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The combined effects of dichloropropane-dichloropropene mixture injected into the soil and of dazomet applied to the soil surface

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Abstract

The effect of injection of different dosages of dichloropropane-dichloropropene (DD) mixture at 15-cm depth combined with different dosages of dazomet distributed on the surface of the soil on densities of *Rotylenchus uniformis* was investigated in a field experiment on sandy soil. The treatments were given at the end of October 1970. The water content of the soil was at field capacity and the temperature about 10 °C. Distributing 5 g or 10 g dazomet per m^2 on the surface of plots treated with 10 ml DD mixture per m^2 (mortality 82%) had the same effects as repeating the DD treatment once or twice, respectively. A better horizontal distribution of the DD mixture would probably have made distributing 5 g dazomet per m^2 on the surface of soil in which a DD treatment killed 80% of the nematodes in the top 20 cm, equivalent to adding two similar DD treatments.

To kill a certain percentage of the eggs of *R. uniformis* in the soil, twice as high a dosage of DD mixture was necessary as to kill the same percentage of juveniles and adults. Eggs and active nematodes were equally sensitive to dazomet.

Introduction

According to Seinhorst (1972) applying high dosages of fumigants without using an expensive soil cover is often not an efficient way of obtaining high degrees of control of nematodes in the field, because of the relative ineffectiveness of the treatment in the top layer. Peters (1955) tried to overcome this handicap by treating the top layer of the soil separately with a water soluble nonvolatile chemical. He poured a cresol solution on the soil surface after injection of dichloropropane-dichloropropene (DD) mixture at 15 cm depth. This method has not been applied extensively in practice probably because cresol solutions were too difficult to handle and no other chemicals for treatment of the top layer of the soil were available or known to be suitable for the purpose, until Kaai and Windrich (1971) combined injection of DD mixture with application of dazomet (3-5-dimethyltetrahydro-1-3-5-2 H thiadiazine 2 thione) to the soil surface. By injecting 12.5, 25, 50 and 100 ml DD mixture per m^2 at 15 cm depth in a clay soil, they obtained mortalities of *Ditylenchus dipsaci* in the top 20 cm of the soil, of only 23%, 46%, 58% and 73%. However, distributing 30 g dazomet per m^2 on the surface of DD treated plots increased these mortalities to 99.0%, 99.7%, 99.6% and 99.8% respectively (average 99.5%). The same average mortality was obtained by covering the DD treated plots with plastic sheet. In Kaai and Windrich's (1971) experiment only one high dosage of dazomet was applied and only in combination with injection of DD mixture. The very high mortalities that were obtained suggest that lower dosages of dazomet might also give good control, especially on sandy soil where DD mixture is generally more effective than on heavier soil. To investigate the relation between the proportion of a nematode population surviving DD treatments and the effectiveness against these nematodes of treatments of the top soil a field experiment was done with different dosages of DD mixture, dazomet and combinations of these chemicals.

Treatments and layout of the experiment

The experimental field was on a medium fine sandy soil. It had been ploughed 10 cm deep in the beginning of August after which autumn turnips were grown until 5 October. After removal of the turnips the field was shallowly worked with a hoe and raked to remove weeds. Because of 37 mm of rainfall during the first two weeks of October soil moisture content was near field capacity.

The field was divided into 150 plots of 1.25 × 1.25 m. The fifteen treatments with DD mixture, dazomet and combinations of the two are tabulated in Fig. 3 and Table 2. They were distributed in ten randomized blocks, each block containing each treatment once. Before giving the different treatments, densities of *Rotylenchus uniformis* in the top 20 cm of the inner m^2 of each plot were determined in 500 g soil from samples each made up of sixty 1 cm wide, 20 cm long cores. The DD mixture was injected with hand injectors in 16 places per square meter (square pattern) at 15 cm depth on 16 October 1970. The dazomet was applied by (gloved) hand after having been mixed with dry soil, and raked in lightly. It was necessary to walk on the plots to do injections. The holes were closed after the injections by pushing soil into them from the side. As a result the top layer of the DD plots became rather compacted. Soil temperatures and rainfall between 16 and 29 October 1970 are given in Table 1. All plots were sampled again as described above on 8 December 1970 and the plots of nine treatments on 22 February 1971 (only those in which a sizeable nematode density was expected).

Apparently aberrant results of treatments with DD mixture on certain plots led us to investigate the effect of the chemicals at different depths. For this purpose from five

Table 1. Rainfall and soil temperature.

