PROVISIONAL ESTIMATE OF CROP LOSS IN SUGARCANE CAUSED BY NEMATODES

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Abstract

Results of more than 130 field trials with nematicides, principally aldicarb, were grouped according to the clay content and parent material of the soil on which the trials were conducted. An estimate of loss in yield due to nematodes was obtained by extrapolating from the results of the field trials to the total area under sugarcane on each soil group. Crop loss per unit area was greatest on the Recent Sands, but the estimated total crop loss was much greater on the more extensive soils derived from Table Mountain Sandstone.

The results suggest that nematodes restrict the growth of cane over a very much greater area than that where nematicides are currently used. The financial implications of this are considerable. This situation is discussed and it is proposed that chemical control should not be the only option available to the cane grower to reduce crop loss by nematodes.

Introduction

Nematodes have long been recognised as a limiting factor in the growth of sugarcane on the poor sandy soils of Natal (Dick[6]). The production of sugarcane on these soils is usually profitable only when nematicides are used (Anon[1]). This has led to considerable research effort to optimize treatment with nematicides (Donaldson[8, 9, 10], Donaldson and Turner[11, 12], Moberly and Clowes[14], Moberly *et al*[15], Rau and Moberly[16], Rostron[18], Spaull and Donaldson[20]). However, little attention has been given to the organisms that cause the problem or to finding alternative means of control. This situation may, in part, be explained by the availability of the very effective, granular carbamate nematicides, aldicarb (Temik 150 G), and carbofuran (Curaterr 100 G and Diafuran 100 G). They are easily applied, especially aldicarb, which can be placed over the cane row, and on poor sandy soils they nearly always improve yield substantially (Donaldson[9]). In the past few years some 14 000 ha of poor Recent sands, which constitute approximately two-thirds of the total area of such soils under cane, have been taken out of cane and planted to timber (unpublished observations, SASA Extension Division). Thus it might be inferred that the sugar industry's problem with nematodes is now much reduced. However, as demonstrated here, the nematode problem is not confined to the poor sandy soils, and at least part of the problem cannot currently be resolved with nematicides.

Methods

The results of 139 nematicide trials conducted over the past 25 years were used to estimate the loss in yield of sugarcane caused by nematodes. Details of almost all the trials have been reported elsewhere (Dick and Harris[7], Donaldson[8, 9, 10], Donaldson and Turner[11, 12], Moberly and Clowes[14], Moberly *et al*,[15] Rau and Moberly[16], Ringelmann[17], Rostron[18], Spaull and Donaldson[20], Thompson[21, 22]).

In most of the trials, plots of sugarcane comprising 5 or 6 rows, 8 to 15 m in length, were treated with 3 kg aldicarb/ha. This is the maximum rate registered for use on sugarcane; it is here referred to as the "standard" rate of application. In a few of the trials 5,6 kg aldicarb, 3 kg carbofuran or 3 kg oxamyl were applied. Aldicarb and carbofuran were applied in the furrow at planting and, for ratoons, either in a shallow furrow on one or both sides of the cane row or over the row. Ratoons were treated soon after harvest in summer, or before spring if the previous crop was harvested in winter. Oxamyl, as a foliar spray, was applied in one trial as a split application after 6 and 11 weeks and, in another trial, when the cane was 450 mm high. In two of the 12 trials on Table Mountain sandstone (TMS) mistbelt soils up to 19 kg aldicarb/ha was used; in six of the remaining ten trials, plots were fumigated before planting with an unspecified quantity of EDB or DBCP (Dick and Harris[7]).

In all trials untreated plots acted as controls. However, in a number of the trials with ratoon cane the treated plots had also been treated in the previous crop, while the controls had never been treated. Treatments were replicated four to eight times except in one trial where only two replicates were used (Donaldson and Turner[12]).

In the trials reported by Ringelmann[17], the response to nematicide treatment was derived from the yields from several bands of three rows of treated cane and three rows of untreated cane. Each row ran the length of the field.

In 17 of the early trials on Recent sands, where the cane was treated with 5,6 kg aldicarb instead of the standard 3 kg/ha, the results have been collated, but they have not been used to derive the crop loss estimates for this soil type. The reason for this is that in 21 other trials on soils derived from Recent sand, data were available for not only the response to the standard rate of application of aldicarb or carbofuran but also for 1,3 to 3,7 times this amount. These data have been used to obtain an estimate of the additional benefit that may be derived from greater nematode control, and thus allow a more realistic estimate to be made of crop loss in those soils. With the exception of one trial on a sandy TMS soil, where cane was also treated with 1,9 times the standard rate, no such information is available for other soil types.

