Plant-parasitic nematodes on field crops in South Africa.

2. Sorghum

Dirk De WAEL and Elizabeth M. JORDAAN
Grain Crops Research Institute, Private Bag X1251,
2520 Potchefstroom, Republic of South Africa.

SUMMARY

Eight sorghum fields, representative of the conditions prevailing in the main sorghum-producing areas of South Africa, were monitored during the 1985/86 growing season. Several potentially harmful nematode species were found. The predominant ectoparasites were Scutellonema brachyurus, Paratrichodorus minor, Paratrophurus anomalus and Rotylenchus devonensis. Pratylenchus zeae, Pratylenchus penetrans and Pratylenchus crenatus were the predominant endoparasites. In the soil, the average increase in the mean numbers of plant-parasitic nematodes was about one and a half times between three and eleven weeks after planting and about fourfold between three weeks after planting and harvest. In the roots, the mean numbers of plant-parasitic nematodes were as high three weeks after planting as at harvest. Between three and eleven weeks after planting the mean numbers of plant-parasitic nematodes in the roots decreased by about 25%. Population densities of all plant-parasitic nematodes in the soil three weeks after planting and at harvest were positively correlated. A highly significant positive correlation was also found between the percentage of plant-parasitic nematodes in the soil and the total number of plant-parasitic nematodes recovered from the soil.

RÉSUMÉ

Les nématodes parasites des cultures en Afrique du Sud. 2. Le Sorgho

Huit champs représentatifs des conditions de production du sorgho en Afrique du Sud, ont été prospectés durant la saison de culture de 1985/1986. Les nématodes ectoparasites dominants sont Scutellonema brachyurus, Paratrichodorus minor, Paratrophurus anomalus et Rotylenchus devonensis. Pratylenchus zeae, Pratylenchus penetrans et Pratylenchus crenatus sont les nématodes endoparasites dominants. La population moyenne de nématodes phytoparasites dans le sol est multipliée par 1,5 entre trois et onze semaines après plantation et par 4 entre trois semaines après plantation et la récolte. Le taux moyen de la population de nématodes dans les racines demeure constant entre trois semaines après plantation et la récolte. Entre trois et onze semaines après plantation, le taux moyen de nématodes décroit dans les racines d'environ 25%. Les nombres totaux de nématodes phytoparasites dans le sol trois semaines après la plantation et à la récolte sont corrélés positivement. Une corrélation positive hautement significative existe également entre le pourcentage de nématodes phytoparasites dans le sol et le nombre total de ceux extraits de la rhizosphère du sorgho.

In South Africa about 0.3 million ha of sorghum (Sorghum bicolor (L.) Moench) are grown annually. During the last five years, sorghum production has increased, also because of the prolonged drought in the summer-rainfall region.

The status of plant-parasitic nematodes as a limiting factor in sorghum production has received rather little attention worldwide although already three decades ago Norton (1958) reported damage caused by Pratylenchus hexiscus Taylor & Jenkins to sorghum (for a review see De Waele, 1984). Loss of grain and forage sorghums in the United States was estimated at 6% (Anon., 1971). Keetch and Buckley (1984) listed ten plant-parasitic nematode species associated with sorghum in South Africa but their check-list did not differentiate between common and rare species. The nematode genera which are known to cause sorghum yield losses (e.g. Meloidogyne, Pratylenchus, Xiphinema) are abundant in South African agricultural soils but the most important plant-parasitic nematode species associated with sorghum in the main sorghum-producing areas are unknown. Such information is, however, needed to initiate specific pathogenicity experiments under controlled conditions.

This paper presents the results of a study to identify the predominant plant-parasitic nematode species on sorghum in South Africa.

Materials and methods

During the 1985/86 growing season, soil and root samples were collected from eight sorghum fields throughout the sorghum-producing areas of South
Africa (Fig. 1) three, five and eleven weeks after planting and at harvest.

The properties of the soil, together with the rainfall, cultivar planted and yield of the eight sorghum fields are given in Table 1. Soil properties and agronomic practices of the selected sorghum fields represent the prevailing production conditions. On all fields sorghum had been grown in monoculture under dryland conditions for at least two consecutive years. Fields were planted between 21st October and 30th December 1985. Minimum tillage was applied at farms 1, 2, 5, 8 and 15; conventional tillage (plough) at the other farms.

