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Plant-parasitic nematodes associated with root and tuber crops in Uganda

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In a nematode survey of eight commonly grown root and tuber crops (cassava, sweet potato, potato, yam, tannia, taro, carrot and turmeric) from 430 fields in Uganda, 69 species of plant-parasitic nematodes representing 28 genera were extracted from soil and roots. About twice as many nematode species were recovered from soil (64) as from roots (36), while 32 species were found only in soil and four species only in roots, usually in mixed populations. *Meloidogyne* spp. (root-knot nematodes) were the most frequently recovered across crops, with the major species (*M. arenaria, M. hapla, M. incognita* and *M. javanica*) observed on cassava. Some nematodes were recovered only from specific crops. Sweet potato yielded the greatest diversity of species (55 species in 25 genera), followed by cassava (40 species in 19 genera) and yam, which was sampled principally in the northern and eastern regions of Uganda (39 species in 14 genera). Results of the study provide baseline information for more detailed local population studies and nematode pathogenicity evaluations on important root and tuber crops.

Key words: carrot, cassava, cocoyam, plant-parasitic nematodes, potato, survey, sweet potato, tannia, taro, turmeric, Uganda.

Root and tuber crops represent the most important food commodity in many subtropical and tropical countries (FAO 2001) and are a vital source of carbohydrates in Africa. The most widely grown of these in Uganda are potato (*Solanum tuberosum* L.), sweet potato (*Ipomoea batatas* (L.) Lam.), cassava (*Manihot esculenta* Crantz), yam (*Dioscorea* spp.), taro (*Colocasia esculenta* (L.) Schott.) and tannia (*Xanthosoma* spp.). Other root and tuber crops that are cultivated as cash crops on a small scale include turmeric (*Curcuma domestica* Loir.) and carrot (*Daucus carota* L.).

Nematodes can cause serious yield and quality reductions in most root and tuber crops. Numerous reports from the tropics and subtropics have detailed the incidence of plant-parasitic nematodes on root and tuber crops or associated crop damage, e.g. Caveness et al. (1981), McSorley et al. (1983), Jatala & Bridge (1990) and Coyne (1995). However, the majority of studies focused on the more globally cultivated crops such as potato, while information on commercially less important crops is relatively scarce (Luc et al. 1990). Given the global importance of root and tuber crops, particularly in relation to food security (Kay 1987), more extensive knowledge of the pest status and effects of plant-parasitic nematodes would be beneficial.

Previous reports detailing plant-parasitic nematode associations with crops in Uganda included studies on pineapple (*Ananas comosus* (L.) Merr.) (Bafokuzara 1982), vegetables (Bafokuzara 1983), banana (*Musa* spp.) (Kashaija et al. 1994) and tobacco (*Nicotiana tabacum* L.) (Anon 1952; Trought 1954), with studies on root and tuber crops limited to cassava (Bridge et al. 1991; Coyne & Namaganda 1994) sweet potato (Namaganda et al. 1993; Coyne & Namaganda 1996) and yam (Mudiope et al. 1998).

Root-knot nematodes (*Meloidogyne* spp.), first identified as a potential threat to cassava production in Uganda by Bridge et al. (1991), are considered to be important pests of yam (Bridge 1973) and the most important nematode pest of sweet potato (Gapasin et al. 1988). They cause serious damage to carrots (Slinger & Bird 1978) and frequently occur in high populations on cocoyams (tannia and taro) (Caveness et al. 1981; Runkulatile & Teri 1990). Other plant-parasitic nematodes regarded as problematic on root and tuber crops include *Scutellonema bradys,* which causes dry rot of yam in West Africa (Jatala & Bridge 1990) and *Hirschmanniella miticausa,* causal agent of 'mitimiti' disease of taro in the south Pacific (Bridge et al. 1983). Nematodes can therefore pose a significant threat to root and tuber crop production.

