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# Endoparasitic Nematodes in Maize Roots in the Western Transvaal as Related to Soil Texture and Rainfall

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*Abstract:* Eight endoparasitic nematode species were recovered from 170 maize root samples in western Transvaal, Republic of South Africa. *Pratylenchus zeae* had the highest average population density (17,454/5 g roots), followed by *P. neglectus* (5,827/5 g roots), *P. penetrans* (5,617/5 g roots), *P. brachyurus* (3,060/5 g roots), *Meloidogyne incognita* plus *M. javanica* (301 juveniles/5 g roots), *P. crenatus* (130/5 g roots), and *Rotylenchulus parvus* (64/5 g roots). The 17 reasonably homogeneous farming areas (RHFA) surveyed could be ranked on the basis of the incidence of the prevalent nematode species. A positive relationship was found between the incidence of *P. brachyurus* and *R. parvus* and long-term average annual rainfall. The incidence of *P. penetrans* and the *Meloidogyne* spp. was positively related to a combination of sand percentage and long-term average annual rainfall.

*Key words:* maize, *Meloidogyne incognita, M. javanica, Pratylenchus brachyurus, P. crenatus, P. neglectus, P. penetrans, P. zeae,* rainfall, *Rotylenchulus parvus,* soil texture, western Transvaal.

Maize (*Zea mays* L.) is the most important crop in the Republic of South Africa. It is grown on about 4 million hectares annually and has produced an annual average of about 2 tons grain per hectare over the last decade.

Attention was first focussed on the possible pest status of nematodes on maize in South Africa in 1976 (13). Although *Pratylenchus zeae* Graham and *P. brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven have been identified as the most common endoparasitic nematodes associated with maize in the major production areas (5,13), there is little published information concerning the incidence of endoparasitic nematode species in western Transvaal. Twenty-five percent of South Africa's maize crop is produced in western Transvaal, which forms the western sector of the Highveld, a plateau situated at 1,700 m altitude.

During 1987, a survey of the endoparasitic nematodes associated with maize roots was conducted in western Transvaal. The objectives were to identify the prevalent species and to determine the relationship to soil texture and long-term average annual rainfall. Sampling was based on a local system of dividing the Highveld into 57 reasonably homogeneous farming areas (RHFA). Each RHFA has a fair degree of uniformity in macroclimate, topography, geology, soil type, agricultural use, and production techniques applied (11).

## MATERIALS AND METHODS

During February 1987, 170 samples of maize roots were taken from 170 fields in 17 RHFA in western Transvaal. Within each RHFA, 10 fields, selected arbitrarily, were sampled at flowering. In each field, three root systems were taken at random and combined to form one sample. In addition to the root sample, a soil sample was also collected for soil texture analysis. Root samples were stored at 10 C and within 1 week the samples were washed and the nematodes were extracted from 5 g fresh roots by sugar centrifugal-flotation (2). Nematodes were killed, fixed in hot 4% formalin, and counted with a stereomicroscope; specific determinations were made from glycerin mounts.

Soil texture was determined by a rapid hydrometer method based on Day's (4) modification of Bouyoucos' (1) technique.

Prominence values (PV = population density $\times \sqrt{\text{frequency of occurrence}}/10$) were calculated for each species. Chi-squared contingency values were calcu-

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TABLE 1. Plant-parasitic nematodes in maize roots in the western Transvaal, Republic of South Africa (n = 170).

| | Nematodes/5 g roots | | | |
|---|---|---|---|---|
| | Frequency (%) | Mean† | Range | Prominence value |
| *Pratylenchus zeae* | 63.9 | 17,454 | 5–42,588 | 13,952 |
| *P. brachyurus* | 46.4 | 3,060 | 9–53,875 | 2,084 |
| *P. penetrans* | 40.4 | 5,617 | 8–59,444 | 3,570 |
| *P. neglectus* | 2.4 | 5,827 | 185–10,440 | 902 |
| *P. crenatus* | 1.2 | 130 | 119–140 | 14 |
| *Rotylenchulus parvus* | 54.8 | 64 | 5–550 | 47 |
| *Meloidogyne* spp. | 16.3 | 301 | 5–1,970 | 121 |

† Average of positive samples.

lated pairwise for the prevalent species to ascertain the significance of joint occurrences. The Kruskal-Wallis rank sum test with Yates correction factor was used to rank the RHFA according to the frequency of occurrence and average density of each of the prevalent species. A canonical correlation analysis was performed to correlate the incidence of the prevalent species with soil texture (percentages of sand and clay) and long-term (10 years or more) average annual rainfall.

