HORTSCIENCE 30(2):292–293. 1995.

Garden Herbs as Hosts for Southern Root-knot Nematode [*Meloidogyne incognita* (Kofoid & White) Chitwood, race 3]

Jerry T. Walker
Department of Plant Pathology, University of Georgia, College of Agricultural and Environmental Sciences, Georgia Station, Griffin, GA 30223

Additional index words. oregano (*Origanum vulgare*), peppermint (*Mentha* ×*piperita*), resistance, root galls, susceptible, tolerant

***Abstract*. Twenty herb species were exposed to root-knot nematode under greenhouse conditions. The root systems were examined for root gall development and nematode reproduction as an indication of host suitability. The herbs evaluated were balm (*Melissa officinalis* L.), basil (*Ocimum basilicum* L.), catnip (*Nepeta cataria* L.), chamomile (*Matricaria recutita* L.), coriander (*Coriandrum sativium* L.), dill (*Anethum graveolens* L.), fennel (*Foeniculum vulgare* Mill.), hyssop (*Hyssopus officinalis* L.), lavender (*Lavandula augustifolia* Mill.), oregano (*Origanum vulgare* L.), peppermint (*Mentha* ×*piperita* L.), rocket-salad (*Erurca vesicaria* L.), rosemary (*Rosmarinus officinalis* L.), rue (*Ruta graveolens* L.), sage (*Salvia officinalis* L.), savory (*Satureja hortensis* L.), sweet marjoram (*Origanum majorana* L.), tansy (*Tanacetum vulgare* L.), thyme (*Thymus vulgaris* L.), and wormwood (*Artemisia absinthium* L.). Peppermint, oregano, and marjoram consistently were free of root galls after exposure to initial nematode populations of two or 15 eggs/cm^3 of soil medium and were considered resistant. All other herb species developed root galls with accompanying egg masses, classifying them as susceptible or hypersusceptible to root-knot nematode. The highest initial nematode egg density (15 eggs/cm^3) significantly decreased dry weights of 14 species. The dry weights of other species were unaffected at these infestation densities after 32- to 42-day exposure.**

Growing herbs has widespread appeal for professional and amateur gardeners. Recently, there has been a resurgence of interest in this group of plants, perhaps because the media and governmental agencies have given greater attention to health foods (Foster, 1991).

Some herb species are known hosts of phytoparasitic nematodes (Chinappen et al., 1988; Inserra et al., 1989; Mustika, 1992; Rhoades, 1988), and conversely, certain herbs or medicinal plants can control nematodes (Haroon and Huettel, 1991; Haseeb and Butool, 1990; Mukhopadhyaya et al., 1980; Tanda et al., 1989). Information on plants with resistance or tolerance to common plant nematodes is becoming increasingly important, especially for urban gardeners where using pesticides for nematode control is limited or nonexistent.

My purpose was to examine a variety of common garden herbs for their suitability as hosts to one of the principal and most widespread nematodes in Georgia, the southern root-knot nematode.

Materials and Methods

All experiments were conducted in a greenhouse where daytime temperatures ranged from 15 to 34C. Herb seeds were sown in a steamed soil mix composed of 2 soil (clay-loam) : 1 vermiculite : 1 Fafard Mix 3 (Conrad Fafard, Agawam, Mass.) (by volume) in 10-cm plastic pots (360 cm^3). After seeds germinated, seedlings were watered daily. Thirty-five milliliters of fertilizer solution (containing 2.6 g 20N–4.3P–16.6K/liter) were drenched into each pot weekly. When seedlings were 1 to 1.5 cm high, the plants within a given species were thinned to about the same number per pot. Thirty days after planting, a suspension of 0, 600, or 5400 nematode eggs, harvested from roots of 'Black Knight' eggplant (*Solanum melongena* L.) by the sodium hypochlorite method (Hussey and Barker, 1973), was pipetted into a hole in the center of each pot; these amounts were equivalent to ≈0, 1.67, or 15 eggs/cm^3 soil mix. There were four replications for each infestation level, and the experiment was repeated with 12 herbs. In an additional test with nine herb species, there were six replications at each of four infestation levels: 0, 1.67, 5, and 15 eggs/cm^3. Replications in all experiments were randomized within blocks by infestation levels to minimize contamination between populations.

