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Plant-parasitic nematodes on field crops in South Africa. 4. Groundnut

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Summary — Sixteen groundnut fields, representative of the conditions prevailing in the groundnut-producing areas of the Orange Free State and Transvaal provinces of South Africa were monitored. Four fields were monitored through the 1986/87 growing season and twelve through the 1987/88 growing season. Eighteen plant-parasitic nematode species were found. The predominant ectoparasites were *Criconemella sphaerocephala* and *Paratrichodorus minor*. The predominant endoparasites in both the roots and pods were *Pratylenchus brachyurus* and *Ditylenchus destructor*. *Paratrichodorus lobatus, Scutellonema brachyurum, Xiphinema coomansi, X. vanderlindei, X. variabile, X. vitis, Longidorus pisi, Rotylenchus brevicaudatus, Rotylenchus incultus, R. triannulatus, R. unisexus, Helicotylenchus dihystera, Pratylenchus zeae* and *Rotylenchulus parvus* were also found. In the soil, total populations of plant-parasitic nematodes increased or remained stable between planting and harvest in five fields, while those in eleven fields decreased. In the roots, total populations decreased between four weeks after planting and harvest in all sixteen fields. In the pods, total populations increased or remained stable between eight weeks after planting and harvest in seven fields, while those in two fields decreased. Plant-parasitic nematodes were absent in the pods of six fields. *C. sphaerocephala, P. minor* and *P. brachyurus* (except in the pods) populations usually decreased over the season, while *D. destructor* populations usually increased, particularly in the pods. *R. parvus* was found with a high occurrence and high numbers in the soil, but infrequently and in low numbers in the roots and pods. Populations decreased over the season and no adult females were found.

Résumé — ***Les nématodes parasites des cultures en Afrique du Sud. 4. Arachide*** — Seize champs représentatifs des conditions de production de l'arachide en Afrique du Sud ont été prospectés durant les saisons de culture de 1986/87 (quatre champs) et 1987/88 (douze champs). Dix-huit espèces de nématodes phytoparasites ont été identifiées. Les ectoparasites prédominants sont *Criconemella sphaerocephala* et *Paratrichodorus minor*. Les endoparasites prédominants dans les racines et les gousses sont *Pratylenchus brachyurus* et *Ditylenchus destructor*. *Paratrichodorus lobatus, Scutellonema brachyurum, Xiphinema coomansi, X. vanderlindei, X. variabile, X. vitis, Longidorus pisi, Rotylenchus brevicaudatus, R. incultus, R. triannulatus, R. unisexus, Helicotylenchus dihystera, Pratylenchus zeae* et *Rotylenchulus parvus* ont également été identifiés. Les populations de nématodes phytoparasites dans le sol croissent ou demeurent constantes entre la plantation et la récolte dans cinq champs et décroissent dans onze champs. Dans tous les champs, les populations de nématodes parasites dans les racines décroissent entre quatre semaines après plantation et la récolte. Dans les gousses, les populations de nématodes parasites croissent ou demeurent constantes entre huit semaines après la plantation et la récolte dans dix champs, et décroissent dans deux champs. Les gousses de quatre champs ne sont pas infestées par les nématodes. Les populations de *C. sphaerocephala, P. minor* et *P. brachyurus* (excepté dans les gousses) décroissent normalement durant la saison de culture pendant que les populations de *D. destructor* croissent habituellement, surtout dans les gousses. La fréquence et la densité de *R. parvus* étaient élevées dans le sol mais non dans les racines ou les gousses. Les populations de *R. parvus* décroissent durant la saison de culture et le stade femelle n'a pas été observé.

Key-words : South Africa, groundnut.

Groundnut (*Arachis hypogaea* L.) is a major oil-seed crop in South Africa. About 200 000 ha are planted annually, producing an average yield of 1000 kg ha^{-1}. In South Africa, groundnut yields are not only limited by low and late summer rains and poor soils, but also by many diseases including those caused directly or indirectly by plant-parasitic nematodes. Indirect damage may include increased secondary infection by fungi (Keetch, 1972) and reduced nodulation and nitrogen fixation (Germani, 1979). In the USA, *Meloidogyne arenaria* (Neal) Chitwood, *Meloidogyne hapla* Chitwood, *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven, *Criconemella ornata* Raski and *Belonolaimus longicaudatus* Rau are the most important plant-parasitic nematodes associated with groundnut (Minton, 1984). They cause an estimated average yield loss of 3.4 % in eight groundnut-producing states (Sturgeon & Lee, 1985). In South Africa, it is estimated that plant-parasitic nematodes cause about 10 % yield loss to the groundnut industry (Keetch, 1989). The following plant-parasitic nematodes have been reported for groundnut : *Radopholus similis* Cobb (Keetch, 1972), *M. arenaria* (Keetch & Buckley, 1984), *M. hapla* (van der Linde, 1956), *P. brachyurus* (Koen, 1969), *Ditylen-*

