# SCREENING FOR RESISTANCE TO *NACOBBUS ABERRANS* AND *GLOBODERA* SPP. IN WILD POTATO SPECIES RESISTANT TO OTHER PATHOGENS

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**Summary.** One hundred and fifty-nine progenies of different species of *Solanum*, reported as resistant to late blight (*Phytophthora infestans*), Colorado potato beetle (*Leptinotarsa decemlineata*) or Potato leaf roll virus, were evaluated for their reaction to Bolivian populations of *Nacobbus aberrans* and *Globodera* spp. *Solanum microdontun, S. acaule and S. okadae* showed a larger number (83, 63 and 88%, respectively) of entries resistant to *N. aberrans*. *Solanum okadae* and *S. microdontun* were also resistant to *Globodera* spp. (57 and 50%, respectively). *Solanum chaucha, S. sparsipilum* and *S. tarijense*, reported to be resistant to Colorado potato beetle, showed 54% of entries resistant to *N. aberrans*.

**Key words:** False root-knot nematode, potato cyst nematode, *Solanum* spp.

In Bolivia, among traditional Andean crops (*Ollucus tuberosus* Caldas*, Oxalis tuberosa* Molina, *Lupinus mutabilis* Sweet, *Chenopodium quinoa* Willdenow, etc.), potato (*Solanum tuberosum* L.) is the most important because of its great diversity and high consumption per capita. In this country, potato is cultivated by small farmers operating in different ecological conditions between 1500 to 4500 metres above sea level. As a result of biotic and abiotic constraints, the national average yield of approximately 4 t/ha is one of the lowest in the world (Franco *et al*., 1992; Zeballos, 1997).

Problems caused by nematodes and other soil-borne pathogens represent some of the most important limiting factors in the maintenance of economic production of potatoes. *Nacobbus aberrans* (Thorne) Thorne *et* Allen, *Globodera rostochiensis* (Wollenweber) Behrens and *G. pallida* (Stone) Behrens are the most important nematode pests of potatoes in Bolivia and other countries in the Andean region. These nematodes are widely distributed in most growing areas in Bolivia, causing both severe direct yield losses (Franco, 1994) and indirect losses due to the disqualification of infected seed potato fields (Dirección Nacional de Semillas, 1996). Of the two species of cyst nematodes, *G. pallida* is more widespread than *G. rostochiensis*. Both species are found most frequently between 3,500 and 4,000 masl, whereas *N. aberrans* can be found frequently between 3,000 and 4,000 masl.

*Nacobbus aberrans*, the "potato rosary nematode" or the "false root-knot nematode", affects marketable potato yields because no large potato tubers are produced as nematode infestation level increases (Franco *et al*., 1998/1999). When this nematode is introduced into a previously non-infested field/area by the use of infected potato seed tubers it is almost impossible to eradicate due to its very wide host range, which covers 69 cultivated and non-cultivated plant species within 17 families (Brodie *et al*., 1993).

Ninety-five countries produce potatoes in the developing world (CIP, 1984) and, in an era of intensive international trade, *N. aberrans* has become a major concern to them, not only because of the potential social and economic consequences of its impact on production*,* but also because of the quarantine implications due to the restrictions imposed by many countries against this pest (CABI and EPPO, 1997).

A series of tactics is used for the control of potato pathogens, but the use of resistant or tolerant cultivars is the most effective, especially when these cultivars are resistant to several pathogens (Jellis, 1992).

Eradication of *Globodera* spp. and *N. aberrans* from contaminated fields is essentially impossible. Management strategies for these two types of nematodes are complex because field populations can consist of species mixtures with different pathotypes (Franco *et al*., 1998). Thus, management requires a harmonious and rational use of several components, such as: crop rotation, trap crops, biological measures, cultural practices, and resistant cultivars. The best strategies are environmentally friendly and avoid soil degradation whilst maintaining plant productivity (Franco *et al*., 1999; Manzanilla *et al*., 2002).

The development of rotation systems that include antagonistic and non-host crops for nematode control depends not only on yield responses, but on economic, ecological, and other constraints in individual situa-

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tions. Although crop rotations are effective for the management of nematodes, many potato producers do not view currently recommended rotation plans as sustainable and economical (Rodriguez-Kabana and Canullo, 1992). If more potato cultivars with resistance both to nematodes and other biotic and abiotic constraints were available, their use could be a sound approach to increasing the yield of potatoes by facilitating the management of factors that limit production.

