# Effects of Wheat and Soybean Planting Date on *Heterodera glycines* Population Dynamics and Soybean Yield with Conventional Tillage

S. R. KOENNING, Former Research Associate, and S. C. ANAND, Professor of Agronomy, Department of Agronomy, University of Missouri, Columbia, Delta Center, P.O. Box 160, Portageville, MO 63873

**ABSTRACT**

Koenning, S. R., and Anand, S. C. 1991. Effects of wheat and soybean planting date on *Heterodera glycines* population dynamics and soybean yield with conventional tillage. Plant Dis. 75:301-304.

The influence of winter wheat (*Triticum aestivum*) cover crop vs. winter fallow and of soybean (*Glycine max*) planting date on the population dynamics of soybean cyst nematode (*Heterodera glycines*) (SCN) was determined during a 2-yr period. Numbers of SCN cysts, eggs, and second-stage juveniles were unaffected by wheat as opposed to winter fallow. Delay in soybean planting associated with double-cropping wheat, however, allowed for a significant decline in the numbers of SCN between early May and late June. Midseason densities of early May soybean plantings were greater than those of mid-June to late June plantings. Soybean yields were greater with a late May planting than with either early May or late June plantings in 1985. Late soybean plantings tended to have greater densities of SCN eggs at soybean maturity, probably a result of less SCN damage in these plots. Neither soybean planting date nor wheat affected soybean yields in 1986. Delayed soybean planting may reduce the damage potential of SCN by reducing inoculum density at planting, but wheat has no direct effect on SCN.

Soybean (*Glycine max* (L.) Merr.) is grown as either a full- or short-season crop in much of the United States. Most soybean cultivars are adaptable to either system. Cropping systems can alter many aspects of crop production, affecting both host and pathogen. Delayed soybean planting may result in lower yields, but several advantages associated with delayed planting may offset yield losses. The ability to produce a winter wheat (*Triticum aestivum* L.) crop is one such advantage. Growers frequently grow both full- and short-season crops in order to spread planting and harvesting operations and thus optimize equipment usage. Soybean/wheat double cropping may be practiced on 20–40% of the U.S. soybean hectarage in any year.

Suppression of soybean yield by the soybean cyst nematode (*Heterodera glycines* Ichinohe) (SCN) was affected by planting date in Georgia (7). There was no reduction in SCN population densities between mid-May and early June in the absence of a host (7). Other researchers (1) found that densities of SCN juveniles were lower with winter wheat than with full-season soybean in June and suggested that wheat might be toxic to *H. glycines*; tillage and planting date effects could not be separated, however. Because wheat produces chemicals toxic to certain weed seeds (11), wheat residues may be toxic to nematodes and may have allelopathic effects on soybean yield (3). The type of tillage also has been shown to influence densities of several plant-parasitic nematodes (12,16), including *H. glycines* (4).

Studies on cropping systems and *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven showed several effects of soybean/wheat double-cropping on this nematode (9,10): 1) Wheat planting resulted in lower population densities of *P. brachyurus* compared with fallow, 2) delayed soybean planting allowed for a further reduction of *P. brachyurus*, and 3) late soybean planting resulted in a shorter growing season and subsequently lower population densities at the end of the season.

Cropping systems must be evaluated in terms of their impact on pest populations as well as on productivity. This research was initiated to better understand the influence of cropping systems on the population dynamics of *H. glycines*. Specific objectives included determining: 1) the effects of soybean planting date on *H. glycines* and soybean yield in the presence of this pest and 2) the influence of a winter wheat crop vs. winter fallow on *H. glycines*.

Present address of first author: Department of Plant Pathology, North Carolina State University, P.O. Box 7616, Raleigh, NC 27695-7616.

Contribution from the Missouri Agricultural Experiment Station. Journal Series No. 11149. Research supported by USDA Grant No. 84-CRSR-2-2375.

Accepted for publication 27 September 1990 (submitted for electronic processing).



