SEASONAL POPULATION DENSITIES OF *HOPLOLAIMUS* COLUMBUS AND THEIR IMPACT ON SOYBEAN YIELD [1]

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ABSTRACT

Pérez E. E., J. D. Mueller, and S. A. Lewis. 2003. Population fluctuations of *Hoplolaimus columbus* throughout the soybean growing season. Nematropica 33:197-207.

During the 1991 and 1992 soybean growing seasons an experiment was conducted near Blackville, South Carolina to study the seasonal population fluctuations of *Hoplolaimus columbus* in soil and roots and their relationship to seed yield of soybean. The soybean 'Braxton', susceptible and intolerant to *H. columbus*, was planted in a field naturally infested with *H. columbus* on 17 May 1991 and 19 May 1992. Nematodes were recovered from soil samples at planting and from soil and root samples at various times during the soybean growing season and at harvest. Nematode/g dry weight of root was highest on early sample dates. Nematode numbers from soil increased over the growing season, with highest numbers from 16- to 20-weeks after planting. *Hoplolaimus columbus* juvenile recovery from soil increased through the growing season and was generally higher than adult recovery. Recovery of *H. columbus* adults from soil or roots remained fairly constant throughout the growing season. Soil population densities were consistently associated with seed yield during the 1991 season and at some dates during the 1992 season, whereas nematode densities in the roots were not associated with yield in either season. In both seasons at 16-weeks after planting, total (adults + juveniles) *H. columbus*/100 cm^3 of soil were significantly ($P \leq 0.05$) correlated with soybean seed yield.

Key words: ecology, *Glycine max*, *Hoplolaimus columbus*, Columbia lance nematode, population dynamics, sampling techniques, soybean.

RESUMEN

Pérez E. E., J. D. Mueller, y S. A. Lewis. 2003. Fluctuaciones poblacionales de *Hoplolaimus columbus* durante la estación de crecimiento de la soja. Nematrópica 33:197-207.

En los años 1991 y 1992 durante las estaciones de crecimiento de soja, se condujo un experimento cerca de Blackville en Carolina del Sur, para estudiar las variación estacional de las poblaciones de *Hoplolaimus columbus* recuperadas de muestras de suelos o extraídas de muestras de raíces y su relación con el rendimiento de semilla de soja. La variedad de soja 'Barxton', susceptible e intolerante a *H. columbus*, fue sembrada el 17 de mayo en 1991 y el 19 de mayo en 1992 en un campo naturalmente infestado con *H. columbus*. Los nematodos fueron extraídos de muestras de suelo al momento de la siembra de soja, y de muestras de suelo y raíces, a distintos intervalos durante el período de crecimeinto de la soja y en cosecha. La cantidad de nematodos/gr. de peso seco raíz fue máximo en las muestras tempranas y decreció durante el período de crecimiento de soja. La cantidad de nematodos extraídos de muestras de suelo incrementó durante el período de crecimiento de soja, con un máximo en muestras tomadas entre las 16 y 20 semanas después de la siembra. La cantidad de *H. columbus* juveniles extraídos de las muestras de suelo o raíces fue siempre mayor que la cantidad de adultos. La cantidad de *H. columbus* adultos extraídos de las muestras de suelo o raíces permaneció relativamente constante durante la estación de crecimiento. La cantidad de nematodos recuperados de las muestras de suelo en diversas fechas durante el año 1991 y en algunas fechas en el año 1992 estuvo asociada con el rendimiento a semilla, sin embargo la cantidad de nematodos extraídos de las muestras de raíces, no estuvo asociada. En las dos estaciones, los coeficientes de correlación entre los números de nematodos en muestras de suelos tomadas 16 semanas después de la siembra y el rendimiento semilla fueron significativos ($P \leq 0.05$).

Palabras claves: dinámica de población, ecología, *Glycine max*, *Hoplolaimus columbus*, nematode de la lanza, soja, técnicas de muestreo.

