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# Effect of Planting Date on Population Densities of *Hoplolaimus columbus* and Yield of Soybean[1]

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*Abstract:* During the 1991 and 1992 soybean growing seasons, field plots were established in South Carolina to study the effect of planting date on at-planting nematode densities and subsequent yield losses caused by *Hoplolaimus columbus*. The susceptible and intolerant soybean cv. Braxton was planted on five dates from 10 May to 28 June in 1991 and from 12 May to 28 June in 1992. Nematodes were recovered from soil samples collected before nematicide treatment with 1,3-D (Pi), at 6 weeks after planting (Pm), and at harvest (Pf). Initial nematode population densities did not differ among the five dates of planting in either year. The increase in numbers of nematodes from planting to 6 weeks after planting (Pm/Pi) and from planting to harvest (Pf/Pi) were not different among the five planting dates in either year. Root samples also were collected at 6 weeks after planting and at harvest, but planting date did not affect the number of nematodes extracted from roots on any sample date in either year. Altering planting dates between early May and late June was not effective in preventing yield suppression due to *H. columbus*.

*Key words:* 1,3-D, chemical control, ecology, *Glycine max*, *Hoplolaimus columbus*, lance nematode, nematode management, pest management, population dynamics, soybean.

Columbia lance nematode, *Hoplolaimus columbus* Sher (21), infests approximately 14% of the 259,200 ha of soybean (*Glycine max* L. Merr.) in South Carolina (12). Infestation levels of cotton fields are even higher, with 37% of fields above the damage threshold (13). In 1968, *H. columbus* was first associated with damage to soybean and cotton in the middle and upper Coastal Plain of South Carolina (5). Yield suppression can be as high as 70%, and in some instances it is not economical to harvest the crop (5,14,20).

Resistance to *H. columbus* has not been identified in any soybean genotypes. Tolerant cultivars have sustained relatively high yields in moderately infested fields in South Carolina (6). The use of tolerance gave an acceptable profit level only when combined with fenamiphos (20). The recision of the registration of DBCP in 1981, suspension of EDB in 1983, and the withdrawal of D-D have left 1,3-D as the only registered fumigant nematicide (9). Successful management of *H. columbus* has been achieved using nonfumigant nematicides such as aldicarb, carbofuran, and fenamiphos, but economic returns were minimal (2,14,17). Subsoiling to a depth of 42 cm, which increases yield by providing deeper and more abundant root growth, is ineffective at high nematode infestation levels (2). Since alternative crops and many weeds are good hosts of *H. columbus*, control of *H. columbus* using crop rotation is limited (4,11).

Nematode parasitism is affected by temperature, and the life cycle is completed within cardinal temperatures specific to each species (3,18,20). Development of *Heterodera glycines* was slow on soybean plants planted early in the season due to lower soil temperatures (22). Early-planted soybean in Alabama escaped severe infection by *H. glycines* in infested fields (16).

In greenhouse experiments, root penetration and reproduction of *H. columbus* on soybean were greater at 30 °C than at 20 °C or 25 °C (15). Field studies have not been done to corroborate those temperature studies.

Planting when soil temperature will allow the crop to develop, but which will allow less nematode activity, may reduce

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nematode-induced yield loss (18). Higher temperatures that are optimum for *H. columbus* reproduction and root penetration are reached in the soil relatively late in the growing season; thus, an early planting date might lessen crop loss. The objective of this study was to determine if lower soil temperatures encountered by planting early in the growing season reduce infection and subsequent yield loss caused by *H. columbus*.

