UNIVERSITY OF WYOMING

Agricultural Experiment Station
Department of Plant Sciences
College of Agriculture

B-975R
August 1997

BIOLOGY AND MANAGEMENT OF THE SUGAR BEET NEMATODE

Fred A. Gray and David W. Koch[1]

The sugar beet nematode, *Heterodera schachtii,* is a major root parasite of sugar beet. It causes serious stand and yield reductions wherever sugar beets are grown. It was first identified in 1859 on roots of sugar beet plants near Halle, Germany. It was first observed in the United States as early as 1895. Today, *H. schachtii* is present in 17 states in the U.S., including Wyoming, and in 39 other sugar beet growing countries throughout the world.

SYMPTOMS

Entire fields may be infested, or they may have one or more localized areas of infestation. Localized infestations may result in well-defined circular or oval areas where plant stand and growth of sugar beet are poor (Figure 1). Over time these areas

Figure 1. Sugar beet field with localized areas of poor growth due to Heterodera schachtii.

Figure 2. Sugar beet plants parasitized by Heterodera schachtii. Note severe stunting and yellowing of diseased plants.

usually become enlarged with tillage. *H. schachtii* can parasitize sugar beet roots of all ages. Seedlings may be severely injured or killed, resulting in poor stands. However, the older the plant when attacked, the less damage will occur. Young plants attacked by *H. schachtii* may have elongated petioles and remain stunted until harvest. When roots are parasitized, outer leaves of plants usually wilt during the hot period of the day or when soil moisture becomes limited. Leaves of parasitized plants also may have pronounced yellowing (Figure 2). Affected plants have small storage roots (Fig. 3). Parasitized tap roots may be severely branched with excess fibrous roots. These are often referred to as "bearded" or "whiskered" roots. When older plants are attacked symptoms are less noticeable.

[1] Professor and Extension agronomist, respectively, Department of Plant Sciences, College of Agriculture, University of Wyoming.

Figure 3. Reduction in size of storage root of sugar beet due to heavy parasitism by Heterodera schachtii.

LIFE CYCLE

H. schachtii is a parasitic roundworm. Its life cycle is shown in Figure 4 (A-G). Eggs and juveniles remain dormant and survive inside the cyst (F), which is the body of the dead female. When the root of a host plant contacts or grows near the cyst and soil moisture is sufficient, root exudates stimulate juveniles to hatch and emerge from the cyst (A & B). Juveniles are attracted and migrate to the fibrous roots, infecting near the root tips (G). After entering the root, they migrate a short distance within the cortical tissue and begin developing into adults that become sedentary (C & D). After three additional molts, adult males emerge from the root (E) and enter the soil. After a fourth molt, the females become lemon shaped and can be seen as small white-yellow dots attached to fibrous roots (G). Males are attracted to the females where fertilization occurs. Up to 200 eggs have been reported to be produced by one female, a few of which are laid outside the body in the soil. However, the majority of the eggs remain inside the female. At maturity, the female dies, and her body wall hardens and is transformed into a light brown to reddish-brown cyst (F), completing the cycle. Cysts are barely visible to the naked eye. The cycle requires four to six weeks, depending on soil temperature. *H. schachtii* reproduces best between 70-80 degrees Fahrenheit, but can reproduce between 50-90 degrees Fahrenheit. Three cycles have been reported to occur during the growing season in western Nebraska.

SURVIVAL IN SOIL

Eggs and/or unhatched juveniles may remain viable within the cyst in irrigated fields for several years (Figure 5). The sugar beet nematode may survive even longer in nonirrigated fallowed soil. Factors affecting survival or rate of decline include soil temperature, soil moisture, susceptibility of plants (including cultivated crops and weeds), soil type, and number of predators and parasites present. High soil populations of *H. schachtii* have been found in sugar beet fields in the sandy loam soils of Goshen County (134 eggs/cubic centimeter [cm^3] or 2,196/ cubic inch [in^3] of soil), as well as in the heavier clay loam soils of Washakie County (200 eggs/cm^3 or 3,277/in^3 of soil).

HOST RANGE

In Wyoming, *H. schachtii* presently causes economic losses only in sugar beet; however it can attack over 200 plant species in 23 different plant families. Most hosts are found in the *Chenopodiaceae* family (includes sugar beet) and the *Cruciferae* family. In addition to sugar beet, other host crops include broccoli, brussels sprout, cabbage, canola, cauliflower, kale, kohlrabi, radish, rhubarb, spinach, table beet, tomato, turnip, and other closely related crops. Crops that are host to *H. schachtii* should not be grown in fields where sugar beets are grown. Weed hosts include mustard, pigweed, lambs-quarters, shepherdspurse, purslane, and other closely related weeds. Good weed control is crucial during rotation if maximum reduction of soil population of *H. schachtii* is to be obtained.

