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THE OCCURRENCE, DISTRIBUTION AND ABUNDANCE OF PLANT PARASITIC NEMATODES IN FOREST AND FRUIT NURSERIES OF SLOVAKIA

by

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Summary. Communities of plant parasitic nematodes from the rhizosphere of various forest and fruit seedlings were studied in forest nurseries at 20 localities in ten regions and in fruit nurseries at three localities in three regions of the Slovak Republic, each with different topographic, climatic and geological conditions. A total of 29 species of plant parasitic nematodes were identified with 25 of them recovered from forest and 11 from fruit nurseries. The abundance of plant parasitic nematodes varied with the individual localities. The highest values were recorded in forest nursery in the Danubian lowland region, 169 specimens in 500 cm^3 of soil, and in fruit nursery in the East Slovakia upland region, 183 specimens in 500 cm^3 of soil. Predominating plant parasitic species was *Helicotylenchus digonicus* with the abundance of 1-156 specimens in 500 cm^3 of soil in forest nurseries and 52-85 specimens in fruit nurseries.

Plant parasitic nematodes are a natural part of soil microedaphon. From the phytopathological point of view they represent the most important group of parasites, having negative effect on the health condition of seedlings of forest and fruit woody plants.

The occurrence of plant parasitic nematodes in forest nurseries in the Slovak Republic has been investigated by Šály (1979), Liskova *et al.* (1996) and Stollárová *et al.* (1996). These investigations were limited to particular areas. In recent years more extensive sampling has been undertaken in forest and fruit nurseries throughout the whole of the Slovak Republic, the results of which are reported here.

Materials and methods

Soil samples were collected from forest tree nurseries at 20 locations in ten regions and from fruit tree nurseries at three locations in three regions of the Slovak Republic, each with different topographic, climatic and geological conditions (Table I).

Soil samples were collected from the rhizosphere of seedlings of coniferous trees (fir, pine and spruce) and deciduous trees (alder, ash, beech, elm, maple, oak and poplar), in forest tree nurseries and from apple, apricot, cherry, greengage, peach, pear, plum, quince and rowan in the fruit tree nurseries. Soil was taken at a depth of 15-20 cm in spring and autumn in 1996 and 1997. Nematodes were extracted from 500 cm^3 aliquots of throughly mixed composite samples by Cobbs decanting and sieving technique as modified by Brown and Boag (1988), killed by gentle heat, fixed in FAA and mounted in anhydrous glycerin. All nematodes were identified and individuals of each species were counted. Among the phytophages were included facultative plant parasitic nematodes as *Ma-*

TABLE I - *Regions sampled and their pedoclimatic characteristics.*

Region	Locality	Altitude (m above sea level)	Average annual		Texture
			Rainfall (mm)	Temperature (°C)	
Forest nurseries					
Danubian lowland	Palárikovo	100	540	10	loam
Beskids foothills	Humenné Kamienka Lubiša Zemplínske Hámre	158	712	8	sandy-loam
Borska lowland	Šajdíkove Humence	200	680	9.5	sand
Slovak karst	Krásnohorská Dlhá Lúka	300	700	8	loam, clay-loam
Turčianska basin	Martin Priekopa Bystrička	390	760	7.2	loam, clay-loam
Slovak Ore Mountains	Košice-Bankov Kavečany Malá Lodina	420	660	8.4	sandy-loam, loam
Levoča hills	Levoča Chrasť nad Hornádom	550	600	6.5	sandy-loam
Low Tatra	Beňuš	557	838	6	sandy-loam
Liptov basin	Liptovský Hrádok	650	700	5.9	sand
Orava highland	Zázrivá Vavrečka Námestovo	800	1100	5	sandy-loam
Fruit nurseries					
East Slovak upland	Čaklov	140	650	9	loam, sandy-loam
Hornonitrianska basin	Bojnice	300	690	8.5	loam, clay-loam
Hornádska basin	Klčov	470	620	6.8	loam, clay-loam