## MATERIALS AND METHODS

Experiments were conducted from November 1984 to November 1986 at the Lee Farm of the University of Missouri Delta Center located near Portageville. The 1984–1985 experiment was conducted in a sandy loam (59.5% sand, 34.3% silt, 6.2% clay, OM 1.4%, pH 5.6) and the 1985–1986 experiment in a loamy sand (74% sand, 25% silt, 1% clay, OM 1.2%, pH 5.9). All plots were planted to the SCN-susceptible soybean cultivar Essex for 1 yr prior to experimentation to increase the SCN population density. The fields were tilled each November to provide a seedbed before the wheat cultivar Rosen was planted in selected plots. Soil samples for nematodes were taken after seedbed preparation immediately before planting wheat. Samples consisted of 25–30 cores, 15 cm deep and 2.5 cm in diameter. Cores were composited and two 450-$cm^3$ subsamples were processed by elutriation (2) and sugar flotation (13). Cysts were crushed in a Ten-Broek homogenizer to free the eggs, which were then counted. Nematode population estimates at the beginning of the wheat season or soybean season were based on the means of two elutriator runs with 450-$cm^3$ soil samples. Nematode counts at other sampling dates were based on a 450-$cm^3$ subsample from a 1,500-$cm^3$ soil sample. Nematode data included numbers of cysts, eggs, and juveniles. Nematode samples were taken from the center of wheat or fallow plots and from the center four rows of soybean plots. Samples were taken before wheat planting, before each soybean planting, and at 6-wk intervals after soybean planting until harvest.

To evaluate the effects of wheat density on *H. glycines*, selected plots were planted with wheat at 46, 92, or 138 kg/ha of seed. All plots planted to wheat received 51.2 kg/ha of ammonium nitrate (33% N) in late February of each year. One set of fallow plots received ammonium nitrate to ensure that observed effects were not related to fertility. The rest of the plots were left fallow during the winter. No further tillage was performed until the day before soybean planting. Essex soybeans were planted on 7 and 27 May and 21 June 1985 and on 2 May and 2 and 21 June 1986. Late June plantings coincided with wheat harvest, and all plots that had been planted to wheat were planted with soybean. One set of wheat plots planted at a rate of 92 kg/ha was burned to remove excess straw. Plots were then chisel-plowed and disked. Herbicides were applied to all plots the day before planting. In 1985, trifluralin herbicide was applied preplant and incorporated at recommended rates and metribuzin was applied preemergence. In 1986, the herbicides were trifluralin and imazaquin applied preplant at labeled rates. Soybean plots consisted of eight rows 0.76 m apart and 9.1 m long. Soybean yield was taken from the center four rows, trimmed from the ends to 6.1 m. Nematode data were transformed ($\log_{10}(N + 1)$) to standardize the variance for statistical purposes. The reduction in numbers of eggs over time was calculated as reduction in eggs per day = (eggs at time 2 − eggs at time 1)/(time 2 − time 1). Plots were arranged in a randomized complete block design. There were six replications in 1985 and eight in 1986. Statistical analyses consisted of analyses of variance (ANOVA) and the use of orthogonal contrasts for planting date effects, where applicable.

## RESULTS AND DISCUSSION

Winter wheat had no influence on overwinter survival of *H. glycines* eggs or juveniles during either 1984–1985 or 1985–1986 (Figs. 1–4). The rate of decline of numbers of SCN eggs did not differ between wheat or fallow treatments and was not related to wheat seeding rates. The numbers of SCN second-stage juveniles were unaffected by any wheat treatment at any sampling date in 1985. In plots planted 7 May 1985, the nematode population increased by 21 June ($P = 0.05$), but populations declined in all plots not planted to soybean (Figs. 1 and 2). This result was expected, since enough time had elapsed for the completion of at least one life cycle of *H. glycines* (15). The second 1985 soybean planting had significantly ($P = 0.05$) greater numbers of SCN eggs and juveniles than the first soybean planting, and both plantings had significantly ($P = 0.05$) greater numbers of eggs than late June plantings at the 2 September 1985 sampling (Figs. 1 and 2). The effects of planting date on the numbers of SCN eggs and juveniles were adequately described by a quadratic model ($P = 0.05$) at this sampling, with the highest densities for the second planting. At soybean maturity (30 September 1985), the SCN population densities of the two early soybean plantings had declined, whereas numbers of SCN eggs in late plantings had increased such that there were no significant effects of planting dates on SCN final population densities (Figs. 1 and 2).

