Influence of Planting Date on Damage to Soybean Caused by *Heterodera glycines*[1]

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Abstract: Bragg soybeans were planted in nematicide-treated and nontreated plots on 15 May, 15 June, 1 July, and 15 July in 1980 and 1981 to determine the influence of planting date on damage caused by *H. glycines*. Although earlier studies showed the nematode was sensitive to high soil temperatures (>34 C), late planting did not reduce damage caused by the nematode. Yields from plots treated with 1, 2-dibromo-3-chloropropane (57.5 kg a.i./ha) were 48, 118, 395, and 403% higher than yields from nontreated plots with planting dates of 15 May, 15 June, 1 July, and 15 July, respectively, when data were averaged over the 2 years. Increase in both seed size and number accounted for the yield increases in treated plots. Soil temperatures were highest during July in 1980, averaging 8.9 and 6.5 hours per day above 34 C at 10- and 20-cm depths, respectively. Larvae populations of *H. glycines* were reduced by the nematicide but not by late planting. These results indicate that damage caused by *H. glycines* may actually increase with later planting and that nematicides may be more beneficial when soybeans are planted late in a double-cropped production system. *Key words:* cyst nematode, soil temperature.

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Results of several studies (3,5,6) suggest that *Heterodera glycines* Ichinohe, the soybean cyst nematode, is sensitive to high soil temperatures. In temperature tank studies, few second-stage larvae penetrated and no subsequent maturation occurred when soybean plants were grown at constant temperatures greater than 34 C. Furthermore, exposure of roots to 35 and 38 C for 4–10 days hindered subsequent development of *H. glycines* even when the temperature was reduced to 24 C (5). Males predominated in roots exposed to 35 C for 4 days, and no adults developed in roots exposed to 35 C and 38 C for 10 days or 38 C for 4 days (5). In this study, second-stage larvae degenerated at 38 C. In studies where diurnally fluctuating temperatures were used, all larvae except those developing into males degenerated when roots were exposed to 38 C for 4 hours daily for 3 or 6 days (5). Only 14% of larvae developed into adult females when exposed to 35 C for 5 hours daily for 3 days; female development essentially stopped after similar exposure for 6 days. Emergence of larvae from cysts was also inhibited above 36 C (6).

In the southeastern United States, approximately 35% of the soybean hectarage is double-cropped, usually following small grain. This cropping system requires the second crop be planted during mid-June to early July, from 1 to 5 weeks later than when single-cropped. Soil temperatures are usually high during planting of double-cropped soybeans in Georgia. As high soil temperatures are detrimental to the development of *H. glycines* (3,5,6), damage to soybeans should be reduced and the nematode build-up retarded with late planting dates. However, the limited data available (2) indicate that late planting of soybeans may have little value in reducing damage to soybeans caused by *H. glycines*. In the study, conducted in Tennessee, no data were presented on soil temperature or nematode populations during the growing season.

The objective of this investigation was to determine whether planting date affects growth retardation and yield losses on soybean caused by *H. glycines* and to study nematode populations associated with soybeans planted on different dates.

MATERIALS AND METHODS

The experiment was conducted at the University of Georgia Plant Sciences Farm near Athens, on Cecil sandy loam (69% sand, 12% silt, 19% clay) naturally infested with *H. glycines*. Rye was planted as a winter cover crop in 1980 but not in 1981. The field was fertilized with 3.7 kg/ha of P and 140 kg/ha of K in 1980 and 88 kg/ha of K in 1981. Soil was plowed 25 cm deep on 11 April and 27 March in 1980 and 1981,

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respectively. Trifluralin (aaa-trifluoro-2, 6-dinitro-N, N-diprophyl-p-toluidine, Treflan, 0.56 kg a.i./ha) was applied preplant for weed control.

Treatments were arranged in five randomized complete blocks in a split-plot design with main plots as planting dates and subplots as either the fumigant DBCP (1, 2-dibromo-3-chloropropane) or no nematicide. DBCP was applied at 57.5 kg a.i./ha 20 cm deep 12.5 cm on each side of the row at planting. Each plot consisted of four 5.8-m rows spaced 96.5 cm apart. Soybeans [*Glycine max* (L.) Merr. 'Bragg'] were planted, 33–40 seed/m, on 29 May, 13 June, 2 July, and 15 July in 1980 and 14 May, 15 June, 1 July, and 15 July in 1981. Plots were irrigated with 2.5 cm water when needed and maintained throughout the growing season under recommended cultural practices. Methyomyl (methyl N-[methylcarbomaye] oxythioacelimidate, Lannate) was applied for insect control when required. Soil temperatures were recorded continuously at 10- and 20-cm depths in a fallow area adjacent to the plots with remote recording thermographs during the growing season.

