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The effect of DD and dazomet treatments on nematode populations at various depths in the soil and on the transmission of soil-borne tobacco rattle virus to gladiolus

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Abstract

The relation between log dosage of DD injected at 15 cm depth or of dazomet applied to the soil surface (all in November 1971) and probit mortality of *Rotylenchus* and trichodorids in the top 20 cm of a field on sandy soil was found to be linear. Dosage increase efficiencies of both chemicals against both nematode species were medium to high. Superficial application of dazomet was very effective against the nematodes that would have survived if only a low dosage of DD had been injected at 15 cm depth. Injection of 40 ml or 80 ml DD per m^2 at 15 cm depth killed all nematodes between 20 cm and 60 cm deep.

Gladiolus planted in the spring of 1972 grew better, flowered earlier and produced more weight of corms on treated than on untreated plots. The poor growth on the untreated plots cannot be ascribed to direct damage by nematodes or to the effect of TRV transmitted to the plants by the viruliferous trichodorids occurring in these plots in high densities. Symptoms of TRV infection in plants grown in 1973 from the corms harvested in the 1972 experimental field showed that only DD treatments had reduced the rate of TRV transmission considerably. However, even the highest dosages of DD had only reduced it from 26 % (on untreated plots) to about 8 %. Most probably, this residual TRV infection was due to transmission by trichodorids that had survived in soil layers below 60 cm depth. Therefore, soil treatment with nematicides, cannot prevent TRV transmission to gladiolus sufficiently where viruliferous trichodorids occur at great depths, as is the case in many sandy soils having a low water table.

Introduction

Tobacco rattle virus (TRV) infection of gladiolus shows mainly as 'notched leaf' either in the year of infection or in plants developing from infected corms. In the first case the 'nose' of the plant was infected prior to emergence from the soil (Cremer & Schenk, 1967) by nematodes living in the top layer of the latter. Cremer (1970) observed a considerable reduction of this type of TRV transmission after application of dichloropropene-dichloropropane (DD) mixture, especially when the soil had been covered with plastic sheeting after injection of the chemical. In the second case, the virus could have been introduced into any part of the plant, in a previous generation. Control of virus transmission by killing virus-carrying nematodes should therefore be effective in all soil layers in which plant parts grow and these nematodes occur. The effect of killing viruliferous nematodes at different depths in the soil by application of DD and dazomet on virus transmission was investigated in a field experiment at Helenaveen.

Materials and methods

The experimental fields. The treatments were made in a field on sandy soil at Helenaveen containing a high density of trichodorids, mainly *Paratrichodorus pachydermus.* Tests with tobacco leaves (Van Hoof, 1965) showed that the nematodes were heavily infected with TRV. The field was ploughed in mid October 1971 and rolled about three weeks later.

To investigate rates of TRV transmission to the corms harvested at Helenaveen, these were planted in 1973 in a field on sandy loam at Lienden. Very few trichodorids and no TRV had been found in several samples from this field. Therefore, the chance that gladiolus would become infected there and show symptoms in the year of infection was considered to be very small.

Treatments. According to Seinhorst (1973a) nematodes in the top layer of soil are killed by the application of dazomet to the soil surface. Very high mortality rates to a considerable depth are obtained by combinations of dazomet applied to the soil surface and DD mixture injected at 15-cm depth. In this experiment the same dosages of both chemicals and the same combinations were tested as in Seinhorst's (1973a) experiment (Table 4). The treatments were made on 3 × 4 m plots. The DD mixture was introduced by hand injector at 15 cm depth with the injection holes 25 cm apart in a square pattern. The holes were closed after the injection. The 20 ml per m^2 were obtained by injecting 0.6 ml in each hole twice. The dazomet was spread on the soil surface after mixing with 3 kg 'red coat' per plot to improve the uniformity of distribution. There were ten replications of each treatment with chemicals and 20 untreated plots. The experiment was laid out in five strips of 96 × 4 m (Fig. 8), each consisting of two blocks in which all treatments and two untreated controls were distributed randomly. The treatments were made on 4 and 5 November, 1971.

Samplings. The central square meter of each plot was sampled on 10 January, 1972, by collecting 80 1 cm wide, 20 cm long cores making a total of about 1.4 kg soil. After gentle mixing, densities of *Rotylenchus uniformis* and trichodorids (mainly *P. pachydermus*) were determined in 500 g from each sample. The first species was chosen because its abundance provided a good basis for judging the effect of the treatments on the nematode population in the top 20 cm, the second because of the expected relation between its density and the rate of transmission of TRV to the gladiolus to be

Table 1. Sampling with 5 cm wide auger on 21 March 1972.

