Sugarbeet Cyst Nematode: Impact on Sugarbeet Production in Idaho and Eastern Oregon

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Nematodes are microscopic worms that may cause serious damage to plants. More than two dozen different nematode species have been reported to cause severe economic damage to sugarbeets wherever they are grown commercially. Yield losses because of nematode damage in sugarbeets can range from 10 to 80 percent, depending on the nematode type and initial populations present in the fields at planting time. In Idaho and eastern Oregon, there are four different species which can be of economic importance if they are not managed properly.

1. Sugarbeet cyst nematode—*Heterodera schachtii*
2. Northern Root-knot—*Meloidogyne hapla*
3. Stubby Root—*Paratrichodorus* or *Trichodorus* spp.
4. Stem Nematode—*Ditylenchus dipsaci*

This report focuses upon the sugarbeet cyst nematode, *Heterodera schachtii*. Nematologists and plant pathologists generally agree that sugarbeet cyst nematode (SCN) is the major pest affecting sugarbeet production in the world, generally accounting for more than 90 percent of the total loss caused by all nematodes. Historically, the spread of the SCN has coincided with the expansion of sugarbeet production to new areas. The nematode was first observed in the United States as early as 1895. By 1907, SCN had been found in California, Utah, Colorado, and Idaho. Today, SCN is present in 17 states of the United States and in 40 different countries. Sugarbeet production has been terminated in Utah and Washington largely because of heavy infestations of SCN, which has made it impossible to grow sugarbeets economically. In warmer climates with a longer growing season, the loss can be higher because the nematode damage is often increased by secondary pathogens. For example, in Idaho, infection with SCN often enhances infection by Rhizoctonia, a fungal disease.

In Idaho and eastern Oregon, SCN has been recognized as one of the most serious problems for the sugarbeet industry. It is, in fact, one of the most important limiting factors in sugarbeet production. Growers must choose between a long rotation practice using non-host plants or the application of expensive nematicides to obtain economic yields in nematode-infested fields. In Idaho and eastern Oregon more than 50 percent of the sugarbeet acreage is infested with SCN at a level where treatment is necessary to obtain economically feasible yields.

Damage caused by SCN depends on the initial nematode population density, the general soil and climatic conditions that influence growth of the host plant, and nematode survival and reproduction rate. Nematode distribution patterns in a field and throughout the soil profile are influenced by the age of the infestation. In newly infested fields nematode distribution is usually limited to small patches and the highest nematode populations will be near the soil surface (0 to 15 cm). In older infestations the nematodes occur in a more uniform pattern and at much greater depths (0 to 50 cm). In general, the highest population occurs about 5 to 25 cm below the soil surface.

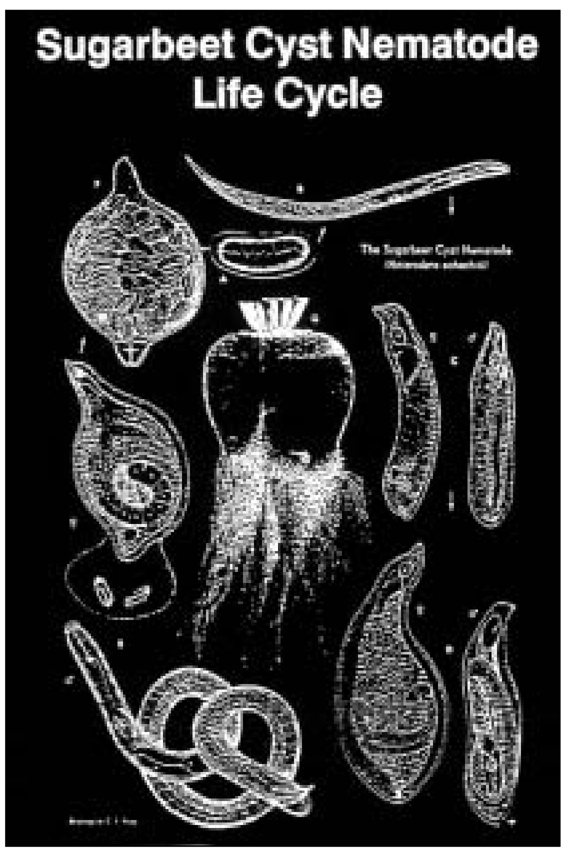

Figure 1. SCN life cycle.