October	Treatment	Rainfall (mm^1)	Average soil temperatures			
			min^1	max^1	min^2	max^2
16	DD mixture					
16–19		12	9	11		
20–22		26.2	9	10	7	10
22	dazomet					
23–25		2.3	9	10		
26–29		25.7	9	10.5	8	10.5

[1] At Wageningen Weather Station (soil temperatures at 10 cm depth)
[2] At 15 cm depth in experimental field

Tabel 1. Regenval en bodemtemperaturen.

to fifteen cores per plot were taken with a 5-cm wide auger on a number of plots to a depth of 15 cm. Each core was divided in 3 cm long pieces which were investigated separately. On one of the plots, treated with 40 g dazomet per m^2 (0.4), the layer between 20 cm and 40 cm deep was sampled with the 5 cm auger. Each of the five cores collected was divided in two pieces, one from between 20 cm and 30 cm deep and one from between 30 cm and 40 cm deep. Again the ten pieces were investigated separately. From soil collected with the 5-cm auger 1.36 times as many *R. uniformis* were recovered per unit weight of soil as from soil collected with the 1-cm auger.

Results

Densities of *R. uniformis* in the different plots before treatment ranged from 530 to 2610 nematodes per 500 g soil and log densities were distributed symmetrically relative to the mean.

The variation between plots could only be partly due to sampling error, which, according to Fig. 1 and Table 2 would have resulted in a range of between about 1.0

Fig. 1. Relation between densities per plot of *R. uniformis* (in nematodes per 5 g soil) at the different samplings. To keep the ratio between average density per treatment after and before treatment = 1, densities after treatments 0.1 and 0.2 were plotted against densities before treatment multiplied by the corresponding average survival rates. All densities found by the second sampling after treatment were multiplied by 0.82 to correct for the 1.22 fold increase in density between the two samplings after treatment.

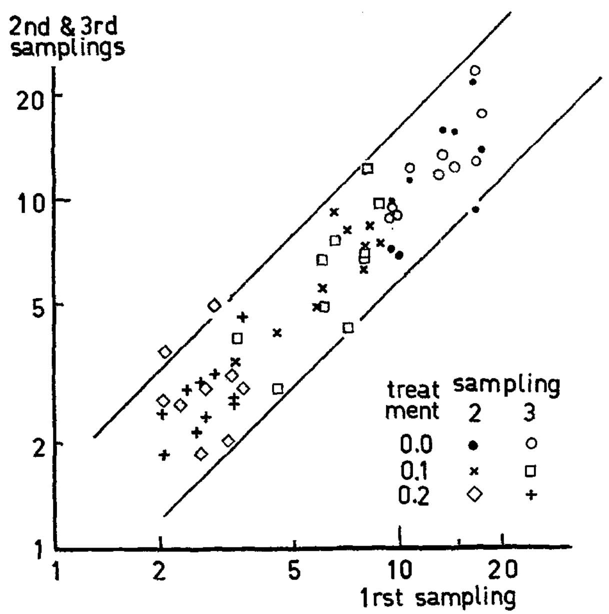

Fig. 1. Verband tussen dichtheden per veldje van R. uniformis (in aantal aaltjes per 5 g grond) bij de verschillende bemonsteringen. Om de verhouding tussen gemiddelde dichtheden voor en na behandeling = 1 te houden werden de dichtheden na behandelingen 0.1 en 0.2 uitgezet tegen dichtheden voor de behandelingen, vermenigvuldigd met het bijbehorende gemiddelde overlevingsgetal. Alle dichtheden volgens de tweede bemonstering na de behandelingen werden vermenigvuldigd met 0,82 ter correctie van de vermeerdering tussen de twee bemonsteringen na de behandelingen.

Tabel 2. Percentages of *R. uniformis* in the top 20 cm of the soil that survived the different treatments, and ratio between range of survival rates and average survival per treatment according to the first sampling after treatment.

Treatment			Range	Average	Range/	Total numbers	ml DD/m² re-
Code	DD ml/m²	dazomet g/m²	% survival	% survival	Average	of nematodes counted after treatment	quired to cause the same mortality (according to Fig. 3)
0.0	0	0	76–126(50)	96	0.56	1237	
0.1		5	49–75(26)	63	0.41	1327	4
0.2		10	9–40(31)	24.3	1.3	2781	8.5
0.3		20	0.5–8(7.5)	3	2.5	423	17
0.4		40	0–0.2	0.03	7.0	6	
1.0	10		6–52(44)	16.5	2.8	2232	
2.0	20		1–13(12)	3.6	3.3	433	
3.0	40		0–1.2	0.16	8.0	11	
4.0	80		0–0.01	0.001	10.0	1	
1.1	10	5	0–12(1)	2.7	4.3	475	20
2.1	20	5	0–10	1.7	6.0	324	25
3.1	40	5	0–0.2	0.04	5.0	3	60
1.2	10	10	0–6.5	1.3	5.1	178	26
1.3	10	20	0–0.35	0.05	7.0	7	60
2.2	20	10	0–1.3	0.17	8.0	28	44

