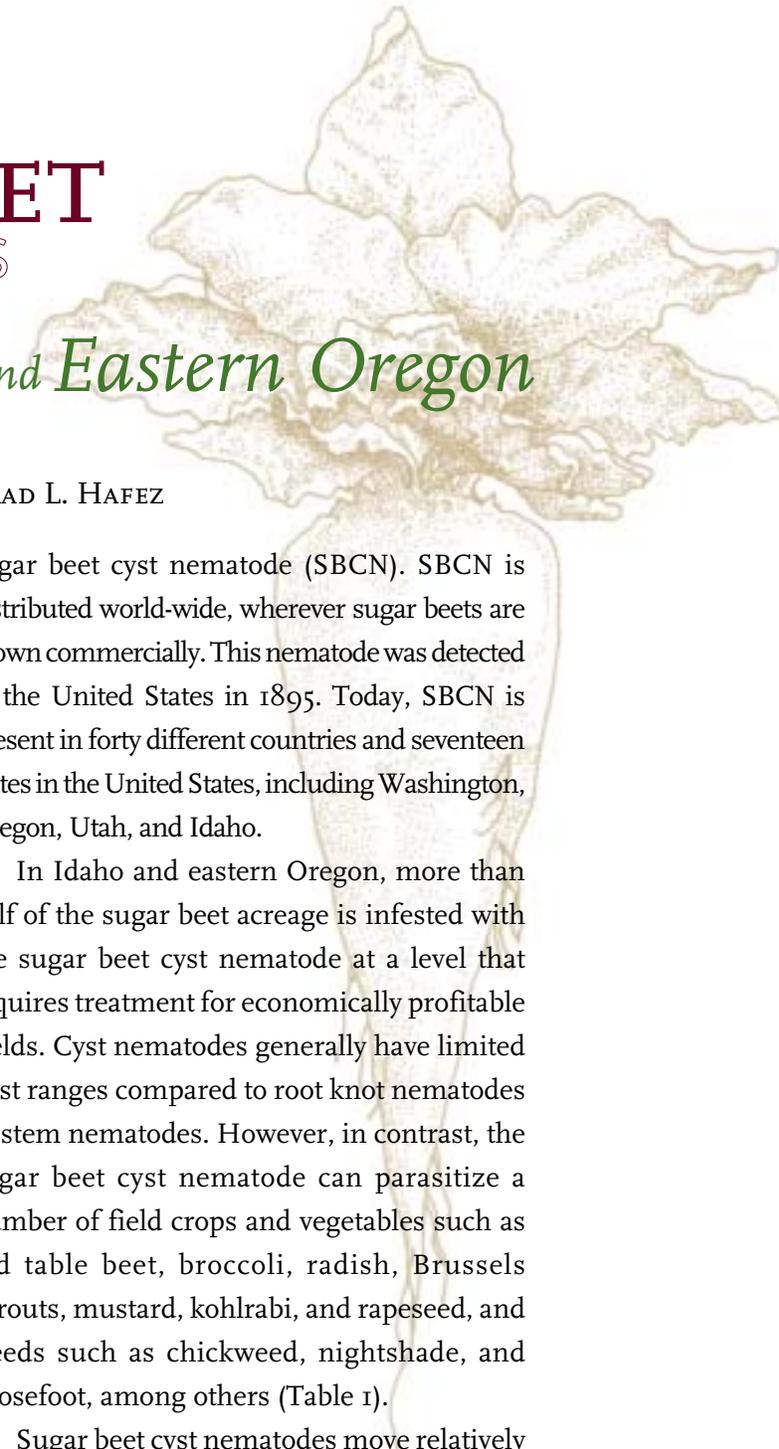


# SUGAR BEET nematodes in Idaho and Eastern Oregon



SAAD L. HAFEZ

NEMATODES THAT PARASITIZE SUGAR BEETS can seriously limit sugar beet production in Idaho and eastern Oregon. Over two dozen species of these microscopic, worm-like animals can cause severe damage to sugar beets world-wide, and sugar beet yield losses due to nematodes have been estimated between 10 and 80 percent. The severity of damage depends on the species of nematode present and population densities in the soil at time of planting. The most common sugar beet nematodes in Idaho and eastern Oregon are the sugar beet cyst nematode (*Heterodera schachtii*), root knot nematodes (*Meloidogyne hapla* and *M. chitwoodi*), and stubby root nematodes (*Paratrichodorus* or *Trichodorus* species). This bulletin covers the three most common sugar beet nematodes in Idaho and eastern Oregon, describes their life cycles and symptoms on sugar beet, outlines the potential economic impact on sugar beet production in the region, and suggests effective management strategies.

## 1. Sugar beet cyst nematode, *Heterodera schachtii*

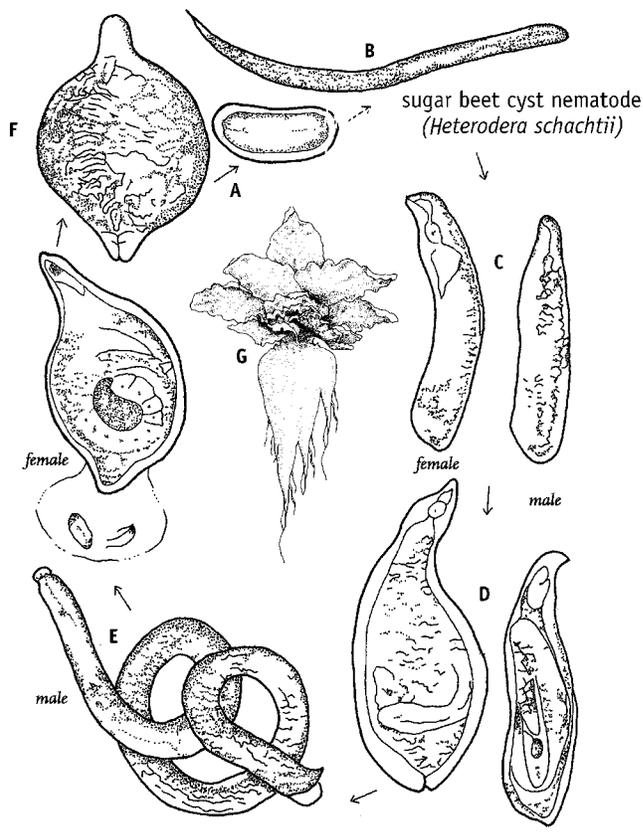
### Distribution and host range

The major nematode affecting sugar beet production in Idaho and eastern Oregon is the

sugar beet cyst nematode (SBCN). SBCN is distributed world-wide, wherever sugar beets are grown commercially. This nematode was detected in the United States in 1895. Today, SBCN is present in forty different countries and seventeen states in the United States, including Washington, Oregon, Utah, and Idaho.

In Idaho and eastern Oregon, more than half of the sugar beet acreage is infested with the sugar beet cyst nematode at a level that requires treatment for economically profitable yields. Cyst nematodes generally have limited host ranges compared to root knot nematodes or stem nematodes. However, in contrast, the sugar beet cyst nematode can parasitize a number of field crops and vegetables such as red table beet, broccoli, radish, Brussels sprouts, mustard, kohlrabi, and rapeseed, and weeds such as chickweed, nightshade, and goosefoot, among others (Table 1).

Sugar beet cyst nematodes move relatively short distances by themselves. However, with the unwitting help of humans, nematodes can be disseminated longer distances from field to field or from region to region. Cysts can be carried from infested areas to clean areas by



**Figure 1.** Life cycle of the sugar beet cyst nematode (*Heterodera schachtii*).

irrigation water, soil that clings to livestock or machinery, soil carried by wind or birds, or infested sugar beet tare dirt that is returned to the field.

