Grass Seed Nematode

and

Production of Bentgrass Seed

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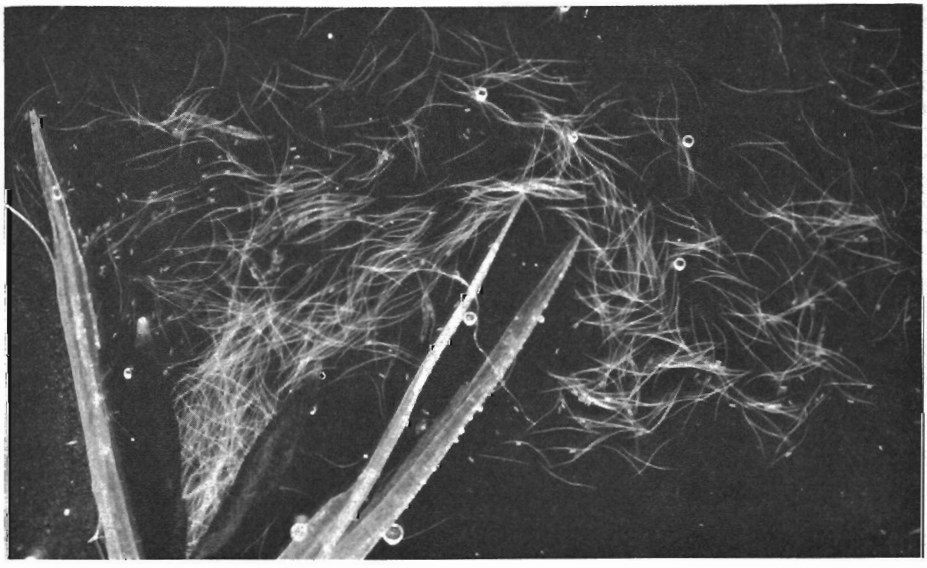
A nematode gall from an infected panicle open to allow the escape of second stage larvae.



. . . . by Harold J. Jensen, H. B. Howell, and W. D. Courtney[1]

Introduction

Fifteen years ago the average yield of an acre of bentgrass in northwestern Oregon and southwestern Washington was approximately 250 pounds. Yields have declined steadily until some fields now produce less than 60 pounds of seed per acre. An acre yield of 200 pounds is usually necessary to grow bentgrass profitably. A major cause of loss is a nematode parasite infecting bentgrass seed heads. Although answers to certain fundamental problems concerning this nematode-plant relationship are still being sought, much information is now available on how the nematode affects seed production.

Symptoms

Many growers recognize the effects of the microscopic worm we call the "grass seed nematode" that causes the developing flower to produce a gall instead of a seed. The infected seed head may have a few galls or may be entirely composed of them. A part of the field may be infested, or the entire field may be severely damaged. The decline in seed yield caused by this nematode is considerable although the precise amount of damage in a particular field is sometimes difficult to determine.

Gall production in the seed heads of bentgrass is a typical response to infection by the "grass seed nematode." In comparison with normal seed development, nematode galls are purplish, 5 to 8 times larger than a seed, the glumes 2 to 3 times longer and the outer paleae 5 to 8 times normal size. Complete suppression of lodicule, stamen, and stigma development was noted. The paleae are sometimes suppressed. The galls contain larvae of the nematode which are capable of infecting new plantings.

Host Range and Distribution

Symptoms of this disease are commonly seen in the bentgrass fields of Clatsop and Columbia Counties in Oregon and Pacific County in Washington. A similar nematode affects Chewings fescue seed production throughout the Willamette Valley. A sample of Highland bentgrass, collected in the northeastern fringe of the Willamette Valley, proved to be

[1] Respectively: Associate Nematologist; Supt. J. J. Astor Branch Experiment Station; and Nematologist, USDA, Western Washington Experiment Station, Puyallup, Washington.

severely infected with a grass seed nematode.

