Plant-parasitic nematodes on field crops in South Africa. 3. Sunflower

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SUMMARY

Fourteen sunflower fields, representative of the conditions prevailing in the main sunflower-producing areas of South Africa, were monitored through the 1984/85 growing season. Twelve plant-parasitic nematode species were found. The predominant ectoparasites were *Scutellonema brachyurum, Paratrichodorus minor* and *Rotylenchus unisexus.* The predominant endoparasites were *Pratylenchus zeae* and larvae of *Meloidogyne* spp. (a mixture of *M. incognita* plus *M. javanica*). *Helicotylenchus dihystera, Paratrophurus anomalus, Trophurus* sp., *Pratylenchus crenatus, Pratylenchus penetrans* and *Rotylenchulus parvus* were also found. In the soil, total populations of plant-parasitic nematodes increased between planting and physiological maturity in eight fields while those in six fields decreased. In the roots, total populations of plant-parasitic nematodes increased between three weeks after planting and physiological maturity in eleven fields while those in two fields decreased. *P. minor* populations usually increased during the growing season. Up to 900 *Meloidogyne* larvae/5 g roots were counted but very few adult females were found and gall formation was never observed. The sunflower cultivars studied thus allowed penetration of the roots by the larvae but inhibited the development of mature females.

RÉSUMÉ

Les nématodes parasites des cultures en Afrique du Sud. 3. Tournesol

Quatorze champs représentatifs des conditions de production du tournesol en Afrique du Sud ont été prospectés durant la saison de culture de 1984/85. Douze espèces de nématodes phytoparasites ont été identifiées. Les ectoparasites prédominants sont *Scutellonema brachyurum, Paratrichodorus minor* et *Rotylenchus unisexus,* et les endoparasites prédominants *Pratylenchus zeae* et des juvéniles de *Meloidogyne* spp. (mélange de *M. incognita* et *M. javanica*). *Helicotylenchus dihystera, Paratrophurus anomalus, Trophurus* sp., *Pratylenchus crenatus, Pratylenchus penetrans* et *Rotylenchulus parvus* ont aussi été identifiés. Les populations des nématodes phytoparasites dans le sol croissaient entre la plantation et la maturité physiologique dans huit champs et décroissaient dans six autres champs. Les populations de nématodes parasites dans les racines s'accroissaient entre trois semaines après plantation et la maturité physiologique dans onze champs et décroissaient dans deux champs. Les populations de *P. minor* croissaient habituellement durant la saison de culture. Jusqu'à 900 juvéniles de *Meloidogyne* pour 5 g de racines ont été dénombrés, mais peu de stades femelles ont été observés, non plus que la formation de galles. Les cultivars de tournesol étudiés permettaient la pénétration des juvéniles de *Meloidogyne* dans les racines mais empêchaient leur développement ultérieur.

Sunflower (*Helianthus annuus* L.) is one of the major oil-seed crops in South Africa. About 310 000 ha are planted annually. Sunflower yields may be suppressed by many diseases including those caused by plant-parasitic nematodes. In the U.S.A., Rich (1979), Keyserling and Bernard (1980) and Rich and Green (1981) reported damage caused by *Meloidogyne javanica* (Treub) Chitwood to sunflower, while inoculation of sunflower seedlings with *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans Stekhoven resulted in wilting and stunded plant growth (Kaplan, Rohde & Tattar, 1976). In South Africa, heavy infestations of sunflower with *Meloidogyne incognita* (Kofoid & White) Chitwood, *Meloidogyne arenaria* (Neal) Chitwood and *M. javanica* have been found (Van der Linde, Clemitson & Crous, 1959; Koen, 1969). Several nematode species, such as *Paratrichodorus minor* (Colbran) Siddiqi and *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven, reported to reproduce on sunflower in the U.S.A. (Rich & Dunn, 1982), are also abundant in South African agricultural soils (De Waele & Jordaan, 1980 *a, b*). Keetch and Buckley (1984) listed eleven plant-parasitic nematode species associated with sunflower in South Africa, but did not differentiate between common and rare species. No information exists regarding the host susceptibility of sunflower to nematodes in South Africa.

