DISTRIBUTION OF NEMATODES IN POTATO FIELDS SOIL IN ANDEAN VALLEYS OF ARGENTINA

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SUMMARY

A survey of nematofauna of potato fields soil was carried out in Andean valleys of the province of Jujuy, Argentina, in 2001. The nematode abundance in the 26 sites studied ranged between 0,6 x 10^5 and 16,2 x 10^5 individuals/m^2 and the number of genera ranged between 8 and 22. Three dominant nematode genera were identified *Chiloplacus*, *Aphelenchus* and *Ditylenchus*. Of the genera detected, 24 were plant-feeding nematodes, 18 were bacterial-feeding, 6 hyphal-feeding, 12 omnivorous and 6 were predators. *Meloidogyne* spp. were detected in 73%, *Pratylenchus* sp. in 69,2% and *Nacobbus aberrans* in 61,5% of the study sites. These results indicated that plant parasitic nematodes, some of which are known to parasitize potato crops, are widespread in the Andean potato growing area. The genera *Bitylenchus*, *Butlerius*, *Cervidellus*, *Crassolabium*, *Dolichorhynchus*, *Enchodelus*, *Labronemella*, *Seleborca*, *Stegelleta* and *Zeldia* were reported for the first time in Argentina.

Key words. Nematofauna, Andean valleys, potato, *Meloidogyne* spp., *Nacobbus aberrans*, *Pratylenchus* sp.

DISTRIBUCIÓN DE NEMATODES EN SUELOS DE CULTIVO DE PAPAS EN LOS VALLES ANDINOS DE LA ARGENTINA

RESUMEN

En el año 2001 se llevó a cabo un estudio sobre la nematofauna del suelo en campos de cultivo de papa en los valles andinos de la provincia de Jujuy, Argentina. La abundancia de nematodes en los 26 sitios estudiados varió de 0,6 x 10^5 a 16,2 x 10^5 individuos/m^2 y el número de géneros de 8 a 22. Se identificaron tres géneros dominantes *Chiloplacus*, *Aphelenchus* y *Ditylenchus*. De los géneros determinados, 24 fueron nematodos fitófagos, 18 bacteriófagos, 6 fungívoros, 12 omnívoros y 6 predadores. *Meloidogyne* spp. presentó una frecuencia en los sitios de estudio del 73%, *Pratylenchus* sp. del 69,2% y *Nacobbus aberrans* 61,5%. Estos resultados indican que los nematodos fitófagos, alguno de los cuales son conocidos como parásitos de la papa, están ampliamente distribuidos en las áreas de crecimiento del cultivo en la Región andina de la provincia de Jujuy. Los géneros *Bitylenchus*, *Butlerius*, *Cervidellus*, *Crassolabium*, *Dolichorhynchus*, *Enchodelus*, *Labronemella*, *Seleborca*, *Stegelleta* y *Zeldia* se presentan por primera vez en la Argentina.

Palabras clave. Nematofauna, valles Andinos, papa, *Meloidogyne* spp., *Nacobbus aberrans*, *Pratylenchus* sp.

INTRODUCTION

Nematodes are a problem in many seed potato production areas of Argentina (Chaves and Torres, 2001). In Northwest Argentina, the potato has been grown for many centuries in the Andean valleys located at high altitudes in the provinces of Catamarca, Jujuy and Salta in what is known as Puna and Prepuna phytogeographical provinces. Several workers have reported the presence of nematodes in northwest Argentina. Brücher (1961) detected the presence of cysts of *Heterodera (=Globodera) rostochiensis* in soils with high humus content at several places in the province of Jujuy, where several wild potato species were found growing in the vicinity. Virsoo (1967) reported the presence of the golden nematode in the province of Catamarca

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and Costilla (cited by Parisi, 1980) discovered the presence of cysts of *Heterodera* and *Globodera* in the provinces of Jujuy, Catamarca and Salta. Chaves (1979) found *Nacobbus aberrans* in the roots of Andean potatoes, cysts of *Globodera* in soil from the provinces of Jujuy and Salta and *Meloidogyne* from the province of Catamarca. Chaves (1987) detected the presence of *Globodera tabacum* in potato fields of Catamarca.

