Plant-parasitic nematodes associated with maize and pearl millet in Namibia

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Twenty-eight plant-parasitic nematode species belonging to 17 genera were identified in soil and root samples collected in 20 maize and five pearl millet fields in Namibia. Eighteen of these species are new records for Namibia. Three agricultural areas were sampled viz. Hardap Dam, Grootfontein-Tsumeb and Kavango-Caprivi. The most common ectoparasites were *Mesocriconema curvatum* and *M. sphaerocephalum*, which were present in 32 % and 28 % of all soil samples, respectively. *Pratylenchus zeae* and *P. penetrans* were the dominant endoparasites, occurring in 64 % and 56 % of all root samples, respectively. The prominence value of *P. zeae* was higher in the Grootfontein-Tsumeb (5047 5 g^{-1} roots) area than in the Kavango-Caprivi (788 5 g^{-1} roots) and Hardap Dam (67 5 g^{-1} roots) areas, while the prominence value of *P. penetrans* was higher at Kavango-Caprivi (3086 5 g^{-1} roots) than at Grootfontein-Tsumeb (1696 g^{-1} roots) and Hardap Dam (23 5 g^{-1} roots). In Kavango-Caprivi, the prominence values of *M. curvatum*, *P. zeae* and *P. penetrans* were always higher for maize than for pearl millet.

Key words: maize, Namibia, pearl millet, *Pennisetum americanum*, plant-parasitic nematodes, survey, *Zea mays*.

Namibia is an arid country with annual rainfall ranging from 100–200 mm in the south to 500–600 mm in the north. Crop production consequently is restricted to about 1 % of the land surface. Maize (*Zea mays* L.) is produced mainly by commercial farmers, either under irrigation in the southern region or under dryland conditions in the northern region. Pearl millet (*Pennisetum americanum* (L.) Leeke), locally known as mohango, is the staple food produced under dryland conditions by small-scale farmers in the Kavango and Caprivi districts in the north. In these districts, maize is grown only at a few irrigated project sites.

Although nematodes are common in field crops in neighbouring South Africa (De Waele & Jordaan 1988a,b; Bolton et al. 1989; Jordaan et al. 1992; Venter et al. 1992), the nematodes associated with field crops in Namibia have not been studied. This paper discusses the plant-parasitic nematodes isolated from maize and pearl millet fields in the country.

Materials and methods

Three major agricultural areas in Namibia were sampled (Fig. 1). The Hardap Dam area is characterised by irrigation farming. Maize is rotated mainly with wheat (*Triticum aestivum* L.) and lucerne (*Medicago sativa* L.). Nematicides are frequently applied only at planting. Soils in the region contain 72–84 % sand. The Grootfontein-Tsumeb area is characterised by dryland farming of maize in monoculture. No nematicides are used and the sand content of the soils is 85–92 %. In the Kavango-Caprivi area maize is planted in monoculture under irrigation and pearl millet under dryland conditions. Nematicides are not used and the sand content of the soils is 94–100 %.

During April 1986, samples were collected from 20 maize and five pearl millet fields in the above areas, 90–150 days after planting. Five plants were arbitrarily selected in each field. Roots and rhizosphere soil collected from the five plants in each field were pooled separately. Nematodes in 100 ml soil from each pooled sample were killed and fixed with hot 4 % formaldehyde within 24 hours of collection. Five grams of root from each pooled sample were macerated in water in a kitchen blender and the nematodes killed and fixed with 4 % hot formaldehyde. In the laboratory, nematodes were extracted from the soil and root samples by sugar centrifugal-flotation (Jenkins 1964; Coolen & D'Herde 1972). Nematode numbers were determined under a dissecting