INTRODUCTION

The Columbia lance nematode, *Hoplolaimus columbus* Sher, is an important pathogen of soybean and cotton in the middle and upper coastal plains of South Carolina. Surveys have detected *H. columbus* in 14% of the soybean and 61% of the cotton hectarages sampled in South Carolina (Lewis *et al.*, 1993; Martin *et al.*, 1994). In soybean, yield loss is due to root necrosis in the parenchyma and endodermal-vascular region caused by endo- and ectoparasitic feeding of *H. columbus* (Lewis *et al.*, 1976; Smith, 1969). Soybean yield losses caused by *H. columbus* feeding can be so severe that crop harvest may not be economical (Fassuliotis *et al.*, 1968; Schmitt and Imbriani, 1987). Management practices to reduce *H. columbus* damage to soybean are limited due to its wide host range, high nematicide costs on a low unit value crop, and the lack of resistant cultivars (Fassuliotis, 1974; Lewis and Smith, 1976; Mueller *et al.*, 1988; Mueller and Sanders, 1987).

Because nematode population densities fluctuate within a growing season, sample collection should be timed according to the purpose of the nematode assay and the population dynamics of the target species (Barker, 1985; Barker *et al.*, 1985; McSorley, 1987). Population dynamics studies convey the numbers and age class distribution of a population through time under certain environmental conditions (Ferris and Wilson, 1987). Information from population dynamics studies, such as the time of maximum nematode population density in a growing season, is important to decide timing of sample collection for nematode assay. For example, samples for evaluations of nematicide and resistant cultivars should be taken when the populations of non-treated, susceptible plants are near maximum, but before the effects of the management tactics have been depleted (Barker, 1985). Also, knowledge of population density changes over time can be used to create models that predict nematode population densities in similar situations. Population fluctuation studies of *H. columbus* on soybean should provide data that can be used to optimize sampling and use this information to improve management strategies.

A defined relationship between crop yield and population densities of plant-parasitic nematodes may aid in management decisions (Seinhorst, 1965). Nematode population densities at planting or at other times during the growing season were negatively correlated with crop yield (Barker and Nusbaum, 1971; Mashela *et al.*, 1991). Consequently, knowledge of root or soil sample dates with a high association between *H. columbus* densities and soybean seed yield could be useful for the development of reliable damage functions. Field studies on *H. columbus* population density changes during the soybean growing season and its association with seed yield are limited. Most studies quantify *H. columbus* population densities extracted only from soil samples taken at most three times during the soybean growing season (Appel and Lewis, 1984; Noe, 1993; Noe *et al.*, 1991). Because *H. columbus* is an endo- and ecto-parasite in soybean, *H. columbus* numbers recovered from soil or roots at different times of the soybean growing season may show different patterns, and exhibit different association levels with seed yield. Therefore, the objectives of this research were primarily to determine life stage densities of *H. columbus* recovered from soil or roots during the soybean growing season, and secondarily to correlate nematode life stage densities to soybean yield to determine if nematode numbers show any relationship to yield.

MATERIALS AND METHODS

During 1991 and 1992 soil and soybean-root samples were collected from 16 plots at various times during the soybean growing season to study the population dynamics of different life stages of *H. columbus*. Numbers of *H. columbus* life stages recovered from soil or soybean-root samples in both seasons at each sampling date were correlated with soybean yield to determine the association between nematode numbers and soybean yield. In 1992 only, an additional 500-cm^3 soil sample was collected from each plot and sampling date to separate the root fraction from the soil fraction. Within each sample, numbers of *H. columbus* adults, juveniles, and total (adults + juveniles) nematodes extracted from the soil fraction were compared to those extracted from the root fraction.

On 17 May 1991, soybean plots were established at the Edisto Research and Education Center, Blackville, South Carolina, in a Dothan sandy loam soil (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 soybean 'Braxton' was used which is susceptible and intolerant to *H. columbus* (Garner *et al.*, 1987). Sixteen plots were established and sampled through time during the soybean growing season. Each plot consisted of six rows 16-m long on 0.96-m centers. All plots were subsoiled in-furrow approximately 36-cm deep at planting. Weed control consisted of a broadcast application of 1.75 liters a.i./ha of trifluralin 44.5% and a mixture of 0.31 kg a.i./ha of metribuzin + 0.052 Kg. a.i./ha of 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 used several times after planting to prevent deer damage.

