RELATIONSHIP BETWEEN TIME OF NEMATICIDE APPLICATION, NUMBERS OF NEMATODES AND RESPONSE TO TREATMENT IN RATOON SUGARCANE

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Abstract

A series of three trials was established on sandy soil at each of three localities to provide information on the timing of nematicide application to cane harvested in winter or spring. Soil and root samples were taken at intervals from some of the sites to monitor changes in the numbers of nematodes. The cane in all the trials was affected by low rainfall. A significant response to treatment with Temik at 20 kg per hectare was recorded in seven of the nine trials. There was no significant difference between the improved yields which resulted when cane was treated at harvest in May or 20 weeks after harvesting. This coincided with the observation that the number of nematodes in the roots remained at a low level or declined during the winter. In trials where the cane was cut in spring (October or November) the response to treatment was significant only where the nematicide was applied at or within six weeks of harvesting. In a trial where treatment was delayed for 15 weeks, the yield was significantly less than that of the crop treated six or ten weeks after harvesting. This coincided with the observation that in untreated plots, root populations of *Meloidogyne* and *Pratylenchus* had increased by 12 weeks after a spring harvest.

Introduction

Rostron[11] found there was no disadvantage in delaying, by up to nine weeks, the application of a nematicide to sugarcane ratooned in July and September. In the latter trial, treatment nine weeks after harvest was superior to treatment three weeks after harvest.

The aim of the work described in this paper was to determine how long the application of a nematicide to cane ratooned in winter or spring could be delayed and, by monitoring the nematode populations, explain why treatment could be delayed without adversely affecting the yield. The results of three of the trials have been reported briefly by Moberly and Clowes[7].

Methods

Three trials, referred to as early winter, late winter and spring trials, were established in ratoon cane at each of three localities: Mposa in Zululand, Tongaat on the Natal north coast and Noodsberg in the Natal midlands. The early and late winter trials at Mposa and all three trials at Noodsberg were adjacent to one another. Details of the sites are given in Table 1. In each trial there were three Temik (aldicarb) treatments applied at different times after harvesting the previous crop (Table 2) and an untreated control. The Temik was applied by hand at a rate of 20 kg/ha (3 kg ai/ha) in a shallow furrow drawn along one side of each cane row. Each trial was arranged in a randomised block design with five replicates (plots). Each plot consisted of five 10 m rows. Stalk heights, the stalk population and yield of cane in the inner three rows were recorded. The cane was fertilized and herbicide applied according to the recommendations of the Experiment Station of the SA Sugar Association.

In the early winter trial at each locality soil and root samples were taken from the control plots and analysed for nematodes whenever the Temik treatments were applied. No samples were taken from the late winter trials. In the spring trials, samples were taken periodically from the plots that were treated with Temik in November, from plots treated in January and from the control plots. Soil samples consisted of 20 cores per plot and were taken to a depth of 220 mm. Root samples were taken from the top 250 mm of soil within 300 mm of each of five stools per plot. Nematodes were extracted from a 100 ml subsample of soil from each of the plots using the decanting-sieving-Baermann tray method. Nematodes were extracted from the roots by incubating a 10 g subsample in a weak hydrogen peroxide solution in a polythene bag for six days (Spaull and Braithwaite[12]).

Temperature and rainfall data (Figures 1 & 2) were taken from nearby meteorological stations; air temperatures are expressed as the mean of the daily maximum and minimum temperature and soil temperatures, as the mean of readings taken at 0800 and 1400 hours each day.

Results

Pratylenchus zeae, Meloidogyne incognita and/or *M. javanica* and species of *Xiphinema, Paratrichodorus, Macroposthonia, Helicotylenchus, Rotylenchulus* and *Paralongidorus* were recovered from the trials at all three localities. Other nematodes recorded were *Scutellonema* at Noodsberg, *Neodolichodorus* and *Discocriconemella* at Tongaat and *Histotylenchus* at Mposa. *Hoplolaimus pararobustus* occurred at both Tongaat and Mposa.