All measurements were taken on the middle two rows of each plot which were end-trimmed at maturity by removing plants 45 cm from each end. The two center rows of each plot (4.88 m in length) were mechanically harvested on 11 November and 20 October in 1980 and 1981, respectively.

Samples for nematode assays were collected from the top 20 cm of soil from the two center rows (ten 2.5-cm cores/row) of each plot prior to each planting date and monthly thereafter. Nematodes were extracted with a combination of elutriation (1) and centrifugal flotation (4). Eggs were extracted from cysts collected on a 60-mesh (250-μm) sieve from 500 cm^3 of soil during elutriation by grinding cysts in 50 ml of tap water in 100-ml polypropylene centrifuge tubes for 1 min at 3,500 rpm with a stainless steel pestle having 1-mm ridges (J. A. Fox, personal communication).

Data were analyzed by analysis of variance for single years and combined over years. Nematode data were transformed [Log_{10} (n+1)] prior to analysis and are presented as antilogs.

RESULTS

Late planting of soybeans did not reduce the severity of disease loss caused by *H. glycines*. Average yields over 2 years of this experiment ranged from 272 kg/ha in nontreated plots planted on 15 July to 1,781 kg/ha for nematicide-treated plots planted 15 June. The most severe nematode damage and lowest yields occurred when soybeans were planted on 1 and 15 July (Fig. 1). Highest yields were obtained from plants in nematicide-treated plots where yields were 11%, 71%, 259%, and 1,427% (in 1980) and 76%, 185%, 599%, and 184% (in 1981) higher than yields from nontreated plots with planting dates of 15 May, 15 June, 1 July, and 15 July, respectively. Yields of plants from nontreated and treated plots usually declined with each successive planting date after 15 June (Fig. 1). The low yield of the 29 May treated plots in 1980 (849 kg/ha) was unexpected.

Plant height and seed weight were also affected by nematode parasitism. Both were

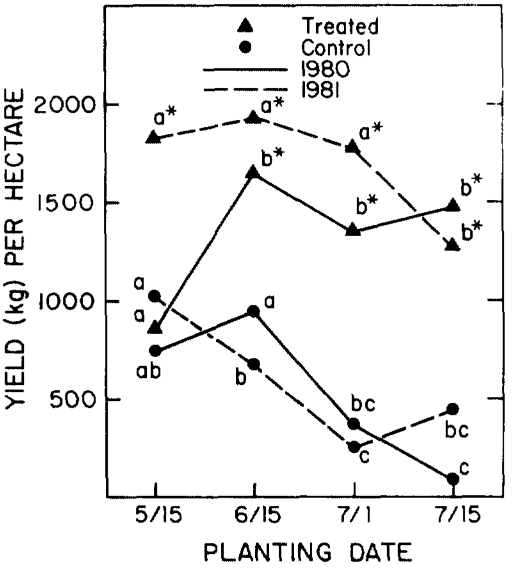

Fig. 1. Influence of planting date and fumigant nematicide on yield of soybeans grown in field plots infested with *Heterodera glycines*. Treated = 1,2-dibromo-3-chloropropane injected at 57.5 kg a.i./ha 20 cm deep 12.5 cm on each side of the row at planting; control = nontreated plots; * = significant difference between treated and nontreated plots within a planting date and year as determined by FLSD ($P = 0.05$). Means within a year followed by the same letter are not significantly different based on FLSD ($P = 0.05$).

generally greater when plants were grown in nematicide-treated plots and decreased with the July planting dates (Table 1). Differences in seed weight between the plants from the nematicide-treated and nontreated plots were greater in 1980 than 1981.

Populations of *H. glycines* were little affected by altering the planting dates. Populations of second-stage larvae in nontreated plots fluctuated more in 1980 than in 1981 (Fig. 2). In 1980, populations for three of the four planting dates initially increased in nontreated plots and declined for two successive sampling dates before increasing. However, the larval populations remained low for the first three sampling dates in 1981 before gradually increasing. Significant differences in nematode populations occurred between nematicide-treated and nontreated plots with the greatest differences being detected in October (Table 2). Second-stage larvae were usually reduced by DBCP at each planting date in both years (Table 2). The larval population in October was approximately four times greater in 1980 than in 1981. Egg densities, however, were higher in 1981 than in 1980 but were affected by DBCP similarly to the second-stage larvae although the egg data were considerably more variable than the larval data.

