POTENTIAL MANAGEMENT APPROACHES FOR THE STING NEMATODE IN BERMUDAGRASS SOD PRODUCTION

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ABSTRACT

The sting nematode (*Belonolaimus longicaudatus*) is a destructive pest of bermudagrass grown for sod. Non-pesticide based management approaches were evaluated in an existing sod field containing a high population of the sting nematode. For each of two years (2002 and 2003), treatments consisted of plots planted to a green manure of oilseed rape (*Brassica napus*), or tilled once in late winter and spring with a rotary hoe, or amended once with poultry litter (2,950 kg ha^{-1}). Control treatments were plots continuously planted to bermudagrass or fumigated with Dazomet. In the first year, none of the treatments reduced the population of sting nematodes in comparison to continuous bermudagrass. In the second year, plots treated with oilseed rape, tillage, and the fumigant contained lower sting nematode populations than those with continuous bermudagrass. This reduction was evident two months following incorporation of the rape, fumigant or the second tillage. Sod quality in both years was higher only in the soil fumigant treatment.

Keywords

Belonolaimus longicaudatus, chicken litter, *Cynodon dactylon*, nematodes, sod, soil amendment

INTRODUCTION

Bermudagrass (*Cynodon dactylon* and *C. dactylon* x *C. transvaalensis*) is the predominant turfgrass used for residential, recreational, commercial, and soil stabilization applications in the southern United States. Bermudagrass has numerous attributes that make it ideally suited for a multitude of applications in this region from athletic fields to lawns. Desirable attributes of bermudagrass include heat tolerance, pest resistance, rapid growth, and rapid recovery from injury or wear. In addition to regional adaptation, the turf is well suited for the sod industry which grows, harvests, and relocates the turf and attached soil to a permanent location. New growth of the sod is initiated from stolon or rhizome tissues that store nutrients and aid in plant survival during establishment, reducing the need for long-term intensive management during the establishment period. Turfgrass stand production using sod is fast, minimizes the possibility of soil erosion, and circumvents weed encroachment associated with establishing a stand by other means.

A destructive pest of bermudagrass sod nurseries in the southern United States is the plant-parasitic nematode *Belonolaimus longicaudatus* Rau (Martin et al., 1998; Perry and Rhoades, 1982). The nematode feeds primarily on roots, but rhizomes can also be damaged. Plant death as a result of feeding is rare; however, the nematodes consume plant photosynthates, arrest root growth, cause lesions, necrosis, and impair root function. Affected bermudagrass is chlorotic, stunted in root and foliar growth, and is often more susceptible to drought stress, and the stand is often invaded by noxious weeds (Giblin-Davis et al., 1992). As a result, the stand is less dense, and deficient in sod strength and quality which are required for harvesting and marketability. Occasionally, when root damage is very severe and soil moisture is lacking, the affected plants may die.

Currently, most management options for nematodes in sod fields depend either on the use of nematicides or fallowing the land. The use of nematicides is an additional production expense, poses a hazard to the applicator, can contaminate surface and subsurface water sources rendering them non-potable, and often leads to long-term reliance on the pesticide. Fallow, removing the land from the production system, is more effective against obligate plant pathogens or those that do not persist in soil for extended periods of time (Maloy, 1993). Fallowing the land results in lost revenue, may cause soil erosion by water or wind, and is often viewed as a marginal management option.

A green manure is usually a plant in the mustard or legume family which is grown and subsequently incorporated into the soil, and during its decomposition can reduce the number of plant pathogens in soil. The use of green manures has been limited primarily to intensively managed agricultural production systems and often reduces the pathogen effects on subsequent crops

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Table 1. Populations of *Belonolaimus longicaudatus* in soil planted to bermudagrass sod (2002) treated with oilseed rape, poultry litter, Dazomet, or tillage.

Treatment	14 March	30 May	20 June	14 August	11 September
Continuous	20†	25	20	9	25
Oilseed Rape	4	15	6	3	20
Tillage	14	15	9	8	10
Litter	-	37	18	4	14
Dazomet	-	23	10	3	7
P < 0.05	NS‡	NS	NS	NS	NS

† Nematode populations determined from 100 cc soil.

‡ NS = Not significant

Table 2. Bermudagrass growth (11 September, 2002) from sod treated with oilseed rape, poultry litter, Dazomet, or tillage.

Treatment	Root length (cm) †	Root color‡	Root wt (g)	Stolon/ rhizome wt (g)	Sod quality§
Continuous	4.4	2.8	2.38 a*f*	0.61	2.2 b
Oilseed Rape	6.7	3.0	1.13 b	0.59	1.8 b
Tillage	7.1	3.2	1.32 b	0.46	1.8 b
Litter	4.0	2.4	1.21 b	0.60	1.8 b
Dazomet	5.9	3.2	2.14 a	1.51	3.2 a
P < 0.05	NS #	NS	0.02	NS	0.03

† Average of 2, 8 cm-diameter. soil samples from each plot from.

‡ Root system color based on a scale of 1 to 5, where 1 = dark, necrotic root and 5 = white, healthy roots.

