Supplement to the Journal of Nematology 27(4S):645–648. 1995.

Response of Perennial Herbaceous Ornamentals to *Meloidogyne hapla*

J. A. LaMondia[1]

Abstract: Sixty-nine herbaceous perennial ornamentals in 56 genera were evaluated for root galling after 2 months in soil infested with *Meloidogyne hapla* under greenhouse conditions. Plants were rated susceptible or resistant based on the number of galls present on the root system. Thirty-six percent had more than 100 galls on the roots (similar to 'Rutgers' tomato controls) and were rated susceptible. Thirty percent of the plants tested did not have galls or egg masses present on the root system and were rated resistant. The remaining 34 percent were intermediate in response. Variation in response to *M. hapla* was observed within plant genera and species. The identification of *M. hapla*-resistant perennial ornamentals will aid in management of this nematode in landscapes and production fields.
Key words: Meloidogyne hapla, nematode, nonhost, ornamental, perennial, resistance, root-knot nematode.

Perennial herbaceous ornamentals are a rapidly expanding segment of the floriculture and nursery industry, with an annual gross receipt value of approximately $1 billion in the United States (11). Perennials are propagated by several methods, including seed, division, and cuttings (2). Vegetative methods of propagation are often easier and may produce better, more uniform plants as well as true named cultivars. Unfortunately, vegetative propagation may result in increased spread and distribution of plant-parasitic nematodes, as evidenced by the presence of *Meloidogyne hapla* in 42 of 106 samples of perennial plants submitted over the last 2 years to the Connecticut Agricultural Experiment Station by growers, distributors, and landscapers (LaMondia, unpubl.).

Herbaceous perennials are a diverse group consisting of about 2,500 herbaceous species in approximately 500 genera (9). The host suitability of many of these species to *M. hapla* is unknown, and the limited number of reports do not always distinguish among *Meloidogyne* species (1, 6,10). Approximately 50% of the market for perennials in North America is in the northern and Great Lakes states and Canada, and the percentage of gross sales attributed to perennials is highest in Canada and the Northeast (11). *Meloidogyne hapla* is of particular concern for this market area as this species can readily overwinter and increase in population density over time on perennials in these areas.

Meloidogyne hapla has been reported to damage a number of woody ornamentals (3,4). Unlike the situation with annual plant systems, the concept of damage threshold levels may not apply to nematodes on perennials. Low initial nematode population densities have the potential to increase on susceptible perennial hosts after the planting year and may cause damage after a period of years (3). As a consequence, control of root-knot nematodes in perennial ornamentals presents a challenge. Chemical control can be difficult, and many perennial species are not included on nematicide labels. Sanitation, accomplished by identifying and eliminating *M. hapla* from planting stock, can be important. Rotation with nonhost species can be effective, especially for field-grown perennials (LaMondia, unpubl.), although successful use of rotation requires knowledge about the host status of a large number of plant species. The objective of this research was to evaluate the host suitability of many common perennial ornamentals grown in the Northeast to *M. hapla.*

Received for publication 12 April 1995.
[1] Associate Scientist, Department of Plant Pathology and Ecology, The Connecticut Agricultural Experiment Station Valley Laboratory, P.O. Box 248, Windsor, CT 06095.
The author thanks White Flower Farm, Litchfield, CT, and Sunny Border Nurseries, Kensington, CT, for the generous donation of plant material and Jane Canepa-Morrison, Mary Klepacki, and Jennifer Monoson for technical assistance.

