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Comparison of Compatible and Incompatible Response of Potato to *Meloidogyne incognita*[1]

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Abstract: One susceptible (D6) and two resistant (E2 and N4) clones of *Solanum sparsipilum* × (*S. phureja* × haploid of *S. tuberosum*) were used to study the responses of potato roots and tubers to race 1 of *Meloidogyne incognita* (Kofoid & White) Chitwood. The compatible response was characterized by rapid penetration of large numbers of second-stage juveniles (J2) into roots, cessation of root growth, and occasional curving of root tips. The life cycle of *M. incognita* in the susceptible clone was completed in 25 days at 23–28 C. The incompatible response was characterized by penetration of fewer J2 into roots, necrosis of feeding sites within 2–7 days, and lack of nematode development. There were no differences in response of tubers from resistant and susceptible clones to nematode infection. Small numbers of J2 were detected in tubers, but they did not develop.

Key words: Meloidogyne incognita, Solanum sparsipilum, Solanum phureja, Solanum tuberosum, potato, root-knot, resistance, susceptibility, compatibility.

Although there are several reports of resistance in *Solanum* spp. to *Meloidogyne* spp. (1,3,5,6,10), we found only two reports that dealt with resistant (incompatible) responses of potato to root-knot nematodes. In one case, only a few larvae penetrated the roots of a resistant cultivar and none developed to maturity (7). In the other, penetration was delayed and development was inhibited in the resistant cultivar (11). Histopathology is not described in these two reports. The only attempt to study tuber response to root-knot nematodes indicated that tubers of a resistant cultivar were not infected when artificially inoculated with *M. incognita* (7). Our objective was to determine the nature of an incompatible response in potato to *M. incognita* and the relation between root and tuber response.

Materials and Methods

Penetration, histopathology, and nematode development: Clones E2 and N4 from a diploid cross of *Solanum sparsipilum* (Britt.) Juz. et Buk. × (*S. phureja* Juz. et Buk. × haploid of *S. tuberosum* L.) were selected for these studies. Both clones are resistant to race 1 of *M. incognita* (2). Clone D6 of the same hybrid cross was used as a susceptible check. Seeds of this cross were obtained from the International Potato Center, Lima, Peru.

Stem cuttings from plants of these potato clones grown in a greenhouse were rooted in vermiculite. After 7–8 days, cuttings with good root primordia were transplanted to specially designed growth trays containing a layer of sterile vermiculite 3 cm deep. Vermiculite in the trays was covered by a sheet of miracloth disinfected with 1% sodium hypochlorite. A styrofoam support in the trays had two rabbet apertures—one at the bottom to allow roots to grow in the basal layer of vermiculite of the tray and the other facing the miracloth to allow roots to grow horizontally over the miracloth. After roots grew over the miracloth, they were carefully arranged for inoculation. The tray, except the part supporting the cuttings, was covered with aluminum foil. Two small holes were made in the foil to permit watering. Trays were placed in a greenhouse at 23–28 C with automatic watering to keep the miracloth constantly wet. When the roots were about 5 cm long, a piece of miracloth (2 × 3 cm) was placed over the root tip and wetted with two or three drops of distilled water. Thirty freshly hatched juveniles (J2) suspended in 2–3 drops of distilled water were placed on the piece of miracloth over the root tip. At various intervals after inocu-

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TABLE 1. Reproduction of *Meloidogyne incognita* on compatible and incompatible clones of *Solanum sparsipilum* × (*S. phureja* × *S. tuberosum*).

Clone	Pi† (eggs/plant)	Eggs/plant after inoculation		Pf/Pi‡
		50 days	75 days	
N4 (incompatible)	10,000	0	0	0
E2 (incompatible)	10,000	0	0	0
D6 (compatible)	10,000	14,720	40,160	4.0

† Pi = initial population.
‡ Pf = final population.

lation, three root tips per treatment were cut 3–4 cm above the inoculation point, stained in acid fuchsin-lactophenol, and examined. Roots were examined 12, 24, and 36 hours and 2, 3, 4, 5, 7, 9, 12, 15, 20, 25, and 30 days after inoculation. In addition, root tips of clones E2 and D6 were collected 12, 24, and 36 hours after inoculation; after being fixed, dehydrated, and embedded in resin (8), they were cut into 40–50-m sections.

Comparison of tuber and root infection: Stem cuttings of the same clones used for penetration studies were rooted in vermiculite. After 8–9 days, three plants per clone were transplanted to 1,000-cm^3 clay pots filled with a mixture of organic soil, sand, and peat (2-1-1). Pots were placed in a growth chamber at 22 C day and 18 C night temperatures with a 16-hour day length. Two days after transplanting, each plant was inoculated with 10,000 eggs; at 50 and 75 days after the first inoculation, each plant was reinoculated with 12,500 eggs. Nematode reproduction in the roots was measured by extracting eggs with sodium hypochlorite (4) 50 and 75 days after the first inoculation. Tuber sections were stained in cold acid fuchsin-lactophenol and examined for nematode reproduction. To study post harvest nematode development, 15 tubers of each clone were stored at room temperature. After 25, 50, and 100 days of storage, tuber sections of five tubers of each clone were stained and examined microscopically.