Tabel 2. Percentages R. uniformis in de bovenste 20 cm van de grond, die de verschillende behandelingen overleefden en verhoudingen tussen het verschil tussen hoogste en laagste percentage overleving en het gemiddelde percentage overleving per behandeling volgens de eerste bemonstering na de behandelingen.

and 1.7 times a certain density. To avoid undue dominance of the results of the treatments on plots with high initial nematode densities, survival rates were calculated for all plots separately and averages of these per treatment. Survival rates according to the first sampling after treatment are given in Table 2 together with the ranges and the ratios between these and the averages. These ratios as well as Fig. 1 indicate that the variations of the survival rates on untreated plots and on plots with treatments 0.1 and 0.2 (5 g and 10 g dazomet per m²) are about the same. Apparently the dazomet killed about the same proportion of the nematodes on all plots that received the same dosage of the chemical. At higher dazomet dosages the variation is much larger. This is probably largely due to the increased sampling error associated with the small numbers of nematodes found in the samples. Survival rates after injection of DD mixture vary more at the same average survival than after dazomet treatments. This is almost entirely due to much higher than average survival rates on one or two of the ten plots of each of the treatments that include a low dosage of DD mixture. That relatively high survival rates in plots with combined treatments were caused by insufficient action of the DD mixture is corroborated by the relatively high nematode densities found at greater depths in one of these plots (Table 4 and 5) and also by the proportions of second stage juveniles in these plots four months after treatment. These were as low as on plots that had received only dazomet whereas they were higher on the plots where DD mixture had killed a fair proportion of the population (see below). Mortalities caused by treatments with DD mixture alone (according to the results of the first sampling after treatment) and with dazomet alone (averages of the first and second samplings after treatment where the latter was done) are plotted on a probit scale against log dosage of the respective chemicals in Fig. 2.

Mortalities caused by the combined treatments according to the first sampling after treatments are plotted against log dosage of DD mixture used in the combinations in Fig. 2. A comparison of the rates of survival according to the first and second samplings after the treatments is given in Table 3.

Densities of *R. uniformis* found by the second sampling after treatment on untreated plots and on plots treated with 5 g dazomet per m^2 were 1.22 times those found by the first sampling after treatment. Similar increases due to hatching of eggs and comple-

Fig. 2. Relation between log dosage of nematicide and probit mortality of *R. uniformis* in the top 20 cm of the soil. Mortalities by combined treatments are plotted at the dosages of DD mixture used in the combination. Mortalities by the dazomet treatments 0.1, 0.2 and 0.3 are averages of those according to the two samplings after treatment, all others are according to the first sampling after treatment.

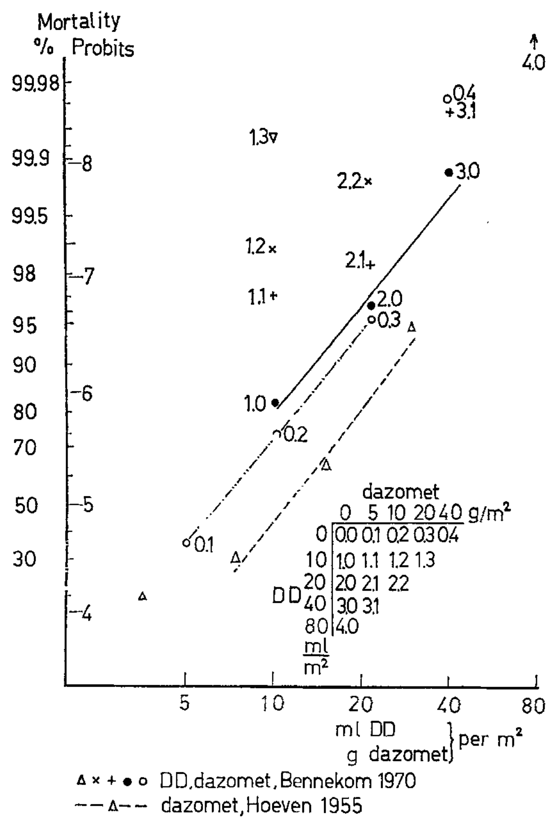

Fig. 2. Verband tussen log dosis nematicide en probitsterfte van R. uniformis in de bovenste 20 cm van de grond. Sterftecijfers voor gecombineerde behandeling zijn weergegeven bij de doses DD gebruikt in de combinatie. Sterftes door de dazometbehandelingen 0.1, 0.2 en 0.3 zijn gemiddelden van die volgens beide bemonsteringen na de behandelingen. Alle andere zijn volgens de eerste bemonstering na de behandelingen.

Table 3. Comparison of rates of survival in nine of the fifteen treatments found by the first and second samplings after treatment.