Plants were removed from the pots 39 to 42 days after adding nematode eggs. The number of plants per pot was recorded, and the roots were washed with running water to dislodge the soil mix. Root systems were examined using a magnifying glass and were rated using a 0 to 4 gall index scale (Kinlock et al., 1987). For the nine herbs, an egg mass index was assigned after counting the number of root galls per replica (Sasser et al., 1984), and a reproductive factor was calculated based on the number of eggs recovered from root samples of three replications, thereby providing an indication of nematode reproduction.

Fresh and dry weights of plant shoots and roots were determined by drying for 10 days at 110C to measure growth responses to nematodes. Data were analyzed by analysis of variance (ANOVA) (SAS Institute, 1985), and the mean values were separated by *t* tests [least significant difference (LSD)].

Results and Discussion

There were no root galls on oregano, peppermint, or sweet marjoram plants exposed to root-knot nematodes. All other herbs developed root galls—the number depended on plant species and level of nematode egg infestation. According to the ANOVA of data from the initial experiment, plant fresh weights were not significantly affected by nematodes; however, the root-gall indices were affected significantly by plant species and nematode infestation levels.

The species × nematode interaction also was highly significant ($P \leq 0.0001$) for root galls. When the experiment was repeated, oregano, peppermint, and sweet marjoram again failed to develop any root galls; there-

Table 1. Mean root-gall index (GI) and grams dry weight (DW) per pot of 12 herb species following inoculation with three concentrations of *Meloidogyne incognita* race 3.

	GI[z]			DW		
	Eggs/cm^3			Eggs/cm^3		
Herb	0	1.6	15	0	1.6	15
Balm	0.0 c[y]	0.5 b	1.0 a	3.47 a	3.13 b	2.85 b
Basil	0.0 c	0.5 b	1.3 a	2.41 a	2.56 a	2.52 a
Coriander	0.0 c	0.4 b	1.0 a	2.69 a	2.84 a	2.84 a
Dill	0.0 c	0.9 b	2.0 a	3.06 a	2.36 b	2.61 ab
Marjoram	0.0 a	0.0 a	0.0 a	2.67 a	2.38 a	2.16 a
Oregano	0.0 a	0.0 a	0.0 a	3.70 a	2.42 b	2.42 b
Peppermint	0.0 a	0.0 a	0.0 a	3.35 a	3.05 a	2.51 b
Rosemary	0.0 c	0.4 b	1.0 a	0.23 b	0.53 a	0.40 ab
Sage	0.0 c	0.5 b	1.0 a	4.16 a	3.79 a	3.31 a
Tansy	0.0 b	0.3 b	0.8 a	2.72 a	2.46 ab	1.81 b
Thyme	0.0 a	0.0 a	0.3 a	2.55 a	1.71 b	0.69 c
Wormwood	0.0 b	0.6 b	2.5 a	2.93 a	2.46 a	2.60 a

[z]GI is based on the Kinloch et al.'s (1987) index; 0 = no galls, 0.2 = less than 5%, 1 = 5% to 25%, 2 = 26% to 50%, 3 = 51% to 75%, and 4 = more than 75% of root surface galled.
[y]Mean based on four replications. Mean separation in rows and within a criterion by *t* tests (least significant difference) at $P \leq 0.05$.

Received for publication 29 Aug. 1994. Accepted for publication 12 Dec. 1994. I thank J.B. Melin, J. Davis, and various reviewers for their assistance and advice. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

fore, they are considered resistant to this nematode (Table 1). Thyme was somewhat tolerant to nematode galling, even at the highest infestation level.

Root-knot nematodes caused a significant decrease ($P \leq 0.05$) in the dry weights of balm, dill, oregano, peppermint, tansy, and thyme in the repeat experiment, but dry weights of basil, coriander, marjoram, sage, and wormwood did not decrease. Rosemary was the only herb where dry weights of nematode-infested plants were higher than those of the controls.

In the evaluation of nine additional herbs, a full-scale general linear model procedure for data analysis was followed. The species × nematode population interaction proved to be highly significant ($P \leq 0.0001$) for most of the dependent variables measured; therefore, analyses were performed on data at each infestation level. The F values for most criteria measured were highly significant at each level; however, only data from the highest infestation level (15 eggs/cm^3; Tables 2 and 3) and for the control (Table 3) are presented.

