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Experiments with nitrification inhibitors and glasshouse lettuce in spring 1980.

S.A. Tooze 1)
J.P.N.L. Roorda van Eysinga 2)
M.Q. van der Meijs

1) Master of Science Candidate at The Pennsylvania State University U.S.A.
2) Instituut voor Bodemvruchtbaarheid, Haren, Gr.

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Introduction

The problem of high nitrate contents in leafy vegetables such as spinach and lettuce has been well documented (Corre et al, 1979). It is believed that with these vegetables nitrates accumulate in amounts which can be hazardous for human consumption especially with small children (Comly, 1945 and Peto 1979). One answer to this problem is the use of nitrification inhibitors with fertilizers in the soil which prevent the conversion of ammonium to nitrate by the biocidal effect on Nitrosomonas bacteria, resulting in lower nitrate contents in plants. In a previous experiment with lettuce, increasing quantities of dicyandiamide (DCD) used in conjunction with ammonium sulfate fertilizer decreased the concentration of NO3-N in the leaf tissue without seriously affecting the yield (Roorda van Eysinga, 1980).

The objective of this studie was to determine 1) the effect of nitrification inhibitors on lettuce yields 2) the best concentration of inhibitor to use without seriously effecting yield.

Materials and methods

The study was carried out in four different commercial, glasshouse locations in the Westland in the Netherlands. The locations where chosen on the basis of low nitrate content in the soil. The soil characteristics for each glasshouse are given in table 1.

Table 1. Characteristics of the soils

Trail	Soil type	pH-KCl	Organic matter %	Clay %	CaCO3 %	1:2 volume extract EC mS/cm	NH4 mmol/l	NO3 mmol/l	weight by volume g/100 ml
B	loam	6.3	3	25	0.4	0.6	0.1	1.3	113
vE	loam	7.1	7	25	8.0	1.2	0.1	2.2	126
P	loamy sand	7.1	5	6	2.2	1.7	0.1	0.7	122
T	dune sand	5.9	4	2	0.3	0.7	0.3	0.3	127

Small plots were used in this experiment because the lettuce had to be destroyed at the conclusion of the experiment due to the unclear influence

of inhibitor residues on human consumption. In each location the experimental area was divided up to accomodate the different fertilizer, -inhibitor combinations with two replications of each treatment. Ammonium sulfate fertilizer was applied in each location at the rate of 10 g per m2 of soil.

In one location decreasing amounts of ammonium sulfate fertilizer were used with increasing amounts of calcium nitrate fertilizer to give different ratios of ammonium to nitrate. In another location Gold-N sulfur coated urea slow-release fertilizer was used.

Varying amounts of N-serve and dicyandiamide were applied along with each fertilizer; the rate of N-serve ranged from 0 to 20 ml/m2 or approximately 14 to 18 ppm active ingrediant/m2. The inhibitors were mixed with the fertilizer as well as possible by hand, applied over the soil surface and then forked into the soil to prevent the tracking of the material from on plot to another. The soil was mechanically rotovated the following day. Within a few days of fertilizing the soil, lettuce seedlings in peat blocks were planted out, the cultivars and planting and harvesting dates are given in table 2.

Table 2. Lettuce cultivars and planting and harvesting dates for each trial

Trial	Cultivar	Planting date	Harvesting date
B	Miranda	1-30-1980	4- 8-1980
vE	Orba	1-25-1980	4- 9-1980
P	Miranda	2- 1-1980	4-10-1980
T	Miranda	2-12-1980	4-15-1980

After harvest the leaf tissue was dried in an oven at 80° C todetermine dry weight. The dried plant material was ground and nitrate concentrations were measured in a distilled water extract using the specific ion electrode. The tissue was also analyzed for nitrapyrin and 6-chloropicolinic acid residue by the Dow Chemical Company of The United Kingdom. Only the results for one trial were available at the time of this report.

Results and discussion

Tables 3 and 4 show the results of the N-serve experiment.

