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Causes of differences in growth pattern, yield and quality of potatoes (*Solanum tuberosum* L.) in short rotations on sandy soil as affected by crop rotation, cultivar and application of granular nematicides

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Summary

A crop rotation experiment was carried out on a light sandy soil in 1979-1986 to study the effects of the frequency of potato cropping on yield, quality and on the occurrence of soil-borne pathogens other than potato cyst nematodes.

Tuber yield decreased markedly with increasing cropping frequency, but also depended on what crops were grown in rotation with potato. Growth during the early part of the season, as well as the length of the growing period, were reduced in short rotations. The fungi *Verticillium dahliae* and *Rhizoctonia solani,* and root-knot nematodes (*Meloidogyne* spp.) were the most important yield reducing pathogens. The effects of rotation depended on the cultivar used.

The percentage of mis-shapen tubers increased with increasing cropping frequency and after application of granular nematicides, but the incidence of common scab (*Streptomyces scabies*) was not affected.

Introduction

From 1979 to 1986 a field experiment was carried out on a sandy soil to study the effects of short rotations on the yield of potato (*Solanum tuberosum* L.) and on the development of soil-borne diseases in the crop.

Earlier reports on this experiment described the effects of various rotations and granular nematicides on the incidence of *Rhizoctonia solani* Kühn (Scholte, 1987) and on *Verticillium dahliae* Kleb. and *Colletotrichum coccodes* (Wallr.) Hughes (Scholte, 1989c). Leijdens & Hofmeester (1986) reported on the effects of the rotations on the occurrence of parasitic nematodes. This paper discusses the effect of rotations on the growth pattern, yield and tuber quality of potato, and suggests causes for reduced yields in short rotations.

Material and methods

Crop rotation experiment. This experiment has already been described (Scholte, 1987: Experiment 1). It was laid out near Wageningen in 1979 on light sandy soil containing 2.6 % organic matter and with a pH (KCl) of 5.2. Four rotations with potato (including continuous cropping) were compared: continuous cropping of potato (P); maize/potato (MP); sugar beet/potato (SP); maize/sugar beet/barley/barley/potato (MSBBP).

The rotations were compared on untreated plots and on plots treated annually with a granular nematicide, which was broadcast the day before planting and incorporated into the soil with a spring-tine cultivator. Oxamyl (Vydate 10G, Shell Nederland Chemie, Den Haag, 10 % a.i., 50 kg ha^{-1}) was applied in 1979–1984 and aldicarb (Temik 10G, Union Carbide Benelux, Maarssen, 10 % a.i., 30 kg ha^{-1}) in 1985 and 1986.

The experiment was laid out in a randomized complete block design with four replications; every crop in a rotation was grown in each year. For example, for the MSBBP rotation there were five untreated and five treated plots in each replication. The cultivar used was Element.

In 1986, the last year of the experiment, each potato plot was split into two, half being planted with cv. Element as before and half with cv. Mirka. 'Mirka' was included because of its high tolerance to *Verticillium dahliae* (Scholte et al., 1985).

The experiment also contained plots continuously cropped with barley since 1979 (preceding crops: rye in 1978 and potato in 1977). In 1986, these barley plots were planted with potatoes for the first time since 1977. This cropping system is designated as RB_7P.

Observations. At the beginning of the growing season the plants which had emerged were counted every 2–3 days. The duration of growth was recorded in days from planting to maturity, which was defined as the stage when ca. 90 % of the plants had no green leaves.

From 1981 to 1986 18 plants distributed evenly over each plot were harvested 74 days after planting. Fresh and dry matter yields and the dry matter content of foliage and tubers as well as the number of main stems (sprouting directly from the seed tuber) and tubers were determined. The dry weight of roots was also assessed in 1983–1985: they were dug out to ca. 20 cm depth and after careful washing in tap water they were separated from stems and stolons. Samples for dry matter determination were dried at 105 °C for at least 18 h in an oven with forced ventilation. Root galls caused by root-knot nematodes (*Meloidogyne hapla* Chitwood and *M. chitwoodi* Golden et al.) were assessed visually in 1983 and 1985. The number of galls was scored using four classes: 0 = none, 1 = few, 2 = moderate, 3 = many. From these figures a root gall index (RGI) was calculated using the formula

$$RGI = 100 \times (0 \times n_0 + 0.33 \times n_1 + 0.67 \times n_2 + n_3)/n_{total}$$

where n = the number in each category 0–3 and total.

At final harvest four rows 0.75×10 m were removed from each plot and the fresh and dry weights and dry matter content of the tubers determined. Common scab (caused by *Streptomyces scabies* (Taxter) Waksman et Henrici) was assessed on 100–150 tubers per plot, and scored in four classes: 0 = free from scab, 1 = slight scab (<20 %), 2 = moderate scab (20–50 %) and 3 = severe scab (>50 %). A common scab index was calculated using the same formula as for the root gall index.

