Journal of Nematology 17(4):464–469. 1985.

Influence of Selected Cultural Practices on Winter Survival of *Pratylenchus brachyurus* and Subsequent Effects on Soybean Yield[1]

S. R. Koenning, D. P. Schmitt, and K. R. Barker[2]

Abstract: Planting date of soybean, *Glycine max,* influenced winter survival of *Pratylenchus brachyurus* in microplots at two locations in North Carolina. Delayed planting resulted in a linear decrease ($P = 0.05$) in the numbers of *P. brachyurus* at soybean harvest. Effects of planting date on nematode numbers persisted over winter, indicating that survival in the absence of a host is density independent. Compared with winter fallow, winter wheat, *Triticum aestivum,* reduced winter survival of *P. brachyurus.* Subsequent soybean yields were suppressed by the overwintering population of this nematode at one location but not at another.

Key words: Glycine max, Triticum aestivum, lesion nematode, cropping systems, cover crops, population dynamics, damage threshold, survival.

Double-cropping systems have become popular in the southeastern United States because soil erosion is minimized and growers can produce two marketable crops per year. Currently, 30% of the soybean, *Glycine max* (L.) Merr., hectarage in North Carolina is double cropped with small grains. Winter cover crops have been shown to influence the population dynamics of plant-parasitic nematodes (6,18). Planting wheat, *Triticum aestivum* (L.), when soil temperatures were high enough to permit penetration of roots by juveniles, increased winter survival of *Meloidogyne incognita* (Kofoid & White) Chitwood permitting the completion of one generation (18).

Winter cover crops also alter the tilth, moisture, temperature, and biota of the soil, which may influence the population dynamics of parasitic nematodes and their damage potential (16). Soybeans double cropped with small grains are planted in mid to late June. Late planting may enhance damage caused by *Heterodera glycines* Ichinohe to soybean (9) or limit the damage potential of *Pratylenchus brachyurus* (Godfrey) Filipjev and Schuurmans-Stekhoven on soybean (12). The impact of winter cover crops currently used in the southeastern United States on the population dynamics and damage potential of plant-parasitic nematodes warrants investiga-

Received for publication 25 January 1985.

[1] Paper No. 9696 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7616.

[2] Former graduate student, Associate Professor, and Professor, respectively, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695. Present address of senior author: P.O. Box 160, Portageville, MO 63873.

The authors thank J. A. Phillips, C. P. Alston, and S. H. Byrd for technical assistance, L. A. Nelson for statistical advice, and Polly Carlsen for manuscript preparation.

The use of trade names in this publication does not imply endorsement by the N.C. Agricultural Research Service of the products named nor criticism of similar ones not mentioned.