This paper presents the results of a study *(i)* to identify the predominant plant-parasitic nematode species associated with sunflower in South Africa, and *(ii)* to

examine their population development between planting and physiological maturity of the crop.

Materials and methods

During the 1984/85 growing season, soil and root samples were collected from fourteen sunflower fields from the sunflower-producing areas of South Africa (Fig. 1), at planting, three and six weeks after planting, at flowering (50 % of the flowers open) and at physiological maturity. The soil properties, rainfall, cultivar planted and crop history of the fourteen sunflower fields are given in Table 1. Soil properties and agronomic practices of the selected sunflower fields represent the prevailing production conditions. Fields 1 to 8 had sandy soils (clay content < 15 %) and fields 9 to 14 clay soils (clay contents > 35 %). On all fields sunflower was grown under dryland conditions. Fields were planted between 19th October 1984 and 9th January 1985. No fertilizers or nematicides were applied in any of the fields. All fields were naturally infested with nematodes.

In each field, soil and roots from nine plants were collected from a 0.25 ha plot and combined. The soil nematodes were extracted from three 100 ml subsamples by a modified decanting and sieving method (Flegg, 1967) using 710 µm and 45 µm sieves, followed by the sugar centrifugal-flotation method of Jenkins (1964). The root nematodes were extracted from three 5 g subsamples by the sugar centrifugal-flotation method (Coolen & D'Herde, 1972). Hot (90°) 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 ml soil or per 5 g roots. 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 $(PV = \text{population density} \times \sqrt{\text{frequency of occurrence}/10})$ were calculated for plant-parasitic nematode population densities in the soil and roots.

Results

Twelve plant-parasitic nematode species were found (Tab. 2). The predominant ectoparasites were *Scutellonema brachyurum* (Steiner) Andrássy, *Paratrichodorus minor* and *Rotylenchus unisexus* Sher. *Helicotylenchus dihystera* (Cobb) Sher occurred in four sunflower fields but its population density remained low (less than 10 individuals/100 ml soil). The predominant endoparasites were *Pratylenchus zeae* Graham and *Meloidogyne* spp. (a mixture of *M. incognita* plus *M. javanica*). *Rotylenchulus parvus* (Williams) Sher was present in seven sunflower fields but the population densities in the soil were not equalled by the population levels in the roots (max. 45 individuals/100 ml soil *vs* max. 18 individuals/5 g roots, respectively). *Pratylenchus crenatus* Loof and *Pratylenchus penetrans* occurred in the soil samples from five and four fields respectively, but only in the root samples from one field each. Telotylenchinae consisted of a mixture of *Paratrophurus anomalus* Kleynhans & Heyns plus a new *Trophurus* species (to be described later) in one field and *P. anomalus* alone in another sunflower field.

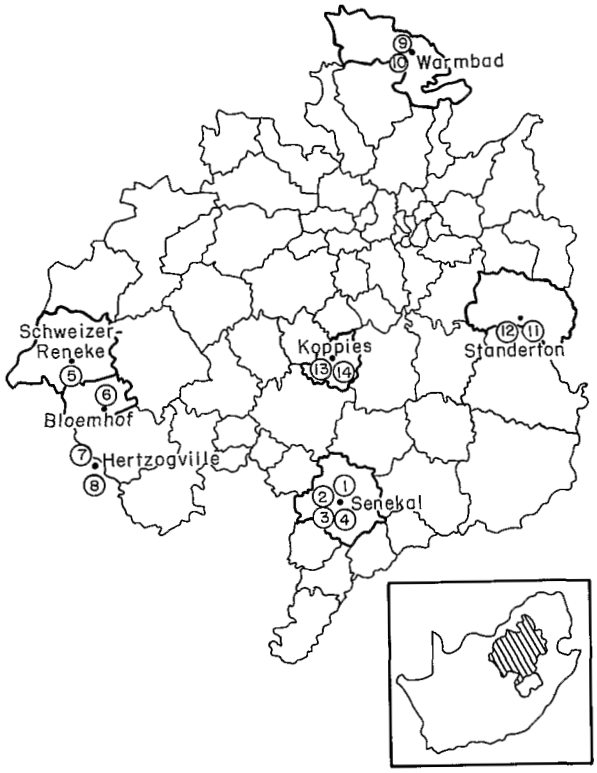

Fig. 1. Sites in the sunflower-production areas of the Transvaal and Highveld, South Africa, where nematode populations were monitored during the 1984/85 growing season.