No detailed information up to date has been reported on the distribution of parasitic nematodes in Andean potato fields in Argentina, despite farmers have observed declining yield in their potato crops. Many indigenous potato varieties are cultivated in Northwest Argentina, generally without any input of pesticides (Clausen *et al.*, 2004). Although crop rotation is practiced under these cropping systems, the host range of many nematodes is wide and it is suspected that plant- parasitic nematodes present in these areas must be important and in some cases one of the causes of yield losses (Rojas *et al.*, 1997).

The aim of this study was to investigate the distribution of nematodes in potato fields soil in the Andean province of Jujuy, to establish the identity of the genera present, as well as the abundance of plant-parasitic nematodes.

MATERIAL AND METHODS

The survey was carried out between 22° and 24° latitude South and 65° and a 66° 30´ longitude West (Fig. 1). The altitude of the area sampled ranged from 2,300 to 3,800 m a.s.l. The predominant soils in the area are Entisols (fluvents and litics) and Aridisols (Vargas Gil *et al.*, 1990). The surveyed area is characterized by a mean annual precipitation of 270 mm and temperatures ranging between 3.6 and 7.7 °C during winter and 11.7 and 14.2 °C in summer.

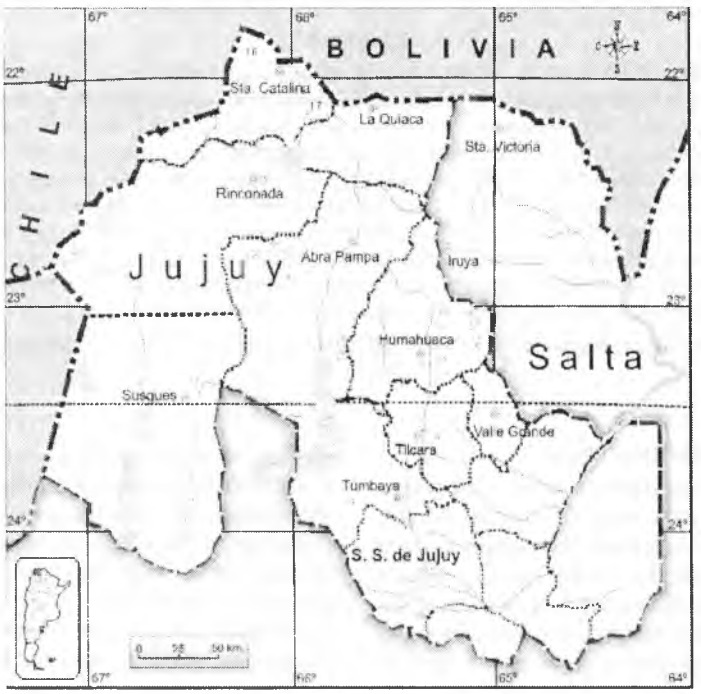

FIGURE 1. **Sites sampled in farmer fields in the province of Jujuy, Argentina, corresponding to Table I.**

Twenty-six sites were sampled between March 24 to April 15, 2001. In each site, the soil was sampled in a zigzag pattern (Dropkin, 1980), by taking 10 subsamples/ 0.25 ha with a cylindrical soil corer of a cross-sectional area of 6.2 cm^2 down to a depth of 20 cm. The sub samples from each site were mixed manually to form a composite sample. At each site longitude and latitude data were obtained by a global positioning system (GPS) and altitude data with an altimeter. Soil samples were analyzed for pH, electric conductivity (EC), and percentage of organic carbon (Corg). Soil texture was determined according to a texture diagram (Dg) (Shirazi and Boersma, 1984).

The soil samples were stored at 5 °C and nematodes extracted within 30 days after sampling by the centrifugal method (Caveness and Jensen, 1955). Nematode cysts were extracted according to the methods of Fenwick (1940) and Andersson (1970). Nematode genera and trophic groups were recorded in 100 cm^3 soil. All the nematodes were identified at the genera level with the exception of the populations of *Nacobbus* and *Globodera*. The populations of *Meloidogyne* contained juveniles at the second stadium and the genus *Pratylenchus* had very few individuals and as a result the identification at the species level was not possible. Total abundance and abundance of plant-parasitic nematodes were estimated by counting the two replicate samples for each locality and adjusting to numbers per m^2. Feeding type classification was determined according to Yeates *et al.* (1993).