Early and late winter trials

Apart from a decline in the root population of *Meloidogyne* at Noodsberg there was little or no change in the number of

TABLE 1

Details of experiment sites

Trial	Site	Soil series	Clay content	Sugarcane variety	Duration of crop (months)	Rainfall mm
Early winter	Mposa	Fernwood	7%	NCo 376	16,8 (May-Sep)	1 107
	Tongaat	Fernwood	3%	NCo 376	18,0 (Apr-Nov)	810
	Noodsberg	Cartref	9%	NCo 293	26,5 (May-Jul)	1 419
Late winter	Mposa	Fernwood	7%	NCo 376	16,8 (May-Sep)	1 017
	Tongaat	Clansthal	5%	N55/805	22,8 (Aug-Jul)	1 845
	Noodsberg	Cartref	9%	NCo 293	22,5 (Sep-Jul)	1 339
Spring	Mposa	Maputa	2%	N8	20,6 (Oct-May)	1 508
	Tongaat	Clansthal	4%	NCo 376	20,9 (Oct-Jul)	1 741
	Noodsberg	Cartref	9%	NCo 293	20,5 (Nov-Jul)	1 250

nematodes in the soil or roots from May to September in any of the early winter trials (Table 3). With the exception of *Meloidogyne* at Noodsberg, numbers of nematodes were relatively low at all three sites on each of the three sampling occasions.