Mixed populations of *P. zeae, P. crenatus* and *P. penetrans*, and of *P. zeae* with *P. crenatus*, were present in two fields each, and of *P. zeae* with *P. penetrans* in one field. *P. crenatus* and *P. penetrans* never occurred together without *P. zeae*. *P. zeae* was found alone in seven fields and *P. crenatus* and *P. penetrans* alone in one field each. *P. zeae* usually outnumbered both *P. crenatus* and *P. penetrans* when these species were present in the same field, except in one field, where *P. crenatus* outnumbered both the other two species.

The population development of the plant-parasitic nematodes between planting and physiological maturity varied from field to field and several different patterns were observed (Fig. 2 A-N). Total populations of plant-parasitic nematodes in the soil increased between planting and physiological maturity in eight fields, while

Table 1

Mean soil properties, cultivar planted, rainfall and crop history of the fourteen sunflower fields monitored during 1984/85 in the Transvaal and Highveld, South Africa

Farm no.	*District*	*Soil type*[1]	*% clay*	*Cultivar*	*Rainfall*[2] *(mm)*	*Crop History*[3]		
						81-82	*82-83*	*83-84*
1	Senekal	SL	15-20	SO 323	265	M	S	S
2	Senekal	SL	14-16	SO 323	265	S	S	S
3	Senekal	LS	8-12	SO 222	178	F	P	S
4	Senekal	LS	8-12	SO 222	209	S	P	S
5	Schweizer-Reneke	LS	10-15	SO 209	129	S	S	S
6	Bloemhof	SL	15	PNR 7225	119	S	M	S
7	Hertzogville	LS	10-12	PNR 40 S	163	W	S	M
8	Hertzogville	S	8-10	PNR 40 S	102	W	W	S
9	Warmbad	CL	50 +	n.a.	268	S	S	F
10	Warmbad	CL	45-50	n.a.	268	Sg	S	S
11	Standerton	CL	40-45	SO 320	357	M	Sg	Sg
12	Standerton	CL	45-50	SO 321	344	Sg	S	Sg
13	Koppies	CL	35-40	AS 504	316	S	S	Sg
14	Koppies	CL	45-50	SO 222	316	Sg	S	Sg

(1) Soil type (SL : Sandy loam; LS : Loamy sand; S : Sand; CL : Clay loam).
(2) Rainfall from three weeks before planting onwards until physiological maturity.
(3) Crop history (M : Maize; S : Sunflower; F : Fallow; P : Potato; W : Wheat; Sg : Sorghum).
n.a. = data not available.

those in six fields decreased. Total populations in eleven fields decreased at the beginning of the season between planting and three weeks after planting, while the total populations in nine fields decreased at the end of the season between flowering and physiological maturity. The total population in one field increased continuously throughout the season (Fig. 2 C), while those in two fields decreased continuously (Fig. 2 K and L). In the roots, total numbers of plant-parasitic nematodes increased between three weeks after planting and physiological maturity in ten fields, and decreased in only three fields. No root populations increased continuously throughout the season, but one root population decreased continuously (Fig. 2 K). One field was found to have no nematodes in the roots (Fig. 2 J).

Many populations of *S. brachyurum* (Fig. 2 K, L and M), *P. zeae* (Fig. 2 K) and *P. crenatus* (Fig. 2 L, and N) on the clay-soil farms with sorghum crop histories peaked in numbers at the beginning of the season and thereafter decreased. Many *Meloidogyne* spp. and *R. parvus* populations peaked in numbers in the middle of the season, at six weeks after planting (Fig. 2 B, F and H) and flowering (Fig. 2 B, F, M and N), respectively, and thereafter decreased. *P. minor* was the only species which increased in numbers, in the soil and roots, until the end of the season, usually in the sandy soils (Fig. 2 A, C, D, E, G, H and I).