Nematode identification at the genus level was made on 30% of the individuals grouped by feeding type, under 500 C magnifications. Nematodes were fixed in hot 4% formaldehyde solution, and mounted in pure dehydrated glycerin (De Grisse, 1969).

RESULTS

As the sampling was carried out in farmers fields, in the majority of the cases the soil samples contained much decayed vegetable matter and the predominant soil type was sandy loam (Table I).

Total nematode abundance in the 26 sites studied ranged between 0.6×10^5 and 16.2×10^5 individuals/ m^2, the number of genera ranged between 8 and 22 at each site and the abundance of plant-parasitic nematodes ranged between 0.02×10^5 and $3.51 \times 10^5/m^2$ (Table II).

The composition of the nematode communities included five main trophic groups with 66 genera identified in the soil samples: plant- feeding (24 genera), bacterial-feeding (18 genera), hyphal-feeding (6 genera), omnivorous (12 genera) and predators (6 genera) (Table III).

Hyphal-feeding nematodes were the dominant group in 81% of the populations investigated, the bacterial-feeding group was dominant in 15% of the sites and the plant-feeding group was dominant in 4%.

In all the sites, three dominant nematode genera were identified: *Chiloplacus*, *Aphelenchus* and *Ditylenchus*, represented more than 5.1% of the populations (Table III).

Meloidogyne spp. was detected in 73% (sites 2, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18, 21, 22, 23 25, 26), *Pratylenchus* in 69.2% (sites 3, 5, 6, 7, 9, 10, 12, 13, 14, 15, 16, 17, 18, 20, 22, 23, 24, 26), *Nacobbus aberrans* in 61.5% (sites 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 18, 22, 23, 26) and cyst nematodes, represented by *Globodera tabacum*, in 15.4% (sites 4, 6, 12, 20) of the sites sampled. The number of juveniles of *Meloidogyne* sp. and *N. aberrans* in the samples ranged between 1 to 134/100 cm^3 of soil and 1 to 77/ 100 cm^3 of soil, respectively. The number of individuals of *Pratylenchus* sp. ranged between 1 to 15/ 100 cm^3 of soil. *Globodera tabacum* populations were represented by 4-6 cysts/200 g of soil containing viable juveniles.

The genera *Bitylenchus*, *Butlerius*, *Cervidellus*, *Crassolabium*, *Dolichorhynchus*, *Enchodelus*, *Labronemella*, *Seleborca*, *Stegelleta* and *Zeldia* were reported for the first time in Argentina.

DISCUSSION

Plant parasitic nematodes are widespread in the potato growing areas of Jujuy. Their presence can be explained as the result of the very active exchange at market places. Rojas *et al.*, 1997 found that the Andean market places, where the native potato varieties are sold or exchanged for seed, contribute to the dispersal of the root knot nematode. The very high incidence of *Nacobbus* in the area of Aparzo and Coctaca is coincident with ancient potato cultivation at these places.

The mean temperature of the sampled areas (Table I) seems low for the reproduction of the majority potato parasitic species of *Meloidogyne* but not for *N. aberrans*. According to Inserra *et al.* (1985), the populations of this latter species from South America complete its development at 15° C

TABLE I. **Characteristics of the sampled sites in Jujuy province** (site code, localities, geographic locations, elevation, soil types, precipitations and temperature monthly average).

