University of Idaho Extension

BUL 909

Nematodes Associated with Onion in Idaho and Eastern Oregon

Saad L. Hafez and Sundararaj Palanisamy

THE TOP THREE ONION-PRODUCING AREAS in the United States are Idaho–eastern Oregon, Washington, and California. Idaho and eastern Oregon plant about 20,200 acres and produce 1.5 billion pounds of onions each year, representing about 23 percent of U.S. bulb onion production (2009).

Nematodes are one of the major constraints in onion production. They are colorless, nonsegmented worms, ranging from 0.5 to 2 mm long. All plant-parasitic nematodes have a stylet, a needlelike structure that acts as a syringe to penetrate plant cells and take up nutrients. Features that allow species identification are visible only with the aid of a microscope.

The most common nematodes on onion in Idaho and eastern Oregon are root-lesion nematodes (*Pratylenchus* spp.), root-knot nematode (*Meloidogyne hapla*), stem nematode (*Ditylenchus dipsaci*), and stubby-root nematodes (*Paratrichodorus* spp. and *Trichodorus* spp.). Feeding by these nematodes can reduce onion plant vigor and induce lesions (areas of diseased tissue), rot, deformation, or galls (localized growth or swelling of plant tissue). Bulb yield can be reduced by as much as 70 percent.

Root-lesion nematodes (*Pratylenchus penetrans* and *P. neglectus*)

Root-lesion nematodes (*Pratylenchus* spp.) are migratory endoparasites, meaning that they are mobile, but live and feed inside a host plant (figure 1). Their common name is derived from the often-conspicuous lesions they cause on host roots. *P. penetrans* and *P. neglectus* are the major nematodes affecting onion in Idaho and eastern Oregon.

Distribution and host range

P. penetrans is found worldwide, primarily in temperate regions. It has more than 350 hosts, including woody plants (e.g., fruit trees and roses) and herbaceous plants (e.g., potato and other vegetables).

Figure 1. Light micrograph of lesion nematode, *Pratylenchus* sp. Photo courtesy of Dr. Jon Eisenback.

Contents

P. neglectus also has a wide host range in temperate regions.

Root-lesion nematodes are most destructive to plant roots in sandy or sandy loam soils. Contaminated irrigation water, machinery, or tare dirt can disseminate these nematodes.

Biology and life cycle

The root-lesion nematode is a migratory endoparasite. Its life cycle is simple and is based on sexual reproduction. Females lay eggs singly inside the host root or in soil. Root-lesion nematodes begin to reproduce soon after onion rootlets are formed; eggs have been recovered from roots of seedlings 7 days after germination.

The first molt occurs in the egg. Second-stage juveniles hatch and molt three more times, between feeding intervals, to become adult. The life cycle may take 30 days, depending on temperature, but is shortest at 86°F. Generally, fourth-stage juveniles, adults, and eggs are the main overwintering stages.

All mobile stages of both sexes invade roots, but most damage is done by fourth-stage juveniles and adults. Root-lesion nematodes feed on the entire root system except root tips. They penetrate and feed on cortical cells and migrate through the dead cell. Later, these cells break down, and cavities are formed. In later stages of attack, nematodes may penetrate and damage the plant's vascular tissues.

Plant symptoms and impact on yield

High nematode populations can seriously reduce plant vigor, bulb yield, and quality. Severity of damage depends on the species of nematode.

Plants infected with root-lesion nematodes have reduced root systems, and affected roots may show lesions (figures 2 and 3). A single nematode causes a lesion 1 to 3 mm long and one to two cells wide. Initially, lesions are long, narrow, grayish, and opaque. When infection is severe, lesions become dark brown and eventually coalesce and turn black. Lesions often are invaded by soil microorganisms, which can weaken the root system, thus reducing water and nutrient uptake, plant vigor, and yield.

Field symptoms usually appear as patches of poor growth and stand loss. The aboveground parts of affected plants are usually stunted and chlorotic, and old leaves die prematurely.

Figure 2. Pathogenicity of *P. penetrans* on onion under microplot conditions. From left to right: 0, 2, 4, 6 or 8 nematodes per cc soil.

Figure 3. Pathogenicity of *P. penetrans* on onion under greenhouse conditions. From left to right: 0, 2, 4, 6 or 8 nematodes per cc soil.

Root-lesion nematodes reduce onion yield indirectly by increasing stress on plants, thus weakening them and making them more susceptible to fungal and bacterial diseases. In microplot and greenhouse studies conducted in Idaho, *P. penetrans* caused 31 to 64 percent reduction in onion yield and 84 percent reduction in maximum dry weight.

