Accepted for publication 2 November 2006. Published 26 February 2007.

Potential for Soybean Cyst Nematode Reproduction on Winter Weeds and Cover Crops in Tennessee

P. A. Donald, USDA-ARS, Crop Genetics and Production Research Unit, **Robert Hayes,** Plant Science Department, University of Tennessee, and **Eric Walker,** USDA-ARS, Crop Genetics and Production Research Unit, Jackson, TN 38301

Corresponding author: P. A. Donald. pdonald@ars.usda.gov

Donald, P. A., Hayes, R., and Walker, E. 2007. Potential for soybean cyst nematode reproduction on winter weeds and cover crops in Tennessee. Online. Plant Health Progress doi:10.1094/PHP-2007-0226-01-RS.

Abstract

The soybean cyst nematode (SCN), *Heterodera glycines*, is a major yield limiting pest of soybean (*Glycine max*). Current SCN management strategies include resistant soybean varieties and rotation with non-host crops. Increased adoption of the early soybean production system (ESPS) combined with a greater incidence of winter weeds from no-tillage practices may increase the population density of SCN during the noncrop period since several winter weeds and cover crops are hosts for SCN. A field experiment with a split-strip design was conducted over three years to evaluate whether SCN reproduced on weeds and cover crops during the noncrop period. Winter weeds and crimson clover roots were examined for females and cysts with eggs. The soil was sampled to determine if an increase in SCN egg population density occurred. We found no indication of SCN reproduction on winter weeds during the noncrop period or on the cover crop crimson clover.

Introduction

The soybean cyst nematode (SCN), *Heterodera glycines*, causes greater yield losses in soybean (*Glycine max*) than any other single plant pathogen (23). Current SCN management strategies target reduction of egg population density at planting. However, recent changes in soybean production practices may lead to an increase in nematode population density between soybean crops. Adoption of early soybean production system (ESPS), which matches the growth and development of early-maturing soybean cultivars with seasonal rainfall patterns within the frost-free period, has increased in recent years (2).

The earlier harvest associated with ESPS results in an extended noncrop period (7), coupled with the widespread use of no-tillage practices, and has increased the incidence of winter weeds (7). Winter weeds such as henbit (*Lamium amplexicaule*), chickweed (*Stellaria media*), and purple deadnettle (*Lamium purpureum*), commonly found in soybean production fields during the noncrop period, are hosts of SCN (15). The presence of SCN, host plants, and soil temperatures above the nematode's developmental threshold may lead to an increase in nematode numbers prior to planting soybean (5).

Cover crops can suppress weeds in addition to providing erosion control and supplementing nutrients (12). However, leguminous cover crops such as hairy vetch (*Vicia villosa*) and crimson clover (*Trifolium incarnatum*) are also hosts of SCN (13,15,16). Increased winter weed incidence, due in part to ESPS and no-tillage practices, and the planting of winter cover crops have the potential to increase SCN population density during the noncrop period prior to soybean planting (5).

The study was conducted from 2002 to 2004 at the West Tennessee Research and Education Center to determine: (i) whether SCN could complete its life cycle on winter weeds commonly found in West Tennessee no-tillage production; and (ii) whether the commonly used cover crops crimson clover (*Trifolium incarnatum*) and wheat (*Triticum aestivum*) increased egg population densitiy of SCN. The plot site had a history of monoculture soybean and had been infested with SCN approximately 40 years earlier.

