NSW GOVERNMENT Industry & Investment

FACTSHEET

Root knot nematode disease

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The disease

Root knot disease is prevalent throughout most of New South Wales. A great many broad- leafed plants are susceptible to infection. Grasses are affected less often and show little obvious knotting. In cultivated crops, the disease is important in the growing of tobacco, tomatoes and many other vegetables, stone fruits, vines and cut flowers. In the production of propagating material and nursery stock constant attention is needed to prevent infection.

Cause

The disease is caused by microscopic, parasitic, soil-inhabiting nematodes, otherwise known as eelworms, of the genus *Meloidogyne.* These nematodes burrow into the soft tissues of young root tips, and cause the nearby root cells to divide and enlarge. Four different species of *Meloidogyne* are common in New South Wales: *M. javanica. M. incognita. M. hapla* and *M. arenaria.*

Symptoms

Affected crops may show one or more of the following signs of attack: slow / stunted growth, yellowing of the leaves, wilting of the plant despite adequate soil water content, collapse of individual plants. Severely infected seedlings produce few roots and usually die rapidly. Heavy infection of older plants causes the plants to wilt unexpectedly and die off early.

Swellings, or galls, develop on the roots of infected plants, as the result of nematode- induced expansion of root cells. The galls vary in size from slight thickenings to lumps 5 to 10 cm across. Stems or leaves may be galled but this is rarely seen in plants growing outdoors. Galls caused by *Meloidogyne hapla* are much smaller than those caused by other species.

All root knot galls damage the vascular tissues of roots and thus interfere with the normal movement of water and nutrients through the plant. They also increase the susceptibility of the root system to invasion by disease-causing fungi and bacteria.

Galls caused by nematodes should not be confused with the small nodules on the roots of leguminous plants such as peas, beans, clover and lucerne. These nodules develop as a result of the presence of beneficial nitrogen-fixing bacteria. True root nodules of this type are readily detached and are pink or green inside.

Root knot nematodes cause losses in potato crops by disfiguring the tubers. Infection shows up conspicuously as pimple-like outgrowths on the skin, and the whole surface may become warty and discoloured. If one of the pimple-like outgrowths is cut open, the nematode may be

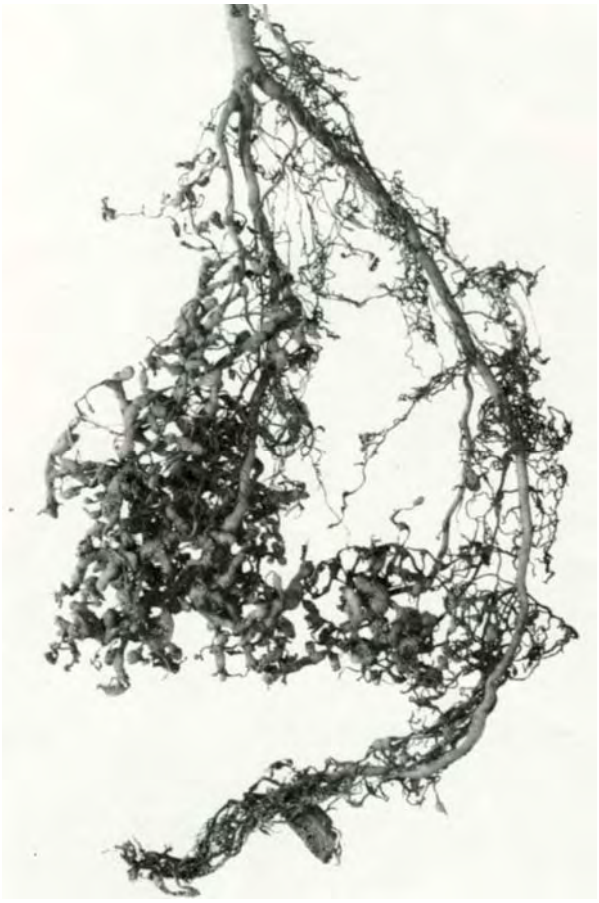

Figure 1 - Small galls caused by nematodes on roots of Chinese gooseberry

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Primefact 1095 First edition. (Replaces Agfact AB. 1)