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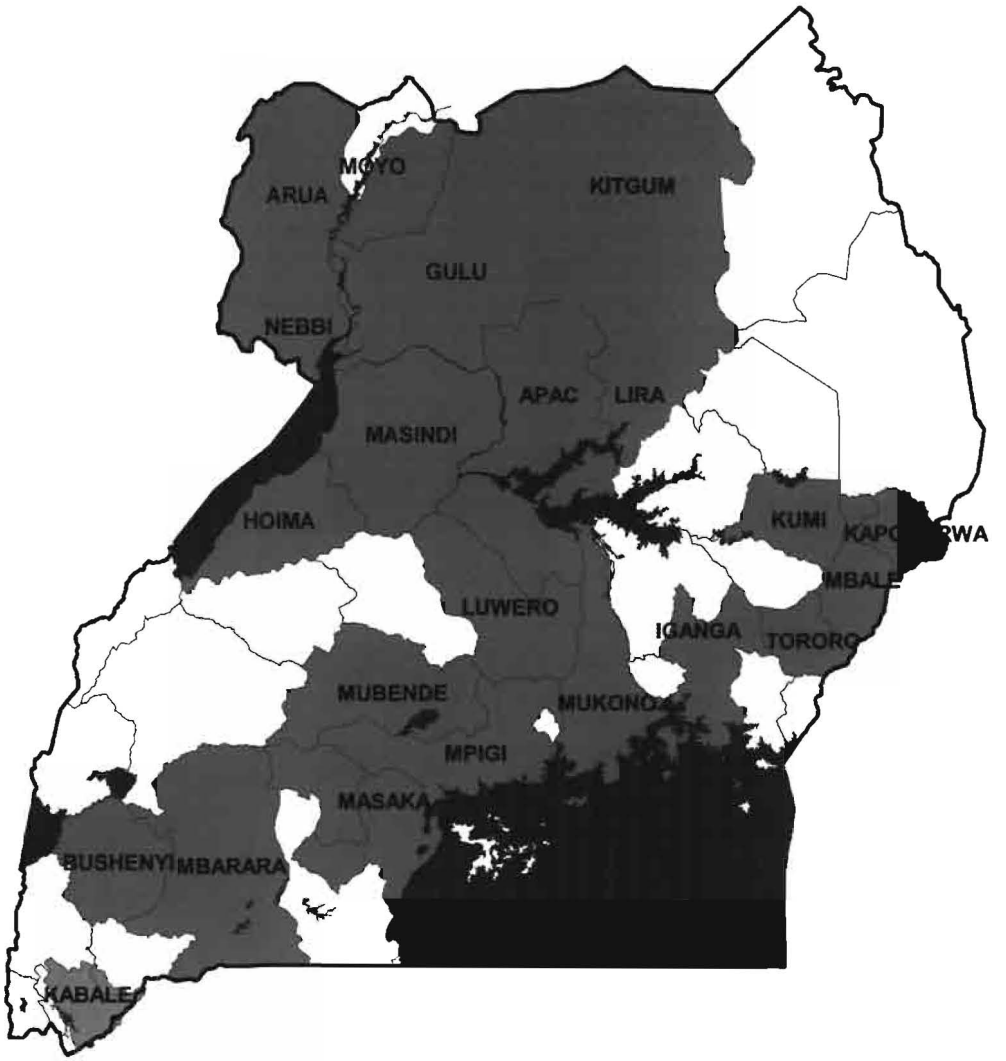


Fig. 1. Map of Uganda showing the districts surveyed in 1993 and 1994 (lighter-grey shading) for plant-parasitic nematodes associated with root and tuber crops.

The objective of this study was to assess the distribution and abundance of plant-parasitic nematodes on root and tuber crops in Uganda, particularly cassava, as a follow-up to the findings of Bridge et al. (1991).