TABLE 1. Galling response of perennial ornamentals grown under greenhouse conditions for 2 months in media infested with *Meloidogyne hapla*

Species	Cultivar	Common name	Gall rating[a]	Literature[b]
Acanthus spinosissiums	—[c]	Bears breeches	4.0	NT
Achillea sp.	Coronation gold	Yarrow	1.0	+
Aconitum arendsii	—	Monkshood	4.0	+
Ajuga reptans	Burgundy glow	Bugleweed	4.0	+
Alchemilla mollis	Improved form	Lady's mantle	1.7	NT
Althea rosea	Chater's doubles	Hollyhock	1.7	+
Aquilegia sp.	Blue star	Columbine	2.6	+
Arabis caucasia	Compinkie	Rockcress	1.5	–
Artemisia sp.	Silver mound	Wormwood	4.0	+
Aster novae-angliae	September ruby	Aster	1.0	+
Aster novae-angliae	Harrington's pink	Aster	1.0	+
Astilbe × arendsii	Peach blossom	Feather flower	4.0	–
Belamcanda chinensis	—	Blackberry lily	1.0	–
Campanula poscharskyana	—	Bell flower	4.0	+
Chelone obliqua	—	Turtlehead	1.0	–
Chrysanthemum coccineum	Giant hybrids	Painted daisy	3.6	+
Chrysanthemum × superbum	Polaris	Shasta daisy	3.0	+
Chrysanthemum × superbum	Exhibition	Shasta daisy	1.0	+
Chrysanthemum parthenium	—	Feverfew	2.7	–
Cimicifuga acerina	—	Fairy candles	4.0	+
Cimicifuga dahurica	—	Fairy candles	4.0	+
Cimicifuga simplex	White pearl	Fairy candles	4.0	+
Clematis sp.	Hagley hybrid	Clematis	4.0	+
Coreopsis verticillata	Moonbeam	Tickseed	4.0	+
Delphinium grandiflorum	Blue mirror	Delphinium	3.2	+
Dianthus barbatus	Indian carpet	Sweet william	1.0	+
Dicentra sp.	Alba	Bleeding heart	2.8	–
Digitalis ambigua	—	Foxglove	1.4	+
Digitalis purpurea	Excelsior hybrids	Foxglove	1.0	+
Doronicum sp.	Magnificum	Leopardbane	2.3	+
Filipendula venusta	Venusta magnifica	Meadowsweet	1.8	–
Gaillardia × grandiflora	Goblin	Blanket flower	1.0	–
Geranium dalmaticum	—	Cranesbill	3.0	–
Helenium autumnale	Brilliant	Sneezeweed	1.0	–
Heliopsis helianthoides	Karat	Orange sunflower	4.0	–
Hypericum polyphyllum	—	St. John's wort	3.4	+
Iris germanica	Afternoon delight	Bearded iris	4.0	+
Iris pumila	Elfin queen	Dwarf iris	1.6	+
Iris siberica	Maranantha	Siberian iris	1.0	+
Lathyrus latifolis	—	Sweet pea	2.7	+
Lavandula angustifolia	Munstead dwarf	Lavender	3.0	+
Liatris scariosa	White spires	Gay feather	1.0	+
Ligularia dentata	Desdemona strain	Senecio	4.0	NT
Lobelia cardinalis	Complement scarlet	Cardinal flower	4.0	+
Lupinus sp.	Russell hybrids	Lupinus	3.0	+
Lycopersicon esculentum	Rutgers	Tomato	4.0	+
Lythrum sp.	Morden's pink	Purple loosestrife	4.0	–
Malva moschata	Alba	Musk mallow	1.7	–
Monarda didyma	Cambridge scarlet	Bee balm	1.0	–
Pachysandra procumbens	—	Alleghany spurge	1.0	+
Pachysandra terminalis	—	Pachysandra	2.4	+
Papaver orientale	Carousel	Oriental poppy	1.0	+
Phlox paniculata	Fairest one	Garden phlox	1.0	+
Phlox stolonifera	Bruce's white	Creeping phlox	1.0	+
Polemonium reptans	Firmament	Jacob's ladder	2.0	–
Potentilla nepalensis	Miss Wilmott	Cinquefoil	3.0	+
Primula × polyanthus	Crescendo mix	Primrose	1.0	+
Rudbeckia sp.	Gold drop	Coneflower	1.0	–