Galls on tubers caused by *M. chitwoodi* were found only in 1983. The percentage of tubers with galls was assessed for each plot. In 1985 and 1986 the fresh weight percentage of mis-shapen tubers (elongated and knobby tubers with protruding eyes) was determined on samples of 100–150 tubers.

Soil pathogens. Earlier papers showed the effects of crop rotation on soil-borne pathogens in this experiment (Scholte, 1987, 1989c; Leijdens & Hofmeester, 1986). Soil infestation with pathogens prior to planting the potato crop is summarized for the period 1981 to 1986. Soil infestation with *V. dahliae* is based on the percentage of infected plants in the field, the rate of infection and the results of a soil test (Scholte, 1989c). Soil infestation with *R. solani* is based on percentage and severity of infected plants in the field (Scholte, 1987), whereas soil infestation with parasitic nematodes is based on their numbers per 100 ml soil (Leijdens & Hofmeester, 1986).

Multiple linear regression analyses are used to find the relative importance of each pathogen to the final tuber yield, and calculations are made to estimate the contribution of *R. solani* to the yield depression in the short rotations.

Results

Crop parameters 74 days after planting. Complete crop emergence was observed on all plots each year. Its rate was not affected by the rotation or nematicide treatment (data not shown).

The nematicides increased haulm and tuber weight in all rotations, but the increase differed between rotations (Table 1). Thus there was a slight increase in MP but a marked increase in P and SP. The order in which the rotations were ranked for yield attributes was changed by the application of nematicides. This is clearly shown for the total dry matter yield. The ranking order from high to low yield was MSBBP = MP > SP > P in untreated plots and MSBBP > MP = SP > P in treated plots.

In untreated plots the dry haulm weight did not differ between the rotations MSBBP and MP, but was much lower in SP and very much lower in P. In untreated plots the tuber weight (fresh and dry matter) differed significantly between all the rotations, in the order MSBBP > MP > SP > P.

In untreated plots the root weight increased in the order MSBBP, MP, P and SP. A close positive linear relationship was found between the root weight and the root gall index ($r=0.99$, $P \leq 0.001$). The root gall index was highest in rotation SP. There were no differences in root weight between rotations when nematicides were used.

The dry matter content of the haulm reflected the growing conditions, so that the best crops had the lowest dry matter contents. Thus the dry matter content of MSBBP plants was lower than that of plants grown in P, with intermediate levels for MP and SP plants. Dry matter content was always lower when nematicides were applied.

No significant differences in dry matter content of the tubers were found between rotations, but it was significantly lower in all rotations if nematicides were applied.

Nematicides increased the number of stems and tubers. No significant differences in the number of main stems and tubers were found between rotations in untreated plots. However, in treated plots the rotation MSBBP produced most stems and tubers, and plots continuously cropped with potato (P) the least. The rotations MP and SP were intermediate.

Crop parameters at final harvest. At final harvest, fresh and dry tuber yields varied greatly between rotations (Table 2). Nematicides increased yield in all rotations, but the extent depended on the rotation. The highest relative increase was found in SP and P and the lowest in MP. The ranking order of the rotations in terms of dry matter yield of tubers was MSBBP > > MP > > SP > > P in untreated plots and

Table 1. Effect of crop rotation and nematicide treatment (N) on various crop parameters at harvest ca. 74 days after planting, averaged over 1981 – 1986.

Crop parameter[a]	N[b]	Rotation[c]								Mean
		P		MP		SP		MSBBP		
Relative total dry weight	–	73		95		84		100		88
	+	91		102		104		114		103
Total dry weight (g/m²)	–	225	c	292	a	258	b	308	a	271
	+	279	c	315	b	320	b	350	a	316***
Tuber fresh weight (g/m²)	–	549	c	750	b	646	bc	879	a	706
	+	713	c	856	b	896	b	1014	a	870***
Tuber dry weight (g/m²)	–	99	c	131	ab	118	bc	152	a	125
	+	122	c	144	b	154	ab	167	a	147***
Haulm dry weight (g/m²)	–	127	c	161	a	140	b	157	a	146
	+	157	c	171	ab	166	bc	182	a	169***
Root dry weight (g/m²)[d]	–	5.19	b	4.80	b	6.07	a	4.63	b	5.17
	+	4.39	a	4.26	a	4.40	a	4.26	a	4.33***
Dry matter content of tubers (%)	–	16.0	a	15.8	a	15.9	a	15.7	a	15.9
	+	15.6	a	15.5	a	15.6	a	15.3	a	15.5***
Dry matter content of haulm (%)	–	10.3	a	9.9	bc	10.0	b	9.7	c	10.0
	+	9.9	a	9.4	b	9.5	b	9.1	c	9.5***
Main stem number/m²	–	16.9	a	18.2	a	17.5	a	17.4	a	17.5
	+	17.4	b	18.4	b	18.7	ab	20.1	a	18.6***
Tuber number/m²	–	55.5	a	58.9	a	61.5	a	62.1	a	59.5
	+	65.8	b	68.3	b	67.2	b	76.3	a	69.4***
Root gall index (0 – 100)[e]	–	40	b	25	bc	68	a	13	c	36
	+	12	a	4	a	4	a	0	a	5***