Variety N55/805 was used in most of the trials. Other varieties, used infrequently, included NCo293, NCo376, NCo382, N8 and N13. For the most part the variety used was that recommended at the time for the particular environment. The trials were harvested after 9 to 27 months when the mass of cane in treated and untreated plots was recorded. For ease of comparison the response to treatment has been converted to tons cane/ha/annum.

The trials have been grouped according to soil parent material and placed in one of four categories depending on the clay content of the soil: 2-5%, 6-10%, 11-20% and 21-35% clay. A single trial on a soil derived from Swaziland Basic Rock containing 46% clay was included in the 21-35% clay group. The total area under sugarcane for each soil group was estimated from unpublished data. An estimate of the total loss in yield of sugarcane attributable to nematodes was calculated from the mean response to treatment with nematicide per hectare per annum for each soil category, and the area of each category. The 40 000 ha of alluvial soils were not included in this exercise because, due to the variable nature of the clay content within the soil profile, it was deemed inadvisable to attempt to estimate the area within the four categories of soil texture. (Only three trials were conducted on alluvial soils. The clay content of the soils on the trial sites and the response to treatment were as follows: 2% clay, 15,0 t cane; 5% clay, 10,3 t cane; and 24% clay, 17,7 t cane/ha/annum).

It should be noted that none of the sites for the trials was selected according to the size and composition of the nematode populations. Rather some were chosen according to the soil parent material and/or according to the clay content of the soil. The other sites were selected because of the relatively poor growth of the cane on a particular soil parent material. However subsequent analysis usually revealed that the poor growth could be related to the clay content of the soil. Thus most of the trial sites are considered to be reasonably representative of the soil textural categories within the various types of parent material and extrapolating from the trial sites to the much greater area under commercial sugarcane is considered to be justified. However, until data from randomly selected sites are available the crop loss estimates for the various soil categories should be regarded as the probable maxima.

Results

With one exception, the effect of nematodes on sugarcane was greatest on Recent sands containing less than 6% clay (Table 1). The exception was the single trial on the soil derived from Swaziland Basic Rock.

Where greater than the standard rate of application was used in the trials on Recent sands, the response to treatment increased on average by approximately 25% (Table 2). Extrapolating to the total area of such soils, the additional cane lost as a result of nematode damage amounts to approximately 33 000 t/annum on the soils with 2-5% clay and approximately 43 000 t/annum where there is 6-10% clay (Table 1). Although not directly comparable, the mean response to treatment with 5,6 kg aldicarb/ha in 17 trials on Recent sands with less than 6% clay was 26,5 ± 3,3 t cane/ha/annum (Thompson[21]). In 39 other trials on Recent sands the response to treatment with 3 kg aldicarb/ha was 19,2 ± 1,7 t cane/ha/annum (see Table 1).

Table 1

Estimated loss in yield of sugarcane due to nematodes in South Africa

No trials	Soil Groups	Yield of untreated cane; t/h/ann	Estimated area under sugarcane; ha	Loss in Yield* t/ha/ann ± SE	Projected total loss t cane/annum
	2-5% clay				
39	Recent sand	36,0	7 200	19,2±1,7	138 240
				(+24%)**	33 178
19	TMS Ordinary	43,3	9 800	9,7±1,6	95,060
					266 478
					-171 220***
	Sub total				95 258
	6-10% clay				
44	Recent sand	62,7	13 500	12,8±1,9	172 800
				(+25%)**	43 200
19	TMS Ordinary	56,6	39 000	8,7±1,7	339 300
					555 300
					- 43 520***
	Sub total				511 780
	11-20% clay				
	Recent sand	-	4 400	-	-
5	TMS Ordinary	52,2	39 000	6,1 ± 3,4	237 900
	Granite	-	30 100	-	-
	Dwyka tillite	-	12 200	-	-
	Middle Ecca sandstone	-	8 600	-	-
	Sub total				237 900
	21-35% clay				
	TMS Ordinary	-	9 800	-	-
12	TMS Mistbelt	63,3	6 500	3,6±1,1	23 400
	Granite	-	7 500	-	-
	Dwyka tillite	-	24 400	-	-
	Middle Ecca sandstone	-	8 600	-	-
1	Swaziland Basic Rock	190,6	2 400	23,5	56 400
	Sub total				79 800
	GRAND TOTAL				924 738

Footnote for table

* Equivalent to the response in yield following treatment with the standard rate of nematicide.