Nematode populations in soil and roots were estimated using two different techniques. Soil samples consisting of 15 to 20 cores (2.5-cm diam. × 20-cm deep) were taken from the two center rows. For each plot, soil samples were taken as follows: at planting (17 May), 2-, 3-, 4-, 6-, 8-, 12-, 16-, and 20-weeks after planting, and at harvest (2 November, 24-weeks after planting). The 15-20 cores were mixed manually and a 250-cm^3 subsample was collected. The subsamples were wet-sieved through 850-µm and 28-µm pore sieves. The material retained by the 28-µm pore sieve was processed by the centrifugal-flotation technique (Jenkins, 1964). The extracted nematodes were dispersed in water in a gridded counting dish. *Hoplolaimus columbus* adults and juveniles were recorded separately. All nematode counts from soil were reported per 100 cm^3 of soil. Root samples consisted of 10 soybean root systems randomly taken from each plot from the 2nd and 5th rows. With the exception of the sample date at planting, root samples were taken on the same dates as soil samples. The 10 soybean roots were cut into ca. 2-cm long pieces and *H. columbus* was extracted from ca. 15 g of fresh root using a modified mist apparatus (Barker *et al.*, 1986). After five days in the mist apparatus, nematodes were collected and counted. *Hoplolaimus columbus* adults and juveniles were enumerated separately. Nematode counts were reported as number/g of fresh or dry root weight. Dry root weights were determined after drying roots for 72 hours in an oven at 80°C.

On 19 May 1992, soybean plots were established in the same site and the experiments were conducted following the protocol of 1991. Soil samples were taken as follows: at planting (19 May), 2-, 3-, 4-, 6-, 8-, 12-, and 16-weeks after planting, and at harvest (1 December, 28-weeks after planting). For each sample date in both seasons, simple linear correlation coefficients were calculated (SAS Institute, Cary, NC) between numbers of *H. columbus* juveniles, adults, or total (adults + juveniles), recovered either from the soil or extracted from roots, and soybean seed yield. Reproductive indexes Pf/Pi (Pf = final nematode population and Pi = initial nematode population) (Oöstenbrink, 1966), were calculated for *H. columbus* population densities in the soil.

In the 1992 season only, an additional 500-cm^3 soil sample was taken from each of the 16 plots at each sample date. Samples were taken at random from the two middle rows within two inches of the soybean plant. From these 500-cm^3 soil samples, roots were separated from the soil using a 850-µm sieve. *Hoplolaimus columbus* was extracted from the root fraction using a modified mist apparatus and from the soil fraction by centrifugal flotation (Barker *et al.*, 1986; Jenkins, 1964). *Hoplolaimus columbus* numbers recovered from the soil fraction were added to *H. columbus* numbers extracted from the root fraction to calculate the total number of *Hoplolaimus columbus* in a 500-cm^3 soil sample. Nematode counts were reported per 100 cm^3 of soil. The percentages of *H. columbus* juveniles, adults, and total (adults + juveniles) extracted from the soil and root fractions were compared using a paired *t* test.

RESULTS

Extraction from roots:

Total nematode density (adults + juveniles) from roots expressed as number/g dry root weight was highest at 2-weeks after planting in the 1991 season and at 6-weeks after planting in the 1992 season (Fig. 1A,B). Juveniles accounted for 75 to 80% of the total number of *H. columbus* collected 2- to 3-weeks after planting and for more than 90% at the remaining sample dates in both seasons (Fig. 1A,B). Recovery of adult *H. columbus*/g root dry weight was highest between 2- to 4-weeks after planting and stayed between 0 and 50 *H. columbus*/g root dry weight for the remaining sample dates in both seasons (Fig. 1A,B). Nematode density from roots expressed as number of *H. columbus*/g root fresh weight (data not shown) showed a similar pattern to that of *H. columbus*/g root dry weight.