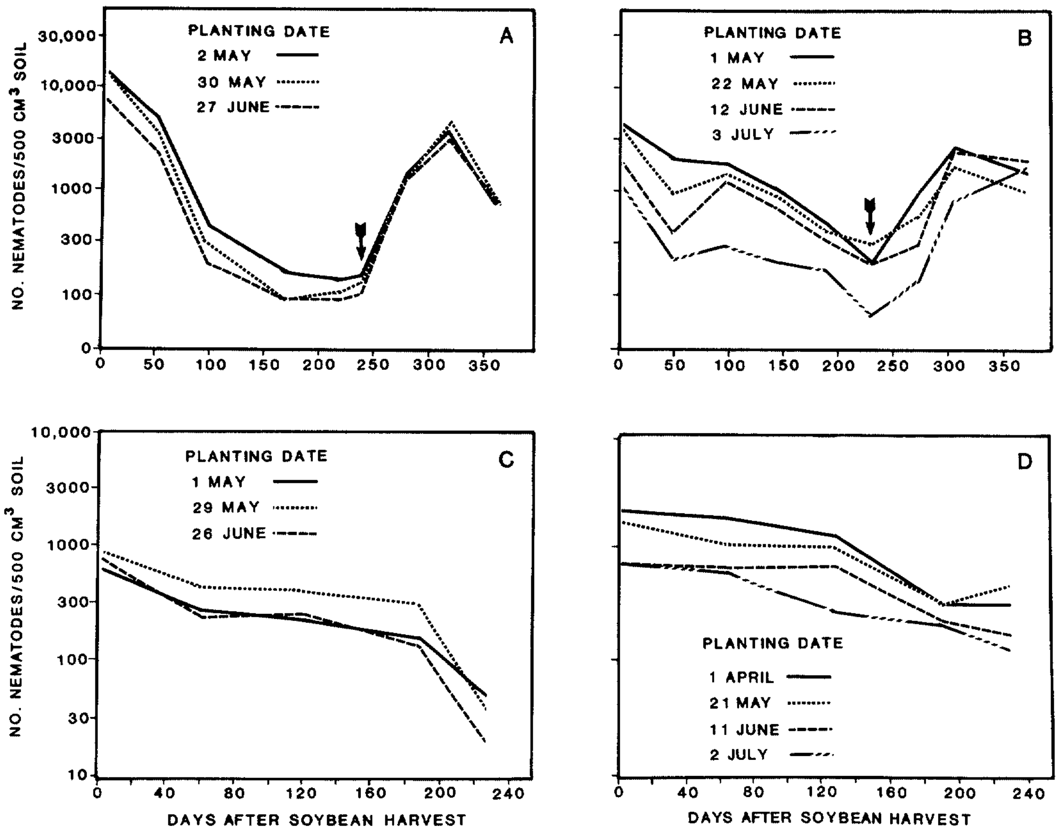

FIG. 1. Winter survival dynamics of *Pratylenchus brachyurus*. A) Central Crops Research Station (CCRS)—1981–82. Plots were replanted with soybean 231 days (arrow) after soybean harvest. B) Border Belt Tobacco Research Station (BBTRS)—1981–82. Plots were replanted with soybean 231 days (arrow) after soybean harvest. C) CCRS—1982–83. D) BBTRS—1982–83. Planting dates in the growing season prior to the overwinter study were used to manipulate population densities of the nematode.

tion. The objectives of this research were to 1) determine the effects of a winter cover crop and the previous year's planting date on the winter survival of *P. brachyurus*, 2) characterize the effects of an overwintered population of *P. brachyurus* on soybean yield, and 3) evaluate the use of double-cropping systems to limit damage to soybean caused by *P. brachyurus*.

MATERIALS AND METHODS

Experiments were conducted from 1981 to 1983 at two locations in North Carolina. Microplots (4) were located at the Central Crops Research Station (CCRS) near Clayton, North Carolina, and at the Border Belt Tobacco Research Station (BBTRS) near Whiteville, North Carolina. The soil type at CCRS was a Norfolk loamy sand (87% sand, 9% silt, 4% clay) and at BBTRS at Goldsboro sandy loam (69% sand, 27% silt, 4% clay). The population of *Pratylenchus brachyurus* was developed on soybean 'Forrest' during a growing season experiment (12). Three final population densities of the nematode at CCRS and four at BBTRS were established by using different planting dates of soybean (12). Soil in the microplots was tilled and planted with 'Arthur 71' wheat or left fallow after soybeans were harvested in 1981 and 1982. Treatments (population density × cover crop) were replicated four times. Plots were found to contain some *Paratrichodorus minor* (Colbran) Siddiqi in late July 1981, but none were detected in 1982. Plots containing wheat were fertilized with 27 g ammonium nitrate in late February both years.

Plots were sampled for nematodes at 6-week intervals in 1981–82 and at 8-week

TABLE 1. Winter survival of *Pratylenchus brachyurus* under wheat and fallow in microplots at Clayton (CCRS) and Whiteville (BBTRS), North Carolina.