Site code	Department/ Locality	Geographic coordinates	Elevation (m a.s.l)	Soil type	Precipitations (mm)	Temp. monthly average (°C)*
1	Tilcara/Maimará	23°36'S-65°24'W	2,371	loam	136	14.7
2	Tilcara/Juella	23°31'S-65°23'W	2,614	silt loam	136	13.7
3	Tilcara/Casa Colorada	23°34'S-65°21'W	3,088	sandy clay loam	136	11.7
4	Tilcara/Casa Colorada	23°34'S-65°21'W	3,088	sandy loam	136	11.7
5	Humahuaca/Aparzo	23°06'S-65°10'W	3,237	sandy loam	175	11.2
6	Humahuaca/Palca de Aparzo	23°06'S-65°08'W	3,435	sandy loam	353	10.1
7	Humahuaca/Palca de Aparzo	23°07'S-65°08'W	3,646	sandy loam	353	9.3
8	Humahuaca/Molloj	23°05'S-65°11'W	3,727	sandy loam	350	8.9
09	Humahuaca/Chorcán	23°03'S-65°12'W	3,885	sandy loam	350	8.3
10	Humahuaca/Pucará	23°12'S-65°15'W	3,374	sandy loam	200	10.6
11	Humahuaca/Ocumazo	23°14'S-65°15'W	3,070	sandy loam	175	11.8
12	Humahuaca/Coctaca	23°09'S-65°16'W	3,186	sandy loam	180	11.4
13	Humahuaca/Coctaca	23°08'S-65°17'W	3,168	loamy sand	180	11.4
14	Cochinoca/Ojo de Agua	22°59'S-66°00'W	3,374	sandy loam	334	10.4
15	Rinconada/Rinconada	22°25'S-66°09'W	3,709	sandy loam	483	9.0
16	Santa Catalina/El Angosto	21°52'S-66°11'W	3,624	loam	461	9.5
17	Santa Catalina/Cienaguillas	22°07'S-65°52'W	3,727	sand	400	9.1
18	Santa Catalina/Cabrería	22°05'S-66°15'W	3,700	sandy loam	400	9.3
19	Santa Catalina/Casira	21°58'S-65°54'W	3,676	loamy sand	400	9.4
20	Cochinoca/Agua Caliente	22°50'S-66°04'W	3,561	sandy loam	334	9.7
21	Cochinoca/Rachaite	22°59'S-66°09'W	3,435	loamy sand	300	10.2
22	Cochinoca/Rachaite	22°59'S-66°09'W	3,435	sandy loam	300	10.2
23	Susques/Corral Blanco	23°22'S-66°23'W	3,587	sandy loam	188	9.7
24	Tumbayá/El Angosto	23°55'S-65°49'W	3,607	sandy loam	200	9.4
25	Cochinoca/Quebraleña	23°17'S-65°46'W	3,618	sand	300	9.4
26	Cochinoca/Agua de Castilla	23°12'S-65°48'W	3,524	sandy loam	300	9.8

* Temperatures corresponding surveyed time were estimated by a regression model (Bianchi *et al.* 1994).
Relationship between nematodes number and temperatures during the survey were estimated by a regression model (Bianchi *et al.*, 1994).

and Franco *et al.* (1998/1999) stated that the populations of *N. aberrans* from the Bolivian Andes present a reduced adaptation to average high temperatures of about 20 ° C.

The number of juveniles of *Meloidogyne* sp. and *Nacobbus aberrans* estimated in 100 m^3 of soil could represent a potentially damaging level to potato production in some sites, but no threshold study of *Nacobbus aberrans* was given and threshold population density of *Meloidogyne* is dependent to the species considered.

The abundance of plant-parasitic nematodes found in this study was lower and the diversity higher than the values reported for other preliminary study of potato fields from Argentina. A survey carried out in potato fields at the different

TABLE II. **Number of total genera and plant-parasitic nematodes at each site.**

Site code	Department/Locality	N° genera	Abundance (N°x10^5/m^2)	
			Total	plant parasitic
1	Tilcara/Maimará	13	16.2	0.70
2	Tilcara/Juella	10	1.7	0.10
3	Tilcara/Casa Colorada	17	5.7	2.30
4	Tilcara/Casa Colorada	17	10.5	2.30
5	Humahuaca/Aparzo	14	1.2	0.24
6	Humahuaca/Palca de Aparzo	22	4.0	0.74
7	Humahuaca/Palca de Aparzo	20	7.1	1.11
8	Humahuaca/Molloj	14	9.9	0.90
9	Humahuaca/Chorcán	17	7.7	0.25
10	Humahuaca/Pucará	18	4.9	0.33
11	Humahuaca/Ocumazo	19	12.8	3.51
12	Humahuaca/Coctaca	22	11.6	2.50
13	Humahuaca/Coctaca	19	7.2	1.95
14	Cochinoca/Ojo de Agua	16	4.3	0.43
15	Rinconada/Rinconada	20	4.3	0.31
16	Santa Catalina/El Angosto	16	3.6	0.93
17	Santa Catalina/Cienaguillas	16	4.0	1.42
18	Santa Catalina/Cabrería	17	4.6	0.40
19	Santa Catalina/Casira	8	0.6	0.02
20	Cochinoca/Agua Caliente	15	4.0	0.40
21	Cochinoca/Rachaite	17	2.0	0.50
22	Cochinoca/Rachaite	17	5.7	2.68
23	Susques/Corral Blanco	18	3.6	0.31
24	Tumbayá/El Angosto	18	6.3	0.55
25	Cochinoca/Quebraleña	15	1.2	0.30
26	Cochinoca/Agua de Castilla	15	7.1	1.02