Impact of Cover Crops

Soil at the field site was a Memphis silt loam (fine-silty, mixed, active, thermic Typic Haplaudalf) and the SCN population was characterized as HG Type 1.3.5.6.7 (race 14). The experiment was a replicated split-strip design with two strips 61 m long by 3 m wide and five subplots per strip for a total of 10 replications per cover crop. Cover crops were planted with a Tye no-till drill 14 November 2002, 10 October 2003, and 15 October 2004. The cover crops were desiccated with glyphosate on 10 to 15 April of each year. The wheat (bin run seed) was planted at 67 kg/ha (Fig. 1) and the crimson clover was planted at 1344 kg/ha (Fig. 2). The soybean cultivar DP415, resistant to SCN race 1 and 3 (11), was planted with a modified Almaco no-till drill on 27 June 2003 and 28 May 2004 in rows spaced 76 cm apart at a seeding rate of 9 seed per 30 cm. Eight soil cores (2.5 cm in diameter × 20 cm deep) were collected and bulked by subplot twice annually. Samples were collected at soybean planting to determine the SCN inoculum potential for the soybean crop and the reproductive rate during the noncrop period for the cover crops. At soybean harvest soil samples were collected to determine the SCN reproductive rate during the soybean season and the inoculum potential for the cover crops. A fallow treatment in the same field and adjacent to the cover crop study was sampled in 2004 to measure the impact of winter weeds without cover crops on SCN egg population density. Cysts of SCN were extracted from the soil using a semi-automatic elutriator and eggs liberated and enumerated following the methodology of Niblack et al. (14). Egg counts were analyzed both as raw data and transformed [log (x + 1)] prior to analysis of variance (SAS Institute Inc., Cary, NC). Data are presented as reproduction using the formula Pf/Pi (end of season egg population density/at planting egg population density). Soil temperature was measured at 10 cm under bare soil at the National Oceanic Atmospheric Association Reference Station at Jackson, TN Experiment Station, which was located 0.8 km from the field plot, to determine if enough heat units were available for SCN to complete its life cycle during the noncrop period.

Fig. 1. Wheat cover crop with associated winter weeds within 0.5-m² quadrant measured April 2003.

Fig. 2. Crimson clover cover crop with winter weeds within 0.5-m² quadrant measured April 2003.

There were no significant differences in SCN reproduction due to cover crops (Table 1). This was surprising given that crimson clover is a host and wheat is a nonhost for SCN. However, both Miller (13) and Riggs and Hamblen (16) indicate that crimson clover is a poor host for SCN. Low soil temperatures may have prevented egg hatch and root penetration. Alston and Schmitt (3) showed that the threshold for SCN egg hatch was between 16 to 20°C. Once the nematode hatches and infects a host plant, the reported developmental threshold ranges from 5 to 14°C (3,18). We used a web-based degree day calculator (10) and hatch threshold of 18°C. Calculations for degree days above 5°F (DD5) on the cover crops were started once the hatch temperature was reached after planting the cover crops. We found that from 14 November 2002 through 31 December 2002 there were 0.2 DD5 and from 1 January 2003 through 15 April 2003 there were 20.7 DD5, for a total of 20.9 DD5 for that season. The next growing season there were 85.3 DD5 from 10 October 2003 through 31 December 2003 and from 1 January 2004 through 15 April 2004 there were 33.0 DD5, for a total of 118.3 DD5 for the season. Juveniles were found in cover crop roots 5 March 2003 and in weed roots 18 February 2004. Our data indicates that in both years, soil temperatures in our study were short of the 372 ± 33 DD5 Alston and Schmitt documented as necessary for completion of the life cycle late in the growing season (3).

Table 1. Average soybean cyst nematode reproduction for cover crop and soybean production periods from 2002-2004 at Jackson, TN.

	Reproduction (Pf/Pi)[x]			
Treatment	**Oct 2002-April 2003 (cover crop)**	**May 2003-Oct 2003 (soybean)**	**Oct 2003-April 2004 (cover crop)**	**April 2004-Oct 2004 (soybean)**
Crimson clover	0.4	1.4	1.5	1.0
Wheat	0.3	1.7	1.5	0.8

[x] No significant differences ($P \leq 0.05$) in reproduction were detected in cover crop, year, or time of sampling.

Host Status of Winter Weeds

In the previously described field study, cover crop and weed roots were sampled in February and April of 2003, and in February, March, and April of 2004. Four points in the cover crop rows were chosen at random for each cover crop for a total of eight replications per cover crop. Roots were dug from a total of one meter length of row, separated by plant species, washed, stained with acid fuchsin, and the entire root system examined microscopically (40×) for presence of SCN in the roots (4). Data presented are the average of the April 2004 samples (Table 2) where most plants were mature enough that they could be accurately identified. Juveniles of SCN were found in low numbers in the roots of most non-host plants; however, all individuals were second-stage juveniles (J2). In host plants, including volunteer soybeans collected prior to frost in the fall and in early spring, there was no development past the third-stage juvenile (J3) (Fig. 3). Adults were not observed. Roots of winter weeds known to be hosts of SCN were also collected from one field in Gibson Co., three fields in Madison Co., and one field in Williamson Co. from 2002 through 2004 immediately prior to soybean planting to determine whether there were females or cysts present on the roots. Data were collected from nine species of dicotyledonous plants and six species of monocotyledonous plants. Plants collected from these fields did not differ in species composition from those reported in Table 2, and a similar lack of SCN development was observed. Chickweed, clovers, henbit, and vetch found in the plots and production fields are all good hosts for the nematode (15).