Month sampled	Winter cover	No. of nematodes (location and year)							
		CCRS 1981–82*		BBTRS 1981–82†		CCRS 1982–83*		BBTRS 1982–83†	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Nov	wheat	11,977	1,875	3,066	558	710	93	1,336	299
	fallow	11,652	962	2,981	446	802	116	1,124	225
Dec	wheat	4,068	745	887	199	206	50	719	261
	fallow	3,038	285	937	234	418‡	65	1,247	274
Jan	wheat	366	139	1,194	224	—	—	—	—
	fallow	268	45	1,241	217	—	—	—	—
Feb	wheat	—	—	—	—	120	30	376	54
	fallow	—	—	—	—	439‡	69	1,152‡	245
Mar	wheat	109	20	532	117	—	—	—	—
	fallow	119	25	848‡	154	—	—	—	—
May	wheat	67	10	161	23	107	19	144	26
	fallow	156‡	28	523‡	102	267‡	53	342‡	43
Jun	wheat	139	21	111	19	18	5	90	22
	fallow	111	14	262‡	61	50‡	10	394‡	89

* All data are means of 12 replicates.
† All data are means of 18 replicates.
‡ Nematode numbers were greater ($P = 0.05$) in plots left fallow than in plots planted in wheat.
— = Not sampled.

intervals in 1982–83. Four 2.5-cm-d soil cores were taken 15–20 cm deep from each plot, and the holes filled with steamed greenhouse soil. Nematodes were extracted from 250 cm^3 soil by elutriation and centrifugation (3), and from roots by Seinhorst mist (3) for 7 days.

The wheat matured in mid June both years and was promptly harvested. All plots were planted with Forrest soybean without tillage after wheat harvest in 1982. Plant height and soybean phenology were recorded several times during the growing season, and the numbers of nodes on the main stems of soybean plants were counted. Soybean yield data were subjected to analysis of variance (ANOVA) for a split split-plot design with the previous year's planting date as whole plots with orthogonal contrasts for equally spaced planting dates, nematode inoculum as subplots and winter cover crop (wheat or fallow) as sub-subplots. Regression analyses were used to compare nematode numbers to soybean yield and the numbers of nodes. Numbers of nematodes [$\log_{10}(n + 1)$] were subjected to ANOVA and orthogonal polynomial contrasts.

All nematode data presented are the sums of root and soil populations recovered. Soil ($r = 0.60$) and root ($r = 0.99$) nematode numbers were correlated with total populations ($P = 0.01$).

RESULTS

The relationships between population densities of *Pratylenchus brachyurus* and survival rates in the winter were largely linear (Fig. 1A–D). Differential survival was evident in June 1982 and late spring 1983 at BBTRS (Fig. 1B, D) and at CCRS in June 1983 (Fig. 1C). Even though numbers of *P. brachyurus* at soybean planting in 1982 were different at CCRS, they became similar during the growing season. At BBTRS, the plots with the greatest nematode numbers at soybean planting had the fewest by soybean harvest (Fig. 1B).

Influence of cover crop: Winter wheat cover crop reduced ($P = 0.01$ to $P = 0.07$) the number of overwintering *P. brachyurus* compared to winter fallow (Table 1). The influence of wheat was evident ($P = 0.05$) in May 1982 at CCRS and March through June 1982 at BBTRS.

Wheat had a more pronounced effect in 1982–83 in limiting ($P = 0.01$) winter survival of *P. brachyurus* than in 1981–82 (Table 1). The effect of wheat in reducing nematode survival was significant much

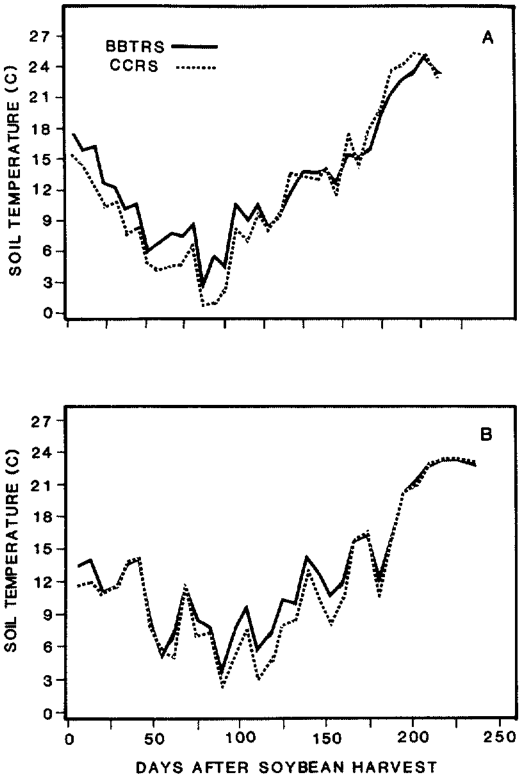

FIG. 2. Mean soil temperatures at 15 cm deep. A) November 1981 to June 1982. B) November 1982 to June 1983.

