THE EFFECTS OF SOIL pH, CLAY CONTENT, RAINFALL AND AGE AT HARVEST ON THE YIELD RESPONSE OF SUGARCANE TO TEMIK

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Abstract

The data from 87 nematicide experiments were reviewed to assess the effect of pH and clay content of the soil, rainfall and age at harvest on the yield of cane growing in soils treated with Temik (aldicarb). The results showed that yield responses were greatest in cane growing in the Fernwood series soils which have a low clay content. Responses tended to decrease as the clay content of the soil increased. Responses to applied Temik were smaller where the pH of the soil was higher than 8,0 than they were when it was lower than 8,0. Rainfall had no apparent effect on the crop's responses to Temik applied on Fernwood series soils but in Clansthal series soils, the response appeared to decrease slightly as the rainfall increased. The results indicated that the magnitude of crop responses to Temik increased with the age at which the crop was harvested and that the mean response to Temik of crops harvested at 20 months or older, was twice that from crops harvested at 13 months or younger. Total crop production per month was nevertheless much greater for treated crops harvested at a young age than at an older age.

Introduction

The generic composition of nematode populations found in Fernwood and Clansthal series soils have been reported to be similar (Dick and Spaull[4]). Results of a survey conducted by the same authors showed that the population of plant parasitic nematodes in the Clansthal series soil was twice that found in the Fernwood series soil. Yield responses of cane to nematicides applied to Clansthal series soils were found generally to be half those of cane in Fernwood series soils which had been treated (Moberly and Clowes[7]). This difference in response to nematicides appears not to be due to differences in numbers and genera of nematodes but to the texture of the soil.

Harris[5] and Spaull and Braithwaite[10] showed that methods of soil sampling and extraction of nematodes from soil and root samples gave variable results. Spaull[9] indicated that *Meliodogyne* spp. were not detected in more than 20% of the fields that were surveyed and this percentage may be even higher. Sampling alone, as a means of assessing whether a nematicide should be used on sugarcane, could therefore be misleading. Moberly *et al*[8] considered that the necessity to apply a nematicide could best be determined by observing the crop's response to nematicide in observations plots.

The presence, numbers and types of nematodes must be important factors influencing the crop's response to nematicide, but because of the difficulties associated with counting and identifying nematodes in samples, other factors need to be considered. Results from 87 nematicide experiments conducted by the South African Sugar Association Experiment Station were reviewed to determine whether factors other than the numbers, types and distribution of nematodes could influence the sometimes large differences that have been observed in the response of sugarcane to Temik.

Methods

Some details of the 87 experiments under review are given in Appendix 1. In most instances, Temik (aldicarb) was applied at a rate of 3,0 kg ai ha^{-1} but in some experiments the rate was 5,6 kg ai ha^{-1}. Cane variety N55/805 was used in 68 experiments, N8 in 11 experiments, NCo 376 in 6 experiments, and N13 in 2 experiments. In each experiment, treatments were replicated at least four times. Each plot consisted of five or six rows 10 m long spaced either 1,0 m or 1,4 m apart. The three or four central rows, excluding 1 m at either end of each row, comprised the net plot from which harvest data were obtained.

Rainfall was recorded at meteorological stations closest to each site for the duration of each experiment. The mean monthly rainfall for each experiment is given in Appendix 1 as well as the rain which fell during the month before the crop was planted and during the first four months of the cropping period, so that its effects during the early stages of crop growth could be assessed.

The pH (in water) and clay content of the soils were determined at the start of each experiment. Because of the large number of experiments and the range in age when the plots were harvested, it was possible to make an assessment of the effect of the age of cane when it is harvested on the yield response after treatment with Temik. Some of the data include cumulative responses to applied Temik because the same plots were either treated or not treated in successive crops. It was considered unlikely that these data would bias the comparisons which were being made.