[a] For each parameter: different letters indicate that differences between rotations within a nematicide treatment are significant at $P \leq 0.05$ (according to the Studentized range test of Tukey).
[b] – = control, + = plots treated annually with a granular nematicide.
[c] P = continuous cropping of potato; MP = maize/potato; SP = sugar beet/potato; MSBBP = maize/sugar beet/barley/barley/potato.
[d] Averaged over 1983 – 1985.
[e] Averaged over 1983 and 1985.
*** Indicate significant effects of the nematicide treatment at $P \leq 0.001$.

MSBBP > > MP ≥ SP > > P in treated plots. The relative differences between rotations were much greater at final harvest than at the harvest 74 days after planting (Tables 1 and 2).

The dry matter content of the tubers increased with increasing cropping frequency in untreated plots, but there were no differences between rotations in plots treated with nematicides (Table 2).

Table 2. Effect of crop rotation and nematicide treatment (N) on various crop parameters at final harvest, averaged over 1981 – 1986.

Parameter [a]	N [b]	Rotation [c]								Mean
		P		MP		SP		MSBBP		
Tuber relative dry weight	–	65		88		74		100		82
	+	82		99		94		117		98
Tuber dry weight (g/m^2)	–	675	d	920	b	773	c	1043	a	853
	+	852	c	1035	b	980	b	1225	a	1023 ***
Tubers fresh weight (g/m^2)	–	2819	d	3872	b	3294	c	4462	a	3612
	+	3572	c	4335	b	4085	b	5188	a	4295 ***
Dry matter content of tubers (%)	–	24.0	a	23.7	ab	23.5	bc	23.3	c	23.6
	+	23.8	a	23.9	a	23.9	a	23.6	a	23.8 *
Fraction of tubers with galls (%)	–	5.8	yz	12.1	x	8.6	xy	1.1	z	6.9
	+	2.5	x	1.3	x	0.3	x	0	x	1.0 ***
Growing period (days)	–	126	d	135	b	131	c	139	a	133
	+	132	d	140	b	136	c	145	a	138 ***

[a] For each parameter: different letters indicate significant differences between rotations within a nematicide treatment at $P \leq 0.10$ (letters x to z) or at $P \leq 0.05$ (letters a to d) (according to the Studentized range test of Tukey).
[b] and [c] For explanation: see Table 1.
* and *** Indicate significant effects of the nematicide treatment at $P \leq 0.05$ and $P \leq 0.001$, respectively.

The duration of the growing season decreased in the order MSBBP, MP, SP and P and increased in all rotations after applications of nematicides (Table 2).

Yield attributes of cvs Element and Mirka in 1986. In 1986 the potato yield was higher in RB_7P than in MSBBP (Table 3). The difference in yield between these two cropping systems was much greater for cv. Element than for cv. Mirka. The tuber yield of both cultivars increased after application of nematicides, both in the MSBBP rotation and in the cropping system with potato after eight years of cereals (RB_7P). However, in the short rotations the cultivars responded differently to the application of nematicides. In P, MP and SP the tuber yield of cv. Element increased appreciably, whereas the yield of cv. Mirka did not react at all.

Tuber quality at final harvest. The effects of rotations and nematicide treatment on the occurrence of common scab and mis-shapen tubers are given only for 1986 (Table 4), because this was the year for which the results of cropping potatoes after eight years of cereals were available. Neither the cropping frequency (the rotational effects) nor the application of nematicides had any effect on the incidence of common scab. This was also true for cv. Element in the preceding years. Averaged over 1981 to 1986 the common scab index ranged between 36 and 41, irrespective of rotation and nematicide treatment.

Table 3. Effect of crop rotation and nematicide treatment (N) on dry weight (g/m^2) of tubers at final harvest, for cultivars Element and Mirka in 1986.

Cultivar [a]	N [b]	Rotation [c]					Mean
		P	MP	SP	MSBBP	RB_7P [d]	
Element	–	754 d	1111 b	894 c	1077 b	1403 a	1048
	+	815 d	1242 b	1065 c	1283 b	1580 a	1197 ***
Mirka	–	1022 c	1496 a	1326 b	1534 a	1613 a	1398
	+	1019 d	1435 c	1318 c	1681 b	1842 a	1459 *

[a], [b] and [c] For explanation: see Table 1.
[d] RB_7P = rye in 1978, barley from 1979 to 1985 and potato in 1986.
* The nematicide effect is significant in MSBBP and RB_7P ($P \leq 0.05$) and not in the other rotations.
*** Indicate significant effects of the nematicide treatment at $P \leq 0.001$.