RESULTS

Compatible response: Meloidogyne incognita juveniles (J2) penetrated the roots of the susceptible clone D6 within 12 hours of inoculation. At 36 hours, up to 11 J2 per root tip were observed and gall formation had begun. Penetration continued for 15 days averaging 2–3 J2 per root tip with a maximum of 22 J2 per root tip. At day 3, necrosis was evident around the tail of one J2, but necrosis was never observed around a head or in the absence of a nematode. At day 6, galls had formed and J2 started to swell. Sexual differentiation was distinguishable at day 12; most of the nematodes were females. Third-stage males and females were evident at day 20. At day 25, adult males and females containing eggs were evident. At day 30, egg masses were present outside the roots.

Incompatible response: Both resistant clones, N4 and E2, responded similarly to infection by *M. incognita.* Few J2 had penetrated roots within 12 hours of inoculation, but maximum penetration did not occur until 2 days after inoculation. Numbers of J2 per root ranged from 0.2 to 7 with an average of 4.3. Up to 3 days after in-

TABLE 2. Penetration of *Meloidogyne incognita* juveniles into tubers of compatible and incompatible clones of *Solanum sparsipilum* × (*S. phureja* × *S. tuberosum*).

Clone	Eggs/plant			Juveniles/tuber		
	Pi*	P50†	P75‡	50 days	75 days	125 days§
N4 (incompatible)	10,000	12,500	12,500	0	4.0	1.7
E2 (incompatible)	10,000	12,500	12,500	0	1.0	1.0
D6 (compatible)	10,000	12,500	12,500	0	1.3	2.7

* Pi = initial inoculum.
† P50 = inoculation 50 days after first inoculation.
‡ P75 = inoculation 75 days after first inoculation.
§ No significant difference between clones.

oculation, some J2 were observed emerging from roots of both clones.

Necrosis was first evident at day 2 in clone N4 and at day 7 in clone E2. In some cases, necrosis was mainly around the head of the juvenile, whereas in others, J2 were surrounded with extensive necrosis. No evidence of giant cell formation was observed. At day 15, J2 were disintegrated. At day 20, some roots had fragments of J2, but at day 25, only necrotic areas were observed.

Reproduction in roots and penetration of tubers: No nematode reproduction was detected in the roots of the resistant clones, E2 and N4, at either 50 or 75 days after inoculation. In the susceptible clone, D6, nematode populations were 14,720 eggs per plant at 50 days and 40,160 eggs per plant at 75 days after the first inoculation (Table 1).

No nematodes were detected in the tubers of any clone 50 days after the first inoculation (Table 2). Small numbers of J2 were detected in tubers of all clones 75 and 125 days after the first inoculation, but there was no evidence of galling of the tubers. No nematodes or signs of infection were evident in any of the post-harvest stored tubers.

Discussion

Clone D6 had a compatible response to *M. incognita* involving considerable root penetration, whereas clones E2 and N4 exhibited incompatible responses with much less root penetration. These studies indicated that attraction of J2 to the root was not as great with resistant as it was with susceptible plants. Localized necrotic areas in the roots observed close to the nematode suggest that J2 migrate while feeding.

The primary incompatible response of potato to *M. incognita* appears to be hypersensitivity to nematode invasion and (or) feeding. Soon after nematode invasion of roots of resistant plants, cells become necrotic and the nematode disintegrates. So far, hypersensitivity is the only type of incompatibility reported in potatoes to root-knot nematodes (7,11). The observation of juveniles exiting roots of the resistant clones suggest that such a phenomenon may be a function of resistance in potato to *M. incognita.* Recent studies with *Globodera rostochiensis* Berhans indicate that exiting of J2 from roots of resistant potato cultivars is a function of resistance in potato to this nematode (9).

Identification of different types of incompatible responses in plants may facilitate the selection for better types of resistance. The good growth and yield of clone E2 under high population densities of *M. incognita* (2) may be related to incompatibility involving exiting of juveniles as well as hypersensitivity to infection. The incompatible response of this clone was delayed and involved less extensive necrosis.

The methodology used in these experiments was simple, practical, fast, and efficient for the purpose of this study. It facilitated a rapid contact between the nematode and the root. The amount of root examined was minimal and sampling error was reduced. Although it is not practical for general screening, the method appears useful for a quick response determination (about 10 days) of selected plant material. Successful nematode development in the compatible clone indicates that this method could be used in other types of studies.

Under the conditions of these tests, differences in nematode penetration and reproduction existed in roots but not in tubers of susceptible and resistant clones. Penetration of tubers by the nematode was delayed and limited, even in those tubers from the susceptible clone. Because nematode penetration and symptom development were suppressed in tubers, it appears that penetration and development of *M. incognita* in tubers requires higher temperatures than those required for parasitism of potato roots, as suggested by Mai et al. (8).

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