The value of wild potato species and primitive forms has been widely acknowledged because there are genes for pest resistance (e.g. potato cyst nematodes) in wild species from Argentina, Bolivia and Peru (*S. chacoense*, *S. microdontum*, *S. spegazzinii*, *S. vernei*, *S. capsicibaccatum*, *S. acaule*, *S. megistacrolobum*, *S. sanctae-rosae*, *S. kurtzianum*, *S. oplocense*, etc.) as well as in the cultivated potatoes of the Andes (*S. tuberosum* ssp. *andigena*, *S. phureja*, *S. ajanhuiri*). Both the cultivated and the wild species have been used as resistance sources (Ellenby, 1954; Dunnett, 1961; Howard *et al*., 1970).

Research carried out with *Globodera pallida* has shown that the species *Solanum vernei, S. multidissectum*, *S. microdontum* and *S. megistacrobolum* possess resistance genes to this nematode (Franco and Evans, 1978). The identification and evaluation of new resistance sources in wild potato species would provide new alternatives for solving the growing problem of *N. aberrans* and *Globodera* spp. in the Andean countries of Latin America (Chavez *et al*., 1988; Ortiz *et al*., 1997).

Therefore, entries of 25 wild species of *Solanum* reported to possess resistance to potato cyst nematodes (*Globodera* spp.), late blight (*Phytophthora infestans* Mont. de Bary), Colorado potato beetle (*Leptinotarsa decemlineata* Say) or the Potato leaf roll virus (PLRV) were evaluated to identify genotypes resistant to *N. aberrans* and *Globodera* spp.

## MATERIALS AND METHODS

The screening was conducted in a greenhouse at the Toralapa Station (Cochabamba, Bolivia), where temperature remained in the range 5.5 to 28.4 °C (average 17.4 °C) during the test. One hundred and fifty-nine entries of 25 different species of *Solanum*, provided from the Potato Introduction Station in Sturgeon Bay (Wisconsin, USA) (Table I) as botanical seed, were evaluated for their reactions to populations of *N. aberrans* and *Globodera* spp. collected from Toralapa Experimental Station (3,453 masl). The types of resistance shown by the entries are given in Table II. The potato cultivar Waych'a (*S. tuberosum* ssp. *andigena*), grown from seed tubers, was used as a susceptible check (control group). The seeds of the various accessions were sown in trays of sterile organic compost and, 35 days later, the seedlings were individually transplanted into 400 g pots containing soil naturally-infested by *N. aberrans* (5 juveniles/$cm^3$ soil) in order to make an evaluation at plant maturity (130-150 days after transplanting) and to obtain tubers. In a similar way, 35-day-old seedlings of the same accessions were also transplanted into 400 g pots containing soil inoculated with a mixture of cysts of *Globodera rostochiensis* and *G. pallida* (10 eggs/$cm^3$ of soil), since that is how potato cyst nematode populations are usually found in field conditions.

The evaluation of the *Solanum* entries for resistance to *N. aberrans* was to check each plant by eye for the presence or absence of galls caused by the nematode on the roots, and to express the number found relative to the susceptible checks (0-100%). The evaluation of the reaction to *Globodera* spp. was based on the number of new nematode females on the roots rated according to a 0-3 scale, where 0 = no females, 1 = very few and difficult to see them, 2 = few females but easily seen, and 3 = many females (Franco *et al*., 1990). A plant was considered resistant to *N. aberrans* when the percentage of galled root was nil or less than 10% and resistant to *Globodera* spp. when rated zero or 1.

## RESULTS AND DISCUSSION

Five entries (83.33%) of S. *microdontum* (PI275150, PI473312, PI498121, PI545901, and PI558220), fifteen entries (62.5%) of *S. acaule* (PI472646, PI473518, PI217450, PI275127, PI310923, PI310924, PI472757, PI472758, PI473320, PI473321, PI473324, PI473423, PI473509, PI545936 and PI558026) and six entries (85.71%) of *S. okadae* (PI458367, PI498063, PI498065, PI558103, PI558104 and PI558105) were resistant to *N. aberrans* (Table I). Other potato species showed fewer resistant entries (*S. demissum*: 1; *S. kurtzianum*: 2; *S. oplocense*: 2; *S. sucrense*: 4; *S. sparsipilum*: 3; *S. vernei*: 3). Within the first group, four entries of *S. okadae*, four of *S. acaule* and three of *S. microdontun* were also resistant to *Globodera* spp., whilst in the second group one entry of *S. demissum*, two of *S. oplocense*, one of *S. sucrense*, one of S. *spegazzinii* and two of *S. vernei* were also resistant to *Globodera* spp. Control plants of cv. Waych'a showed 60% of roots nodulated by *N. aberrans* and a maximum degree of infestation by *Globodera* spp. However, no resistance to *N. aberrans* or *Globodera* was found in the entries of *S. sanctae-rosae* (4 entries), *S. phureja* (2), *S. stoloniferum* (2), *S. capsicibaccatum* (1), *S. infundibuliforme* (2), *S. polyadenium* (1), *S. pinnatisectum* (1) or *S. verrucosum* (1), all of which are quite common potato species at lower altitudes.