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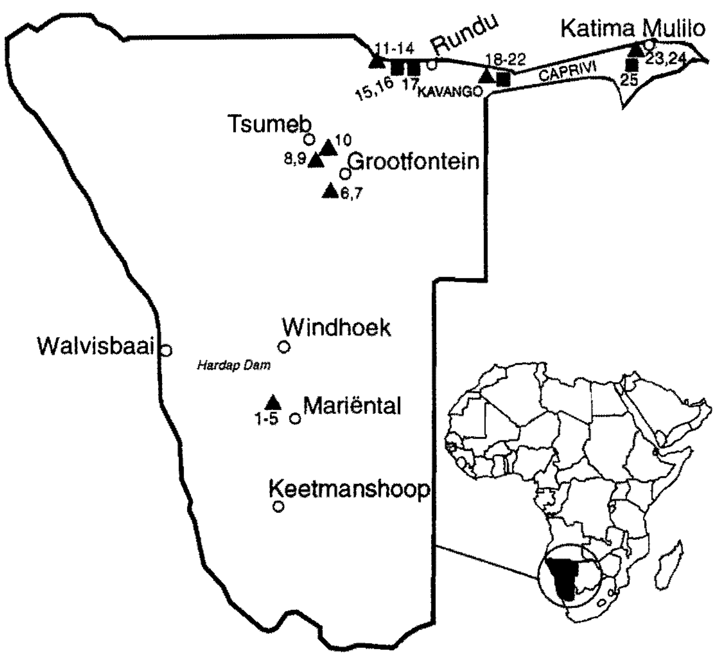

Fig. 1. Map of Namibia showing areas (shaded) and crops (maize ▲, pearl millet ■) sampled for nematodes.

microscope. Plant-parasitic nematodes were transferred to anhydrous glycerin (De Grisse 1969), mounted on slides by the paraffin-ring method and identified. Prominence values (PV = population density $\times \sqrt{\text{frequency of occurrence}/10}$) were calculated for each nematode species.

Results

More than 28 plant-parasitic nematode species belonging to 16 genera were identified in the soil and root samples collected from the 25 fields (Tables 1, 2). Twenty-four species were found in the soil samples (Table 1). The most common ectoparasites were *Mesocriconema curvatum* and *M. sphaerocephalum,* which occurred in 32 % and 28 %, respectively, of all soil samples. Juveniles of an unidentified *Xiphinema* species were recovered from 24 % of all soil samples in relatively high densities (on average 32 individuals 100 ml^{-1} soil). All other ectoparasitic species were found less frequently. Thirteen of these occurred in only one soil sample.

Five species were found in the root samples (Table 2). The most common endoparasites were *Pratylenchus zeae* and *P. penetrans,* which were present in 64 % and 56 %, respectively, of all root samples. Juveniles of an unidentified *Meloidogyne* species were recovered from 20 % of all root samples, albeit in low densities (on average nine individuals 5 g^{-1} roots).

Although *Rotylenchulus parvus* occurred in 60 % and 56 %, respectively, of all soil and root samples, the high population levels in the soil (5564 individuals 100 ml^{-1} soil) were not matched by high population levels in the roots (46 individuals 5 g^{-1} roots). *Pratylenchus* spp. were not found in any of the soil samples. *Criconema mutabile, Helicotylenchus dihystera, Scutellonema magniphasmum* and *Tylenchorhynchus brevilineatus* were present only in a few soil samples (Table 1), but in high densities (>800 individuals100 ml^{-1} soil or 5 g^{-1} roots).

Nineteen and 16 species were associated with maize and pearl millet, respectively. These included all endoparasitic species, except *P. brachyurus* in pearl millet. Eight species were associated with both maize and pearl millet. Only the endoparasites *P. zeae* and *P. penetrans* and the sedentary ectoparasite *R. parvus,* were found in all three areas sampled (Table 2). Hardap Dam area had the smallest diversity (seven species) followed by the Grootfontein-Tsumeb (eight species) and Kavango-Caprivi (23 species) areas.

Table 1. Frequency of occurrence, mean population density and prominence value (PV)[a] of the predominant nematodes recovered from soil samples in maize and pearl millet fields in Namibia.

