Response of Two Alfalfa Cultivars to *Meloidogyne hapla*[1]

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Soil infestations of the northern root-knot nematode *Meloidogyne hapla* Chitwood are common on alfalfa (*Medicago sativa* L.) in temperate areas of Europe and North America (1,3). Field observations indicate that newly planted alfalfa seedlings may be damaged by *M. hapla* and that the Washoe cultivar has a damage threshold level in the greenhouse of less than one nematode per cm^3 of soil (6).

To obtain further information on the relationship between alfalfa growth and initial densities of two native populations of *M. hapla,* greenhouse experiments were conducted in Bari, Italy, and Prosser, Washington, on *M. hapla* susceptible 'Washoe' and resistant 'Nevada Syn XX' alfalfa.

Bari, Italy: Cylindrical plastic pots (5 × 30 cm) each containing 500 cm^3 of steam-pasteurized sandy loam soil (66% sand, 21% silt, 11% clay, 2% organic matter) were infested with *M. hapla* eggs (P_f) in geometric series from 0 to 1,024 eggs/cm^3 soil (Fig. 1A). The eggs, obtained from a *M. hapla*-infested sugarbeet (*Beta vulgaris* L.) field and cultured on tomato (*Lycopersicon esculentum* Mill. cv. Roma) in a greenhouse, were recovered by the NaOCl method (5). Inoculum for each level was thoroughly mixed into the soil and placed in pots. Pots were individually planted with three pregerminated seeds of either *M. hapla*-susceptible Washoe or resistant Nevada Syn XX alfalfa, randomized in eight replicates and maintained at 23–26 C on a greenhouse bench. Plants were thinned after emergence to one seedling per pot. After 60 days, the above-ground parts were harvested, oven-dried, and weighed. The roots were left in the pots for another 20 days and then removed. The soil was mixed

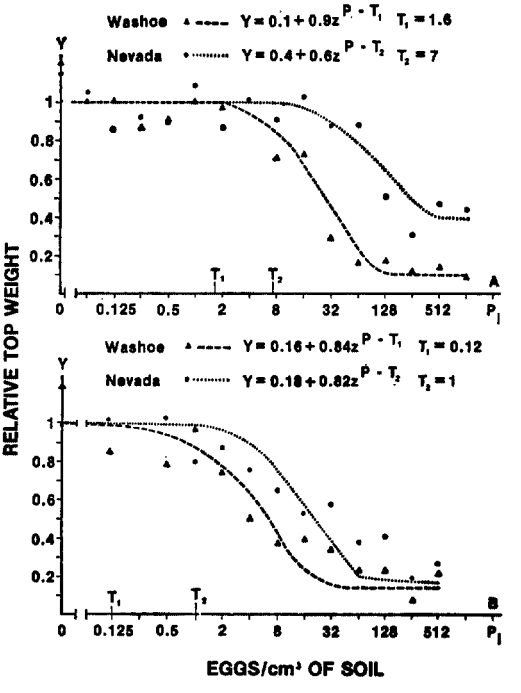

Fig. 1. Relationship between the initial density (P_f) of an Italian (A) and an American population (B) of *Meloidogyne hapla* and the relative dry weight of tops of susceptible (Washoe) and resistant (Nevada Syn XX) alfalfa cultivars, 60 days after planting in infested soil.

and 50-cm^3 soil aliquants were placed in Baermann funnels for extraction of second-stage juveniles (J_2).

Prosser, Washington: Plastic pots (7 × 7 × 10 cm) each containing 450 cm^3 of bromoethane-treated loamy sand (82.3% sand, 14.5% silt, 2.9 clay, 0.3 % organic matter) were infested as previously described. The inoculum was obtained from a nematode-infested alfalfa field and cultured on 'Rutgers' tomato in a greenhouse. Each pot was planted with a single pregerminated seedling; the plants were grown in a greenhouse as previously described. Plants were harvested after 60 days; tops were oven-dried and weights recorded. Roots were immediately examined for nematode infection and reproduction; reproduction was determined by counting eggs recovered by the NaOCl method (5) from infected roots of each plant.

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Plant response to the initial populations (P_i) was fitted to the model $y = m + (1-m)z^{P-T}$ for $P > T$ and $y = 1$ for $P < T$ (where y = relative yield, m = relative minimum yield, $z < 1$, P = initial nematode density, $z^{-T} = 1.05$, and T = tolerance limit) (7). Tolerance limits to the Italian population were 1.6 and 7 eggs/cm^3 soil for the susceptible and resistant cultivars, respectively (Fig. 1A); tolerance limits to the Washington State population were 0.125 and 1 egg/cm^3 soil for the susceptible and resistant cultivars, respectively (Fig. 1B). Tolerance limits and minimum yields were consistently different between varieties for both nematode populations. Greater tolerance limits of both cultivars to the Italian *M. hapla* population than to the American population, suggested that the American population was more virulent. However, the diverse geographical and soil conditions of the two experiments may have played an important role in the different degrees of virulence of the two nematode populations. Maximum growth suppression was 90% for Washoe and 60% for Nevada Syn XX with the Italian population and 84% and 82%, respectively, with the Washington State population.