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chus destructor Thorne (De Waele *et al.*, 1989), *Rotylenchulus parvus* (Williams) Sher (Van den Berg, 1978), *Rotylenchus unisexus* Sher (Van den Berg & Heyns, 1974), *Meloidogyne incognita* (Kofoid & White) Chitwood (Keetch & Buckley, 1984), *Meloidogyne javanica* (Treub) Chitwood (Keetch & Buckley, 1984; Coetzee, 1968), *Xiphinema vanderlindei* Heyns (Heyns, 1962) and *Xiphinema variabile* Heyns (Keetch & Buckley, 1984). The relative importance of these nematode species or the host susceptibility of groundnut to these species is, however, unknown.

This paper presents the results of a study *i)* to identify the predominant plant-parasitic nematode species associated with groundnut in South Africa, and *ii)* to examine their population development between planting and physiological maturity of the crop.

Materials and methods

During the 1986/87 and 1987/88 growing seasons, soil, root and pod samples were collected from four and twelve groundnut fields, respectively. These fields were representative of the groundnut-producing areas of South Africa (Fig. 1). The samples were taken at planting, four, eight and twelve weeks after planting, and at harvest. The soil properties, cultivar, rainfall (with/without supplementary irrigation) and crop-history of the sixteen groundnut fields are given in Table 1. Fields were planted between 28 October and 4 November 1986, and between 21 October and 9 December 1987. No fertilizers or nematicides were applied in any of the fields. All fields were naturally infested with nematodes.

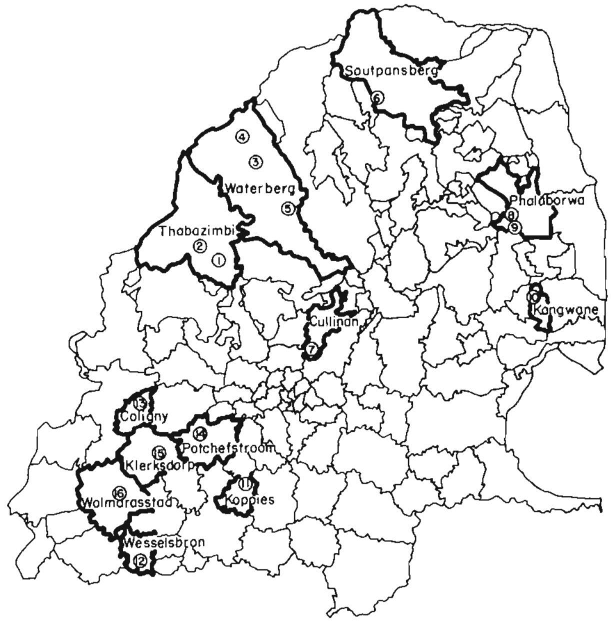

Fig. 1. Sites in the groundnut production areas of the Transvaal and Orange Free State, South Africa, where nematode populations were monitored during the 1986/87 and 1987/88 growing seasons.

In each field, soil, roots and pods from nine plants were collected from a 0.25 ha plot and combined. The nematodes were extracted from three 100 ml subsamples by a modified decanting and sieving method (Flegg,

Table 1. Mean soil properties, cultivar planted, rainfall and crop history of sixteen groundnut fields, cv. Sellie, monitored during 1986/87 and 1987/88 in the Transvaal and Orange Free State, South Africa.

Farm no.	*District*	*Soil type (1)*	*% clay*	*Rainfall (2) (mm)*	*Crop History (3)*							
					Summer 83-84	*Summer 84-85*	*Winter 85*	*Summer 85-86*	*Winter 86*	*Summer 86-87*	*Winter 87*	*Summer 87-88*
1	Thabazimbi	L	18	464 I		M + W		G		P		*
2	Thabazimbi	S	8	477 I		F		F		T		*
3	Waterberg	S	8	327		M		G		G		*
4	Waterberg	S	6	441 I		M		P		G		*
5	Waterberg	LS	10	445		F		F		T		*
6	Soutpansberg	LS	9	207 I	M	F		F		F	Po	*
7	Cullinan	S	9	492		M		M		M		*
8	Phalaborwa	S	8	316 I		F	D	C		M	D	*
9	Phalaborwa	S	8	400 I		M	O	F	To	F	O	*
10	Kangwane	S	8	n.a.		F		F		F		*
11	Koppies	S	9	612		M		M		M		*
12	Wesselsbron	S	7	398	M	M		M		* (4)		
13	Coligny	LS	13	528	M	M		M		*		
14	Potchefstroom	LS	11	609		M		M		M		*
15	Klerksdorp	LS	11	279	M	M		M		*		
16	Wolmaransstad	S	8	352	M	M		M		*		