Treatment	Depth (cm) of sampling	Number of plots	Cores/plot
untreated	0–21	4	2
	20–60	5	1
DD 10 ml/m^2	0–21	2	3
DD 20 ml/m^2	0–21	1	3
DD 20 ml/m^2 + daz. 5 g/m^2	0–21	1	3
DD 40 ml/m^2	20–60	10	1
daz. 20 g/m^2	20–60	10	1

Tabel 1. Bemonstering met 5 cm wijde boor op 21 maart 1972.

planted. Several plots were sampled again on 21 March 1972, this time by taking 5 cm wide cores at different depths (Table 1). The top 21 cm of some of the plots treated with 10 ml and 20 ml DD per m^2 was then sampled to check on a suspected poor operation of the injector. Deeper layers of other plots were sampled to investigate the depth of penetration of the higher dosages of both chemicals. The cores from the top 21 cm were divided into 3 cm long pieces which were then investigated individually. Those from between 20 cm and 60 cm deep were divided into pieces from 20 to 30 cm deep, 30 to 40 cm deep and 40 to 60 cm deep which were then investigated separately.

Plant material, planting and further cultural measures. Gladiolus, cv Peter Pears, size 4/6 was planted on all plots on 13 April 1972 at a rate of 615 corms per plot (about 20 per meter) in rows 40 cm apart.

The plants were lifted and the corms collected on 16 and 18 October 1972. The latter were dried at 25°C, 'cleaned' and stored at 15°C until April 1973. Then about 300 corms from each plot were planted in the field at Lienden. By the beginning of August many plants showed symptoms of TRV infection: slow and irregular sprouting of corms, twisting, distortion to the shape of a Turkish sword and necrotic striping of leaves and 'notched leaf', shortening and twisting of stem and inflorescence and

Fig. 1. Gladiolus cv Peter Pears on experimental field at Lienden, August 1973. Left: healthy-plant; right: plant with symptoms of TRV attack.

Fig. 1. Gladiool cv Peter Pears op proefveld te Lienden, augustus 1973. Links: gezonde plant; rechts: plant met symptomen van TRV-aantasting.

Fig. 2. Deformed and spike-shaped inflorescences of gladilus cv Peter Pears caused by TRV infection (Lienden, August 1973).

Fig. 2. Misvormde en spichtige bloeiwijzen van gladiool cv Peter Pears aangetast door TRV (Lienden, augustus 1973).

spike-shaped inflorescences (Fig. 1 and 2). All plants were uprooted on 8 August 1973 and then examined individually.

Results and discussion

Comparison of the methods of sampling and of dates of sampling. The numbers of *R. uniformis* found in the top 20 cm of soil at the two sampling dates and under the different treatments are compared in Fig. 3A, those of trichodorids in Fig. 3B. According to Fig. 3A, the densities of *R. uniformis* found by sampling with the 5 cm auger in March 1972 were on average 1.7 times as high as those found in January 1972 with the 1 cm auger. For untreated plots alone, the ratio was 1.3. According to Fig. 3B, sampling untreated plots with the 5 cm auger in March 1972 yielded 1.6 times as many trichodorids per unit weight of soil, as sampling with the 1 cm auger in January 1972. However, on the treated plots sampled on both dates, the ratio between the two densities found was 3.7. Densities of trichodorids between 20 and 30 cm depth on other plots were up to eight times as high as those in untreated top layers. Therefore, even a slight upward migration or a slightly greater sampling depth at the second sampling because of compaction of the soil could easily have caused much higher counts at the second than at the first sampling date, especially where

Fig. 3. Relations between population densities of *R. uniformis* (A) and of trichodorids (B) found at two sampling dates. For meaning of treatment codes see Table 4. Scales in nematodes/500 g soil.

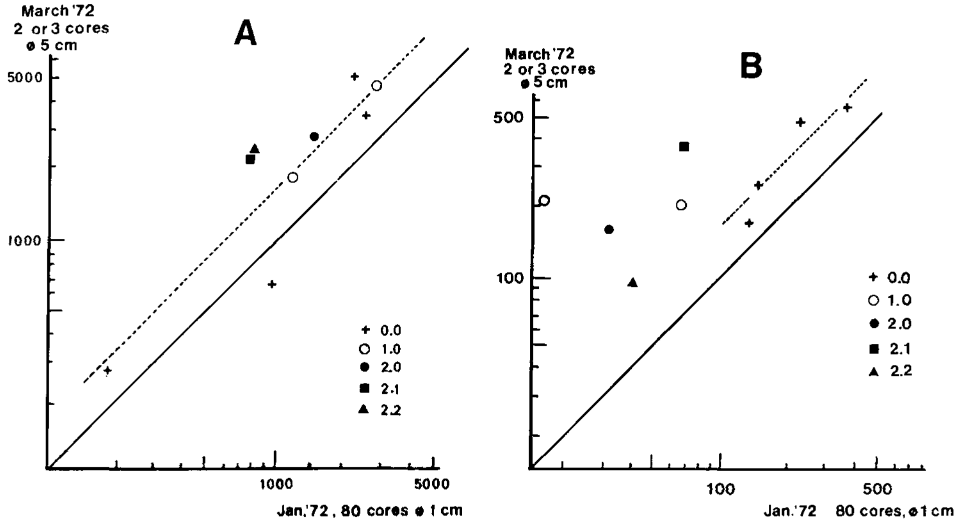

Fig. 3. Betrekking tussen bevolkingsdichtheden van R. uniformis (A) en van trichodoriden (B) op twee bemonsteringsdata. Zie tabel 4 voor de betekenis van de behandelingscodes. Schalen in aaltjes/500 g grond.