Table 2. Average number of second-stage (J2) and third stage (J3) juveniles of soybean cyst nematode (SCN) found in plant roots in April 2004 at Jackson, TN.

Plant species	No. plants examined per m row	No. SCN juveniles (J2) in roots
Annual bluegrass (*Poa annua*)	19	0
Carolina geranium (*Geranium carolinianum*)	1	0
Chickweed, common (*Stellaria media*)[x]	7	18
Chickweed, mouse-ear (*Cerastium vulgatum*)[x]	10	0
Clover (other)[x]	20	57
Crimson clover (*Trifolium incarnatum*)[x]	8	91
Downy brome (*Bromus tectorum*)	1	0
Grass	1	0
Henbit (*Lamium amplexicaule*)[x]	36	28[y]
Italian ryegrass (*Lolium multiflorum*)	3	0
Lady's thumb (*Polygonum persicaria*)	1	1
Vetch (*Vicia* sp.)[x]	12	72
Wheat (*Triticum aestivum*)	10	0
White clover (*Trifolium repens*)[x]	24	56
Wild garlic (*Allium vineale*)	2	0

[x] Soybean cyst nematode host.

[y] Multiple plants with third stage juveniles (J3) present in roots.

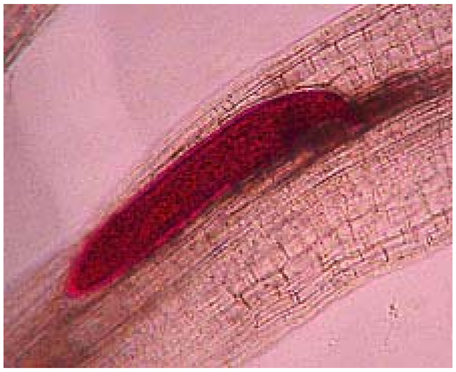

Fig. 3. Soybean cyst nematode third stage juveniles (J3) stained with acid fuchsin in volunteer soybean root collected November 2004.

Summary and Implications for Disease Management

Nematode development and reproduction are influenced by a variety of factors such as environment (9,17,22,25), host (1,6), dormancy (8,20,21,24), and management (11,19). These experiments were conducted using dates of planting and harvest with a shorter noncrop period than ESPS production practices. SCN adults were not found on winter weed or cover crop roots nor was an increase in egg population density detected between soybean harvest in the fall and soybean planting in the spring. Several factors may have limited infection of weed and cover crop hosts by SCN. The hatch rate of SCN eggs may have been low due to soil temperatures below the hatch threshold or to egg dormancy. Previous studies have shown dormancy is induced in eggs produced in the late summer

(8,20,21,24). Furthermore, SCN infection and development is reduced in soils with a high moisture content (25). The wet conditions typical of Tennessee winters may have prevented many J2 from infecting host plants.

Our results indicate that no SCN reproduction occurred during the noncrop period in Tennessee, and that the presence of winter weed hosts of the nematode does not pose a threat to current SCN management practices.

Disclaimer and Acknowledgments

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA.

This report was partially funded by a grant from the Tennessee Soybean Promotion Board. We appreciate the technical assistance of Barbara Michaud, Chris Street, Alan Blackwell, and Benny McLemore.