## RESULTS AND DISCUSSION

Eight endoparasitic nematode species were recovered from maize roots in the 17 RHFA surveyed (Table 1). Of the *Pratylenchus* spp., *P. zeae* had the highest prominence value followed by *P. penetrans* (Cobb) Filipjev & Schuurmans Stekhoven and *P. brachyurus*. A similar observation was made during previous surveys of maize fields in South Africa (5). In western Transvaal, the average population densities of these three species were much higher; *P. penetrans* also occurred more frequently. *P. neglectus* (Rensch) Filipjev & Schuurmans Stekhoven and *P. crenatus* Loof were present in the roots in less than 3% of the samples. The average population density of *P. neglectus* was higher than that of *P. brachyurus* and comparable with that of *P. penetrans*. The three other endoparasitic nematode species recovered were *Rotylenchulus parvus* (Williams) Sher, *Meloidogyne incognita* (Kofoid & White) Chitwood, and *M. javanica* (Treub) Chitwood. The *Meloidogyne* species always occurred in mixed populations. The frequency of occurrence of *R. parvus* was high, but its average population density was low, hence the low prominence value. The *Meloidogyne* spp. were present in almost 20% of the root samples, with an average population density of 301 juveniles/5 g roots. Similar observations for *R. parvus* and mixed populations of both *Meloidogyne* spp. were made by De Waele and Jordaan (5). Maize is a good host for most of these species (3,5–7,9) and yield increases have been obtained following their control with nematicides (5,12,13). Their pathogenicity to maize, however, is still not well documented.

Among the five prevalent endoparasitic nematode species, highly significant ($P = 0.001$) negative relationships were found between *P. zeae* and *P. brachyurus* and between *P. brachyurus* and *P. penetrans* (Table 2). The reasons for these negative relationships are unknown, but the preference

TABLE 2. Chi-squared values for joint occurrences of the prevalent plant-parasitic nematode species associated with maize roots in the western Transvaal, Republic of South Africa.

| | Pz | Pb | Pp | Rp |
|---|---|---|---|---|
| *P. brachyurus* | −8.6*** | | | |
| *P. penetrans* | 0.0 | −27.8*** | | |
| *Rotylenchulus parvus* | 0.0 | 3.3 | 0.1 | |
| *Meloidogyne* spp. | 2.4 | 0.9 | 0.0 | 0.8 |

*** Significant at $P = 0.001$.

Negative values indicate a deficit of joint occurrences and consequently a negative association between species.

TABLE 3. Frequency (F %) and average density (AD) of plant-parasitic nematode species in maize roots in the western Transvaal, Republic of South Africa, and ranking order (R) of RHFA based on the incidence of each nematode species.

| | *Pratylenchus zeae* | | | *P. brachyurus* | | | *P. penetrans* | | | *Rotylenchulus parvus* | | | *Meloidogyne* spp. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RHFA† | F % | AD | R | F % | AD | R | F % | AD | R | F % | AD | R | F % | AD | R |
| 6001 | 90 | 1,771 | 3 | 20 | 217 | 14 | 80 | 596 | 5 | 90 | 178 | 1 | 10 | 5 | 10 |
| 6002 | 40 | 353 | 15 | 100 | 4,467 | 2 | 0 | 0 | 16 | 60 | 68 | 8 | 10 | 20 | 9 |
| 6004 | 40 | 1,288 | 12 | 20 | 843 | 12 | 100 | 8,479 | 1 | 80 | 152 | 2 | 0 | 0 | 14 |
| 6005 | 90 | 2,743 | 2 | 10 | 1,309 | 15 | 80 | 6,415 | 3 | 40 | 11 | 14 | 0 | 0 | 14 |
| 6006 | 70 | 1,445 | 6 | 80 | 2,265 | 3 | 40 | 1,848 | 8 | 60 | 22 | 10 | 50 | 484 | 3 |
| 6007 | 40 | 1,428 | 13 | 30 | 104 | 11 | 100 | 2,699 | 2 | 20 | 28 | 17 | 10 | 125 | 6 |
| 6008 | 80 | 5,243 | 4 | 20 | 41 | 16 | 80 | 13,276 | 4 | 20 | 8 | 15 | 10 | 5 | 14 |
| 6010 | 70 | 1,747 | 9 | 80 | 2,464 | 4 | 10 | 149 | 14 | 70 | 16 | 9 | 10 | 5 | 10 |
| 6016 | 10 | 319 | 17 | 90 | 10,730 | 1 | 10 | 1,155 | 12 | 70 | 100 | 3 | 0 | 0 | 14 |
| 6017 | 80 | 369 | 10 | 80 | 497 | 5 | 0 | 0 | 16 | 70 | 30 | 6 | 20 | 343 | 4 |
| 6018 | 60 | 442 | 11 | 50 | 1,655 | 7 | 20 | 88 | 11 | 50 | 14 | 12 | 0 | 0 | 14 |
| 6027 | 70 | 533 | 8 | 40 | 1,117 | 9 | 20 | 3,598 | 9 | 12 | 25 | 16 | 70 | 526 | 1 |
| 6028 | 90 | 20,611 | 1 | 30 | 4,487 | 10 | 60 | 10,154 | 6 | 70 | 73 | 4 | 70 | 264 | 2 |
| 6029 | 30 | 955 | 14 | 30 | 6,278 | 8 | 40 | 8,463 | 7 | 50 | 112 | 5 | 0 | 0 | 14 |
| 6030 | 90 | 827 | 5 | 0 | 0 | 17 | 10 | 313 | 13 | 30 | 37 | 13 | 10 | 20 | 7 |
| 6032 | 60 | 16 | 16 | 30 | 21 | 13 | 10 | 55 | 15 | 80 | 22 | 7 | 10 | 150 | 5 |
| 6055 | 70 | 5,127 | 7 | 70 | 1,878 | 6 | 20 | 594 | 10 | 40 | 39 | 11 | 10 | 55 | 8 |
| $\chi^2$ for ranking‡ | | | 48.66* | | | 58.4* | | | 70.94** | | | 40.35** | | | 27.14* |
| *P* | | | 0.01 | | | 0.01 | | | 0.01 | | | 0.01 | | | 0.05 |