## MATERIALS AND METHODS

Experiments were established in 1991 and 1992 at the Edisto Research and Education Center, Blackville, South Carolina, in a Dothan sandy loam (85% sand, 10% silt, 5% clay; 0.5% organic matter). The soil was naturally infested with *H. columbus* and had been planted to soybean the previous 3 years. The *H. columbus* susceptible and intolerant cultivar Braxton was planted (6). Plots were arranged in a split-split-plot experimental design with two nematicide treatments (treated with 1,3-D and not treated) as the whole plot factor in a randomized complete block design, five dates of planting as the sub-plots, and three sample dates (at planting, 6 weeks after planting, and harvest) as sub-sub-plots. Treatments were replicated six times. Experimental units consisted of four 16-m long rows on 0.96-m centers. All plots were in-furrow subsoiled approximately 36 cm deep at planting. A subplot was either not treated or treated with 269 ml a.i. of 1,3-D/100 m of row applied 32 cm deep. Weed control consisted of a broadcast application of 1.75 liters/ha of 44.5% trifluralin and a mixture of 0.31 kg a.i./ha of metribuzin + 0.052 a.i./ha chlorimuron ethyl. Additional weed control consisted of mechanical cultivation. The experimental area was fertilized before planting with 420 kg/ha of 0-10-30 N-P-K. Ammonium soaps of higher fatty acids were applied several times after planting to prevent damage from deer. Soil temperature was recorded at a depth of 15 cm between 8:30 a.m. and 10:00 a.m. for each plot at planting.

Nematode samples consisted of 15 to 20 cores (2.5-cm diam. × 20-cm deep) taken from the two center rows of each plot at planting, 6 weeks after planting, and at harvest. The 15 to 20 cores were mixed manually and a 250-$cm^3$ subsample was collected. The subsamples were wet-sieved through nested 850-$\mu$m and 28-$\mu$m pore sieves. The material retained on the 28-$\mu$m pore sieve was processed by centrifugal flotation (8). The extracted nematodes were dispersed in water in a gridded counting dish, identified, and enumerated. All nematode counts from soil were standardized to 100 $cm^3$ of soil. Six weeks after planting and at harvest, 10 root systems were taken at random from the first and fourth rows of each plot. A 15-g fresh weight subsample was taken at random, and nematodes were extracted using a modified mist apparatus (1). After 5 days, nematodes were counted and then standardized to the number per gram fresh or dry weight of root. Roots were dried for 72 hours in an oven at 80 °C. In 1991, planting dates were 10 May, 17 May, 31 May, 14 June, and 28 June, and in 1992 were 12 May, 19 May, 2 June, 16 June, and 30 June. In 1991 1,3-D was applied at planting; in 1992 it was applied 14 days before the first date of planting. The center two rows of each four-row plot were harvested. Seeds were dried to 8% moisture and weights adjusted to a standard 13%.

Data were subjected to analysis of variance using SAS (SAS Institute, Cary, NC). Means were compared using Fisher's LSD.

## RESULTS

*Population densities in soil:* In 1991 and 1992, treatment with 1,3-D resulted in fewer ($P \leq 0.05$) *H. columbus* extracted from soil at 6 weeks after planting and at harvest over all planting dates (Table 1). Planting date did not affect population densities of *H. columbus* in soil, and there was no planting date × sampling time interaction ($P > 0.05$).

Initial nematode population densities (Pi) did not differ among the five planting

TABLE 1. Population densities of *Hoplolaimus columbus* per 100 $cm^3$ of soil from soybean plots treated with 1,3-D or not treated, at planting (Pi), 6 weeks after planting (Pm), and at harvest (Pf), 1991 and 1992.

| Treatment | Number of nematodes | | | |
|---|---|---|---|---|
| | Pi | Pm | Pf | Mean |
| | | 1991 | | |
| 1,3-D | 25 a | 8 a | 18 a | 17 a |
| Untreated | 37 a | 32 b | 68 b | 46 b |
| | | 1992 | | |
| 1,3-D | 3 a | 2 a | 6 a | 4 a |
| Untreated | 18 b | 14 b | 41 b | 26 b |

All data are means of six replications over five planting dates. Within a year, means in a column with a letter in common are not different (LSD = 0.05).

dates in either year ($P > 0.05$). The increase in number of nematodes from planting to 6 weeks after planting (Pm/Pi) and from planting to harvest (Pf/Pi) was not different among the five planting dates in either year ($P > 0.05$) (Table 2).