chemical treatment had reduced nematode densities in the top 20 cm. Migration could hardly explain the higher densities of *Rotylenchus* at the second sampling date. This is more likely due to mechanical destruction of nematodes by the use of the 1 cm auger as supposed by Seinhorst (1973a).

Vertical distribution of the nematodes in untreated soil. The nematicides spread through the soil from the level of introduction, i.e. the surface or 15 cm deep. The relative effects of the different dosages therefore depend on the vertical distribution of the nematodes at the time of treatment. Unfortunately, the investigation of this distribution had to be postponed until four and a half months after treatment and could only be done on a limited number of plots. Changes may have occurred during this period, such as depletion of the top layer of the soil of nematodes. However, certain trends found are most probably more permanent. The vertical distributions of *Rotylenchus* and trichodorids on untreated plots are given in Table 2 and 3. The figures in Table 3 are averages of proportions of total numbers in 5 cm wide, 60 cm long cores found in the indicated portion of these cores. This total number is the sum of the number in a core between 20 and 60 cm deep and the number in 660 g (≈ weight of 20 cm long, 5 cm wide cylinder of soil) from the top 20 cm. The number in this 660 g top soil is further considered to be the number according to the January sampling of the plot multiplied by 1.3 for *Rotylenchus* and 1.6 for trichorids to correct for losses caused by sampling with the 1 cm wide auger. The ratio between the densities in layers 0–10 cm and 10–20 cm is assumed to be 37 : 63 for *Rotylenchus* and 29 : 71 for trichodorids (according to Table 2).

Table 2. Percentages of *Rotylenchus* and trichodorid populations between 0 and 21 cm deep, occurring at the indicated depths.

Depth (cm) below surface	*Rotylenchus*			Trichodorids	
	6 plots with high densities (15 cores)		plot with low density (2 cores)		
0– 3	4	(2–10)	18	1	(0–4)
3– 6	9	(5–16)	15	4	(2–25)
6– 9	14	(8–21)	15	14	(3–35)
9–12	18		25	20	
12–15	18	(10–35)	16	20	(8–43)
15–18	17		6	19	
18–21	16	(5–26)	5	20	
0–21	100		100	100	

Tabel 2. Percentages van de Rotylenchus en trichodoriden bevolkingen tussen 0 en 21 cm diep voorkomend op de aangegeven diepten.

Table 3. Percentages of *Rotylenchus* and trichodorids between 0 and 60 cm deep occurring at the indicated depths.

Depth (cm) below surface	*Rotylenchus*	Trichodorids
0–10	31	7
10–20	53	16
20–30	13	43
30–40	2	19
40–60	1	15
0–60	100	100

Tabel 3. Percentages Rotylenchus en trichodoriden tussen 0 en 60 cm diepte voorkomend op de aangegeven diepten.

Rotylenchus and trichodorid densities appeared to increase from the surface to about 9 cm depth and remained constant until 15 cm (*Rotylenchus*) or 21 cm (trichodorids) depth. However, *Rotylenchus* densities below 20 cm depth were much lower than between 10 and 20 cm depth, whereas trichodorid densities between 20 and 30 cm depth were considerably higher than above that level. In one plot with a very low density of *Rotylenchus*, relative densities were higher in the top 6 cm and lower between 15 cm and 21 cm deep than in the other plots (Table 2).

Effect of treatments on nematodes in top 20 cm of soil. In twelve plots treated with various dosages of DD densities of *Rotylenchus* and trichodorids after treatment were of the same order as those in untreated plots. Five of these twelve plots were sampled again, but with a 5 cm wide auger (Table 1). The vertical distribution

Table 4. Percentage of *Rotylenchus* and trichodorids in the top 20 cm of the soil surviving various treatments.