Results

Clay content of the soil

The mean yield response to applied Temik in the 48 experiments conducted in Fernwood series soils (less than 6% clay) was 27 tons cane ha^{-1}, which is equivalent to an average of 55% more than the yields from the untreated plots. The increase of 13,1 tons cane ha^{-1} resulting from Temik applied to Clansthal series soils (39 experiments) was equivalent to an 18% higher yield than that of the untreated cane. The variation in the mean yields of untreated cane from 44 tons ha^{-1} in soil with 2% clay to 93 tons cane ha^{-1} in soil with 8% clay is shown in Table 1. The responses to applied Temik were greater when the clay content of the soil was less than 6% than when it was 6% or more. The mean yield response of cane in soil with 2% clay was 27 tons ha^{-1} and 12,0 tons ha^{-1} in soil with 9% clay. The responses to treatment with Temik are expressed as a percentage of the yields of untreated cane in Table 1.

TABLE 1

Mean yield from control plots and responses to Temik applied to soils with different clay contents

Soil clay % at 0-200 mm	2	3	5	6	7	8	9	
Mean yields from control plots (tc ha^{-1})	44	49	45	63	66	82	93	79
Mean yield response (tc ha^{-1})	27	26	23	32	12	15	17	12
Mean response as % of control	61	53	51	51	18	18	18	15
No. of experiments	16	13	10	9	23	11	2	3
S.E. of mean yield response (tc ha^{-1})	3,3	3,5	2,6	9,1	2,9	3,7	0	5,3

pH of the soil

The mean response in cane yield to applied Temik in experiments conducted on soil with a pH higher than 8,0 was substantially smaller than it was in experiments conducted on acid soils. The yields of the untreated cane grown in the alkaline soils were greater than those of untreated cane grown in acid soils. Most of the experiments were conducted on acid soils of the Fernwood series (less than 6% clay) (Table 2). To avoid the possible confounding effects which the clay content of the soil may have had when considering the effects of soil pH, the results of experiments conducted in soils containing approximately 6% clay, were reviewed.

TABLE 2

Mean cane yield from control plots and responses to Temik applied to soils with pH less than 8,0 and greater than 8,0

Details	Soil pH	
	<8,0	>8,0
Mean yields from control plots (tc ha^{-1})	55	80
Mean yield response (tc ha^{-1})	24	7
Mean response as % of control	44	9
No. of experiments on Fernwood soil	45	26
No. of experiments on Clansthal soil	3	13
S.E. of mean yields from control (tc ha^{-1})	3,0	7,5
S.E. of mean yield response (tc ha^{-1})	1,9	1,5

The data from 23 experiments where the clay content of the soil was approximately 6%, are contained in Table 3. The mean response of cane to Temik in 16 experiments was 15 tons ha^{-1} when the pH was below 8;0 and 6 tons ha^{-1} in seven experiments when the pH was above 8,0.

Rainfall

The effect of rainfall, expressed as the average monthly rainfall for the duration of each crop, on cane yields and responses to Temik are shown in Figure 1. In Clansthal series soils, the yields of untreated cane increased as the mean monthly rainfall increased from less than 54 to 104 mm. This trend was not as consistent in untreated cane grown in Fernwood series soils. Responses to Temik tended to decrease slightly with increasing rainfall in Clansthal series soils and to increase in Fernwood series soils as the average monthly rainfall increased from 54 to 104 mm. Yield responses did not follow these trends where mean monthly rainfall was either less than 54 mm or more than 104 mm.

TABLE 3

Mean cane yields from control plots and responses to Temik applied to soils containing about 6% clay when the pH was above or below 8,0

Details	Soil pH	
	<8,0	>8,0
Mean yields from control plots (tc ha^{-1})	67	63
Mean yield response (tc ha^{-1})	15	6
Response as % of control	22	10
No. of experiments	16	7
S.E. of mean yield from control (tc ha^{-1})	4,4	8,4
S.E. of mean yield response (tc ha^{-1})	3,9	1,6

The data presented in Table 4 indicate that the responses to Temik at sites where less than 200 mm rainfall was received during the first five months of the cropping period, were substantially greater than in experiments where more than 200 mm was received during the same period. Responses to Temik did not appear to vary significantly when rainfall during the first five months of the crop's growth exceeded 200 mm.

