RESPONSE OF WILD AND CULTIVATED POTATO CLONES TO ITALIAN POPULATIONS OF ROOT KNOT NEMATODES *MELOIDOGYNE* SPP.

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ABSTRACT

Di Vito, M., N. Greco, D. Carputo, L. Frusciante 2003. Response of wild and cultivated potato clones to Italian populations of root-knot nematodes *Meloidogyne* spp. Nematropica 33:65-72.

The reaction of potato clones of *Solanum acaule*, *S. bulbocastanum*, *S. canasense*, *S. cardiophyllum*, *S. chacoense*, *S. commersonii*, *S. etuberosum*, *S. fendleri*, *S. tarijense*, *S. tuberosum* and *S. tuberosum* × *S. phureja* to Italian populations of *Meloidogyne arenaria*, *M. hapla, M. incognita* and *M. javanica* was evaluated in a glasshouse. Five seedlings of each clone were transplanted into trays filled with steam sterilized sandy soil and inoculated with 10,000 eggs of each nematode species per plant. One clone each of *S. chacoense* and *S. tuberosum* were resistant to all *Meloidogyne* spp. tested. One clone each of *S. commersonii, S. tarijense* and *S. tuberosum* were resistant only to *M. javanica*. The remaining clones were susceptible to all four species of root knot nematodes. The potential of resistant genotypes in potato breeding is discussed.

Key words: *Meloidogyne* spp., potato, resistance, root knot nematodes, *Solanum* spp.

RESUMEN

Di Vito, M., N. Greco, D. Carputo, L. Frusciante 2003. Respuesta de clones de papa silvestres y cultivados a poblaciones italianas del nematodo agallador *Meloidogyne* spp. Nematropica 33:65-72.

Se evaluó en invernadero la reacción de clones de *Solanum acaule*, *S. bulbocastanum*, *S. canasense*, *S. cardiophyllum*, *S. chacoense*, *S. commersonii, S. etuberosum*, *S. f*endleri, *S. tarijense*, *S. tuberosum* and *S. tuberosum* × *S. phureja* a poblaciones italianas de *Meloidogyne arenaria*, *M. hapla*, *M. incognita* y *M. javanica*. Cinco semillas de cada clon fueron trasplantadas a bandejas que contenían suelo arenoso tratado con vapor e inoculado con 10000 huevos de cada especie de *Meloidogyne*. Solamente un clon de *S. commersoni*, uno de *S. tarijense* y uno de *S. tuberosum* presentaron resistencia a *M. javanica*. Todos los demás clones resultaron susceptibles a las cuatro especies de *Meloidogyne* evaluadas. Se discute el potencial de los genotipos resistentes en el mejoramiento de la papa.

Palabras claves: Meloidogyne spp., papa, resistencia, nemátodos agalladores, *Solanum* spp.

INTRODUCTION

Potato is among the world's most cultivated crops for human consumption. In many areas, plant parasitic nematodes are among constraints which limit its productivity (Jatala and Bridge, 1990; Brodie *et al.*, 1993). In Italy, potato is mainly planted from mid fall to early spring, and harvested from early spring to early fall. However, in the coastal area of south Italy, as well as many other Mediterranean countries, potato also is planted in late summer to be harvested in the fall. Under these conditions, warm season species of root-knot nematodes (*Meloidogyne* spp.), which are rather common in Mediterranean and tropical climates (Mendoza and Jatala, 1985), may cause damage to young plants. Control of root-knot nematodes by crop

rotation is rather difficult because of their wide host ranges. Other control strategies are usually expensive and some may also cause pollution. The use of resistant cultivars could be a more viable option to control these pathogens.

Unfortunately, only little attention has been given to screening and breeding for resistance to *Meloidogyne* spp. (Phillis, 1994) in potato, and no potato cultivar resistant to these nematodes is available in Europe. Therefore, genotypes of wild *Solanum* species and clones of the cultivated potato *S. tuberosum* at an advanced selection stage were screened for resistance to the most common root-knot nematodes occurring in Italy. The aim of this work was to identify new sources of resistance to be used in future breeding programs.

MATERIALS AND METHODS

Plant material tested is listed in Table 1. The three *S. tuberosum* advanced clones and

Table 1. Clones, pedigree and ploidy of potato plant material used in this study.