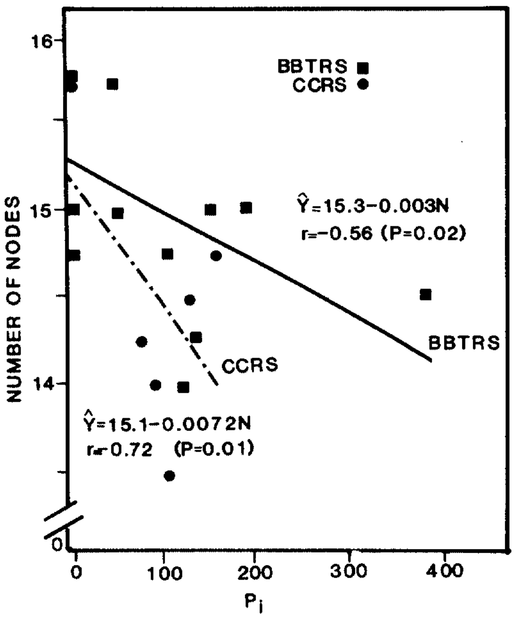

FIG. 3. The effects of *Pratylenchus brachyurus* on the number of nodes on the main stems of soybean at Central Crops Research Station and Border Belt Tobacco Research Station. P_i = initial population density.

earlier in 1982–83 than in the previous year. Reduction in nematode populations in response to a winter wheat cover crop occurred at all nematode population densities.

Influence of climate and location on overwinter survival of Pratylenchus brachyurus: Nematode populations declined after soybean harvest both years at both locations (Fig. 1A–D). Soil temperatures during fall and winter were markedly lower at CCRS than at BBTRS in both years (Fig. 2A, B). The lowest soil temperatures occurred in 1981–82, 85–100 days after soybean harvest, at both locations (Fig. 2A, B). Nematode survival rates at CCRS and BBTRS were 1 and 6% in 1981–82 and 4 and 19% in 1982–83, respectively. Greater nematode survival at BBTRS in both years resulted in the maintenance of damaging levels of *P. brachyurus* (20) at this location, whereas nematode population densities at CCRS fell below the damage threshold (Fig. 1A–D).

Paratrichodorus minor and Pratylenchus brachyurus interaction: The population densities of *P. minor* at BBTRS fluctuated widely within plots over time. *Paratrichodorus minor* increased ($P = 0.02$) in plots planted with wheat during winter and spring compared to fallow plots (approximately 300 vs. 100 per 500 cm^3 soil, respectively). Reproduction of *P. minor* was suppressed in plots containing *P. brachyurus* ($P = 0.01$). *P. minor* had no apparent effect on *P. brachyurus* populations. The population densities of these two species were not correlated in plots containing both species.

Soybean yields: Plant growth, as measured by height and the number of nodes on the main stems, was suppressed ($P = 0.03$–0.06) by *P. brachyurus* at both locations. The number of nodes on the main stem were negatively correlated with the number of nematodes at planting ($P = 0.01$) at both locations (Fig. 3).

The relationship of initial soil nematode population density against yield was curvilinear ($P = 0.06$) at CCRS and linear ($P = 0.02$) at BBTRS (Fig. 4). Soybean yields were suppressed ($P = 0.07$) by this nema-

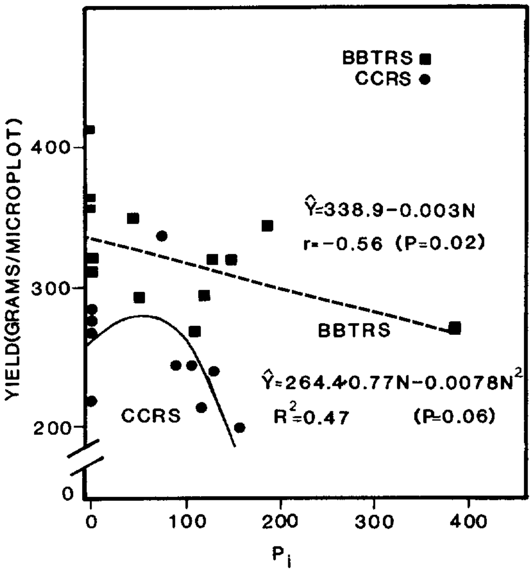

FIG. 4. The influence of *Pratylenchus brachyurus* on the soybean yield at Central Crops Research Station and Border Belt Tobacco Research Station. P_i = initial population density.