TABLE 4

The effect of rainfall (mm^{-1}) during the first 5 months of the crop period on cane yield responses (tc ha^{-1}) to Temik applied to cane in Fernwood and Clansthal series soils

Details	Rainfall (mm^{-1}) during first 5 months				
	<200	200-350	351-500	501-650	>650
Response, Fernwood series soils (tc ha^{-1})	37	25	23	24	31
No. of experiments	7	8	10	14	9
S.E. of mean response (tc ha^{-1})	5,1	5,8	3,0	4,7	5,8
Response, Clansthal series soils (tc ha^{-1})	22	15	10	14	9
No. of experiments	4	6	14	12	3
S.E. of mean response (tc ha^{-1})	13,3	6,0	2,0	2,5	2,6

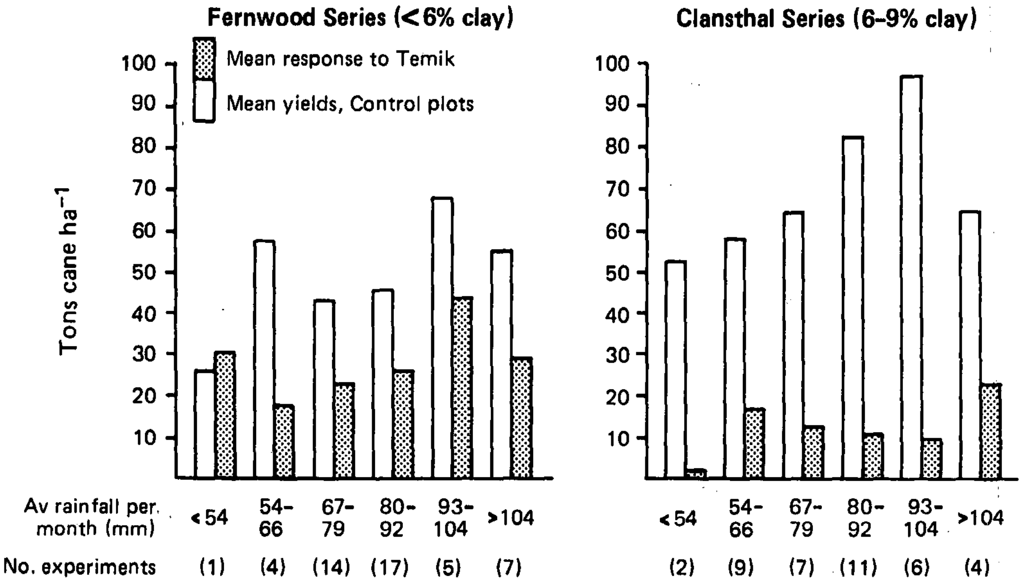

FIGURE 1 The effect of rainfall on mean cane yields and responses to Temik applied to cane in Fernwood and Clansthal series soils.

Age at harvest

The effect of the age of cane when it was harvested, on the yield response to Temik applied to Recent Sands, can be seen in Table 5.

TABLE 5

The influence of age at harvest on mean cane yield response (tc ha-1) to applied Temik

Details	Age at harvest (mths^{-1})			
	<13,1	13,1 to 16	16,1 to 20	>20
Mean yields from control plots (tc ha^{-1})	53	63	62	61
Mean yields from control plots (tc ha^{-1}mth^{-1})	4,9	4,3	3,4	2,9
Mean yield response (tc ha^{-1})	14	21	23	28
Mean response as % of control	26	33	37	46
No. of experiments	24	25	28	10
S.E. of mean yields from control (tc ha^{-1})	4,6	3,9	6,6	9,4
S.E. of mean yield response (tc ha^{-1})	2,5	3,2	3,3	5,2

Yields of cane which was not treated with Temik varied very little with the age at which it was harvested except that which was harvested at 13 months or younger, when yields were lower. The mean yield response to Temik of cane harvested when it was older than 20 months was twice that of cane harvested at the age of 13 months or younger. The response to Temik tended to increase with increasing age at harvest in the four age categories.