Nematode densities in the soil: Total nematode density (adults + juveniles) was highest at 20- and at 16-weeks after planting in the 1991 and 1992 seasons, respectively (Fig. 1C,D). With the exception of 4-weeks after planting in the 1992 season, juvenile numbers accounted for at least 50% of the total population at all sample dates (Fig. 1C,D). Adult densities remained between 10 and 38 nematodes/100 cm^3 of soil on all sample dates in both seasons. Total density increased over the growing season with Pf/Pi values of 2.2 and 1.8 for the 1991 and 1992 seasons, respectively. In both seasons, there was a positive linear relationship

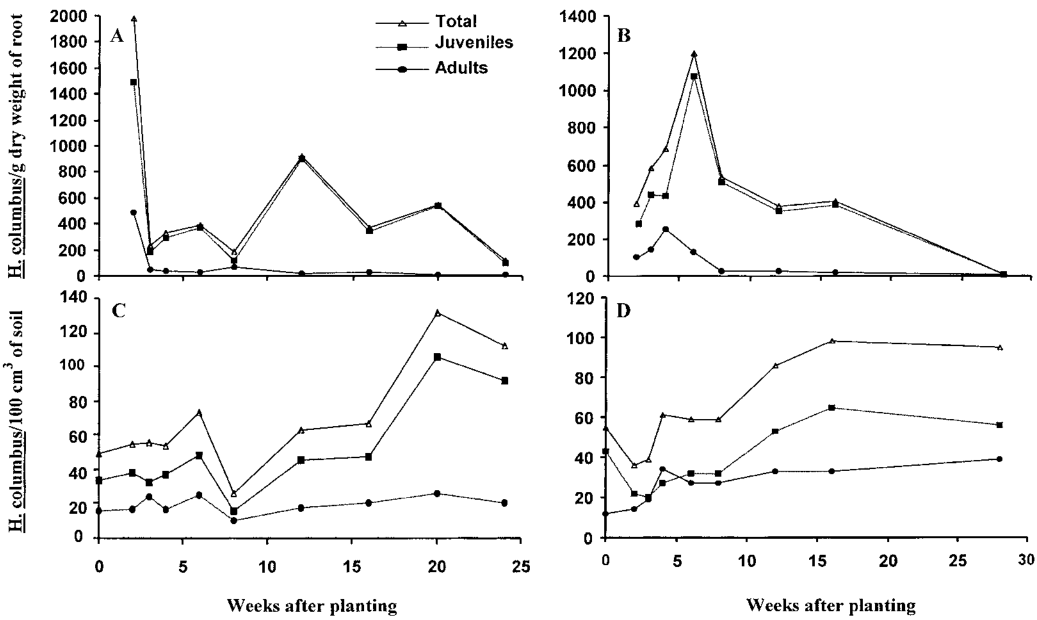

Fig. 1. Number of *Hoplolaimus columbus* adults, juveniles, or total (adults + juveniles) recovered from soil or extracted from soybean roots at different sample dates. A) Number of *H. columbus* extracted from roots, 1991 season. B) Number of *H. columbus* extracted from roots, 1992 season. C) Number of *H. columbus* recovered from soil, 1991 season. D) Number of *H. columbus* recovered from soil, 1992 season.

($P \leq 0.05$) between total (adults + juveniles) *H. columbus*/100 cm^3 of soil (y) and weeks after planting (x) (1991, $\hat{Y} = 2.9x + 40.8$, $r^2 = 0.60$; 1992, $\hat{Y} = 2.3x + 46.1$, $r^2 = 0.72$). The slopes of the regression equations from the 1991 and 1992 seasons were not significantly different ($P > 0.05$). The regression equation for the combined data from the 1991 and 1992 seasons was $\hat{Y} = 2.60x + 43.13$ ($r^2 = 0.63$, $P \leq 0.05$) (Fig. 2). Thus, there was an increase of 2.6 *H. columbus*/100 cm^3 of soil per week after planting.