#### **Life cycle and survival of the sugar beet cyst nematode**

The sugar beet cyst nematode has six stages in its lifecycle: the egg, first-, second-, third-, and fourth-stage larvae, and the adult stage (Figure 1). Root exudates from host plants stimulate hatching of eggs. Second-stage larvae, the infective stage, emerge from eggs and invade small roots where the nematodes feed on cells in the cortex and stele. When feeding, cyst nematodes produce chemicals that stimulate plant cells to enlarge into giant

cells. Males, required for reproduction, continue to grow as they mature, but they retain their thread-like shape. Females, however, swell into a lemon shape as they develop during the third and fourth larval stages (Figure 1) and they become sedentary. The swollen female body, filled with eggs in a gelatinous matrix, bursts through root tissue and is exposed on the outside of the root while the head and neck remains embedded in the root. When female nematodes are fully mature, or when feeding is interrupted, the body wall undergoes a tanning process and turns brown. At this stage, the female is dead, and her body, now called a cyst, can hold up to 500 eggs. The cyst detaches from the roots and lies free in the soil. Eggs within cysts can survive for many years, and they will not hatch readily unless they are stimulated by root secretions, from host plants, when soil temperature and moisture are suitable. When the eggs hatch, second stage larvae once again emerge and invade new roots, and if a proper host is not found, the larvae will die. The number of sugar beet cyst nematode generations per year depends on the climatic conditions. Under optimal soil moisture and temperature, and if an appropriate host is present, the life cycle of the sugar beet cyst nematode (from hatching of larvae to formation of new larvae) can be completed in four to six weeks.

No one knows for certain how long the sugar beet cyst nematode can survive without a host, but a small percentage of eggs within cysts reportedly can survive fallow conditions for over 12 years. Eggs must be inside cysts to survive such long periods without a host. The



annual rate of decline of viable eggs and larvae in fields after removal of sugar beet or another host crop can vary from 40 to 50% (Table 2). The actual rate of decline depends on the type of soil, soil temperature, soil moisture, history of pesticide use (including herbicides), susceptibility and availability of host plants (including weeds), and the presence of predators and parasites.

### **Symptoms of the sugar beet cyst nematode and impact on yield**

General nematode injury begins in fields as small patches of poorly growing plants that can exhibit stunted growth, yellowing foliage, and other symptoms of nutrient deficiency (Figure 2). Infected plants may wilt on warm days, and wilting may persist even with adequate soil moisture. Small seedlings are especially susceptible to death in heavy infestations, and surviving beets are typically small with excessively hairy roots (Figure 3). If a plant is carefully removed from the soil, the small, white, lemon-shaped females and brown cysts may be seen on the beet roots. Yield reductions increase as infection severity increases. If the infestation is severe enough, entire seedling stands can be lost.

## **2. Root knot nematodes**

**(*Meloidogyne hapla* and *M. chitwoodi*)**

### **Distribution and host range**

Although there are several species of root knot nematode in this region, the two most common on sugar beet in Idaho and eastern Oregon are the Northern root knot nematode (*M. hapla*) and the Columbia root knot nematode (*M. chitwoodi*). The Northern root



**Figure 2.** Typical field symptoms of nematode infestations. Foliar symptoms usually not diagnostic because they resemble symptoms of other maladies such as nutrient deficiencies or root rotting organisms.



**Figure 3.** The sugar beet cyst nematode can cause small, excessively hairy roots. Small, white lemon-shaped females and brown cysts may be seen on beet roots infested with the sugar beet cyst nematode.



knot nematode is distributed in sugar beet production areas throughout the northern and southern United States, and the Columbia root knot nematode is found in the Columbia River Basin in Washington, Oregon, and in Idaho, northern California, and parts of Nevada. Both species can attack sugar beets, but neither species is as economically damaging as other root knot nematode species reported in Europe or as the sugar beet cyst nematode. However, reports of Northern root knot nematode damage on sugar beets have increased during the past several years, particularly in eastern Idaho and Washington state.

