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Soil fumigation and crop rotation to control spraing disease in potatoes

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Abstract

Growing resistant potato cultivars is of little help in avoiding damage by spraing, because of regionally differing strains of tobacco rattle virus and of special requirements of the processing industry.

On soil, fumigated in 1971 during autumn with a solution of dichloropropene-dichloropropane (660 g/l) at 250 l/ha, the vectors *Trichodorus* spp., were effectively controlled and the tuber disorder did not appear in the next year's potato crop. But potatoes from the treated plots had an unacceptable off-flavour. In the second crop after treatment, control was still good and there was no difference in flavour between potatoes from treated and untreated plots.

Disease incidence was significantly lower after spring barley than after sugarbeet, maize, or potatoes.

Introduction

Spraing disease or corky ring spot of potato tubers is mainly caused by tobacco rattle virus (TRV), transmitted by nematodes of the genus *Trichodorus* (Van Hoof, 1968; Harrison, 1970). The disease occurs only on light-textured and peaty soils, the preferential habitat of the nematode vectors. In the Netherlands on fields known to harbour the disease, damage is avoided by not growing potatoes or by using resistant cultivars. But there is a high demand for potatoes and the potato-industry prefers particular varieties like 'Bintje'. This paper reports on a study to reduce or control spraing disease by growing resistant cultivars, soil fumigation, and crop rotation.

Materials and methods

Varietal resistance was tested by growing three plants of each cultivar randomly distributed in fields, where spraing occurred in the previous potato crop at three sites (Overloon, Noord Brabant; Creil, Noord-Oost Polder; Wehe, Groningen).

Before planting soil samples were analysed for *Trichodorus* and tested for TRV. At harvest, all tubers were cut up and the rate of spraing was quoted on a scale from O (severe necrosis in all the tubers) to 10 (no tubers with necrosis). In fact, the figures indicated resistance to the disease.

The effect of soil fumigation and crop rotation was studied in two experiments on sandy soil on fields, where spraing had occurred in 80% of the tubers of 'Bintje'. Dichloropropene-dichloropropane mixture (DD 660 g/l) was applied in October 1971 at a depth of 18 cm by a chisel-injector followed by a roll. Each field consisted of five

25 × 6 m strips treated at a rate of 100, 250, split dose of 250 in October and 3 weeks later 250 l/ha, and two untreated strips. In 30 × 5 m strips at right angles to the soil fumigation strips, the following crops were grown in 1972: sugarbeet, maize, potato 'Eersteling', potato 'Bintje', and spring barley. Special care was taken to control weeds. In 1973, 'Bintje' potatoes were grown on all the plots.

Soil samples were taken before treatment (October 1971), after treatment (December 1971), during the growing season (August 1972), after harvest of the first crop (November 1972), and after harvest of the second crop (October 1973). The samples were taken with an auger 10 cm diameter to a depth of 60 cm.

From each plot compound samples were taken. From five cores the topsoil (0–20 cm), the middle part (20–40 cm), and the subsoil (40–60 cm) was bulked. Nematodes were extracted from subsamples of 200 ml soil by Oostenbrink's elutriation technique. The presence of TRV was tested by growing a young 'White Burley' tobacco plant in the remnant soil samples. Four weeks after planting, the roots of these tobacco bait plants were ground in a mortar and the sap was rubbed onto carborundum-dusted leaves of two other 'White Burley' test plants. When TRV was present characteristic necrotic rings and spots appeared on the leaves 2–4 days after inoculation.

Spraing was assessed by cutting up 200 tubers per plot and determining the percentage of tubers with symptoms. In 1972, potato tubers from all plots were assessed for flavour by organoleptic tasting of boiled tubers. In 1973, this was done in samples from the plots that received the highest dose of DD in 1971, and from all plots grown previously with sugarbeet and spring barley.

Results

Different rates of attack were recorded between different cultivars at each site, but also for the same cultivar at different sites (Table 1). While 'Saturna' was not and 'Mara' severely affected at the three sites, 'Bintje' and 'Eigenheimer' were more

Table 1. Resistance to spraing in six potato cultivars at three sites.

	Site		
	Overloon	Creil	Wehe
Trichodorus spp.	*T. pachydermus* *T. similis*	*T. teres*	*T. primitivus*
per 200 ml soil	27	75	94
incidence of TRV in soil	80%	75%	90%
Incidence of spraing in potato cultivars			
Saturna	10	10	10
Jaerla	10	10	7
Bintje	5	10	9
Eigenheimer	5	9	10
Proton	8	6	6
Mara	2	2	5

Tabel 1. Resistentie voor kringerigheid bij zes aardappelcultivars op drie plaatsen.

diseased at Overloon than on the other two sites. 'Jaerla' was more so at Wehe, and 'Proton' at Creil and Wehe.

In both soil fumigation experiments, a clear correlation was found between increasing amounts of DD applied and decreasing *Trichodorus* densities, TRV-infectivity of soil, and spraing incidence in both potato cultivars in 1972 (Table 2). However, in 1972 the flavour of the potatoes from the plots treated with 250 l/ha or more was unacceptable.