Materials and methods

Root and soil samples were collected in 1993 and 1994 from the following crops at 430 sites in Uganda: cassava (166 fields), sweet potato (132), yam (57), potato (35), tannia (24), taro (8), carrot (5) and turmeric (3). The sites were situated in 22 districts, viz. Arua, Moyo, Nebbi, Gulu, Kitgum, Apac, Lira (northern Uganda); Kumi, Kapchorwa, Mbale, Tororo, Iganga (eastern Uganda); Mukono, Mpigi, Luwero, Masaka, Mubende (central Uganda); Masindi, Hoima, Bushenyi, Mbarara, Kabale (western Uganda) (Fig. 1). Samples were taken from 5–10 individual plants at each site and pooled to form a composite sample. Nematodes were extracted from 100 ml of soil and 10 g of fresh roots from the composite sample. Soil immediately adjacent to roots and/or tubers was removed from each plant to maximise the retrieval of nematodes associated with the crop. The nematodes extracted from soil should therefore be considered as

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associated with the crop sampled, although their derivation from weeds present cannot be ruled out. Roots were washed, surface-dried and cut into c. 2 cm segments before removing a 10 g fresh mass sub-sample. With the exception of sweet potato, root sub-samples were macerated in an electric blender for 15–30 seconds. Sweet potato root sub-samples were chopped finely with a knife as macerated roots quickly deteriorated, suppressing nematode activity. Nematodes from soil and roots were extracted for 24–36 hours by a modified Baermann funnel technique (Hooper 1990). The extracted nematodes were killed and fixed in hot TAF (2 % triethanolamine and 7 % formalin solution)] (Hooper 1986). Vermiform nematodes were identified to species level from adults and counted using a stereomicroscope. Where no adults existed, nematodes were identified to genus level only. *Meloidogyne* spp. were identified primarily according to perineal patterns, supported by observations on juveniles. Identifications were confirmed by D J Hunt, M R Siddiqi and J E Machon at CABI Bioscience, Egham, UK. The frequency of occurrence for each species identified was calculated for each of the four regions in Uganda. Mean population densities were calculated for each species observed and the maximum density recorded for each crop.

Results

In total, 69 nematode species representing 28 genera were collected from the various samples. Sixty-four species were recovered from soil and 36 from roots. Of these, 32 species were recovered only from soil and four only from roots (Table 1). The taxonomic composition (Table 1) and population densities (Table 2) varied between crops and regions (Tables 3–6). However, there was a general positive relationship between the number of fields sampled and the number of species encountered on the crops. Some species primarily regarded as fungivorous (e.g. *Aphelenchoides bicaudatus, Aphelenchus avenae, Filenchus* spp. *Tylenchus* spp., *Malenchus* spp.), rather than genuinely parasitic on higher plants, have been recorded to provide a comprehensive account of the species observed. Genera such as *Aphelenchus* were often encountered in high densities.

Forty species from 19 genera were associated with cassava. Of these, five species were associated with cassava only (*Criconemoides* sp., *Hemicriconemoides* cf. *brachyurus, Paratrichodorus minor, Sakia* sp. and *Varotylus* sp.) and 24 species were recovered only from soil, although samples invariably contained mixed populations of nematodes (Table 1). It should be noted that the genus *Varotylus* is accepted only by Siddiqi (2002), but is otherwise considered as *Rotylenchus* (A Swart, pers. comm.). More species of nematodes were associated with sweet potato than with any other crop (55 species from 24 genera). Among these, 12 species were associated with sweet potato only. Yam was sampled mostly in the northern and eastern regions of Uganda. Thirty-nine species from 14 genera were recovered from yam soils and roots and only two of these were associated with yam only (*Hemicycliophora nyanzae* and *Pratylenchus sudanensis*).

As the occurrence of some crops depended on geographic location, no qualitative or quantitative comparisons between regions were possible. For example, potato was encountered almost exclusively in the eastern and western regions as it grows best in the highlands (1800 m asl), whereas yam was cultivated mainly in northern and eastern Uganda.

