RESEARCH NOTES

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Interactions Between Six Warm-Season Legumes and Three Species of Root-Knot Nematodes[1]

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Key words: *Aeschynomene americana* (aeschynomene), *Alysicarpus vaginalis* (alyceclover), *Cajanus cajan* (pigeonpea), *Crotalaria spectabilis* (showy crotalaria), *Desmodium heterocarpon* (carpon desmodium), *Indigofera hirsuta* (hairy indigo), *Meloidogyne arenaria* race 1 (peanut root-knot nematode), *Meloidogyne incognita* race 3 (southern root-knot nematode), *Meloidogyne javanica* (javanese root-knot nematode), plant resistance.

In the southeastern United States, root-knot nematodes (*Meloidogyne* spp.) are a major limiting factor in the establishment and production of several forage legumes. Major genera of forage plants, including *Trifolium, Vicia, Alysicarpus, Indigofera, Cajanus, Aeschynomene, Desmodium, Medicago,* and *Lotus,* are susceptible to at least one species of root-knot nematode (2). Economic and environmental considerations prevent the widespread use of chemicals to control nematodes in forages. Therefore, it is essential to identify or develop nematode-resistant cultivars of these crops.

Hairy indigo (*Indigofera hirsuta* L.) is an erect-branched annual legume reported to be resistant to root-knot nematodes (15,19,24). However, *M. arenaria, M. hapla, M. incognita* var. *acrita, M. javanica,* and *M. incognita* have all been reported to gall roots of hairy indigo (7,14).

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is widely utilized as a legume grain crop in tropical regions (25). Heavy infestations of *M. incognita* (5), *M. hapla* (14), *M. arenaria* (14), and *M. javanica* (5) have been noted in pigeonpea, as has some resistance to *M. javanica* (5,14) and *M. incognita* (14).

Showy crotalaria (*Crotalaria spectabilis* Roth.) has been reported to be resistant to root-knot nematodes (11,20) although it did not effectively reduce populations of root-knot nematodes when used as a cover crop in one study (9).

Aeschynomene (*Aeschynomene americana* L.), also called American jointvetch, has been reported as being resistant to *Meloidogyne* spp. (10). Roots were galled by all five species of root-knot nematodes used in another test, in which heaviest galling was caused by *M. incognita* var. *acrita* (14). Over 50% of *A. americana* plant introductions were rather heavily galled by *M. incognita,* with less galling caused by *M. arenaria* and *M. javanica* (17).

Carpon desmodium (*Desmodium heterocarpon* (L.) DC.) is highly susceptible to root-knot nematodes and is not recommended for planting in any infested area (10). A few breeding lines of *D. heterocarpon* had some resistance to *M. incognita* but no resistance to *M. arenaria* or *M. javanica* (17). Alyceclover (*Alysicarpus vaginalis* (L.) DC.) has been reported to be highly susceptible to root-knot nematodes (1–3,13,14,23).

Evaluation of plant susceptibility to root-knot nematodes is often based solely on the number of root galls or a subjective root gall rating. Galls can form on resistant plants with little or no nematode reproduction (22). Assessment of nematode reproduction in addition to gall ratings might improve evaluation of plant resistance. The objective of this research was to use egg mass ratings, egg counts, and gall ratings to measure the interactions between the

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TABLE 1. Mean gall scores of six warm season legumes inoculated with three species of root-knot nematodes, *Meloidogyne* spp. Experiment 1.

Legume	Mean gall rating		
	M. arenaria	*M. incognita*	*M. javanica*
Alyceclover	4.3 b	4.6 a	2.2 b
Aeschynomene	0.0 d	2.7 c	0.2 c
Showy crotalaria	0.0 d	0.0 d	0.0 c
Carpon desmodium	5.0 a	5.0 a	3.6 a
Hairy indigo	3.8 c	3.3 b	0.0 c
Pigeonpea	3.8 c	0.0 d	0.0 c

Means are based on a 0–5 root gall rating scale (0 = no galls, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = more than 100 galls). Each rating is the mean of four observations pooled from each of three replications.