There were significantly ($P = 0.05$) more SCN juveniles in winter fallow plots than in winter wheat plots before early soybean planting at the 2 May 1986 sampling date (Fig. 3A and B) when analyzed by orthogonal contrasts. The numbers of SCN eggs, however, did not differ significantly between any treatment at this date. Samples taken 2 June 1986 had significantly ($P = 0.05$) greater numbers of eggs in the plots planted to soybean than in those not planted to soybean, as occurred in 1985 (Fig. 4A and B). There was no effect of wheat on numbers of SCN eggs or juveniles at this date, and there were no significant differences in SCN eggs or juveniles at the 21 June 1986 sampling. The 5 August and 5 September 1986 samplings showed the same trend in SCN egg numbers, with a negative linear relationship ($P = 0.05$)

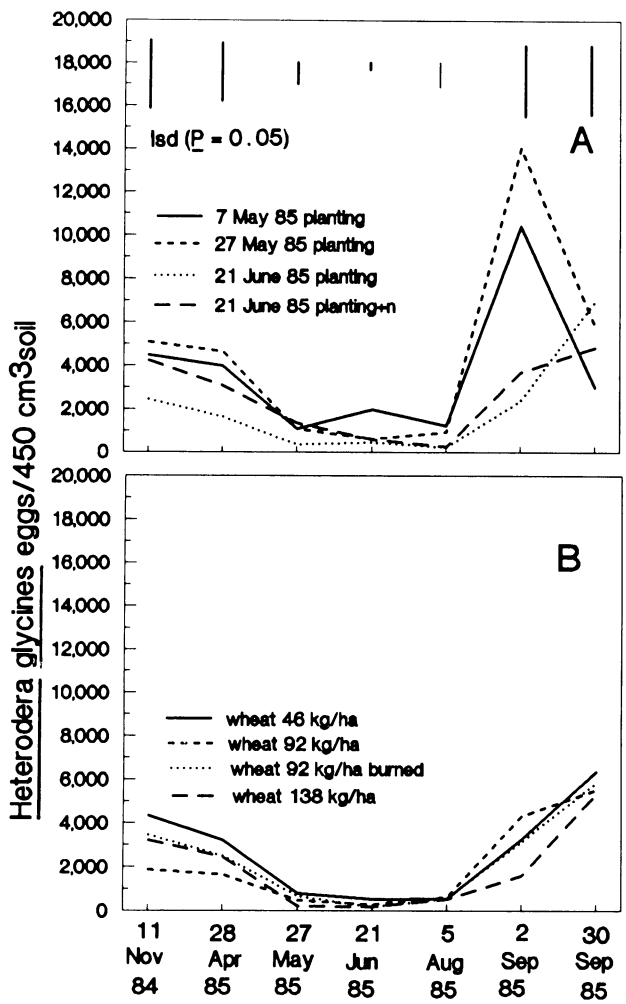


**Fig. 1.** Influence of soybean planting date on numbers of eggs of *Heterodera glycines* per 450 cm³ of soil during 1984–1985 **(A)** in fallow plots and **(B)** in winter wheat cover crop. Essex soybeans were planted 7 and 27 May and 21 June 1985; winter wheat plots were planted 21 June. One set of wheat plots was burned and one set of fallow plots received ammonium nitrate fertilizer in February 1985. Vertical bars represent LSD ($P = 0.05$) for each sampling date.