Sugarbeet cyst nematode life cycle

Plant parasitic nematodes depend on the presence of living plants for their survival and reproduction. The sugarbeet cyst nematode has six stages in its life cycle: the egg, four larval stages and the adult stage (Figure 1). Second-stage larvae, hatching from fertilized eggs, are the infective stage invading small roots where they feed on cells in the cortex and stele, causing formation of giant cells. Males are required for reproduction and retain a thread-like shape throughout their life cycle. In females, as size increases during development of third and fourth larval stages, the swollen body bursts from the root tissues so that adults have the swollen portion of the body exposed on the root surface with the head and neck embedded in the root. Adult females, which are white or light yellow in color, lay eggs into a gelatinous matrix. These eggs later hatch and the second-stage larvae invade new roots. When the female nematodes are fully mature, or when feeding is interrupted, the body wall undergoes a tanning process and becomes brown in color. At this stage the dead female body containing 300 to 500 eggs is referred to as a "cyst." The cyst become detached from roots, lying free in the soil. Eggs in the cyst may remain viable for long periods of time and may not hatch readily unless stimulated by root secretions, usually of host plants. The larvae will die if a proper host is not present (Table 1). The number of generations per year varies with climatic conditions. Approximately half of the eggs hatch each year under suitable conditions of moisture and temperature. Under optimum conditions and soil temperatures the life cycle (from hatching of larvae to the formation of new larvae) takes four to six weeks.

Table 1. Brief list of Sugarbeet Cyst Nematode, *H. schachtii,* Host Range.

Field crops and vegetables	Weeds	Ornamental plants
Wild beet	Broadleaf dock	Candy tuft
Red table beet	Cattle spinach	Nasturtium
Sugarbeet	Chickweeds	Carnation
Swiss chard	common	Arache
Leaf Beet	mouseear	
Spinach	Goosefoot	
Horseradish	common lambsquarter	
Common mustard	Russian thistle	
Kohlrabi	Knotweeds	
Rutabaga	prostrate knotweed	
Rape or coleseed	Mustards	
Turnip	blus mustard	
Broccoli	field pennycress or fanweed	
Brussels sprouts	flixweed or tansy mustard	
Cabbage	shepards purse	
Cauliflower	tumble mustard	
Radish	wild mustard	
Dill	Nightshades	
Kale	cutleaf nightshade	
Rhubarb	black nightshade	
Tomato	buffalobur	
	hairy nightshade	
	Wright groundcherry	
	Pigweeds	
	smooth pigweed	
	redroot pigweed	
	prostrate pigweed	
	tumble pigweed	
	Pokeweed	
	Purslane	

The maximum time SCN can survive in the soil without a host plant is unknown. A small percentage of the eggs in the cyst can survive in fallowed conditions for more than 12 years after the removal of sugarbeets. Depending on climatic and edaphic factors affecting hatching and survival, the annual rate of decline in fields from which sugarbeets have been removed may vary from 40-50 percent (Table 2). Important factors affecting SCN persistence and survival are: soil type, moisture and temperature; history of pesticide use (including herbicides); susceptibility and availability of host plants (cultivated crops and weeds); and the presence of predators and parasites.

Figure 2. Field plants, patches of SCN infestation.

Plant symptoms of SCN damage in the field

- Nematode injury first appears in the beet fields as small patches with poorly growing plants (Figure 2).
- Stunted growth.
- Yellow foliage and nutrient deficiency.
- Plants wilt on warm days and wilting persists, even with high moisture levels in the soil.
- Small seedlings may be killed by heavy infections.
- Surviving beets are usually small and have excessive hair-like roots (Figure 3).
- The presence of small lemon-shaped white bodies of the female nematodes and brown cysts on the beets (Figure 4). Yield is reduced in relation to the severity of infection.

Table 2. The estimated effect of eight consecutive years of planting non-host crops before beets on the number of viable eggs in sugarbeet cyst nematode*.

No. of viable cyst in 500 cm^3 soil	Cyst age (year)	% of viable eggs	No. of viable eggs in 500 cm^3 soil
4	1	100	2,000
4	2	60	1,200
4	3	36	720
4	4	22	432
4	5	13	260
4	6	8	156
4	7	5	94
4	8	3	56

*Hypothetical sample assuming that four cysts are present each year with a declining number of viable eggs at the rate of 40 percent each year.