Clone	Pedigree	Ploidy
CS8617	*Solanum tuberosum*, DTO14XW879	4x
CS8621	*S. tuberosum,* Vivax × Rosalie	4x
CS8632	*S. tuberosum,* Superior × M6	4x
acl 1A	*S. acaule*, PI 210029	4x
acl 1E	*S. acaule*, PI 210029	4x
acl 2A	*S. acaule*, PI 472652	4x
blb 1E	*S. bulbocastanum,* PI 275190	2x
blb 2A	*S. bulbocastanum,* PI 275188	2x
blb 2D	*S. bulbocastanum,* PI 275188	2x
blb 2E	*S. bulbocastanum,* PI 275188	2x
can 1B	*S. canasense*, PI 265863	2x
cph 1C	*S. cardiophyllum*, PI 283062	2x
cph 2D	*S. cardiophyllum*, PI 347759	2x
cph 2E	*S. cardiophyllum*, PI 347759	2x
chc 1C	*S. chacoense*, PI 133124	2x
chc 1E	*S. chacoense*, PI 133124	2x
cmm 1T	*S. commersonii*, PI 243503	2x
etb 3	*S. etuberosum*, UA1318	2x
fen 1D	*S. fendleri*, PI 275165	4x
fen 1E	*S. fendleri*, PI 275165	4x
fen 2D	*S. fendleri*, PI 458417	4x
tar 1C	*S. tarijense*, PI 414150	2x
tar 2B	*S. tarijense,* PI 414148	2x
UP88P5	*S. phureja* × *S. tuberosum*	2x

the *S. tuberosum* × *S. phureja* hybrid were produced by the University of Naples breeding program, and were available as *in vitro* tissue culture plants. All the other wild species came as true seed from IR-1 Potato Introduction Project, Sturgeon Bay, WI. The wild species, included three clones of *S. acaule* Bitter (2n = 4x = 48), four of *S. bulbocastanum* Dunal (2n = 2x = 24), one of *S. canasense* Hawkes (2n = 2x = 24), three of *S. cardiophyllum* Lindl (2n = 2x = 24), two of *S. chacoense* Bitter (2n = 2x = 24), one of *S. commersonii* Dunal (2n = 2x = 24), one of *S. etuberosum* Lindl (2n = 2x = 24), three of *S. fendleri* A. Gray (2n = 4x = 48)and two of *S. tarijense* Hawkes (2n = 2x = 24).

The nematode populations tested were *Meloidogyne incognita* (Kofoid *et* White) Chitwood host race 1 (Taylor and Sasser, 1978; Di Vito and Cianciotta, 1991) from sugarbeet at Castellaneta (province of Taranto), *M. javanica* (Treub) Chitwood from peach at San Ferdinando (province of Foggia), *M. arenaria* (Neal) Chitwood host race 2 from peach at Verona and *M. hapla* Chitwood from sugarbeet at Foggia. Nematodes were reared on tomato (*Lycopersicon esculentum* Mill.) cv Rutgers in a glasshouse at 26 ± 2°C and the inoculum was extracted from infested roots by using the sodium hypochlorite method (Hussey and Barker, 1973).

Seeds of wild species were germinated *in vitro*, and random seedlings from each plant introduction were chosen for screening and maintained as micropropagated plants on MS medium with 1% sucrose and 0.8% agar, and incubated at 4000 lux, 16 h light, 24°C (Carputo *et al.*, 1996). To produce material for screening tests, 4-week-old plants of each genotype were transferred into styrofoam trays containing sterile soil, allowed to acclimate and then transferred to plastic trays filled with steam sterilized sandy soil. Seven days later, five seedlings of each clone were inoculated with 10,000 eggs and juveniles per plant of each root knot nematode population. Tomato cv Rutgers was used as a susceptible control and good nematode reproduction host.

Trays with potato plants were randomly arranged on benches in a glasshouse maintained at 26 ± 2°C. Forty days after inoculation the plants were uprooted, the roots were gently washed free of adhering soil and the egg masses stained by dipping the roots in a Phloxine B solution (0.15 g/l tap water) for 15 minutes (Dickson and Ben Struble, 1965). The gall and egg mass indexes were assessed according to a 0-5 scale, where 0 = 0 gall and/or egg masses, 1 = 1-2 galls and/or egg masses, 2 = 3-10, 3 = 11-30, 4 = 31-100 and 5 = more than 100 galls and/or egg masses (Taylor and Sasser, 1978). Genotypes were considered resistant when the average gall and/or egg mass index was ≤ 2 (Taylor and Sasser, 1978). The resistant clones were re-tested to confirm their resistance.