Discussion

The substantially larger responses to Temik of cane growing in Fernwood compared with Clansthal series soils reported by Moberly *et al*[8], are corroborated by these results. The clay content of soils appears to influence substantially the magnitude of the response to Temik. Abdellatif *et al*[1] showed that carbamate biocides are absorbed by clay particles and so reduce the concentration of the chemical which is freely available in the soil water. The rate at which aldicarb enters the roots may therefore be reduced in the sandy soils with the relatively high clay content. The smaller responses of cane to Temik in the heavier Clansthal series soils are likely to be due to additional factors such as better water holding capacity, higher cation exchange capacity, better crop growth and nematode damage having less effect on the yields of untreated cane.

Temik is unstable in alkaline soils and Harris[6] suspected that the high alkalinity of soils in some of the experiments north of Durban, was responsible for Temik not being effective. The results from this review indicate that in sandy soils which have a pH more than 8,0, the responses to Temik may be about 12% smaller than in sandy soils which have a pH less than 8,0.

The results tend to corroborate the reports by Bhirud and Pitre[3] that responses to Temik in the light, sandy soils increase as rainfall increases. There is, however, evidence that responses to Temik on the relatively heavier Clansthal series soils are reduced as rainfall increases. It appears that more than 200 mm of rain during the first five months of the crop has no effect on the efficacy of Temik but that responses are likely to be greater if rainfall is less than 200 mm during this period.

Because sugarcane is grown in a wide range of ecological zones in South Africa, the age at which it is harvested may be between about 12 and 24 months. The results indicated that the magnitude of the responses was greatest when cane was harvested when it was older than 12 months. However, as shown in Table 5, the performance of untreated crops declined from 4,3 tc ha^{-1} mth^{-1} when harvested at 13,1 to 16 months of age, to 2,9 when harvested at ages greater than 20 months. Thus two successive treated crops harvested at 13 months of age would yield 134 tc ha^{-1}, whereas one treated crop harvested at more than 20 months of age would yield only 89 tc ha^{-1}. The increasing response per crop to treatment with Temik as the crop age increases should thus clearly not be construed as an advantage. This finding has important practical implications because there are other advantages in harvesting cane when it is young (Atkinson *et al*[2]).

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REFERENCES

1. Abdellatif, MA, Hermanson, HP and Reynolds, HT (1967). Effect of soil clay and organic matter content upon systemic efficacy of two Carbamate insecticides. *J. econ. Ent.* 60: 1445–1450.
2. Atkinson, PR, Carnegie, AJM and Smaill, RJ (1981). A history of the outbreaks of *Eldana saccharina* Walker, in Natal. *Proc. S. Afr. Sug. Technol. Ass.* 55: 111–115.
3. Bhirud, KM and Pitre, HN (1972). Influences of soil class and soil moisture on bioactivity of carbofuran and disulfoton in corn in greenhouse tests: Relationship of leafhopper vector control and corn stunt disease incidence. *J. econ. Ent.*, Vol 65 No. 2: 324–329.
4. Dick, J and Spaull, VW (1982). Nematode Pests of Sugarcane. In DP Keetch and J Heyns, (eds), Nematology in southern Africa, Sci. Bull. *Dept. Agric. Fish. Repub. S. Afr.*, No. 400: 47–50.
5. Harris, RHG (1975). Studies of nematode populations in sugarcane soil profiles. *Proc. S. Afr. Sug. Technol. Ass.* 49: 164–170.
6. Harris, RHG (1972). Effects of nematicides and methods of applying them on field grown sugarcane. *Proc. S. Afr. Sug. Technol. Ass.* 46: 226–229.
7. Moberly, PK and Clowes, MStJ (1981). Trials with nematicides registered for use on sugarcane in South Africa. *Proc. S. Afr. Sug. Technol. Ass.* 55: 92–98.
8. Moberly, PK, Harris, RG and Millard, E (1974). An investigation into the problem of poor sugarcane growth on some sandy soils on the Natal sugarbelt. *Proc. int. Soc. of Sug. Cane Technol.* 15: 923–931.
9. Spaull, VW (1981). Nematodes associated with sugarcane in South Africa. *Phytophylactica* 13: 175–179.
10. Spaull, VW and Braithwaite, JMC (1979). A comparison of methods for extracting nematodes from soil and roots of sugarcane. *Proc. S. Afr. Sug. Technol. Ass.* 53: 103–107.