Treatment		Sampling	
DD (ml/m²)	dazomet (g/m²)	1	2
0	0	100	100
0	5	63	62
0	10	24	24
0	20	3	7.2
10	0	16.5	19
20	0	3.6	7.2
10	5	2.7	3.0
10	10	1.3	1.9
20	5	1.7	4.7

Tabel 3. Vergelijking van de percentages overleving bij negen van de vijftien behandelingen gevonden bij de eerste en de tweede bemonstering van het proefveld na de behandelingen.

tion of moults were found repeatedly in pot experiments after removal of the host plant. Apparently hatching was not inhibited in this experiment by the relatively low temperatures between the two sampling dates (0 °–6 °C at 10 cm depth at the Wageningen weather station).

The supposed effect of the dazomet in a combined treatment on the proportion of the population surviving the DD treatment was calculated as follows: if a proportion a of the nematode population survived a treatment with a certain dosage of DD mixture and a proportion b one with the same dosage of DD mixture together with a certain dosage of dazomet, then the dazomet killed a proportion $1-b/a$ of the population that survived the DD treatment. The value of a was supposed to be the same whether the DD mixture was applied alone or in combination with dazomet. The probits of the mortalities thus calculated for the two series of samplings after the treatments are plotted against log mortality obtained with DD mixture alone (log $(1-a)$) in Fig. 3.

The same calculations were also made omitting the supposedly aberrant mortalities and the results are also included in Fig. 3 and 4 (underlined symbols).

Densities of *R. uniformis* populations at different depths on single plots after different treatments are given in Table 4. These densities, expressed as percentages of those that presumably would have been found at the same depths if the plots had not been treated, are given in Table 5. To calculate these percentages it was assumed that the distribution of the proportions of the total population between 0 and 21 cm depth over 3-cm thick layers was the same in all plots, the top 3 cm containing 3 %, the next 3 cm 12 % and each of the remaining five 3-cm layers 17 % of the total population between 0 and 21 cm. With the help of these figures densities that would have been found in the different layers at the time of the second sampling after treatment, if the plots had not been treated, were calculated from the densities found in the samples taken before treatment corrected for increase by hatching of eggs and for the difference in recovery between using a 1-cm wide and a 5-cm wide auger for the sampling. Densities in deeper layers supposedly unaffected by the treatment in the 10 g and one of the 20 g dazomet per m² plots were much higher than expected according to the determinations before

Fig. 3. Relation between the proportion *a* of the *R. uniformis* population that survived a DD treatment and mortality 1-*b*/*a* caused by different dosages of dazomet to the surviving population. *b* = proportion of population that survived the combined treatment. Underlined symbols stand for calculations with corrected values of *a* and *b*/*a* (page 199).

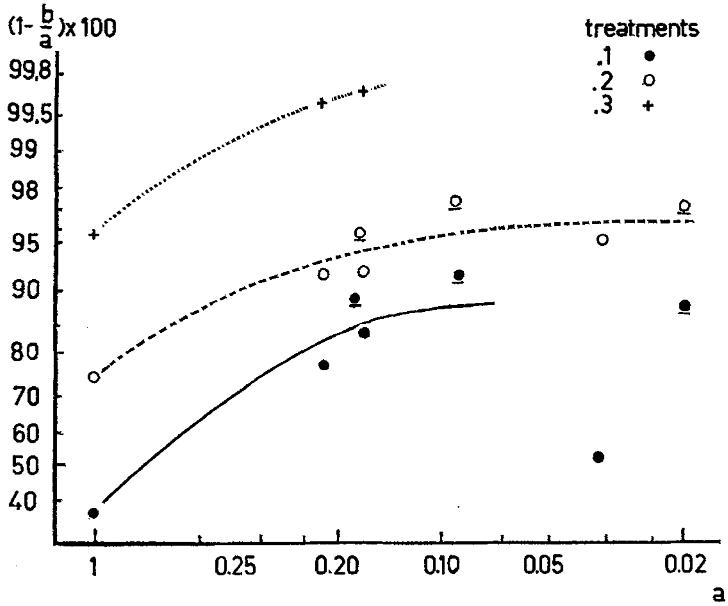

Fig. 3. Betrekking tussen deel a van de R. uniformis bevolking, dat een behandeling met DD overleefde en de sterfte 1 — b/a veroorzaakt door verschillende doses dazomet in de overlevende bevolking. b = deel van de bevolking, dat de gecombineerde behandeling overleefde. Onderstreepte tekens geven waarden van a en b weer, gebaseerd op gecorrigeerde bevolkingsdichtheid cijfers (pag. 199).