(1) Soil type (L : Loam; S : Sand; LS : Loamy sand) — (2) Rainfall from planting until harvest; I : rainfall supplemented by irrigation — (3) Crop History (M : Maize; W : Watermelons; G : Groundnuts; P : Pumpkins; F : Fallow; T : Tobacco; Po : Potatoes; D. : Drybeans; C : Cotton; O : Onions; To : Tomatoes) — n.a. data not available — (4) * Season in which the field was planted to groundnuts and sampled.

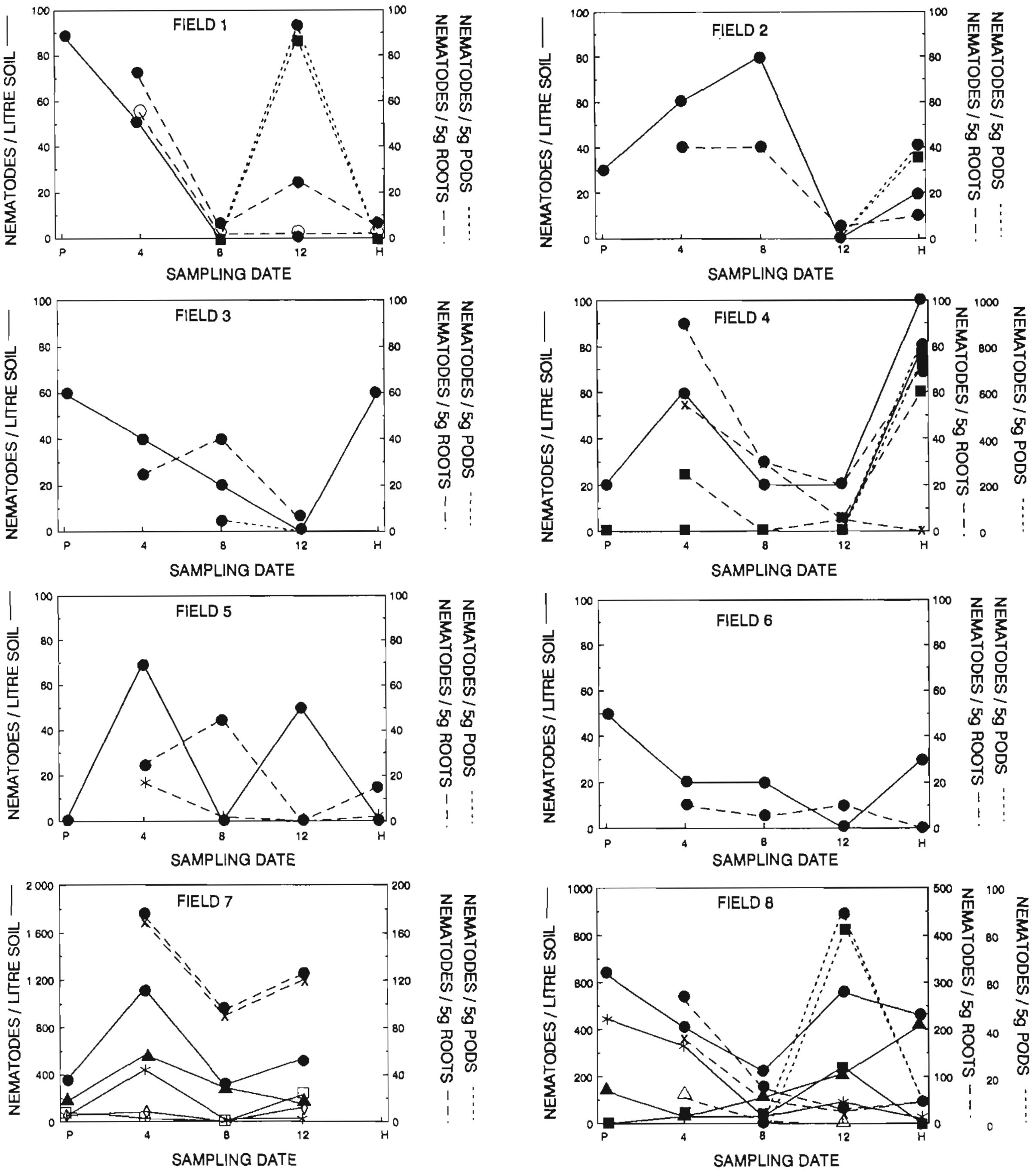

Fig. 2. 1-16. Seasonal population fluctuations of the predominant plant-parasitic nematodes in the soil rhizosphere, roots and pods of groundnut plants in sixteen fields, Transvaal and Orange Free State, South Africa. Numbers of nematodes per dm³ soil, 5 g roots or 5 g pods. Total number of plant-parasitic nematodes in the soil (——●), in the roots (-----●) and in the pods (·······●); *Paratrichodorus minor* (◇); *Criconemella sphaerocephala* (*); *Xiphinema vanderlindei* (□); *Scutellonema brachyurum* (♦); *Rotylenchus unisexus* (△); *Pratylenchus brachyurus* (x); *Pratylenchus zeae* (○); *Ditylenchus destructor* (■) and *Rotylenchulus parvus* (▲); m = missing data. Populations with max. < 60/dm³ soil; < 50/5 g roots; < 10/5 g pods, not plotted on these graphs.