The grass seed nematode from bentgrass also will infect a number of other grasses. The following data were obtained from a three-year testing period and included a transfer back to the original host.[2]

1. Seaside bentgrass	*Agrostis palustris*
2. Velvet bentgrass	*Agrostis canina*
3. Highland bentgrass	*Agrostis tenuis*
4. Spike bent	*Agrostis exarata*
5. Redtop	*Agrostis alba*

The following grasses apparently were not hosts since they failed to become infected during the same three-year period:

1. Creeping timothy	*Phleum pratense*
2. Chewings fescue	*Festuca rubra* v. *cummutata*
3. Creeping red fescue	*Festuca rubra*
4. Kentucky bluegrass	*Poa pratensis*
5. Annual bluegrass	*Poa annua*
6. Bluegrass	*Poa sylvestris*
7. Velvetgrass	*Holcus lanatus*
8. Sweet vernal grass	*Anthoxanthum odoratum*

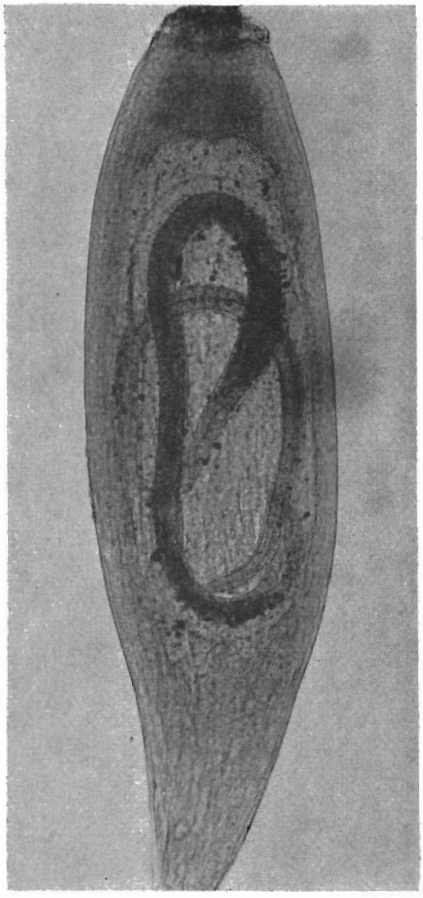
Life History

In the field some galls mature and fall to the ground about harvest time. Many others are scattered among the stubble due to the harvesting operations, thus ensuring an adequate supply of nematodes for infection of succeeding crops. The galls remain as such in the stubble until they become softened by fall and winter rains enabling thousands of encased larvae to escape.

The larvae (or young nematodes) then move about in a film of moisture and make their way along the surface of the soil and existing vegetation. Eventually some of the larvae enter the bentgrass sheaths and remain near the growing points until the young ovules start to develop in the "boot" during the early spring. The bentgrass nematodes remain in the second larval stage from the time of liberation to the development of the inflorescence the following year. During most of this period the nematodes remain adjacent to the growing point that is usually enclosed in a foliar sheath. In fall or midwinter the nematodes can be found on the soil or in nearby vegetation.

Only one generation of nematodes is produced each year. After the larvae make their way into the blossom end of the young ovule they begin to feed on the developing seed. As they feed, the young seed begins to transform into an elongated gall instead of a seed. By the time the panicle emerges from the boot, the galls are almost

[2] Courtney, W. D. and H. B. Howell, 1952. Investigations on the bentgrass nematode, *Anguina agrostis* (Steinbuch 1799) Filipjev 1936. U. S. Dept. of Agriculture, Plant Disease Reporter 36 (3):75-83.



Nematodes enclosed in a developing bentgrass gall. Females are larger than transparent males.

completely developed. After the nematodes have entered the seed they quickly change to third stage larvae, fourth stage larvae, and then to adults (see picture).

One to three females and a similar number of males are generally found in each infected ovule. If, however, only females or males find their way into a young flower, gall development is confined to the glumes and paleae and the ovary does not enlarge. Thus, the ovary or the portion of the flower that contains the nematodes does not become a gall.

When both males and females are present, the females are fertilized and each produces hundreds of eggs during an estimated two-week laying period. Shortly after egg laying, the adults die, disintegrate, and soon disappear. Within the egg, larval development commences immediately, passing through the first stage, undergoing the first moult, and advancing to second stage larvae, the infective stage. As second stage larvae, they "hatch" or are released from the egg. Development from second stage larvae to adults requires from 3 to 4 weeks; however, under unfavorable conditions second stage larvae may become dormant and overwinter.