Data were statistically analyzed by ANOVA and compared with Duncan's tests (Duncan, 1955).

RESULTS AND DISCUSSION

The greenhouse conditions during the experiment (26 ± 2°C and 30-70% of RH) favoured the development of potato clones and nematode populations. Observation of roots of the susceptible tomato revealed that the gall index was maximum (rated 5).

Significant differences were found among tested genotypes in terms of both gall index and egg mass index. Of the *S. tuberosum* clones evaluated, CS8617 showed mean gall indices of 1, 0, 0 and 0.4 when inoculated with *M. arenaria*, *M. hapla*, *M. incognita* and *M. javanica*, respectively (Table 2). Low gall ratings were confirmed by the observation of no to few egg masses (Table 3). Therefore, *S. tuberosum* CS8617

Table 2. Root gall index of *Meloidogyne arenaria*, *M. hapla*, *M. incognita* and *M. javanica* on roots of wild and cultivated potato clones.

Solanum spp.	Clone	Gall index (0-5)			
		M. arenaria	*M. hapla*	*M. incognita*	*M. javanica*
S. tuberosum	CS8617	1.0 A b*	0 A a	0 A a	0.4 A a
"	CS8621	=	=	=	2.4 BC b
"	CS8632	3.8 BC cde	3.4 B c	3.8 BC cde	2.0 B b
S. acaule	acl 1A	4.4 BC de	4.2 BC cde	4.0 BCD de	3.8 DE cd
"	acl 1E	3.8 BC cde	3.4 B c	4.2 BCD def	3.4 CD c
"	acl 2A	4.2 BC cde	3.8 BC cd	4.4 CD def	3.8 DE cd
S. bulbocastanum	blb 2A	3.8 BC cde	=	4.2 BCD def	3.4 CD c
"	blb 2D	4.2 BC cde	4.2 BC cde	4.2 BCD def	3.4 CD c
"	blb 1E	4.6 C e	4.2 BC cde	4.0 BCD def	4.0 DE cde
"	blb 2E	4.2 BC cde	4.4 BC de	4.0 BCD de	3.6 DE c
S. canasense	can 1B	4.2 BC cde	4.8 C e	5.0 D f	4.6 DE de
S. cardiophyllum	cph 1C	3.8 BC cde	3.4 B c	4.6 CD ef	4.6 DE de
"	cph 2D	3.8 BC cde	4.6 C de	5.0 D f	4.8 E e
"	cph 2E	4.2 BC cde	4.4 BC de	5.0 D f	4.8 E e
S. chacoense	chc 1C	4.2 BC cde	3.4 B c	3.6 BC cd	4.0 DE cde
"	chc 1E	0.2 A a	0.8 A b	0.8 A b	0.6 A a
S. commersonii	cmm 1T	=	=	=	1.0 A a
S. etuberosum	etb 3	3.4 B c	4.6 C de	4.2 BCD def	3.8 DE cd
S. fendleri	fen 1D	4.4 BC de	4.4 BC de	4.4 CD def	3.4 CD c
"	fen 2D	3.6 BC cd	4.8 C e	4.0 BCD de	3.8 DE cd
"	fen 1E	4.2 BC cde	4.8 C e	4.0 BCD de	3.4 CD c
S. tarijense	tar 2B	4.4 BC de	4.8 C e	4.0 BCD de	0.4 A a
"	tar 1C	3.6 BC cd	4.0 BC cde	3.2 B c	2.2 B b
S. phureja × *S. tuberosum*	UP88P5	=	=	4.0 BCD de	=
Tomato "Rutgers"		5.0 C e	5.0 C e	4.8 D f	4.9 E e

*Means followed by same letters in the same column are not significantly different according to Duncan's Multiple Range Test (capital letters for P = 0.01; small letters for P = 0.05).

was considered resistant to all root-knot nematode species (Table 4). Clone CS8621 was only tested for resistance to *M. javanica*. Despite a low gall index (rated 2) (Table 2), it allowed the nematode to produce many egg masses (rated 5) (Table 3). Therefore, this clone was considered susceptible (Table 4). Clone CS8632 was resistant to *M. javanica*, inducing the formation of few galls on the roots (rated 2) (Table 2) and no egg masses (Table 3), but was susceptible to the other three root knot species (Tables 2-4). All resistant clones confirmed their resistance in the second test.

Table 3. Egg mass index of *Meloidogyne arenaria*, *M. hapla*, *M. incognita* and *M. javanica* on roots of wild and cultivated potato clones.

