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Resistance of *Lathyrus* Species and Accessions to the Northern Root-knot Nematode, *Meloidogyne hapla*[1]

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Abstract: The leguminous plant genus *Lathyrus* contains many species useful for soil conservation and reclamation. Some of these species may also have value in the United States for forage production. The extent of genetic variation among *Lathyrus* populations in reaction to most disease pathogens is not known. We examined 28 USDA Agricultural Research Service Plant Introduction accessions representing 16 *Lathyrus* species for their ability to tolerate attack by the northern root-knot nematode, *Meloidogyne hapla.* There were differences in the percentage of root tissue galled and in the nematode reproductive index among species and among accessions within species. Root biomass of infected plants was significantly less than that of uninfected plants of the same accession. Accessions of *L. ochrus* and *L. tingitanus* were susceptible to *M. hapla,* whereas *L. latifolius, L. sylvestris,* and *L. hirsutus* were resistant. The variation among *Lathyrus* spp. in root galling and reproductive indices of *M. hapla* warrant the inclusion of these traits in *Lathyrus* breeding programs.

Key words: alfalfa, flatpea, forage, germplasm, grasspea, *Lathyrus,* legume, *Meloidogyne hapla,* nematode, pathogenicity, peavine, perennial pea, vetchling.

The leguminous genus *Lathyrus* contains 130 or more herbaceous annual and perennial species widely distributed as wild and cultivated plants in temperate regions (1,3). This genus was first cultivated in the Balkan peninsula about 8,000 years ago during the Neolithic period (12). *Lathyrus cicera* L., *L. hirsutus* L., *L. latifolius* L., *L. ochrus* (L.) DC., *L. sativus* L., and *L. sylvestris* L. are used for green manure, erosion control, and other conservation purposes. 'Lathco' flatpea, *L. sylvestris,* is a cultivar released in 1972 by the Soil Conservation Service for use in the northeastern United States (14). Roughpea, *L. hirsutus,* is used for soil improvement and early spring pasture in the southern states (13). *Lathyrus japonicus* Wild., *L. maritimus* L., and other perennial species may also have potential in conservation and reclamation as well as in forage production (16). In India and Java, *L. sativus* is an important fodder during cool winter periods.

Although these legumes are of minor economic importance in North America, their wide range of adaptation, resistance to environmental stresses, and potential for increased use in sustainable agriculture and the repair of ecologically damaged sites warrants further cultivar development. Breeders are interested in the genetic improvement of several species (5,6, 10).

Information about the damage induced by plant-parasitic nematodes to *Lathyrus* species is slight and mainly is limited to *L. sylvestris,* which is susceptible to infection by *Meloidogyne incognita* Chitwood and *Heterodera* spp., (11,19). The host status of *Lathyrus* spp. to the northern root-knot nematode, *M. hapla* Chitwood, which commonly occurs in the northwestern United States, is not known. The purpose of this study was to assess the host status and relative resistance of *Lathyrus* species and accessions to *M. hapla.*

Materials and Methods

Seeds of 28 accessions representing 16 *Lathyrus* species were obtained from the USDA Agricultural Research Service Plant Germplasm Introduction and Testing Research Laboratory at Pullman, Washington, and the Forage and Range Research Laboratory at Logan, Utah. Alfalfa (*Medicago sativa* L.) accessions used as reference standards were 'Ranger' (susceptible to *M. hapla*) and 'Syn. XX' (resistant) (7). Seeds were mechanically scarified, germinated, and transplanted into individual 6-cm-d plastic containers containing 540 cm^3 of

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TABLE 1. Root galling, reproduction, and effects of *Meloidogyne hapla* on *Lathyrus* species and plant introductions (PI).

Species	PI number	No. of infected plants	Root gall rating†		Nematode reproductive index‡		Change in dry weight (%)§			
									Total plant	
			Mean	Standard error	Mean	Standard error	Root mean	Shoot mean	Mean	Standard error
L. annuus	255365	10	2.3	0.2	6.6	1.4	−3	124	79	61
	268322	10	1.9	0.2	4.9	1.4	−64	15	−27	8
	Species mean		2.1	0.2	5.8	1.0	−33	69	26	32
L. aphaca	227520	10	2.8	0.2	4.7	0.3	−37	74	43	44
L. cicer	230664	10	1.4	0.2	0.9	0.2	−50	55	34	24
L. cicera	283512	10	1.8	0.2	0.8	0.3	−52	5	−2	18
L. clymenum	283494	10	2.5	0.2	8.3	1.2	−9	38	26	21
	283518	10	1.5	0.2	0.7	0.3	−43	39	22	24
	Species mean		2.0	0.2	4.5	1.1	−25	38	24	15
L. gorgoni	358859	10	1.9	0.2	5.2	1.3	−47	3	−9	20
L. hierosolymitanus	358829	10	2.5	0.2	9.4	0.7	−18	24	17	21
	358832	10	2.4	0.2	8.8	1.4	−62	−8	−22	23
	Species mean		2.5	0.2	9.1	0.8	−40	8	−2	16
L. hirsutus	440462	10	1.1	0.2	0.5	0.1	−17	68	46	33
L. latifolius	236481	10	1.1	0.2	0.2	0.1	−25	18	−6	18
	UT 2921	10	1.1	0.1	0.6	0.2	−61	−27	−45	10
	Species mean		1.1	0.2	0.4	0.1	−43	5	−25	11
L. nigrivalvis	451858	10	2.7	0.2	11.6	1.4	−45	12	−7	14