localities of the Tunuyán and San Carlos Departments, province of Mendoza (1000 m a.s.l.) by Vega and Galmarini (1970) documented 13 genera of plant-parasitic nematodes and a density ranging between 0.2 x 10^5 and 14 x 10^5 individuals/m^2. A survey conducted in potato fields of 14 localities from the southeastern region of the Buenos Aires province (130 m a.s.l.), found a high density of plant-parasitic nematodes, but a lower number of genera: 9 genera and 5.3 x 10^5 and 48 x 10^5 individuals/m^2 (Chaves and Torres, 1993). As the sampling method and nematode extraction were the same in the Buenos Aires and Jujuy surveys, the variation in nematode density and diversity could be the result of variations in the environmental conditions.

The sampling carried out in this work confirm data reported by Chaves (1979), who found *Nacobbus aberrans* on wild *Solanum* in the localities of Cajas

TABLE III. **Absolute and relative frequency of the nematode genera found in the Jujuy province.**

Nematodes	N° of samples with genera	Af. (%)**	Rf. (%)***	Nematodes	N° of samples with genera	Af. (%)	Rf. (%)
Plant-feeding				**Hyphal-feeding**			
Aorolaimus	11	42.3	2.6	*Aphelenchoides*	15	57.5	3.6
Bastria	1	3.8	0.23	*Aphelenchus*	25	96	6.0
Bitylenchus	2	7.7	0.48	*Ditylenchus*	22	84.6	5.2
Boleodorus	3	11.5	0.71	*Nothotylenchus*	3	11.5	0.71
Coslenchus	1	3.8	0.23	*Paraphelenchus*	4	15.4	0.95
Criconema	6	23	1.4	*Tylencholaimellus*	1	3.8	0.23
Criconemella	8	30.7	1.9	**Omnivorous**			
Dolichorhynchus	10	38.4	2.4	*Aporcelaimellus*	14	53.8	3.3
Filenchus	9	34.6	2.4	*Aporcelaimus*	2	7.7	0.48
Globodera (cyst)	4	15.4	0.95	*Crassolabium*	1	3.8	0.23
Helicotylenchus	1	3.8	0.23	*Discolaimoides*	2	7.7	0.48
Hemicycliophora	2	7.7	0.48	*Dorylaimellus*	1	3.8	0.23
Hoplolaimus	1	3.8	0.23	*Ecumenicus*	9	34.6	2.1
Meloidogyne J2 *	19	73	4.5	*Enchodelus*	2	7.7	0.48
Merlinius	1	3.8	0.23	*Eudorylaimus*	2	7.7	0.48
Nacobbus J2 *	16	61.5	3.8	*Labronemella*	1	3.8	0.23
Neothada	1	3.8	0.23	*Mesodorylaimus*	2	7.7	0.48
Paratylenchus	1	3.8	0.23	*Minidorylaimus*	1	3.8	0.23
Pratylenchus	18	69.2	4.3	*Thonus*	4	15.4	0.95
Psilenchus	2	7.7	0.48	**Predators**			
Quinisulcius	7	26.9	1.7	*Butlerius*	1	3.8	0.23
Rotylenchus	1	3.8	0.23	*Carcharolaimus*	1	3.8	0.23
Tylenchus	11	42.3	2.6	*Coomansus*	1	3.8	0.23
Tylenchorhynchus	7	26.9	1.7	*Discolaimium*	2	7.7	0.48
Bacterial-feeding				***Discolaimus***	1	3.8	0.23
Acrobeles	7	26.9	1.7	*Mylonchulus*	3	11.5	0.71
Acrobeloides	16	61.5	3.8				
Anaplectus	3	11.5	0.71				
Cephalobus	13	50	3.1				
Cervidellus	1	3.8	0.23				
Chiloplacus	22	84.6	5.2				
Cruznema	3	11.5	0.71				
Distolabrellus	1	3.8	0.23				
Eucephalobus	18	69.2	4.3				
Mesorhabditis	18	69.2	4.3				
Monhystera	1	3.8	0.23				
Panagrolaimus	2	7.7	0.48				
Plectus	7	26.9	1.7				
Prismatolaimus	3	11.5	0.71				
Rhabditis	18	69.2	4.3				
Seleborca	16	61.5	3.8				
Stegelleta	2	7.7	0.48				
Zeldia	3	11.5	0.71				