The potato species identified as resistant to one or both nematodes are distributed in the Andean regions of Argentina, Bolivia and Peru, mostly between 2,300 and 4,250 m asl. After analysis of the results in relation to potato species with resistance to the other pathogens (Table II), it was observed that seven (54%) of the entries found resistant to *N. aberrans* in the three wild species (*S. chacoense*, *S. sparsipilum*, *S. tarijense*) are also reported as resistant to the Colorado potato beetle (viz.

**Table I.** *Solanum* species evaluated for resistance to *Nacobbus aberrans* and *Globodera* spp.

| *Solanum* species and (abbreviation) | Entries evaluated | Entries resistant to *N. aberrans* | | Entries resistant to *N. aberrans* and *Globodera* spp. | |
|---|---|---|---|---|---|
| | | Number | Origin | Number | Origin |
| *S. acaule (acl)* | | 8 | Argentina | 2 | Argentina |
| | | 1 | Peru | 2 | Bolivia |
| | | 6 | Bolivia | | |
| Total | 24 | 15 (63%)[1] | | 4 (17%) | |
| *S. berthaultii (ber)* | | 2 | Bolivia | | |
| Total | 9 | 2 (22%) | | | |
| *S. bulbocastanum (blb)* | | 1 | Mexico | 1 | Mexico |
| Total | 1 | 1 (100%) | | 1 (100%) | |
| *S. chacoense (chc)* | | 6 | Argentina | 5 | Argentina |
| Total | 11 | 6 (55%) | | 5 (45%) | |
| *S. demissum (dms)* | | 1 | Mexico | 1 | Mexico |
| Total | 6 | 1 (17%) | | 1 (17%) | |
| *S. gourlayi (grl)* | | 1 | Argentina | | |
| Total | 9 | 1 (11%) | | | |
| *S. kurtzianum (ktz)* | | 2 | Argentina | | |
| Total | 2 | 2 (100%) | | | |
| *S. microdontum (mcd)* | | 4 | Argentina | 2 | Argentina |
| | | 1 | Bolivia | 1 | Bolivia |
| Total | 6 | 5 (83%) | | 3 (50%) | |
| *S. megistacrolobum (mga)* | | 3 | Bolivia | 2 | Argentina |
| | | 2 | Argentina | 1 | Bolivia |
| Total | 12 | 5 (42%) | | 3 (25%) | |
| *S. okadae (oka)* | | 4 | Argentina | 1 | Bolivia |
| | | 2 | Bolivia | 3 | Argentina |
| Total | 7 | 6 (86%) | | 4 (57%) | |
| *S. oplocense (opl)* | | 2 | Argentina | 2 | Argentina |
| Total | 13 | 2 (15%) | | 2 (15%) | |
| *S. sucrense (scr)* | | 4 | Bolivia | 1 | Bolivia |
| Total | 7 | 4 (57%) | | 1 (14%) | |
| *S. spegazzinii (spg)* | | 1 | Argentina | 1 | Argentina |
| Total | 7 | 1 (14%) | | 1 (14%) | |
| *S. sparsipilum (spl)* | | 3 | Bolivia | 1 | Bolivia |
| Total | 8 | 3 (38%) | | 1 (13%) | |
| *S. tarijense (tar)* | | 1 | Argentina | 1 | Bolivia |
| | | 2 | Bolivia | | |
| Total | 10 | 3 (30%) | | 1 (10%) | |

Continued

**Table I.** Continuation.

| *Solanum* species and (abbreviation) | Entries evaluated | Entries resistant to *N. aberrans* | | Entries resistant to *N. aberrans* and *Globodera* spp. | |
|---|---|---|---|---|---|
| | | Number | Origin | Number | Origin |
| *S. tuberosum (tbr)* | | 1 | Peru | 1 | Argentina |
| | | 1 | Argentina | | |
| Total | 5 | 2 (40%) | | 1 (20%) | |
| *S. vernei (vrn)* | | 3 | Argentina | 2 | Argentina |
| Total | 8 | 3 (38%) | | 2 (25%) | |
| *S. capsicibaccatum (cap)* | 1 | 0 | | 0 | |
| *S infundibuliforme (ifd)* | 2 | 0 | | 0 | |
| *S. phureja (phu)* | 2 | 0 | | 0 | |
| *S. polyadenium (pld)* | 1 | 0 | | 0 | |
| *S. pinnatisectum (pnt)* | 1 | 0 | | 0 | |
| *S. sanctae-rosae (sct)* | 4 | 0 | | 0 | |
| *S. stoloniferum (sto)* | 2 | 0 | | 0 | |
| *S. verrucosum* | 1 | 0 | | 0 | |

[1] % of resistant entries in the total tested are in brackets.