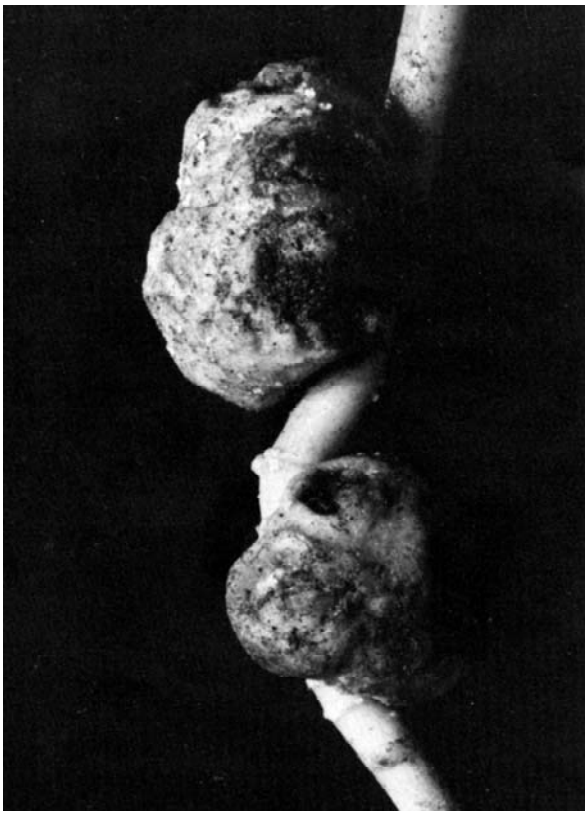

Figure 2 – Large galls on root of paw paw

seen as a small, glistening body embedded in the tissue.

Nematode life-cycle

Second stage juveniles of nematodes (larvae) hatch from eggs laid in either the soil or plant tissues. On emergence, the juveniles, thread-like in appearance, actively seek the tips of roots for invasion. When established in the root tissue, the nematodes feed on the plant cells and grow. The infected cell is then stimulated to enlarge which become the feeding sites for the nematode. As the nematodes mature they moult three times inside the roots. During the final developmental stage, the body of the female changes into a spherical or pear-shape while the male remains long and cylindrical. At this stage, the female is large enough to be seen with the naked eye when galled root tissue is broken open. Under climatic conditions favourable for nematode activity, fully developed females may commence egg laying 3 to 4 weeks after entry into root tissue and can produce up to 2000 eggs. The eggs generally hatch in warm moist soils and some eggs can survive for at least a year. In some subtropical regions up to ten generations can be produced per year. However, in the Sydney district and areas with similar cool winters, the nematodes are less active during the winter months compared to summer / warmer months.