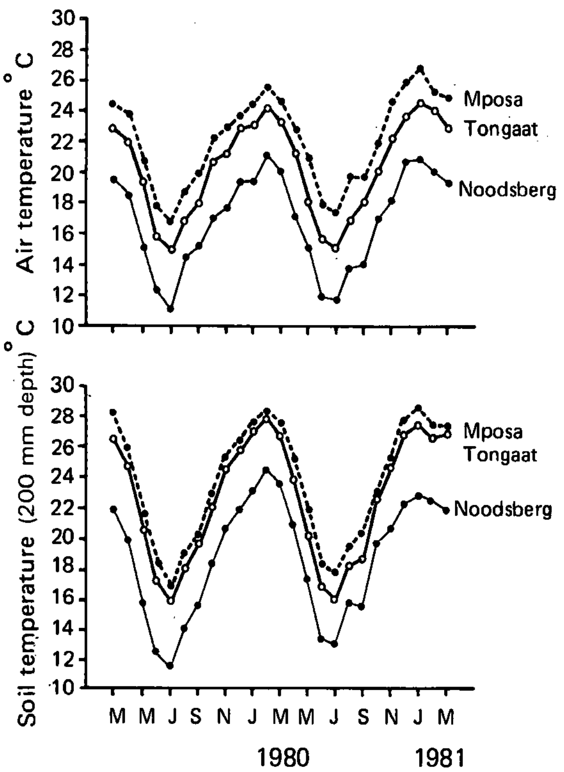

FIGURE 1 Air temperature and soil temperature at a depth of 200 mm

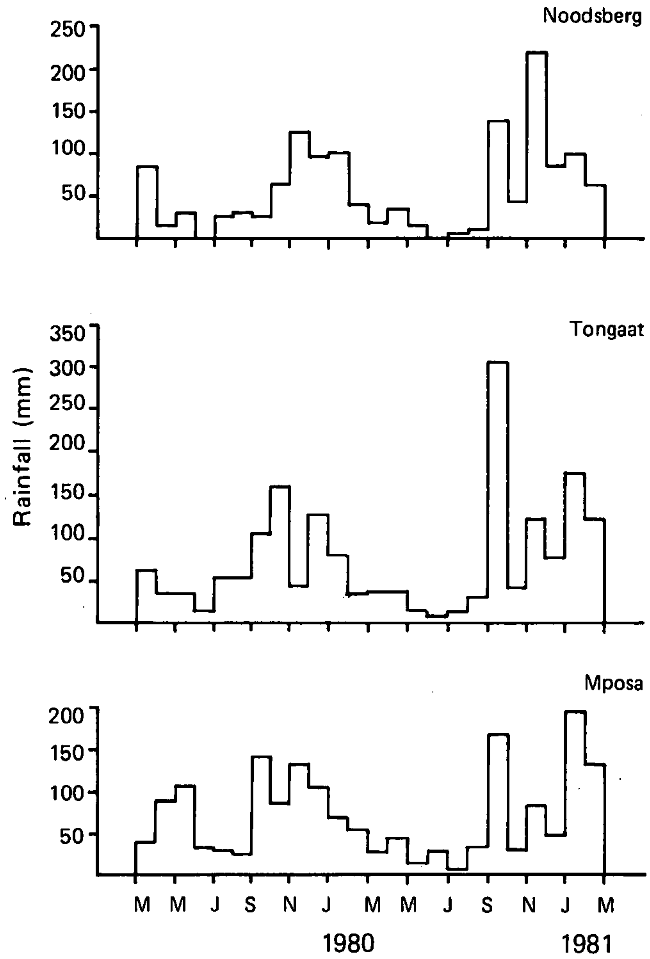

FIGURE 2 Monthly rainfall at the three localities

TABLE 2

Summary of Temik treatments and yield data

Trial	Site	Time of application: Date	Time of application: Weeks after harvest	Tons cane per hectare Control	Tons cane per hectare Treated	LSD P<0,05	Coefficient of variation %
Early winter	Mposa	1 May '79 4 Jul '79 17 Sep '79	0 9,1 19,9	31	59* 52* 65*	13,9	19,5
	Tongaat	30 Apr '79 5 Jul '79 4 Sep '79	0 9,4 18,0	26	56* 48* 49*	10,9	17,7
	Noodsberg	2 May '79 2 Jul '79 10 Sep '79	0 8,7 18,8	26	34 37* 29	8,7	20,2
Late winter	Mposa	17 Sep '79 8 Oct '79 12 Nov '79	19,9 22,9 27,9	42	77* 64* 61*	16,3	19,3
	Tongaat	4 Sep '79 4 Oct '79 8 Nov '79	1,0 5,3 10,3	56	57 55 59	15,0	19,2
	Noodsberg	10 Sep '79 3 Oct '79 8 Nov '79	0 3,4 8,6	40	49 51 56*	11,8	17,4
Spring	Mposa	12 Nov '79 14 Dec '79 15 Jan '80	6,0 10,6 15,1	32	41* 39 31†	7,8	15,8
	Tongaat	8 Nov '79 4 Dec '79 14 Jan '80	2,3 6,0 11,9	26	34 40 46	23,7	47,2
	Noodsberg	8 Nov '79 10 Dec '79 9 Jan '80	0 4,6 8,9	30	44* 42 40	12,8	23,8

* Yield significantly different from control (P<0,05)

† Yield significantly different from other treatments (P<0,05)

TABLE 3

Numbers of *Pratylenchus* and *Meloidogyne* per 10 g roots and total number of nematodes per 100 ml soil in the early winter trials

Site	May	Jul	Sep
Mposa:			
Pratylenchus	75	31	79
Meloidogyne	697	79	455
Total (soil)	202	224	205
Tongaat:			
Pratylenchus	308	89	145
Meloidogyne	3	5	0
Total (soil)	293	268	227
Noodsberg:			
Pratylenchus	883	822	412
Meloidogyne	2 157	863	262
Total (soil)	587	328	389