The adult stage is usually reached by the time the panicle emerges from the boot. The panicle, however, may contain galls in various stages of development, from fully formed galls containing dormant nematodes to progressively young galls containing various larval stages. Several workers assume that the nematodes will perish if they fail to reach the developing inflorescence of a host plant within a year after leaving the gall in which they were born.

Length of Life

One of the most remarkable features of the grass seed nematode is the ability of larvae, within the protective gall, to remain alive for a long time when kept in dry storage or mixed with seed. This extends the normal one-year cycle to a period of years. Several researchers who have attempted to determine the longevity of the bentgrass seed nematode have found that larvae remain in a quiescent

state for periods up to ten years. For periods greater than ten years the percentage of survivors decreases rapidly.

To determine if galls contain living larvae, the dried gall must be placed in water or in a moist chamber for about three days. Galls so treated can then be ruptured and the viability of the nematodes proven by observing their motility.

Dispersal and Infection

Numerous surveys have shown that the pest is confined to areas producing seed and areas where seed, straw, or other discarded materials from this production have been transported. Repeated observations also have shown that harvesting machinery, trucks, wagons, seed containers, burlap bags, and the clothing of workmen may contain large numbers of galls. Dozens of galls may adhere to shoes or boots of workers, and to hooves of livestock that walk through infested fields after a heavy dew or rain. Galls are also scattered by various operations involving threshing machines and other harvesting equipment. As the season progresses, galls may be dispersed over large areas by wind or surface water.

Nematode infected bentgrass was found growing along roadsides several miles distant from the nearest infested field. These infections may have resulted from hauling hay or movement of livestock. Since the nematode has been found on bentgrass in a few areas adjacent to diseased fields, the question of whether or not the nematode is native is still debatable. While accidental scattering of infections within an area cannot be entirely avoided, contaminated seed should not be planted in new areas or in fields where the pest has been controlled.

Control

Control of this pest involves elimination of the nematode from infested areas and prevention of reinfestation from nearby sources. As previously mentioned, the nematode occurs in bentgrass along fence rows, around stumps,and various building structures. Any successful control program must consider these sources of reinfection. The following methods of control have been investigated:

1. *Control by crop rotation and fallow.* Rotation and fallow programs are based on the following facts: (1) Nematodes will not develop to the adult stage and reproduce unless they can reach developing flowers of one of the host plants listed above. In fact, active larvae from the galls will die if they do not reach such a flower within one year. (2) Rotation with any crop, except a host plant, on infested soil will fill this condition, as will any method of fallow which completely prevents growth of host grasses.

Crop rotation has been effective for controlling this pest in some areas of Columbia County, but impractical in severely infested areas of Clatsop County. This is because:

The infested fields occur in areas where the rainfall is so high that eradication of the vegetative and seed producing bentgrass is extremely difficult.

Acid soil makes the decomposition of organic material very slow, leading

to an excessive accumulation of unrotted crop debris that includes nematode galls.

Gradual uncovering of sunken stumpage makes adequate plowing difficult.

Uncultivated areas such as those along fence rows, highways, and railroad right-of-ways, and around buildings and stumpage provide sources of volunteer bentgrass which serve as infection reservoirs.

In the areas of Columbia County where a fallow-rotation program is practical, various cereals are planted after fallow. Usually an infested field is not replanted to bentgrass for 2 or 3 years. Also, some measure of control has been obtained in the Clatsop County area by keeping the infested fields as fallow as possible for one growing season. In a field trial at the J. J. Astor Branch Station, a damaging nematode population was reduced to a trace by a three-year fallow program.

2. *Stubble Burning.* Although burning stubble shortly after harvest, as recommended by Hardison[3] (1946), is an effective control method for a similar problem of Chewings fescue, results have not been satisfactory for bentgrass in Clatsop County. This method is unsatisfactory because the large amount of rainfall usually makes stubble burning impractical, the accumulated crop debris insulates the galls against heat, and the wind-row distribution of the straw leads to an uneven stubble burn.