Across crops, symptoms of root galling, characteristic of root-knot nematode (*Meloidogyne* spp.) damage, were often observed. *Meloidogyne* spp. were recovered frequently and occurred on all crops. The major species, *M. arenaria, M. hapla, M. incognita* and *M. javanica,* were all present. Highest population densities of *Meloidogyne* spp. occurred on cassava.

Discussion

This report provides a baseline data set on the distribution and abundance of plant-parasitic nematodes of root and tuber crops in Uganda. While a wide diversity of genera and species were associated with the crops, particularly from soil, the pathogenic role of most of the species remains unclear. The present study was stimulated following observations by Bridge et al. (1991) of severe *Meloidogyne* galling damage to cassava, and the findings indicated that *Meloidogyne* spp. were indeed frequently associated with cassava. The extent of damage that *Meloidogyne* spp. cause to cassava, however, still has to be verified. In a separate study, Coyne & Namaganda (1994) observed high levels of galling damage to harvested cassava roots in Uganda. Although Coyne & Talwana (2000) later correlated galling damage in the field with yield loss, data to

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Table 1. Occurrence of plant-parasitic nematodes in roots and soil of root and tuber crops in Uganda.

Nematode	Soil								Roots							
	Taro	Yam	Sw potato	Cassava	Potato	Tannia	Turmeric	Carrot	Taro	Yam	Sw potato	Cassava	Potato	Tannia	Turmeric	Carrot
	6[a]	36	53	44	28	15	1	12	4	16	26	24	11	15	5	5
Aphelenchoides sp.	+	+	+	+	+	+			+		+	+	+			+
A. bicaudatus		+								+	+	+		+	+	
Aphelenchus sp.		+	+	+			+			+	+	+	+	+		
A. avenae		+	+	+	+	+				+	+	+		+	+	
Boleodorus sp.		+	+													
Criconemella sp.			+	+	+											
Criconemoides sp.												+				
Ditylenchus sp.		+	+	+						+	+	+		+		
Filenchus sp.		+	+	+						+	+	+		+		
Helicotylenchus sp.		+	+	+	+						+	+		+		
H. dihystera	+	+	+	+	+	+		+								
H. martini			+	+												
H. microcephalus		+	+	+	+	+										
H. multicinctus			+	+	+	+					+	+		+		
H. cf. *paraplatyurus*					+											
H. cf. *platyurus*			+		+											
H. pseudorobustus		+	+	+	+											
H. cf. *stylocercus*			+		+								+			
Hemicriconemoides sp.		+	+	+												
H. cf. *affinis*			+	+												
H. cf. *brachyurus*				+												
H. cocophillus		+	+	+												
Hemicycliophora sp.		+	+	+	+						+	+				
H. nyanzae		+														
Hoplolaimus sp.			+													
H. pararobustus		+		+						+						
Malenchus sp.		+	+	+				+								
Meloidogyne sp.	+		+	+	+	+		+	+		+	+	+	+		+
M. arenaria			+	+							+	+		+		
M. hapla	+		+	+	+	+		+	+		+	+	+	+		+
M. incognita		+	+	+	+	+					+	+	+	+		
M. javanica		+	+	+	+	+		+		+	+	+	+	+	+	+
Neopsilenchus sp.								+								
Ogma sp.			+													
O. cf. *decalineatum*			+													
Ottolenchus sp.			+								+					
Paratrichodorus sp.		+	+	+	+					+						
P. cf. *allius*			+													
P. minor				+												
Paratylenchus sp.					+											
Pratylenchus sp.		+	+	+						+	+	+				
P. brachyurus		+	+	+						+	+	+		+		
P. goodeyi			+													
P. cf. *pseudopratensis*										+						
P. sudanensis		+								+						
P. zeae											+					
Rotylenchulus sp.		+	+	+	+	+			+		+	+	+			

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Table 1 (*continued*)