Association between H. columbus densities and soybean yield:

At all sample dates in both seasons, correlation coefficients were low ($P > 0.05$) between nematode numbers/g dry root weight and soybean seed yield (data not shown). At several dates in the 1991 and at some dates in the 1992 season, there was a negative linear association ($P \leq 0.05$) between *H. columbus* recovered from the soil and seed yield (Table 1). Yield losses ranged from 0 to 34% and from 0 to 54% in the 1991 and 1992 seasons, respectively. In both seasons, there was a negative linear relationship ($P \leq 0.05$) between soybean yield (y) and total (adults + juveniles) *H. columbus*/100 cm^3 of soil recovered 16-weeks after planting (x) (1991, $\hat{Y} = -2.8x + 1688$, $r^2 = 0.51$; 1992, $\hat{Y} = -2.6x + 1187$, $r^2 = 0.56$). The slopes of the regression equations from the 1991 and 1992 seasons were not significantly different ($P > 0.05$). The regression equation for the combined data from the 1991 and 1992 seasons was $\hat{Y} = -3.8x + 1533$ ($r^2 = 0.49$; $P \leq 0.05$) (Fig. 3). Thus, for each *H. columbus* recovered/100 cm^3 of soil 16-weeks after planting there could be a predicted soybean yield loss of 3.8 Kg/ha.

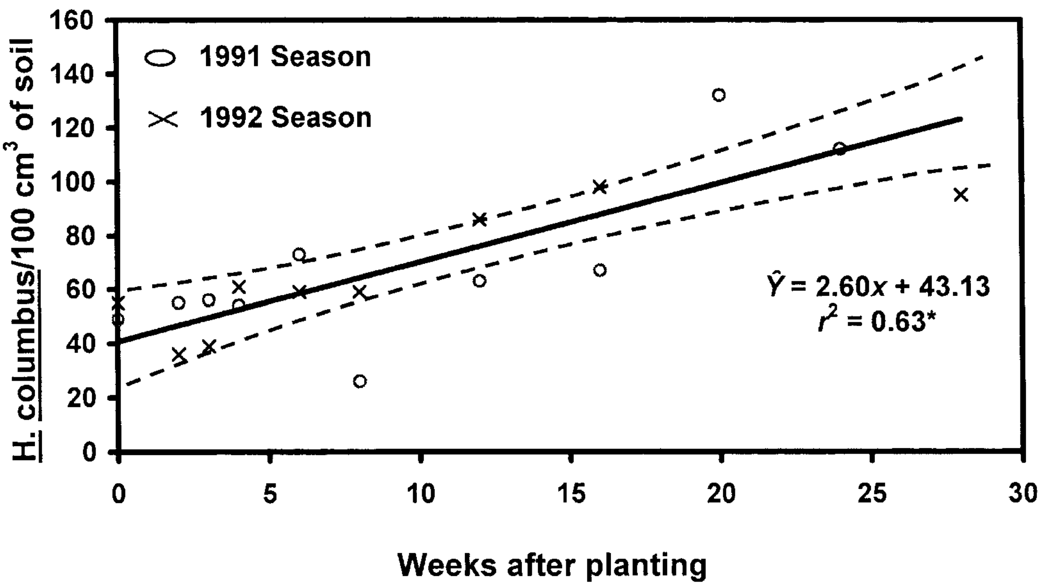

Fig. 2. Relationship between number of *Hoplolaimus columbus*/100 cm^3 of soil extracted and weeks after planting. Combined regression of data from seasons 1991 and 1992. Dotted lines represent upper and lower 95% confidence limits. *Significant at $P \leq 0.05$.