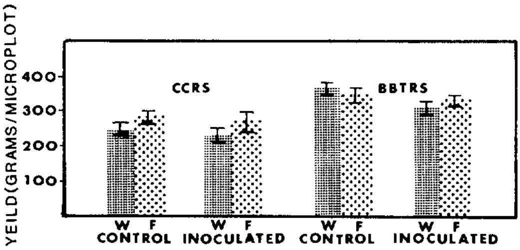

FIG. 5. The effects of wheat or fallow and *Pratylenchus brachyurus* on soybean yield at Central Crops Research Station and Border Belt Tobacco Research Station.

tode at BBTRS (Fig. 5). Winter cover crop had little effect on soybean yield.

DISCUSSION

Factors affecting winter survival of *Pratylenchus brachyurus* are important because nematode management decisions are often based on fall sampling. Decline in population density of *P. brachyurus* was generally density independent. Soil temperature and starvation probably were the primary factors affecting survival. However, large populations from a severely damaged crop may cause a slight deviation from density independence, which occurred at BBTRS in 1981–82.

P. brachyurus population increases during mid winter or spring, which occurred in both years at BBTRS, could be the result of errors in sampling or recovery (5), but similar trends have been documented for *Pratylenchus zeae* (2). Egg hatch and (or) some form of dormancy may occur in species of *Pratylenchus* which may account for some variation in their seasonal population dynamics or the numbers recovered from soil. Further research is needed to determine the factors responsible for these fluctuations in soil nematode populations.

Winter wheat cover crop can be used to reduce the numbers of overwintering *P. brachyurus*. Wheat–soybean double cropping will reduce the damage potential of this pest on soybean for several reasons: 1) wheat reduces survival of this nematode; 2) a double-cropping system results in delayed planting of soybean which allows for a further decline in numbers of this pest in soil; and 3) delayed planting reduces the damage potential of *P. brachyurus* (12) and limits population build-up during the growing season on soybean.

The mechanism by which wheat reduces overwinter survival of *P. brachyurus* is unknown. Soil moisture (10,15) effects were probably minor in this experiment. *P. brachyurus* penetrates wheat roots (S. R. Koenning, unpubl.) but reproduction is unlikely to occur at the low soil temperatures encountered during the winter (1,14,17). 'Atlas 61' wheat is a host for this nematode but allows little reproduction (7). Since rye and timothy produce substances toxic to *P. penetrans* (19), wheat may produce substances which may be toxic to *P. brachyurus*. Wheat produces substances toxic to certain weeds (13).

P. brachyurus did not overwinter at population densities high enough to cause damage to soybean at CCRS either year (20), but damaging levels overwintered at BBTRS both years. The sandier soil at CCRS is subject to greater fluctuations in soil moisture than are the finer textured soils at BBTRS resulting in greater daily soil temperature extremes at CCRS. Differences in soil texture may account for some of the variation in *P. brachyurus* survival between years, but soil temperature may be more important. Winter survival of *P. brachyurus* increased with depth in the soil (11) where soil temperatures are higher than they are closer to the surface.

Pratylenchus brachyurus is near its northern limit in distribution in North Carolina (14). CCRS and BBTRS have average freeze-free periods of 200–210 days and 230–240 days, respectively (8). Coupling weather and soil texture data should improve the disease forecasting system for *P. brachyurus* on soybeans. For example, yields were suppressed at BBTRS in 1982 by *P. brachyurus* where nematode densities remained high over winter.

Paratrichodorus minor accounted for little of the variance encountered in this experiment. It may be a problem in double-cropping systems in which corn and small grains are grown since *P. minor* is relatively widespread in North Carolina.