Nematode species	PV per area				All areas		
	Maize			Pearl millet	Frequency of occurrence (%)	Population density (100 ml^{-1} soil)	PV
	Hardap Dam (n = 5)	Grootfontein-Tsumeb (n = 5)	Kavango-Caprivi (n = 10)	Kavango-Caprivi (n = 5)			
Hemicriconemoides brachyurus	1	0	0	13	4	30	60
Hemicycliophora lutosa	379	0	0	0	4	2	0
Criconema mutabile	0	0	0	0	4	847	169
Mesocriconema sphaerocephalum	0	38	251	0	28	248	131
Mesocriconema curvatum	0	0	717	100	32	734	415
Helicotylenchus pseudorobustus	2	0	0	66	4	148	30
Helicotylenchus dihystera	0	0	536	0	8	849	240
Rotylenchus unisexus	0	0	4	0	4	14	3
Rotylenchus capensis	0	0	0	80	4	178	36
Rotylenchus karooensis	0	330	0	0	12	426	148
Rotylenchus brevicaudatus	0	0	0	80	4	178	36
Hoplolaimus pararobustus	0	0	140	33	12	232	80
Scutellonema magniphasmum	0	0	536	0	4	1694	339
Scutellonema brachyurus	0	0	0	2	4	4	1
Scutellonema unum	0	0	0	13	4	30	6
Tylenchorhynchus dewaelei	0	—	18	0	8	—	—
Tylenchorhynchus brevilineatus	0	0	0	1040	12	1463	507
Tylenchorhynchus avaricus	0	0	3	2	8	8	2
Histotylenchus histoides	0	0	0	66	4	148	30
Histotylenchus spp.	0	0	0	57	4	127	25
Rotylenchulus parvus	14805	1762	261	1582	60	5564	4310
Paratrichodorus minor	48	0	0	0	8	76	22
Longidorus pisi	0	13	0	0	4	30	6
Xiphinema spp.	0	8	0	42	24	32	16

[a]PV = population density × $\sqrt{\text{frequency of occurrence}}/10$ in 100 ml soil.

Table 2. Frequency of occurrence, mean population density and prominence values (PV)[a] of the predominant nematodes recovered from roots of maize and pearl millet in Namibia.

Nematode species	PV per area				All areas		
	Maize			Pearl millet	Frequency of occurrence (%)	Population density (5 g^{-1} roots)	PV
	Hardap Dam (n = 5)	Grootfontein-Tsumeb (n = 5)	Kavango-Caprivi (n = 10)	Kavango-Caprivi (n = 5)			
Pratylenchus zeae	67	5047	788	326	64	1956	1565
Pratylenchus brachyurus	0	0	197	0	4	1392	278
Pratylenchus penetrans	23	1696	3086	1118	44	2698	1790
Rotylenchulus parvus	30	97	6	1	56	46	34
Meloidogyne spp.	0	67	5	0	20	9	4

[a]PV = population density × $\sqrt{\text{frequency of occurrence}}/10$ in 5 g roots.

Only five species were not recorded in the Kavango-Caprivi area, namely *Hemicycliophora lutosa, C. mutabile* and *Paratrichodorus minor,* found only at Hardap Dam, and *Rotylenchus karooensis* and *Longidorus pisi*, found only in the Grootfontein-Tsumeb area.

Prominence values of the most common endoparasites differed between areas (Table 2). The prominence value of *P. zeae* was higher in the Grootfontein-Tsumeb area (5047 5 g^{-1} roots) than in the Kavango-Caprivi (788 5 g^{-1} roots) and Hardap Dam (67 5 g^{-1} roots) areas. *P. penetrans* showed a similar trend, with a prominence value of 3086 5 g^{-1} roots in the Kavango-Caprivi area, 1696 5 g^{-1} roots and 923 5 g^{-1} roots in the Grootfontein-Tsumeb and Hardap Dam areas. In the Kavango-Caprivi area the prominence values of *M. curvatum, P. zeae* and *P. penetrans* were always higher for maize than for pearl millet.