Table 3 Nitrate content (mmol NO3-N per g dry matter) in lettuce heads as influenced by the application of N-serve (mixed with ammonium sulphate)

ml N-serve/m2	B	vE	P	T	Relative mean
0	1.73	1.98	1.68	0.48	100
2.5	1.02	1.29	1.50	0.78	90
5	0.95	1.13	1.32	0.49	73
10	0.79	1.16	1.30	0.45	69
20	0.75	1.14	1.19	0.48	68

Table 4 Yield (average head weight in g) as influended by the application of N-serve (mixed with ammonium sulphate)

ml N-serve/m2	B	vE	P	T	Relative mean
0	238	315	236	248	100
2.5	238	323	236	288	104
5.0	235	312	233	274	102
10.0	228	308	234	265	101
20.0	211	311	229	274	99

Increasing the rate of N-serve applied with the ammonium sulfate fertilizer resulted in a decrease in the NO3N concentrations of the leaf head tissue with only a slight reduction in yield. Trial B showed the greatest N-serve effect with a 57% reduction in NO3-N concentrations from the lowest to highest rate of N-serve applied. The relative reduction in NO3-N for each trial is presented in figure 1. The concentration of NO3-N was considerable lower for trial T than for the other trials. A. possible explanation for this is the higher radiaton levels which occured before trial T was harvested. The radiation levels for this period from March to April are presented in figure 2.

Soils that are high in nitrogen usualy contain nitrogen mainly in the form of NO3-N. It was hypothesized that applying N-serve to this type of soil would have little effect. This is demonstrated in the vE trial (see table 5) were decreasing levels of ammonium sulfate were applied with increasing levels of calcium nitrate at a constant rate of N-serve.

Table 5 Nitrate content (mmol NO3-N per g dry matter) and yield (average head weight in g) as influenced by the application of 5 ml N-serve per different rates of ammonium sulfate and calcium nitrate fertilizers for the vE trial

Treatment on N-base					
ammonium sulfate (%)	$CaNO_3^-$ (%)	Yield	Relative yield	NO_3-N	relative NO_3
100	0	314	100	1.17	100
90	13	322	94	1.15	98
80	26	328	104	1.31	112
70	39	332	106	1.30	111
60	52	339	108	1.34	115
50	65	322	94	1.62	138

With increasing ratios of nitrate to ammonium in the fertilizer the nitrat concentration in the lettuce tissue increase. This indicates that soils high in nitrogen would have to be througly leached before N-serve could be applied.

In trial T N-serve was applied with the slow-release fertilizer, Gold-N and the results are presented in table 6.

Table 6 Nitrate content (mmol NO3-N per g dry matter) and yield (average head weight in g) as influenced by the application of N-serve (mixed with 50 g Gold-N) for the T trial

ml N-serve/m2	Yield	Relative yield	NO_3-N	Relative NO_3
0	276	100	0.69	100
5	258	93	0.30	43
10	254	92	0.27	39

The results obtained were similar to those obtained with ammonium sulfate fertilizer indicating that N-serve is effective with Gold-N as well.

Table 7 and table 8 show the results of the DCD experiment.

Table 7 Nitrate content (mmol NO3-N per g dry matter) in lettuce heads as influenced by the application of dicyandiamide (mixed with ammonium sulphate)

g DCD/m2	B	vE	P	T	Relative mean
0.0	2.04	1.31	1.75	0.49	100
3.0	-	1.07	-	-	82
5.0	1.04	-	-	0.27	60
6.0	-	0.86	-	-	66
9.0	-	1.23	-	-	94
10.0	0.82	-	0.77	0.35	58
12.0	-	0.80	-	-	61

Table 8 Yield (average head weight in g) as influenced by the application of dicyandiamide (mixed with ammonium sulphate)

g DCD/m2	B	vE	P	T	Relative yield
0.0	250	318	220	254	100
3.0	-	337	-	-	106
5.0	244	-	-	252	100
6.0	-	326	-	-	102
9.0	-	319	-	-	100
10.0	240	-	214	252	98
12.0	-	346	-	-	109

Increasing the rate of DCD applied decreased the concentration of NO3-N in the leaf tissue with only a slight reduction in yield. However the physical appearance of the lettuce heads with the highest DCD treatments was affected (figure 3). The lettuce leaves grew in an upright

manner resulting in a more on less tulp-shaped head. There was also some chlorosis of the upper part of the leaves and scorching of the leaf edges. These effects may have been due in part to high ammonium concentrations in the soil.

The results of the analysis for nitrapyrin and 6-chloropicolinic acid residue for trial B are given in table 9. The concentrations were less than 1 ppm for each treatment and researchers at Dow Chemical Company indicate that these levels are relatively low.