APPENDIX 1

Details of nematicide experiments

Trial no.	Crop	Variety	Age at harvest mths^{-1}	Rainfall mm^{-1}		Soil (0–200 mm^{-1})		Cane yields (tc ha^{-1})		
				Average month^{-1}	First 5 months	pH	Clay %	Control	Treated	Response
1	P	N8	16,5	77	364	6,2	2	54	64	10
2	P	NCo 376	16,5	77	364	6,2	2	24	49	25
3	R1	N8	19,8	82	353	6,2	2	20	38	18
4	R2	N8	10,1	62	555	6,7	2	11	35	24
5	R1	N8	20,6	51	487	6,4	2	32	41	9
6	P	N8	12,0	73	297	6,5	2	14	40	26
7	P	N55/805	14,3	95	661	4,9	2	56	82	26

Trial no.	Crop	Variety	Age at harvest mths^{-1}	Rainfall mm^{-1}		Soil (0–200 mm^{-1})		Cane yields (tc ha^{-1})		
				Average month^{-1}	First 5 months	pH	Clay %	Control	Treated	Response
8	R1	N55/805	18,2	88	510	6,4	2	77	88	11
9	P	N55/805	18,6	63	599	7,0	2	54	77	23
10	P	N55/805	20,0	80		5,3	2	55	110	45
11	R1	N55/805	14,9	76	283	5,6	2	49	76	27
12	P	N55/805	19,1	95	937	6,3	2	72	118	46
13	R1	N55/805	15,2	80	619	7,0	2	34	56	22
14	P	N55/805	19,4	57		5,1	2	78	113	25
15	P	N55/805	21,3	76		5,1	2	51	107	56
16	R1	N55/805	12,7	85		6,8	2	23	65	42
17	P	N8	12,4	72	278	6,7	3	21	41	20
18	R2	N55/805	16,3	76	91	6,8	3	45	59	14
19	R2	N55/805	15,0	81	215	6,8	3	46	72	26
20	R2	N55/805	18,0	45	189	5,3	3	26	56	30
21	R2	N55/805	22,1	116	639	6,0	3	51	94	43
22	R3	N55/805	15,8	70	400	6,0	3	31	61	30
23	R1	N55/805	18,8	78	372	6,8	3	89	116	27
24	R2	NCO 376	17,9	71	273	7,6	3	41	52	11
25	P	N55/805	14,5	75	661	5,0	3	72	95	23
26	R1	N55/805	18,2	88	510	5,0	3	99	100	1
27	P	N55/805	21,5	86	661	4,9	3	21	51	30
28	R1	N55/805	17,5	81	518	6,9	3	18	57	39
29	P	N55/805	20,4	97		6,8	3	77	125	48
30	R2	N55/805	20,9	83	517	5,0	4	26	46	20
31	P	N55/805	18,0	120	666	5,0	4	59	71	12
32	P	N55/805	12,4	104	824	6,1	4	33	65	32
33	R1	N55/805	11,7	156	1 255	6,5	4	72	96	24
34	R3	N55/805	16,4	71	413	6,1	4	11	36	25
35	R4	N55/805	19,4	90	509	6,1	4	17	32	15
36	R1	N55/805	14,4	113	382	6,0	4	40	62	22
37	P	NCO 376	20,5	81	510	7,5	4	67	107	40
38	R1	NCO 376	23,2	74	202	7,5	4	65	79	14