The host range of root knot nematodes is wide. They attack potatoes, alfalfa (*M. hapla*), and wheat (*M. chitwoodi*), among other crops that are commonly grown in rotation with sugar beets in Idaho and eastern Oregon. Root knot nematode populations can increase dramatically when susceptible crops are grown in rotation with sugar beets.

### Life cycle and survival of root knot nematodes

The root knot nematode life cycle has six stages: the egg, first-, second-, third-, and fourth-stage larvae, and the adult stage (Figure 4). Second stage juveniles emerge from eggs and

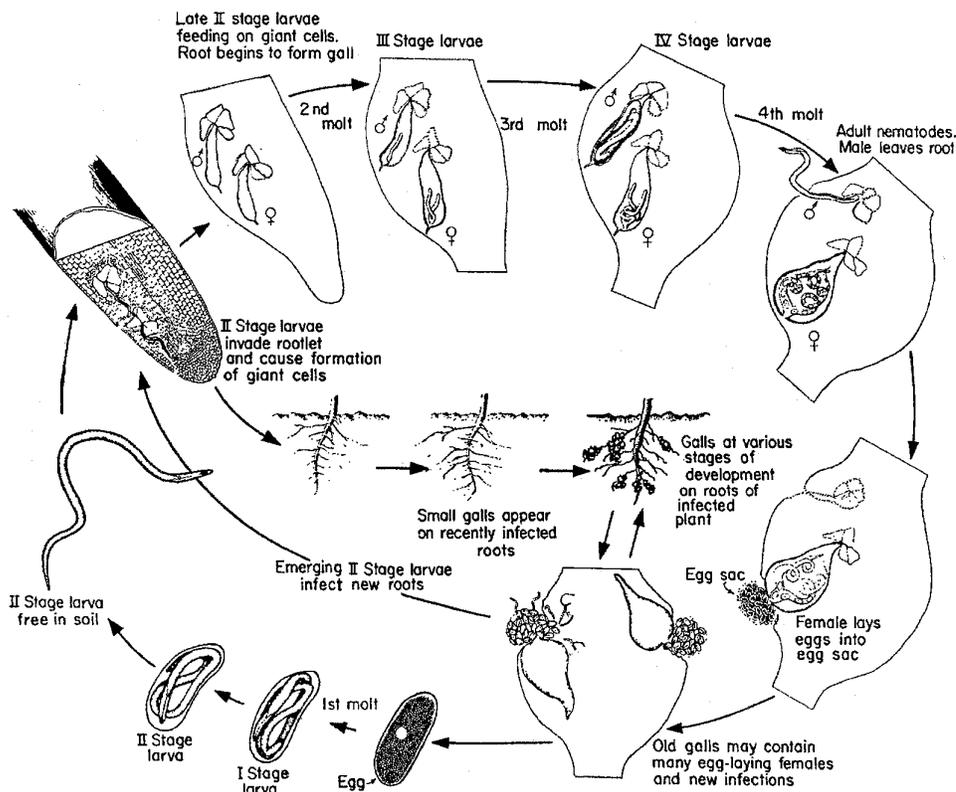


Figure 4. Life cycle of root knot nematodes.



invade sugar beet roots. They mature to adults within the sugar beet root in as few as 20–25 days. Like SBCN, female root knot nematodes become sedentary as they mature. The root knot nematode female swells into a sack-like shape and lays 50–1,000 eggs in a gelatinous matrix outside her body. Unlike sugar beet cyst nematode eggs, root knot nematode eggs hatch readily, without the stimulus of root exudates. Depending on climatic conditions (soil temperature), several generations can occur in one growing season. Root knot nematodes survive winters as eggs or as second-stage juveniles in soil or in plant tissue.

#### **Symptoms of root knot nematodes and impact on yield**

Several factors influence the severity of damage caused by root knot nematodes. High population densities and warm soil temperatures at time of sugarbeet planting can lead to severely damaged seedlings. Damage includes stunting and sometimes plant death. More typical symptoms, usually not seen until later in the growing season, are similar to those caused by the sugar beet cyst nematode. These symptoms include stunting, yellowing of foliage, wilting in the presence of adequate soil moisture (particularly on warm days), or general nutrient and micronutrient deficiencies. In a severely infested field, galls may form on lateral roots and sometimes on main tap roots (Figure 5). Severely infected and galled plants may also suffer from secondary pathogens that cause roots to begin to rot in the field, making harvest difficult and increasing losses.

