Effects of *Meloidogyne incognita* on Forage Yields of Four Annual Clovers

G. L. WINDHAM, Research Plant Pathologist, and G. A. PEDERSON, Research Geneticist, USDA-ARS-CSRL, Forage Research Unit, Mississippi State, MS 39762

ABSTRACT

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The effects of the southern root-knot nematode (*Meloidogyne incognita*) on productivity of four annual clover cultivars were determined by comparing yields in infested and noninfested plots during 1986 and 1987. The clover cultivars included Bigbee berseem, Chief and Tibbee crimson, and Yuchi arrowleaf. Highest numbers of *M. incognita* eggs at the final sampling dates were recovered from Bigbee plots both years. In May 1987, egg numbers were higher than initial levels for Bigbee, Chief, and Tibbee. Differences ($P = 0.05$) between yields of control and nematode-infested plots were found for Bigbee on 26 March 1986 and 29 April 1987 and for total forage yields in 1986. Maximum yield losses for Yuchi were 29.9% on 26 February 1986 and 28.8% ($P = 0.05$) on 19 March 1987, respectively. Although Yuchi yields were initially suppressed each year, total forage yields of nematode-infected plants were not different ($P = 0.05$) from those of the control at later harvest dates. Tibbee and Chief appeared to be relatively tolerant to *M. incognita*.

Annual clovers (*Trifolium* spp.) are excellent hosts for several species of root-knot nematodes found in the southeastern United States (6,8). *Meloidogyne* spp. can cause severe galling and stunting of clover plants. Root-knot nematodes have been associated with stunted and unproductive stands of crimson (*Trifolium incarnatum* L.) and arrowleaf (*T. vesiculosum* Savi) clovers (7).

Several *Trifolium* spp. have been evaluated for resistance to *Meloidogyne* spp. in greenhouse and field studies. Quesenberry et al (8) developed a rapid screening technique to evaluate crimson clover and other legumes for resistance to root-knot nematodes. All crimson clover lines evaluated were rated moderately susceptible. Berseem clover (*T. alexandrinum* L.) germ plasm has also been screened for resistance to *Meloidogyne* spp. (1). Nine germ plasm sources were severely galled by three root-knot species, and limited variability in gall scores was observed.

The effects of *M. incognita* (Kofoid & White) Chitwood on forage yields of annual clovers have not been quantified under field conditions. Because annual clovers are a cool-season crop and *M. incognita* is favored by warm temperatures, the impact of this nematode on forage yields of these clovers may be limited.

The objective of our research was to quantify the effects of *M. incognita* on forage yields of four annual clover cultivars under field conditions.

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MATERIALS AND METHODS

Plots were located at the Truck Crops Experiment Station, Crystal Springs, MS, in a Providence silt loam (pH 6.6). The field had been fallow for 1 yr, and plant-parasitic nematode numbers were below detectable levels in March 1985. A race 4 *M. incognita* population was increased in nematode plots by growing infected tomato (*Lycopersicon esculentum* Mill. 'Floradel') before planting clover. Uninoculated tomato plants were grown in the control plots. Tomato plants were transplanted on 18 April 1985 and 17 June 1986.

Clovers studied were Bigbee berseem, Tibbee and Chief crimson, and Yuchi arrowleaf. Seed was inoculated with the appropriate *Rhizobium* strain (Nitragin, Milwaukee, WI) and broadcast on a prepared seedbed on 9 October 1985 and 18 September 1986. Seeding rates were 16.8 kg/ha for arrowleaf and 22.2 kg/ha for berseem and crimson. Plots were 2.4 × 4.8 m and bordered by a tall fescue sod to minimize movement of nematodes between plots. A randomized complete block design with five replicates was used.

Nematode population densities were determined on 27 September 1985 (from tomato); 19 February, 25 April, and 18 September 1986 (from tomato); and 1 February and 28 May 1987. Ten to 12 soil cores 2.5 cm in diameter were taken 10–15 cm deep from each plot. Nematodes were extracted from 500-cm^3 soil samples by a sieving-centrifugation method (2). Eggs were extracted from egg masses on roots with NaOCl (4).

Bigbee and Yuchi plots were harvested by cutting a 1-m swath at a stubble height of 7 cm through the center of each plot with rotary mowers equipped with collection baskets. Crimson clover plots were harvested by cutting a 0.91-m swath through the center of each plot with a sickle-bar mower. Bigbee and Yuchi plots were harvested on 26 February, 26 March, 17 April, and 4 June 1986 and on 19 March and 29 April 1987. Tibbee and Chief plots were harvested once at full bloom on 17 April 1986 and 29 April 1987.