39	P	N55/805	13,2	125	639	6,2	4	55	77	22
40	R3	N55/805	15,8	102	294	5,8	5	56	121	65
41	R4	N55/805	10,9	86	427	6,1	5	28	71	43
42	P	N8	13,1	64	380	6,3	5	62	82	20
43	R1	N55/805	14,9	102	291	8,6	5	108	120	12
44	R2	N55/805	14,0	81	651	8,4	5	76	87	11
45	R3	N55/805	11,0	86	575	8,4	5	70	74	4
46	R4	N55/805	18,9	59	534	7,9	5	89	89	0
47	P	N55/805	14,6	103	661	5,8	5	44	115	71
48	R1	N55/805	18,6	87	510	5,8	5	38	104	66
49	P	N55/805	19,0	117	937	5,0	6	42	109	67
50	R1	N55/805	15,7	78	619	6,3	6	31	57	26
51	P	N8	13,4	73	504	6,3	6	85	92	7
52	P	N13	13,4	73	504	6,3	6	66	88	22
53	R1	N8	16,6	94	293	6,6	6	98	102	4
54	R1	N13	16,6	94	293	6,6	6	90	105	15
55	R4	N55/805	14,7	99	548	5,7	6	62	81	19
56	R5	N55/805	16,0	65	456	5,7	6	77	103	26
57	P	N55/805	20,4	99	624	8,8	6	112	119	7
58	R1	N55/805	15,2	79	353	8,8	6	73	85	12
59	R2	N55/805	11,6	86	495	8,8	6	58	61	3
60	P	N55/805	13,2	94	515	5,3	6	69	82	13
61	R1	N55/805	12,3	124	469	5,3	6	78	82	4
62	R2	N55/805	11,8	69	691	5,2	6	68	72	4
63	R3	N55/805	11,6	65	510	5,2	6	51	54	3
64	P	N55/805	14,0	79	372	5,4	6	78	83	5
65	R1	N55/805	12,1	75	416	5,4	6	70	79	9
66	R2	N55/805	13,6	91	665	5,4	6	69	78	9
67	R3	N55/805	11,3	66	447	5,4	6	43	47	4
68	P	N55/805	11,8	68	495	8,6	6	47	58	11
69	R1	N55/805	11,1	61	496	8,6	6	45	52	7
70	R2	N55/805	10,6	41	423	8,6	6	44	46	2
71	R5	N55/805	15,4	51	232	8,6	6	61	61	0
72	P	N55/805	12,6	60		5,2	7	79	84	5
73	R1	N55/805	17,9	79		6,9	7	119	111	0
74	P	N8	11,5	62	515	4,8	7	52	71	19
75	R1	N8	16,9	97	380	4,8	7	73	98	25
76	P	N55/805	19,7	93	648	8,4	7	152	137	0
77	R1	N55/805	13,8	78	282	8,9	7	99	101	2
78	R2	N55/805	12,2	80	405	8,7	7	94	101	7
79	R2	N55/805	11,8	90	533	5,0	7	86	104	18
80	R3	N55/805	12,3	122	657	5,0	7	74	89	15
81	R1	NCO 376	16,8	66	260	5,2	7	31	65	34
82	R1	NCO 376	16,8	66	260	5,2	7	42	77	35
83	P	N55/805	20,7	66		5,6	8	107	124	17
84	R1	N55/805	14,3	79	470	6,6	8	79	96	17
85	P	N55/805	17,4	84	629	8,2	9	116	141	25
86	R1	N55/805	13,0	73	381	8,5	9	57	63	6
87	R2	N55/805	11,2	114	639	8,5	9	64	69	5