Nematode spread (dissemination)

Plant parasitic nematodes are capable of moving only relatively short distances under their own power. Studies of nematode spread indicate that humankind is often the culprit, unintentionally contributing to the dissemination of this pest. Sugarbeet cyst nematode is spread easily within a field, from field to field, or from area to area. Cysts contain eggs that can be disseminated in irrigation water and in soil adhering to livestock or machinery. Soil containing cysts can also be spread wind, birds and return of infested tare dirt back to the field.

Soil sampling for sugarbeet cyst nematode detection

Analysis of soil and root samples is necessary to confirm suspected SCN presence in sugarbeet fields before or after planting. Samples can be taken with a soil sampling tube or probe, trowel, or shovel. Samples should be taken before any treatment decision is required, and when soils are not excessively wet, dry, or frozen. Samples should be taken from the root zone by removing the top 2 inches of soil and then sampling to a depth of 15 to 18 inches. Include sugarbeet plants if sample is taken during the growing season. Random representative samples should be taken throughout the field, but if a previous crop indicated a problem spot a separate sample should be taken from that area. At least 4 to 5 tubes (subsamples) per acre should be obtained, thoroughly mixed, and approximately one pint to one quart of soil submitted for testing. The sample should be placed in a durable, moisture resistant sample bag. Keep the sample cool, ideally 50°F, do not leave in direct sunlight or car trunk, and send or deliver to the laboratory as soon as possible. Samples must be labeled with information (location, soil type, cropping history, current and anticipated crop, last nematicide used, etc.) which may aid in identification and diagnosis.

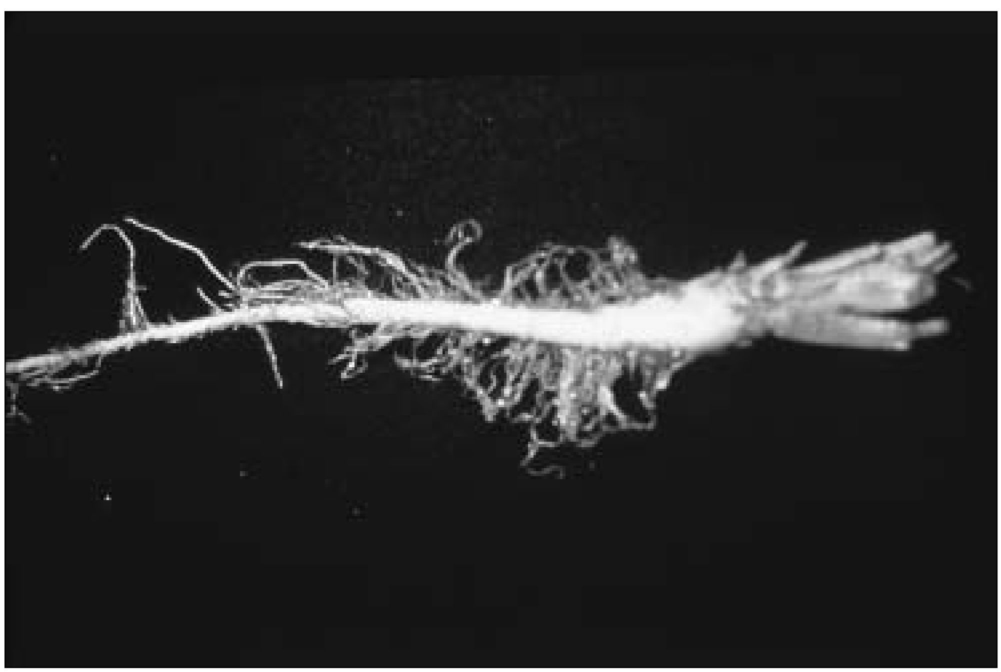

Figure 3. Beets with small and excessively hairy roots.

Sugarbeet cyst nematode management

After a SCN problem has been diagnosed, a nematode management program must be planned by integrating various methods which have been shown to be effective. This will probably involve a combination of chemical and non-chemical tactics.

Basic strategies for sugarbeet cyst nematode management
- Prevention
- Cultural practices
- Resistant cultivars
- Nematode resistant catch crops
- Chemical control

Prevention

"An ounce of prevention is worth a pound of cure" is an old adage appropriate for the economic management of SCN. There are many ways of preventing nematode infestation.
- Do not return tare dirt to fields.
- Avoid moving soil from infested fields to clean fields with farm machinery.
- Avoid using irrigation waste water.
- Avoid using fresh manure fertilizer from feed lots where livestock were grazing in infested fields.
- Avoid moving grazing livestock from infested fields to clean fields.
- Plant seed free of plant debris and soil.