Table 2. Mean number of root galls, egg mass indices (EMI), and reproductive factor (RF) for nine herbs exposed to *Meloidogyne incognita* race 3 at 15 eggs/cm^3.

Herb	Root galls (no.)[z]	EMI[y]	RF[x]
Catnip	1.9 bc[w]	0.20 b–d	---
Chamomile	4.0 a	0.20 b–d	1.85
Hyssop	1.9 bc	0.15 cd	2.67
Lavender, English, Munstead	3.4 ab	0.27 b	0.04
Lavender, English, Lilac	3.7 a	0.25 b	0.37
Rocket-salad	0.4 c	0.10 d	0.00
Rue, common	1.4 c	0.16 cd	0.00
Summer savory	1.0 c	0.14 d	0.46
Sweet fennel	4.4 a	0.38 a	0.59
$LSD_{0.05}$	1.7	0.10	---

[z]Mean number of galls per plant, based on six replicates. Root galls were absent on control plants.
[y]EMI per plant at 15 eggs/cm^3, using a scale from 0 to 5 (0 = none, 1 = 1 to 2, 2 = 3 to 10, 3 = 11 to 30, 4 = 31 to 100, and 5 = more than 100 egg masses).
[x]RF based on eggs recovered from three root subsamples adjusted by fresh root weight and divided by initial infestation population.
[w]Mean separation within columns by *t* test (least significant difference) at $P \leq 0.05$.

Overall, the number of galls increased significantly with increased number of eggs added originally. Chamomile and sweet fennel had the most galls at the high-infestation level, but their counts were not significantly higher than those on lavender. Rocket-salad (a Cruciferae member) had the lowest count but was not significantly different than rue or summer savory. Other herbs were intermediate in their reaction. No root galls were found on any control plants. Egg mass indices generally reflected the number of root galls on most herbs, with highest indices resulting with 15 eggs/cm^3.

The mean plant stem and root dry weights for all herbs combined in the experiment with nine herbs did not differ among the three egg infestation levels, but all were significantly lower than the noninfested plant weight. Combining data for all herbs, the lowest shoot : root ratios occurred in the controls (1.6), with significantly higher ratios in the infested series (1.95 and 2.11).

All experiments were conducted primarily during the fall and winter to avoid high greenhouse temperatures that could affect plant responses. Numerous herb species are suitable for southern gardens even in full sun (Colditz et al., 1982), but we wanted the environment to be as favorable as possible for plant growth.

Although these evaluations were conducted mainly with annual herbs, many species can grow as perennials in the southern United States and, therefore, would be subject to nematode invasion and reproduction for a longer time. The lasting effects of tolerant or resistant herbs on plant pathogenic nematode populations under field conditions should be addressed because certain annuals [e.g., sesame (*Sesamum indicum* L.) and marigolds (*Tagetes erecta* L.)] are known to suppress root-knot nematode populations (Odour-Owino, 1993; Verma et al., 1978).

Based on the results of these experiments, herbs, just as with other plants, vary greatly in susceptibility or resistance to southern root-knot nematode. If not resistant, a few species, (i.e., marjoram, peppermint, and oregano) were tolerant to this nematode. If tolerance exists in the susceptible herbs, perhaps an assay method could be devised to detect degrees of tolerance. Trudgill (1991) suggested that tolerance to nematodes is an important attribute in many low-value crops, where nematicides and resistant cultivars are not available. Undoubtedly, using resistant or tolerant cultivars will receive greater attention as a management tool for plant health-care programs in specialty crops. Resistance to nematodes on major crops have improved rapidly because of decreasing availability of nematicides and advances in molecular biology (Roberts, 1992). Perhaps many of these advances will be applicable to herbs as well.

Table 3. Root and stem dry weights (DW) and shoot : root ratios (S : R) of nine herbs exposed to *Meliodogyne incognita* race 3 at 0 and 15 eggs/cm^3.