Soil type	Reaction	Plant species
black soils	neutral-alcaline	*Quercus robur* L. (oak), *Populus nigra* L. (poplar)
brown forest	neutral, weak acid	*Quercus petraea* (Mattusch.) Liebl., *Q. robur* *Fagus silvatica* L. (beech), *Pinus silvestris* L. (pine), *Larix decidua* Mill. (larch)
turfy	strong acid	*Q. petraea*, *F. silvatica*
red, brown forest	neutral-alcaline	*Pinus nigra* Arnold, *P. silvestris*
brown forest	neutral, weak acid	*Fraximus excelsior* L. (ash), *Q. robur*, *Alnus glutinosa* (L.) Gaertn. (alder), *Ulmus laevis* Pall. (elm)
brown forest	weak acid, acid	*F. silvatica*, *Tilia cordata* Mill. (lime tree), *Q. petraea*, *Acer pseudoplatanus* L. (maple), *Abies alba* Mill. (fir), *Picea abies* (L.) (spruce) Karst., *P. silvestris*, *P. nigra*
brown forest	acid	*Q. petraea*, *P. abies*
brown forest	acid	*F. silvatica*, *A. pseudoplatanus*, *F. excelsior*, *P. abies*, *A. alba*
brown forest	neutral, weak acid	*F. silvatica*, *L. decidua*, *Picea pungens* Engelm., *A. alba*
brown forest illimerized	acid	*F. silvatica*, *F. excelsior*, *A. pseudoplatanus* *A. glutinosa*, *P. abies*, *A. alba*
brown forest	acid	*Malus nitis* (Wallr.) Mausf. (apple), *Pyrus communis* L. (pear), *Prunus domestica* L. (plum), *Persica vulgaris* Mill. (peach), *Armeniaca vulgaris* Lam. (apricot), *Cydonia oblonge* Mill. (quince)
gley, illimerized	acid, weak acid	*M. nitis*, *P. communis*, *P. domestica*, *A. vulgaris*, *P. vulgaris*, *Cerasus avium* (L.) Moench (cherry)
gley, brown forest	neutral	*M. nitis*, *C. avium*, *P. domestica*, *Prunus italica* (Borkh.) Gams (greengage), *Sorbus edulis Dieck* (rowan)

TABLE II - *Abundance individual (in 500 cm^3 soil) of plant parasitic nematode species in forest and fruit nurseries in*