*Population densities in roots:* In both years, nematicide treatment resulted in fewer *H. columbus* extracted from roots over all planting dates ($P \leq 0.05$) (Table 3). In 1991 and 1992, there were significant nematicide × sampling time interactions with greater reduction resulting from nematicide treatment at 6 weeks after planting than at harvest ($P \leq 0.05$) (Table 3). In both years, numbers of *H. columbus* were lower at harvest than at 6 weeks after planting over all planting dates and for nematicide treatments ($P \leq 0.05$) (Table 3).

*Yield:* There was a significant effect of planting date on yield in 1991, but not in 1992 (Tables 4,5). In 1991, yield from soybean planted on 28 June was lower than that of the other four planting dates ($P \leq 0.05$) (Table 4).

Nematicide treatment resulted in increased soybean seed yield in 1991 and 1992 ($P \leq 0.05$) (Tables 4,5). Percentage yield loss was not different among planting dates in either year ($P > 0.05$) (Tables 4,5).

*Soil temperatures:* In 1991, soil temperatures 15 cm deep at planting on 17 May, 14 June, and 28 June were not different ($P > 0.05$). The temperature at planting was highest on 14 June and lowest on 10 May (Table 4). In 1992, soil temperatures 15 cm deep at planting on 12 May and 19 May were not different ($P > 0.05$). The highest temperature was on 30 June and the lowest on 19 May (Table 5).

## DISCUSSION

The hypothesis of the research reported herein was that *H. columbus*-induced yield loss on soybean would be greater at later

TABLE 2. Initial population density (Pi) of *Hoplolaimus columbus* and ratio between nematodes recovered from soil at 6 weeks after planting (Pm) and at harvest (Pf) in control plots not treated with 1,3-D on five planting dates, 1991 and 1992.

| Planting date[a] | Pi | | Pm/Pi | | Pf/Pi | |
|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1991 | 1992 | 1991 | 1992 |
| 1 | 23 a | 24 a | 2.00 a | 0.40 a | 3.70 a | 1.75 a |
| 2 | 45 a | 22 a | 1.10 a | 1.14 a | 1.70 a | 1.64 a |
| 3 | 33 a | 11 a | 1.00 a | 0.91 a | 1.50 a | 3.18 a |
| 4 | 30 a | 21 a | 0.50 a | 0.81 a | 2.57 a | 1.05 a |
| 5 | 52 a | 14 a | 0.52 a | 0.50 a | 1.00 a | 4.93 a |

All data are means of six replications over five planting dates. Within a year, means in a column with a letter in common are not different (LSD = 0.05).

[a] Planting dates 1991: 1 = 10 May, 2 = 17 May, 3 = 31 May, 4 = 14 June, 5 = 28 June. Planting dates 1992: 1 = 12 May, 2 = 19 May, 3 = 2 June, 4 = 16 June, 5 = 30 June.

TABLE 3. Mean recovery of *Hoplolaimus columbus* per gram dry weight of root from plots treated with 1,3-D or not treated, 1991 and 1992.

| | 1991 | | 1992 | |
|---|---|---|---|---|
| | 6 Weeks after planting | Harvest | 6 Weeks after planting | Harvest |
| Treated | 41 a | 10 a | 43 a | 1 a |
| Untreated | 276 b | 42 a | 205 b | 3 a |
| Mean across treatments | 158 | 26 | 124 | 2 |

All data are means of six replications over five planting dates. Within a year, means in a column with a letter in common are not different (LSD = 0.05).

planting dates. The rationale for this hypothesis was that infection and reproduction of *H. columbus* was greater at 30 °C than at either 20 °C or 25 °C (15). By planting at a series of different planting dates, we hoped to achieve a range of temperatures at planting, but the data suggest that this goal was not realized. The change in soil temperature during the planting season was 1.5 °C and 4 °C for 1991 and 1992, respectively. These relatively narrow ranges in soil temperatures in our experiments were recorded at planting from 8:30 a.m. to 10:00 a.m. Since temperatures were not recorded on days between planting, temperature effects for those days were not reflected in the analysis.