The number of hours per day that soil temperatures exceeded 34 C was greater in July than any other month during the growing season. Although soil temperatures were recorded continuously during each

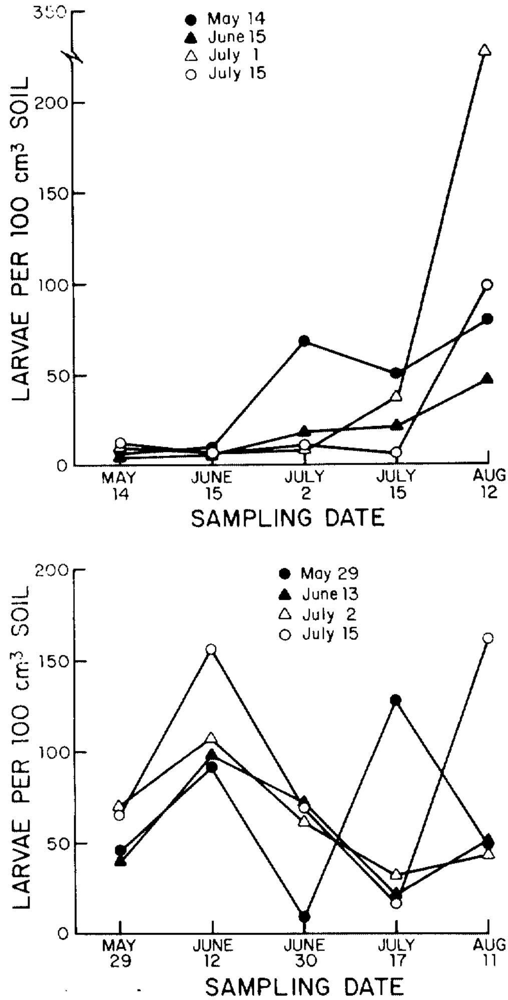

Fig. 2. Influence of planting date on populations of *Heterodera glycines*. Top: 1980. Bottom: 1981.

Table 1. Effect of planting date and nematicide treatment on plant height and seed weight of Bragg soybeans growing in field plots infested with *Heterodera glycines*.

Planting date	Nematicide†	Plant height (cm)		Seed weight (gm/100 seed)	
		1980	1981	1980	1981
15 May	+	69	80	15.8*	14.4
	−	61	73	14.6	14.4
15 June	+	81*	86*	16.3*	14.4*
	−	68	68	15.3	13.2
1 July	+	57*	65*	14.2	12.9
	−	48	51	13.3	12.6
15 July	+	50*	54	13.9*	13.1
	−	37	54	11.9	12.8

†1,2-dibromo-3-chloropropane (57.5 kg a.i./ha) injected 20-cm deep 12.5 cm on each side of the row at planting.

*Significant difference between nematicide-treated and nontreated plots within a planting date as determined by FLSD (P = 0.05).

Table 2. Effect of planting date and nematicide on populations of *Heterodera glycines* on Bragg soybeans.

Planting date	Nematicide†	Eggs‡ (×10³)		Larvae‡	
		1980	1981	1980	1981
15 May	+	8.5abc//	8.5*b	126b	8*b
	—	10.4bc	57.6c	211b	105c
15 June	+	3.7*a	9.5*b	15*a	7*b
	—	15.0c	55.9c	642c	160c
1 July	+	5.9abc	4.9*ab	12*a	6*ab
	—	10.4bc	40.7c	637c	162c
15 July	+	5.5ab	4.3*a	6*a	2*a
	—	11.8bc	47.8c	690c	104c

†1,2-dibromo-3-chloropropane (57.5 kg a.i./ha) injected 20-cm deep 12.5 cm on each side of the row at planting.

‡Eggs per 500 cm³ and larvae per 100 cm³ soil collected 13 October.

//Means followed by the same letter within a column are not significantly different based on an FLSD (P = 0.05) performed on Log_{10} (n + 1) transformed data.