DISTRIBUTION AND SPREAD

Cysts have been found in the soil profile in Wyoming from the surface down to 36 inches. The greatest concentration is usually found in the root zone (0-12 inches). Spread of cysts may occur in many ways. Long distance spread has most likely been from cysts in soil peds (round balls of soil) with seed. Contaminated soil can also be spread on machinery or animal hooves. Short-distance spread occurs through irrigation water. This can occur

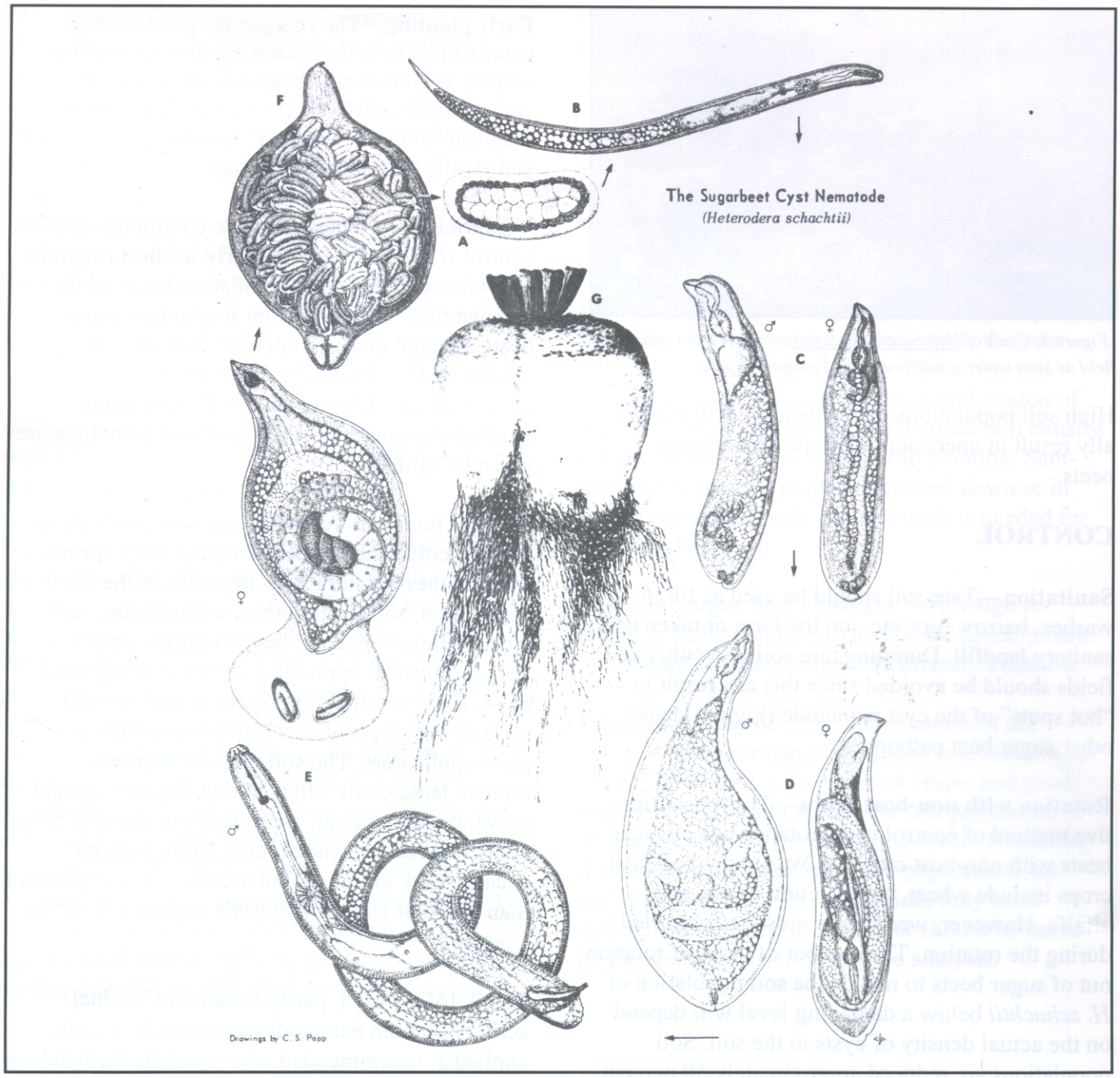

Figure 4. Life cycle of the "sugar beet cyst nematode" Heterodera schachtii. Drawing by C.S. Papp.

throughout the canal system, as well as in surface water within a given field. Other means of spread include wind-blown soil and cysts, and cysts in feces of birds and other animals. Many of the cysts attached to roots are shaken off (with attached "tare" soil) during unloading at beet receiving stations. Therefore, tare soil from infested fields may have a high number of egg-filled cysts.