All yield data were subjected to analysis of variance. Means of forage yields from nematode-infested and control plots for each cultivar were compared by least significant differences (LSD) ($P = 0.05$).

RESULTS AND DISCUSSION

In 1985, initial juvenile numbers following tomato ranged from 832 in Tibbee plots to 1,227 in Bigbee plots (Table 1). Low numbers of juveniles were recovered in February 1986 with a slight increase in April for all clovers except Tibbee. Initial egg numbers in 1985 ranged from 1,382 to 2,563/500 cm^3 of soil for Chief and Yuchi, respectively. Eggs were recovered from clover roots in February 1986, though at lower levels. Reproduction of *M. incognita* increased through the spring in the Bigbee and Tibbee plots.

Initial juvenile numbers were lower at planting in 1986 than at planting the previous year, ranging from 59 to 768 in Chief and Yuchi plots, respectively. Juveniles decreased in February 1987 in Bigbee, Chief, and Yuchi plots, then increased at the last sampling date. Juvenile numbers in Tibbee plots increased throughout the growing season. Initial egg numbers ranged from 633 in Tibbee plots to 2,710 in Yuchi plots. All clovers supported lower reproduction (eggs) at the February sampling date; however, egg production had increased by the last sampling date in May. More eggs were recovered in May than at planting for Bigbee, Chief, and Tibbee.

On 26 February 1986, yields were greater in control plots of Bigbee and Yuchi clovers (Table 2). Percent difference in yield [(control − nematode-infested)/control] × 100 were 2.1 and 29.9 in Bigbee and Yuchi plots, respectively.

At the second harvest (26 March 1986), yields were numerically greater in control plots than in nematode-infested plots of Bigbee and Yuchi. Mean yields between treatments were significantly different ($P = 0.05$) for Bigbee. Percent differences in yields between control and nematode-infested plots were 3.0 for Yuchi and 15.3 for Bigbee.

Mean yields were numerically greater in control plots than in nematode-infested plots of Bigbee and Chief at the third harvest (17 April 1986). Percent differences ranged from an increase of 14.5 for Yuchi to a reduction of 12.0 for Bigbee. Forage yields for Tibbee were increased in plots infested by *M. incognita*.

Infested Bigbee plots continued to yield less than check plots at the last harvest (4 June 1986). There was a 12.9% increase from Yuchi and a 22.4% decrease from Bigbee. Total yield reductions were 1.4, 10.0, and 10.9% for Yuchi, Chief, and Bigbee, respectively. Total yields of Bigbee were significantly ($P = 0.05$) suppressed by *M. incognita*.

At the first harvest in 1987 (19 March), mean yields were significantly ($P = 0.05$) greater in control plots of Yuchi than those infested with *M. incognita* (Table 3). Control plots yielded 10.7% more than infested plots from Bigbee and 28.8% less from Yuchi.

Mean yields at the final harvest (29 April 1987) were numerically greater in control plots of Bigbee, Chief, and Tibbee than plots infested with *M. incognita*. Mean yields between treatments were statistically different ($P = 0.05$) for Bigbee. Nematode infestation was associated with an increase of 17.2% for Yuchi to a decrease of 12.6% for Bigbee. Total yield losses in 1987 ranged from 0.4 for Tibbee to 3.6% for Yuchi. Clover yields were not significantly affected by *M. incognita* in 1987.

Our study indicates the potential damage from *M. incognita* of annual clovers in forage production systems. Forage yields of Bigbee were suppressed in nematode-infested plots on five of six harvest dates. Yuchi forage yields were initially suppressed by the nematode both years. As the growing season progressed, however, the effects of the nematode decreased and the forage yields were actually higher in nematode-infested plots. A similar response has been reported for several nematode species (3). Legumes infected with *M. incognita* formed more lateral roots than healthy plants (5). This response may explain the increased forage yields by Yuchi in nematode-infested plots.