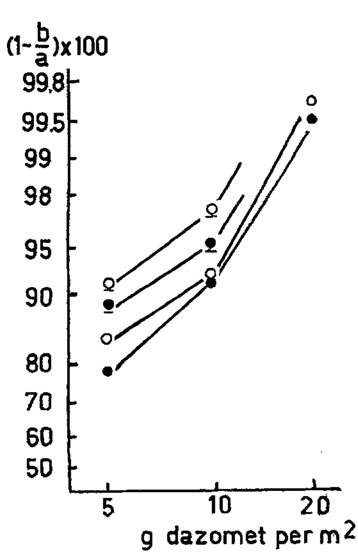

Fig. 4. Relation between dosage of dazomet used in combination with 10 ml DD mixture per m^2 and mortality 1-*b*/*a* caused to the proportion *a* of the population that survived the DD treatment. *b* = proportion of population that survived the combined treatments. Dots: mortalities according to first sampling, open rounds: mortalities according to second sampling after treatment. Underlined symbols: corrected figures (page 199).

Fig. 4. Betrekking tussen dosis dazomet toegediend in combinatie met 10 ml DD mengsel per m^2 en sterfte 1-b/a van het deel a van de bevolking dat de behandeling met DD overleefde. b = deel van de bevolking, dat de gecombineerde behandelingen overleefde. Stippen: sterfte volgens de eerste, cirkels: sterfte volgens tweede bemonstering na de behandeling. Onderstreepte tekens: gecorrigeerde cijfers (pag. 199).

Table 4. Densities of *R. uniformis* per 500 g soil (five 5 cm wide, 3 cm long cores) at different depths in single plots after different treatments. Densities between brackets: estimations used to calculate % survival in Table 5.

Depth (cm)	Untreated	DD mixture 10 ml/m²	DD mixture 20 ml/m²	Dazomet 5 g/m²	Dazomet 10 g/m²	Dazomet 20 g/m² 1	Dazomet 20 g/m² 2	DD 10 ml/m² dazomet 5 g/m²
0–3	393	235	359	0	(0)	(0)	(0)	10
3–6	2039	1545	976	208	(110)	(0)	(0)	148
6–9	3152	1200	1053	490	655	(0)	(0)	862
9–12	2463	691	(250)	1095	1645	795	(0)	1462
12–15	2563	533	(0)	(2700)	3240	1988	(0)	1403
15–18	(2500)	(530)	(0)	(2700)	(3300)	2792	180	(1400)
18–21	(2500)	(700)	(250)	(2700)	(3300)	(3000)	293	(1500)
0–20		1880	1820	2160	2050[2]	1850[3]	2900	3590
un-treated[1]	2150				(2800)	(2500)		

[1] Densities found in respective plots before treatment × 1.2 to correct for increase between samplings and × 1.36 to correct for difference in recovery from samples taken with the 1 cm and the 5 cm-wide auger.

[2,3] There is a discrepancy between these figures and the densities found in the layers 12–15 cm and 15–18 cm respectively. Therefore, for making Table 5 these figures were supposed to be 14/17 × 3300 ≃ 2800 and 14/17 × 3000 ≃ 2500 respectively.

Tabel 4. Dichtheden van R. uniformis per 500 g grond (vijf 5 cm dikke, 3 cm lange cylinders) op verschillende diepten op afzonderlijke veldjes en na verschillende behandelingen. Dichtheden tussen haakjes toegevoegde schattingen gebruikt voor berekening van percentages overleving in Tabel 5.

Table 5. Percentages of *R. uniformis* that survived different treatments, at different depths in single plots estimated from the data of Table 4.

	Depth (cm)	DD mixture 10 ml/m²	DD mixture 20 ml/m²	Dazomet 5 g/m²	Dazomet 10 g/m²	Dazomet 20 g/m² 1	Dazomet 20 g/m² 2	DD 10 ml/m² dazomet 5 g/m²
	0–3	100	100	0	(0)	(0)	(0)	2
	3–6	75	50	10	(5)	(0)	(0)	5
	6–9	60	30	20	(15)	(0)	(0)	20
	9–12	30	(10)	50	50	20	(0)	30
	12–15	35	(0)	(100)	100	50	(0)	30
	15–18	(25)	(0)	(100)	(100)	90	5	(30)
	18–21	(30)	(10)	(100)	(100)	100	10	(30)
% survival (0–21 cm depth)	according to Table 4	38	15	65	65	43	2	20
	according to 2nd sampling after treatment	44	11	80	36	14	1	17

Table 5. Percentages R. uniformis die verschillende behandelingen overleefden op verschillende dieptes afgeleid uit Tabel 4.

treatment. Average density untreated was here considered to be 14/17 of that in the layers supposed to be unaffected by the treatment. The figures of Table 5 can be interpreted as proportions of the soil at a certain depth that did not receive a sufficient sum of concentration time products to kill nematodes. Fig. 5 is an interpretation of these percentages as found on the plots with treatment 1.0 and 0.1 into continuous lines for the relation between depth and percentage of soil volume free of nematodes. Instead of the 25% of the soil volume between 12 and 15 cm depth that still contained nematodes according to Table 5, the DD treatment is supposed in Fig. 5 to have killed all nematodes below 12 cm. The line for treatment 1.1 was obtained by multiplying the proportions of the soil volume still containing nematodes at each depth, thus assuming that the chemicals spread in the soil independently of each other.