None of the parameters recorded in our tests, which measured the effect of planting date on nematode population dynamics, were consistently different among planting dates in either year. In 1991, the lowest yield, which occurred in untreated plots on the last planting date, was not due to nematode damage since low yield also was observed for nematicide-treated plots. Population densities of *H. columbus* in roots tended to be lower at harvest than at 6 weeks after planting; the opposite was observed for population levels in soil. This confirms the migratory nature of this parasite and indicates that optimum sampling time for roots and soil is different.

Others have indicated that planting date may affect the damage potential of *H. columbus* on soybean (Lewis, pers. comm.; Musen & Maxwell, pers. comm.). Early planting date in Braxton soybean increased yield (7), which may explain the findings of other researchers concerning early-planted soybean.

An early planting date may give the nematode a longer period to reproduce, provided that temperatures are favorable. Population densities of *Pratylenchus brachyurus* on soybean increased more on early-planted soybean than on late-planted soybean (10). Thus, the effect of a low soil temperature on nematode reproduction was offset by the longer growing period of

TABLE 4. Temperature at planting and soybean yield over five planting dates for plots treated with 1,3-D (+) and not treated (−), 1991.

| Planting date | Temperature at planting °C | Yield (kg/ha) | | | Yield loss[a] % |
|---|---|---|---|---|---|
| | | + | − | Mean | |
| 10 May | 25.6 c | 1,482 a | 1,433 a | 1,457 a | 3 a |
| 17 May | 26.8 a | 1,697 a | 1,499 a | 1,598 a | 12 a |
| 31 May | 26.2 b | 1,624 a | 1,395 a | 1,509 a | 14 a |
| 14 June | 27.1 a | 1,620 a | 1,572 a | 1,596 a | 3 a |
| 28 June | 26.7 a | 1,159 b | 840 b | 999 b | 17 a |
| Mean | | 1,515 | 1,348 | | |

All data are means of six replications over five planting dates. Within a year, means in a column with a letter in common are not different (LSD = 0.05).

[a] Percentage yield loss = (Yield of treated plots − yield untreated plots) × 100/yield of untreated plots.

TABLE 5. Temperature at planting and soybean yield over five planting dates for plots treated with 1,3-D (+) and not treated (−), 1992.

| Planting date | Temperature at planting °C | Yield (kg/ha) + | Yield (kg/ha) − | Yield (kg/ha) Mean | Yield loss[a] % |
|---|---|---|---|---|---|
| 12 May | 22.1 d | 1,030 a | 930 a | 980 a | 10 a |
| 19 May | 22.0 d | 1,187 a | 895 a | 1,041 a | 24 a |
| 2 June | 23.4 c | 1,194 a | 767 a | 980 a | 35 a |
| 16 June | 25.0 b | 1,100 a | 930 a | 1,015 a | 15 a |
| 30 June | 26.0 a | 1,157 a | 807 a | 1,082 a | 30 a |
| Mean | | 1,134 | 866 | | |

All data are means of six replications over five planting dates. Within a year, means in a column with a letter in common are not different (LSD = 0.05).

[a] Percentage yield loss = (Yield of treated plots − yield untreated plots) × 100/yield of untreated plots.

early-planted soybean. *Heterodera glycines* populations were lower when soybean was planted late in the growing season, resulting in lower yield loss (19). Early planting dates also resulted in lower crop loss in Alabama (16).

The hypothesis that planting date may affect *H. columbus* parasitism and subsequent crop loss is still valid if it is assumed that massive invasion of a young seedling is more injurious than invasion of an older, more established plant later in the season. However, a longer growing period before flowering may permit enough vegetative growth to mask nematode damage.

Our results are limited by the specific environmental conditions during the experiment. Future experiments with higher Pi of *H. columbus* could provide greater sensitivity for evaluating the effect of planting date on the population dynamics of *H. columbus*. In our experiments, soybean yield was lower than normal in the nematicide-treated plots, indicating that other factors limited soybean yield.

The effect of planting date on reduction of seed yield loss was not consistent. The use of planting dates between early May and late June to manage *H. columbus* on soybean in South Carolina was not effective and should not be recommended.

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