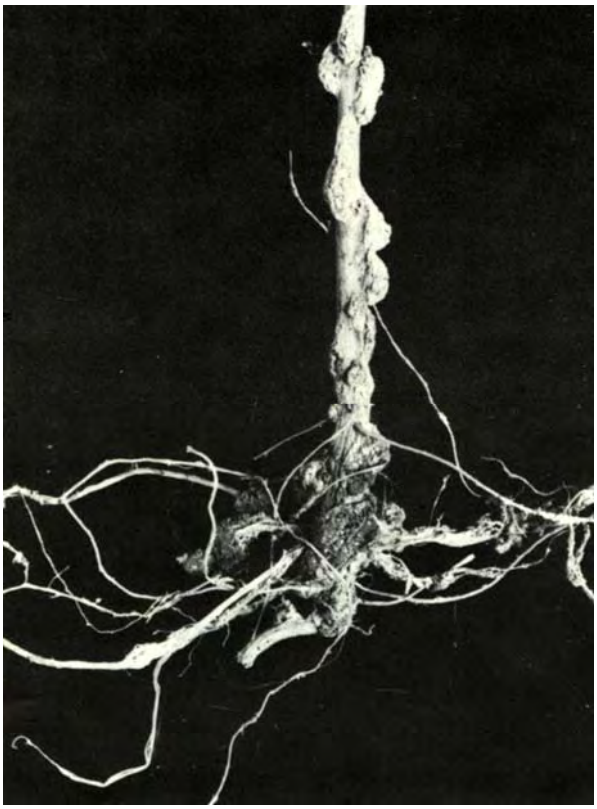

Figure 3 - Galls caused by root knot nematode on stem of a bean plant

Infection and spread

Nematodes are most often introduced into a new paddock or area by planting seedlings, tubers, or young plants that are already infected with root knot. It can also be spread to new areas by running water, cultivation tools and machinery, animals and footwear. Without the help of these distributing agents, spread is only a few centimetres each year within a paddock.

The disease is favoured by warm weather and is most troublesome in sandy soils.

Figure 4 - Root knot nematode infection produces a small, warty, unattractive potato

Control

Management strategies

Sanitation: preventing buildup and spread

As far as possible, grow your own seedlings and other propagating material in nematode free soil, and test your soil for nematodes before planting in main fields. If your field soil has nematodes, take preventive measures (e.g. soil sterilisation, chemical application, cultivation of non-host crops etc.) before planting any materials.

If you have obtained rooted plants, tubers, or other materials from a nursery or other outside source, you should examine them carefully for signs of root knot nematode infection (e.g. 'galls'). Discard or refuse to accept delivery of infected plants.

Before preparing the soil, thoroughly clean any implements that have been used in contaminated areas.

Burn diseased plants

Do not throw the refuse on to compost or manure heaps. Before feeding affected potatoes to livestock, boil them to destroy nematodes.

Practise crop rotation

Do not plant susceptible crops repeatedly in the same areas. Alternate with crops tolerant of root knot nematodes, for example maize, onions, cabbages and cauliflowers. Cultivate a green manuring crop, such as, sorghum in summer and oats or barley in winter. Incorporate the green manures into the soil and ensure that the organic matters have decomposed prior to planting.

Summer fallow

Summer fallowing, in which all vegetation is kept off the infested area, is a cheap and effective way to reduce nematode numbers. Till the soil after each period of rain. This will not stop nematode eggs from hatching but, without food plants, the young worms will die.

Solarisation

Solarisation involves covering raised and moist beds with clear plastic for 2–4 months during the hottest months of the year. The increased soil temperature helps to kill many soil borne pests and pathogens including root knot nematode. Nematodes in these moist beds will hatch out from eggs, move around for roots and will die of starvation.

Organic amendments

Beneficial microorganisms are in high numbers in soil amended with different organic matters. Some beneficial fungi and bacteria are parasites of nematode eggs and also prey on nematodes. The parasitised eggs do not hatch and thus populations are reduced. The predatory nematodes that prey on other nematodes are also high in organic amended soil. Thus organic amendments enhance biological suppression of parasitic nematodes in soil. The organic matters mostly used to control root knot nematodes are poultry manure, pigeon litter, sawdust and various crop residues.

Soil sterilisation and fumigation

If you have to use nematode-infested soil, treat it to reduce or eliminate the nematode population. From the several methods available, select one that suits your need, bearing in mind the cost of treatment in relation to the crop value.

Low-temperature steaming

In recent years it has been recognised that high-temperature steaming of soil (82^0C and above) destroys soil nutrients and breaks down soil structure, as well as killing the soil microorganisms. Since both useful microorganisms are removed from the soil as well as disease- causing ones, there is little competition for any parasitic fungi that invade the soil after steaming. Therefore, if the fungi that cause damping-off type diseases are introduced into soil sterilised by high-temperature steaming, losses of seedlings will be much greater than in unsterilised soil. To overcome these problems methods of low-temperature steaming were developed. The soil is treated for 30 minutes at 60^0C. This will eradicate nematodes and other harmful organisms without killing too many of the beneficial organisms in the soil.