Solanum spp.	Clone	Egg masses index (0-5)			
		M. arenaria	*M. hapla*	*M. incognita*	*M. javanica*
S. tuberosum	CS8617	0.6 A a*	0 A a	0.2 A a	0 A a
"	CS8621	=	=	=	4.6 BC cd
"	CS8632	3.8 B bc	3.6 BC bc	4.2 BC bc	0 A a
S. acaule	acl 1A	4.0 B bcd	4.0 BCDE bcde	4.0 B b	3.8 BC bc
"	acl 1E	3.6 B b	3.6 BC bc	4.4 BC bcd	3.6 B b
"	acl 2A	4.2 B bcd	3.8 BCD bcd	4.6 BC bcd	3.8 BC bc
S. bulbocastanum	blb 1E	3.8 B bc	=	4.0 B b	3.8 BC bc
"	blb 2A	4.0 B bcd	4.2 BCDE cdef	4.6 BC bcd	4.0 BC bcd
"	blb 2D	4.6 B d	4.2 BCDE cdef	4.0 B b	4.0 BC bcd
"	blb 2E	4.2 B bcd	4.4 CDE def	4.4 BC bcd	4.4 BC bcd
S. canasense	can 1B	4.2 B bcd	4.8 E f	5.0 C d	3.6 B b
S. cardiophyllum	cph 1C	4.2 B bcd	4.6 DE ef	4.0 B b	4.6 BC cd
"	cph 2D	4.2 B bcd	4.6 DE ef	4.6 BC bcd	4.0 BC bcd
"	cph 2E	4.2 B bcd	4.6 DE ef	5.0 C d	4.8 BC d
S. chacoense	chc 1C	3.8 B bcd	3.4 B b	5.0 C d	4.2 BC bcd
"	chc 1E	0 A a	0.2 A a	0.2 A a	0.6 A a
S. commersonii	cmm 1T	=	=	=	0 A a
S. etuberosum	etb 3	4.0 B bcd	4.6 DE ef	5.0 C d	4.2 BC bcd
S. fendleri	fen 1D	4.4 B cd	4.4 CDE def	4.4 BC bcd	4.2 BC bcd
"	fen 1E	4.0 B bcd	4.6 DE ef	4.8 BC cd	4.0 BC bcd
"	fen 2D	4.2 B bcd	4.0 BCDE bcde	4.4 BC bcd	4.2 BC bcd
S. tarijense	tar 2B	4.0 B bcd	3.8 BCD bcd	4.2 BC bc	0 A a
"	tar 1C	4.4 B cd	4.8 E f	3.2 B b	4.6 BC cd
S. phureja × *S. tuberosum*	UP88P5	=	=	4.0 B b	=
Tomato "Rutgers"		5.0 B d	5.0 E f	5.0 C d	5.0 C d

*Means followed by same letters in the same column are not significantly different according to Duncan's multiple range test (capital letters for P = 0.01; small letters for P = 0.05).

Mendoza and Jatala (1985) reported resistance to warm season species of *Meloidogyne* in crosses of *S. tuberosum* with wild *Solanum* sp. of the International Potato Center (CIP), Peru. Moreover, resistance to *M. incognita* was observed by Mian *et al.* (1990) in a potato cv Lalmoddah and to *M. arenaria*, *M. incognita*, *M. hapla* and *M. javanica* by Grammatikaki *et al.*, (1999) in some gametoclones derived from anther culture of genotypes of *S. tuberosum*. The presence of resistance to several species of *Meloidogyne* in the same clone, as in CS8617, would make easier the

Table 4. Reaction type of potato clones tested against *Meloidogyne arenaria*, *M. hapla*, *M. incognita* and *M. javanica* according to gall and egg mass index on roots.

Solanum spp.	Clone	Reaction type			
		M. arenaria	*M. hapla*	*M. incognita*	*M. javanica*
S. tuberosum	CS8617	R*	R	R	R
"	CS8621	=	=	=	S
"	CS8632	S	S	S	R
S. acaule	acl 1A	S	S	S	S
"	acl 1E	S	S	S	S
"	acl 2A	S	S	S	S
S. bulbocastanum	blb 1E	S	=	S	S
"	blb 2A	S	S	S	S
"	blb 2D	S	S	S	S
"	blb 2E	S	S	S	S
S. canasense	can 1B	S	S	S	S
S. cardiophyllum	cph 1C	S	S	S	S
"	cph 2D	S	S	S	S
"	cph 2E	S	S	S	S
S. chacoense	chc 1C	S	S	S	S
"	chc 1E	R	R	R	R
S. commersonii	cmm 1T	=	=	=	R
S. etuberosum	etb 3	S	S	S	S
S. fendleri	fen 1D	S	S	S	S
"	fen 1E	S	S	S	S
"	fen 2D	S	S	S	S
S. tarijense	tar 2B	S	S	S	R
"	tar 1C	S	S	S	S
S. phureja × *S. tuberosum*	UP88P5	=	=	S	=