Management of root-lesion nematode

Crop rotation and cultivar selection. Crop rotation is not effective for control of root-lesion nematodes, as these species have a wide host range. Utilization of resistant cultivars is a sustainable practice for nematode control. However, there is limited information about onion cultivars that are resistant to *P. penetrans* and *P. neglectus*.

Chemical control. Chemical control is the most common practice. Effectiveness is enhanced when application follows a period of fallow.

Preplant fall fumigation is probably the most effective tactic to reduce populations of root-lesion nematodes to below economic damage thresholds. Telone II (1,3-dichloropropene) is an effective preplant soil fumigant for nematodes. Fumigants are usually injected below ground behind a tractor.

Nonfumigant nematicides can also be applied preplant or at planting, but are not as effective as fumigants. Vydate (oxamyl) can reduce the population of *P. penetrans*, and metam sodium provides good control in some cases.

Root-knot nematode (*Meloidogyne hapla*)

Distribution and host range

Root-knot nematodes (*Meloidogyne* spp.) are found primarily in tropical to subtropical regions, but *M. hapla* and *M. chitwoodi* are well adapted to temperate climates. The most common root-knot nematode on onion in Idaho and eastern Oregon is the northern root-knot nematode (*Meloidogyne hapla*). This species is distributed throughout Idaho and also attacks sugar beet, potato, and mint.

Population density of *Meloidogyne* spp. is higher in lighter soil. Some species will not persist in heavy soil.

Biology and life cycle

Root-knot nematodes are sedentary endoparasitic nematodes (i.e., they feed in a single location within the plant). Their life cycle has six stages: egg; first-, second-, third-, and fourth-stage larva; and adult.

Mature females deposit 50 to 1,000 eggs in a gelatinous matrix within root tissue. The eggs hatch readily, without the need for root exudate stimulus. Second-stage juveniles emerge from eggs and invade roots, establishing giant cells with galls, where the nematodes feed and become sedentary. These juveniles develop into pearly white, swollen females, which mature to adults within the galls in as few as 20 to 25 days.

Four or five generations may occur in one growing season. Root-knot nematodes survive the winter as eggs or second-stage juveniles, either in the soil or in plant tissue.

Plant symptoms and impact on yield

Reports of root-knot nematode damage on onion have increased during the past several years, particularly in western Idaho and Washington. Total losses can occur in *M. hapla*-infested onion fields.

Several factors influence the severity of damage. High population densities and warm soil temperatures at planting can lead to severe early damage. Root-knot nematode populations can increase dramatically when susceptible crops are grown in rotation with onion. Damage may be most severe following alfalfa hay crops and during years with warm spring temperatures. Cooler spring weather may delay infection, resulting in less injury.

Feeding by emerging root-knot nematodes can result in stunting and wilting of the plant, leading to plant death before maturity. More typical symptoms, usually seen later in the growing season, include stunting, yellowing foliage, wilting in the presence of adequate soil moisture (particularly on warm days), or general nutrient and micronutrient deficiencies. If the preplant nematode population was high, small galls may be visible on the roots. However, root galls on onion are usually small and barely noticeable, often no more than slight swellings (figure 4). Field symptoms usually appear as patches of poor and stunted growth.

Studies found that onion plant and bulb growth was reduced as inoculum levels increased, with significant reduction beginning at two *M. hapla* per cubic centimeter of soil (figure 5). Greenhouse experiments showed total plant dry weight reduction of 40.6 to 59.6 percent. In a microplot experiment, the maximum reduction in bulb weight was 41.3 percent, found at eight *M. hapla* per cubic centimeter of soil. Significantly more damage was caused by *M. hapla* than *M. incognita* when the two species were inoculated at the same density.

Figure 4. Pathogenicity of *M. hapla* on onion under microplot conditions. From left to right: 0, 2, 4, or 8 nematodes per cc soil.

Figure 5. Pathogenicity of *M. hapla* on onion under microplot conditions. From left to right: 0, 2, 4, or 8 nematodes and 4 *M. incognita* per *cc* soil.

P. penetrans and *M. hapla* often exist together in Idaho onion fields. Under greenhouse conditions, inoculation of *M. hapla* and *P. penetrans* alone or in combination reduced onion plant growth, with *P. penetrans* causing greater damage. However, more reduction in plant growth occurred when *P. penetrans* and *M. hapla* were inoculated simultaneously than when either species was inoculated alone (figures 6 and 7). Competition between *P. penetrans* and *M. hapla* suppressed the multiplication rate of both species when they were together in soil. The suppressive effect of *P. penetrans* on *M. hapla* was more than that of *M. hapla* on *P. penetrans*.