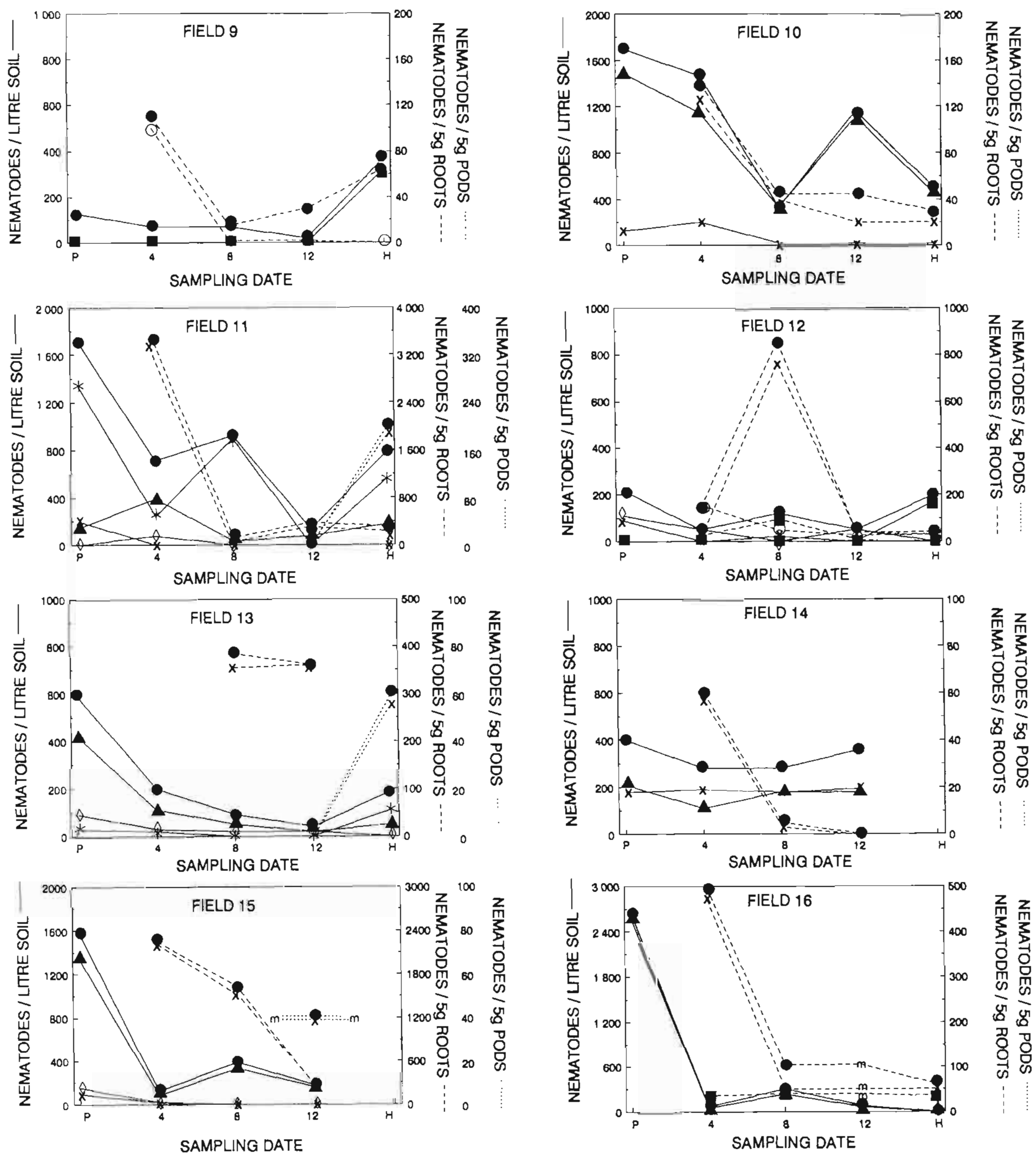

Fig. 2. 1-16. Seasonal population fluctuations of the predominant plant-parasitic nematodes in the soil rhizosphere, roots and pods of groundnut plants in sixteen fields, Transvaal and Orange Free State, South Africa. Numbers of nematodes per dm^3 soil, 5 g roots or 5 g pods. Total number of plant-parasitic nematodes in the soil (——●), in the roots (-----●) and in the pods (.......●); *Paratrichodorus minor* (◊); *Criconemella sphaerocephala* (*); *Xiphinema vanderlindei* (□); *Scutellonema brachyurum* (♦); *Rotylenchus unisexus* (△); *Pratylenchus brachyurus* (x); *Pratylenchus zeae* (○); *Ditylenchus destructor* (■) and *Rotylenchulus parvus* (▲); m = missing data. Populations with max. < 60/dm^3 soil; < 50/5 g roots; < 10/5 g pods, not plotted on these graphs.

1967) using 710 µm and 45 µm sieves, followed by the sugar centrifugal-flotation method of Jenkins (1964). The root and pod nematodes were extracted from three 5 g subsamples by the sugar centrifugal-flotation method (Coolen & D'Herde, 1972). Hot (90 °C) 4 % formalin was added to kill and fix the nematodes. Nematode population levels were determined and expressed either as the number of nematodes per 100 cm³ soil, per 5 g roots or per 5 g pods. Two hundred nematodes from each sample were transferred to anhydrous glycerin (De Grisse, 1969), mounted on slides by the paraffin-ring method and identified.