* R = resistant, gall and/or egg masses index ≤ 2; S = susceptible, gall and/or egg masses index >2.

introgression of the resistance to several species of rootknot nematode in same cultigen of *S. tuberosum*.

The presence of resistance to *Meloidogyne* spp. in the new clones of *S. tuberosum* is of great interest because both resistant clones (CS8617 and CS8632) are at an advanced selection stage. In addition, clone CS8617 also has been reported as resistant to the potato cyst nematode *Globodera rostochiensis* (Wollenweber) Behrens pathotype Ro2 (Greco *et al.*, 2002), the most widespread pathotype in Italy (Greco *et al.*, 1999; 2002). Because of its good agronomic performances, this clone is now being registered as a new cultivar and, therefore, it offers promise for its cultivation in southern Italy and other areas

where both cyst and root-knot nematodes occur. Clone CS8617 is being crossed with haploid inducers IVP35 of *S. phureja* to produce haploid genotypes that can be employed to better understand the genetic control of the resistance. Indeed, *S. tuberosum* haploids show disomic inheritance patterns, that are much simpler than the tetrasomic inheritance of tetraploid genotypes.

Of the wild *Solanum* species and clones tested, clone chc 1E of *S. chacoense* was resistant to all four root knot nematode species tested as its roots showed very poor galling (Table 2) and were free of or contained only a few egg masses and/or galls (Tables 3). Clone cmm 1T of *S. commersonii*, which was tested only against *M. javanica*, was also classified as resistant to this species; beside having low root gall index this clone did not allow egg production. Clone tar 2B of *S. tarijense*, tested against all four root-knot nematodes, was considered resistant to only *M. javanica* being rated 0 for egg masses index and 0.4 for gall index. The remaining clones were susceptible to all nematodes tested.

It is well known that wild tetraploid and diploid *Solanum* species possess valuable traits lacking in the cultivated genotypes. Thus, the identification of genotypes resistant to *Meloidogyne* spp. may greatly contribute to development of resistant *S. tuberosum* cultivars.

Results of this work confirmed the occurrence of resistance to the major root knot nematode species in diploid *S. chacoense* (Hawkes and Hjerting, 1989; Hawkes, 1990; Hawkes, 1994). This species had never been tested against Italian populations of root-knot nematodes. The finding of the resistance to *M. javanica* in *S. tarijense* and in *S. commersonii* appear to be new. Clone cmm 1T of *S. commersoni* was tested only against *M. javanica*, and therefore the evaluation of its reaction against the other root knot nematode species would be interesting. These resistant wild species are very interesting from the breeding standpoint, in that they carry many other useful traits, including high dry matter content of tubers and resistance to biotic as well as abiotic stresses (Hanneman and Bamberg, 1986; Hawkes and Hjerting, 1989; Hawkes, 1990; Hawkes, 1994). *Solanum chacoense* is resistant to various pathogens, pests, and to drought stress (Hawkes and Hjerting, 1989; Hawkes, 1990; Hawkes, 1994). The glycoalkaloids contained in leaves make this species particularly interesting in breeding for insect resistance. *Solanum chacoense* is sexually compatible with *S. tuberosum* haploids, and thus can be used in sexually polyploidization crossing schemes (Peloquin *et al.*, 1999). The same holds true for *S. tarijense*. Also noteworthy is the resistance found in *S. commersonii*. This species has a very high resistance to low temperatures (up to -5°C), and is able to acclimate up to -10°C. Therefore, it is particularly interesting for the Mediterranean area, where early potatoes are grown during winter. Although this species is sexually isolated and cannot be crossed with *S. tuberosum* haploids, breeding strategies based on ploidy bridge production have been developed (Carputo *et al.*, 1997), and hybrids are already available for use in breeding for nematode resistance.

Further investigations are necessary to identify the number of genes involved in the observed resistance and their inheritance, in order to design specific breeding programs for resistance of potato to *Meloidogyne* spp.

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