**Table II.** Evaluation of wild species of potato for their resistance to *N. aberrans* and *Globodera* spp. according to their resistance to other potato pathogens.

| Resistant to | Entries evaluated | Entries resistant to *N. aberrans* (2 evaluations) | | | | Entries resistant to *N. aberrans* and *Globodera* spp. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Total | N° | abrev. | % | Total | N° | abrev. | % |
| Colorado potato beetle | 13 | 7 (54%)[1] | 5 | chc | 83.3 | 5 (38%) | 4 | chc | 66.7 |
| | | | 1 | spl | 100.0 | | 1 | spl | 100.0 |
| | | | 1 | tar | 33.3 | | | | |
| Potato Leaf Roll Virus (PLRV) | 23 | 9 (39%) | 2 | acl | 50.0 | 5 (22%) | 1 | acl | 25.0 |
| | | | 1 | ber | 33.3 | | 1 | ber | 33.3 |
| | | | 1 | chc | 50.0 | | 1 | chc | 50.0 |
| | | | 1 | grl | 100.0 | | 1 | tar | 50.0 |
| | | | 1 | mga | 100.0 | | 1 | tbr | 50.0 |
| | | | 1 | tar | 50.0 | | | | |
| | | | 2 | tbr | 100.0 | | | | |
| Late blight *(P. infestans)* | 13 | 2 (15%) | 1 | blb | 100.0 | 2 (15%) | 1 | blb | 100.0 |
| | | | 1 | mcd | 100.0 | | 1 | mcd | 100.0 |
| Others | 110 | 39 (35%) | 9 | acl | 45.0 | 18 (16%) | 4 | acl | 20.0 |
| | | | 1 | ber | 25.0 | | 2 | mcd | 40.0 |
| | | | 2 | ktz | 100.0 | | 3 | mga | 27.3 |
| | | | 4 | mcd | 80.0 | | 4 | oka | 66.7 |
| | | | 4 | mga | 36.4 | | 2 | opl | 16.7 |
| | | | 6 | oka | 100.0 | | 1 | scr | 14.3 |
| | | | 2 | opl | 16.7 | | 2 | vrn | 25.0 |
| | | | 4 | scr | 57.1 | | | | |
| | | | 1 | spg | 16.7 | | | | |
| | | | 2 | spl | 33.3 | | | | |
| | | | 1 | tar | 20.0 | | | | |
| | | | 3 | vrn | 37.5 | | | | |

[1] % of resistant entries in the total are in brackets.

PI133123, PI209411, PI265576, PI473402, PI473405, PI473504 and PI473242). However, the gene for resistance to the Colorado potato beetle in *S. chacoense* appears to be more strongly associated in some way with resistance to *N. aberrans* and *Globodera* spp. than in entries of the other two species. In the case of entries resistant to Potato leaf roll virus, there seems to be an association of the virus resistance genes in the species *S. gourlayi, S. megistacrolobum* and *S. tuberosum* with resistance to *N. aberrans*. Similarly, in *S. bulbocastanum* and *S. microdontum*, reported to possess genes for late blight resistance, there also may be an association with *N. aberrans* and *Globodera* spp. resistance. Within the group of entries with resistance to other pathogens, the potato species *S. microdontum*, *S. acaule* and *S. okadae* showed resistance to *N. aberrans* and the latter also showed resistance to *Globodera* spp.

The results obtained on resistance to *Globodera* spp. confirmed earlier results with wild potato species from Argentina and Bolivia (Chavez *et al*., 1988) but this is the first report on the resistance of wild potato species to *N. aberrans* and to both of the most common and damaging potato pest nematodes in the Andean region of Bolivia. Those potato species found with resistance to potato cyst nematodes and the rosary nematode and already reported to have resistance to the other potato pests (i.e., late blight, Colorado potato beetle or the Potato leaf roll virus) should be further investigated in order to identify entries with multiple resistance to potato pests.

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