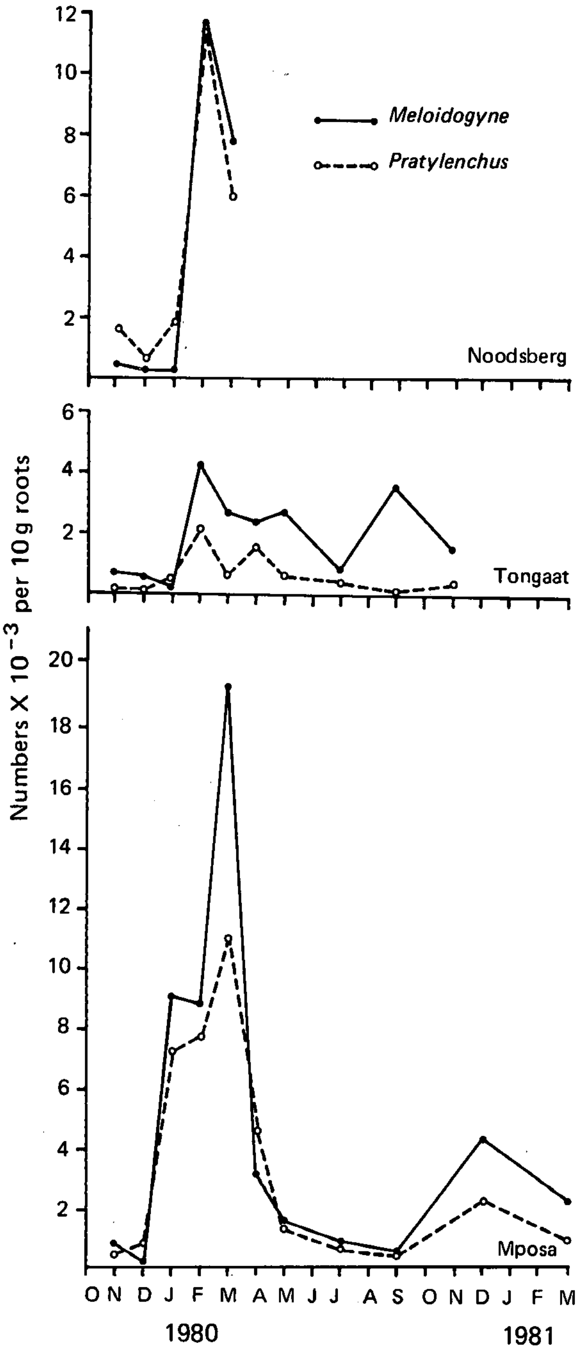

FIGURE 3 Changes in numbers of *Meloidogyne* and *Pratylenchus* within the roots of cane in the control plots of the spring trials

Sugarcane yield from the control plots was low at all three sites in both the early and late winter trials, probably because of the low rainfall. In the early winter trials, although there were no differences in stalk height and population, cane treated at harvest at Mposa and Tongaat was, within two months, greener than untreated cane. The cane at Noodsberg showed no response to treatment during the first six months after harvesting the previous crop.

The initial and two delayed treatments with Temik significantly increased the yield of cane in the early winter trials at Mposa and Tongaat (Table 2). At Mposa, in the late winter trial, the three treatments were applied some time after harvest and all significantly increased cane yield. In both trials at Noodsberg, only the treatment applied two months after harvest gave a significant response. There was no significant difference between yields from the nematicide treatments at any of the sites, although in both trials at Mposa there was an indication that treatment applied in September, five months after harvesting, was superior to treatment before or after that time (Table 2). There was no response to treatment in the second trial at Tongaat.

Spring trials

At Mposa the previous crop was cut on 1 October, at Tongaat on 23 October and at Noodsberg on 8 November. At each site root populations of the endoparasites, *Meloidogyne* and *Pratylenchus,* were low for two months after cutting. By the third month however, numbers had increased markedly at Mposa and Noodsberg and to a lesser extent at Tongaat (Figure 3). At Mposa the highest populations of nematodes in the roots occurred two months after the initial rise but at Tongaat there was no further increase in numbers (Figure 3). Numbers decreased sharply from the maximum population level at Mposa, but more gradually at Tongaat, reaching a minimum in mid to late winter. The samples taken at Mposa indicate that there was an increase in numbers during the second summer but that it was much less marked than in the first summer (Figure 3).

There was no consistent pattern of change in the number of *Xiphinema* and *Paratrichodorus* in the soil nor in the soil populations of *Meloidogyne* and *Pratylenchus* in the three trials (Figures 4 & 5).

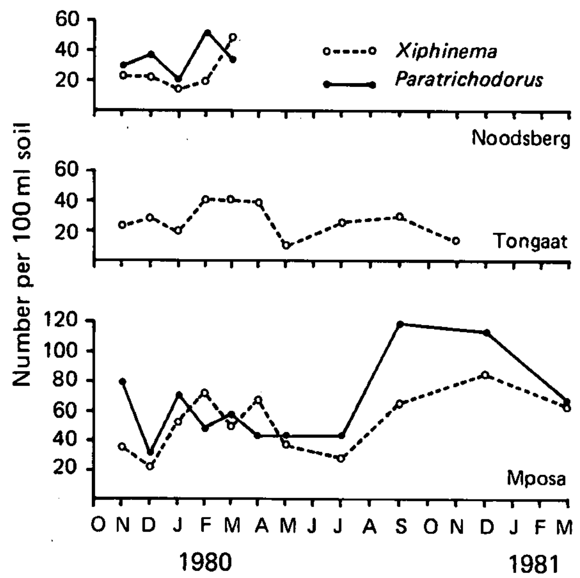

FIGURE 4 Changes in numbers of *Paratrichodorus* and *Xiphinema* in the control plots of the spring trials