Cultural practices

Damage from SCN may be reduced by employing a combination of various crop management practices such as crop rotation, weed control, early planting, organic manure application, and proper fertilization.

a. Crop rotation

Crop rotation is the simplest and cheapest method of manipulating SCN populations. It is easier to institute a system of crop rotation for narrow host range species of nematode such as SCN. To reduce the SCN population, sugarbeets should be rotated with non-host crops such as grain, corn, onions, potatoes, alfalfa, mint, or beans for various lengths of time depending on nematode infestation levels. Refer to Table 2 for an illustration of the effect of 8 years of rotation on the number of viable eggs from infestation levels of four cysts per 500 cm^3 soil. Control of weeds, especially SCN host species (Table 1), in rotation crops is essential to help reduce SCN populations before planting sugarbeets.

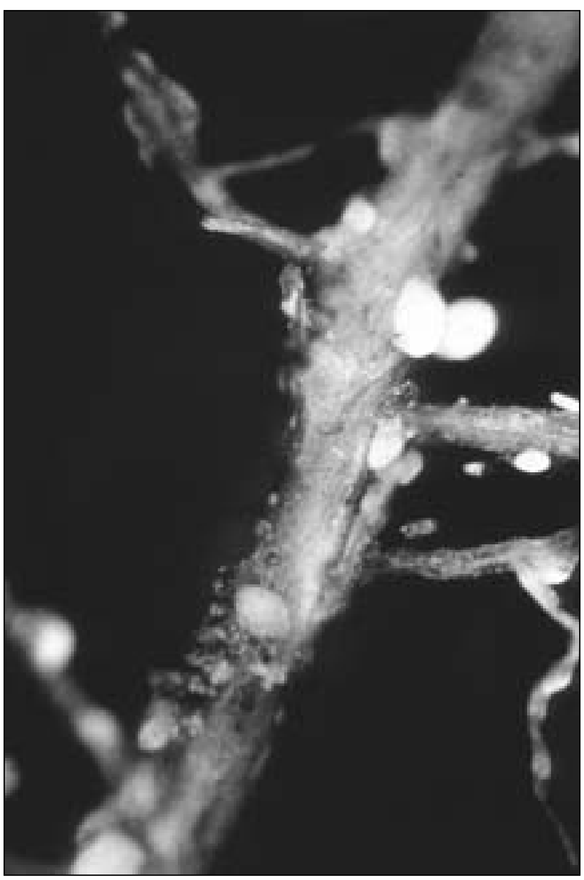

Figure 4. Lemon-shaped white E's and brown cysts.

b. Early planting (escape)

Planting sugarbeets as early as possible when soil temperatures are low (50° to 55°F) greatly reduces the rate of nematode hatching, movement, and invasion. Therefore, the crop may escape economic damage when planted early. Also, well established sugarbeet plants can withstand later attack by nematodes.

c. Organic manure

Organic manure (aged manure from non-infested fields) may help reduce nematode populations and subsequent damage by enhancing the activity of nematode-destroying organisms in the soil. The breakdown of organic manure will produce higher concentrations of carbon dioxide and toxic acids that kill nematodes. Organic manure improves soil physical properties that may enhance plant growth and reduce nematode infection. The addition of organic manure to achieve desirable benefits is a long-term process.

d. Proper fertilization

Proper fertilization and general nutritional status of sugarbeet plants will reduce the impact of SCN damage. Higher fertilizer applications may reduce crop losses where a light nematode infestation is present. Severity of nematode damage is more pronounced under stressful field conditions.

Resistant cultivars

Although research is underway to develop sugarbeet cultivars that are resistant to SCN, agronomically acceptable cultivars are not available. However, a test has been conducted and promising results obtained for several sugarbeet hybrids. Hybrids were evaluated under greenhouse conditions to determine their susceptibility to SCN by measuring population increases. Results of this test indicated that most of the hybrids tested significantly reduced the nematode population in comparison with the susceptible variety Mono Hy RH 83.

Nematode resistant catch crops

Catch (trap) crops of oil radish (*Raphanus sativus* spp. *oleifera*) and white mustard (*Sinapis alba*) have been developed for SCN management. A minimum of eight weeks growth is required for catch crops to be effective. Plantings of catch crops occur in fall or spring. Oftentimes, catch crops are planted after small grain harvest in the summer and are allowed to grow for a minimum of eight weeks or until killing frost. Planting date for this practice is usually between the last week in July and the last week in August. Develop-

Table 3. Effect of spring planted oil radish and white mustard on sugarbeet cyst nematode populations. Parma, Idaho. Saad L. Hafez, 1991.