Soil texture was determined by a rapid hydrometer method based on Day's (1965) modification of Bouyoucos' (1951) technique. Soil type was determined according to the triangular textural diagram (Hodgson, 1974). All fields were naturally infested with nematodes.

In each sorghum field, soil and roots from fifteen sorghum plants were collected along the diagonal of a 0.25 ha plot and combined. The soil nematodes were extracted from five 200 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 (Jenkins, 1964). The root nematodes were extracted from five 5g subsamples by the sugar centrifugal-flotation method (Coolen &...
# Plant-parasitic nematodes in South Africa. 2. Sorghum

## Table 1

Main soil properties, rainfall, cultivar planted and yield of eight sorghum fields monitored during 1985/1986, South Africa.

<table>
<thead>
<tr>
<th>Farm no.</th>
<th>District</th>
<th>Soil form</th>
<th>% sand</th>
<th>% loam</th>
<th>% clay</th>
<th>Soil type</th>
<th>Rainfall</th>
<th>Cultivar</th>
<th>Yield (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nigel</td>
<td>Valrivier</td>
<td>74</td>
<td>12</td>
<td>14</td>
<td>SL</td>
<td>417</td>
<td>PNR 8469</td>
<td>3.8</td>
</tr>
<tr>
<td>2</td>
<td>Nigel</td>
<td>Sterkspruit</td>
<td>64</td>
<td>10</td>
<td>26</td>
<td>SCL</td>
<td>303</td>
<td>NK 283</td>
<td>1.1</td>
</tr>
<tr>
<td>4</td>
<td>Wolmaransstad</td>
<td>Hutton</td>
<td>87</td>
<td>11</td>
<td>2</td>
<td>S</td>
<td>178</td>
<td>NK 300</td>
<td>1.34</td>
</tr>
<tr>
<td>5</td>
<td>Koppies</td>
<td>Arcadia</td>
<td>62</td>
<td>22</td>
<td>16</td>
<td>SL</td>
<td>260</td>
<td>NK 283</td>
<td>0.5</td>
</tr>
<tr>
<td>8</td>
<td>Parys</td>
<td>Arcadia</td>
<td>71</td>
<td>11</td>
<td>18</td>
<td>SL</td>
<td>177</td>
<td>BC 34</td>
<td>0.6</td>
</tr>
<tr>
<td>9</td>
<td>Parys</td>
<td>Arcadia</td>
<td>72</td>
<td>15</td>
<td>13</td>
<td>SL</td>
<td>166</td>
<td>PNR 8469</td>
<td>0.95</td>
</tr>
<tr>
<td>15</td>
<td>Warmbad</td>
<td>Clovelly</td>
<td>70</td>
<td>16</td>
<td>14</td>
<td>SL</td>
<td>217</td>
<td>NK 283</td>
<td>0.4</td>
</tr>
<tr>
<td>16</td>
<td>Potgietersrus</td>
<td>Shortlands</td>
<td>65</td>
<td>23</td>
<td>12</td>
<td>SL</td>
<td>391</td>
<td>PNR 8468</td>
<td>3.0</td>
</tr>
</tbody>
</table>

1. Soil form according to MacVicar et al. (1977)
2. Soil texture as determined by the Bouyoucos' hydrometer method (Bouyoucos, 1951; Day, 1965)
3. Soil type (S: Sand; LS: loamy Sand; SL: sandy loam; SCL: sandy clay loam)
4. Rainfall from one week before planting onwards until 11 weeks after planting

## Table 2

Frequency of occurrence, mean population density and prominence value (PV) of the pre-dominant plant-parasitic nematodes recovered from soil and sorghum roots in eight sorghum fields, South Africa, 3, 5, 11 weeks after planting and at harvest

\[(PV = \text{population density} \times \frac{\text{frequency of occurrence}}{10})\]

<table>
<thead>
<tr>
<th>Frequency of occurrence (%)</th>
<th>Mean population density</th>
<th>Prominence value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Nematodes/100 ml soil)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>or 5g roots</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 wks</td>
<td>5 wks</td>
</tr>
<tr>
<td></td>
<td>11 wks</td>
<td>harvest</td>
</tr>
<tr>
<td></td>
<td>3 and 11 wks and harvest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 wks</td>
<td>5 wks</td>
</tr>
<tr>
<td></td>
<td>11 wks</td>
<td>harvest</td>
</tr>
</tbody>
</table>