Figure 6. Concomitant interaction of *M. hapla* and *P. penetrans* on onion under greenhouse conditions. From left to right: 0 nematodes, *M. hapla* alone, *P. penetrans* alone, and *M. hapla* and *P. penetrans* together.

Figure 7. Concomitant interaction of *M. hapla* and *P. penetrans* on onion under microplot conditions. From left to right: 0 nematodes, *M. hapla* alone, *P. penetrans* alone, and *M. hapla* and *P. penetrans* together.

Management of root-knot nematode

The preplant population of root-knot nematode should be considered when considering management options, such as the need for soil fumigation. Nematode numbers usually are high following a rotation of alfalfa, corn, potato, vegetables, cereals, or grasses.

Crop rotation. Crop rotation is not a successful management tool for root-knot nematodes in onion due to their wide host range. However, nonhost crops such as corn or small grains can reduce population densities.

Chemical control. Preplant fall soil fumigation can be effective.

Stem nematode (*Ditylenchus dipsaci*)

Distribution and host range

Stem nematode, *Ditylenchus dipsaci*, is widespread and is known to attack more than 500 plant species, including many weeds. Principal hosts are alfalfa, fava bean, garlic, leek, corn, narcissus, oat, onion, pea, potato, rye, wheat, strawberry, daffodil, and sugar beet. In no other known nematode species do individuals exhibit as much variation in host preference. In Idaho and eastern Oregon, stem nematodes have been found in soil where a variety of crops have been grown, as well as in alfalfa plants.

The stem nematode occurs mainly in sandy clay and clay soils, often in areas where onions are cultivated, and in loamy and sandy soils. Infection may originate from the soil or infested seed.

Biology and life cycle

The stem nematode is migratory and endoparasitic. Its life cycle has six stages: egg; first-, second-, third-, and fourth-stage larva; and adult. Both larvae and adult nematodes are slender and mobile. Reproduction is sexual.

Stem nematodes become active at 32 to 35°F and begin to reproduce at 41°F. At 59°F, the life cycle is completed in 19 to 23 days. A mature female lives 45 to 73 days and lays 200 to 500 eggs during her lifetime. Therefore, this nematode can reproduce explosively during a growing season under favorable conditions.

The first molt takes place inside the egg, after which the second-stage larva hatches. All stages of stem nematode are able to penetrate plant tissue, including germinating seed. This nematode lives within the plant and feeds in stems, leaves, and bulbs.

Fourth-stage larvae are resistant to adverse conditions and can survive long periods in the soil and in plant debris. They are capable of living without water if desiccation develops slowly. Under these conditions, nematodes enter an inactive state (anabiosis) in maturing seed or desiccating plant tissue, where they can survive for many years.

Plant symptoms and impact on yield

Stem nematode can seriously limit yield, quality, and vigor, causing up to 40 percent damage on plant growth in the field (figure 8). The severity of damage depends on environmental factors and population densities at the time of planting.

Stem nematodes affect both foliage and bulbs (figure 9). High populations can contribute to damping-off. Infested seedlings become stunted, twisted, and deformed, with short, thickened leaves (figure 9). Leaves may be pale green to yellow (figure 10)

Figure 8. Typical field symptom on onion caused by the stem nematode. Photo courtesy of Dr. Jon Eisenback.

Figure 9. Onion seedlings uninoculated (left) and inoculated (right) with stem and bulb nematodes.

and frequently contain yellowish spots. Seedlings in severely infested areas of the field may die (figure 11).

More mature plants may be stunted, with shortened, thickened, twisted, and distorted leaves. Leaves may have yellow spots, swellings, or open lesions. Outer leaves begin to die back. Stems and necks are often softened.

Infected plants produce a high incidence of doubles, cracked bulbs, and culls. Young bulbs become soft, swollen, and misshapen, causing a disease symptom known as "bloat." Softening begins at the neck and gradually proceeds downward. The scales appear pale gray, and bulbs desiccate and split at the base under dry conditions.

Under moist conditions, secondary invaders such as bacteria, fungi, and onion maggots induce soft rot and decay of the bulbs. Severe damage to infected bulbs may occur in storage.

Figure 10. Pathogenicity of stem nematode on onion under different inoculum levels. From top to bottom: 0, 4, 6, and 8 nematodes per cc soil.

Figure 11. Uninoculated plants (left) and onion plants inoculated with stem nematode (right).

Management of stem nematode

Crop rotation. Crop rotation with a nonhost crops such as wheat, bean, and corn can control stem nematodes.