TABLE 1. *Continued*

Salvia azurea	Grandiflora	Meadow sage	2.3	+
Salvia haematodes	—	Meadow sage	4.0	+
Salvia jurisicii	—	Meadow sage	3.4	+
Scabiosa caucasica	Fama	Pincushion flower	4.0	−
Stachys byzantina	Lanatna	Lamb's ear	4.0	+
Stokesia laevis	Blue Danube	Stokes aster	1.4	−
Thalictrum speciosissimum	—	Meadow rue	3.4	−
Tradescantia sp.	J. C. Weguelin	Spiderwort	1.0	+
Verbascum phoeniceum	Benary's hybrid	Mullein	1.4	+
Veronica spicata	Icicle	Speedwell	4.0	+
Vinca minor	Bowles variety	Periwinkle	1.0	+
Viola cucullata	Priceana	Swiss violet	2.0	+

Kruskal-Wallis results: T = 330.37; df = 69; Prob. T > Chi square = 0.0001. ANOVA: MSE = 0.177; df = 361; F = 47.07; P = 0.0001; LSD = 0.14.

[a] Gall ratings: 1 = no galls; 2 = 1–10 galls; 3 = 11–100 galls; 4 = >100 galls per root system. Data are means of five or six observations.

[b] Host status in the literature: + = reported as a host; − = not reported as a host; NT = not reported or not tested.

[c] No cultivar name given.

MATERIALS AND METHODS

Perennial ornamentals were supplied as 1- to 2-year-old potted or bare-root plants. Potted plants were grown in a medium of 41% sand, 22% vermiculite, 22% perlite, and 15% peat, or a blend of 25% compost, 20% perlite, 20% peat, 15% bark, 15% sand, and 5% stone dust. Bare-root plants were potted in a 2:1 mix of pasteurized Merrimac fine sandy loam (73.4% sand, 21.4% silt, 5.2% clay) and Sunshine Mix no. 3 (Fisons Western Corp., Downers Grove, IL). Perennials were grown in pots containing 700 or 1,400 cm^3 mix, depending on plant size. 'Rutgers' tomato (*Lycopersicon esculentum*) plants were grown for 2 months from seed and used as nematode-susceptible controls.

Meloidogyne hapla inoculum consisted of a mixture of isolates originally recovered from lettuce in New York and strawberries or cranesbill geranium in Connecticut. Species identification was confirmed by observation of perineal patterns. Eggs were produced on 'Rutgers' tomato in the greenhouse and extracted with NaOCl (7). A suspension of 10,000 or 20,000 eggs and second-stage juveniles (J2) was placed in four holes per pot for 700 and 1,400 cm^3 pots, respectively. Five to seven replicate pots of each plant species were infested, and three uninfested plants served as controls.

Plants were grown in the greenhouse on a peat bed for 2 months. When galls and egg masses were apparent on nematode-susceptible tomato controls, roots of test plants were washed free of soil and rated for galls. Root galling was rated on a 1–4 scale as follows: 1 = no galls; 2 = 1–10 galls; 3 = 11–100 galls; and 4 = >100 galls per root system. In some cases, such as when small root galls were present on fine roots, the roots were soaked in dilute phloxine B (5) to aid in the identification of egg masses.

Gall ratings were subjected to the nonparametric Kruskal-Wallis test and analysis of variance. Means were separated by LSD.