Steam is mixed with regulated amounts of air, by either a venturi steam injector, or by blowing steam into an air pipe. Very efficient equipment is available commercially. Aerated steam passes into a chamber in the base of a soil treatment bin. The soil rests on a mesh screen above this chamber. The top of the box is covered with sacking or a tarpaulin.

Plastic pots are also safely and efficiently sterilised by this method. See Agfact AB.6 *Soil Treatment in the Nursery* for further information on this topic.

Chemical fumigation

Training

Application of chloropicrin (e.g Telone™) in NSW can only be made by fumigators who hold certificates of competency as set out in relation to

that work in the National Standard for Licensing Pest Management Technicians (e.g. Telone™ training program).

Applicators of metham sodium and dazomet in NSW are advised to attend the registrant's training program managed by Agsafe.

Application of Temik® in NSW requires users to attend a training program and be issued with an Aventis CropScience Certificate of Accreditation prior to purchase and use.

Risks

All fumigants are harmful if they contact the skin or if the vapours are inhaled. Follow the safety directions on the label.

A number of fumigants suitable for sterilising potting and seedbed soil are on the market (see list). These range from products that are gaseous at room temperatures and must be applied from gas cylinders under gas-tight conditions, to liquids that can be mixed with water and watered on in solution. All are unspecific, that is, they act not only against nematodes but also against most other soil borne pest and disease organisms.

Soil fumigation can cause the release of large amounts of available nitrogen, particularly the readily absorbed ammonium form. For this reason, you should use nitrate rather than the ammonium form of nitrogen fertilisers and apply them as a top dressing after planting, not as a basic dressing before planting.

Sterilising glasshouse soil

Where crops such as tomatoes are grown in the same glasshouse each year, soil sterilisation is essential, not only to control nematodes, but also to control parasitic fungi, insects and weeds. The high returns from glasshouse crops make it worthwhile to use steam sterilisation or a chemical, which combines fumigant action against all four pests.

Steam heat treatment. Steam treatment at 60° C for 30 minutes will kill all nematodes, soil insects, and most fungi and bacteria that cause plant diseases. At 82° C it will also kill almost all weed seeds. Steam may be applied through fixed steam lines or movable hollow-spiked harrows.

Sterilising with fumigants. Glasshouse soils are generally most economically treated with products that are mixtures of fumigants. These products are effective against nematodes and fungi. This is particularly important with tomatoes, in which you must control the *Fusarium* and *Verticillium* wilt fungi as well as root knot nematodes.

Some fumigants may damage certain crops. See the section on fumigation of seedbed or potting soil for more details and note the information given there on the use of nitrogen fertilisers in conjunction with fumigation.

If manure or compost is to be applied this should be done before fumigation, to ensure that the added material will also be treated. As stated previously, fumigation in this situation can result in the release of large amounts of available nitrogen and cause excessive vegetative growth. For this reason manuring should be done well before fumigation. Allow several extra weeks between fumigation and planting.

Before treatment, prepare the soil for planting the crop. Break up any clods and lumps, and make sure all crop residues have decomposed. Allow 2 weeks between soil treatment and planting.

Field treatment: large areas

Preplanting fumigation. Note that soil fumigants are toxic to plants, and thus can only be applied prior to planting.

Soil preparation - Before fumigation, prepare the soil in advance of seeding or planting. See there are no clods, lumps and undecomposed crop residues, and have the soil moderately loose. Remove any remaining roots of the preceding crop or allow them time to decay. If manure or compost is needed, mix it with the soil before fumigation. Results are best when the soil is fairly moist and the temperature above 16°C.