Prominence values :

$$(PV = \text{population density} \times \sqrt{\text{frequency of occurence}/10})$$

were caculated for plant-parasitic nematode population densities in the soil, roots and pods.

Results

Eighteen plant-parasitic nematode species were found (Table 2). The predominant ectoparasites were *Criconemella sphaerocephala* (Taylor) Luc & Raski (P.V. = 14.0 in the soil at planting) and *Paratrichodorus minor* (Colbran) Siddiqi (P.V. = 3.7 in soil at planting). *Paratrichodorus lobatus* (Colbran) Siddiqi, *Scutellonema brachyurum* (Steiner) Andrássy, *Xiphinema coomansi* Kruger & Heyns, *Xiphinema vanderlindei*, *Xiphinema variabile*, *Xiphinema vitis* Heyns, *Longidorus pisi* Edwards, Misra & Singh, *Rotylenchus brevicaudatus* Colbran, *Rotylenchus incultus* Sher, *Rotylenchus triannulatus* Van den Berg & Heyns, *Rotylenchus unisexus*, and *Helicotylenchus dihystera* (Cobb) Sher were also found. The predominant endoparasites were *Pratylenchus brachyurus* (P.V. = 507.6 in the roots at 4 weeks) and *Ditylenchus destructor* (P.V. = 105.3 in the pods at harvest). *Pratylenchus zeae* Graham and *Rotylenchulus parvus* were also found.