Treatments			Survival	
Code	DD (ml/m²)	dazomet (g/m²)	*Rotylenchus uniformis*	Trichodorids
0.0	0	0	100	100
0.1	0	5	98	60
0.2	0	10	29	10
0.3	0	20	0.06	0.43
0.4	0	40	0	0
1.0	10	0	23	18
2.0	20	0	4	7.6
3.0	40	0	0.09	0
4.0	80	0	0.04	0
1.1	10	5	2.6	2
1.2	10	10	0.8	0.2
1.3	10	20	0.07	0.0
2.1	20	5	1.0	3
2.2	20	10	0.4	2.4
3.1	40	5	0	0

Tabel 4. Percentages Rotylenchus en trichodoriden in de bovenste 20 cm van de grond, die de verschillende behandelingen overleefden.

of the nematodes found indicated that the DD treatments had been partly or entirely ineffective (high nematode densities between 10 cm and 20 cm deep). As this was due to technical failure and is not typical of DD treatments in general, all twelve plots were excluded from calculations of treatment effects or, partly, considered to be untreated plots (three plots in Table 2).

Average nematode densities were calculated per treatment as arithmetic means. Survival rates were then calculated as ratios between average densities on treated and untreated plots. The results are given in Table 4 and Fig. 4A and 4B. Survival rates of less than 1 % in *R. uniformis* and less than about 8 % in trichodorids are based on very low numbers of nematodes counted and, therefore, have large coefficients of variability. No conclusions can therefore be drawn from these figures on differences in effectiveness of the treatments involved. The set up of the experiment does not allow the calculation of meaningful experimental errors of survival rates from the data. This would have required sampling of all plots before and after treatment, as only then could the effect of irregular plot to plot distribution of the nematodes be separated from the sampling and treatment errors. The set up of this experiment is based on the assumption that average densities before treatment (in the ten plots used for each treatment) were about the same. This assumption is supported by the average densities of *R. uniformis* in the two sets of the untreated plots and the ten plots treated with 5 g dazomet per m² (1287, 1203 and 1233 nematodes per 500 g soil). This range is well within the limits to be expected on the grounds of the standard deviation of log density of about 0.075 (95 % of the observations between 1 time and 2 times a certain number) for a single sample if at least 100 nematodes are counted (Seinhorst, 1973a). This

Fig. 4. Relation between dosage of DD and of dazomet and mortality of *R. uniformis* (A) and of trichodorids (B) in the top 20 cm of the soil.

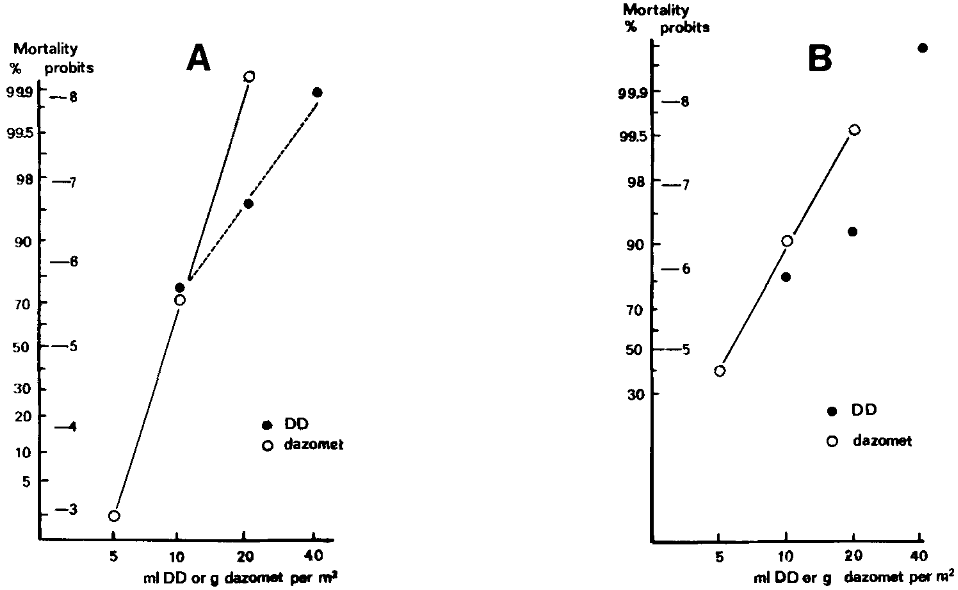

Fig. 4. Betrekking tussen dosis DD en dazomet en sterfte van R. uniformis (A) en van trichodoriden (B) in de bovenste 20 cm van de grond.

results in a standard deviation of log survival rates of $\sqrt{2} \times 0.075 = 0.105$ (Seinhorst's 1973a figure already includes the relatively small treatment error). If survival rates are calculated from geometric means (to stabilize the otherwise density-dependent sampling error), their coefficient of variability with ten plots per treatment is about 11 %. However, this figure is only applicable to cases where more than 100 nematodes were counted per plot. At lower densities the error strongly increases with decrease of density.

Fig. 4A and B support Seinhorst's (1973) opinion that the relation between dosage of nematicide and mortality of nematodes in the top 20 cm of the soil is well approximated by a linear regression of probit mortality of the nematodes on log dosage of the chemical. The very small deviations of the observations from this linear relation could be an indication that experimental errors are small.