Nematode	Soil								Roots							
	Taro	Yam	Sw potato	Cassava	Potato	Tannia	Turmeric	Carrot	Taro	Yam	Sw potato	Cassava	Potato	Tannia	Turmeric	Carrot
R. parvus			+	+												
R. reniformis			+	+	+	+					+	+	+			
R. variabilis		+		+							+					
Rotylenchus sp.			+													
R. unisexus		+		+	+	+										
Sakia sp.												+				
Scutellonema sp.		+	+	+	+	+				+	+	+			+	
S. brachyurus	+	+	+	+	+	+		+		+	+					
S. clathricaudatum		+	+	+						+		+				
S. magniphasmum		+	+	+	+			+						+		
S. paralabiatum		+	+	+	+			+			+		+			+
S. unum		+	+	+							+					
Sphaeronema sp.			+													
Tylenchorhynchus sp.		+	+		+			+				+	+			
T. cf. *annulatus*			+													
T. cf. *capitatus*			+													
Tylenchulus sp.			+	+	+			+								
Tylenchus sp.	+	+	+	+		+		+		+	+	+		+	+	
Varotylus sp.				+												
Xiphinema sp.		+	+	+												
X. ebriense			+													
X. elongatum		+	+	+	+											

[a]Number of species associated with each crop in soil and in roots.

support this observation are limited. There remains no doubt, however, that inoculation of cassava stems with *Meloidogyne* spp. at planting results in damage to the crop (Caveness 1982; Talwana et al. 1997; Coyne & Talwana 2000; Makumbi-Kidza et al., in press), but how this relates to the situation and losses in the field requires further examination.

The findings of this survey largely concur with those of similar studies elsewhere and include the major nematodes affecting root and tuber crops worldwide (Hogger 1971; McSorley et al. 1983; Jatala & Bridge 1990). Namaganda et al. (1993) and Coyne & Namaganda (1996) sampled for nematodes associated with cassava and sweet potato in mainly the central region (Mpigi, Mubende, Kibale, Masindi and Luwero districts) of Uganda, data which complement the present study. It is noteworthy, however, that *S. bradys,* the major nematode pest of yam in West Africa (Bridge, 1973), was not observed on yam in the present study. *P. sudanensis* was recovered, but not *Pratylenchus coffeae,* which causes damage similar to *S. bradys* in Central America (Jatala & Bridge 1990). While the presence of these two important pests cannot be discounted, considering that some nematodes were identified only to genus level in the absence of adults, it is unlikely they were present. Both species are distinctive in terms of morphology and biology and readily achieve large population densities on yam when present (Jatala & Bridge 1990). Subsequent studies examining the importance of *P. sudanensis* and *Meloidogyne* spp. on yam have indicated that *P. sudanensis,* widely distributed throughout Uganda, indeed appears to be associated with poor yam quality and production (J Mudiope, unpubl.), whereas *Meloidogyne* spp. seem to constitute a serious constraint to the introduction of new, high-yielding yam cultivars from West Africa (Mudiope et al. 1998).

Recent studies on cassava (Makumbi-Kidza et al., in press), suggest that *Meloidogyne* spp. affect cassava production by reducing sprouting

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Table 2. Combined maximum (and mean) plant-parasitic nematode population densities per 100 ml soil and 10 g fresh root mass occurring on root and tuber crops in Uganda.