† Reasonably homogeneous farming areas.

‡ Chi-squared value for significance levels: * 5% = 26.3, ** 1% = 32.

TABLE 4. Canonical correlation between population densities of endoparasitic nematode species recovered from maize roots in the western Transvaal, Republic of South Africa, and three environmental factors.

| Canonical variable | Canonical correlation | Chi-square | Standardized canonical coefficients | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Left hand variables | | | | | | | Right hand variables | | |
| | | | Pz | Pb | Pp | Pc | Pn | M | Rp | Percent sand | Percent clay | Rainfall |
| $C_1$ | 0.479 | 69.11** | 0.3 | 0.8 | 0.0 | 0.3 | −0.2 | 0.0 | 0.4 | −0.1 | 0.0 | 0.9 |
| $C_2$ | 0.375 | 29.41* | 0.0 | 0.1 | 0.5 | −0.3 | 0.2 | 0.7 | 0.3 | 0.5 | −0.6 | 0.5 |
| $C_3$ | 0.202 | 6.34 | 0.2 | 0.0 | 0.1 | 0.1 | −0.1 | 0.0 | −0.1 | 0.7 | 0.7 | 0.1 |

*Pratylenchus zeae* (Pz), *P. brachyurus* (Pb), *P. penetrans* (Pp), *P. crenatus* (Pc), *P. neglectus* (Pn), *Meloidogyne* spp. (M), *Rotylenchulus parvus* (Rp).
* $P = 0.05$, ** $P = 0.01$.

of *P. brachyurus* for soils with a higher clay content may be important.

The prevalent endoparasitic nematode species varies among the RHFA, and the 17 RHFA surveyed could be ranked on the frequency of occurrence and average population density of each species (Table 3). The highest incidence of *P. zeae* was found in loamy sand to sandy soils in the RHFA 6005, 6008, 6028, and 6055, which have an average annual rainfall of 500–590 mm. Maize roots grown in sandy loam to loamy sand soils in the RHFA 6002, 6006, 6010, 6016, and 6055 contained the highest incidence of *P. brachyurus*. These RHFA are characterized by a comparatively high average annual rainfall of 570–610 mm. The highest incidence of *P. penetrans* was in loamy sand to sandy soils in the RHFA 6004, 6005, 6007, 6008, and 6028; highest *Meloidogyne* incidence was in sandy soils in the RHFA 6005, 6027, and 6028. The average annual rainfall in all these RHFA was 500–580 mm. These data allow the identification of those RHFA in which the environmental conditions favor the incidence of potentially harmful nematodes. Especially at risk are those RHFA in which the incidence of several species is high, such as 6005 and 6028.

Two of the canonical correlations were significant (Table 4). The first canonical variable was interpreted as a positive correlation ($P = 0.01$) of the incidence of *P. brachyurus* and *R. parvus* with the average annual rainfall. The second canonical variable was interpreted as a positive correlation ($P = 0.05$) of the incidence of *P. penetrans* and *Meloidogyne* spp. with sand percentage and average annual rainfall combined. Since 1982 western Transvaal has experienced drought and discrepancies in maize yield responses to nematicides applied before and during the drought have been observed (10). The observation that increased rainfall favors the increased incidence of most of the prevalent endoparasitic nematode species associated with maize roots may explain these discrepancies.

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