Dosage increase efficiencies (Seinhorst, 1973) were average to high for both chemicals (1.2 and 0.6 probit units per doubling of the dosage for DD, 2.5 and 1.5 probit units per doubling of the dosage for dazomet against *Rotylenchus* and trichodorids, respectively). The higher dosage increase efficiency of dazomet, applied superficially, as compared to that of DD injected at 15 cm depth could possibly be explained by the strong increase of nematode density with depth. Therefore, the lowest dosage of dazomet only killed the relatively few nematodes in the top 3 cm, whereas the lowest dosage of DD was active where nematode density was highest.

The effect of the combined treatment is somewhat obscured by the uncertainty of the effect of the low dosages of DD and the very low survival rates at the higher

Table 5. Numbers of trichodorids and *Rotylenchus* per 500 g soil between 20 cm and 60 cm depth on treated and untreated plots (one 5 cm wide core per plot).

Depth (cm)	Trichodorids			*Rotylenchus*		
	untreated (5 plots)	20 g dazomet per m^2 (10 plots)	40 ml DD per m^2 (10 plots)	untreated (5 plots)	20 g dazomet per m^2 (10 plots)	40 ml DD per m^2 (10 plots)
20–30	896 (140–1490)	358 (1–930)	0	489 (55–850)	348 (0–1425)	0
30–40	392 (215–590)	479 (0–1590)	0	82 (33–115)	156 (0–850)	0
40–60	154 (53–384)	166 (1–692)	0	18 (1–45)	21 (0–148)	0

Tabel 5. Aantallen trichodoriden en Rotylenchus per 500 g grond tussen 20 en 60 cm diepte op behandelde en onbehandelde veldjes (één 5 cm dikke steek grond per veldje).

dosages of each of the chemicals when applied singly. The effect of the superficial treatments with dazomet on nematodes that survived the DD treatments in plots with combined treatments was calculated by supposing that the effect of a certain dosage of DD was the same when applied singly or in combination with dazomet (Seinhorst, 1973). If no plots are excluded from the calculations because of a poor effect of the DD, 5 g and 10 g dazomet per m^2 would have killed 90 % and 97 % of the *Rotylenchus* population and 63.5 % and 96 %, of the trichodorids that survived a treatment with 10 ml DD per m^2, respectively. Elimination of all plots where an insufficient effect of DD could be suspected results in 89 % and 96.5 % for *Rotylenchus* and 89 % and 98.8 % for trichodorids. However, when none of the plots treated with the two chemicals, but the two treated with 10 ml DD per m^2 with high survival rates, are excluded from the calculations (the most unfavourable assumption), the figures become 84 % and 94.8 % for *Rotylenchus* and 53 % and 94.8 % for trichodorids. The figures found for *R. uniformis* are in good agreement with those found by Seinhorst (1973a). The high mortality caused by 5 g dazomet per m^2 to the nematode population that survived DD treatment may seem in contradiction with the virtual absence of an effect of this dazomet dosage on the *R. uniformis* population when applied alone. However, the 90 % killed of the population that survived treatment with 10 ml DD per m^2 only constitutes about 18 % of the original population. As the coefficient of variability of survival rates is at least 11 % the discrepancy could very well be due to sampling error.

Effect of treatments on nematodes below 20 cm depth. In none of the samples from between 20 cm and 60 cm deep on plots treated with 40 ml DD per m^2 were *Rotylenchus* or trichodorids found. The treatment with 20 g dazomet per m^2 had no effect below 20 cm deep on several plots, but reduced populations very strongly as deep down as 60 cm on others (Table 5).

Composition of the Rotylenchus uniformis population in untreated plots and plots treated with DD. According to Fig. 5 the proportion of adults of *R. uniformis* in populations in untreated soil was smaller at high than at low population densities. The cause is unknown. Treatment with DD reversed this trend (Fig. 6), indicating that adults are more sensitive to DD than juveniles. Where populations had been

Fig. 5. Relation between population density of *R. uniformis* and proportion of adults in untreated plots. ● = 100 g samples taken with 5 cm wide auger; ○ = composite samples taken with 1 cm auger.

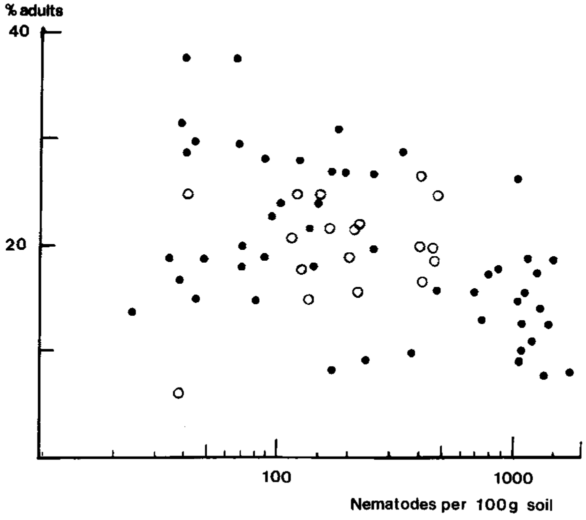

Fig. 5. Betrekking tussen bevolkingsdichtheid van R. uniformis and percentage volwassen dieren in onbehandelde veldjes. ● = *monsters van 100 g genomen met 5 cm wijde boor;* ○ = *monsters genomen met 1 cm wijde boor.*

Fig. 6. Relation between population density of *R. uniformis* and proportion of adults in plots treated with DD. For meaning of treatment codes see Table 4.