### Soil

- **Paratrichodorus minor**: 25, 50, 37.5, 50, 25, 87.5, 87.5, 87.5
- **Longidorus pitz**: 37.5
- **Scutellonema brachyurus**: 50, 12, 14, 13, 14
- **Pratylenchus anomalus**: 25, 45, 90, 60, 18
- **Rotylenchus devonensis**: 25, 45, 90, 60, 18
- **Rotylenchulus pares**: 87.5, 153, 54, 218, 504
- **Pratylenchus spp.**: 87.5, 12, 13, 108
- **All plant-parasitic nematodes**: 100, 195, 165, 323, 809

### Roots

- **Pratylenchus zeae**: 100, 1 098, 713, 790, 682
- **Pratylenchus penetrans**: 87.5, 620, 298, 348, 357
- **Pratylenchus reniformis**: 62.5, 100, 237, 259, 406
- **Pratylenchus brachyurus**: 12.5, 300, 0, 0
- **Rotylenchulus pares**: 100, 45, 28, 33, 19
- **Meloidogyne spp.**: 25, 5, 15, 0
- **Spiral nematodes**: 100, 9, 48, 21
- **All plant-parasitic nematodes**: 100, 1 768, 1 146, 1 280, 1 878

<table>
<thead>
<tr>
<th></th>
<th>3 wks</th>
<th>5 wks</th>
<th>11 wks</th>
<th>harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coeff. correl.</td>
<td>0.5</td>
<td>1.5</td>
<td>112.5</td>
<td>11.5</td>
</tr>
<tr>
<td>(Nematodes/100 ml soil)</td>
<td>0.163 n.s. + 0.172 n.s.</td>
<td>141.3</td>
<td>50.0</td>
<td>203.9</td>
</tr>
<tr>
<td>(Nematodes/100 ml soil)</td>
<td>0.126 n.s. + 0.255 n.s.</td>
<td>11.2</td>
<td>11.2</td>
<td>12.2</td>
</tr>
<tr>
<td>Coeff. correl.</td>
<td>0.5</td>
<td>1.5</td>
<td>112.5</td>
<td>11.5</td>
</tr>
</tbody>
</table>

* Significant at P < 0.01; n.s. = not significant.

D’Herde, 1972). The extracted nematodes were killed and fixed in hot 4 % formalin. Nematode population levels were determined in a counting dish under a stereoscopic microscope and expressed either as the number of nematodes per 100 ml soil or per 5g roots. For species identification, plant-parasitic nematodes were transferred to anhydrous glycerin (De Grisse, 1969) and mounted on slides by the paraffin-ring method.
Prominence values \((P.V. = \text{population density} \times \sqrt{\text{frequency of occurrence}/10})\) and correlation coefficients were calculated for plant-parasitic nematode population densities in soil and roots three and eleven weeks after planting and at harvest. The relationship between the percentage of plant-parasitic nematodes in the soil and the total number of plant-parasitic nematodes in the soil was also calculated (percentage plant-parasitic nematodes in the soil: freeliving + plant-parasitic nematodes in the soil plant/parasitic nematodes in the soil \(\times 100\)).

**Results**

The predominant ectoparasites were *Scutellonema brachyurus* (Steiner) AndrAssy, *Paratrophurus anomalus* Kleynhans & Heyns, *Rotylenchus devonensis* van den Berg and *Paratrichodorus minor* (Colbran) Siddiqi. Predominant endoparasites were *Pratylenchus zeae* Graham, *Pratylenchus penetrans* Cobb and *Pratylenchus crenatus* Loof. *Longidorus pisi* Edward, Misra & Singh occurred in four sorghum fields but its population density remained low (mean density: 12 individuals/100 ml soil). *Rotylenchulus parvus* (Williams) Sher was present in most sorghum fields but the high populations in the soil (mean density: 227 individuals/100 ml soil) were not matched by high populations in the roots (mean density: 31 individuals/5g roots). *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven and larvae of *Meloidogyne* spp. were present in only one and two sorghum fields respectively.

Mean density of the larvae of *Meloidogyne* spp. was six individuals/5g roots (Tab. 2).

---

**Fig. 2 (A-D).** Seasonal population fluctuations of plant-parasitic nematodes in rhizosphere and roots of sorghum plants in eight sorghum fields, South Africa. Numbers of nematodes per dm\(^3\) soil or 5g roots.
In the roots, the very low numbers of Pratylenchus spp. usually occurred in mixed populations (Tab. 3). A monospecific population of *P. zea* was present in only one field. *P. zea* usually outnumbered the other *Pratylenchus* spp. present although in two fields *P. penetrans* and *P. crenatus* outnumbered *P. zea*.