*second stage juveniles.
Af: Absolute frequency.
Rf: Relative frequency.
**Absolute frequency (%): (number of samples containing a specie/ number of samples collected) x 100.
***Relative frequency (%): (frequency of specie/ sum of frequency of all specie) x 100.

and Yavi, (province of Jujuy) and at Santa Victoria, Chiyuyoc and Colausulí (province of Salta); and an undetermined *Globodera* sp. associated with wild *Solanum* species at Santa Catalina, Yavi and Chaupi Rodero, province of Jujuy (3,000-3,800 m a.s.l.). Doucet and Lax (2005) found *Nacobbus aberrans* on potato tubers of *Solanum tuberosum* subsp. *andigenum* (varieties 'Chacarera redonda', 'Ojosa', 'Colorada', 'Collareja' and 'Collareja redonda"), and *Meloidogyne incognita* and *M. javanica* on 'Tuni' and 'Negra' varieties, from the Andean regions of Jujuy and Salta provinces. Furthermore, Lax *et al.* (2005) reported the finding of *N. aberrans* on tubers of Andean varieties from the localities of Palca de Aparzo, Yavi and Purmamarca (Jujuy) and from Campo Carreras, Santa Victoria *and* Iruya (Salta), as well as *M. javanica* from the area of Humahuaca and Yavi. *M. javanica* and *M. incognita* were also detected on tubers of native potatoes from Alfarcito (Jujuy).

González de Ojeda *et al.* (1978) in a survey of nematodes from potato fields at Tafi del Valle, Tucumán province (2,400 m a.s.l.) found *Meloidogyne javanica, Nacobbus aberrans*, *Tylenchorhynchus cylindricus, Aphelenchoides bicaudatus, Aphelenchus avenae* and *Rotylenchus, Tylenchus, Ditylenchus, Hoplolainus, Trichodorus and Xiphinema* species, but no data on nematode density was given and, therefore, no comparison with our study is possible.

Globodera tabacum was found in a potato field at Aconquija, province of Catamarca, near 2,500 m a.s.l. (Chaves, 1987) and *G.pallida* on roots of *S. tuberosum* subsp. *andigenum* from Iruya, province of Salta (Lax *et al.*, 2005). Contrarily to the finding of Brücher (1961), *Globodera rostochiensis* has not been found in the surveys of plant-parasitic nematodes carried out in the high mountain region of northwest Argentina.

CONCLUSIONS

In the sites studied the nematode trophic groups were represented by plant-feeding, bacterial-feeding, hyphal-feeding, omnivorous and predators. In all the sites, three dominant nematode genera were identified: *Chiloplacus*, *Aphelenchus* and *Ditylenchus*, representing more than 5.1% of the populations sampled.

Among the 66 genera of nematodes detected in the potato fields of the Andean valleys, two genera of the plant-feeding trophic group, 4 genera of bacterial-feeding, 3 genera of omnivorous and 1 genera of predators were reported for the first time in the Argentinean nematofauna.

The plant-parasitic genera *Meloidogyne, Pratylenchus* and *Nacobbus* are widespread in the potato growing areas of Jujuy, as they were detected in 73%, 69% and 61% of the sites sampled, respectively. The potato is an excellent host plant for these genera. We consider that it is a priority to identify and characterize the species of these genera as they include several species which causes severe damage in the potato crop.

Globodera rostochiensis was not found in the sites studied; only *G. tabacum* was found in four of these sites.

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