Tibbee and Chief crimson clovers were relatively tolerant to *M. incognita*, which confirms previous reports (1,8). These cultivars could be used in pastures with

Table 1. Numbers of *Meloidogyne incognita* juveniles and eggs for four annual clovers during two growing seasons

Clover cultivar	Sept.[a] 1985	Feb. 1986	Apr. 1986	Sept. 1986	Feb. 1987	May 1987
			Juveniles per 500 cm^3 of soil			
Bigbee	1,227[b]	10	46	387	40	121
Chief	1,188	14	24	59	26	102
Tibbee	832	15	8	68	131	316
Yuchi	940	8	11	768	35	124
			Eggs per 500 cm^3 of soil			
Bigbee	1,728	123	809	1,161	17	1,548
Chief	1,382	123	35	985	211	1,267
Tibbee	1,555	123	246	633	352	1,267
Yuchi	2,563	193	0	2,710	140	1,126

[a] Nematode population densities in September 1985 and 1986 were determined before clover planting.
[b] Values are means of five replicates.

Table 2. Forage yields (dry weights) for control and root-knot nematode-infested plots of four annual clover cultivars at four harvest dates in 1986

Clover cultivar	Control		Nematode-infested		Difference (%)[b]	LSD ($P = 0.05$)
	$\bar{x}$[a]	SD	$\bar{x}$	SD		
			26 February			
Bigbee	1,672	153	1,637	207	2.1	NS
Yuchi	1,126	102	790	323	29.9	NS
			26 March			
Bigbee	1,347	178	1,141	179	15.3	192
Yuchi	1,371	158	1,330	660	3.0	NS
			17 April			
Bigbee	955	152	841	215	12.0	NS
Chief	5,742	989	5,170	1,032	10.0	NS
Tibbee	5,190	1,045	5,657	858	−8.9	NS
Yuchi	1,103	146	1,263	286	−14.5	NS
			4 June			
Bigbee	726	225	564	106	22.4	NS
Yuchi	1,145	285	1,293	272	−12.9	NS
			Totals			
Bigbee	4,701	438	4,185	396	10.9	260
Chief	5,742	989	5,170	1,032	10.0	NS
Tibbee	5,190	1,045	5,657	858	−8.9	NS
Yuchi	4,747	626	4,677	1,088	1.4	NS

[a] $\bar{x}$ = Arithmetic mean of the harvest weights (in kg/ha), and SD = standard deviation of the mean.
[b] Percent difference = [(control − nematode-infested)/control] × 100.

Table 3. Forage yields (dry weights) for control and root-knot nematode-infested plots of four annual clover cultivars at two harvest dates in 1987

Clover cultivar	Control		Nematode-infested		Difference (%)[b]	LSD ($P = 0.05$)
	$\bar{x}$[a]	SD	$\bar{x}$	SD		
			19 March			
Bigbee	1,363	144	1,510	71	−10.7	NS
Yuchi	1,444	94	1,044	287	28.8	311
			29 April			
Bigbee	1,770	280	1,548	212	12.6	205
Chief	6,308	857	6,249	1,200	1.0	NS
Tibbee	5,526	841	5,506	1,115	0.4	NS
Yuchi	1,667	243	1,955	319	−17.2	NS
			Totals			
Bigbee	3,134	401	3,059	224	2.3	NS
Chief	6,308	857	6,249	1,200	1.0	NS
Tibbee	5,526	841	5,506	1,115	0.4	NS
Yuchi	3,111	320	2,999	290	3.6	NS

[a] $\bar{x}$ = Arithmetic mean of the harvest weights (in kg/ha), and SD = standard deviation of the mean.
[b] Percent difference = [(control × nematode-infested)/control] × 100.

light infestations of *M. incognita*. As with other tolerant crops, however, nematode numbers can increase to damaging levels.

The effects of the nematode on clover yields were more pronounced in 1986. Rainfall for the first 4 mo of 1986 was 446 mm below normal. The combined stress of the nematode and low soil moisture may have caused the greater yield reductions.

Soil temperature did not appear to be a limiting factor in *M. incognita* development on annual clovers in the field we selected. Soil temperatures remained above the threshold of 10 C for juvenile development (10) and 8 C for egg development (9) from planting to mid-December and after mid-February both years. Soil moisture may have had an adverse effect on nematode development. Low numbers of eggs and juveniles were recovered in April 1986, perhaps because of an extremely dry spring. However, greater numbers of eggs and juveniles were recovered in May 1987.

Annual clovers are excellent hosts for root-knot nematode species. We have demonstrated that forage yields of Bigbee berseem clover can be detrimentally affected by *M. incognita*. However, if root-knot nematodes are not widely distributed in forage production systems in the southeastern United States, this potential problem may not be realized.

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