Means in the same column followed by the same letter are not significantly different according to Duncan's new multiple-range test ($P = 0.05$).

above legumes and three species of root-knot nematodes.

During late 1983 and early 1984, two experiments were conducted in a greenhouse at the University of Florida, Gainesville. Alyceclover (source: common type from Johnson and Faris, Co.), aeschynomene (source: common type from C. M. Payne and Son, Inc.), showy crotalaria (source: common type from Dr. G. M. Prine, University of Florida), hairy indigo (source: common type from Johnson and Faris, Co.), 'Norman' pigeonpea, and 'Florida' carpon desmodium were evaluated for their resistance to the three most important root-knot nematode species in Florida. The nematodes used were *M. javanica* (Treub, 1885) Chitwood, 1949 (collected from soybeans in Suwannee County, Florida, in 1975); *M. arenaria* race 1 (Neal, 1889) Chitwood, 1949 (collected from 'Florunner' peanuts in Levy County, Florida, in 1981); and *M. incognita* race 3 (Kofoid and White, 1919) Chitwood, 1949 (collected from soybeans in Santa Rosa County, Florida, in 1981). The nematodes were identified by the North Carolina host differential test (22) and morphometrics. Inoculum was prepared using the method of Hussey and Barker (8). Plants were inoculated with nematodes and grown in "Super-Cell" Cone-tainers holding approximately 150 cm^3 soil.

Experiment 1: A split-plot design, replicated three times, was utilized with the six legumes as main plots and nematode species as subplots. Seeds germinated in petri dishes were transplanted, one into each Cone-tainer filled with methyl bromide sterilized Arredondo fine sand (5% silt, 2% clay, 92% sand, 1% organic matter, pH 6.1).

After 10 days plants were inoculated with 1,500 nematode eggs and juveniles in a 5-ml suspension per cone. Noninoculated plants were controls.

The plants were grown in a greenhouse at 25 C for 62 days after inoculation, then removed from the Cone-tainers and the roots gently washed free of soil. Root galling was rated on a 0–5 system as follows: 0 = no galls, 1 = 1–2 galls, 2 = 3–10 galls, 3 = 11–30 galls, 4 = 31–100 galls, and 5 = more than 100 galls.

Experiment 2: The experimental design was a split-plot with nematode species as main plots and plant species as subplots replicated four times.

Plants were grown as in Experiment 1. Soil was removed by washing, and the root systems were placed in 0.015% aqueous Phloxine B for 20 minutes to stain egg masses (6). Roots were then rated for galling and egg masses. Egg masses were rated on a scale similar to the gall rating.

Root systems from each subplot of six plants were combined and the nematode eggs extracted in 0.5% NaOCl with vigorous agitation for 1 minute (8). The extract was poured through a 75-μm-pore sieve nested over a 20-μm-pore sieve. Eggs caught on the lower sieve were washed into a beaker, the volume adjusted to 100 ml, and the eggs in three 2-ml aliquots were counted; the results are expressed as numbers of eggs per 100 mg (fresh weight) of roots.

Showy crotalaria exhibited no signs of galls, egg masses, or reproduction by any of the three *Meloidogyne* species.

Alyceclover was highly susceptible to all three root-knot species except *M. javanica* in Experiment 1 (Table 1). The gall rating of 4.9 in Experiment 2 was consistent with egg mass ratings and numbers of eggs.

Aeschynomene was moderately susceptible to *M. incognita,* which caused 11–30 galls per root system and produced few egg masses or eggs. Aeschynomene was resistant to both *M. javanica* and *M. arenaria* (Tables 1 and 2).

Florida carpon desmodium was severely damaged by *M. arenaria* and *M. incognita*

and slightly less damaged by *M. javanica*. Reproduction, as measured by both egg mass ratings and egg counts, were consistent with gall ratings.

Norman pigeonpea was severely galled by *M. arenaria*, but no galls were caused by *M. javanica* or *M. incognita*. *M. arenaria* produced 2,200 eggs/100 mg pigeonpea roots; reproduction of *M. incognita* and *M. javanica* was negligible.