DAMAGE

Initial soil population density of 2 to 3 eggs and/or juveniles per cm^3 of soil (32-49/in^3) may result in yield loss. The amount of damage is determined largely by the level of parasitism and the length of favorable environmental conditions. Plant damage is most severe following wet springs that provide optimum conditions for root infection.

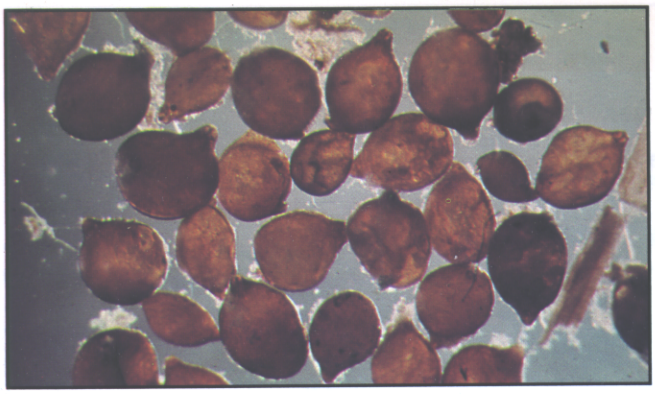

Figure 5. Cysts of Heterodera schachtii removed from sugar beet field as seen under a microscope (35 magnifications).

High soil populations of *H. schachtii* will eventually result in uneconomic production of sugar beets.

CONTROL

Sanitation—Tare soil should be used as fill in washes, barrow pits, etc., on the farm or taken to a sanitary landfill. Dumping tare soil into cultivated fields should be avoided since this can result in "hot spots" of the cyst nematode (Figure 1) and other sugar beet pathogens.

Rotation with non-host crops—The most effective method of control is the rotation out of sugar beets with non-host crops. In Wyoming, non-host crops include wheat, barley, corn, beans, and alfalfa. However, weed hosts must be controlled during the rotation. The number of years of rotation out of sugar beets to reduce the soil population of *H. schachtii* below a damaging level will depend on the actual density of cysts in the soil. Soil populations are reduced approximately 50 percent during each year of rotation. For example, if you had a population level of 10 eggs/cm^3 (160 eggs/in^3) of soil and you rotated one year with corn, the soil population would be expected to be reduced to 5 eggs/cm^3 (80 eggs/in^3). If you continued your rotation for one additional year, the population would be expected to be reduced to 2.5 eggs/cm^3 (40 eggs/in^3), and so on. A rotation of three to five years is usually required to maintain populations below a level that will result in economic loss.

Early planting—The younger the plant is when parasitism occurs, the greater the damage and loss will be. Therefore, planting early when the soil temperature is relatively cool allows sugar beet to establish before *H. schachtii* juveniles become active and greatly reduces plant damage.

Nematicides—Nematicides are commonly used to control *H. schachtii,* particularly in short rotations and when the nematode population is above the damage threshold level prior to planting sugar beets. Several nematicides are labeled for the control of *H. schachtii* on sugar beets. Nematicides, as well as their labeled rates and application methods for control of the sugar beet nematode are given in Table 1.

The soil fumigant Telone® II must be applied preplant in either the fall or during the early spring. Effectiveness of fumigants depends on the depth of application, soil temperature, soil moisture, soil type, compaction, and organic matter content. Telone II can be applied by chisel or moldboard plow. It is extremely important to seal the soil surface with presswheels following moleboard plow applicators. The soil must be worked to remove large clods which allows a good seal and prevents the fumigant escaping from the soil. When applied at recommended rates, fumigants are usually more effective, but are also more expensive than granular contact materials such as Temik® or Counter®.

Temik 15G is used, partly because of its dual activity on both nematodes and insects. Temik, applied at recommended rates, inhibits the hatching of juveniles and disorients juveniles and adult males in the soil. Under furrow irrigation, Temik granules are drilled in beneath and to the side of the seed row. When taken up by the plant, they become systemic and inhibit the development of *H. schachtii* after they penetrate into the sugar beet root. The label also allows for a split application at planting and post-plant sidedressing.

Counter 15G and Counter 20CR also have dual activity, are registered for suppression of the sugar beet nematode, and are useful for low to moderate nematode populations.