The population development of plant-parasitic nematodes between three weeks after planting and harvest varied from field to field and several different patterns were observed (Fig. 2 A-H).

In general, populations of plant-parasitic nematodes in the soil were low three weeks after planting but increased one and a half times eleven weeks after planting and about fourfold at harvest.

In five fields, plant-parasitic nematode populations in the soil increased sharply towards harvest (Fig. 2 A, B, C, D, G & H). In two fields the plant-parasitic nematode numbers in the soil were highest eleven weeks after planting (Fig. 2 C & F) while in one field populations fluctuated throughout the growing season (Fig. 2 E). The end result, however, was always a higher population in the soil at harvest than three weeks after planting.

In the roots, the mean numbers of plant-parasitic nematodes were, generally, as high three weeks after planting as at harvest. Between three and eleven weeks after planting the mean plant-parasitic nematode population density in the roots decreased, on average, by about 25%.

Low initial plant-parasitic nematode populations in the roots three weeks after planting always resulted in
Table 3
Occurrence of mixed populations of Pratylenchus spp. recovered from sorghum roots in eight sorghum fields
(mean density during the growing season/5g roots)

<table>
<thead>
<tr>
<th>Farm no.</th>
<th>P. zeae</th>
<th>P. penetrans</th>
<th>P. crenatus</th>
<th>P. brachyurus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 117</td>
<td>53</td>
<td>104</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>705</td>
<td>536</td>
<td>307</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>1 938</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>189</td>
<td>263</td>
<td>468</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>711</td>
<td>354</td>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>1 852</td>
<td>463</td>
<td>115</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>1 117</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>54</td>
<td>56</td>
<td>0</td>
<td>76</td>
</tr>
</tbody>
</table>

high populations at harvest (Fig. 2 A, B, D & E) and vice versa (Fig. 2 C, F, G & H).

Neither the increase nor the decrease of the plant-parasitic nematode populations in the roots were usually continuous. In three fields, plant-parasitic nematode populations stabilised between five weeks after planting and harvest after a decrease between three and five weeks after planting (Fig. 2 C, G & H).

The population densities of all plant-parasitic nematodes in the soil three weeks after planting were positively correlated ($P < 0.01$) with their population densities at harvest (Tab. 2). The percentage of plant-parasitic nematodes present in the soil was positively correlated ($P < 0.001$) with the total number of plant-parasitic nematodes recovered from the soil (Fig. 3).

Many of the predominant parasitic nematodes (except *P. zeae* and *P. penetrans*) found during the present study of sorghum in South Africa have never before been associated with this crop. This is especially surprising since *S. brachyurus* and *P. minor* are polyphagous, cosmopolitan species (Siddiqi, 1974; Heyns, 1975). From host plant studies in the USA, Kraus-Schmidt and Lewis (1979) even considered sorghum a non-host for *S. brachyurus*. In this study *S. brachyurus* was found to be primarily a root ectoparasite which invaded the deeper cortical layers of sorghum. In one field (farm 1) 4 135 individuals/5g roots were present at harvest.

Previous reports that sorghum was a good host for *P. zeae* (Endo, 1959; Ayoub, 1961; Bee-Rodriguez & Ayala, 1977b) were confirmed.

In the past the known occurrence of *P. anomalus*, *R. devonensis*, *P. penetrans* and *P. crenatus* in South Africa was limited to a few localities and host plants (Van den Berg, 1971, 1976; Kleynhans & Heyns, 1983) but this study indicates that these species are much more widespread in local agricultural soils. The presence of *L. pisi* in 50 % of the sorghum fields sampled was also surprising. This species has a world-wide distribution (Heyns et al., 1984) and is common in South Africa (Jacobs & Heyns, 1982) but has never been reported from sorghum. Populations were low but this could be the result of the extraction technique which is known to be unsuitable for longidorids (Coolen & D'Herde, 1977). In reality population levels could have been five to ten times higher.