The maximum total number of plant-parasitic nematodes at any one stage, on a single field, was 257/100 cm³ in the soil (Fig. 2.16), 3400/5 g in the roots (Fig. 2.11) and 805/5 g in the pods (Fig. 2.4). In the soil total populations decreased between planting and harvest in eleven fields, remained stable in two, and increased in three; in the roots the total populations decreased between 4 weeks after planting and harvest in all sixteen fields; but in the pods the total populations decreased between 8 weeks after planting and harvest in two fields, remained stable in one, and increased in six fields (Fig. 2.1-16). Plant-parasitic nematodes were not found in the pods from six fields (Fig. 2.5, 6, 7, 9, 10, 12). Underdeveloped pods at sampling made it impossible to follow population development over time on three fields (Fig. 2.14, 15, 16). In the soil, low total plant-parasitic nematode populations were found in the hot, dry (but often supplemented by irrigation) north-western Transvaal (fields 1 to 6, max. 10 nematodes/100 cm³; Fig. 2.1-6) where the soil is often sun-baked and hard, compared to the temperate central Transvaal (field 7, max. 113 nematodes/100 cm³; Fig. 2.7), humid subtropical (often supplemented by irrigation) eastern Transvaal (fields 8 to 10, max. 170 nematodes/100 cm³; Fig. 2.8-10), temperate Orange Free State (fields 11 and 12, max. 172 nematodes/100 cm³; Fig. 2.11, 12), and warm south-western Transvaal (fields 13 to 16, max. 257 nematodes/100 cm³; Fig. 2.13-16). Similarly, in the roots, low total populations were found in the north-western Transvaal (max. 90/5 g; Fig. 2.4) and increasing total numbers in the central Transvaal (max. 175/5 g; Fig. 2.7), eastern Transvaal (max. 265/5 g; Fig. 2.8), south-western Transvaal (max. 2250/5 g; Fig. 2.15) and Orange Free State (max. 3400/5 g; Fig. 2.11).

C. sphaerocephala was found in the soil and roots of 87.5 % and 12.5 % of the fields, respectively (Table 2), in maximum numbers of 135/100 cm³ soil (Fig. 2.11) and 15/5 g roots (Fig. 2.5). Populations usually decreased over the season. This species was not found in the pods. *P. minor* was found in the soil of 87.5 % of the fields, but was not found in the roots or pods (Table 2). Populations usually decreased over the season, with a maximum of 15/100 cm³ soil (Fig. 2.15). The predominant ectoparasites *C. sphaerocephala* and *P. minor* were found together in twelve fields, and both usually in very low numbers, indicating that inter-species competition was unlikely. While *P. minor* was found in fairly equal numbers in all fields, showing no obvious preference for area, soil-type, rainfall or crop-history, *C. sphaerocephala* was found in highest numbers in field 8 (eastern Transvaal; Fig. 2.8) and field 11 (Orange Free State; Fig. 2.11) where the soil was sandy and the rainfall high or supplemented by irrigation.

P. brachyurus was found in the roots of 81.3 % of the fields, pods of 50.0 % of the fields and *Pratylenchus* spp. (juveniles only) in the soil of 62.5 % of the fields (Table 2) in maximum numbers of 3400/5 g roots (Fig. 2.11), 62/5 g pods (Fig. 2.13) and 23/100 cm³ soil (Fig. 2.11). Populations usually decreased in the soil and roots over the season but increased in the pods. *D. destructor* was found in the roots, pods and soil of 68.8 %, 37.5 % and 43.8 % of the fields, respectively, in maximum numbers of 60/5 g roots (Fig. 2.4), 795/5 g pods (Fig. 2.4) and 32/100 cm³ soil (Fig. 2.9). In the roots, an equal number of populations increased as did decrease, and most populations in the pods and soil peaked from 12 weeks (flowering) to harvest. *P. brachyurus* was found in all the fields and in highest numbers in the Orange Free State (max. 3400/5 g; Fig. 2.11) and south-western Transvaal (max. 2250/5 g; Fig. 2.15) where the rainfall was not supplemented by irrigation, and with a lower occurrence and numbers in the north-western, central and eastern Transvaal (max. 180/5 g; Fig. 2.8). This species was, however, found in highest numbers in two fields (11 and 15;

Table 2. Frequency of occurrence, mean population density and prominence value (PV) of the predominant nematodes recovered from soil and groundnut roots and pods in sixteen groundnut fields in the Transvaal and Orange Free State, South Africa, at planting (P), 4, 8 and 12 weeks after planting, and at harvest (H).