Trap crops—Several cultivars of nematode-resistant "trap crops" have been developed in Germany to control the sugar beet nematode. 'Adagio' radish or 'Metex' mustard are planted following harvest of a small grain crop and are allowed to grow into the late fall-early winter. Root exudates from these crops stimulate nematode juveniles to hatch, leave the cyst, and swim toward the roots in search of food (Figure 4). However, these cultivars have been bred to prevent reproduction on their roots. Studies in Germany indicate that a minimum soil temperature of 40 degrees Fahrenheit or higher is needed for hatching to occur. Trap crops are plowed down in late fall. Most juveniles which hatch and leave the cyst die during the winter months, thus lowering the soil population.

Research conducted in Wyoming has shown best results are obtained in the Big Horn Basin when trap crops are planted in July following barley harvest. Seed should be planted in July, or soon thereafter, and irrigated to allow for maximum plant growth. It is essential to control volunteer barley, which would smother the trap crop. Residual soil nitrogen following malting barley may be too low for vigorous trap crop growth. In the absence of a soil test, 50-70 pounds of nitrogen fertilizer per acre should be applied. In eastern Wyoming planting trap crops in July or early August following irrigated winter or spring wheat or spring planted feed barley should produce equally good results. Seeding after corn or bean harvest does not provide sufficient time for trap crop growth and effective nematode control. Seed of 'Adagio' and 'Metex', available from Hilleshog (Sandoz Seeds), Hilleshog Mono-hy, Inc., in Longmont, Colorado, may be obtained through your local seed dealer. Trap crops, when used in conjunction with a non-host rotation crop, further lower the soil population of *H. schachtii* and reduce the need for nematicide in the following sugar beet crop. Both radish and mustard trap crops also provide excellent forage for grazing of livestock during late summer-early fall. Trap crops are normally planted in small grain stubble the year proceeding sugar beet planting. Therefore, soil nematode samples should be taken mid-season of the grain crop to determine if nematode soil density is high enough to justify trap crop planting. Sampling when the trap crops are plowed down or in the spring will indicate if nematicide is needed for the sugar beet crop.

Resistant sugar beet cultivars—Although research is being conducted toward the development of resistant cultivars, none are currently available.

Integrated control—The combination of the proper disposal or handling of tare soil, rotation for three to five years with non-host crops, and good weed control, should reduce the soil population of *H. schachtii* below the damaging level. However, if shorter rotations are used and populations are still high, trap crops or nematicides may be required. The decision to use either should be based on the results of a soil nematode analysis.

Table 1. Soil fumigant, insecticide/nematicides, trap crops, and recommended application and seeding rates for control of the sugar beet nematode.

Treatment	Application time	Recommended per acre rate	Application method	Row spacing (inches)	Rate/1000ft. of row
Soil Fumigant[a]					
Telone® II[b]	preplant	18.0 gal	broadcast	12-24	53-106 fl. oz./outlet
	preplant	17.3 gal	row treatment	22	93 fl. oz./outlet
	preplant	12.7 gal	row treatment	30	93 fl. oz./outlet
Systemic Insecticide/Nematicide[a]					
Temik® Brand 15G[c]	at planting	27-33 lb	row treatment	22	18-22 oz./row
	at planting	20-24 lb	row treatment	30	18-22 oz./row
Counter® 15G[d]	at planting	27 lb	row treatment	22	18 oz./row
	at planting	19.6 lb	row treatment	30	18 oz./row
Counter® 20CR®[d]	at planting	17.9 lb	row treatment	22	12 oz./row
	at planting	13.1 lb	row treatment	30	12 oz./row
Trap Crops					
'Adagio' radish		20-25 lb	drilled	6-8	
'Metex' mustard		15-18 lb	drilled	6-8	

[a] Read the pesticide label prior to application. All nematicides listed are categorized as "Restricted Use Pesticides." Active ingredients for the soil fumigant and insecticides/nematicides listed are Telone® II (1,3-dichloropropene), Temik® (aldicarb), and Counter® (terbufos).

[b] Eighteen gal/A are recommended when applied as a broadcast treatment. When Telone is applied as a row treatment, flow rate should be set at 93 fl. oz./outlet. Rows should be bedded up and seed drilled into the treated beds following a seven day waiting period, or longer when soil is cold or wet.

[c] Temik should be drilled in 3 to 4 inches deep and 3 inches from the seed row on the water furrow side at the time of planting.

[d] Counter should be drilled 2 inches to the side of the seed and 2 to 4 inches below the seed. All formulations of Counter are recommended for suppression of moderate populations of the sugar beet nematode.

James J. Jacobs, Director, Agricultural Experiment Station, University of Wyoming, Box 3354, Laramie, WY 82071.

8/97