Because nematode densities in the top layers of the soil were much lower than in deeper layers the proportion of the soil volume freed of nematodes by the DD treatments was smaller and that freed of nematodes by the dazomet treatments larger than the proportions of the nematode populations killed. If we assume that 10 ml DD mixture per m^2 did not kill nematodes in the top 3 cm of the soil (14% of the soil volume between 0 and 21 cm depth containing about 3% of the population) then of the surviving 16% (according to the first sampling after treatment) 13% occurred in deeper layers. If two thirds of these occurred between 3 and 6 cm (orginally containing about 12% of the population) and one third in deeper layers (containing 17% of the nematodes per 3 cm depth then the nematodes were not affected by the treatment with 10 ml DD mixture per m^2 in $14\% + 2/3 \times 13/12 \times 14\% + 1/3 \times 13/17 \times 14\% = 27\%$ of the soil volume between 0 and 21 cm depth. The proportion of the top 3 cm of the soil freed of nematodes by 20 ml DD per m^2 cannot be estimated within sufficiently narrow limits to make calculations of the proportion of the soil freed of nematodes by this dosage of DD mixture worthwhile. The 40 ml DD per m^2 treatment left only 0.16% of the nematodes alive. Even if these nematodes only occurred in the top 3 cm and survival is grossly under-estimated the proportion of the soil not freed of nema-

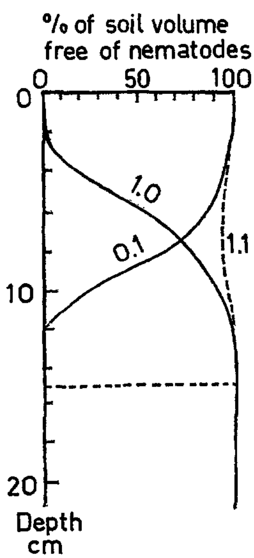

Fig. 5. Relation between depth in soil and proportion of soil volume free of nematodes after treatments 1.0, 0.1, and 1.1.

Fig. 5. Betrekking tussen diepte in de grond en deel van het bodemvolume dat vrij was van aaltjes na behandelingen 1.0, 0.1, en 1.1.

todes could hardly exceed 2%. Together with the 27% calculated for the 10 ml DD per m^2 treatment this results in a minimum dosage increase efficiency of 0.7 probit units per doubling of the dosage, against 0.9 probit units for the survival rates. Then 91% of the soil between 0 and 21 cm depth would have been freed of nematodes by 20 ml DD mixture per m^2 (96.4% of the nematodes killed according to Tables 2 and 3 and Fig. 2).

The 37% of the nematodes that were killed by the 5 g dazomet per m^2 treatment comprise almost all the 15% of the original population between 0 and 21 cm depth occurring in the top 6 cm (28% of the soil volume). The remaining 22% were therefore killed in the soil between 6 and 21 cm depth originally containing 85% of the total population. Therefore $28\% + 22/85 \times 72\% = 47\%$ of the soil volume between 0 and 21 cm depth was freed of nematodes by the 5 g dazomet per m^2 treatment.

If nematode densities in all layers had been the same as those between 6 and 21 cm depth the total density would have been 1.2 times that actually measured. The treatment with 10 ml DD mixture + 5 g dazomet per m^2 would still have left the same numbers of nematodes alive, practically all below 6 cm depth, and would therefore have freed $100 - 2.7/1.2\% = 97.7\%$ of the soil volume from nematodes, compared with killing 97.3% of the population.

Discussion

Mortalities found by the first sampling after the treatments. The mortalities obtained by the DD treatments were much greater than generally found on sandy soil with the same dosages (Seinhorst, 1972). Also both probit mortality and probit % of soil volume freed of nematodes increased by about 0.8 unit per doubling of the dosage, against about half a unit in other experiments. This is probably due to a favourable degree of compaction of the top layer of the soil, perhaps together with a favourable temperature and moisture content. The effect of the different dosages of dazomet was very similar to that of the same dosages of DD mixture. The great dosage increase efficiency (Seinhorst, 1972) of the chemical indicates that, despite the superficial application, the chemical penetrated well into the soil. This is in accordance with observations by Seinhorst, Bijloo and Klinkenberg (1956) as interpreted by Seinhorst (1972) (Fig. 2). However, in their experiment (at 24 °C soil temperature) twice as much of the chemical was needed to obtain the same mortalities. According to data from one plot 40 g dazomet per m^2 killed almost all nematodes between 20 cm and 30 cm depth and more than 90% of those between 30 cm and 40 cm depth.