	DW (mg)[z]				S : R[y]	
	Eggs/cm³				Eggs/cm³	
	0		15			
Herb	Root	Stem	Root	Stem	0	15
Catnip	123 a[x]	108 a	56 ab	66 bc	0.97 e	1.23 c
Chamomile	48 bc	50 de	38 b–d	37 d	1.09 de	1.00 c
Hyssop	138 a	107 a	64 a	69 bc	0.82 e	1.18 c
Lavender, Munstead	49 bc	106 a	41 b–d	75 ab	2.19 a	2.02 b
Lavender, Lilac	34 bc	76 b–d	34 cd	75 ab	2.21 a	2.28 b
Rocket-salad	18 c	30 e	12 e	22 d	1.65 bc	1.93 b
Rue, common	35 bc	67 cd	25 c–e	45 cd	2.09 ab	1.83 b
Summer savory	51 b	96 ab	21 de	82 ab	1.93 a–c	4.30 a
Sweet fennel	54 b	79 bc	42 bc	94 a	1.51 cd	2.23 b
$LSD_{0.05}$	32	27	21	25	0.48	0.46

[z]Mean DW per plant based on total number plants in six replications.
[y]Shoot : root ratios based on total dry weights of six replications.
[x]Mean separation within columns by least significant difference at $P \leq 0.05$.

Literature Cited

Chinappen, M., P. Jokhun, and F. Lamberti. 1988. A decline in thyme associated with *Rotylenchulus parvus* in Mauritius. Nematologia Mediterranea 16:233–234.

Colditz, P., J.M. Barber, and D. Granberry. 1982. Herbs for Georgia gardens. Univ. of Georgia, College of Agr. Coop. Ext. Circ. 620.

Foster, S. 1991. Herbs for health. Amer. Horticulturist November:2–4.

Haroon, S. and R.N. Huettel. 1991. Induced hatching and juvenile mortality caused by some medicinal plants to soybean cyst nematodes. Phytopathology 81:702. (Abstr.)

Haseeb, A. and F. Butool. 1990. Evaluation of nematicidal properties in some members of the family *Lamiaceae*. Intl. Nematol. Network Nwsl. 7:24–26.

Hussey, R.S. and K.R. Barker. 1973. A comparison of methods of collecting inocula of *Meloidogyne* species including a new technique. Plant Dis. Rptr. 57:1025–1028.

Inserra, R.N. and H.L. Rhoades. 1989. Some nematode problems of spearmint in Florida. Nematol. Circ. 167.

Kinlock, R.A., C.K. Hiebsch, and H.A. Peacock. 1987. Galling and yields of soybean cultivars grown in *Meloidogyne arenaria* infested soil. J. Nematol. 19:233–239.

Mukhopadhyaya, M.C., T.K. Das, P.R. Chattopadhyay, and T. Bose. 1980. Control of root-knot nematode, *Meloidogyne incognita* with *Typhonium tribolatum*, an annual herb. Nematologica 26:277–280.

Mustika, I. 1992. Effects of *Meloidogyne incognita* and *Fusarium solani* on black pepper (*Piper nigrum* L.). Ind. Crops Res. J. 4:7–13.

Odour-Owino, P. 1993. Effects of aldicarb, *Datura stramonium*, *Datura metel*, and *Tagetes minuta* on the pathogenicity of root-knot nematodes in Kenya. Crop Protection 12:315–317.

Rhoades, H.L. 1988. Effects of several phytoparasitic nematodes on the growth of basil, *Ocimum basilicum*. Ann. Applied Nematol. 2:22–24.

Roberts, P.A. 1992. Current status of the availability, development, and use of host plant resistance to nematodes. J. Nematol. 24:213–227.

SAS Institute. 1985. SAS user's guide: Statistics. Version 5th ed. SAS Institute, Cary, N.C.

Sasser, J.N., C.C. Carter, and K.M. Hartman. 1984. Standardization of host suitability studies and reporting of resistance to root-knot nematodes. Crop Nematode Research and Control Project North Carolina State Univ. Graphics, Raleigh.

Tanda, A.S., A.S. Atwal, and Y.P.S. Bajaj. 1989. In vitro inhibition of root-knot nematode *Meloidogyne incognita* by sesame root exudate and its amino acids. Nematologica 35:115–124.

Trudgill, D.L. 1991. Resistance to and tolerance of plant parasitic nematodes in plants. Annu. Rev. Phytopathol. 29:167–192.

Verma, M.K., H.C. Sharma, and V.N. Pathak. 1978. Efficacy of *Tagetes patula* and *Sesamum oriental* against root-knot of eggplant. Plant Dis. Rptr. 62:274–275.