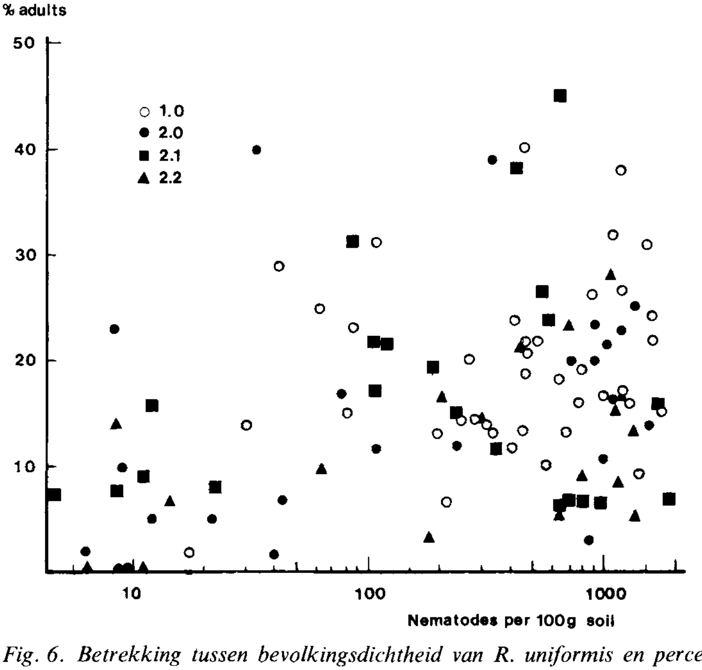

Fig. 6. Betrekking tussen bevolkingsdichtheid van R. uniformis en percentage volwassen dieren in met DD behandelde veldjes. Zie Tabel 4 voor betekenis van behandelingscodes.

Fig. 7. Differences in flowering after treatments on experimental field at Helenaveen. Front plot: 5 g dazomet, second row of plots from left to right: 80 ml DD, untreated, 10 ml DD + 5 g dazomet, third row, from left to right: 40 g dazomet, 20 g dazomet, 80 ml DD, 20 ml DD + 10 g dazomet, all per m^2.

Fig. 7. Verschillen in bloei na verschillende behandelingen op proefveld te Helenaveen. Voorste veldje: 5 g dazomet, tweede rij veldjes, van links naar rechts: 80 ml DD, onbehandeld, 10 ml DD + 5 g dazomet, derde rij veldjes, van links naar rechts 40 g dazomet, 20 g dazomet, 80 ml DD, 20 ml DD + 10 g dazomet, alles per m^2.

reduced strongly by a DD treatment (the low densities in Fig. 6), the proportion of second stage juveniles tended to be much larger than in unaffected or only slightly reduced populations, as was also found by Seinhorst (1973a).

Effect of treatment on corm weight. The plants on treated plots flowered about two weeks earlier than those on untreated ones (Fig. 7). In addition yields of corms on the first plots were considerably higher than on the latter (Table 6). However, treatments did not reduce plot to plot variation within treatments. Mapping of yields expressed as percentages of treatment means revealed a distinct pattern in the productivity of the experimental field (Fig. 8). This pattern was not correlated with the

Table 6. Yields of corms in 1972 and percentages of plants with TRV symptoms in 1973.

Treatment		Yield in % of that at 80 ml DD per m²	% plants with TRV symptoms in 1973 average (range)	Reduction in DD treatments	Reduction by addition of dazomet treatments
DD (ml/m²)	dazomet (g/m²)				
0	0	73	26 (5–75)		
0	5	79	30 (12–73)		-4
0	10	76	14 (1–35)		12
0	20	95	24 (9–72)		2
0	40	99.5	15 (3–70)		11
10	0	89	16 (4–38)	10	
20	0	93	12 (8–21)	14	
40	0	98	7 (1–18)	19	
80	0	100	8 (1–18)	18	
10	5	86	12 (1–45)		4
10	10	95	18 (7–57)		-2
10	20	94	15 (4–49)		1
20	5	91.5	14 (2–34)		-2
20	10	93	8 (2–19)		4
40	5	99.5	6 (2–17)		1

Tabel 6. Knolopbrengst in 1972 en percentages planten met TRV-symptomen in 1973.

density of either of the nematode species in the top 20 cm of the plots expressed as percentages of the average density per treatment.

