Population Densities of Plant-Parasitic Nematodes in Multiple-Cropping and Tillage Systems

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Abstract

Hairy vetch *(Vicia sativa* L.) succeeded by corn *(Zea mays* L.) or grain sorghum *(Sorghum bicolor* L. Moench) were seeded in split plots randomized within whole plots of no-tillage versus conventional tillage over four growing seasons (1980-83). The vetch-corn cropping system increased the density of *Meloidogyne incognita* 2.9 X more than the vetch-grain sorghum cropping system. In contrast, the vetch-grain sorghum cropping system increased density of *Criconemella ornata* 0.7 X more than the vetch-corn cropping system. *Meloidogyne incognita* and *C. ornata* were affected more by these cropping systems than were *Pratylenchus hrachyurus* or *Paratrichordorus minor*. Multiple cropping systems, and crop host preference affected nematode population densities, whereas tillage treatments, conventional or no-tillage, had little effect on them.

Introduction

Minimum tillage and multiple cropping systems are being adopted rapidly by agriculturists in the southeastern United States (Gallaher, 1980), but few reports exist on their effects on population densities of plant-parasitic nematodes (Stinner and Crossley, 1982; Johnson, 1985). Yet, considerable progress was made during the past 20 years in characterizing the relationships between nematode densities and plant growth and yield in conventional agricultural systems (Barker and Olthof, 1976).

Population densities of *Meloidogyne incognita* and *Paratrichodorus christie* were not affected by tillage methods in field corn *(Zea mays* L.), (Fortnum and Karlen, 1985). Control of *M. incognita* in minimum tilled soybean *(Glycines mar* L. Merrill) was similar to that obtained in conventional tilled soybean (Minton and Parker, 1987). Greater population densities of *Pratylenchus scribneri* were reported in conventional tilled soybean than in no-tilled (Alby et al., 1983). Of seven tillage regimes tested, the greatest numbers of nematodes usually occurred in no-tilled ridge plots, and the lowest numbers generally occurred in spring-fall-plowed plots (Thomas, 1978). Our objective was to determine the effect of long-term double cropping and tillage systems on the population dynamics of plant-parasitic nematodes.

Materials and Methods

Hairy vetch *(Vicia sativa* L.) succeeded by corn and grain sorghum *(Sorghum bicolor* L. Moench) was grown in split plots randomized within whole plots no-tillage versus conventional tillage over five growing seasons (1979-83). Treatments with and without subsoiling were included in both tillage systems and were replicated four times. Each split plot was 25 ft. long and 45 ft. wide. From 1979 to 1981 the cropping systems included vetch succeeded by corn or by grain sorghum. Crops included hairy vetch, 'DeKalb XL71' corn and 'DeKalb BR64' sorghum. In 1982 and 1983 plots planted previously to corn or sorghum were split between corn and sorghum.

The soil was an Arredondo loamy sand (89% sand, 6% silt, 5% clay, 1.1% organic matter; pH 6.2; loamy siliceous,

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hyperthermic, Grossarenic Paleudult). Each fall the plots were harrowed three times and 30 lb. A^{-1} of hairy vetch was drill planted in rows spaced 7 inches apart. The vetch was topdressed with 20-16-85-4-2 lb. A^{-1} of N-P-K-Mg-S plus 4.5 lb. A^{-1} Frit 503 and killed with paraquat in late March or early April.

In conventional tillage plots the soil was rototilled twice before planting. Grain sorghum or corn was planted directly into no-tillage or conventional tillage plots in 2.5 ft-wide rows with and without subsoiling using a two-row Brown-Harden Super-Seeder®. Fertilizer and herbicide applications and planting or corn and grain sorghum were done in a single operation (Corella et al., 1988). When the sorghum was about 5 inches tall a post-emergence application of atrazine 2.0 lb. a.i. A^{-1} was broadcast over the sorghum. Both corn and grain sorghum received at least one post directed application of herbicides: ametryn 1.0 lb. a.i. A^{-1} and 2, 4-D, 0.5 lb. a.i. A^{-1} for additional weed control when plants were about 20 inches tall.