Generally, the northern root knot nematode causes more damage on sugar beets



**Figure 5.** Root knot nematodes can cause plants to form galls on infected sugar beet roots and the main taproot.

than the Columbia root knot nematode. Yield reductions induced by root knot nematodes can range from slight to more than 50 percent, with 25 percent reductions commonly reported. Total losses can potentially occur in severely infested fields. Damage from the northern root knot nematode may be most severe following alfalfa hay crops and during years with warm spring temperatures. Cooler seasons may delay infection and less injury may occur.

### **3. Stubby root nematodes (*Trichodorus* and *Paratrichodorus* species)**

#### **Distribution and host range**

Stubby root nematodes are found in sandy, moist, cool soils. Until recently, problems with stubby root nematodes on sugar beets have been



confined to parts of Europe and California. Problems with stubby root nematodes have now been consistently documented in eastern Idaho for several years. Stubby root nematodes apparently have a wide host range that includes cereal crops and potatoes.

#### **Life cycle and survival of stubby root nematodes**

Stubby root nematodes are migratory ectoparasites. That is, during each stage of their life cycle, stubby root nematodes are mobile and they feed on the outside of roots. They are very mobile in the soil, and they often travel long vertical distances. Eggs are laid in soil, where all stages of the life cycle occur. The life cycle is relatively simple because all four larval stages outside the egg resemble the adult stage, except larvae are smaller. Because several generations can be produced within a year, large populations of stubby root nematodes can develop quickly. Their numbers can also decline rapidly after the crop is removed, so sampling at peak population times is critical to determine their population density more accurately. They may survive cold winters by migrating below the frost line and under going dormancy.

#### **Symptoms of stubby root nematodes and impact on yield**

Stubby root nematodes feed on main tap roots and lateral root tips, causing swollen, stubby-ended root tips (Figure 6). Root tips are often killed by these nematodes, and surviving roots become branched (forked) and distorted (Figure 7). Plants are seldom killed by this nematode. Damage by stubby root nematodes is greater in wet seasons. Above ground symptoms caused by the stubby root nematode resemble symptoms of other nematodes and can include poor growth, yellowing, and stunting.



**Figure 6.** Stubby root nematodes cause stubby-ended, swollen tips.



**Figure 7.** Forked, distorted root symptoms caused by a stubby root nematode infection.

### **General Sugar Beet Nematode Management**

#### **Prevention**

Preventing nematode infestations is the most economical method of managing them, and several ways of preventing nematode infestations exist.

- \*Composting tare dirt before returning it to clean fields should eliminate nematodes that survive in sugar beet tare dirt.

- \*Avoid moving soil from infested fields to clean fields with farm machinery.



\*Avoid using contaminated irrigation water (e.g., irrigation waste water).

\*Composting fresh manure fertilizer from feed lots (where livestock were grazing in infested fields) before applying to fields should eliminate surviving nematodes.

\*Avoid moving livestock from infested fields to clean fields.

\*Plant seed free of plant debris and soil that may harbor nematodes.

Although prevention is the most economical means of managing nematodes, management decisions are often made after a nematode problem is diagnosed. The most effective management programs integrate various proven methods, and usually involve a combination of cultural practices, use of resistant cultivars (when available), nematode resistant trap crops, and chemical control.

#### **Cultural practices**

Damage from plant parasitic nematodes can be reduced by employing a combination of various crop management practices such as crop rotation, weed control, early planting, use of organic manure, and proper fertilization.