Percent recovery of Hoplolaimus columbus from soil and root fractions within a sample, 1992 season:

With the exception of 12-weeks after planting, the percentage of *H. columbus* adult recovery was higher ($P \leq 0.05$) or equal ($P > 0.05$) in the soil fraction than in the root fraction (Table 2). At planting and at harvest adults were recovered only from the soil fraction (Table 2). With the exception of 6-weeks after planting, percentage of *H. columbus* juvenile recovery was higher ($P \leq 0.05$) or equal ($P > 0.05$) in the soil fraction than in the root fraction (Table 2). At all sample dates, total percentage of *H. columbus* recovery (adults + juveniles) was higher ($P \leq 0.05$) or equal ($P > 0.05$) in the soil fraction than in the root fraction (Table 2).

DISCUSSION

Numbers of *Hoplolaimus columbus* extracted from the soil increased in both growing seasons, which confirms that soybean is a suitable host. Numbers of nematodes extracted from soil increased approximately every 6 weeks, which may coincide with the life cycle duration of *H. columbus* in field-grown soybean. This finding agrees with a 45- to 49-days life cycle length reported previously for *H. columbus* (Smith, 1969). The finding of maximum nematode numbers recovered from the soil between 16- and 20-weeks after planting is similar to previous work (Bird *et al.*, 1974). Maximum population densities in the soil between 16- and 20-weeks after planting may suggest a third complete life cycle of *H. columbus* during the soybean growing season. Nematode numbers/g dry root weight did not follow the same pattern as nematode numbers extracted from soil samples in either season. Nematode recovery from soybean root samples was much lower in the mid to late season samples than in the very early season samples.

Table 1. Linear correlation coefficients between number of Hop*lolaimus columbus*/100 cm^3 of soil and soybean seed yield, 1991 and 1992 seasons.

	1991			1992		
Weeks after planting	Adults (A)	Juveniles (J)	Total (A + J)	Adults (A)	Juveniles (J)	Total (A + J)
0	-0.48*	-0.38	-0.50*	-0.10	-0.01	-0.05
2	-0.27	-0.58*	-0.51*	-0.41	-0.15	-0.29
3	-0.53*	-0.64**	-0.61**	-0.08	-0.33	-0.13
4	-0.48	-0.55*	-0.59**	-0.28	-0.23	-0.29
6	-0.23	-0.56*	-0.54*	-0.15	-0.08	-0.12
8	-0.05	-0.34	-0.24	-0.35	-0.05	-0.30
12	-0.59*	-0.53*	-0.57**	-0.01	-0.50*	-0.41
16	-0.08	-0.55*	-0.51*	-0.69**	-0.31	-0.56*
20	-0.57*	-0.61**	-0.65**	—	—	—
24	-0.33	-0.29	-0.32	—	—	—
28	—	—	—	-0.51*	-0.54*	-0.55*

*Significant at $P \leq 0.05$, n = 16.
**Significant at $P \leq 0.01$, n = 16.

The decrease in nematode population density/g dry root weight could be due to a dilution effect caused by root weight increasing at a disproportionately higher rate than nematode numbers. Another reason could be a nematode response to a decline in root biomass in the fall, which is probably a result of carbohydrate allocation toward stems and leaves as the soybeans approach maturity.

Juvenile numbers in the soil or in roots were consistently higher than adult numbers in both seasons. Adult population densities remained constant even after increases of the total population in both seasons. Nyczepir and Lewis (1979) also found higher numbers of juveniles than adults inside 'Forrest' soybean roots, and reported that the juvenile soil population increased with increasing temperatures while the adult population did not. However, in the same study they reported that in the soil the majority of *H. columbus* were adults. Soil temperature, Pi, and soybean cultivar may affect the number of *H. columbus* adults in the soil and explain the difference in findings between our study and that of Nyczepir and Lewis (1979). Juveniles accounted for more than 75% of the total nematode population recovered from the roots in both seasons. Eggs of *H. columbus* are deposited in cortical areas and adjacent to the epidermis (Lewis *et al.*, 1976; Smith, 1969). Some adults penetrate the roots only to feed and lay eggs, and then depart (Smith, 1969). This is evidence that all life stages of *H. columbus* can be found inside soybean roots. A report indicated that *H. columbus* behaved mainly as an endoparasite in 'Hampton 266A' soybean, whereas an endo- and ectoparasitic behavior was observed on 'Braxton' soybean (Lewis *et al.*, 1976; Supramana *et al.*, 2001). The parasitic behavior of *H. columbus* on soybeans may be variable and affected by soybean cultivar and environ-