Table 9 Nitrapyrin tissue and 6-chloropicolinic acid residues (in mg per kg fresh) in lettuce tissue following treatment of the soil with N-serve for trial B

ml N-serve/m2	nitrapyrin	6-chloropicolinic aced
0	0.11	0.17
2.5	0.04	0.30
5	0.06	0.46
10	0.05	0.64
20	0.24	0.82

Conclusions

The use of N-serve nitrification inhibitor with ammonium sulfate fertilizer reduced the NO3-N concentrations in lettuce head tissue without seriously affecting yield. N-serve applied with Gold-N fertilizer gave similar results. Based on the results of this study 5 or 10 ml N-serve per 100 g ammonium sulfate appears to give the best results. Soils high in NO3-N must be leached for N-serve to be effective.
The DCD nitrification inhibiter applied with ammonium sulfate fertilizer reduced NO3-N concentrations in lettuce tissue. With higher concentrations the heads were 'tulip' shaped with chlorosis and scorching of the leaf edges. Based on the results 5 g DCD per 100 g ammonium sulfate appears to give the best results.

Literature

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Fig. 1. Reduction in nitrate content of lettuce heads in relative figures as influenced by N-serve applications.

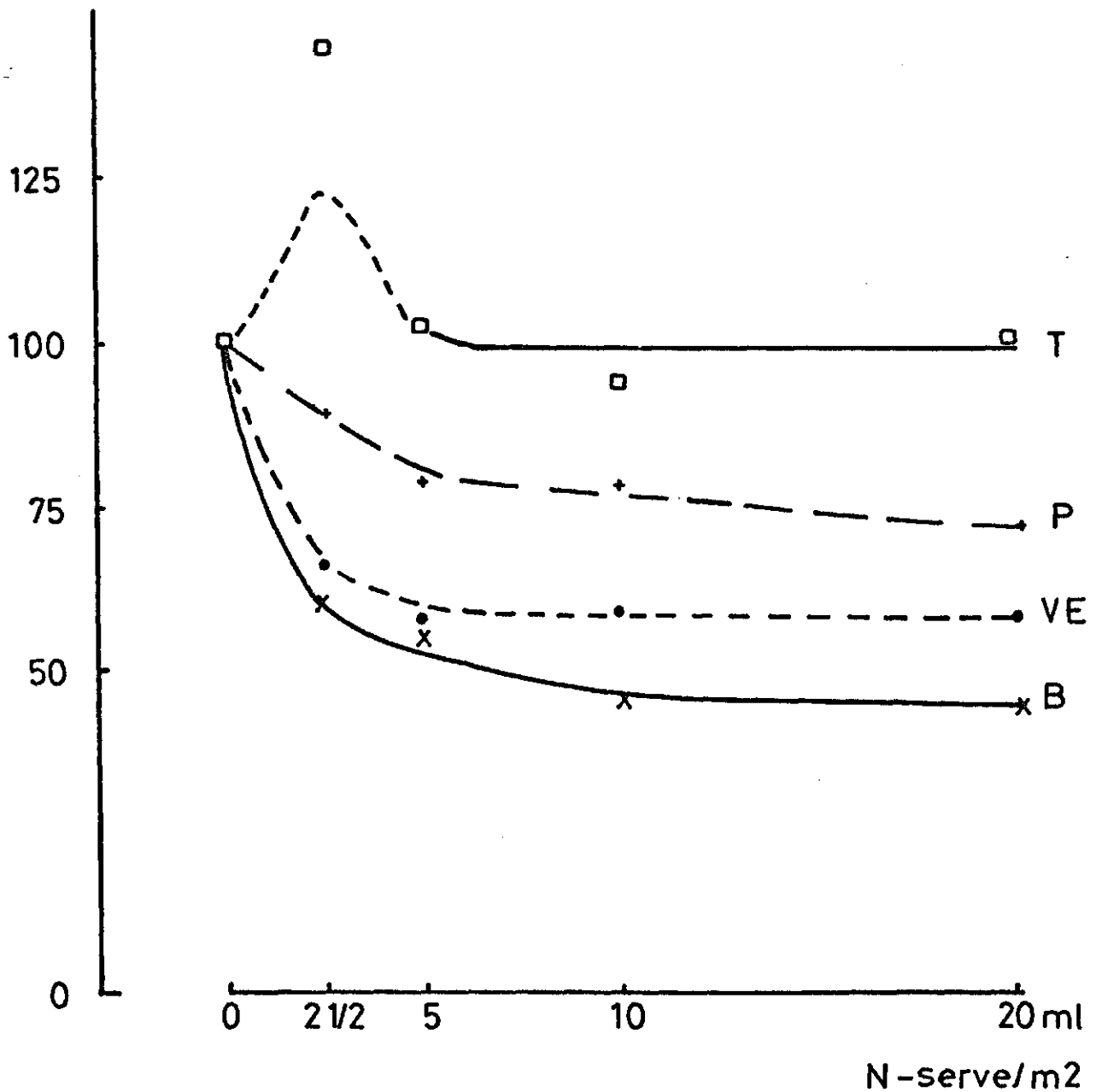

Fig. 2. Sommation of global radiation daysums (J/cm^2) at the end of the growing period.