According to Fig. 3 all three dazomet treatments killed a much greater proportion of the nematodes that survived a treatment with 10 ml DD mixture per m^2 in the top 20 cm of the soil than of the original population. A further reduction of the population by a higher dosage of DD mixture did not increase the mortality inflicted or the surviving nematodes by dazomet. Fig. 5 explains this. If the upper limit of effectiveness of the fumigant and the lower limit of that of the dazomet were horizontal planes (horizontal lines for treatments 0.1 and 1.0 in Fig. 5) increasing the mortality caused by the fumigant would bring the two planes closer together and thereby increase the apparent effect of the dazomet on the surviving population until the two planes would meet and all nematodes would be killed by the combined treatments. However, the areas of effectiveness of the two chemicals are delimited by irregular boundaries, as could be concluded from the distribution of the nematodes in the separate soil columns from single treated plots. This leaves a considerable proportion of the soil, well above the average boundary of penetration of the dazomet and well below that of the DD mixture, unaffected by the chemical as indicated in Fig. 5. This figure also shows that in this situation increasing the dosage of DD mixture, i.e. moving the line for treatment with the fumigant (1.0) upward, hardly decreases the proportion of the total area above line 1.0 (proportion of the soil volume not affected by the fumigant) lying below line 0.1 (proportion of the soil volume affected by neither the fumigant nor the dazomet).

Applying more dazomet increases probit mortality of the population surviving a treatment with 10 ml DD mixture per m^2 about as much as in treatments with dazomet alone (Fig. 2 and 4).

According to Fig. 3 and 4 the values of $1-b/a$ are always higher for the corrected figures than for the original ones at the same value of a. This is in accordance with Fig. 6: at the same mortality caused by a DD treatment, the dazomet addition is the more effective the better the DD disinfected the deeper layers of the soil. It would be ideal to apply the fumigant in a horizontal plane even if another distribution would result in the same mortality caused by the DD mixture alone.

Which treatments with DD mixture alone can be replaced by combined ones? Judging from percentage survival of the nematodes in this experiment, adding treatments with

Fig. 6. Relation between mortality caused by different treatments, proportion of second stage juveniles in the surviving populations and the kind of treatment.

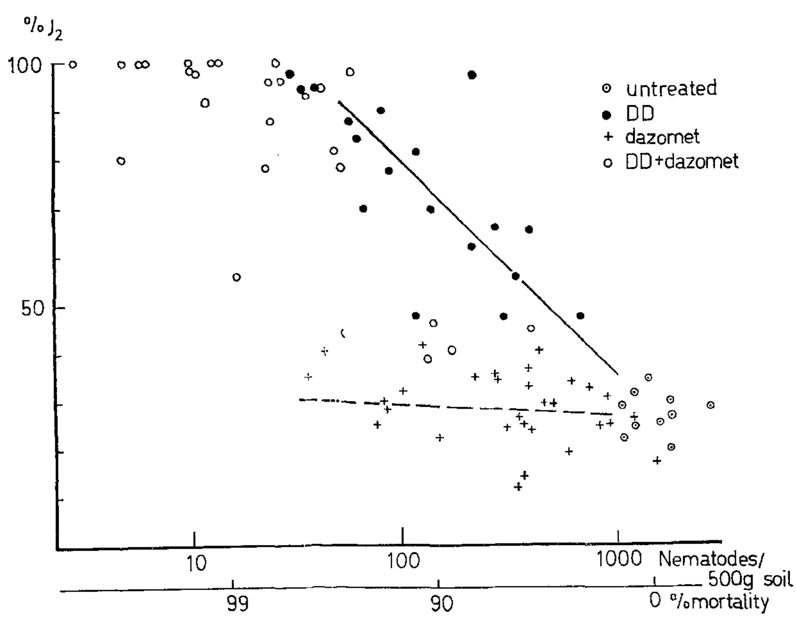

Fig. 6. Betrekking tussen sterfte veroorzaakt door verschillende behandelingen, deel van de overlevende bevolking bestaande uit iuvenile dieren van het tweede ontwikkelingsstadium en de soort behandeling.