Discussion

Of the predominant parasitic nematodes found during the present study, *S. brachyurum* has previously been reported on sunflower in South Africa (van den Berg & Heyns, 1973) while *P. minor* and *P. zeae* have been found associated with this crop in the U.S.A. (Rich and Dunn (1982) made a similar observation. In the *unisexus* on sunflower. *R. unisexus* is the most widespread and abundant *Rotylenchus* species in South Africa (Van den Berg & Heyns, 1974). The observation that *P. minor* populations increased during the growing season while the population numbers of most other parasitic nematode species decreased during the same period indicates that sunflower is a good host for *P. minor*. Rich and Dunn (1982) made a similar observation. In the present study, both *S. brachyurum* and *P. minor* invaded the deeper cortical layers of sunflower (up to 596 and 350 individuals/5 g roots of *S. brachyurum* and *P. minor*, respectively, were found). *P. minor*, *S. brachyurum* and *P. zeae* were also among the predominant parasitic nematodes associated with maize and sorghum in South Africa (De Waele & Jordaan, 1988 *a*, *b*).

H. dihystera is the most widely distributed *Helicotylenchus* species in South Africa (Van den Berg & Heyns, 1975). This species occurred in four of the sunflower fields but in very low numbers (max. 21 individuals/100 ml soil).

Table 2

Frequency of occurrence, mean population density and prominence value (PV) of the predominant nematodes recovered from soil and sunflower roots in fourteen sunflower fields in the Transvaal and Highveld, South Africa, at planting, 3 and 6 weeks after planting, 50 % flowering, and at physiological maturity

(PV = population density $\times \sqrt{\text{Frequency of occurrence}/10}$*)*

Nematode species	*Frequency of occurrence %*	*Mean population density /100 ml soil or /5 g roots*					*Prominence values*				
		P	*3 wk*	*6 wk*	*Fl*	*PM*	*P*	*3 wk*	*6 wk*	*Fl*	*PM*
SOIL											
Scutellonema brachyurum	71.4 %	184	136	56	22	35	155.5	114.9	47.3	18.6	29.6
Paratrichodorus minor	71.4 %	28	22	67	102	140	23.7	18.6	56.6	86.2	118.3
Rotylenchus unisexus	50.0 %	22	14	30	20	22	15.5	9.9	21.2	14.1	15.5
Helicotylenchus dihystera	28.6 %	4	4	4	7	4	2.1	2.1	2.1	3.7	2.1
Paratrophurus spp.	14.3 %	105	7	7	98	63	39.7	2.6	2.6	37.1	23.8
Pratylenchus zeae	78.6 %	79	48	17	18	3	70.0	39.9	15.1	16.0	2.7
Pratylenchus crenatus	35.7 %	266	118	48	31	20	158.9	70.5	28.7	18.5	11.9
Pratylenchus penetrans	28.6 %	14	4	11	25	0	7.5	2.1	5.9	13.4	0
Rotylenchulus parvus	78.6 %	45	6	8	29	4	39.9	5.3	7.1	25.7	3.5
Meloidogyne spp.	28.6 %	0	18	42	25	46	0	9.6	22.5	13.4	24.6
All plant-parasitic nematodes	100 %	747	374	290	377	337					
ROOTS											
Pratylenchus zeae	78.6 %		50	53	15	37		44.3	47.0	13.3	32.8
Pratylenchus crenatus	7.1 %		0	14	56	0		0	3.7	14.9	0
Pratylenchus penetrans	7.1 %		28	14	42	0		7.5	3.7	11.2	0
Rotylenchulus parvus	50.0 %		6	2	18	4		4.2	1.4	12.7	2.8
Meloidogyne spp.	35.7 %		8	266	95	56		4.8	158.9	56.8	33.5
Scutellonema brachyurum	64.3 %		76	17	8	37		60.9	13.6	6.4	29.7
Paratrichodorus minor	57.1 %		4	5	65	68		3.0	3.8	49.1	51.4
Rotylenchus unisexus	21.4 %		9	37	5	23		4.2	17.1	2.3	10.6
Paratrophurus spp.	7.1 %		14	42	126	14		3.7	11.2	33.6	3.7
All plant-parasitic nematodes	90.0 %		195	450	430	239					