Which cause of yield reduction was removed by the nematicidal treatments cannot be derived from the available data. Treatments with 20 g dazomet per m² had a considerable effect on yield, but reduced nematode populations below 20 cm depth on only half of the plots. Therefore, the cause was probably located in the top 20 cm. Regression of yields on nematode densities do not exclude nematodes as a cause. However, the tolerance limit (Seinhorst, 1965, 1973b) of gladious to *Rotylenchus* would have been between 0.5 and 2 nematodes per 500 g soil and to *P. pachydermus* 0.05 to 0.2 nematodes per 500 g soil, if either of these had been the cause of the low yields on untreated plots. Both figures are improbably low. No other plant parasitic nematode species were found in sizable numbers.

Symptoms of TRV infection in 1972. Very few plants with TRV symptoms were found during 1972. This indicates that the corms planted were free of the virus and also that no virus was transmitted to the noses of the corms during early stages of development.

Effect of treatments on percentage of corms infected with TRV. Table 6 gives the rates of infection with TRV of the plants grown in 1973 from the corms harvested from untreated and treated plots in 1972. As the field used for this part of the experiment contained very few trichodorids, symptoms seen in a plant could only mean that the corm had become infected during the previous year. Apparently none of the treat-

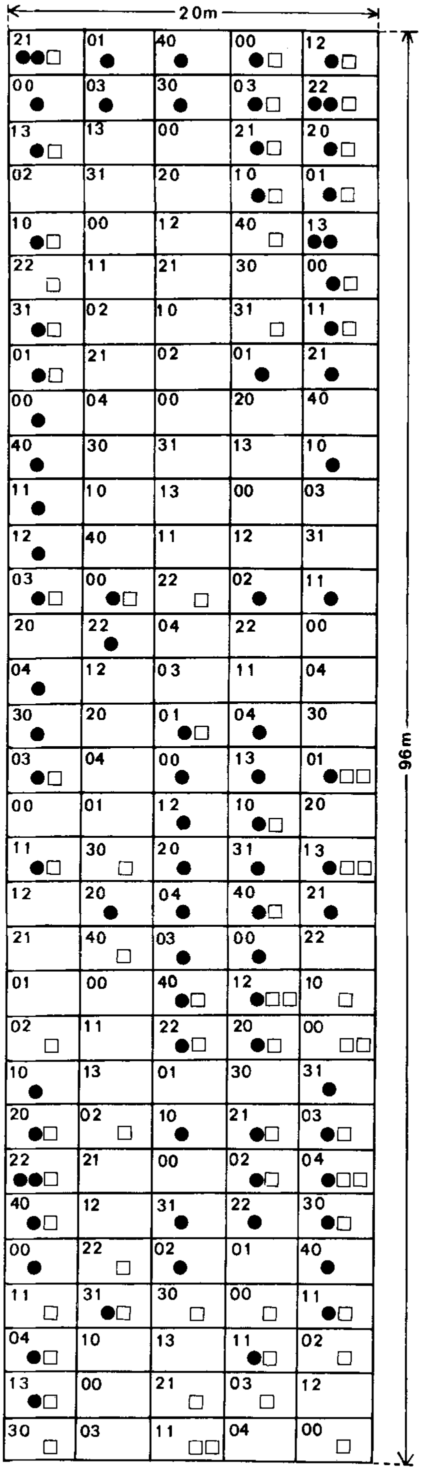

Fig. 8. Map of experimental field with yields of corms in 1972 (● between average of all plots with same treatment and 1.25 times this average, ●● more than 1.25 times this average) and rates of TRV infection in corms (□ between average of all plots with same treatment and 2.5 times this average, □□ more than 2.5 times this average.) No indication: yield of corms or proportion of plants infected with TRV less than average of all plots with same treatment. For meaning of treatment codes (upper left corner of each plot) see Table 4.

Fig. 8. Kaart van proefveld met knolopbrengsten in 1972 (● tussen gemiddelde over alle veldjes met dezelfde behandeling en 1,25 maal dit gemiddelde, ●● meer dan 1,25 maal dit gemiddelde) en mate van TRV-infectie in knollen (□ tussen gemiddelde van alle veldjes met dezelfde behandeling en 2,5 maal dit gemiddelde, □□ meer dan 2,5 maal dit gemiddelde). Geen aanduiding: knolopbrengst of TRV-infectie minder dan gemiddelde van alle veldjes met dezelfde behandeling. Zie tabel 4 voor betekenis van behandelingscodes (in linker bovenhoek van elk veldje)

ments had prevented this infection sufficiently. All nematodes between 20 and 60 cm deep were killed by 40 ml DD per m^2. We may therefore assume that 80 ml DD per m^2 was equally effective to at least that depth. Trichodorids are the only known vectors of the virus and are known to occur at much greater depth in soils similar to that of the experimental field. Therefore, trichodorids occurring below 60 cm deep were most probably responsible for the residual 8% infection on plots treated with the highest dosage of DD.