Nematode species	Frequency of occurrence %	Mean population density/100 ml soil, 5 g roots or 5 g pods					Prominence values (P.V.) (= population density × $\sqrt{\text{frequency}/10}$)				
		P	4 wk	8 wk	12 wk	H	P	4 wk	8 wk	12 wk	H
SOIL											
Criconemella sphaerocephala	87.5	15	9	7	1	6	14.0	8.4	6.5	0.9	5.6
Paratrichodorus minor	87.5	4	3	1	2	0	3.7	2.8	0.9	1.9	0
Paratrichodorus lobatus	6.3	0	2	0	0	0	0	0.5	0	0	0
Scutellonema brachyurum	50.0	10	4	4	3	3	7.1	2.8	2.8	2.1	2.1
Xiphinema coomansi	6.3	2	0	2	0	2	0.5	0	0.5	0	0.5
Xiphinema vanderlindei	43.8	3	1	1	6	1	2.0	0.7	0.7	4.0	0.7
Xiphinema variabile	6.3	1	0	0	2	0	0.3	0	0	0.5	0
Xiphinema vitis	6.3	1	0	0	2	0	0.3	0	0	0.5	0
Longidorus pisi	6.3	0	0	0	0	2	0	0	0	0	0.5
Rotylenchus brevicaudatus	6.3	1	3	0	1	0	0.3	0.8	0	0.3	0
Rotylenchus incultus	6.3	19	20	1	0	2	4.8	5.0	0.3	0	0.5
Rotylenchus triannulatus	6.3	19	19	0	0	0	4.8	4.8	0	0	0
Helicotylenchus dihystera	12.5	2	7	6	7	3	0.7	2.5	2.1	2.5	1.1
Pratylenchus spp.	62.5	8	5	2	3	2	6.3	4.0	1.6	2.4	1.6
Ditylenchus destructor	43.8	1	1	1	5	9	0.7	0.7	0.7	3.3	6.0
Rotylenchulus parvus	93.8	44	17	11	13	10	42.6	16.5	10.7	12.6	9.7
All plant-parasitic nematodes	100										
ROOTS											
Pratylenchus brachyurus	81.3		563	242	98	48		507.6	218.2	88.5	43.3
Pratylenchus zeae	62.5		33	10	1	1		26.1	7.9	0.8	0.8
Ditylenchus destructor	68.8		10	19	9	19		8.3	15.8	7.5	8.3
Rotylenchulus parvus	31.3		4	0	2	4		2.2	0	1.1	2.2
Criconemella sphaerocephala	12.5		13	0	0	0		4.6	0	0	0
Scutellonema brachyurum	31.3		7	3	2	1		3.9	1.7	1.1	0.6
Rotylenchus unisexus	18.8		30	7	0	0		13.0	3.0	0	0
Helicotylenchus dihystera	6.3		0	5	5	0		0	1.3	1.3	0
All plant-parasitic nematodes	100										
PODS											
Pratylenchus brachyurus	50.0			2	8	70			1.4	5.7	49.5
Pratylenchus zeae	18.8			3	0	6			1.3	0	2.6
Ditylenchus destructor	37.5			0	31	172			0	19.0	105.3
Rotylenchus parvus	12.5			2	0	3			0.7	0	1.1
Rotylenchus unisexus	6.3			0	0	1			0	0	0.3
All plant-parasitic nematodes	75.0										

Fig. 2.11 and 15) with very different total rainfalls (Table 1), but both of which had 3-year-maize crop-histories (Table 1). *D. destructor*, on the other hand, was found with a greater occurrence (nine of the ten fields; Fig. 2.1-8) in the north-western, central an eastern Transvaal, where the rainfall is most often supplemented by irrigation, than in the Orange Free State and south-western Transvaal (two of the six fields; Fig. 2.11-16), although in comparable numbers in all the fields of both major regions (max. 60/5 g and 75/5 g; Fig. 2.4 and 12, respectively) and showing no obvious preference for soil-type and crop-history. In the pods, *P. brachyurus* was also found with a greater occurrence and numbers in the Orange Free state and south-western Transvaal (five of the six fields, max. 211/5 g; Fig. 2.11) than in the north-west, central and eastern Tvl (three of the ten fields, max. 5/5 g; Fig. 2.8), while *D. destructor* was found with a greater occurrence and numbers (five of the ten fields, max. 795/5 g; Fig. 2.4) in the north-west, central and eastern Transvaal than in the Orange Free State and south-western Transvaal (one of the six fields, max. 6/5 g).

R. parvus was found with a low occurrence and in very low numbers in the roots (31.3 %, max. ave. 4/5 g; Table 2) and pods (12.5 %, max. 3/5 g; Table 2), and with a high occurrence and in high numbers in the soil (93.8 %, max. 44/100 cm^3; Table 2). Populations in the soil were highest in fields in the eastern (field 10; Fig. 2.10) and south-western Transvaal (fields 15 and 16; Fig. 2.15, 16). These populations, however, decreased from planting to harvest. No adult females were found.