Forest nurseries:	Danubian lowland	Beskids foothills	Borska lowland	Slovak karst	Turčianska basin
Ectoparasitic species		3.5	–	20	35.3
Bitylenchus dubius (Bütschli, 1873) Siddiqi, 1986	–	–	–	–	7
B. maximus (Allen, 1955) Siddiqi, 1986	–	–	–	–	–
Merlinius brevidens (Allen, 1955) Siddiqi, 1970	–	–	–	–	–
Tylenchorhynchus cylindricus Cobb, 1913	–	1	–	–	–
T. macrurus (Goodey, 1932) Filipjev, 1936	–	–	–	–	–
T. vulgaris Upadhyay *et* Sethi, 1972	–	15	–	5	22.3
Rotylenchus fallorobustus Sher, 1965	–	–	–	–	–
R. robustus (de Man, 1876) Filipjev, 1936	–	–	–	–	–
Helicotylenchus canadiensis Wasseem, 1961	–	4.7	5	50	38.3
H. digonicus Perry, in Perry, Darling *et* Thorne, 1959	156	–	–	–	3
H. exallus Sher, 1966	–	–	–	–	–
H. nannus Steiner, 1945	–	–	–	–	17.3
H. pseudorobustus (Steiner, 1914) Golden, 1956	–	15.7	–	4	–
H. varicaudatus Yuen, 1964	–	2.5	–	–	–
Paratylenchus goodeyi Oostenbrink, 1953	–	–	–	–	1
P. hamatus Thorne *et* Allen, 1950	–	–	–	1	–
Macroposthonia annulatiformis de Grisse *et* Loof, 1967	–	0.7	–	–	–
M. complexa (Jairajpuri, 1964) de Grisse *et* Loof, 1965	–	–	–	–	–
M. crenata (Loof, 1964) de Grisse *et* Loof, 1965	–	–	–	1	–
M. kralli Ivanova, 1976	–	–	–	–	–
M. similis (Cobb, 1918) de Grisse *et* Loof, 1965	–	–	–	–	–
M. xenoplax (Raski, 1952) de Grisse *et* Loof, 1965	13	–	–	–	–
Criconema cobbi (Micoletzky, 1925) Siddiqi, 1986	–	–	–	–	–
Xiphinema taylori Lamberti, Ciancio, Agostinelli *et* Coiro, 1991	–	–	–	2	0.3
Trichodorus sparsus Szcygiel, 1968	–				
Endoparasitic species		–	–	–	–
Pratylenchus thornei Sher *et* Allen, 1953	–	1.7	–	–	8.6
P. pratensis (de Man, 1880) Filipjev, 1936	–				
Facultative plant parasites		–	–	–	–
Malenchus exiguus (Massey, 1969) Andrássy, 1980	–	3.7	–	–	–
Coslenchus costatus (de Man, 1921) Siddiqi, 1978	–				

different regions of the Slovak Republic.

Slovak Ore Mountains	Levoča hills	Low Tatra	Liptov basin	Orava highland	**Fruit nurseries:**	East Slovak upland	Hornonitrianska basin	Hornádska basin
0.6	3.5	1	7	–		–	–	–
1.3	–	–	–	2		18	3	5
–	–	–	–	–		20	27	–
–	–	–	–	–		17	21	–
–	–	–	–	–		–	–	–
–	–	–	–	–		7	–	–
22.3	–	–	–	1.6		7	5	2
20.6	0.5	1	–	3		–	–	–
–	9.5	–	–	–		–	–	–
2.3	14	1	3	22.3		85	52	66
–	–	–	–	–		–	–	–
1.6	–	–	–	–		–	–	–
–	–	–	–	–		–	–	–
12	–	–	–	–		11	13	12
15.6	0.5	23	2	15		–	–	–
–	–	–	–	–		–	–	–
0.6	–	–	–	–		–	–	–
–	–	–	–	–		–	–	–
0.6	–	–	–	–		–	–	–
0.6	–	–	–	–		–	–	–
0.6	–	–	–	–		–	–	–
–	–	–	–	–		–	–	–
–	–	–	–	–		1	–	–
-1.5	–	–	–			–	–	–
–	–	–	–	–		–	–	–
1.3	–	–	–	–		–	–	–
1.3	–	–	–	0.3		–	–	5
–	–	–	27	5.3		13	–	10
0.6	–	–	–	–		4	–	–

lenchus exiguus (Massey) Andrássy (syn. *Tylenchus exiguus*) and *Coslenchus costatus* (de Man) Siddiqi.

Results

In the soil samples, taken from the rhizosphere of forest and fruit trees, 1778 specimens of plant parasitic nematodes were identified (1374 specimens from forest nurseries and 404 specimens from fruit nurseries); 29 species of plant parasitic nematodes were identified in total: 25 in forest nurseries and 11 species in fruit nurseries. The abundance of individual plant parasitic nematode species in forest and fruit nurseries of various regions of the Slovak Republic is given in Table II. The total abundance of plant parasitic nematodes and the total abundance of plant nematodes detected are presented in Table III. A survey of the occurrence of plant parasitic nematodes in some forest and fruit nurseries in association with species of forest and fruit trees is given in Table IV. The number of plant parasitic species and their percentage occurrence from the total nematode fauna were different in forest and fruit nurseries of individual regions (Tables V, VI).