The present study confirms that *Paratrophurus anomalus, Pratylenchus penetrans* and *P. crenatus* are widespread in local agricultural soils (De Waele & Jordan, 1988 *a, b*). Of these nematode species only *P. penetrans* has previously been found on sunflower (Kaplan & Rohde, 1976; Kaplan *et al.*, 1976).

The absence of *Longidorus pisi* Edward, Misra & Singh and *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven in the sunflower fields investigated is surprising. Both species are widespread in South Africa (Van den Berg, 1971; Jacobs & Heyns, 1982) and occur frequently in local maize and sorghum fields (De Waele & Jordaan, 1988 *a, b*). *P. brachyurus* has previously been reported on sunflower in South Africa (Koen, 1967) and in the U.S.A. (Rich & Dunn, 1982).

M. incognita and *M. javanica* are widespread in South Africa and are considered serious pests of many crops (Keetch & Heyns, 1982). Sunflower has been reported as a good host for both species (see e.g. Van der Linde *et al.*, 1959; Koen, 1969; Rich, 1979; Keyserling & Bernard, 1980; Rich & Green, 1981; Rich & Dunn, 1982). During the present study, *M. incognita* and *M. javanica* were found in seven of the sunflower fields. Although up to 900 larvae/5 g roots were counted, very few adult females were found and gall formation was never observed. This suggests that the sunflower cultivars studied allowed the penetration of the roots by the larvae but inhibited the development of mature females. Resistance of sunflower genotypes to *M. incognita* and *M. javanica* has been reported by Green, Genung and Killinger (1978), Rich and Green (1981), Rich and Dunn (1982) and Antonio and Dall'Agnol (1983).

R. parvus occurred in eleven of the sunflower fields but it is very doubtful if sunflower is a good host. Population densities of *R. parvus* in the soil and root samples remained very low during the growing season (on average, less than 50 individuals/100 ml soil and 20 individuals/5 g roots). Moreover, *R. parvus* was not found in the root samples of four out of the eleven sunflower fields in which the species was present in the

soil samples, and no adult females were found. *R. parvus* has not been found on sunflower before.

Data on the pathogenicity of the plant-parasitic nematodes most commonly associated with sunflower in South Africa is scarce. Inoculations of 2 000 *P. penetrans* per seedling caused extensive lesion formation and browning of sunflower roots, particularly the tap root (Kaplan *et al.*, 1976). Lesion formation was caused by the breakdown of cortical cells (Dickerson, Darling & Griffin, 1964; Acedo & Rohde, 1971). Inoculation of 12 000 *P. penetrans* per seedling severely stunted the sunflower plants, many seedlings died after two weeks while those that survived had very few roots (Kaplan *et al.*, 1976). *M. javanica* caused plant growth suppression of sunflower (Rich, 1979; Keyserling & Bernard, 1980; Rich & Green, 1981).

At planting, the population densities of many populations of the predominant parasitic nematode species in the soil were already high. This observation suggests that nematode species were able to survive the dry fallow period between growing seasons. Anhydrobiosis occurs in *S. brachyurum* and *P. penetrans* (Demeure, Freckman & Van Gundy, 1979 *a*, 1979 *b*; Townshend, 1984).

A sorghum crop history on the clay-soil farms apparently affected the population development of *S. brachyurum*, *P. zeae* and *P. crenatus*. De Waele and Jordaan (1988 *b*) reported that the population numbers of these species on sorghum were still very high at harvest. As a result, the populations were also high at planting of the next crop, sunflower, but declined rapidly through the season under this crop.