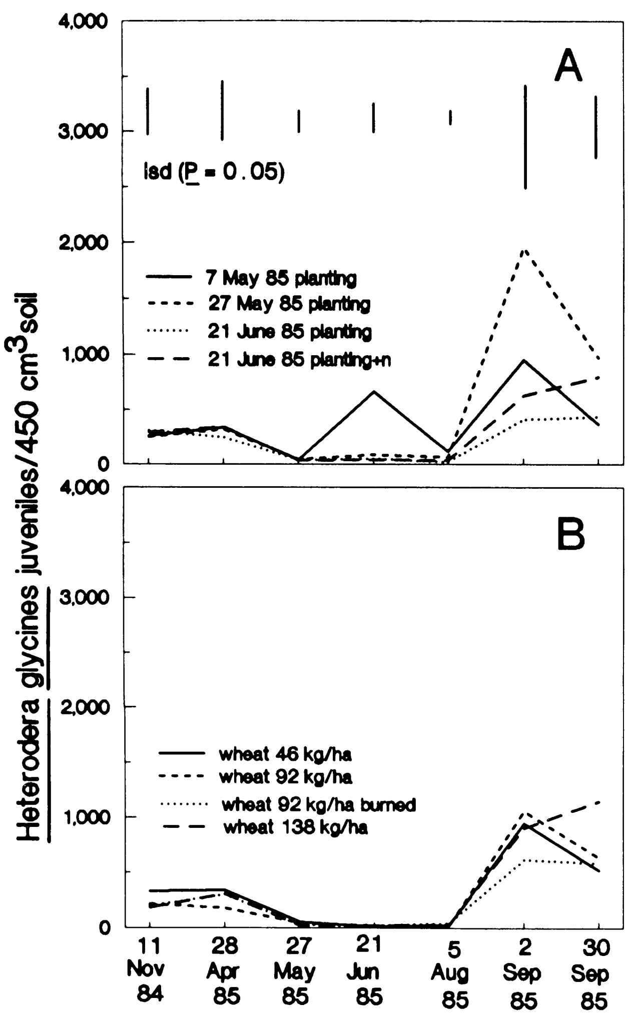


**Fig. 2.** Influence of soybean planting date on numbers of juveniles of *Heterodera glycines* during 1984–1985 **(A)** in fallow plots and **(B)** in winter wheat cover crop. Essex soybeans were planted 7 and 27 May and 21 June 1985; winter wheat plots were planted 21 June. One set of wheat plots was burned and one set of fallow plots received ammonium nitrate fertilizer in February 1985. Vertical bars represent LSD ($P = 0.05$) for each sampling date.

between planting date and numbers of eggs. Early plantings had greater numbers of SCN eggs, but the numbers of second-stage juveniles were similar for all plantings. These trends were reversed at soybean maturity, when the numbers of SCN eggs were significantly ($P = 0.05$) higher in late plantings (Fig. 4A and B). Fallow plots that were planted late had significantly greater ($P = 0.05$) densities of SCN eggs than plots containing wheat (Fig. 4A and B).

The initial population densities for 1985–1986 were more than twice the densities for 1984–1985. Thus, the nematode data for the 2 yr must be compared cautiously because of possible density-dependent factors. Rates of decline were lowest during the winter–spring period (November–May) in both years (Table 1). The apparent higher mortality during winter 1985–1986 than during 1984–1985 may be an artifact of sampling, because the 1985–1986 sample interval included 14 more days of spring, when decline accelerated, than the 1984–1985 interval. The rates of decline of SCN eggs for the May period were similar for the 2 yr. Although the rates of decline for the late May–June period were much higher in 1986 than in 1985, these data agree with other work on overwinter survival (6) in that relatively few SCN died during winter. Rates of decline of SCN cysts and eggs were higher in summer than in winter in the absence of a host (6). Furthermore, decline in summer was density-dependent (6), whereas the winter decline of SCN eggs was density-dependent in some years and not in others. Thus, the greater decline encountered in the present work could be a result of density-dependent factors or could reflect variation in survival rates from year to year as a result of abiotic environmental factors. More research on SCN survival in different environments is needed.

Our research shows that lower SCN densities associated with double-cropping wheat and soybean are a result of soybean planting date and not wheat per se. Baird and Bernard (1) suggested that wheat residue may produce substances toxic to nematodes that resulted in lower SCN juvenile population densities. We encountered lower SCN juvenile densities only at one sampling, on 3 May 1986. A wheat crop removes soil water through transpiration, resulting in different moisture regimes between wheat plots and fallow plots. A reasonable explanation for higher SCN juvenile densities on 3 May 1986 in fallow plots is that moisture was more favorable for hatch in fallow plots than in wheat plots. Wheat has a marginal, if any, effect on SCN survival.

Soybean yields were not affected by wheat (Table 2) vs. fallow treatments. Soybean yield was adequately described by a quadratic model ($P = 0.05$) in 1985, with an optimum planting date in late May (Table 2). Soybean yield was highest for the second planting date in 1986, although yields were not statistically different (Table 2). This agrees with current Missouri recommendations for soybean planting from mid-May to early June. Early or late planting resulted in the lowest soybean yields both years. Soybean yields were much lower in 1986 than in 1985 because of: 1) the twofold to threefold increased density of *H. glycines* and 2) the greater sand content in the