different dosages of dazomet to treatments with different dosages of DD mixture is equivalent to increasing the DD dosage with about double as many ml per m^2 as grams dazomet were applied per m^2 (Fig. 2, Table 2). According to proportion of the soil volume between 0 and 21 cm depth freed of nematodes it is equivalent to increasing the DD dosage with about four times as many ml per m^2 as grams dazomet were applied per m^2. In treatments with only one chemical about 1 ml DD mixture was equivalent to 1 g dazomet. However, the results with DD alone were much better in this experiment than in many others where 20 ml per m^2 or more were needed to obtain a mortality of 80% (Seinhorst, 1972). Moreover, dosage increase efficiency is usually much less than in the experiment reported here. If 20 ml DD mixture per m^2 would cause a mortality of 80%, if probit mortality would increase by 0.5 unit per doubling of the dosage of DD and if dazomet would have the same effect as in this experiment, then adding a 5 g dazomet per m^2 treatment to one with 20 ml DD mixture per m^2 would be more than equivalent to adding a new treatment with 20 ml DD mixture per m^2 after ploughing the field (split application of 40 ml DD mixture per m^2) or to an increase from 20 ml/m^2 to 160 ml/m^2 for a single treatment (according to Fig. 1 in Seinhorst, 1972). On the one hand one could suppose that the dazomet might be less effective, or on the other hand instead of the 10 ml per m^2 in this experiment 20 ml DD mixture per m^2 or more is generally needed to obtain 80% mortality in the top 20 cm of the soil. This higher dosage would most probably disinfect the deeper soil layers better and therefore the dazomet treatment would be more effective against the surviving nematodes than at the 80% mortality caused by the 10 ml DD mixture per m^2 in this experiment.

Difference in sensitivity to DD mixture between eggs and active animals. Fig. 6 indicates a marked increase of second stage juveniles in the populations, with decrease of population density in the plots treated with DD mixture but not in those treated with dazomet alone. As initial densities per ten plots of each treatment varied little, the range of densities found in the second sampling can also be represented by a range of mortalities, which leads to the conclusion that the proportion of second stage juveniles increases linearly with mortality on the plots treated with DD mixture. It is unlikely that this stage is more resistent to DD mixture than others. Therefore the most plausible hypothesis is that eggs are more resistent to DD mixture than the juveniles and adults, and that a large proportion of the second stage juveniles found in the samples taken about four months after the treatments had hatched from eggs between the first and second sampling after the treatment.

The relation between DD dosage and mortality of eggs can be calculated with the help of the line drawn in Fig. 6 through the points for proportions of second stage juveniles in relation to population density on DD treated plots. If the proportion of second stage juveniles is y at a survival rate of the total population of x (Fig. 6), the survival of second stage juveniles in eggs a, that of all stages after hatching b and the proportion of the total population on untreated plots that hatched from eggs after the treatment c, then $y = ac/x$ and $x = ac + b(1-c)$. If we further assume that the relation between probit mortality of eggs and log dosage of the fumigant is linear, a set of values for a, b, and c can be found that fits best to all assumptions made. The result of calculations of a, b, and c was that about twice as much fumigant had been needed to kill a certain proportion of the eggs as to kill the same proportion of active animals, and that about 20% of the population found in the untreated plots at the second sampling date after treatment had hatched from eggs after the treatments. Mortalities calculated as sums of the mortalities of the 80% active animals and 20% eggs therefore lead to figures comparable with those found at the second sampling after the treatment date.

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Samenvatting

De gecombineerde werking van in de grond geïnjiceerd dichloorpropaan-dichloorpropeen mengsel en op de oppervlakte van de grond gestrooide dazomet

De uitwerking op dichtheden van *Rotylenchus uniformis* van verschillende doses dichloorpropaan-dichloorpropeen(DD)mengsel, op 15 cm diepte in de grond gebracht, gecombineerd met verschillende doses dazomet, die op de oppervlakte van de grond werden gestrooid, werd onderzocht op een proefveld op zandgrond. De behandelingen werden eind oktober 1970 uitgevoerd bij een bodemtemperatuur van ongeveer 10 °C (Tabel 1). Het watergehalte van de grond was ongeveer op veldcapaciteit door regenval voor de behandelingen. De werking van de verschillende behandelingen op de aaltjes in de bovenste 20 cm van de grond is weergegeven in de Tabel 2 en 3 en Fig. 2 en 3, die van enkele behandelingen op verschillende diepten in de grond in Tabel 4 en 5 en Fig. 6. Strooien van 5 g en 10 g dazomet per m^2 op de oppervlakte van veldjes, die tevens behandeld waren met 10 ml DD mengsel per m^2 (sterfte van de aaltjes 82%) had hetzelfde effect als wanneer deze behandeling met DD éénmaal resp. tweemaal herhaald zou zijn. Bij een betere horizontale verdeling van het DD-mengsel in de grond zou een behandeling met dit nematicide, die 80% van de aaltjes in de bovenste 20 cm van de grond doodde, gecombineerd met strooien van 5 g dazomet per m^2 op de oppervlakte waarschijnlijk gelijkwaardig zijn geweest aan drie behandelingen met DD-mengsel, die telkens 80% van de bij de behandeling nog aanwezige aaltjes doodden.

Volgens berekeningen naar aanleiding van Fig. 7 is voor het doden van een bepaald percentage van de eieren van *R. uniformis* tweemaal zoveel DD-mengsel nodig als voor het doden van hetzelfde percentage jonge en volwassen dieren. Alle stadia van het aaltje waren even gevoelig voor dazomet.

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