Nematode	Cassava 166[a]	Sweet potato 132	Yam 57	Potato 35	Taro 8	Tannia 24	Carrot 5	Turmeric 3
Aphelenchoides sp.	350 (44)	150 (39)	2200 (149)	26 (18)	110	65 (42)		18 (13)
A. bicaudatus	40 (19)	20 (14)	200					
Aphelenchus sp.	15000 (906)	320 (60)	950 (265)	15		30		10
A. avenae	2000 (106)	270 (63)	1100 (161)	240 (43)	35	100 (49)		16
Boleodorus sp.		33	10					
Criconemella sp.	10	17 (9)		52				
Criconemoides sp.	20							
Ditylenchus sp.	24 (18)	60 (34)	25 (19)		70	14		
Filenchus sp.		15	10			19 (12)		
Helicotylenchus sp.	120 (31)	100 (42)	260 (96)	60 (30)		5		
H. dihystera	250 (139)	150 (72)	755	70 (9)	60	100 (67)	60	
H. martini	35	200						
H. microcephalus	110	200 (65)	20	30 (23)		500		
H. multicinctus	450 (117)	25 (18)	200 (113)	15		450 (188)		
H. pseudorobustus	35 (28)	60 (43)	120 (50)	100 (37)				
H. cf. *platyurus*		155		120 (70)				
H. cf. *paraplatyurus*				15				
H. cf. *stylocercus*		200 (109)		500 (112)				
Hemicriconemoides sp.	75	25 (23)	25					
H. cf. *affinis*	4	8						
H. cf. *brachyurus*	9							
H. cocophillus	11	18	22					
Hemicycliophora sp.	11 (10)	32 (27)	18					
H. nyanzae			20					
Hoplolaimus sp.		10 (9)						
H. pararobustus	289 (180)		90 (45)					
Malenchus sp.	23	150 (88)	5		19			
Meloidogyne sp.	3000 (343)	3000 (195)	3800 (225)	650 (137)	520 (313)	350 (65)	120 (69)	30 (23)
M. arenaria	3500 (1770)	10				29		
M. hapla	60 (43)		500 (450)	1100	30	750 (332)	250	
M. incognita	4500 (452)	1300 (728)	500 (380)	625 (478)		120 (87)		
M. javanica	400 (176)	35	2000	3500 (1783)		250	420	
Neopsilenchus sp.							20	
Ogma sp.		15						
O. cf. *decalineatum*		10						
Ottolenchus sp.		150 (80)						
Paratrichodorus sp.	105 (46)	20 (17)	28 (18)	25				
P. cf. *allius*		13						
P. minor	15							
Paratylenchus sp.				20				
Pratylenchus sp.	112 (25)	65 (18)	120 (70)					
P. brachyurus	804 (116)	130 (52)	400 (101)			50 (34)		
P. goodeyi		18						
P. pseudopratensis			180 (77)					
P. sudanensis			630 (468)					
P. zeae		45 (32)						
Rotylenchulus sp.	85 (44)	270 (89)	700 (250)	128 (31)	29			
R. parvus	50	70						
R. reniformis	200 (55)	1932 (745)		60 (45)		100 (45)		
R. variabilis	220 (75)	300	260 (160)					
Rotylenchus sp.		30						
R. unisexus	25 (19)		25	20		28		
Sakia sp.	12							

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Table 2 (*continued*)

Nematode	Cassava	Sweet potato	Yam	Potato	Taro	Tannia	Carrot	Turmeric
Scutellonema sp.	90 (79)	312 (73)	585 (132)	20 (15)		21 (18)		21
S. brachyurus	90 (28)	580 (164)	400 (190)	210 (95)	150	60	23	
S. clathricaudatum	350 (75)	250 (54)	1200 (447)					
S. magniphasmum	250 (138)	220 (71)	20 (14)	30 (21)		33	18	
S. paralabiatum	350 (84)	300 (103)	40 (24)	250 (69)			60	
S. unum	200 (89)	400 (204)	210 (70)					
Sphaeronema sp.		50						
Tylenchorhynchus sp.	22	85 (31)	29	250 (78)			29	
T. cf. *annulatus*		20						
T. cf. *capitatus*		14						
Tylenchulus sp.	23	200 (110)		12			12	
Tylenchus sp.	320 (31)	50 (18)	300 (59)	70 (28)		350 (68)		40
Varotylus sp.	15							
Xiphinema sp.	10	10 (6)	5					
X. ebriense		25						
X. elongatum	12	9 (7)	9	14 (12)				

[a]Total number of fields sampled.

and causing damage to young plantlets. However, the pathogenic status of most nematode species associated with root and tuber crops in Uganda remains to be determined. This study nevertheless provides a substantial foundation for further work on the relationship between plant-parasitic nematodes and root and tuber crops, with the aim of developing improved breeding programmes and cropping systems.