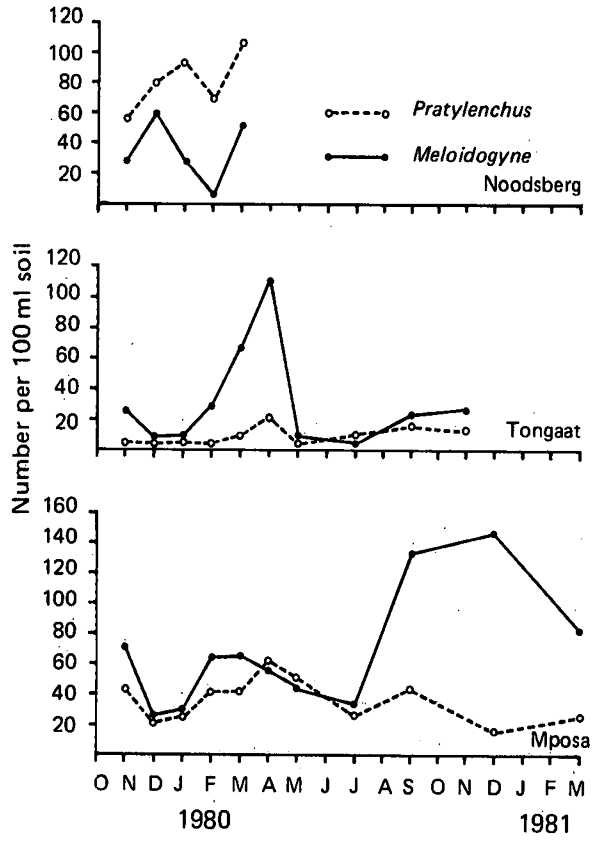

FIGURE 5 Changes in numbers of *Meloidogyne* and *Pratylenchus* in the soil of the control plots of the spring trials

There was no significant effect of treatment with Temik on the number of nematodes in the roots (Table 4) or soil at any of the sites. However large variations in numbers within the control and treated plots may have obscured any such effect.

Growth differences following treatment were first observed in December at Mposa and in January at Tongaat and Noodsberg. Treatment with Temik at harvest at Noodsberg and six weeks after harvest at Mposa resulted in significant increases in cane yield (Table 2). The application of Temik 15 weeks after cane was harvested at Mposa was the only nematicide treatment in the three series of trials where the yield of cane from one such treatment was significantly less than that from another (Table 2). In all nine trials, differences between stalk heights, stalk populations and yields of sugar were similar to those for cane yield.

Discussion

The results from the early winter trials show that nematodes affected the growth of sugarcane at all three sites and that nematicide application to cane ratooned in early winter could be delayed for up to five months without significantly affecting the response to treatment. It may be assumed therefore that nematode damage to roots of untreated cane occurred in spring, after the last application of Temik. Alternatively if the damage occurred in winter, the cane was able to compensate following treatment with the nematicide. There was an indication that nematodes did have an effect on the cane at the two warmer sites during the winter. At Mposa and Tongaat cane which was treated with Temik at harvest in May was, two months later, greener than untreated cane, although there was no difference in stalk height or population. Data collected at the time of harvesting at Mposa, show that the early greening did not confer an advantage over the cane in the plots treated later (Table 2). This suggests that compensation did occur. However it is more likely that the delayed treatments in the early winter trials were effective because they were applied before most of the damage occurred. During the winter there were few nematodes in the roots (Table 3). This was probably due to a combination of (1), insufficient feeding sites on the largely suberized roots of the old root system and limited growth of the new root system and (2), reduced activity of the nematodes as a result of the low winter temperatures (Figure 1). Low temperatures are known to limit migration of and root penetration by *Meloidogyne* (Prot and van Gundy[9]; Roberts *et al*[10]) and to slow down the development of both *Pratylenchus* and *Meloidogyne* within roots (Milne and du Plessis[6]; Olowe and Corbett[8]; Vrain *et al*[13]). Low rainfall during the winter (Figure 2) may also have limited both nematode activity (Wallace[14]) and root growth (Glover[4]). No samples were taken after September in the early winter trials but it is to be expected that as soil temperatures and rainfall increased, root growth would be stimulated and more nematodes could invade and develop within the roots. Treatment with a nematicide after any such increase in numbers in spring would be less effective than treatment before the increase. This might explain the apparent greater response to treatment in September than in November in the late winter trial at Mposa (Table 2) but further studies are required.