Table 2. Effect of soil fumigation with DD on *Trichodorus* population density (Tr.) in soil (per 200 ml), TRV-infectivity of soil (percentage of samples), and spraing incidence. Averages of two experiments.

Sampling date	DD treatment (l/ha) in October 1971							
	0		100		250		250 + 250	
	Tr.	TRV	Tr.	TRV	Tr.	TRV	Tr.	TRV
October 1971	38	86	70	94	18	83	30	89
Chemical treatment December 1971	62	86	38*	50*	0**	22**	0**	0**
Several crops November 1972	22	81	13*	78	0.3**	36**	0.1**	28**
Potatoes Oktober 1973	14	73	7*	67	0.1**	29**	0.3**	62
	Spraing incidence in % of tubers							
1972; 'Eersteling'	68		26**		2**		0**	
1972; 'Bintje'	33		11**		2**		0**	
1973; 'Bintje'	9		5*		1**		0**	

*Significant at $P \leqslant 0.05$; **significant at $P \leqslant 0.01$.

Tabel 2. Effect van grondontsmetting met DD op de Trichodorus-populatiedichtheid (Tr.) in de grond (per 200 ml), de aantoonbaarheid van TRV in de grond (percentage van de monsters) en het optreden van kringerigheid. Gemiddelden van twee proefvelden.

In 1973, the effect of soil fumigation persisted. However, spraing incidence in 'Bintje' in the untreated plots was less also. Then, no differences in flavour could be detected between potatoes from treated and untreated plots.

In the crop rotation experiments no differences in *Trichodorus* density and TRV-infectivity of soil were found between samples from plots where different crops had been grown in 1972 (Table 3). But in untreated plots, spraing incidence in 1973, was significantly less in potatoes grown after barley than in potatoes after sugarbeet, maize, and potatoes.

Discussion

The difference in spraing incidence in the same potato cultivar at different sites (Table 1) can be explained by the occurrence of different strains of TRV. Many strains of TRV have been described (Harrison, 1970), and Van Hoof (1968) showed specificity in *Trichodorus* population and TRV strain relations in the Netherlands.

Table 3. Effect of crop rotation on *Trichodorus* population density (Tr.) in soil (per 200 ml), TRV-infectivity of soil (percentage of samples), and spraing incidence in 'Bintje' potatoes (percentage of tubers). Average of two experiments.

Previous crop	1971-12		1972-08	1972-11		Spraing incidence
	Tr.	TRV	Tr.	Tr.	TRV	
Sugarbeet	47	75	21	14	100	10
Maize	82	75	64	18	75	12
'Eersteling'	47	75	59	14	88	8
'Bintje'	58	100	54	30	88	9
Spring barley	82	75	103	27	88	4*

*Significant at $P \leqslant 0.05$.

Tabel 3. Effect van vruchtwisseling op de Trichodorus-populatiedichtheid (Tr.) in de grond (per 200 ml), de aantoonbaarheid van TRV in de grond (percentage van de monsters) en het optreden van kringerigheid bij 'Bintje' (percentage van de knollen). Gemiddelden van twee proefvelden.

The regional occurrence of different strains of TRV has resulted in resistant potato cultivars being only regionally important for avoidance of spraing. 'Bintje' potatoes, generally considered resistant (Harrison, 1968), are badly affected in the Overloon region where potato purée industry demands this particular cultivar.

Soil fumigation with 250 l/ha or more effectively controlled *Trichodorus* in the upper 60 cm of the sandy soil. In the second year after soil fumigation control was still effective (Table 2).

Although TRV-infectivity of soil was not completely destroyed, indicating that some *Trichodorus* eelworms survived, spraing disease was effectively controlled in the first and the second potato crop after fumigation. The same results were reported in Scotland by Cooper and Thomas (1971).

TRV-infectivity could still be detected by growing tobacco bait plants in residues of the soil samples of more than 200 ml, whereas no *Trichodorus* was extracted from 200 ml soil from fumigated plots, where hardly any spraing occurred in potatoes. This can be attributed to a higher sensitivity of tobacco to systemic infection than of potatoe to local infection by TRV.

Soil fumigation with 100 l/ha gave insufficient control, and two application of 250 l were not better than one. As in the first year after soil fumigation, the potatoes from the plots where spraing disease was effectively controlled had an unacceptable off-flavour. Soil fumigation in the autumn before a potato crop was unsuitable for control of spraing disease in ware potatoes in my trials.

In the second crop after soil fumigation, no differences in flavour could be detected between potatoes from untreated plots and plots treated with 250 + 250 l/ha. Taste of the potatoes from untreated plots was not given a high assessment. Potatoes from the plots previously grown with barley or maize tended to have a better flavour than those from plots with beet or potatoes. It is not clear whether the poorer flavour of the potatoes in the second year after fumigation must be attributed to persistence and dispersal of breakdown products of DD or to other causes.

