

Tillage and Multiple Cropping Systems and Population Dynamics of Phytoparasitic Nematodes¹

R. N. GALLAHER,² D. W. DICKSON,³
J. F. CORELLA,² AND T. E. HEWLETT³

Abstract: The effect of two cropping and tillage systems on the population dynamics of four nematode species was evaluated on a loamy sand. Hairy vetch succeeded by corn or grain sorghum was 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× more than the vetch-grain sorghum cropping system. In contrast, the vetch-grain sorghum cropping system increased the density of *Criconebella ornata* 0.7× more than the vetch-corn cropping system. *Meloidogyne incognita* and *C. ornata* were affected more by these cropping systems than were *Pratylenchus brachyurus* or *Paratrichodorus minor*. Multiple cropping systems, vetch varieties, and crop host preference affected nematode population densities, whereas tillage treatments, conventional or no-tillage, had little effect on them.

Keywords: corn, *Criconebella ornata*, cultural practice, grain sorghum, lesion nematode, *Meloidogyne incognita*, multiple cropping, *Paratrichodorus minor*, phytoparasitic nematode, population dynamics, root-knot nematode, *Pratylenchus brachyurus*, *Sorghum bicolor*, stubby-root nematode, tillage, vetch, *Vicia* spp., *Zea* may.

Minimum tillage, or planting directly into an untilled seedbed and the absence of tillage operations through harvest, and multiple cropping, or growing two or more crops the same year on the same land area, are being adopted rapidly in the United States (11). A better understanding is needed of their effects on soil populations of phytoparasitic nematodes. Nematode density increases are reported on crops in the field, with corresponding suppressions in yields, but tillage systems have not been related to soil population levels of phytoparasitic nematodes (1,10,14-16).

Population densities of several phytoparasitic nematodes generally are greatest in no-tillage plots and lowest in fall-plowed or spring-plowed plots (2,21). Phytoparasitic nematode numbers are greater in no-tillage grain sorghum (*Sorghum bicolor* L. Moench) than under conventional tillage (20). Population densities of *Pratylenchus* sp., however, are less in untilled soils (2).

Meloidogyne incognita (Kofoid & White) Chitwood and *Criconebella* spp. population levels increase on corn following subsoiling, but numbers of *Pratylenchus zeae* Graham are not affected (18). Subsoiling increases corn yield and root and nematode distribution in the soil profile with little increase in either roots or nematode number. *Meloidogyne* spp. populations are manipulated by intensive cropping systems and by crops within each system (13). When crops are grown in close sequence in the same field, nematodes that build up on the first crop may be important to the success of the second crop (6).

Incorporation of nematode varietal resistance is beneficial in a number of vegetables and field crops (9), but little work has been done with forage legumes. Interest in nematode resistance in forage legumes is increasing because of higher fertilizer costs and the demand for high quality forage. Most of the research in forage legumes involves *Medicago sativa* L. (7), *Trifolium* spp., and other tropical forage legumes (4,17). Vetch (*Vicia sativa* L.) has also received attention in nematode resistance breeding programs (5).

The objective of this study was to determine the effect of long-term double crop-

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² Professor and Graduate Assistant, Department of Agronomy, University of Florida, Gainesville, FL 32611-0541.

³ Professor and Biological Scientist III, Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611-0611.

ping systems and tillage management on the population dynamics of phytoparasitic nematodes.

MATERIALS AND METHODS

Hairy vetch succeeded by corn or grain sorghum was grown in split plots randomized within whole plots of 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 7.6 m long and 13.7 m wide. From 1979 to 1981 the cropping systems included vetch succeeded by corn or by grain sorghum. In 1981 tillage plots were split again with vetch cultivars as the split-split plot treatment. Crops included hairy vetch and four vetch cultivars—Vantage, Cahaba White, Vanguard, and Nova II; 'DeKalb XL71' corn, and 'DeKalb BR64' sorghum. The four vetch cultivars reportedly had root-knot nematode resistance (5). In 1982 and 1983 plots previously planted 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, hyperthermic, Grossarenic Paleudult). Hairy vetch, used as a winter cover crop, was killed with paraquat, 1 liter/ha in late March or early April. Each fall the plots were harrowed three times and 33 kg/ha of hairy vetch seed was drill planted in rows spaced 0.18 m apart. The vetch was topdressed with 20-16-85-4-2 kg/ha of N-P-K-Mg-S plus 5 kg/ha Frit 503.