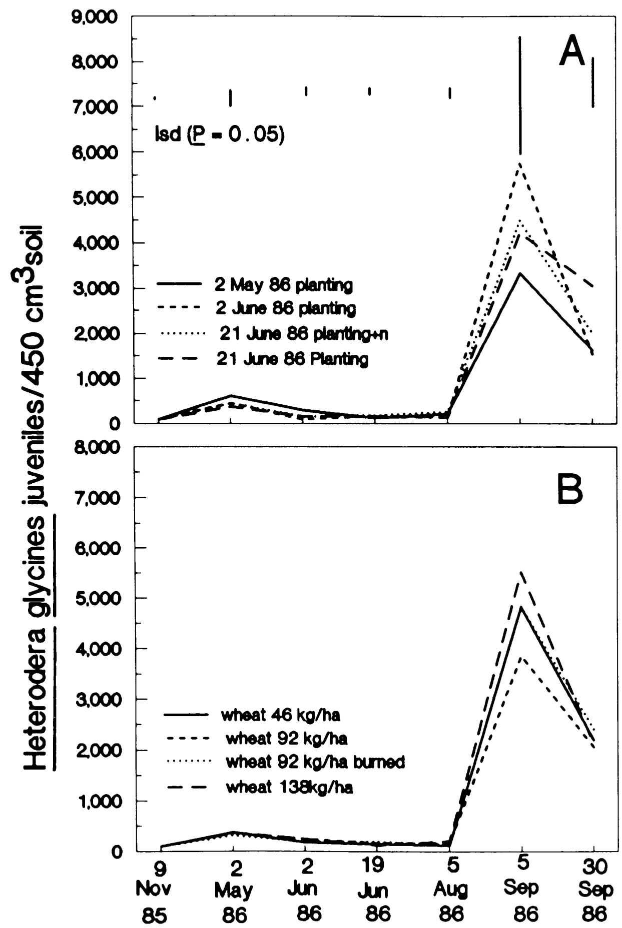


**Fig. 3.** Influence of **(A)** planting date and **(B)** winter wheat cover crop on numbers of juveniles of *Heterodera glycines* during 1985–1986. Essex soybeans were planted 2 May and 2 and 21 June 1986; winter wheat plots were planted 21 June. One set of wheat plots was burned and one set of fallow plots received ammonium nitrate fertilizer in February 1986. Numbers of juveniles were greater in fallow than in wheat plots when analyzed by orthogonal contrasts for the 2 May sampling. Vertical bars represent LSD ($P = 0.05$) for each sampling date.

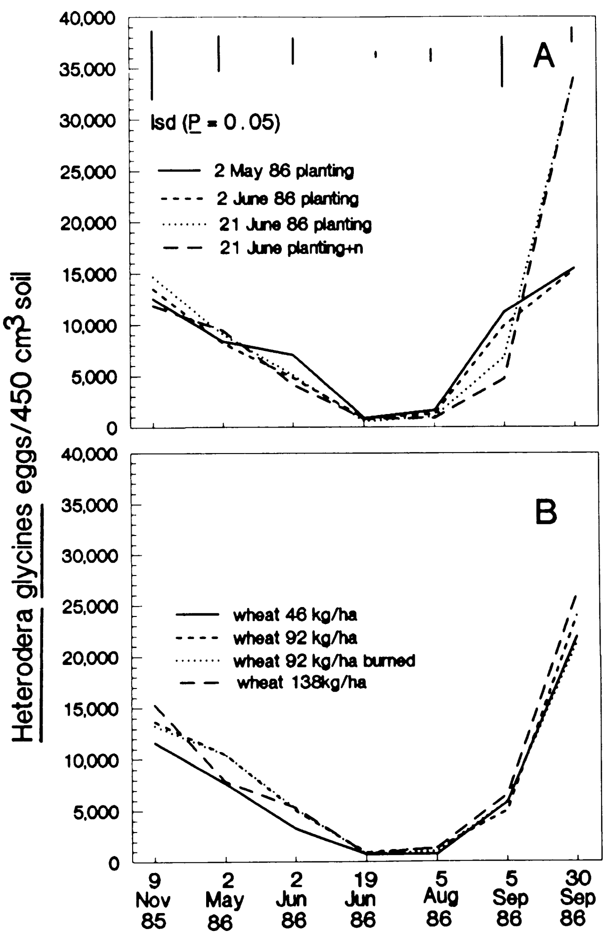


**Fig. 4.** Influence of **(A)** planting date and **(B)** winter wheat cover crop on numbers of eggs of *Heterodera glycines* per 450 $cm^3$ of soil during 1985–1986. Essex soybeans were planted 2 May and 2 and 21 June 1986; winter wheat plots were planted 21 June. Selected wheat plots were burned before soybeans were planted and selected late-planted plots received ammonium nitrate fertilizer in February 1986. Vertical bars represent LSD ($P = 0.05$) for each sampling date.