Unlike corm yields, TRV infection was not affected by dosages of dazomet up to at least 10 g/m^2. Apparently, nematodes occurring below 20 cm deep were largely responsible for the virus transmission. Also adding treatments with up to 20 g dazomet per m^2 to DD treatments had little or no effect.

Despite the great infectivity of the trichodorid population in the top layer found in the autumn of 1971, only 26% of the plants on the untreated plots became infected in 1972. The rate of infection varied considerably from plot to plot and between different parts of the field although the density of trichodorids was high in all untreated plots. The reasons are unknown. Apparently the neceassary conditions for virus transmission were distributed very irregularly in the 1972 experimental field. Rates of transmission were calculated as percentages of averages per treatment. Plots with more than the average rate of transmission for the treatments given are indicated on the map of the experimental field in Fig. 8. There is a considerable degree of coincidence of relatively high yields of corms and high rates of TRV transmission, but no clue to a causal relation. Both the low average infection rate on the untreated plots and the positive correlation between weight of corms harvested in 1972 and virus infection in 1973 preclude TRV infection of the gladiolus roots in 1972 as a cause of poor yields on untreated plots and on plots treated with low dosages of the chemicals.

Conclusions

TRV transmission to gladiolus cannot be prevented sufficiently by chemical treatments killing trichodorids down to 60 cm deep if these nematodes also occur below that level. This precludes application of the customary nematicidal treatments, even with high dosages as a practical means of preventing TRV infection of gladiolus. However, these treatments could be effective in fields with relatively high water tables, which limit the depth to which nematodes occur.

Additional treatment of the top layer of the soil had no effect in our experiment. However, conditions in the top layer may favour virus transmission in other fields and/or other years. The effectiveness of a high rate of nematode control in the top layers of soils where populations of virus-transmitting nematodes can be eradicated to a sufficient depth should therefore be investigated.

Both DD and dazomet treatments increased corm yield considerably, probably by controlling a so far unknown agent which probably attacked the root cortex.

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Samenvatting

Het effect van aaltjesdodende behandelingen op aaltjesbevolkingen op verschillende diepten in de grond en op de overbrenging van tabaksratelvirus op gladiool

Op een proefveld op lichte zandgrond werd het effect nagegaan van behandelingen in de herfst van 1972 met DD, op de oppervlakte gestrooide dazomet en van combinaties van deze beide op de bevolkingsdichtheid op verschillende diepten van *Rotylenchus uniformis* en trichodoriden (voornamelijk *Paratrichodorus pachydermus*) en op de overbrenging van tabaksratelvirus (TRV) op in 1973 geteelde gladiolen. De waarnemingen ondersteunen de opvatting, dat de betrekking tussen log dosis DD of dazomet en probit sterfte van de aaltjes goed wordt benaderd door een rechtlijnig verband (Fig. 4). Het effect van dosisvergroting van beide stoffen was bij beide aaltjessoorten gemiddeld tot groot. Oppervlakkige behandeling met dazomet was zeer effectief tegen aaltjes, die de DD-behandeling overleefden. Met 40 ml en 80 ml DD per m^2 op 15 cm diepte ingebracht, werden alle aaltjes van 20 tot 60 cm diep gedood (Tabel 4 en 5).

Gladiolen die in het voorjaar van 1972 op het proefveld werden geplant groeiden beter, bloeiden eerder (Fig. 7) en produceerden een groter gewicht aan knollen op behandelde dan op onbehandelde veldjes (Tabel 6). Dit kon niet toegeschreven worden aan het doden van schadelijke aaltjes. Ook waren er geen symptomen van overbrenging van TRV door de zwaar met dit virus besmette trichodoriden. Symptomen van TRV-infectie in planten die in 1973 werden geteeld uit de knollen, die op de verschillende veldjes van de veldproef in 1972 werden geoogst, toonden aan dat alleen de DD-behandeling enige vermindering van overbrenging van het virus had veroorzaakt (Tabel 6). Zelfs de hoogste dosis DD had het gemiddelde percentage infectie echter slechts verminderd tot een derde van dat in planten van onbehandelde veldjes, waarin het 26 % was. Hoogstwaarschijnlijk was deze overblijvende aantasting veroorzaakt door TRV-overdracht door aaltjes, die beneden 60 cm diep in de grond de behandelingen hadden overleefd. Behandeling van de grond met nematiciden is dus onvoldoende effectief tegen TRV-overdracht door trichodoriden naar gladiool, wanneer deze aaltjes op grotere diepte in de grond voorkomen.

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