L. ochrus	226008	10	3.5	0.2	10.5	0.6	−28	−18	−21	10
	422473	8	2.0	0.2	5.9	0.9	15	211	150	150
	Species mean		2.8	0.2	8.5	0.7	−9	85	56	26
L. pseudocicera	358848	10	2.8	0.2	9.9	1.4	−36	35	18	27
L. sativus	230345	10	3.0	0.2	7.6	1.2	−11	27	19	31
	391431	6	1.9	0.2	10.5	3.8	−26	24	13	42
	422532	10	1.8	0.2	5.2	1.0	−29	37	25	24
	422543	10	2.4	0.2	8.9	1.4	2	48	41	41
	426764	10	2.6	0.2	9.2	1.5	−45	27	12	18
	UT 2541	10	2.0	0.2	7.9	1.4	−33	30	20	39
	Species mean		2.3	0.1	8.1	0.7	−24	32	21	15
L. sylvestris	282765	10	1.1	0.2	0.2	0.1	−35	37	−3	36
	348879	4	1.0	0.0	0.1	0.0	−5	110	41	55
	Species mean		1.0	0.1	0.2	0.1	−26	59	10	30
L. szowitsii	269921	10	2.4	0.2	7.1	1.3	−32	6	0	13
L. tingitanus	292797	10	3.3	0.2	57.8	17.2	−21	31	17	17
	493288	10	2.6	0.2	14.4	1.9	−34	11	−3	17
	Species mean		3.0	0.2	36.1	9.8	−27	20	7	12
Lathyrus species mean			2.2	0.1	7.9	0.9	−31	35	16	7
Medicago sativa checks:										
	'Ranger'	10	1.6	0.2	1.5	0.4	−50	17	−14	21
	'Syn XX'	10	1.4	0.2	1.7	0.3	−13	38	13	29
	Species mean		1.5	0.1	1.6	0.2	−32	27	0	18
Mean of all accessions			2.1	0.1	7.5	0.8	−31	35	15	6
LSD (P = 0.05)			0.6		9.4		37	89	69	

† Rated on a scale of 1 to 6: 1 = no galls, 2 = 1 to 10% root tissue galled, 3 = 11 to 30% root tissue galled, 4 = 31 to 50% root tissue galled, 5 = 51 to 80% root tissue galled, and 6 = 81 to 100% root tissue galled.

‡ Reproductive index = Pf/Pi where Pf = the final number of nematodes per plant and Pi = the initial number of nematodes per plant.

§ Change in dry weight = ([Infected plant weight − Uninfected plant weight]/Uninfected plant weight) × 100.

steam-sterilized Kidman fine sandy loam soil (coarse–loamy mixed mesic Calcic Haploxeroll; 84% sand, 8% silt, 8% clay; pH 7.4, 1.0% OM) from 29 August to 26 September 1990. Before transplanting, seedlings were inoculated with commercial peat-based *Rhizobium leguminosarum* Frank inocula appropriate for the macrosymbiont species. Single-plant experimental units were arranged in a randomized complete block design with 10 replications.

The *M. hapla* population used in this study was collected initially from lettuce (*Lactuca sativa* L.) at Ogden, Utah, and cultured on 'Rutgers' tomato (*Lycopersicon esculentum* Mill.) under greenhouse conditions. Inocula (eggs) were collected using sodium hypochlorite (9). After 21–28 days of plant growth, 1,000 *M. hapla* eggs per container in an aqueous suspension were poured into four holes (10 cm deep) in the soil around the base of each plant. Plants were grown in a greenhouse at 26 ± 3 C, and supplemental light for a 19-hour daylength was provided by high-output fluorescent lamps.