**Table 1.** Decline in numbers of *Heterodera glycines* eggs per day in 450-cm$^3$ soil samples over different time intervals in response to winter wheat and winter fallow

| Time intervals | Decline in eggs per day Fallow | Wheat | ANOVA |
|---|---|---|---|
| 1984–1985 | | | |
| 11 Nov. 1984–19 April 1985[a] | −4.5 | −4.75 | NS |
| 19 April 1985–21 May 1985[b] | −56.1 | −48.9 | NS |
| 21 May 1985–21 June 1985[c] | −14.2 | −10.5 | NS |
| 1985–1986 | | | |
| 9 Nov. 1985–2 May 1986[d] | −25.1 | −24.8 | NS |
| 2 May 1986–30 May 1986[e] | −42.9 | −43.3 | NS |
| 30 May 1986–21 June 1986[f] | −197.2 | −195.6 | NS |

[a] Means of 24 replicates.
[b] Means of 18 replicates for fallow and 24 for wheat; first soybean planting not included in analysis.
[c] Means of 24 replicates for fallow and 12 for wheat; first and second soybean plantings not included in analysis.
[d] Means of 32 replicates.
[e] Means of 24 replicates for fallow and 32 for wheat; first soybean planting not included in analysis.
[f] Means of 16 replicates for fallow and 32 for wheat; first and second soybean plantings not included in analysis.

**Table 2.** Influence on soybean yields of soybean planting date and of winter wheat vs. winter fallow in field plots infested with *Heterodera glycines*[a]

| Fallow vs. wheat | 1985 Planting date | 1985 Yield (kg/ha) | 1986 Planting date | 1986 Yield (kg/ha) |
|---|---|---|---|---|
| Fallow | 7 May | 2,782 | 2 May | 1,195 |
| | 27 May | 3,434 | 2 June | 1,288 |
| | 21 June | 2,520 | 21 June | 1,190 |
| Fallow + $NH_4NO_3$ | 21 June | 2,298 | 21 June | 1,231 |
| Wheat | | | | |
| 46 kg/ha of seed | 21 June | 2,849 | 21 June | 1,193 |
| 92 kg/ha of seed | 21 June | 2,621 | 21 June | 1,206 |
| 92 kg/ha of seed, plots burned | 21 June | 2,775 | 21 June | 1,141 |
| 138 kg/ha of seed | 21 June | 2,557 | 21 June | 1,114 |

[a] Means of six replicates for 1985 and eight for 1986. Yields were quadratic ($P = 0.05$) with respect to planting date in 1985 and were not significantly different in 1986.

soil. Soybean yield suppression as a result of SCN is related to preplant population density (6,15) and soil texture (8). The lack of yield differences between early and late soybean plantings could be a result of less SCN damage to soybean in late plantings or a result of the large population decline between early and late plantings. Late plantings in 1986 probably sustained less yield suppression from SCN because final SCN population densities were much greater for late plantings. This conclusion is reasonable, since host damage by an obligate parasite such as SCN results in a lower equilibrium population density (5). Other research has shown that nematicides are not consistently cost-effective in double-cropped soybean (14). The lack of nematicidal treatments in our research, however, does not firmly establish reduced yield suppression.

There was a trend toward lower soybean yield in response to the rate at which wheat was planted (Table 2), but the differences were not statistically significant. Allelopathy of wheat toward soybean (3) could be responsible for marginal soybean yield loss and may have been a confounding factor in our research. Reduced early soybean growth caused by wheat residue may have resulted in lower SCN densities in late plantings with wheat than in fallow plots.

Wheat residue is frequently burned before soybean is planted, which may ameliorate any allelopathic effects of wheat residue on soybean or reduce the nematicidal effects of the residue. Similarly, nitrogen carryover from wheat fertilization could affect the subsequent crop and/or pests. Burning wheat residue had no measurable effect in this study on either soybean yield or nematode population densities. Fertilization of fallow plots resulted in increased weed problems but did not affect soybean yield or nematode densities.