*Significant differences between nematicide treated and nontreated plots within a planting date as determined by FLSD (P = 0.05) performed on Log_{10} (n + 1) transformed data.

growing season, only data from June and July of 1980 are presented (Fig. 3). Temperatures were higher in 1980 than in 1981. During July of 1980, the soil temperature fluctuated greatly at the 10-cm depth, less so at 20-cm, and averaged 8.9 and 6.5 h/day (1981 average was 5.4 and 3 h/day) above 34 C at 10- and 20-cm depths, respectively. The maximum soil temperature during July frequently exceeded 40 C at the 10-cm depth and 35 C at the 20-cm depth. The soil temperature fluctuated more in June than in July and rarely reached 40 C at the 10-cm depth. The cumulative weekly rainfall is presented in Figure 4, but it frequently rained less than 0.5 cm. Plots were irrigated eight times in 1980 and seven times in 1981.

DISCUSSION

Our results from field tests in the Georgia piedmont as well as those of Epps and Chambers (2) in Tennessee suggest that damage to soybean caused by *H. glycines* is not reduced by late planting although the nematode was sensitive to high soil temperatures in greenhouse tests (3,5). Nematode activity apparently was not suppressed by the high temperatures in our tests since damage actually increased with later planting and larval populations did not decline as would be expected. The mean daily maximum temperature in July of 1980 in Georgia was 4 C higher than the mean for a 32-year period. If temperature failed to retard *H. glycines* in 1980, it is unlikely to do so in other years when temperatures are likely to be lower. However, the above-average temperatures and below-normal rainfall in 1980 and 1981 may have caused unusual stress on the soybean plants, accentuating damage caused by *H. glycines.* Although plots were irrigated frequently, the unusually high temperatures probably created moisture stress on plants and may have affected nematode activities. We do not know how the moisture stress situation influenced *H. glycines* in our tests, but soil moisture altered certain activities of the nematode in other studies (6,7). In 1982, when rainfall was above normal, populations of *H. glycines* were lower in our field plots than in 1980-81 (authors, unpublished).

Most of the greenhouse studies that demonstrated sensitivity of *H. glycines* to high temperature were conducted at constant soil temperatures (3,5). Our soil temperature data show that there is considerable diurnal fluctuations in field soil temperature, especially at a 10-cm depth, indicating the difficulty in relating results of controlled soil temperature experiments to field situations. In the only greenhouse study conducted with diurnally fluctuating soil temperature, Ross (5) reported that 35 or 38 C for 4 and 8 hours per day for 3 or 6 days drastically suppressed the devel-

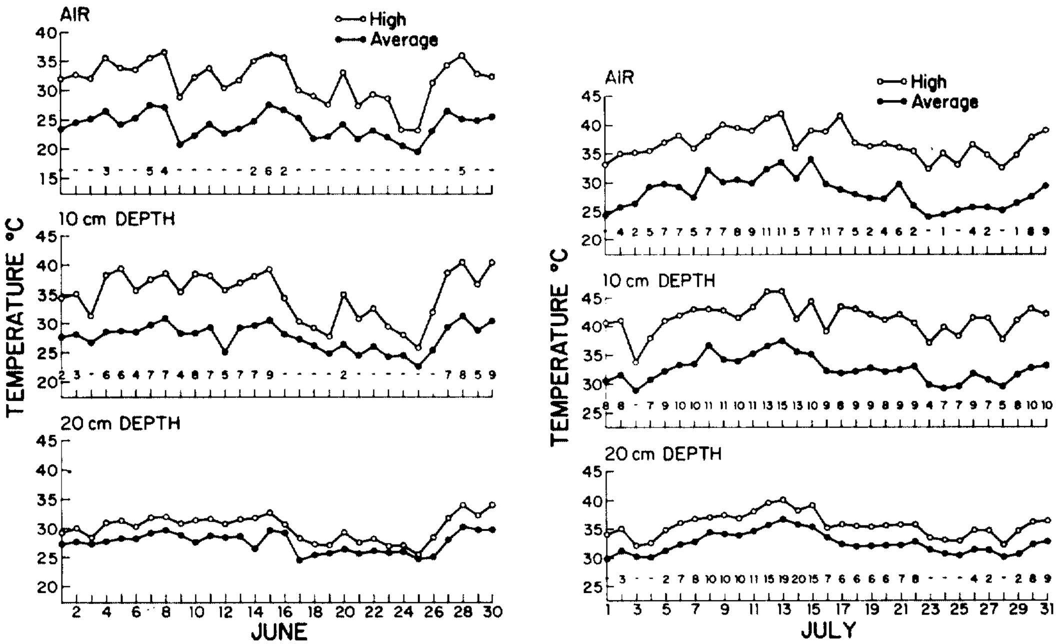

Fig. 3. Daily maximum and mean air and soil temperatures at 10- and 20-cm depths in June and July 1980. The number of hours per day that temperatures were > 34 C are presented.