Discussion

The ectoparasites, *C. sphaerocephala* and *P. minor*, although found prominent in this survey, have not previously been reported on groundnuts in South Africa. A nematode of the same genus as *C. sphaerocephala*, *C. ornata*, is important in the USA where it causes yield losses, enhances *Cylindrocladium* black rot of groundnut and causes groundnut " yellows " (Barker, Schmitt & Campos, 1982). *X. vanderlindei*, *X. variabile* and *R. unisexus* are confirmed on groundnuts but this study gives the first report of *P. lobatus*, *S. brachyurum*, *X. coomansi*, *X. vitis*, *L. pisi*, *R. brevicaudatus*, *R. incultus*, *R. triannulatus* and *H. dihystera* on this crop in South Africa. A nematode of the same genus as *S. brachyurum*, *S. cavenessi*, found in Senegal, retards and restricts the establishment and functioning of symbiosis between groundnut plants and both endomycorrhizae and *Rhizobium*, thus reducing nodulation, up-take of phosphorus and nitrogen fixation (Germani, Diem & Dommergues, 1980). *H. dihystera* has been found on groundnuts in the USA, although it is of lesser importance (Sasser, Nelson & Garriss, 1966).

The predominant endoparasitic nematodes found in this survey, *P. brachyurus* (Koen, 1969) and *D. destructor* (De Waele *et al.*, 1989) have previously been found on groundnuts in South Africa. *P. brachyurus* is important on groundnuts in the USA, causing up to 2.0 % yield losses (Sturgeon & Lee, 1985). This species attacks the roots, pegs and pods causing reduction in the size of the root system (Minton, 1984), necrotic lesions on the roots and shells (Starr, 1984), peg rot (Good & Stansell, 1965) and decreasing both yield and market quality (Starr, 1984). *P. brachyurus* has also been found on more than 80 % of the groundnut fields in Egypt (Oteifa, 1962) and has been a problem on groundnuts in Zimbabwe (Keetch & Buckley, 1984) and Australia (Saint-Smith *et al.*, 1972). A species, *Aphelenchoides arachidis* Bos, which causes similar symptoms and is found in the same plant tissues as *D. destructor*, is important in Nigeria (Bos, 1977). In South Africa, *D. destructor* stimulates second generation germination of up to 25 % of the seeds into plants in the field, decreases seed mass by up to 20-50 %, and can cause sprouting and discolouration of harvested seed (decreasing the market quality) to such an extent that edible seed (639 $/metric ton, March 1990) is devalued to undergrade (4 $/metric ton) (Venter, De Waele & Meyer, 1991). This study also confirms the endoparasite *R. parvus* as a parasite of groundnut, although it is doubtful that groundnut is a good host. This species was found with a high occurrence in the soil, but with a very low occurrence in the roots and pods, and always in very low numbers. No adult females were found. *P. zeae* has not previously been reported on groundnuts in South Africa.

The absence of *Meloidogyne* spp. in the groundnut fields investigated is surprising since they are widespread and serious pests of many crops in South Africa (Heyns, 1971). In the USA, *M. arenaria* and *M. hapla* are considered the most important nematodes on groundnuts, causing up to 5 % yield losses (Sturgeon, 1986). *M. incognita* and *M. javanica* have been reported on a variety of groundnut cultivars in South Africa (Keetch & Buckley, 1984).

Lowest total numbers of plant-parasitic nematodes were found in the more arid areas, in spite of supplementary irrigation. The distribution of *P. minor* was apparently not affected by soil-type, rainfall or crop-history, while *C. sphaerocephala* was found in highest numbers in well watered fields. *D. destructor* was found with a higher incidence in the northerly areas, but showed no obvious preference for soil-type, rainfall or crop-history. *P. brachyurus* was found with a higher incidence in the southerly areas, and showed a preference for a maize crop-history. De Waele and Jordaan (1988) found maize to be a good host for *P. brachyurus.* Good and Stansel (1965) found that irrigation markedly increased numbers of *P. brachyurus* in groundnut shells (from 14/5 g to 1354/5 g) and Jordaan, De Waele and Van Rooyen (1989) found highest numbers of *P. brachyurus* from areas characterised by a comparatively high average annual rainfall. Conversely, Koen (1967) observed that infestations in the fields were more severe during hot, dry years. In this study *P. brachyurus* was found with a higher incidence in fields which were not irrigated and had very different total rainfalls.

Since most populations of plant-parasitic nematodes in the pods of groundnut increased over the season, but most populations in the soil and roots decreased, it is apparent that the pod system is the most important for groundnut-parasitic nematodes, particularly for *D. destructor* and *P. brachyurus.*

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