§ Sod quality based on a scale of 1 to 5, where 1 = thin, poor quality sod and 5 = thick, healthy sod.

f Within columns, means followed by the same letter are not significantly different according to Fisher's Protected LSD (0.05).

NS = Not significant

(Candole and Rothrock, 1997; Lyle et al., 1948; Viaene and Abawi, 1998). The incorporation of green manures can improve soil physical and chemical properties, microbial activity, and may release compounds that are toxic to fungi or nematodes during decomposition.

Similar to green manures, organic soil amendments which are high in nitrogen content, such as poultry litter, have been shown to decrease initial plant-parasitic nematode populations or their damage to a subsequent crop in other cropping systems (Kaplan and Noe,1993; Muller and Gooch, 1983; Opperman, et al., 1993). Organic soil amendments can increase bermudagrass growth and reduce the time required to produce harvestable sod (Flanagan et al., 1993). In addition, poultry litter contains nearly 30, 25, and 20 kg of N, P_2O_5, and K_2O t^{-1}, respectively, as well as significant amounts of valuable secondary nutrients such as Ca, Mg, and S. The organic matter in poultry litter can improve the physical and chemical properties of soil. The poultry industry has been expanding in the southern United States and has led to a waste disposal problem. The identification of additional desirable attributes of poultry litter may increase its economic value, permitting it to be transported farther, and increase the total agricultural land available for its utilization. The objective of this research was to evaluate a green manure, an organic soil amendment, and tillage for the suppression of *B. longicaudatus* in bermudagrass sod.

MATERIALS AND METHODS

On March 14, 2002 and April 1, 2003 field plots (7.6 m x 7.6 m) were established at a commercial bermudagrass sod facility in Indianola, OK that was naturally infested with the sting nematode (*B. longicaudatus*). The soil type was a loamy sand (85% sand, 7.5 % silt, and 7.5% clay), with a pH of 5.9, organic matter was 1.09 %, and thatch thickness less than 1cm. Plots planted with oilseed rape (*Brassica napus* L.) seed (11.4 kg ha^{-1}) were tilled prior to seeding using a rotary hoe. In 2002, the seed was broadcast onto the soil surface and incorporated using steel rakes. In 2003, the seed was placed into the soil at a depth of 2.5 cm using a Hege 500 (Hege Maschinen, Austria) seed drill. Following seeding, the soil was compacted using a sod roller. On the same dates, the tillage treatment was established using the rotary hoe and the soil was compacted using a sod roller.

On May 30, 2002, and June 4, 2003 poultry litter at a rate of 2,950 kg ha^{-1} and Dazomet (Certis U.S.A L.L.C., Columbia MD) at a rate of 394 kg ha^{-1} were broadcast onto the soil surface and incorporated using a rotary hoe and compacted using a sod roller. Oilseed rape and tillage plots were tilled once more using a rotary hoe and compacted using a sod roller. Irrigation was used during the next seven days to provide a water seal on the soil surface. Only plots treated with Dazomet required sprigging with bermudagrass obtained from a *B. longicaudatus*-free location on 0.5 m centers on June 20, 2002, and July 8, 2003. Plots cropped continuously to bermudagrass were used as a control. The study area was mowed twice a month to a height of 2.5 - 3.5 cm. All plots were fertilized three times during the growing season at a rate of 49.4 kg N ha^{-1} per application. A randomized complete block design with five replications was used in both years.

Nematode populations were determined on a monthly basis during the growing season by collecting 10 soil samples (2.54 cm-diameter x 10 cm deep) from each plot and nematodes were extracted from a 100 cm^3 sub sample of soil by sieving and centrifugal floatation (Ayoub, 1980). Plant parasitic nematodes were identified to genus, and total populations from 100 cm^3 soil were determined using a compound light microscope.

Sod quality was rated on September 11, 2002 and September 2, 2003 on a scale of 1 to 5, where 1 = thin, poor quality sod and 5 = thick, healthy sod. Turfgrass growth was evaluated on the same dates by collecting two, 8 cm-diameter. soil samples from each plot. Plants were washed free of soil and the root system was rated for color on a

Table 3. Populations of *Belonolaimus longicaudatus* in soil planted to bermudagrass sod (2003) treated with oilseed rape, poultry litter, Dazomet, or tillage.

Treatment	1 March	4 June	8 July	4 August	2 September
Continuous	66†	102	72 a§	67 a	136 a
Oilseed Rape	25	33	24 bc	14 b	75 ab
Tillage	14	21	17 c	19 b	38 b
Litter	-	68	52 ab	16 b	55 b
Dazomet	-	103	8 c	14 b	36 b
P < 0.05	NS‡	NS	0.01	0.001	0.05

† Nematode populations determined from 100 cc soil.

‡ NS = Not significant

§Within columns, means followed by the same letter are not significantly different according to Fisher's Protected LSD (0.05)

Table 4. Bermudagrass growth (2 September, 2003) from sod treated with oilseed rape, poultry litter, Dazomet, or tillage.