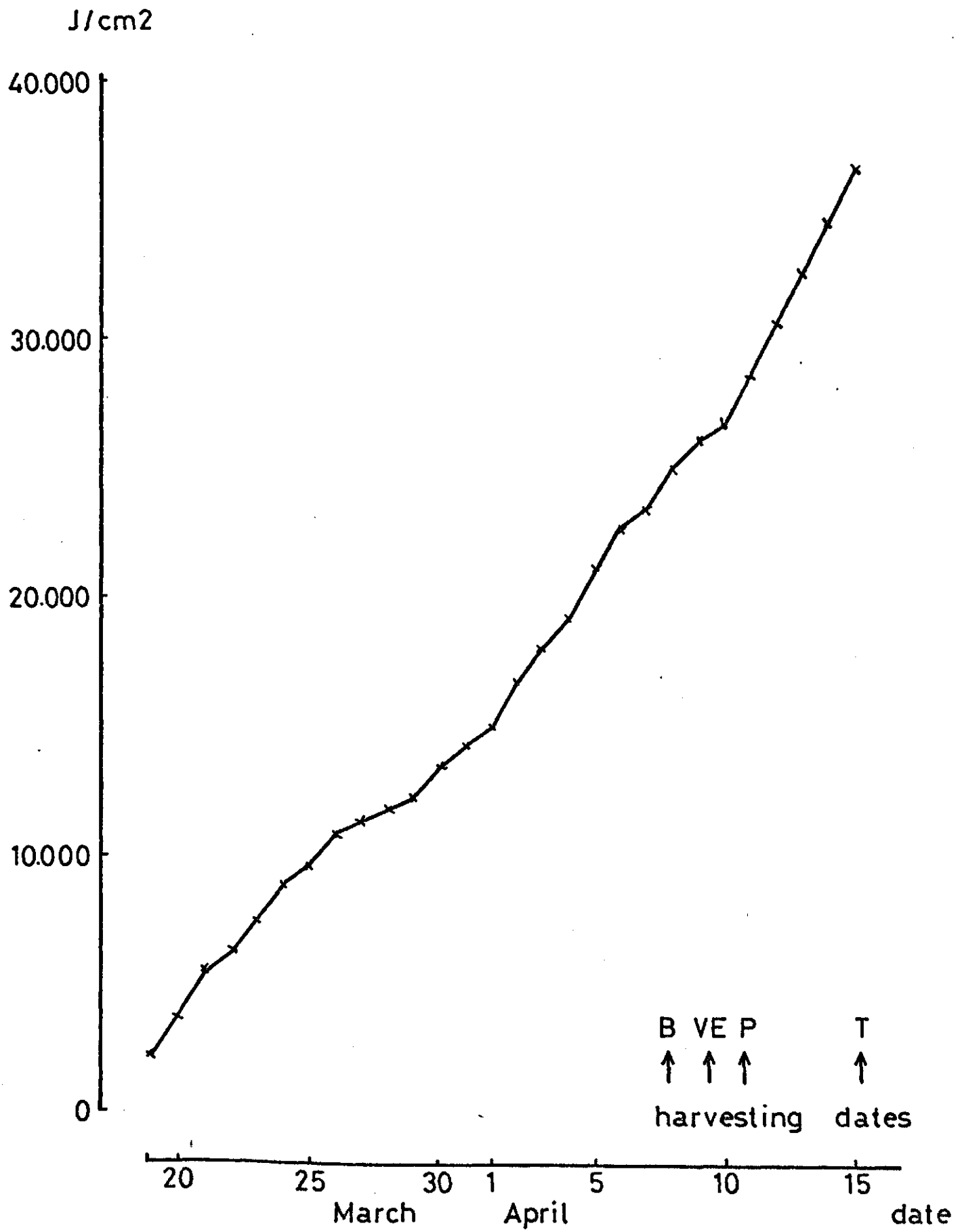

Fig. 3. Lettuce cv. Orba, the left one treated with 10 g dicyandiamide per m^2 soil.