Searing experiments, conducted with a gasoline-fire weed burner in the spring, not only failed to control the nematodes but reduced the number of seed heads that formed to a mere trace.

3. *Chemical Control.* Several materials have been used as sprays or drenches to reduce the nematode population in severely infested fields. In early trials sodium nitrate and cyanamide were tested. This mixture was used at a rate of 200 pounds per acre, and was applied during the fall to small plots. No significant decrease of nematodes resulted from any of the chemicals used. During recent years attempts have been made to control the pest with several of the most promising fungicides, insecticides, and nematocides, including many of the newer systemic materials. All materials were applied as drenches or foliar sprays. Significant results were not obtained in either greenhouse or field trials. Apparently nematodes are well protected against nematocides once they establish themselves in the ovules of the bentgrass.

4. *Prevention of Seed Development.* Various field plot experiments have shown that nematode infection can be substantially reduced by preventing bentgrass from going to seed. This was accomplished by clipping the bentgrass turf at various time intervals to simulate pasturing or cutting for silage or hay. Results indicate prevention of seed formation may be rather effective, but the nematodes were not eradicated. For example, clipping to simulate pasturing was not only superior to other trials but actually reduced the infection from 75% to 10%. However, the remaining infection increased during the following year.

A few growers are attempting to control this pest by pasturing; in some fields results have been good, in others poor. Cattle do not graze close enough to prevent seed formation, nor do they graze near enough to ditch banks, fence rows, stumps, and other obstructions to remove all sources of infection. Any

[3] Hardison, John R. 1947. Preliminary suggestions for control of the grass seed nematode. Oregon Seed Growers League, Proc. 6th Ann. Meeting., Dec. 1946: 69, 71, 73, 74.

surviving seed heads are potential reservoirs of reinfection. A combination of pasturing and mowing would be more effective.

Clipping trials that simulated silage or hay cutting also resulted in considerably reduced gall formation. The time to cut the hay crop is much more critical than that for cutting silage since cutting too late may allow some galls to mature and shatter during haying operations. Thus, the effectiveness of this control method would be nullified.

5. *Seed Treatment.* Planting galls or parts of galls along with the bentgrass seed is another source of infection. Although modern harvesting and cleaning methods remove most of the nematode galls, broken galls are frequently recovered from processed seed.

A hot water treatment of cleaned seed did not kill the nematodes within unbroken galls, but eliminated those in broken galls. This treatment includes a presoak period and a hot water bath at 126°F for 15 minutes. However, bentgrass seed is difficult to wet, and a detergent must be included in the bath to ensure success of the treatment. The drying of treated seed presents a special problem.

6. *General Sanitation Practices.* Sanitation measures are not intended to constitute an entire control program, but to supplement those already suggested. All activities that contribute to the dissemination of nematodes or reinfection should be curtailed as much as possible. Fields free from this pest should be harvested first, and those most severely infected harvested last. Remove all trash and chaff from machinery, combines, tractors, trucks, and wagons before leaving an infected field. Inspect clothing, trouser cuffs, and pockets for galls. If burlap bags are used, obtain new ones or use only bags that have been disinfected.

Destroy volunteer bentgrass in adjacent uncultivated areas, since these plants act as infection reservoirs. Obtain seed from reliable sources, certified free from grass seed nematodes.

Summary

The grass seed nematode seriously damages the seed crops of bentgrasses in certain parts of southwestern Washington and northwestern Oregon. Nematodes remain as second stage larvae next to the growing point until the grass flowers. During flower development, the larvae change quickly to adults. Approximately 1,000 eggs are laid by each female. These hatch immediately and the larvae become dormant in the drying galls. This cycle from second stage larvae to adult nematodes can be completed in 3 or 4 weeks, or if interrupted, may be completed over several years. The larvae cannot live in the soil for more than one year unless they find a suitable host plant.

The infection is usually spread from area to area by harvesting machinery, by movement of crop refuse, and by contaminated seed.

Control is extremely difficult, but can be accomplished in some areas by crop rotation and fallow. Control by nematode-killing chemicals, stubble burning and searing the turf have not been satisfactory. Prevention of seed formation by pasturing, clipping, and destruction of volunteer bentgrass in uncultivated places is the best control method that has been tested.