Treatment	Root length (cm) †	Root color‡	Root wt (g)	Stolon/ rhizome wt (g)	Sod quality§
Continuous	6.0	3.7	1.11	1.33	2.6 b*f*
Oilseed Rape	6.0	3.4	0.89	1.29	2.6 b
Tillage	9.8	3.5	1.06	0.91	2.4 b
Litter	7.8	3.5	1.02	1.11	2.0 b
Dazomet	8.3	3.3	0.66	0.79	4.4 a
P < 0.05	NS #	NS	NS	NS	0.04

† Average of 2, 8 cm-diameter. soil samples from each plot from.

‡ Root system color based on a scale of 1 to 5, where 1 = dark, necrotic root and 5 = white, healthy roots.

§ Sod quality based on a scale of 1 to 5, where 1 = thin, poor quality sod and 5 = thick, healthy sod.

f Within columns, means followed by the same letter are not significantly different according to Fisher's Protected LSD (0.05).

\# NS = Not significant

scale of 1 to 5, where 1 = dark, necrotic root and 5 = white, healthy roots. The average root system length was determined and the root system was separated from crown and stolon/rhizome tissues. Dry root weight and stolon/rhizome weight were determined by drying the tissues in an oven (Fisher Scientific International, Inc, Hampton, NH) at 50 C for 48 h. In the spring of the following year (April 1, 2003 and May 5, 2004, respectively) plots established in the previous year were rated for sod quality as previously described. Data were analyzed using SAS (version 9; SAS Institute, Cary, NC). Treatment means were compared using Fisher's Protected Least Significant Difference at $P < 0.05$.

RESULTS

In 2002, none of the treatments reduced nematode population in comparison to the non-treated control (Table 1). Bermudagrass root length, root color, and stolon/rhizome weight were not affected by any treatment when compared to the non-treated control (Table 2). Root weight was greater for plants in the non-treated control and Dazomet fumigated plots. Sod quality at the end of the season was only improved by the Dazomet treatment. None of the treatments resulted in different sod qualities in the spring of the following year (data not shown).

In 2003, oilseed rape, tillage, and the Dazomet treatments reduced nematode populations for two months after incorporation in comparison to the non-treated control (Table 3). The reduction was present three months after incorporation for the tillage and Dazomet treatments. Poultry litter treated plots contained lower nematode populations than the non-treated control two months after treatment. This reduction was still present in September. Bermudagrass root length, root color, root weight, and stolon/rhizome weight were not affected by any treatment when compared to the non-treated control (Table 4). Sod quality at the end of the season was only increased by the Dazomet treatment. The Dazomet treatment resulted in greater sod quality in the spring of the following year ($P < 0.001$) (data not shown).

DISCUSSION

The availability of post-plant nematicides in the United States has steadily declined in recent years. Currently, there is only one remaining product (1,3-Dichloropropene) on the market that is available for nematode suppression in existing bermudagrass sod. There is a need for alternative approaches for nematode suppression in existing turfgrass sod production. Soil amendments have been used for other cropping systems to reduce nematode populations (Muller and Gooch, 1983) and may have application in sod production.

Decomposition of certain plants, such as oilseed rape, will release low levels of compounds, including glucosinolates, into the soil which are known to suppress nematode populations (Stark, 1995). Similarly, the addition of nitrogen rich organic materials to soil, such as poultry litter, can suppress nematode populations (Kaplan and Noe, 1993; Muller and Gooch, 1983). The mechanism of suppression has been attributed to enhanced microbial competition or ammoniacal nitrogen (Rodriguez-Kabana, 1986). Sod growers will often till nematode-infested fields to minimize weed infestation and reduce grass establishment. This approach can also incorporate organic matter residing on the soil surface into the soil profile where it may improve soil structure.

Ideally, an alternative approach would require little or no capital investment, could easily be integrated into the current production system, and not remove fields from production for an extended period of time. Early spring-planted cover crops, soil amendments that are incorporated in early summer, and tillage were selected for evaluation because they meet these requirements for sod producers.

Although nematode populations were not reduced by any treatment in 2002, there was a general trend for lower nematode populations in treated plots. In 2003, it appeared that the poultry litter required more than 30 days to have an effect on nematode populations. This delay may indicate that the reduction in nematodes was related to a slow increase in microbial antagonists versus ammoniacal nitrogen which would be expected to be released shortly after incorporation. The threshold for *B. longicaudatus* is generally accepted to be above 20 nematodes /100 cm^3 soil. With the exception of the Dazomet, litter, and tillage treatments in 2002, treatments did not suppress nematode populations below the threshold in September. This may account for the absence of treatment effect for most plant growth variables examined. The trend toward greater root weights in the non-treated control may be a result of nematode feeding injury, which caused the roots to become swollen and stubby in appearance. The new roots produced by plants in treated plots were observed to be more fibrous and typical of bermudagrass.

Future studies should examine the effects of higher rates of poultry litter. The rate used in this study was that for pasture-applied litter that is not incorporated into the soil. Higher rates would not pose a threat to surface water because the litter is placed below the soil surface. A fall-planted oilseed rape may permit greater biomass and subsequent suppression of nematode populations.

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