No significant influence was found of different crops grown for one season as reported by Symalla (1971) on *Trichodorus* density and TRV-infectivity in soil

samples taken in autumn of 1972 (Table 3). Lack of host-plant effect on *Trichodorus* density may be due to sampling time. In August 1972, highest numbers of *Trichodorus* were extracted from soil samples taken from barley plots. The absence of an effect of the previous crop on TRV-infectivity in soil may be due to the high sensitivity of the test method, with tobacco bait plants reacting to even one viruliferous *Trichodorus*.

Significantly lower spraing incidence in potatoes grown after barley may be explained by a lower proportion of TRV-bearing *Trichodorus* after barley. Viruliferous *Trichodorus*, not having access to roots, are known to retain TRV for at least three years (Van Hoof, 1970). Poor host plants may have the same effect on TRV rentention in the vector. On good host plants a high proportion of TRV-bearing *Trichodorus* may moult and lose their virus. When such a plant is not a host for TRV, a lower proportion of viruliferous vectors may result.

From these experiments it may be concluded that the disease in 'Bintje' may be controlled by first growing a crop of spring barley, and in 'Eersteling' and 'Bintje' by soil fumigation. As a complete kill of *Trichodorus* in soil is not achieved by soil fumigation, it may be assumed that the disease will recur when crops are grown on which these nematodes breed and that enable them to acquire the virus. Therefore an integrated control of the disease in 'Bintje' must be preferred, by soil fumigation and crop rotation with spring barley, taking care of control of weed hosts of TRV.

The chance of flavour deterioration of potatoes can be limited by first growing a crop of spring barley or maize in soil fumigated with DD in the autumn before, taking into account a nitrogen effect from the fumigation.

Samenvatting

Grondontsmetting en vruchtwisseling ter bestrijding van kringerigheid bij aardappelen

Kringerigheid bij aardappelen wordt voornamelijk veroorzaakt door tabaksratelvirus (TRV) dat wordt overgebracht door *Trichodorus*-aaltjes, die voorkomen in lichte en organische gronden. Het telen van resistente aardappelrassen biedt slechts beperkte mogelijkheden om schade door kringerigheid te voorkomen, doordat regionaal verschillende stammen van het virus voorkomen (Tabel 1) en de industrie zeer bepaalde rassen wenst.

Grondontsmetting met 250 l DD/ha in de herfst gaf een effectieve doding van *Trichodorus* in de bovenste 60 cm van de grond en kringerigheid trad slechts op in een zeer laag percentage van de knollen. Dit effect werd ook een jaar later nog waargenomen (Tabel 2). Grondontsmetting met 100 l DD/ha was onvoldoende en de toepassing van tweemaal 250 l nauwelijks beter. De aardappelen die geteeld waren in het jaar direkt na de grondontsmetting hadden echter een ontoelaatbaar afwijkende smaak. In het daaropvolgende jaar verschilden ze niet in smaak van die van de onbehandelde veldjes.

Op beide proefvelden was het percentage knollen met kringerigheid lager na de voorvrucht zomergerst dan na biet, mais en aardappel (Tabel 3).

Uit deze proefresultaten blijkt, dat de ziekte bij 'Bintje' kan worden bestreden door de teelt van zomergerst, en bij 'Eersteling' en 'Bintje' door grondontsmetting. Aangezien door grondontsmetting geen volledige doding van *Trichodorus* in de grond wordt bereikt, mag worden aangenomen dat de ziekte zal terugkeren wanneer gewas-

sen worden geteeld waarop deze aaltjes zich vermeerderen en waaruit ze het virus kunnen opnemen. De voorkeur moet daarom worden gegeven aan een geïntegreerde bestrijding van de ziekte door toepassing van grondontsmetting en vruchtwisseling met zomergerst, waarbij zorg zal moeten worden besteed aan de bestrijding van onkruidwaardplanten van TRV.

De kans op smaakafwijking bij aardappelen kan worden beperkt door eerst zomergerst of maïs te telen na de grondontsmetting met DD, waarbij rekening zal moeten worden gehouden met een stikstofeffect van de grondontsmetting.

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Book review

P. Grijpma: Contributions to an integrated control programme of *Hypsipyla grandella* (Zeller) in Costa Rica. Diss. Agricultural University, Wageningen, 1974, 147 pp.

This thesis is a collection of papers published from 1970 to 1974 in the Journal 'Turrialba'. The shoot borer *Hypsipyla grandella* is the main pest in young plantations of mahogany (*Swietenia* spp.) and Spanish cedar (*Cedrela* spp.) in Latin America. The study focuses on the natural resistance to borer attack in mahogany and cedar. Two exotic species, African mahogany (*Khaya ivorensis*) and Australian cedar (*Toona ciliata*) were found to be immune to this pest. Two toxic components in the aqueous fraction of young leaves and shoots are held responsible for this resistance. Use of these exotic species could contribute to the solution of the shoot borer problem.

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