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 0.75-m-wide rows with and without subsoiling using a two-row Brown-Harden Super-Seeder (Brown Mfg. Co., Banks, AL). Fertilizer and herbicide applications and planting of corn and grain sorghum were done in a single operation (3). When the sorghum was about 0.12 m tall a post-emergence application of atrazine (2.2 kg a.i./ha) was broadcast over the sorghum. Both

corn and grain sorghum received at least one post-directed application of herbicides: ametryn (1.12 kg a.i./ha) and 2,4-D (0.56 kg a.i./ha) for additional weed control when plants were about 0.5 m 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 0.15 m deep were taken with a sampling tube (2.5 cm d), 20 cores composited from each plot. Samples were placed in plastic bags and stored at 10 C until processed 2–5 days after sampling. The soil was mixed and a 250-cm³ aliquant was processed by sugar-flotation-centrifugation (12). Root samples consisting of bulked roots from five or more plants selected at random from each plot were also assayed (8). 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, 3 = 11–30, 4 = 31–100, and 5 = > 100 galls per root system (19).

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 brachyurus* (Godfrey) Filipjev & Schuurmans-Stekhoven averaged over 4 years were 3.9× and 1.9× 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 *Criconebella ornata* (Raski) Luc & Raski were 1.7× higher under the vetch–grain sorghum cropping system compared to the vetch–corn double cropping system. The numbers of *Paratrichodorus minor* (Culbran) Siddiqi and *P. brachyurus* in roots in the soil were not affected by either cropping system or tillage system (Table 1). The

TABLE 1. Population densities of four nematode species and root-gall indices of *Meloidogyne incognita* during 4 years of two cropping systems showing the effects of each crop.

Cropping system	Mean no. of nematodes/250 cm ³ soil†				Root-gall index‡	<i>Pratylenchus brachyurus</i> per 10 g roots§
	<i>Meloidogyne incognita</i>	<i>Criconebella ornata</i>	<i>Pratylenchus brachyurus</i>	<i>Paratrichodoros minor</i>		
Vetch-corn	82*	130*	28	51	3.3*	231*
Vetch	17*	190*	33	40	3.1 a	326 a
Corn	151	134	43	38	3.6 a	158 a
Vetch-sorghum	21	215	24	48	1.5	123
Vetch	8*	263*	23	25	0.8 b	81 b
Sorghum	41	242	29	29	2.9 a	155 a

* = Significant differences between crops within a system ($P = 0.05$) according to F -test.

† Each mean is an average of a) four replications \times four tillage treatments \times 13 sampling dates for systems or b) four replications \times four tillage treatments \times eight sampling dates for individual crops.

‡ Each mean is an average of four replications \times four tillage treatments \times five sampling dates. Numbers in columns followed by the same letters are not different according to Duncan's new multiple-range test ($P = 0.05$). Root-gall index: 0 = no galling, 1 = 1-2, 2 = 3-10, 3 = 11-30, 4 = 31-100, 5 = >100 galls per plant.

§ Each mean is an average of four replications \times four tillage treatments \times eight sampling dates.

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 1). Population levels of *M. incognita* were higher under corn in the field than under grain sorghum. 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 (Table 1). 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 (Table 1).

When plots previously planted 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 \times that in the sorghum-vetch-corn system and 7.1 \times that in the sorghum-vetch-sorghum cropping system. The mean number of *M. incognita* in the corn-vetch-grain sorghum was 2.6 \times that in the sorghum-vetch-sorghum cropping system and sorghum-vetch-corn was 2.8 \times that in the sorghum-vetch-sorghum cropping system (Table 2). 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. The mean number of *P. brachyurus*

TABLE 2. Population densities of four phytoparasitic nematodes in the final crop of four multiple cropping systems.