** Correction for increased response to above standard rate of nematicide on Recent sands. See text and Table 2.

*** Correction for cane treated with nematicide. See text.

The loss in yield of sugarcane per unit area on TMS-derived soils was smaller than that on Recent sands (Table 1). However, because the area under cane on TMS soils was much greater, the estimated total loss on such soils was much larger. In the single trial on the TMS soil where more than the standard rate of nematicide was also tested, the response was increased by more than 50% (Table 2).

Table 2

Response of sugarcane to treatment with the maximum registered rate of aldicarb or carbofuran (3 kg/ha) and to 1,3 to 3,7 times this amount

Soil parent material (number of trials)	Clay content	Mean control yield t cane/ha	Mean response to treatment with 3 kg/ha of aldicarb or carbofuran t cane/ha	Mean percentage increase in response to treatment with 1,3 to 3,7 times the maximum registered rate of application (range)
Recent sands (13)	2- 5%	45,0	28,0	24% (0 to 96%)
Recent sands (8)	6-10%	62,1	14,4	25% (-20 to 83%)
TMS (1)	6-10%	48,0	21,0	52%

Few nematicide trials were conducted on soils with more than 10% clay and no data are available for soils derived from Dwyka tillite, Granite or Middle Ecca sandstone. The large response to treatment with a nematicide on the heavier alluvial soil and on the soil derived from Swaziland Basic Rock shows that nematodes can limit the growth of sugarcane even on the more heavily textured soils.

The combined estimated loss in yield for each soil category, including the corrections to the values for the Recent sands, would amount to approximately 1 100 000 t cane/annum, if no chemicals were used to control nematodes. In fact sufficient aldicarb and carbofuran was sold in 1989 to treat approximately 12 000 ha (T Hagemann; EJ Watt: personal communication). Assuming that the average age of cane at harvest on the sandy soils was approximately 14 months and that a similar amount of nematicide is sold each year, the area treated with nematicide in 1989 amounted to approximately 14 000 ha. If this included all the fields of Recent sand with less than 6% clay, (i.e. 7 200 ha) and the remaining 6 800 ha were divided evenly between TMS soils with less than 6% clay and Recent sands with 6-10% clay, the loss in yield on these sands would be reduced by 214 740 t cane, (i.e. 138 240 + [3 400 × 9,7] = 171 220 t cane for the 2-5% clay category and [3 400 x 12,8] = 43 520 t cane for the 6-10% clay category). (Table 1).

Discussion

The data indicate that the annual loss due to nematodes in the South African sugar industry could amount to approximately 900 000 tons cane (Table 1). This takes no account of any losses that may occur on the more than 100 000 ha of soils derived from Alluvium, Dwyka tillite, Granite or Middle Ecca sandstone. The estimates in Table 1 are based on the assumption that the field trials are representative of the range in environments and nematode communities that occur within a particular soil group within the sugar industry. This should be a reasonable assumption where data are plentiful, as for example from the Recent sands, but estimates derived from only a few trials, as with those on TMS soils and those in the 21-35% clay category, may not be so reliable. It is also assumed that commercial responses to treatment with nematicides will be as great as those observed in experiments, and this is unlikely to be so.

Besides the loss in yield of sugarcane there are additional costs that may arise from the damage caused by nematodes, at least on the poor sandy soils. Cane affected by nematodes takes longer to develop a full canopy of leaves over the interrow. Thus weeds, which would otherwise be more quickly shaded out by the cane leaves, are able to flourish and necessitate additional weed control. Also, judging by the residual or carryover response to treatment with nematicide (Spaull and Cadet[19]) nematodes cause a slow decline in the vigour of cane. As a result fewer high yielding ratoon crops are obtained, which necessitates replanting more frequently. Because nematodes restrict root growth, the cane plant is unable to make full use of nutrients applied to the soil, resulting in less efficient use of fertilizer.