Planting wheat can reduce soil populations of *P. brachyurus* below damaging levels. Therefore, *P. brachyurus* is unlikely to be a problem on soybeans in a wheat–soybean double-cropping system.

Literature Cited

1. Acosta, N., and R. B. Malek. 1979. Influence of temperature on population development of eight species of *Pratylenchus* on soybean. Journal of Nematology 11:229–232.

2. Barker, K. R., C. J. Nusbaum, and L. A. Nelson. 1969. Seasonal population dynamics of selected plant-parasitic nematodes as measured by three extraction procedures. Journal of Nematology 1:232–239.

3. Barker, K. R., chairman. 1978. Determining nematode responses to control agents. Pp. 114–125 *in* I. Zehr, ed. Methods for evaluating plant fungicides, nematicides, and bactericides. American Phytopathological Society, St. Paul, Minn.

4. Barker, K. R., B. I. Daughtry, and D. W. Corbett. 1979. Equipment and techniques for establishing microplots for study of soilborne pathogens. Journal of Nematology 11:106–108.

5. Bird, G. W. 1971. Influence of incubation solution on the rate of recovery of *Pratylenchus brachyurus* from cotton roots. Journal of Nematology 3: 378–385.

6. Dunn, R. A. 1972. Importance of depth in soil, presence of host roots and role of eggs as compared to vermiform stages. Journal of Nematology 4:221–222 (Abstr.).

7. Endo, B. Y. 1959. Responses of root-lesion nematodes, *Pratylenchus brachyurus* and *P. zeae*, to various plants and soil types. Phytopathology 49:417–421.

8. Hardy, A. V., and J. D. Hardy. 1971. Weather and climate in North Carolina. North Carolina Agricultural Experiment Station, Technical Bulletin 396.

9. Hussey, R. S., and H. R. Boerma. 1983. Influence of planting date on damage to soybean caused by *Heterodera glycines*. Journal of Nematology 15:253–258.

10. Kable, P. F., and W. F. Mai. 1968. Influence of soil moisture on *Pratylenchus penetrans*. Nematologica 14:101–122.

11. Koen, H. 1967. Notes on the host range, ecology and population dynamics of *Pratylenchus brachyurus*. Nematologica 13:118–124.

12. Koenning, S. R. 1983. The influence of planting date on the damage potential and population dynamics of *Pratylenchus brachyurus* on soybean. Ph.D. dissertation, North Carolina State University, Raleigh.

13. Liebl, R. A., and A. D. Worsham. 1983. Inhibition of pitted morning glory (*Ipomea lacumosa* L.) and certain other weed species by phytotoxic components of wheat (*Triticum aestivum* L.) straw. Journal of Chemical Ecology 9:1027–1045.

14. Lindsey, D. W., and E. J. Cairns. 1971. Pathogenicity of the lesion nematode, *Pratylenchus brachyurus*, on six soybean cultivars. Journal of Nematology 3:220–226.

15. Norton, D. C., and N. Burns. 1971. Colonization and sex ratios of *Pratylenchus alleni* in soybean roots under two soil moisture regimes. Journal of Nematology 3:374–377.

16. Norton, D. C. 1978. Ecology of plant-parasitic nematodes. New York: John Wiley and Sons.

17. Olowe, T., and D. C. M. Corbett. 1976. Aspects of the biology of *Pratylenchus brachyurus* and *P. zeae*. Nematologica 22:202–211.

18. Robbins, P. A., S. D. Van Gundy, and H. E. McKinney. 1981. Effects of soil temperature and planting date of wheat, *Meloidogyne incognita* reproduction, soil populations, and grain yield. Journal of Nematology 13:338–345.

19. Sayre, R. M., Z. A. Patrick, and H. J. Thorpe. 1965. Identification of a selective nematicidal component in extracts of plant residues decomposing in soil. Nematologica 11:263–268.

20. Schmitt, D. P., and K. R. Barker. 1981. Damage and reproductive potentials of *Pratylenchus brachyurus* and *Pratylenchus penetrans* on soybean. Journal of Nematology 13:327–332.