TABLE III - *Total abundance of nematodes in forest and fruit nurseries in different regions of the Slovak Republic (individuals in 500 cm^3 soil).*

	Plant parasitic	Free living
Forest nurseries		
Danubian lowland	169	1406
Beskids foothills	48.7	170.2
Borska lowland	5	237
Slovak karst	83	554
Turčianska basin	133.3	396.6
Slovak Ore Mountains	82.6	562.6
Levoča hills	29.5	86.5
Low Tatra	26	253
Liptov basin	39	513
Orava highland	49.6	393
Fruit nurseries		
East Slovak upland	183	1556
Hornonitrianska basin	121	320
Hornadska basin	100	890

In the forest nurseries in the localities of the Levoča hills region plant parasitic nematodes showed the greatest percentage occurrence, 34.1%. They were also prevalent in the localities of the Turčianska basin region, 33.6%; and the Beskids foothills region, 28.6%, but rare, only 2.1% of the total nematode fauna in the locality of the Borska lowland region.

The highest number of plant parasitic nematode species was recorded in the localities of the Slovak Ore Mountains region; while, fewest species were detected in the locality in the Borska lowland region (1). The analysis suggested that the predominating ectoparasitic species were *Helicotylenchus digonicus* (Perry) Darling *et* Thorne (locality of the Danubian lowland region, 156 specimens in 500 cm^3 of soil), *Bitylenchus dubius* (Bütschli) Siddiqi (localities of the Turčianska basin region, 35.3 specimens), *Malenchus exiguus* (Massey) Andrássy (locality of the Liptov basin region, 27 specimens), *Rotylenchus fallorobustus* Sher (localities of the Slovak Ore Mountains region, 22.3 specimens and the Turčianska basin region, 22.3 specimens) and *Rotylenchus robustus* (de Man) Filipjev (localities of the Slovak Ore Mountains region, 20.6 specimens). The plant parasitic species *H. digonicus* was predominant in six regions of the Slovak Republic with different topographic, climatic and geological conditions. Only two endoparasitic species were found, *Pratylenchus thornei* Sher *et* Allen was identified in the localities of the Slovak Ore Mountains region and *P. pratensis* (de Man) Filipjev was recorded from the localities of the Beskids foothills region, the Turčianska basin, the Slovak Ore Mountains and the Orava highland. The study on the occurrence of plant parasitic species in forest nurseries in the selected regions showed a sporadical occurrence of species such as *H. pseudoro-*

bustus (Steiner) Golden, *Paratylenchus hamatus* Thorne *et* Allen and *H. exallus* Sher in the localities of the Turčianska basin region, *H. canadensis* Wasseem and *Xiphinema taylori* Lamberti, Ciancio, Agostinelli *et* Coiro in the localities of the Levoča hills, *Macroposthonia complexa* (Jairajpuri) de Grisse *et* Loof and *Tylenchorhynchus macrurus* (Goodey) Filipjev in the localities of the Beskids foothills region, *Macroposthonia similis* (Cobb) de Grisse *et* Loof, *M. crenata* (Loof) De Grisse *et* Loof in the localities of the Slovak Ore Mountains region and *M. xenoplax* (Raski) De Grisse *et* Loof in the locality of the Danubian lowland region. The plant parasitic species *Paratylenchus goodeyi* Oostenbrink was frequently recorded from the higher situated and cooler localities of regions Slovak Ore Mountains, Low Tatra and Orava highland, with predominating sandy-loamy soils.