Sanitation. Use of noncontaminated sets, bulbs, or seed help to control this nematode. Clean farm equipment to remove soil before moving between fields. Dispose of contaminated cull onions, sets, and seeds away from the field, where they will not contaminate irrigation canals. Destroy infested plants and debris from fields and storage areas.

Chemical control. Field fumigation has been shown to effectively control these nematodes. Apply a registered fumigant in the fall prior to planting a susceptible crop the following spring.

Stubby-root nematodes (*Paratrichodorus* or *Trichodorus* spp.)

Distribution and host range

Stubby-root nematodes have a wide host range, including cereals, corn, bean, sugar beet, and potato. *Paratrichodorus allius*, *P. minor*, and *P. porosus* are common in Idaho and eastern Oregon. Problems with stubby-root nematodes have been consistently documented in eastern Idaho for several years.

Stubby-root nematodes are found in sandy, moist, cool soils.

Biology and life cycle

Stubby-root nematodes are migratory ectoparasites (i.e., they feed on the outside of roots). They are very mobile in the soil and often travel long vertical distances in response to changes in soil moisture and temperature, sometimes residing at soil depths of more than 40 inches. To survive cold winters, they may migrate below the frost line and undergo dormancy.

The life cycle of the stubby-root nematode is relatively simple. Eggs are laid in soil, where all stages of the life cycle occur. All four juvenile stages resemble the adult stage, except that juveniles are smaller.

Since several generations can be produced within a year, large populations of stubby-root nematodes can develop quickly. Their numbers can decline rapidly after the crop is removed, so sampling at peak population times is critical to determining population density.

Plant symptoms and impact on yield

Damage by stubby-root nematodes is profoundly influenced by soil moisture and is greater in wet seasons and in sandy soil. Feeding causes roots to be short and yellow-brown. With continued feeding, the root tips become darker, stubby, more branched (forked), and distorted, resulting in a reduction in bulb size (figure 12). Root tips are often killed.

Plants are seldom killed by this nematode. Aboveground symptoms resemble symptoms of other nematodes and can include poor growth, yellowing, and stunting.

Figure 12. Stubby root nematode damage on onion—infested on left, control on right. Photo courtesy of Dr. Jon Eisenback.

Management of stubby-root nematodes

Chemical control. Stubby-root nematodes are difficult to control with fumigants because of their mobility in the soil.

Stubby-root nematodes have been controlled effectively with nonfumigant nematicides, but metam sodium does not work well. When applied at planting, a nonfumigant, systemic carbamate nematicide such as Vydate (oxamyl) remains active for 8 to 12 weeks after application and is an ideal option for Idaho. Vydate's systemic activity affects nematodes as they feed on roots.

Detecting nematodes in onion fields

Since distribution of nematodes is seldom uniform and may change rapidly, preplant collection of representative soil samples is the basis for diagnosis. In the fall before planting, collect soil from areas showing symptoms and from unaffected areas for comparison. First remove the upper 2 inches of soil, and then collect cores to a depth of 15 to 20 inches. (Following prolonged fallow, dry, or freezing conditions, take deeper cores, up to 30 inches.) Each sample should contain at least 20 individual cores (if representing less than 5 acres, at least 4 cores per acre).

Combine the soil cores in a clean bucket and mix thoroughly. Place 1 quart of the mixture or plant roots in a sturdy, moisture-retaining bag and attach an identification tag to the outside. Keep the sample cool, ideally at 50 to 55°F, and deliver or mail it immediately to the laboratory.

The Authors

Saad L. Hafez, Director, Nematode Diagnostic Laboratory, University of Idaho, Parma Research and Extension Center

Sundararaj Palanisamy, Department of Zoology, Bharathiar University, Coimbatore, India

Photo credit

Photos in Figures 1, 8, and 12 are courtesy of Dr. Jon Eisenback, Professor, Plant Pathology, Physiology, & Weed Science, 103 Price Hall, Blacksburg, VA 24061.

ALWAYS read and follow the instructions printed on the pesticide label. The pesticide recommendations in this UI publication do not substitute for instructions on the label. Pesticide laws and labels change frequently and may have changed since this publication was written. Some pesticides may have been withdrawn or had certain uses prohibited. Use pesticides with care. Do not use a pesticide unless the specific plant, animal, or other application site is specifically listed on the label. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

Trade Names—To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater—To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Barbara Petty, Director of University of Idaho Extension, University of Idaho, Moscow, Idaho 83844. The University of Idaho has a policy of nondiscrimination on the basis of race, color, religion, national origin, sex, sexual orientation, gender identity/expression, age, disability or status as a Vietnam-era veteran.

Published August 2016