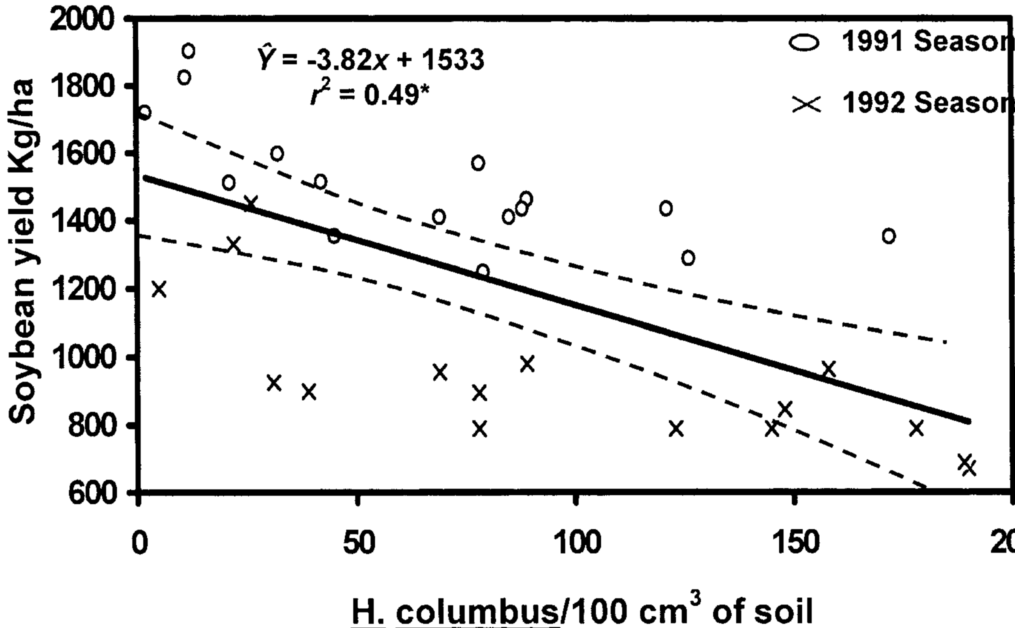

Fig. 3. Relationship between Kg/ha of soybean yield and number of *Hoplolaimus columbus*/100 cm^3 of soil extracted 16-weeks after planting. Combined regression of data from seasons 1991 and 1992. Dotted lines represent upper and lower 95% confidence limits. *Significant at $P \leq 0.05$.

mental factors. A majority of *H. columbus* juveniles in soil and root samples throughout the soybean growing season is an indication of a stable age distribution in root and soil environments. Stable age distributions are approached by any population in a steady environment, regardless of whether the population is increasing in size, decreasing, or holding steady (Wilson and Bossert, 1971).

Negative correlations at all sample dates in the 1991 season and at the late sample dates in the 1992 season between *H. columbus* soil population densities and seed yield, indicated that lower seed yield may be associated with increasing nematode recovery at any sample date. Our finding confirms previous reports of poor soybean growth associated with *H. columbus* infested soil and the need to manage this pathogen in order to achieve maximum soybean yields (Appel and Lewis, 1984; Fassuliotis *et al.*, 1968). *Hoplolaimus columbus* numbers extracted from soybean roots were not associated with seed yield in either year. According to the sampling methodology we used, soil population density estimates of *H. columbus* would be preferable to population density estimates from soybean roots to predict yield loss associated with *H. columbus* damage. The lack of association between density population estimates from soybean root samples and seed yield may be due to sampling error. Numerous fine roots that may harbor significant numbers of *H. columbus* were lost when digging the roots out of the soil in field plots. Also, the entire root mass of two-week old plants is probably suitable for nematode feeding. In contrast, most of the root mass of older plants may not be suitable for nematode feeding. Nematode counts from soybean-root samples may show a good association with yield loss if

Table 2. Percentage of *Hoplolaimus columbus* adults, juveniles, or total (adults + juveniles), recovered from the soil fraction (SF) versus the root fraction (RF) of 500-cm^3 soil samples taken at different weeks after soybean planting, 1992 season.