Table IV shows the difference in the occurrence of individual species of plant parasitic nematodes in association with individual species of forest trees. The highest numbers of species of plant nematodes (17) were present in the rhizosphere of oak, 12 in the rhizosphere of lime tree and 12 in the rhizosphere of spruce. *Tylenchorhynchus macrurus* (Goodey) Filipjev, *H. nannus* Steiner, *M. crenata* (Loof) De Grisse *et* Loof, *X. taylori*, *Trichodorus sparsus* Szcygiel, *Pratylenchus thornei* and *Coslenchus costatus* were rare and their presence was observed in the rhizosphere of one to three species of trees. *Bitylenchus dubius*, *Rotylenchus fallorobustus*, *H. digonicus*, *H. varicaudatus* Yuen and *Paratylenchus goodeyi* were present in the rhizosphere of most investigated species of forest trees.

In the fruit nurseries, the highest percentage occurrence of phytophages was in the locality in the Hornadska basin region, 31.2%, while the lowest was in the locality of the East Slovak upland region, 11.8% of the total nematode fauna. The greatest number of plant parasitic nematode species was recorded in the locality of the East Slovak upland region (10) and, the lowest in the locality of the Hornádska basin region (6). The predominating ectoparasitic species were *H. digonicus* (the East Slovak upland region, 85 specimens in 500 cm^3 of soil), *Merlinius brevidens* (Allen) Siddiqi (the Hornonitrianska basin region, 27 specimens) and *Tylenchorhynchus cylindricus* Cobb (the Hornonitrianska basin region, 21 specimens). Conversely, the ectoparasitic species *Coslenchus costatus* occurred sporadicaly only in the locality in the East Slovakia upland region. The only endoparasitic species was *Pratylenchus pratensis*, recorded in the locality in the Hornádska basin region. The fruit nurseries in all three regions studied showed the predominance of *H. digonicus* with presence of *Bitylenchus maximus* (Allen) Siddiqi, *Rotylenchus fallorobustus* and *H. varicaudatus*. A frequent occurrence of *M. brevidens* and *T. cylindricus* was ascertained in the warmer and lower situated localities in the East Slovak upland region and the Hornonitrianska basin region.

In fruit nurseries, similarly to forest nurseries, it was observed (Table IV) that some plant parasitic nematodes e.g. *B. maximus*, *H. digonicus*, *H. varicaudatus* and *Malenchus exiguus* (Massey) Andrássy occurred in association with nearly all sampled fruit species. On the other hand, the other species, e.g. *Tylenchorhynchus vulgaris* Upadhyay, Swarup *et* Sethi, *Criconema cobbi* (Micoletzky) Taylor, *P. pratensis* and *C. costatus* were rare and their occurrence was observed associated with one to two species of trees. The largest numbers of species of plant nematodes (8) were observed in the rhizosphere of apple trees. Only three species were found in the rhizosphere of greengage and quince trees.

Discussion

The species of plant parasitic nematode identified in some forest nurseries in various regions of Slovakia are considered as important pests, affecting the production of forest seedling mate-

TABLE IV - *Plant parasitic nematodes in some forest and fruit nurseries of the Slovak Republic in association with forest*

Forest trees:	*Alnus glutinosa*	*Fraxinus excelsior*	*Fagus silvatica*	*Ulmus laevis*	*Abies alba*	*Tilia cordata*	*Acer pseudoplatanus*	*Quercus robur*	*Pinus silvestris*
Ectoparasitic species									
Bitylenchus dubius	+	+	+	+	+	+		+	+
B. maximus	+	+		+	+	+		+	
Merlinius brevidens									
Tylenchorhynchus cylindricus									
T. macrurus								+	+
T. vulgaris									
Rotylenchus fallorobustus	+	+	+	+		+	+	+	+
R. robustus		+				+	+	+	+
Helicotylenchus canadensis						+		+	
H. digonicus	+	+	+	+	+	+	+	+	+
H. exallus		+		+				+	
H. nannus						+			
H. pseudorobustus	+	+		+				+	
H. varicaudatus	+	+			+		+	+	+
Paratylenchus goodeyi	+		+	+	+	+	+	+	+
P. hamatus								+	
Macroposthonia annulatiformis									
M. complexa			+						
M. crenata								+	
M. kralli									
M. similis			+						
M. xenoplax									
Criconema cobbi									
Xiphinema taylori						+		+	
Trichodorus sparsus		+			+			+	
Endoparasitic species									
Pratylenchus thornei			+						
P. pratensis		+	+	+		+	+	+	
Facultative plant parasites									
Malenchus exiguus		+	+	+		+		+	
Coslenchus costatus						+			