Several *Meloidogyne* spp. and *P. brachyurus* occur in South Africa and are considered serious pests of many

![Graph](image-url)
crops (Keetch & Heyns, 1982) but on sorghum these nematodes occurred infrequently and in low numbers. Sorghum is a good host for several Meloidogyne spp. (Aytan & Dickerson, 1969; Birchfield, 1983) so that its use for crop rotation in fields infested with Meloidogyne incognita (Kofoid & White) Chitwood has been discouraged in the USA (Carter & Nieto, 1975). On the other hand, resistance of sorghum genotypes to Meloidogyne spp. and Pratylenchus brachyurus has been reported (Whitehead, Ledger & Kariuki, 1963; Sharma & De S. Medeiros, 1982).

Sorghum apparently is also a good host for Rotylenchulus parvus. However, population densities of R. parvus in sorghum roots remained low while its prominence values in the soil were high compared with the other plant-parasitic nematode species present (Tab. 2). De Waele and Jordaan (1988) report a similar situation for R. parvus in maize. The growth of sorghum is not affected by high soil populations of R. parvus because no feeding takes place before the nematodes enter the roots (Dasgupta & Raski, 1968). The same authors also point out that R. parvus has the potential to develop into an important agricultural pest.

S. brachyurus, P. minor and P. zeae were also among the predominant parasitic nematodes associated with maize in South Africa (De Waele & Jordaan, 1988). The pathogenicity of these plant-parasitic nematodes most commonly associated with sorghum in South Africa has never been studied. However, many of them are known to be potential pathogens on other crops and their influence on sorghum will have to be established.

P. zeae at 500 and 1 500 nematodes per 15-cm-diameter pot suppressed plant growth of sorghum and induced root necrosis (Bees-Rodriguez & Ayala, 1977a; Cuarezma-Teran & Trevathan, 1985).

Damage to sorghum induced by hoplolaimids, root-knot nematodes, trichodorids and longidorids has been reported (Orr, 1967; Lamberti, 1969; Dasgupta, Nand & Seshadri, 1970; Chevres-Roman, Gross & Sasser, 1971; Marks & Elliot, 1973; Ediz & Dickerson, 1976; Smolik, 1977; Orr & Morey, 1978).

The observation that P. zeae usually outnumbers other Pratylenchus species when present in mixed populations leads to the conclusion that P. zeae dominates not only P. brachyurus (Olowe & Corbett, 1976; De Waele & Jordaan, 1988) but also P. penetrans and P. cre- natus. One possible cause for this is the shorter life cycle of P. zeae which is on maize three weeks at 30 to 35°C (Olowe & Corbett, 1976) compared with 35 days at 28°C on peas (Dickerson, 1961) and 35 days at 21°C on potatoes and onions (Wong & Perria, 1968).

In moist soil which is allowed to dry out, S. brachyurus and P. penetrans exhibit anhydrobiosis (Demeure, Frecman & Van Gundy, 1979a, 1979b; Townshend, 1984). De Waele & Jordaan (1988), suggest that the predominant plant-parasitic nematodes of maize display the same mechanism. Anhydrobiosis may also occur in those plant-parasitic nematodes associated with sorghum in South Africa which would explain how these organisms are able to survive almost six months of drought between growing seasons.

The different population development patterns observed between three weeks after planting and harvest could be the result of many interactions. It will therefore be difficult to forecast the population development of sorghum nematodes at the beginning of the growing season.

The correlation coefficients between mean nematode population densities three weeks after planting and harvest (Tab. 2) indicate that root-lesion nematodes leave decaying sorghum roots as soon as they are physiologically mature.

In sorghum planted after 15th November, large populations of plant parasitic nematodes were observed three weeks after planting (Fig. 2 C, F, G & H). However, it is unclear if prolonged exposure to high moisture levels in the soil induced quiescent Pratylenchus populations to resume activity, even in the absence of growing sorghum roots.

Large populations of ecto- and endoparasitic nematodes also occurred in soils with more than 15% clay (Fig. 2 B, D & E). This suggests that sorghum grown in clay soils can also be attacked by nematodes.

The percentage of plant-parasitic nematodes present in the rhizosphere of sorghum can be used to indicate the potential for nematode infestation since this parameter was positively correlated with the total number of plant-parasitic nematodes present around the roots.

Acknowledgements

The authors wish to thank Drs E. van den Berg and K. Kleyhans, Plant Protection Research Institute, Pretoria, for their help with the identification of some species; Dr D. Keetch, PPRI, for critical reading of the manuscript and R. Wilken, J. Nel and R. Swanepoel for technical assistance.

References


Birchfield, W. (1983). Wheat and grain sorghum varietal...