#### ***Crop rotation.***

Crop rotation is effective when the nematode has a relatively narrow host range, such as SBCN. Crop rotation is the easiest and cheapest method of manipulating SBCN populations, and rotating sugar beets with nonhost crops such as grain, corn, onion, potato, alfalfa, mint, or bean for various lengths of time (depending on the severity of infestation) should reduce SBCN populations. Table 2 illustrates the possible effect of rotation with nonhost crops for up to 7 years in a

hypothetical field that has an initial SBCN population of 15 viable eggs and larvae per cm<sup>3</sup> soil. Controlling host weeds (Table 1) in rotation crops is essential to achieve the best SBCN reduction.

Crop rotation can have limited success, however, when the nematode pest has a relatively wide host range, as in root knot nematodes and stubby root nematodes. Small grains followed by clean fall fallow reduces population levels of root knot nematodes, particularly the northern root knot nematode. Corn, when grown for two consecutive years, has reportedly reduced northern root knot nematode populations sufficiently to obtain higher sugar beet yields.

#### ***Early planting (escape).***

Planting sugar beet as early as possible when soil temperatures are low (50-55F) should help the crop become established and escape economic damage before the rate of nematode hatching, movement, and invasion increases as soil temperature increases. Well-established sugar beet plants can withstand later attack by nematodes.

#### ***Organic manure.***

Using organic manure (from non-infested fields) may help to reduce nematode populations by enhancing the activity of nematode-destroying organisms in the soil. As organic manure crops degrade, they release high concentrations of carbon disulfide and toxic acids that can kill nematodes. Organic manure improves physical properties of soil that may enhance plant growth and increase plant tolerance to nematode infection. Addition of organic manure to achieve desirable benefits is a long-term process.



### **Proper fertilization.**

Proper fertilization and good nutritional status of sugar beet plants should help reduce the impact of nematode damage. Applying higher amounts of fertilizer may lower crop losses from light nematode infestations. Severity of nematode damage is more pronounced under stressful field conditions.

### **Resistant cultivars**

Although researchers have identified sources of SBCN resistance in sugar beets, agronomically acceptable cultivars are currently not available. Several sugar beet hybrids have been evaluated for SBCN resistance in greenhouse tests, and most of the hybrids that were tested significantly reduced SBCN populations compared to the susceptible varieties Mono Hy RH 83 and WS-PM-9. Cultivars that are resistant to root knot nematodes or stubby root nematodes are not available.

### **Nematode resistant trap crops**

Trap (catch) crops such as SBCN-resistant varieties of oil radish (*Raphanus sativus* spp. *Oleifera*) and white mustard (*Sinapis alba*) have been specially developed for SBCN management. As the trap crop develops in SBCN-infested soil, it triggers the nematode eggs to hatch, but the newly hatched juveniles are unable to develop into reproductive adults. The nematode population density in the soil is reduced and conditions are again favorable for sugar beet production. Trap crops can be planted in early spring or late summer. They are often planted after small grain harvests (between the last week in July and the last week in August). A minimum of eight weeks growth is required to achieve the best SBCN population

reduction. Details on the effectiveness and cultural management of trap crops can be found in the CIS publication, “Cultural Management of Green Manure Trap Crops in Sugar Beet Rotations for Sugar Beet Cyst Nematode Management.” (University of Idaho CIS 1071).

### **Chemical control**

Severe nematode infestations may require the use of nematicides. Because nematicide registrations may change, growers should consult the most recent Pacific Northwest Disease Control Handbook for current recommendations. Following are some tips to optimize effectiveness of chemical applications.

- \*Use only labeled chemicals and recommended rates.

- \*Carefully calibrate and maintain machinery to avoid over or under application.

- \*Apply the chemicals only when soil conditions (moisture, temperature, and preparation) are suitable.

- \*Treat the ends of fields, even if they will not be planted, to avoid re-contamination.

- \*Implement and maintain an effective weed control program.

- \*Avoid bringing nematode-contaminated equipment into treated fields.

- \*Irrigation should follow application as soon as possible when using systemic nematicides.