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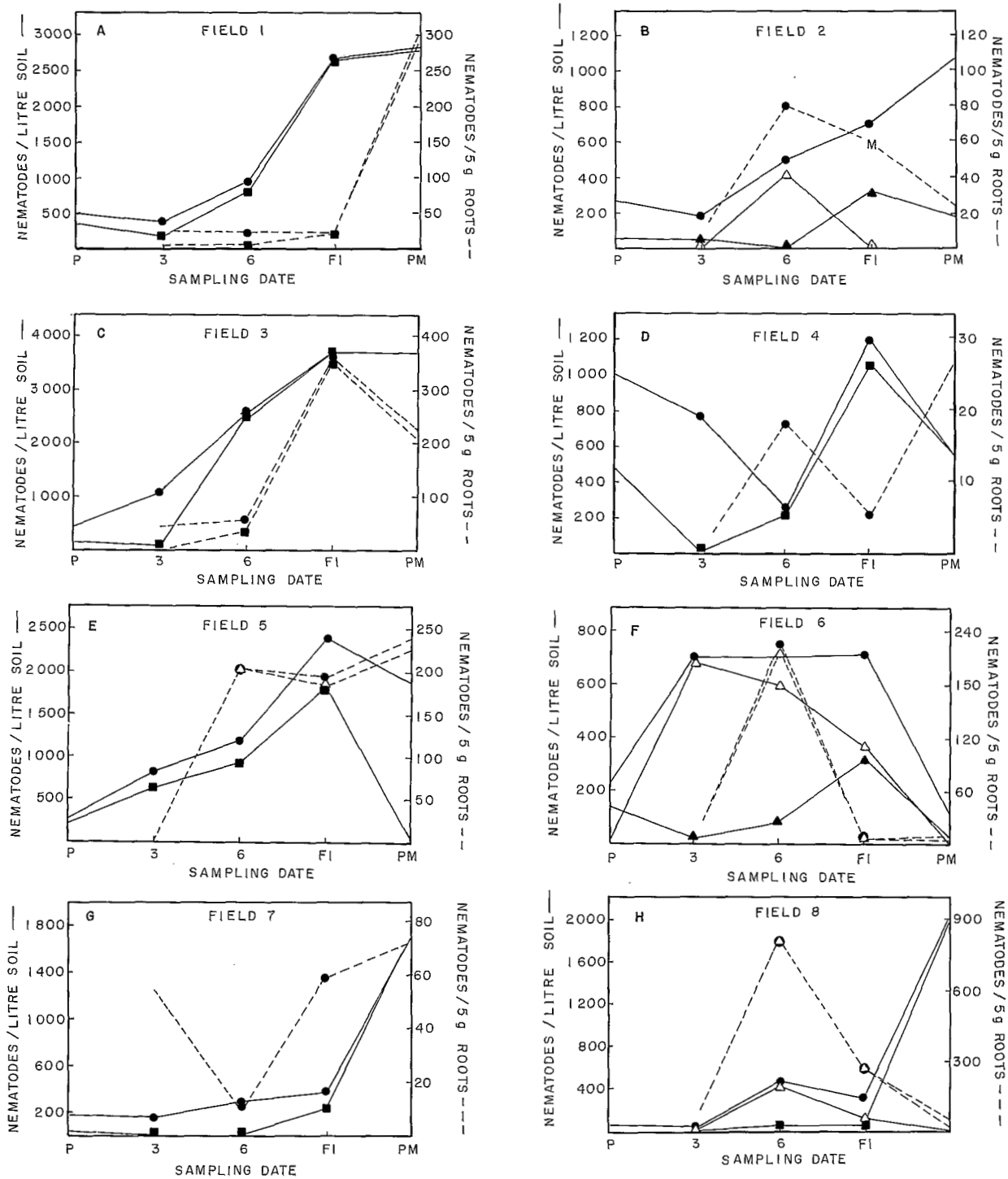
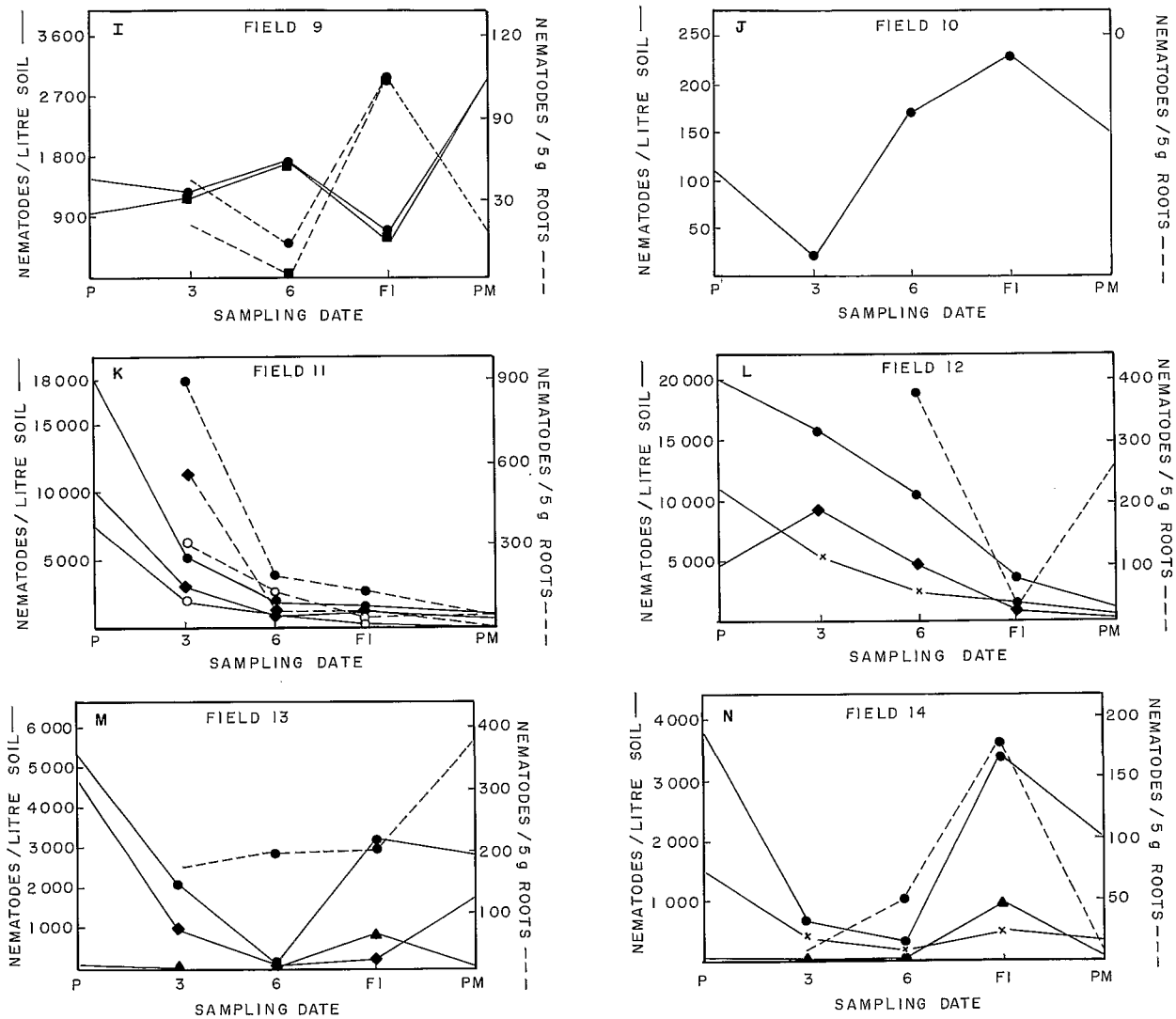


Fig. 2 A-N. Seasonal population fluctuations of the predominant plant-parasitic nematodes in the rhizosphere and roots of sunflower plants in fourteen fields, Transvaal and Highveld, South Africa. Numbers of nematodes 1 dm^3 soil or 5 g roots. Total number of plant-parasitic nematodes in the soil (—●) and in the roots (- - -●); *Paratrichodorus minor* (■); *Scutellonema brachyurum* (♦); *Pratylenchus zeae* (○); *Pratylenchus crenatus* (×); *Meloidogyne* spp. (△) and *Rotylenchulus parvus* (▲); M = missing sample.



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