Methods of application - The choice of fumigant for large areas is restricted by financial considerations. The cheaper fumigants usually only control nematodes, not other pests . These fumigants are applied at a depth of 15 to 20 cm from fumigation equipment mounted on a tined or chisel point cultivator drawn by a tractor. Fumigant is fed from a container through a metering device to tubing, which delivers it to outlets behind the tines. Fumigants with low vapour pressure and dispersing ability (e.g. Metham sodium) can be applied with spray nozzles. Fumigant may be fed by gravity flow. Details of the construction of a gravity flow fumigation machine are given later in this Agfact. In more efficient equipment, fumigant is fed under pressure by means of a power take-off or a pump driven by land wheel, or by attaching a gas cylinder. If you are not familiar with the application methods, ask your supplier for application details.

Read the container label very carefully for full directions on how much fumigant to use per hectare and for full safety directions.

Soil surface sealing - A float or light roller should be drawn behind the fumigator to close the furrows and compact the surface soil. If possible, irrigate the soil after treatment to further seal the surface

against escape of fumigant. It is necessary to water frequently and lightly for the first 3–4 days. The plastic sheeting can also be used for surface sealing to avoid any escape of fumigant. The most widely used plastic sheeting is linear low-density polyethylene (LDPE).

After I to 2 weeks, plough the area to release any remaining fumigant. It is usual to allow 3 weeks between fumigation and planting.

Treatment with non-fumigant nematicides. Non-fumigant nematicides act quite differently to fumigant nematicides. They dissolve in water and move through the soil in solution rather than as a gas. For this reason, their action is not so dependent on the soil temperature at the time they are applied. Also, when applying non- fumigant nematicides soil tilth and moisture are not as critical as they are for fumigant nematicides. As non-fumigant nematicides do not damage plants at rates normally used for nematode control, they can be applied at any time from I week before planting up to the time of planting.

Several non~fumigant nematicides are currently registered in New South Wales. These, and the crops on which they may be used, are listed in the supplement to this Agfact. Two formulations, granular or emulsifiable liquid concentrate, are available for use against root knot nematodes. Granular formulations are safer to use since they contain 10 per cent or less active ingredient, but they are more expensive than the emulsifiable concentrate. Granules may be easier to apply because they can be broadcast by means of a fertiliser spreader and then cultivated in by using a rotary hoe. The liquid formulation can be applied through drip or trickle irrigation. It has an advantage in that it can be applied mixed with herbicides.

Safety precautions and detailed instructions for the use of these nematicides are set out on, the container labels. Read the label carefully and strictly follow instructions.

Field treatment: smaller areas

Preplanting fumigation. Mark out the area to be fumigated with a series of parallel lines, 30 cm apart, then with another series of lines 30 cm apart at right angles to the first series. The fumigant injection points are at the crossing of these lines in alternate rows, and midway between the points of intersection in the remaining rows. This gives a 'staggered' effect, which makes it easier to cover the whole area to be treated.

Inject 2 mL of fumigant into each hole by means of a soil injector set to inject at a depth of 15 cm. If an injector is not available, holes can be made with a pointed stick, and fumigant poured into them through a funnel.

Immediately after treatment, seal each hole by tramping with the heel, making the soil as flat and smooth as possible. Small areas can be smoothed over with a hand rake. Moist soils will benefit from the use of a roller.