RESULTS AND DISCUSSION

Plants grown in uninfested soil were not galled and were used to compare root morphology with those grown in infested soil. When both sets of plants had swollen roots or unusual morphology, roots were dissected and examined for root-knot nematodes. The gall ratings of 67 species of flowering perennials in 56 genera varied ($P = 0.001$) and ranged from resistant (rating of 1.0) to susceptible (rating of 4.0) (Table 1). Approximately 30% of the species tested did not develop galls after 2 months and were considered resistant. This was comparable to reports that 25–30% of annual plants are resistant to root-knot nematodes (12,13). Egg masses were not detected in the absence of galls. Mc-

Sorley and Frederick (8) found that gall and egg mass numbers could both be used to rate plant host status and that the results from both were similar for almost all annual bedding plants tested. Additionally, about 38% of the species tested had gall ratings of 3.0 or greater. Many of these plants had several hundred galls and egg masses on the roots. The remaining plants were intermediate in response (15% with ratings of 1.1 to 2.0, and 17% with gall ratings of 2.1 to 3.0).

A comparison of these results to previous reports was attempted, but many reports did not include *Meloidogyne* species and (or) plant cultivar. Seventeen genera or species found to be hosts of *M. hapla* in this report were listed previously as nonhosts (1,6,10) or not found in the literature. Alternatively, 10 genera or species found to be resistant to *M. hapla* in the present study had been reported previously as hosts of root-knot nematodes. These discrepancies occur because plant species may respond very differently to other *Meloidogyne* species (8).

As shown by the responses of *Chrysanthemum, Iris,* and *Pachysandra,* my results also indicate that there may be considerable variation in response to *M. hapla* within genera or even within species. This variation may be important to plant breeders or in the selection of cultivars for use in *M. hapla*-infested soil.

Meloidogyne hapla is the most common and important root-knot nematode species infecting perennials in the Northeast. The identification of species or cultivars resistant to *M. hapla* is an important first step in nematode control by rotation because a considerable percentage of perennial ornamentals are field-grown in nurseries. Long-term rotation with a few *M. hapla*-resistant species has been a successful means of root-knot nematode control in infested nursery field soils (LaMondia, unpubl.). Rotation may also be of use to landscapers and home gardeners planting or replanting in areas infested with *M. hapla*. The long-term effects of nematode infection on herbaceous perennial plant growth and performance remain to be determined.

Literature Cited

1. Anonymous, 1960. Index of plant diseases in the United States. USDA Handbook No. 165. Washington, D.C.
2. Armitage, A. 1991. Best methods for propagating perennials. Greenhouse Grower 9:88–92.
3. Benson, D. M., and K. R. Barker. 1985. Nematodes–a threat to ornamental plants in the nursery and landscape. Plant Disease 69:97–100.
4. Bernard, E. C., and W. T. Witte. 1987. Parasitism of woody ornamentals by *Meloidogyne hapla.* Supplement to the Journal of Nematology 1:41–45.
5. Holbrook, C. C., D. A. Knauft, and D. W. Dickson. 1983. A technique for screening peanut for resistance to *Meloidogyne arenaria.* Plant Disease 67:957–958.
6. Horst, R. K. 1979. Westcott's plant disease handbook, 4th edition. New York: Van Nostrand Reinhold.
7. Hussey, R. S., and K. R. Barker. 1973. A comparison of methods of collecting inocula of *Meloidogyne* spp., including a new technique. Plant Disease Reporter 57:1025–1028.
8. McSorley, R., and J. J. Frederick. 1994. Response of some common annual bedding plants to three species of *Meloidogyne.* Supplement to the Journal of Nematology 26:773–777.
9. Phillips, R., and M. Fix. 1991. Perennials. New York: Random House.
10. Pirone, P. P. 1978. Diseases and pests of ornamental plants., 5th edition. New York: John Wiley.
11. Rhodus, T. 1994. Views on management. Perennial Plants 2:26–34.
12. Singh, J. P., and Q. Majeed. 1991. Screening of ornamental annuals to the root-knot nematode, *Meloidogyne incognita* in Iraq. Indian Phytopathology 44:179–184.
13. Walker, J. T., J. B. Melin, and J. Davis. 1994. Sensitivity of bedding plants to southern root-knot nematode, *Meloidogyne incognita* race 3. Supplement to the Journal of Nematology 26:778–781.