In a sandy soil, aldicarb and its oxidation products have a half life of less than 14 days and within four weeks less than 25% remain (Bromilow[3]). Thus, assuming that most of the nematode damage occurred in spring in the early winter trials, the effectiveness of the initial treatment applied in early winter could not have been due to the persistence of the nematicide in the soil. Instead, the early winter treatment probably reduced the size of the nematode populations which, because of low

TABLE 4

Total number of endoparasitic nematodes per 10 g roots during the first five months in the spring trials

Site	November		December		January		February		March	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Mposa:										
Control	1 702	1 157	1 034	1 045	15 112	5 902	16 586	3 594	30 370	9 981
Temik 6 week delay	1 109*	323	1 909	2 912	14 740	4 979	7 870	2 807	20 720	7 253
Temik 15 week delay	-		-		17 698*	7 512	11 390	6 290	41 068	19 893
Tongaat:										
Control	1 334	1 066	730	895	968	722	6 754	3 252	3 807	4 768
Temik 2 week delay	866*	541	926	1 092	521	885	4 336	3 705	1 798	2 106
Temik 12 week delay	-		-		1 012*	862	3 812	4 320	2 153	2 510
Noodsberg:										
Control	1 748	422	765	432	1 999	639	23 108	14 640	13 776	2 273
Temik 0 week delay	2 336*	2 279	1 719	1 284	2 053	1 195	11 376	3 016	4 680	2 717
Temik 9 week delay	-		-		2 038*	1 172	21 976	9 154	5 088	3 379

* Number present at time of treatment.

temperatures, did not recover until after the cane had established a large root system.

In the spring trial at Mposa, where the previous crop was harvested in early October, the yield from the 15 week delayed treatment applied in January, was significantly less than yields from plots treated at six or ten weeks after harvest (Table 2). In fact the yield was no better than that from the control plots. When this treatment was applied, the root populations of *Meloidogyne* and *Pratylenchus* had increased markedly from the low levels during the preceding two months (Figure 3). *M. incognita, M. javanica* and *P. zeae* are known pathogens of sugarcane (Anon[1]; Apt and Koike[2]; Khan[5]). Thus it seems likely that root damage had already occurred when the nematicide was applied and/or the populations were too large to be adequately controlled by the treatment. In the spring trial at Noodsberg, where there were no significant differences between the yields due to the various times of application, all treatments were applied before the large increase in numbers in February (Figure 3). At Tongaat, although the differences between the yields of cane from the control and treated plots were large, they were not statistically significant. However the coefficient of variation for the yield data was large (47%). The *Meloidogyne* and *Pratylenchus* populations were much smaller at this site than at Mposa or Noodsberg.

M. incognita, M. javanica and *P. zeae* require approximately 10 000 degree hours above 10°C to complete their life cycle (Milne and du Plessis[6]; Vrain *et al*[13]; and calculated from data given by Olowe and Corbett[8]). During the two months after harvest in the spring trials, there was approximately 20 000 degree hours above 10°C at a soil depth of 200 mm at Mposa; 22 000 at Tongaat and 16 000 at Noodsberg. During this period new roots grew rapidly, so presumably suitable feeding sites were available for the nematodes. At Mposa and Tongaat, and to a lesser extent at Noodsberg, an increase in the number of *Meloidogyne* and *Pratylenchus* was therefore expected by the end of the second month but this occurred three months after harvest (Figure 3). The delay may have been as a result of the rapid growth of the new roots during the first two months, such that root density increased at a greater rate than nematode density. Presumably by the third month, the rate at which the nematodes increased was greater than root growth (growth could, for example, have been limited by nematode damage).

The reason for the sharp decline in the number of nematodes at Mposa in March (Figure 3) is not known. Since soil temperatures were still favourable for nematode development, the decline may have been related to a change in the condition of the roots and/or the very low rainfall during March.

Apart from an increase during spring and the second summer at Mposa, the number of ectoparasitic nematodes was low (Figure 4). However symptoms of root damage similar to those caused by trichodorids were frequently observed; the roots, particularly the lateral branches, were stunted, coarse and brittle. Furthermore *Paratrichodorus* was recorded in the third trial at Mposa in every plot on every sampling occasion. *Xiphinema* was equally common in this trial. The importance of these ectoparasites in sugarcane agriculture requires investigation.

Acknowledgements

We acknowledge with thanks the help of Mrs. J.M.C. Braithwaite, Messrs. R. Dhrumaraj, K. Subramoney; other members of the Agronomy department; staff of the Biometry and Chemistry departments and the co-operators upon whose land the work was conducted. Special thanks to Dr. M. St. J. Clowes who initiated the trials.

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