### **Management Decisions Based on Economic Thresholds**

#### **Economic thresholds for nematode pests**

The economic injury level of a particular pest is the “break-even” population density level, when the cost of pest management at this



population density exactly equals the increased crop return. *Economic thresholds* are defined as the pest population levels at which management action should be taken to avoid reaching the economic injury level. Economic thresholds of nematodes often vary from region to region. For example, the economic threshold for the sugar beet cyst nematode in the Magic Valley of southern Idaho is three eggs and larvae per 1 cubic centimeter (cc) soil. In the Treasure Valley region of southwestern Idaho, where the growing season is slightly longer than the Magic Valley, the economic threshold for the sugar beet cyst nematode is two eggs and larvae per 1 cc soil. Economic threshold levels of the Northern root knot nematode or stubby root nematodes are currently unknown for sugar beet. Consequently, management decisions for these nematodes are often based on the presence of the nematode and previous problems rather than economic threshold levels.

### **Soil sampling**

Soil and root sampling is critical to determine if a nematode pest is present and to find out its population density. If economic threshold levels are known, as in the case for the sugar beet cyst nematode, the population density can be determined for any field, and management programs based on economic thresholds can be developed. If the economic threshold level of a nematode species is not known, a management program based on the presence of the nematode or past diagnosed problems with the nematode (or both) can be implemented. The bulletin, "Sampling Procedure to Diagnose Nematode Infestations"

(University of Idaho CIS 1056), provides detailed information on a soil sampling procedure. Good sampling procedures are essential for proper diagnoses and making for effective management decisions.



**Table 1.** Partial list of hosts of the sugar beet cyst nematode.

<b>Field crops and vegetables</b>	<b>Weeds</b>	<b>Ornamental plants</b>
Wild beet	Broadleaf dock	Candy tuft
Red table beet	Cattle spinach	Nasturtium
Sugar beet	Chickweeds	Carnation
Swiss chard	<i>common</i>	Arache
Leaf Beet	<i>mouseear</i>	
Spinach	Goosefoot	
Horseradish	<i>common lambsquarter</i>	
Common mustard	<i>Russian thistle</i>	
Kohlrabi	Knot weeds	
Rutabaga	<i>prostrate knotweed</i>	
Rape or coleseed	Mustards	
Turnip	<i>blue mustard</i>	
Broccoli	<i>field pennycress or fanweed</i>	
Brussel sprouts	<i>flixweed or tansy mustard</i>	
Cabbage	<i>shepards purse</i>	
Cauliflower	<i>tumble mustard</i>	
Radish	<i>wild mustard</i>	
Dill	Nightshades	
Kale	<i>cutleaf nightshade</i>	
Rhubarb	Pigweeds	
	<i>smooth pigweed</i>	
	<i>redroot pigweed</i>	
	<i>prostrate pigweed</i>	
	<i>tumble pig weed</i>	
	Pokeweed	
	Purslane	

**Table 2.** Illustration of the potential effect of rotation with nonhost crops for up to 7 years on sugar beet cyst nematode populations. In this example, a hypothetical field has an initial nematode population of 15 viable eggs and larvae per 1 cm<sup>3</sup> soil in Year 0 (the year sugar beet or another host was planted). A 40% rate of decline is calculated for each subsequent year that nonhosts are planted.

<b>Year after a sugar beet crop</b>	<b>Estimated number of viable eggs + larvae remaining per 1 cm<sup>3</sup> soil</b>
0	15.0
1	9.0
2	5.4
3	3.2
4	1.9
5	1.2
6	0.7
7	0.4



### **Suggested reading**

Hafez, Saad L. *Cultural Management of Green Manure Trap Crops in Sugar Beet Rotations for Sugar Beet Cyst Nematode Management*. University of Idaho CIS 1071.

Hafez, Saad L. *Sampling procedure to diagnose nematode infestations*. University of Idaho CIS 1056.

Steele, A. E. 1986. Nematode parasites of sugar beet. Pages 33-36 In: *Compendium of Beet Diseases and Insects*. Whitney, E.D and James E. Duff, eds. American Phytopathological Society, APS Press: St. Paul.

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