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Table 3. Frequency of occurrence (%) of plant-parasitic nematodes on root and tuber crops in central Uganda.

Nematode	Cassava 27[a]	Sweet potato 19	Yam 7	Taro 4	Tannia 11
Aphelenchoides sp.	26	11	43		
A. bicaudatus	4	16	27		
Aphelenchus sp.		5	14		
A. avenae	26	5	57		18
Boleodorus sp.		5			
Criconemella sp.		5			
Filenchus sp.			14		9
Ditylenchus sp.	7	5			
Helicotylenchus sp.	7	11			
H. dihystera	4	21		25	27
H. martini	4				
H. microcephalus		5			
H. multicinctus	7	5	27		18
H. pseudorobustus	4				

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Table 3 (*continued*)

Nematode	Cassava	Sweet potato	Yam	Taro	Tannia
Hemicycliophora sp.		5			
Malenchus sp.	4				
Meloidogyne sp.	30	63	71	25	36
M. hapla	4			25	27
M. incognita	59	26	14		9
M. javanica	7	5			
Ogma cf. *decalineatum*		5			
Paratrichodorus sp.	4				
P. minor	4				
Pratylenchus sp.	4		14		
P. brachyurus	30	5			
Rotylenchulus sp.	15	26	57		9
R. reniformis	19	26			9
R. variabilis	7	5			
Rotylenchus sp.		5			
R. unisexus	4				
Sakia sp.	4				
Scutellonema sp.	7	21			46
S. brachyurus	4	5	27	25	9
S. clathricaudatum	4				
S. unum	11	5			
Sphaeronema sp.		5	14		
Tylenchorhynchus sp.		5			
Tylenchus sp.	11	26	27	25	
Tylenchulus sp.		5			
Xiphinema sp.		16			
X. elongatum	4		14		

[a]Number of fields sampled in the region.

Table 4. Frequency of occurrence (%) of plant-parasitic nematodes on root and tuber crops in eastern Uganda.

Nematode	Cassava 27[a]	Sweet potato 19	Potato 4	Taro 4	Yam 15	Tannia 4
Aphelenchoides sp.	19	21	25	25	40	50
A. bicaudatus	7		25			
Aphelenchus sp.	7	5				
A. avenae	44	53	25	25	40	50
Criconemella sp.	4					
Ditylenchus sp.		21		25		
Helicotylenchus sp.					13	
H. dihystera	4	5			7	
H. multicinctus	4	5				50
H. pseudorobustus	4	5			13	
Hemicriconemoides cocophillus	4				7	
Hemicycliophora sp.	4					
H. nyanzae					7	
Hoplolaimus pararobustus	4				7	
Meloidogyne sp.	67	21	75	50	53	100
M. hapla					7	
M. incognita	7		50			

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Table 4 (*continued*)

Nematode	Cassava	Sweet potato	Potato	Taro	Yam	Tannia
Ogma sp.		5				
Paratrichodorus sp.	7	5	25		13	
Pratylenchus sp.	19	5			27	
P. brachyurus	19				7	
P. pseudopratensis					20	
P. sudanensis					27	
P. zeae		11				
Rotylenchulus sp.	11	11		25	13	
R. reniformis	7	11				
R. variabilis	4				27	
Rotylenchus unisexus			25			
Scutellonema sp.	15				20	
S. magniphasmum	4	5			13	
S. paralabiatum	4	5			13	
Tylenchus sp.	22	11	75			75
Varotylus sp.	4					
Xiphinema sp.	4					

[a]Number of fields sampled in the region.

Table 5. Frequency of occurrence (%) of plant-parasitic nematodes on root and tuber crops in northern Uganda.