Hussey and Boerma (7) found a decline in soybean yield as planting date was delayed, regardless of nematicidal treatment, in Georgia. They found little decline in SCN densities from the initiation of soybean planting. The greatest decline in SCN numbers, however, may have occurred before the start of their experiment.

The value of double-cropping wheat and soybean as a tactic for managing SCN lies in the decline of the nematode population associated with delayed planting. The use of delayed soybean planting as the sole tactic for managing *H. glycines* is not effective if maximal soybean yields are to be obtained under conventional tillage. Delayed planting and/or double-cropping should be integrated with other management tactics, such the use of resistant cultivars and rotation to minimize soybean yield suppression caused by *H. glycines*. Double-cropping wheat and soybean may be considered as a reasonable management tactic if: 1) the value of the two crops offsets the soybean yield loss associated with delayed planting; 2) row spacing, which is commonly reduced in late soybean plantings, increases soybean yield; and 3) double-cropping is combined with other tactics that reduce initial inoculum density or incorporate effective SCN resistance.

## LITERATURE CITED


1. Baird, S. M., and Bernard, E. C. 1984. Nematode population and community dynamics in soybean-wheat cropping and tillage regimes. J. Nematol. 16:379-386.
2. Byrd, D. W., Jr., Barker, K. R., Ferris, H., Nusbaum, C. J., Griffin, W. E., Small, R. H., and Stone, C. A. 1976. Two semi-automatic elutriators for extracting nematodes and certain fungi from soil. J. Nematol. 8:206-212.
3. Caviness, C. E., Collins, F. C., and Sullivan, M. 1986. Effect of wheat residue on early growth of soybean. Arkansas Farm Res. 35:8.
4. Chambers, A. Y., and McCutchen, T. C. 1983. Effects of no-tillage on soybean cyst nematodes and foliar diseases. (Abstr.) Pages 13-14 in: Proc. Southern Soybean Dis. Workers.
5. Ferris, H. 1985. Density-dependent nematode seasonal multiplication rates and overwinter survivorship. A critical point model. J. Nematol. 17:93-100.
6. Francl, L. J., and Dropkin, V. H. 1986. *Heterodera glycines* population dynamics and relation of initial population to soybean yield. Plant Dis. 70:791-795.
7. Hussey, R. S., and Boerma, H. R. 1983. Influence of planting date on damage to soybean caused by *Heterodera glycines*. J. Nematol. 15:253-258.
8. Koenning, S. R., Anand, S. C., and Wrather, J. A. 1988. Effect of within-field variation in soil texture on *Heterodera glycines* and soybean yield. J. Nematol. 20:373-380.
9. Koenning, S. R., Schmitt, D. P., and Barker, K. R. 1985. Influence of planting date on population dynamics and damage potential of *Pratylenchus brachyurus* on soybean. J. Nematol. 17:428-434.
10. Koenning, S. R., Schmitt, D. P., and Barker, K. R. 1985. Influence of selected cultural practices on winter survival of *Pratylenchus brachyurus* and subsequent effects on soybean yield. J. Nematol. 17:464-469.
11. Liebl, R. A., and Worsham, A. D. 1983. Inhibition of pitted morning glory (*Ipomea lacumosa* L.) and certain other weed species by phytotoxic components of wheat (*Triticum aestivum* L.) straw. J. Chem. Ecol. 9:1027-1045.
12. Parmelee, R. W., and Stern, D. 1984. Nematode trophic structure in conventional and no-till agro-ecosystems. (Abstr.) Bull. Ecol. South Am. 65:26.
13. Reilly, J. J., and Grant, C. E. 1985. Seasonal fluctuations of *Globodera solanacearum* as estimated by two soil extraction techniques. J. Nematol. 17:354-360.
14. Schmitt, D. P., and Nelson, L. A. 1987. Chemical control of selected plant-parasitic nematodes in soybeans double-cropped with wheat in no-till and conventional tillage systems. Plant Dis. 71:323-326.
15. Schmitt, D. P., and Noel, G. R. 1984. Nematode parasites of soybeans. Pages 13-59 in: Plant and Insect Parasitic Nematodes. W. R. Nickle, ed. Marcel Dekker, New York.
16. Thomas, S. H. 1978. Population densities of nematodes under seven tillage regimes. J. Nematol. 10:24-27.