Only one field yielded all three *Pratylenchus* spp., while *P. zeae* and *P. penetrans* occurred together in nine fields. *P. zeae* was the only *Pratylenchus* sp. in six fields and *P. penetrans* and *P. brachyurus* in one field each. In the field where all three *Pratylenchus* species were present, *P. penetrans* outnumbered *P. zeae,* which in turn outnumbered *P. brachyurus.* The highest *Pratylenchus* population densities found were 22455, 19383 and 2769 5 g^{-1} roots for *P. zeae, P. penetrans* and *P. brachyurus,* respectively.

Discussion

In a survey of nematodes associated with maize in South Africa (De Waele & Jordaan 1988a), *M. sphaerocephalum* was also reported as a predominant ectoparasite, together with *P. minor* and *Scutellonema brachyurus.* In Namibia, *P. minor* was found only on maize at Hardap Dam (PV = 47.8 5 g^{-1} roots), whereas *S. brachyurus* was recovered only from pearl millet in the Kavango-Caprivi area (PV = 1.8 5 g^{-1} roots). The widespread occurrence of *S. brachyurus* on maize in South Africa (Walters 1979; De Waele & Jordaan 1988a) therefore may not apply to other southern African countries. This species has been reported from numerous hosts (Sher, 1963; Siddiqi 1974) elsewhere but rarely on cereals, which are considered non-hosts (Kraus-Schmidt & Lewis 1979). *M. curvatum* was not recorded during the maize survey in South Africa. *L.pisi,* which was present in two-thirds of the South African maize fields sampled by De Waele & Jordaan (1988a), was recorded at low frequencies only on maize in Namibia (PV = 13.4 5 g^{-1} roots).

In South Africa, *P. zeae* and *P. brachyurus* are the predominant endoparasites associated with maize, while *P. penetrans* occurs considerably less frequently (De Waele & Jordaan 1988a). Maize has been reported as a suitable host for all three of the above *Pratylenchus* species (Swarup & Sosa-Moss 1990). In Namibia, *P. brachyurus* was found on maize only in the Kavango-Caprivi area (PV = 196.8 5 g^{-1} roots). The high frequency of occurrence of *P. penetrans* (44 %) is surprising as this species prefers temperatures of 20–24 °C (Loof 1978), which are lower than in the areas sampled.

As in South Africa (De Waele & Jordaan 1988a), population densities of *R. parvus* in maize roots remained rather low in Namibia, although prominence values in the soil were high compared to other plant-parasitic nematodes. This contradicts reports by Shepherd (1977) and Furstenberg & Heyns (1978) who regard maize as a good host of *R. parvus.*

The frequency of occurrence of *Meloidogyne* spp. in Namibia and South Africa (De Waele & Jordaan 1988a) is comparable. A recent study (Riekert 1996) showed that the presence on maize and damage caused by *Meloidogyne* spp. in South Africa have been greatly underestimated. The similarity of occurrence in the two countries suggests that root-knot nematodes are also important pathogens of maize in Namibia. The diversity of the plant-parasitic nematofauna associated with maize was greater in Namibia (19 species in 20 maize fields) than in South Africa (nine species in 14 maize fields) (De Waele & Jordaan 1988a).

Eighteen of the species collected during this study constitute new records for Namibia, viz. *Criconema mutabile, Helicotylenchus dihystera, H. pseudorobustus, Hemicriconemoides brachyurus, Hemicycliophora lutosa, Longidorus pisi, Mesocriconema curvatum, M. sphaerocephalum, Pratylenchus brachyurus, P. zeae, P. penetrans, Rotylenchulus parvus, Rotylenchus brevicaudatus, R. karooensis, R. unisex, Scutellonema brachyurus, S. magniphasmum* and *S. unum.*

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