Soil samples for nematode assay were taken from the two middle rows of each plot yearly when each crop was at or near harvest. Samples from the crop rhizosphere 6-8 inches deep were taken with a sampling tube (1 inch diameter), 20 cores composited from each plot. Samples were placed in plastic bags and stored at 50°F until processed 2-5 days after sampling. The soil was mixed and a 1/2 pint aliquant was processed by sugar-flotation-centrifugation (Jenkins, 1969). Root samples consisting of bulked roots from five or more plants selected at random from each plot were also assayed (Endo, 1959). Nematodes were counted and identified to species. Roots of 20 plants from each plot were rated for root-knot nematode galling based on the following scale: 0 = no galls; 1 = 1-2; 2 =3-10; 4= 31-100; and 5 = > 100 galls per root system (Taylor and Sasser, 1978). All data were subjected to analysis of variance and treatment means were compared by Duncan's new multiple-range test. Differences referred to in the text were significant at ($P < 0.05$).

Results and Discussion

The mean population densities of *M. incognita* second-stage juveniles and *Pratylenchus bruchyurus* averaged over 4 years were 3.9 X and 1.9 X higher, respectively, under vetch-corn double cropping than under the vetch-grain sorghum double cropping system (Table 1). *Meloidogyne incognita* or *P. brachyurus* were not affected by tillage. In contrast, mean population densities of *Criconemella ornata* were 1.7 X higher under the vetch-grain sorghum cropping system compared to the vetch-corn double cropping system. The numbers of *Paratrichodorus minor* and *P. brachyurus* in roots in the soil were not affected by either cropping system or tillage system. The root-gall index was higher under vetch-corn cropping than vetch-grain sorghum cropping. Tillage treatments did not influence the root-gall index.

The mean nematode population densities were also affected by the crop species grown in the two cropping systems (Table 2). Population densities of *M. incognita* were higher when corn was growing in the field than when grain sorghum was growing. In contrast, *C. ornata* population densities were higher under grain sorghum than under corn, whereas, *P. minor* and *P. brachyurus* soil population densities were not influenced by the crop species. Vetch had lower root-gall indices when it was preceded by sorghum than when it was preceded by corn. The mean number of *P. brachyurus* in vetch roots was higher following corn than grain sorghum. The numbers of *P. brachyurus* in grain sorghum and corn roots were not different.

When plots planted previously to corn or grain sorghum were split, half corn and half grain sorghum, the mean number of *M. incognita* juveniles in the corn-vetch-corn-cropping system was 2.9 X that in the sorghum-vetch-corn system, and 7.1 X that in the sorghum-vetch-grain sorghum cropping system (Table 3). The mean number of *M. incognita* in the corn-vetch-grain sorghum was 2.6 X that in the sorghum-vetch-sorghum cropping system and sorghum-vetch-corn was 2.8 X that in the sorghum-vetch-sorghum cropping system. The mean number of *C. ornata* was highest in the sorghum-vetch-sorghum system compared with the other cropping sequences, whereas it was lowest in the corn-vetch-corn system. *Pratylenchus brachyurus* had a higher mean number in the corn-vetch-corn and corn-vetch-sorghum than in the sorghum-vetch-corn and the sorghum-vetch-sorghum system. *Paratrichodorus minor* did not respond to any of the systems tested.

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Table 1. Soil or root population densities of four nematode species averaged over 4 years following a vetch-corn or vetch-sorghum cropping system each grown in no-tillage or conventional tillage with or without subsoiling.