Nematode	Cassava 54[a]	Sweet potato 44	Yam 35	Tannia 3	Turmeric 3
Aphelenchoides sp.	19	16	20	33	67
Aphelenchus sp.	20	25	29	33	33
A. avenae	41	18	20	33	33
Criconemoides sp.	2	2			
Ditylenchus sp.	2	2	11		
Helicotylenchus sp.	6	9	3		
H. dihystera				33	
H. microcephalus	2	7	3		
H. pseudorobustus	4		9		
Hemicriconemoides sp.	2	2	3		
H. cf. *affinis*		2			
H. cocophillus		2			
Hemicycliophora sp.	2		3		
Hoplolaimus sp.		2			
H. pararobustus	2		6		
Malenchus sp.		2	3		
Meloidogyne sp.	61	36	49	33	67
M. arenaria	4				
M. hapla			3		
M. incognita	17	7	6	33	
M. javanica			3		
Ottolenchus sp.		2			
Paratrichodorus sp.	4		9		
Pratylenchus sp.	6	7	6		
P. brachyurus	33	11	14	33	
Rotylenchulus sp.		5	6		
Rotylenchus unisexus	2		3	33	

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Table 5 (*continued*)

Nematode	Cassava	Sweet potato	Yam	Tannia	Turmeric
Scutellonema sp.	17	9	14	33	33
S. brachyurus	11	7	14		
S. clathricaudatum	7	21	9		
S. magniphasmum	2	7			
S. paralabiatum	9	18	6		
S. unum	2	11	20		
Tylenchorhynchus sp.	2	2	3		
Tylenchulus sp.	2	2			33
Tylenchus sp.	6	9	3		
Xiphinema sp.			3		
X. ebriense		2			
X. elongatum		2			

[a]Number of fields sampled in the region.

Table 6. Frequency of occurrence (%) of plant-parasitic nematodes on root and tuber crops in western Uganda.

Nematode	Cassava 58[a]	Sweet potato 50	Tannia 6	Potato 31	Carrot 5
Aphelenchoides sp.	4	10		23	
A. bicaudatus	2				
Aphelenchus sp.		2		3	
A. avenae	12	16	50	45	
Criconemella sp.		4			
Ditylenchus sp.	4	8	17		
Filenchus sp.		2	17		
Helicotylenchus sp.	7	14	17	13	
H. dihystera	5	8	17	7	20
H. martini		2			
H. microcephalus		6	17	7	
H. multicinctus	7	2	50	3	
H. cf. *paraplatyurus*				3	
H. cf. *platyurus*		2		10	
H. pseudorobustus		2		13	
H. cf. *stylocercus*		4		16	
Hemicriconemoides sp.		2	17		
H. cf. *affinis*	2				
H. cf. *brachyurus*	2				
Hemicycliophora sp.		10			
Hoplolaimus sp.		2			
Malenchus sp.		2			20
Meloidogyne sp.	52	50	33	65	40
M. arenaria	2				
M. hapla	2	2	50	3	
M. incognita	28				
M. javanica	4		17	10	20
Neopsilenchus sp.					20
Ottolenchus sp.		2			
Paratrichodorus sp.		4			
P. cf. *allius*		2			

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Table 6 (*continued*)

Nematode	Cassava	Sweet potato	Tannia	Potato	Carrot
Paratylenchus sp.				3	
Pratylenchus sp.	21	20			
P. brachyurus	28	2	17		
P. goodeyi		2			
Rotylenchulus sp.	2	12		36	
R. parvus	2	2			
R. reniformis	14	16		7	
R. variabilis	2				
Scutellonema sp.	24	42	17	7	
S. brachyurum		6		23	20
S. clathricaudatum	4	2			
S. magniphasmum	4		17	7	20
S. paralabiatum	14			39	40
S. unum	4	8			
Tylenchulus sp.				3	20
Tylenchus sp.	7	4	17		
Tylenchorhynchus sp.				16	20
T. cf. *annulatus*	2				
T. cf. *capitatus*	2				
Xiphinema elongatum	2			10	

[a]Number of fields sampled in the region.

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