	Nematode Population in 500 cm^3 soil									
	Pre-Planting 3/24/91			Post-Planting 06/04/91			Post-Planting 07/15/91			
Crop	V.C.	E&L/ cyst	Total E&L	V.C.	E&L/ cyst	Total E&L	V.C.	E&L/ cyst	Total E&L	% Reduction
'Pegletta'	18.0	178	3,204	12.2	108	1,318	8.0	134	1,072	66.5
'Nemex'	12.0	132	1,584	9.8	110	1,078	9.6	127	1,219	23.0
'Maxi'	8.0	168	1,344	11.0	111	1,221	1.6	108	173	87.1
Fallow	17.6	176	3,086	20.6	146	3,008	12.2	174	2,223	28.0

Abbreviations: V.C. =viable cysts, E&L= eggs and larvae.

Planting date: 3/29/91
Plowing date: 7/16/91

Table 4. Effect of fall planted oil radish and white mustard on sugarbeet cyst nematode populations. Parma, ID 1992 - 93.

Crop	Viable Cysts 8/6/92*	Viable Cysts 4/20/93**	Total eggs & larvae 8/6/92	Total eggs & larvae 4/20/93	%Reduction
'Adagio' radish	16.8	3.0	2,167	171	92
'Ultimo' radish	15.3	4.5	2,010	225	89
'Remonta' radish	9.0	2.5	936	110	88
'Pegletta' radish	11.5	2.5	1,484	193	87
'Metex' mustard	12.5	3.0	1,288	201	84
'Maxi' mustard	8.5	2.8	1,139	235	79
'Martigena' mustard	11.5	8.0	1,806	688	62
Fallow control	6.8	5.5	1,149	679	41

* 8/6/92 = Before planting green manure crops.
**4/20/93 = Before planting sugarbeets.

ment of the catch crop in nematode-infested soil triggers the nematode eggs to hatch but adults are not able to reproduce. The nematode population density in the soil is reduced and conditions are again favorable for sugarbeet production. The practice is presently being utilized on about 250,000 acres in Germany.

Nematode-resistant catch crops, (oil radish and white mustard) were tested in Idaho to evaluate their potential use in SCN integrated management programs. Results indicated that 'Pegletta' and 'Nemex' oil radish and 'Maxi' white mustard significantly reduced the number of SCN eggs by 67, 23, and 87 percent, respectively. Fallow was used as the control treatment and reduced SCN eggs by 28 percent of the initial population (Table 3). Research conducted in fields at Worland, Wyoming, produced similar results. Results of these studies indicated that resistant catch crops should be used as a part of an integrated pest management system.

Table 5. Effect of fall planted oil radish and white mustard on sugarbeet yield and percent sugar the following season, Parma, 1993.

Crop	Sugarbeet root yield (T/acre)	Yield increase (T/acre)	Sugar %
'Adagio' radish	31.4 a*	9.3	17.0
'Metex' mustard	29.1 a	7.0	17.2
'Pegletta' radish	28.6 a	6.5	16.9
'Ultimo' radish	28.2 a	6.1	16.5
'Maxi' mustard	28.1 a	6.0	16.8
'Remonta' radish	27.6 a	5.5	17.4
'Martigena' mustard	25.9 b	3.8	17.1
Fallow control	22.1 b	—	17.4

*Means followed by different letters are significantly different (p=0.05).

Different cultivars of catch crops have different levels of resistance and none of them are absolute. Seven catch crops were fall-planted in Idaho to determine their influence on SCN populations and sugarbeet yield the following year. Population results indicate that dramatic reductions of SCN up to 92 percent may be obtained with catch crops when compared with fallow, which showed a population reduction of 41percent (Table 4). Yield increases between 3.8 and 9.3 tons per acre were observed when beets were planted after catch crops (Table 5). Sugarbeet yield following six of the seven catch crops was statistically higher than the fallow treatment. No statistical differences were detected for percent sugar in the crop grown in areas previously planted to catch crops.

Important factors to consider when employing catch crops include careful selection of a resistant catch crop cultivar, dense planting and deep root penetration, and utilizing optimum conditions of temperature and moisture to maximize egg hatching.

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. The following are some tips to optimize effectiveness of chemical application.

- 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 recontamination.
- 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.

About the authors

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