Sixty days after inoculation with *M. hapla* eggs, host resistance (4) and nematode population responses were assessed by the procedures of Griffin et al. (8). Each plant was evaluated for the percentage of root tissue galled on a scale of 1 to 6 with 1 = no galls, 2 = 1 to 10%, 3 = 11 to 30%, 4 = 31 to 50%, 5 = 51 to 80%, and 6 = 81 to 100%. Eggs were extracted from root tissue (9), and the nematode reproductive index was computed as $Ri = Pf/Pi$, where Ri is the reproductive index, Pf is the final number of nematodes per plant, and Pi is the initial number of nematodes per plant (in this case, Pi = 1,000). For our purposes, we consider that an index of less than 1.0 indicates resistance, whereas an index greater than 1.0 indicates susceptibility (4).

Plant tolerance (4) was assessed by the differences in the root, shoot, and entire plant mean dry weights of infected plants minus those of noninfected plants expressed as a percentage of the mean weights of noninfected plants for each accession. Data were analyzed by the method of least squares to fit general linear models, and by correlation procedures (18).

Results

Values of root-gall indices were small in the majority of *Lathyrus* spp. accessions and also in the resistant and susceptible alfalfas (Table 1). Root gall ratings, however, differed ($P < 0.01$) among accessions within the *Lathyrus* species, among the *Lathyrus* species, and between the two genera. No galls were observed on the roots of four plants of one accession (PI 358879) of *L. sylvestris* from Yugoslavia. The most galls were found on PI 226008, an *L. ochrus* introduced from Israel, which had a mean gall rating of 3.5. Both accessions of *L. tingitanus* L. also were galled severely by *M. hapla.*

Lathyrus latifolius, L. sylvestris, and one accession of *L. hirsutus* appeared to be highly resistant to northern root-knot nematodes as indicated by the low levels of galling and reproductive indices below 1.0. Mean nematode reproductive indices ranged from 0.1 for the highly resistant accession of *L. sylvestris* from Yugoslavia, PI 358879, to 57.8 for a highly susceptible *L. tingitanus* introduction from Sweden, PI 292797. As with the gall ratings, *L. latifolius* and *L. sylvestris* also had the lowest mean reproductive indices of less than 0.5 and *L. tingitanus* had the highest reproductive index, exceeding 35.0 (Table 1). Nematode reproduction levels on the two alfalfa accessions were similar. Overall, the mean reproductive index for the genus *Lathyrus* was about 5 times greater ($P < 0.05$) than that for *Medicago* (Table 1); however, there were highly significant ($P < 0.01$) differences among *Lathyrus* species and accessions. The two measures of resistance, gall rating and reproductive index, were positively correlated ($r = 0.49$; $P < 0.01$).

Mean dry root weight of infected *Lathyrus* plants was 0.18 ± 0.01 g and that of uninfected plants was 0.35 ± 0.02 g ($P < 0.01$). The average reduction in root weight of *Lathyrus* plants was 31%. However, dry shoot weights of infected (1.26 ± 0.05 g) and uninfected (1.25 ± 0.06 g) plants were essentially the same ($P > 0.05$). Average total dry weight was 1.44 ± 0.06 g for infected plants and 1.59 ± 0.07 g for uninfected plants. *Lathyrus* species did not differ in their tolerance to *M. hapla,* as measured by changes in weight of shoots or entire plants ($P > 0.05$). None of the tolerance traits were strongly associated with either the gall rating or the reproductive index values ($r = \leqslant -0.13$; $P > 0.05$).

Discussion

The gall ratings and the nematode reproductive index of several accessions within *Lathyrus* spp. differed enough to provide sources of resistance for genetic improvement. As in an earlier survey of *Lathyrus* germplasm for resistance to *Cercospora* (15), some lines were highly resistant to *M. hapla.* It would be useful to determine the relationship between resistance and root concentrations of lathyrogenic toxins (1,2). Evaluating a broad range of germplasm and then selecting and increasing the more resistant introductions has often resulted in sufficient improvement for the release of economically important cultivars of minor legume species (16,17).

Root-knot nematode infection markedly reduced the biomass of *Lathyrus* plant roots but did not reduce above-ground growth in the majority of the plants tested. Shoot growth or forage yield of plants grown in favorable environments could not be used to screen *Lathyrus* germplasm for resistance to northern root-knot nematode because the above-ground growth masks the relative susceptibility or resistance of accessions. Total weight of infected plants was 16% greater than that of uninfected plants. Environmental conditions under which the study was conducted must, however, be taken into consideration. The limited sample of *Lathyrus* species studied did not differ in whole plant tolerance to the northern root-knot nematode when grown in an adequately fertilized and watered greenhouse environment. The significant reduction in root weight indicates that infected plants exposed to drought stress could be more severely affected by the nematode parasitism. Plant responses in a more stressful environment might reveal genetic differences of value in plant breeding programs.

The magnitude of the observed reactions among *Lathyrus* species and accessions to *M. hapla* indicate that screening and selection of plants for root-knot resistance would be possible. Resistance to *M. hapla* is an attribute that should be considered when breeding and improving *Lathyrus* for forage production and adaptation.

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