	Adults (A)		Juveniles (J)		Total (A + J)	
Weeks after planting	SF	RF	SF	RF	SF	RF
[a]0	100*	0	82*	18	86*	14
2	53	47	84*	16	68*	32
3	75*	25	58	42	66*	34
4	73*	27	54	46	62	38
6	64	36	31	69*	42	58
8	97*	7	96*	4	94*	6
12	25	75*	78*	22	72*	28
16	89*	11	78*	22	83*	17
28	100*	0	48	52	72*	28

[a]At planting the root fraction was composed from weed and crop roots from the previous season.
*Indicates significant difference between percentage of nematodes recovered from the SF and percentage of nematodes extracted from the RF, according to a *t* test ($P \leq 0.05$). The asterisk is associated with the higher mean. Data are averages from 16 replicates.

we sample only the root fractions that contain nematodes.

Hoplolaimus columbus densities 16 weeks after planting accounted for 49% of the variation in yield. Other variables besides *H. columbus* reduced yield in our experiments. However, *H. columbus* densities 16 weeks after planting were possibly the single most important factor limiting soybean yield. The yield suppression function indicated a maximum soybean yield loss of 53% over a range of 2 to 190 *H. columbus*/cm^3 extracted from soil 16-weeks after planting. Estimates of yield losses in our study were within ranges previously reported for *H. columbus* on ‘Braxton’ soybean and other varieties susceptible to *H. columbus* (Appel and Lewis, 1984; Lewis *et al.*, 1976; Mueller and Sanders, 1987; Noe, 1993; Schmitt and Imbriani, 1987). The damage function indicated that a population of 80 *H. columbus*/100 cm^3 of soil 16-weeks after planting resulted in a 20% yield reduction. The *H. columbus* soil population increase function indicated an increase of 2.8 *H. columbus* per week. This information combined with the damage function, indicated that a population at planting > 43 *H. columbus*/100 cm^3 of soil would cause at least a 20% yield reduction. This finding is similar to a report of 50 *H. columbus*/100 cm^3 of soil causing a 20% yield reduction on ‘Davis’ soybean (Appel and Lewis, 1984). It should be recognized that the estimates derived from our regression models posses an error due to statistical variation. The yield loss and population density estimates were obtained using a representative value from a likely range shown by the 95% confidence limit lines.

When a single 500-cm^3-soil sample was divided into soil and root fractions, more than 50% of *H. columbus* numbers were extracted from the soil fraction. Davis and Noe (2000) also reported a majority *H. columbus* numbers extracted from the soil fraction of soil samples in cotton fields. Nematode extraction from the soil and root fractions of samples taken at planting in the 1992 season revealed that *H. columbus* adults were recovered only from the soil fractions and juveniles in both the soil and root fractions. This may be an indication that *H. columbus* overwinters as an adult only in the soil and as a juvenile in both soil and roots. Most of the live root fractions from soil samples at planting were probably from weeds and could be an important reservoir of *H. columbus* (Fassuliotis, 1974; Högger and Bird, 1976; Lewis and Smith, 1976).

The current study provides important background data on the seasonal population dynamics cycle and age structure of *H. columbus* in soybean, which is a necessity for sampling and crop loss studies. Based on the findings of this study, soil samples for evaluations of control methods should be taken when *H. columbus* populations are at their highest during the fall months. Nematode damage functions using nematode counts from samples taken 16-weeks after soybean planting could be useful to predict the potential for exceeding damage thresholds of *H. columbus* on 'Braxon' soybean and maybe other cultivars. Although the late season damage functions are not useful to implement control measures for the current crop, they may lead to the development of improved management decision tools.

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