opment of second-stage larvae of *H. glycines* into females. Long exposures to these diurnal high temperatures were more detrimental than short exposures of equal total duration, suggesting that widely fluctuating soil temperatures would have little effect on nematode development. The soil temperature in July in our study often greatly exceeded (degrees and hours duration) the temperature that retarded *H. glycines* de-

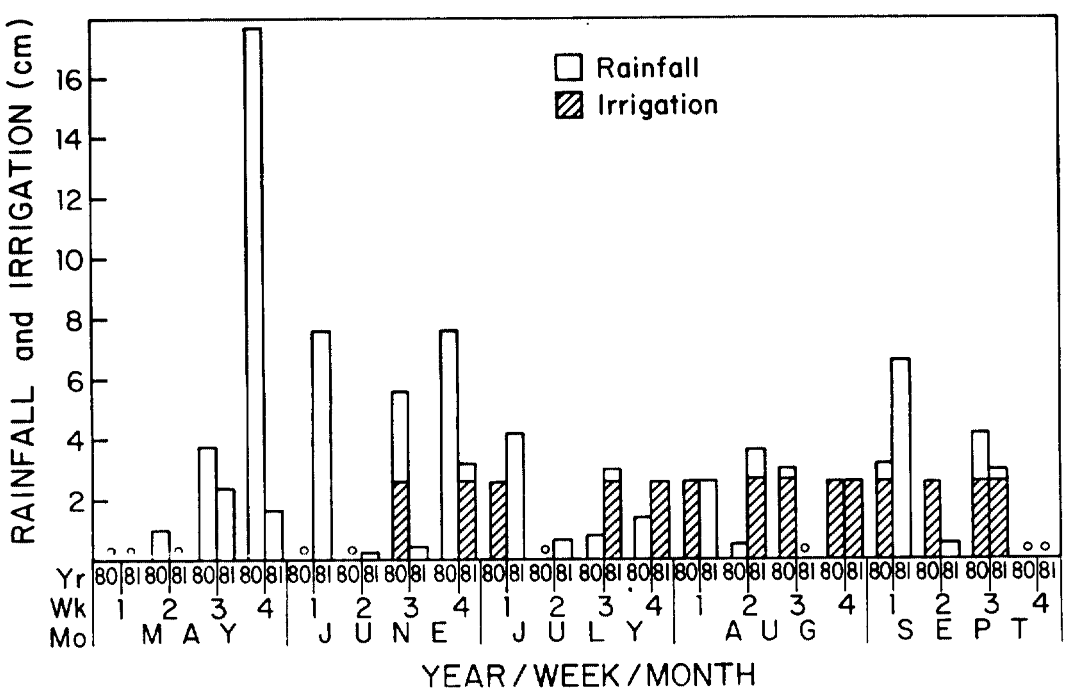

Fig. 4. Cumulative weekly rainfall and irrigation water during the 1980 and 1981 growing season.

velopment in earlier work (5) without any significant effect on the total nematode population. Although soil temperatures were recorded under a fallow condition in our study, plant canopy should not significantly alter the soil temperature until 3 weeks or later after planting. This should be sufficient time to retard the development of *H. glycines* and reduce the nematode damage to soybean.

Future studies on the influence of environmental factors on nematode development and resulting crop damage should be conducted under field conditions, as has been done for *H. schachtii* (8), where interdependent physical factors are continually fluctuating. The soil temperatures observed in our study were apparently not sufficiently high for a long enough duration to affect *H. glycines,* and the minimum temperatures were close to the optimum temperatures for hatch, larvae emergence from cyst, and root penetration. Our study does indicate, however, that nematicides may actually be more beneficial when soybeans are planted late in the season.

The decrease in yield of Bragg soybean with the later planting dates indicates the optimum planting date for this cultivar in the Georgia piedmont is in mid-May to early June, as is presently recommended. The low yield in 1980 of the plants from the 15 May treated plots may have been due to the poor efficacy of the nematicide. Larvae and egg counts for the nontreated and treated plots for this planting date were similar.

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