. Further copies of this leaflet may be obtained from the Secretariat of the Pacific Community, Plant Protection Service, Private Mail Bag, Suva, Fiji Islands or from our website, www.spc.int/pps or email us at pps@spc.int.

Secretariat of the Pacific Community Cataloguing-in-publication data

Gowen, S.R. et al

Root-knot nematodes / by S.R. Gowen, T.K. Ruabete and J.G. Wright

(Pest Advisory Leaflet no. 9 / Secretariat of the Pacific Community)
ISSN 1017-6276; 3rd edition

1. Nematode diseases of plants – Oceania. 2. Agricultural pests – Control. 3. Plant nematodes as carriers of disease – Oceania.
I. Title. II. Secretariat of the Pacific Community. III. Series.

630.99 AACR2
Agdex Pacific Islands 638
ISBN 982-00-0084-X