The costs of treatment of cane with a nematicide will vary with time and from one farm to another, but based on average figures, the present minimum cost of treatment of plant and ratoon cane is roughly equivalent to the value of 8 to 10 t cane/ha. Thus to be economic, the response to aldicarb or carbofuran must equal or exceed 8 to 10 t cane per crop per hectare. It should be noted that the average duration of the experimental crops was greater than 12 months, and thus for most of the trials in Table 1 response per crop was greater than response per annum.

Based on volume of sales and age of cane at harvest, aldicarb and carbofuran are used on approximately 14 000 ha of sugarcane. This is approximately a half of the 30 000 ha where economic responses to treatment with nematicide might be expected (Table 1). The reason for this is not clear but it may be because the average response on some of the soils does not exceed the minimum cost of treatment sufficiently to make the practice attractive to the grower. Of the total of 139 trials used to compile the data in Table 1, 25% gave a response to treatment that was less than the average cost of the treatment, i.e. less than 8 t cane/ha/crop. In addition, the data indicate that on the Recent sands, even where the nematicides were applied at the maximum registered rate, the response was some 25% less than that achieved if more nematicide were used (Table 2).

It appears from the foregoing (assuming that the extrapolations are warranted) that: (i) nematodes restrict the growth of cane over a much greater area than that where chemical control is used (ii) nematodes restrict the growth of cane over a wider area than that where the cost of treatment is justified, and (iii) a proportion of the cane lost to nematodes cannot be prevented by the use of nematicides applied at the current maximum registered rate.

The first situation may be resolved by more widespread use of nematicides. However all three situations would be alleviated by the availability of varieties that are not seriously affected by nematodes. The use of such resistant or tolerant varieties is the only method of control that requires no additional financial input. But on the poorest sands, where the damage caused by the nematodes is greatest, it is probable that a degree of resistance or tolerance alone would not be sufficient to prevent appreciable crop loss. In these situations a nematicide or some other means of control would also be required.

In Brazil the variety SP 70-1143, which is resistant to *Meloidogyne javanica*, is very widely grown on the sandy soils where this species is the dominant plant parasitic nematode (GR Machado, personal communication). However, in South Africa sugarcane is damaged by a diverse assemblage of species, in particular *M javanica*, *M incognita*, *Pratylenchus zeae*, *Xiphinema elongatum* and a species of *Paratrichodorus*. It is unlikely that general resistance to these species will be found (Luc and Reversat[13]) particularly when several other favourable attributes must also be combined with this trait. Thus tolerance to nematodes, rather than resistance, should be sought. Cadet *et al*[5] recommended that when searching for such tolerance, attention should be given to those varieties that quickly replace the sett roots with a rapidly expanding shoot root system. However, their recommendation was for cane growing in Burkina Faso. There the dominant endoparasites, *M incognita* and *P zeae*, limit the growth and development of the sett roots of the plant crop which in turn restricts the development and survival of the primary and secondary tillers. As a result, the number of stalks and thus yield of the plant crop are affected (Cadet and Spaull[4]). In contrast the ratoon crop in Burkina Faso is largely unaffected by nematodes (Cadet[2]). The reason for this is not properly understood (Cadet[3]).

In South Africa, from rather limited evidence, it appears that the interaction between nematodes and sugarcane is more involved. In plant cane not only do the endoparasites, *Meloidogyne incognita*, *M javanica* and *P zeae* affect the number of stalks, as in Burkina Faso, but as a result of the serious damage the dominant ectoparasites, *Xiphinema elongatum* and *Paratrichodorus* sp cause to the shoot roots, these species have a marked effect on the length of the stalks (Cadet and Spaull[4]). In ratoon cane the endoparasites seem not to be as important, and the loss in yield is due almost entirely to the damage caused by *X elongatum* and possibly *Paratrichodorus* sp. Thus varietal tolerance to nematodes in South Africa may involve more than simply the rate at which the sett roots are replaced by shoot roots.

Conclusions

Projections from these trial data indicate that more than 900 000 t cane could be lost each year because of nematodes. However this needs to be confirmed. The use of nematicides may not be as widely accepted in the sugar industry as the practice deserves. There are a number of situations where the response to treatment with a nematicide is insufficient to justify the cost of the chemical. In addition, the level of control achieved with the maximum registered rate of nematicide is insufficient to prevent an appreciable loss of cane. It is suggested that the use of tolerant varieties, integrated with other control measures, where necessary, would prevent much of the crop loss currently attributable to nematodes.

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