It was difficult to compare nematode reproduction among the various cultivar × population combinations, since the relative extraction efficiencies for the final population measurements were unknown. If the extraction efficiency of the Italian population was 25%, reproduction occurred on Washoe at low population densities (Fig. 2, Table 1). The plant damage at the highest initial densities resulted in final den-

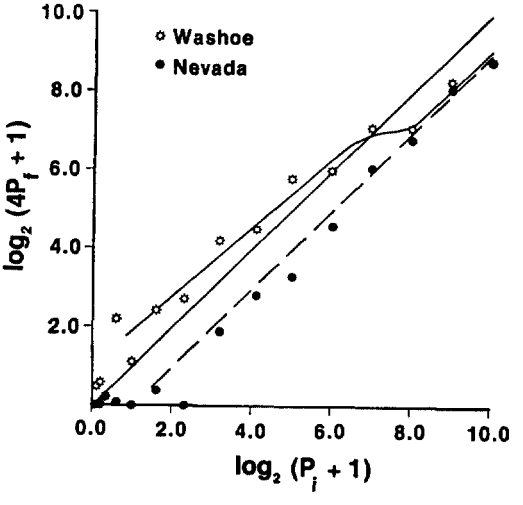

Fig. 2. Relationship between initial (P_i) and final (P_f) density of an Italian population of *Meloidogyne hapla* on the susceptible (Washoe) and resistant (Nevada Syn XX) alfalfa cultivars.

Table 1. Number of *Meloidogyne hapla* second-stage juveniles (J_2) of an Italian population and eggs produced by an American population on susceptible (Washoe) and resistant (Nevada Syn XX) alfalfa cultivars 80 and 60 days after planting in infested soil.

Initial nematode density (eggs/cm^3 of soil)	Final population			
	Italian† (J_2/cm^3 soil)		American‡ (eggs/g fresh root)	
	Washoe	Nevada Syn XX	Washoe	Nevada Syn XX
0.063	0.10	0.00	—	—
0.125	0.12	0.00	0.17	0.00
0.25	0.04	0.04	—	—
0.5	0.90	0.02**	0.22	0.00
1.0	0.28	0.00**	1.14	0.00
2.0	1.04	0.08**	2.96	0.01
4.0	1.34	0.00**	4.10	0.00
8.0	4.24	0.68*	5.33	0.01
16.0	5.48	1.50*	2.78	0.00
32.0	13.88	2.20*	2.64	0.02
64.0	15.00	5.94**	0.22	0.00
128.0	33.12	16.72*	0.22	0.00
256.0	33.80	28.48	0.11	0.04
512.0	78.86	67.74	0.14	0.00
1024.0	109.74	111.44	—	—

* and ** indicate a lower ($P = 0.05$ and 0.01, respectively) nematode density in the Italian population comparing Nevada Syn XX to Washoe according to the Student t test.

†80 days after planting in infested soil.

‡60 days after planting in infested soil.

sities that were lower than initial densities (Fig. 2, Table 1). Assuming a similar extraction efficiency for the Washington State population, the general nature of the relationship between initial and final nematode densities on Washoe was similar to the Italian population. The final densities of J_2 of the Italian population were lower than the initial densities at all inoculum levels in the resistant Nevada Syn XX (Fig. 2, Table 1). Only a few eggs in the American final population were detected on the resistant Nevada Syn XX (Table 1).

The results of these experiments confirm a low tolerance limit for Washoe seedlings to the Washington State *M. hapla* population. The tolerance limit to the Italian population was slightly higher than previously reported (6), perhaps because of more uniform distribution of inoculum about root systems. The data confirm the resistance of Nevada Syn XX to other *M. hapla* populations in addition to that reported by Griffin (4). However, early growth of the resistant Nevada Syn XX was inhibited by high numbers of the Italian and American *M. hapla* populations, even though nematodes reproduced poorly or not at all (Fig. 1 A–B, Table 1). The highest nematode densities used in these studies, although generally greater than those under field conditions, caused growth suppression of both cultivars in the seedling stage. Consequently, stand establishment of the resistant cultivar is a potential problem at high population densities of *M. hapla*. Suppressed plant growth is usually of limited duration in the field, because nematode damage is greater in small seedlings than in older plants and the value of m increases with plant age (2). Yield loss is usually the result of stand loss in the seedling stage and increased weed competition.

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