Literature Cited

1. Acedo, J. R., Dropkin, V. H., and Luedders, V. D. 1984. Nematode population attrition and histopathology of *Heterodera glycines*-soybean associations. J Nematol. 16:48-57.
2. Anonymous. 2005. Crops: Soybeans, current situation. Online. MSUcares Nov 4, 2005. Miss. Agric. and Forestry Exp. Stn., Miss. State Univ. Ext. Serv., Mississippi State, MS.
3. Alston, D. G., and Schmitt, D. P. 1987. Development of *Heterodera glycines* life stages as influenced by temperature. J. Nematol. 20:366-372.
4. Byrd, D. W., Jr., Kirkpatrick, T., and Barker, K. R. 1983. An improved technique for clearing and staining plant tissues for detection of nematodes. J. Nematol. 15:142-143.
5. Creech, J. E., Johnson, W. G., Faghihi, J., Ferris, V. R., and Westphal, A. 2005. First report of soybean cyst nematode reproduction on purple deadnettle under field conditions. Online. Crop Management doi:10.1094/CM-2005-0715-01-BR.
6. Donald, P. A., Pierson, P. E., St. Martin, S. K., Sellers, P. R., Noel, G. R., MacGuidwin, A. E., Faghihi, J., Ferris, V. R., Grau, C. R., Jardine, D. J., Helakeberhan, H., Niblack, T. L., Stienstra, W. C., Tylka, G. L., Wheeler, T. A., Wysong, D. S. 2006. Assessing *Heterodera glycines*-resistant and susceptible cultivar yield response. J Nematol. 38:76-82.
7. Heatherly, L. G., Elmore, C. D., Wesley, R. A., and Spurlock, S. R. 2001. Row spacing and weed management systems for nonirrigated early soybean production system plantings in the Midsouthern USA. Crop Sci. 41:784-791.
8. Hill, N. S., and Schmitt, D. P. 1989. Influence of temperature and soybean phenology on dormancy induction of *Heterodera glycines*. J. Nematol. 21:361-369.
9. Johnson, A. B., Kim, K. S., Riggs, R. D., and Scott, H. D. 1993. Location of *Heterodera glycines* induced syncytia in soybean as affected by soil water regimes. J Nematol. 25:422-426.
10. Klein, B. 1999. Growing degree day worksheet. NW Mich. Hortic. Res. Stn., Mich. State Univ., Traverse City, MI.
11. Koenning, S. R. 2004. Resistance of soybean cultivars to field populations of *Heterodera glycines* in North Carolina. Plant Dis. 88:942-950.
12. Lal, R., Regnier, E., Eckert, D. J., Edwards, W. M., and Hammond, R. 1991. Expectations of cover crops for sustainable agriculture. Pages 1-11 in: Cover Crops for Clean Water. W. L. Hargrove, ed. Soil and Water Conserv. Soc., Ankeny, IA.
13. Miller, L. I. 1967. Development of eleven isolates of *Heterodera glycines* on six legumes. Phytopath. (Abstr.) 57:647.
14. Niblack, T. L., Heinz, R. D., Smith, G. S., and Donald, P. A. 1993. Distribution, density, and diversity of *Heterodera glycines* in Missouri. J. Nematol. (Suppl.) 25:880-886.
15. Riggs, R. D. 1992. Host range. Pages 107-114 in: Biology and Management of Soybean Cyst Nematode. R. D. Riggs and J. A. Wrather, eds. American Phytopathological Society, St. Paul, MN.
16. Riggs, R. D., and Hamblen, M. L. 1962. Soybean-cyst nematode host studies in the family Leguminosae. Ark. Agric. Exp. Stn. Rep. Series 110, Fayetteville, AR.
17. Ross, J. P. 1963. Seasonal variation of larval emergence from cysts of the soybean cyst nematode, *Heterodera glycines*. Phytopath. 53:608-609.

18. Ross, J. P. 1964. Effect of soil temperature on development of *Heterodera glycines* in soybean roots. Phytopath. 54:1228-1231.
19. Schmitt, D. P., Corbin, F. T., and Nelson, L. A. 1983. Population dynamics of *Heterodera glycines* and soybean response in soil treated with selected nematicides and herbicides. J. Nematol. 15:432-437.
20. Sipes, B. S., Schmitt, D. P., and Barker, K. R. 1992. Fertility of three parasitic biotypes of *Heterodera glycines*. Phytopath. 82:999-1001.
21. Sipes, B. S., Schmitt, D. P., and Barker, K. R. 1992. Fitness components and selection of biotypes of *Heterodera glycines*. J. Nematol. 24:415-424.
22. Slack, D. A., Riggs, R. D., and Hamblen, M. L. 1981. Nematode control in soybeans: Rotation and population dynamics of soybean cyst and other nematodes. Ark. Agric. Exp. Stn. Rep. Series 263, Fayetteville, AR.
23. Wrather, J. A., and Koenning, S. R. 2006. Estimates of disease effects on soybean yields in the United States 2003-2005. J. Nematol. 38:173-180.
24. Yen, J. H., Niblack, T. L., and Wiebold, W. J. 1995. Dormancy of *Heterodera glycines* in Missouri. J. Nematol. 27:155-163.
25. Young, L. D., and Heatherly, L. G. 1988. Soybean cyst nematode effect on soybean grown at controlled soil water potentials. Crop Sci. 28:543-545.