Cropping system	Mean no. of nematodes/250 cm ³ soil			
	<i>Meloidogyne incognita</i>	<i>Criconebella ornata</i>	<i>Pratylenchus brachyurus</i>	<i>Paratrichodoros minor</i>
Corn-vetch-corn	128 a	155 d	32 a	8 a
Corn-vetch-sorghum	46 b	230 c	40 a	8 a
Sorghum-vetch-corn	50 b	290 b	9 b	10 a
Sorghum-vetch-sorghum	18 c	334 a	14 b	8 a

Data in columns followed by the same letter are not different according to Duncan's new multiple-range test ($P = 0.05$). All means are an average of four replications \times four tillage treatments \times two sampling dates.

TABLE 3. Population densities of four nematode species and root-gall indices for five vetches.

Vetches	Mean no. of nematodes/250 cm ³ soil				Root-gall index†	<i>Pratylenchus brachyurus</i> per 10 g roots
	<i>Meloidogyne incognita</i>	<i>Criconebella ornata</i>	<i>Pratylenchus brachyurus</i>	<i>Paratrichodorus minor</i>		
Hairy	77 a	124 b	13 a	57 a	2.1 a	6.6 b
Vantage	3 b	187 a	14 a	89 a	0.1 b	10.3 b
Cahaba White	3 b	158 a	14 a	91 a	0.0 b	27.0 a
Vanguard	7 b	193 a	20 a	77 a	0.0 b	20.7 a
Nova II	4 b	125 b	19 a	99 a	0.0 b	11.5 b

Data in columns followed by the same letter are not different according to Duncan's new multiple-range test ($P = 0.05$). All means are an average of four replications \times four tillage treatments \times two cropping systems \times two 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.

was higher in the corn-vetch-corn and corn-vetch-sorghum systems than in the sorghum-vetch-corn and the sorghum-vetch-sorghum systems. *Paratrichodorus minor* did not respond to any of the systems tested.

A significant response in the populations of two 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 49 total nematodes per 250 cm³ soil for no-tillage and conventional tillage, respectively). No individual nematode species had population differences 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

the vetch-corn cropping system. This was attributed to the higher population of ring nematodes 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.

Hairy vetch was a more suitable host for *M. incognita* than other vetches (Table 3). Few or no root-knot nematode galls were found on the four nematode-resistant cultivars. Vanguard and Cahaba White had the highest number of *P. brachyurus* per 10 g roots. Vantage, Cahaba White, and Vanguard supported a higher population level of *C. ornata* than hairy vetch and Nova II. The mean numbers of *P. brachyurus* and *P. minor* from soil did not differ among cultivars.

The root-gall index of hairy vetch was highest among the five vetches in the vetch-corn cropping system, and there was a trend for it to be higher than that recorded in other vetches in the vetch-sorghum system (Table 4). Hairy vetch had fewer root-knot nematodes per 10 g roots than the other vetches when grown in the vetch-corn cropping system. Vanguard and Nova II had the highest numbers of root-knot nematodes per 10 g roots in the vetch-sorghum cropping system.

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. in-*

TABLE 4. *Meloidogyne incognita* root-gall indices and number of juveniles in roots of vetch in vetch-corn versus vetch-grain sorghum double cropping systems.

Vetches	Root-gall index†		No. nematodes/10 g roots	
	Vetch-corn	Vetch-sorghum	Vetch-corn	Vetch-sorghum
	Hairy	3.4 a	0.8 a	5.8 b
Vantage	0.2 b	0.0 a	12.8 a	7.4 c
Cahaba White	0.0 b	0.0 a	10.2 a	4.4 c
Vanguard	0.1 b	0.0 a	10.2 a	31.2 a
Nova II	0.1 b	0.0 a	12.0 a	20.0 b

Means within a column followed by the same letter are not different according to Duncan's new multiple-range test ($P = 0.05$). All means are an average of four replications \times four tillage treatments \times two cropping systems \times two 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.

cognita was absent or few in numbers, the vetch-corn double cropping sequence was best.

Only 2 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; it was higher in no-tillage plots.

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