Hairy indigo was moderately galled by *M. incognita* and *M. javanica* and somewhat more heavily by *M. arenaria*. However, comparatively few eggs were produced on this host by any species.

Knowledge of the susceptibility and host suitability of specific forage legumes to root-knot nematodes can be important for at least two reasons: the potential effect of the endemic root-knot nematode species on growth and forage production of given legumes, and the likely effect of each legume on endemic *Meloidogyne* populations with regard to increasing or decreasing the risk of root-knot damage to susceptible crops to be grown after forage.

Root-galling as measured by visual gall indices is often correlated with yield suppression although not directly related (16,17). Galling and yield suppression are, in fact, usually used as the principal selection criterion when breeding *Meloidogyne*-resistant cultivars to be used to reduce crop yield losses (21). If pronounced galling is taken as a predictor of yield reductions, results of both experiments make it clear that alyceclover and carpon desmodium are poor risks on land infested with any of these species and that some other legumes are likely to be adversely affected by one or more of the *Meloidogyne* species.

However, if the greater emphasis in selecting a legume is to be on its likely effect on the root-knot nematode populations which might pose a risk to a susceptible subsequent crop, relying solely on gall indices could result in rejection of useful candidates. For examples, hairy indigo and pigeonpea had equal gall ratings when inoculated with *M. arenaria* in Experiment 2, but egg production was 65 times greater on pigeonpea than on hairy indigo. This is consistent with frequent observations that *M. arenaria* severely damaged and developed very high field populations in pigeonpea agronomic trials on the University of Florida Agronomy Farm in the 1982 and 1983 growing seasons (pers. obs. and comm. from G. M. Prine; species identified by R. A. Dunn). Although hairy indigo was galled in our tests, as noted by Minton et al. (14) and Good et al. (7), relatively few eggs were produced on it by any of these species. Hence, its successful use by Rhoades (18) to manage *M. incognita* and *M. javanica* is not inconsistent with reports of root galling. Though it was not immune in these studies, hairy indigo's usefulness for suppressing root-knot nematode seems to be further supported by this work.

TABLE 2. Mean gall ratings, mean egg mass ratings and mean eggs per 100 mg of roots for six warm season legumes inoculated with three species of root-knot nematodes (*Meloidogyne* spp.). Experiment 2.

Legume	*M. arenaria*	*M. incognita*	*M. javanica*
	Root gall rating		
Alyceclover	4.9 a	5.0 a	4.9 a
Aeschynomene	0.0 c	3.3 c	2.0 d
Showy crotalaria	0.0 c	0.0 d	0.0 e
Carpon desmodium	4.7 a	4.2 b	3.8 b
Hairy indigo	4.2 b	3.0 c	3.2 c
Pigeonpea	4.2 b	0.0 d	0.0 e
	Egg mass rating		
Alyceclover	4.7 a	4.9 a	4.6 a
Aeschynomene	0.0 c	2.2 b	1.1 d
Showy crotalaria	0.0 c	0.0 d	0.0 e
Carpon desmodium	4.8 a	4.4 a	3.8 b
Hairy indigo	2.7 b	1.6 c	2.2 c
Pigeonpea	4.9 a	0.0 d	0.0 e
	Eggs per 100 mg of roots		
Alyceclover	675 b	675 a	660 a
Aeschynomene	2 c	15 b	3 c
Showy crotalaria	0 c	0 b	0 c
Carpon desmodium	660 b	900 a	200 b
Hairy indigo	30 c	20 b	4 c
Pigeonpea	2,200 a	2 b	1 c

Root gall and egg mass scores are means based on a 0–5 rating scale (0 = no galls or egg masses, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = more than 100 galls or egg masses). Each score is the mean of six observations pooled from each of four replications.

Means in the same column, for a particular parameter, followed by the same letter are not statistically different according to Duncan's new multiple-range test ($P = 0.05$).

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