rials (Gubina, 1980; Mancini *et al.*, 1983; Sutherland and Webster, 1993). The latter authors describe the symptoms of seedlings affected in forest nurseries, such as degeneration of roots, chlorosis of leaves and pine-needles and stunted sprouts. Hijink (1969) in Holland pointed out the harmful effect of *Rotylenchus robustus* on spruce trees. Specimens of this species were found in forest nurseries at four localities in Slovakia. Riffle (1968) pursued the studies of plant parasitic nematodes, parasitizing pine trees; among them also he included *M. exiguus*. The presence of *H. digonicus* was recorded in forest nurseries of all the ten regions studied in the Slovak Republic. Mancini *et al.* (1983) in Italy observed the reduction of seedling tops and roots of pines, caused by this ectoparasitic species. The ectoparasitic species *T. sparsus* was found in forest nurseries of the regions of Slovak karst and Turčianska basin. This species

and fruit trees.

Populus nigra	*Picea abies*	**Fruit trees:**	*Malus nitis*	*Ameniaca vulgaris*	*Cerasus avium*	*Prunus italica*	*Prunus persica*	*Pyrus communis*	*Prunus domestica*	*Cydonia oblonga*	*Sorbus edulis*
	+										
	+		+	+	+		+	+	+	+	
			+	+			+	+	+		
	+		+				+	+	+		
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	+		+	+	+			+			
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			+								

has been frequently recorded from Tatra National Park forest nurseries (Lišková *et al.*, 1996) and productive forests throughout of the Slovak Republic territory (Lišková and Sturhan, 1996).

The plant parasitic nematodes identified in fruit nurseries of the Slovak Republic are considered by Fitzell *et al.* (1994) and Wood (1992) as phytopathologically important for the cultivation of seedling materials of orchard trees. According to Nyczepir and Halbrendt (1993), these are especially the members of the endoparasitic genus *Pratylenchus*, detected in fruit nursery at the Hornádska basin region. The predominant species in all the fruit nurseries studied was *H. digonicus*. Fitzell *et al.* (1994) studied the pathogenicity of nematodes of the genus *Helicotylenchus* in the rhizosphere of apple trees and a consequent reduction of their root system. Also, Lan (1992) studied the plant parasitic nematodes in the rhizosphere of peach-

TABLE V - *Number and percentage occurrence of plant parasitic nematodes in the total nematode fauna in forest nurseries of the Slovak Republic.*

Location	No. species	% of total nematode fauna
Danubian lowland	2	12.1
Beskids foothills	9	28.6
Borska lowland	1	2.1
Slovak karst	7	15.0
Turčianska basin	9	33.6
Slovak Ore Mountains	15	22.0
Levoča hills	6	34.1
Low Tatra	4	10.3
Liptov basin	4	8.0
Orava highland	8	13.0

TABLE VI - *Number and percentage occurrence of plant parasitic nematodes in the total nematode fauna in fruit nurseries in the Slovak Republic.*

Location	No. species	% of total nematode fauna
East Slovak upland	11	11.8
Hornonitrianska basin	7	13.6
Hornádska basin	6	31.2

trees in fruit nurseries of the United States of America and reported the presence of nematodes of the genus *Helicotylenchus*.

This review of the communities of plant parasitic nematodes in some forest and fruit nurseries of Slovakia provides the basic information about the occurrence and distribution of individual species of plant parasitic nematodes and shows their potential negative influence on the cultivation of seedling materials.

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