Cropping system	Avg. no. nematodes/pint soil[1]					
	Criconemella ornata	*Meloidogyne incognita*	*Parutrichodorus minor*	*Pratylenchus brachyurus*	*Root-gall* index[2]	*Pratylenchus bruchyurus* per 0.1 oz. roots[2]
Vetch-corn	130*	82*	51 NS	28 NS	3.3*	65.5*
Vetch-sorghum	215	21	48	24	1.5	34.9

*Significant differences between cropping systems according to F test ($P < 0.05$).

[1]Each mean is an average of four replications x four tillage treatments x 13 sampling dates.

[2]Each mean is an average of four replications x four tillage treatments x eight sampling dates. Root-gall index: 0 = no galling, 1 = 1-2, 2 = 3-10. 3 = 11-30, 4 = 31-100, 5 = > 100 galls per plant.

Table 2. Soil or root population densities of four nematode species averaged over 4 years following a corn or grain sorghum each grown in a cropping system of no-tillage or conventional tillage with or without subsoiling.

Cropping system	Crop	Avg. no. nematodes/1/2 pint soil[1] *Criconemella ornata*	*Meloidogyne incognita*	*Paratrichodorus minor*	*Pratylenchus brachyurus*	Root-gall index[2]	*Pratylenchus brachyurus* per 0.1 oz. roots
Vetch-corn	Vetch	190*	17*	40 NS	33 NS	3.1 a	92.4
	Corn	134	151	38	43	3.6 a	44.8 a
Vetch-sorghum	Vetch	263*	8*	25 NS	23 NS	0.8 b	23.0 b
	Sorghum	242	41	29	29	2.9 a	43.9 a

*Significant differences between crops within a cropping system according to F test ($P < 0.05$). NS = nonsignificant.
'Each mean is an average of four replications x four tillage treatments x 13 sampling dates.
'Each mean is an average of four replications x four tillage treatments x8 sampling dates. Numbers in columns followed by the same letter are not significantly different according to DMRT ($p < 0.05$). Root-gall index: 0 = no galling, 1 = 1-2.2 = 3-10, 3 = 11-30. 4 = 31-100, 5 = < 100 galls per plant.

Table 3. Soil population densities of four nematode species following the final crop of a four multiple cropping system each grown in no-tillage or conventional tillage with or without subsoiling.

Cropping system	Avg. no. nematodes/l/2 pint soil *Criconeme ornata*	*Meloidogyne incognita*	*Paratrichodorus minor*	*Pratylenchus brachyurlcr*
Corn-vetch-corn	155 d	128 a	8 a	32 a
Corn-vetch-sorghum	230 c	46 b	8 a	40 a
Sorghum-vetch-corn	290 b	50 b	10 a	9 b
Sorghum-vetch-sorghum	334 a	18 c	8 a	9 b

Data in columns followed by the same letter are not significantly different according to DMRT ($P < 0.05$). All means are an average of four replicates x four tillage treatments x two sampling dates.

nematodes was caused by tillage treatments on only two sampling dates. Total nematodes were higher in no-tillage plots on both of these dates (average of 92 and 40 total nematodes per 1/2 pint of soil for no-tillage and conventional tillage, respectively). No individual nematode species had difference in population densities related to tillage. Effect of tillage treatment on nematode population densities depended on the cropping system and the vetch-grain sorghum cropping system had more effect than vetch-corn cropping system. This was attributed to the higher population density of *C. ornata* in the vetch-grain sorghum cropping system. Nematode population densities responded to tillage only when hairy vetch was growing in the field and the preceding nematode counts were the highest found among all sampling dates.

Grain sorghum suppressed *M. incognita* better than corn for succession double cropping with vetch when moderate to high population densities of *M. incognita* were present; however, when C. *ornata* was present in high population densities and *M. incognita* were absent or few in numbers. the vetch-corn double cropping sequence was best. Only two of 18 sampling dates showed a significant response in the populations of nematodes to tillage. Ring nematode was affected by tillage management more than the other nematodes, and this nematode was higher in no-tillage plots.

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