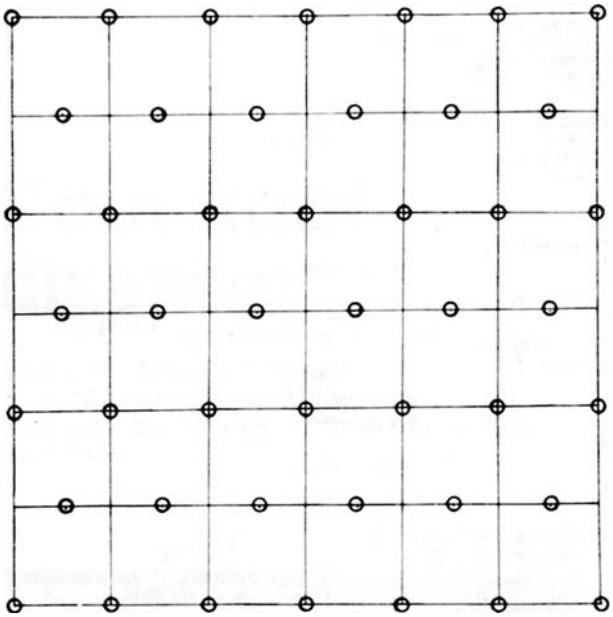

Figure 5 – Recommended staggered arrangement of injection holes

Fumigation will be improved if, immediately after raking, the soil is sprinkled with water, just to the point where it no longer soaks in readily. After 2 weeks, fork the soil over and leave one more week before planting.

Water-on type fumigants are convenient for treating areas such as strawberry beds and nurseries and for row treatment for vegetables.

Remember you must wear protective clothing and other safety equipments when handling fumigants. Read the label for instruction details.

Pre planting fumigation of soil for trees and shrubs. A circular area from I to 2 m in diameter, intended as a planting site, can be fumigated in a manner similar to that set out above for small areas of soil.

As fruit trees, particularly peach, are susceptible to root knot infection, it is important that the soil be free of root knot nematode. Note that fumigants should be used only as a preplanting treatment and are highly toxic to established plants.

Figure 6 – Hand injector for preplant fumigation of small areas

Treatment of established plants. Non-fumigant nematicides may be applied to the soil around plants of certain species (Table 1). Always check the label directions to be sure you are using the nematicide correctly.

Registered fumigant and non-fumigant nematicides in NSW, Australia.

IMPORTANT: PESTICIDES ACT 1999

Pesticides listed here were registered at November 2010 (Source: Infopest November 2010). Note that you must use only a currently registered pesticide, and it is not to be used for any purpose or in any way contrary to the directions on the label, unless a permit has been obtained under the Act.

Fumigants: The following soil fumigants are registered in NSW, Australia.

Dazomet (Basamid ®, Cerlong®) – A general low volatile sterilising fumigant which releases methyl isothiocyanate (MIT) gas. Formulated as a fine powder, which is broadcast and then cultivated in.

Metham sodium (Chemfarm Metham, Alfire Metham Sodium, Delfarm Metahm Sodium, etc) – a liquid, low volatile, water soluble fumigant that breaks down to MIT gas in soil.

1,3 - Dichloropropene (Telone™ C-35, Inline*, Telone™, Triform® 35 etc) – a liquid fumigant and highly volatile that will need surface sealing after application, may increase ammonium nitrogen level in soil after application, suppresses weeds.

Chloropicrin (Telone™ C-60, Tri-form 60®) – a granular fumigant, less volatile but highly dispersive into soil, highly toxic to humans, need soil surface sealing immediately after application.

Non fumigant nematicides : The following nematicides have been registered in NSW for using on different crops.

Fenamiphos (Nemacur ®, Redback®, Fenamiphos 400®, etc) – A general nematicide that has been registered to control soil borne plant parasitic nematodes in a wide range of crops in NSW e.g. most vegetables, cucurbits, banana and banana planting material, citrus, grapevines, mushrooms, ornamentals, flower bulbs and corms, strawberries and turf. Fenamiphos products are the only nematicide that can be used in vegetable crops in NSW.

Cadusafos (Rugby 100 G®) – Registered in NSW to control nematodes in banana, citrus and tobacco.

Aldicarb (Temik ®) – Crops that can be treated to control nematodes in NSW are sugarcane, oranges and mandarin.

Oxamyl (Vydate ® L) – A water soluble liquid nematicide that can be used to control nematodes of banana in NSW.

Terbufos (Hunter® 150G, Counter® 150G) – Registered in NSW to control nematodes in banana, wheat and barley.

Always read the label

Users of agricultural or veterinary chemical products must always read the label and any permit, before using the product, and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or not made in this publication.

Other resources

'Getting the Most from Methyl Bromide Alternatives', Shanks, Alan, et al, Knoxville 2004

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