Table 4. Effect of crop rotation and nematicide treatment (N) on common scab index (0 – 100) of tubers and on the fraction of mis-shapen tubers (fresh weight) in 1986, averaged over two cultivars.

Parameter [a]	N [b]	Rotation [c]					Mean
		P	MP	SP	MSBBP	RB_7P [d]	
Common scab index	–	57	55	45	58	57	54
	+	54	52	52	47	48	50
	Mean	55 a	53 a	49 a	52 a	52 a	
Weight % of mis-shapen tubers	–	8.6	3.3	3.3	2.8	1.1	3.8
	+	21.5	8.4	5.1	2.2	2.4	7.9 **
	Mean	15.1 a	5.9 b	4.2 b	2.5 b	1.7 b	

[a], [b] and [c] For explanation: see Table 1.
[d] For explanation: see Table 3.
** The nematicide effect is significant in P and MP ($P \leq 0.05$) and not in the other rotations.

The nematicide treatment increased the fresh weight percentage of mis-shapen tubers. However, this increase was significant ($P \leq 0.05$) only in the rotations P and MP. The percentage of mis-shapen tubers was high in P and much lower in the other rotations. Similar results were obtained in 1985 (data not shown). In that year the weight percentage of mis-shapen tubers increased significantly in P, from 15.1 % in the control to 24.9 % in the nematicide treatment, and in MP from 2.8 to 9.3 %. Levels in the other rotations were low and not affected by the nematicide.

In 1983 many tubers showed galls resulting from *M. chitwoodi* at final harvest. This was the only year in which these galls occurred; they were probably promoted by the weather conditions that year (a cool and very wet spring was followed by high tempera-

Table 5. Soil infestation with soil pathogens prior to planting the potato in various crop rotations. +, + +, + + +, + + + + and + + + + + indicate a low, moderate, high, severe and very severe infestation, respectively.

Pathogen	Rotation [a]			
	P	MP	SP	MSBBP
V. dahliae [b]	+ + + + +	+ + + +	+ + + +	+ +
R. solani [c]	+ + + + +	+ + +	+ + +	+
Meloidogyne spp. [d]	+ + + + +	+ +	+ + + +	+ +
Pratylenchus spp. [d]	+	+ + +	+	+ + +
Tylenchorhynchus dubius [d]	+	+ + +	+	+ + + +
Rotylenchus robustus [d]	+ +	+	+ + +	+
Paratylenchus projectus [d]	+	+	+ + +	+

[a] For explanation: see Table 1.
[b] Scholte (1989c).
[c] Scholte (1987).
[d] Leijdens & Hofmeester (1986).

tures during summer). Most tubers with galls were found in the rotation MP, fewer were found in SP and fewest in MSBBP (Table 2). The application of nematicides greatly reduced the number of tubers with galls.

Effects of soil pathogens on yield. Soil infestation with *V. dahliae* and *R. solani* increased with increasing cropping frequency of potato (Table 5), whereas the number of nematodes also depended on the suitability of the other crops grown in rotation.

Multiple linear regression analysis showed that *V. dahliae*, *Meloidogyne* spp. and *R. solani* accounted for 91 % ($P \leq 0.01$) of the total variation in dry tuber weight for cv. Element (averaged over 1981 to 1986) at final harvest. *V. dahliae* accounted for by far the greatest variation and *R. solani* the least. The same pathogens explained 88 % ($P \leq 0.01$) of the total variation for cv. Mirka (used only in 1986), but in this case *R. solani* accounted for by far the greatest variation. When *C. coccodes* was included in the regression analysis models of both cultivars, it did not increase the percentage variation that could be explained.

R. solani attacks on stems and stolons were assessed in 1981–1986 (Scholte, 1987). Scholte (1989b) also assessed the effects of stem and stolon attacks of *R. solani* on final tuber yield. The contribution of *R. solani* to the tuber yield depressions in the short rotations are shown in Table 6. Only a limited part of the yield depressions in the short rotations could be ascribed to *R. solani* for cv. Element. However, its contribution to the yield depressin of Mirka in 1986 was high.

Discussion

Yields decreased with increased frequency of potato cropping. Differences in growth between the short rotations and the five-year rotation MSBBP were noticeable during the early part of the growing season. Growth of potatoes was particularly reduced in P and SP rotations. The main cause of the reduced growth in these short rotations

Table 6. Decrease (%) in dry tuber yield in the rotations P, MP and SP compared with the rotation MSBBP for cvs Element (averaged over 1981 – 1986) and Mirka (1986), and the estimated contribution of *R. solani* to yield decrease.

Rotation[a]	Element				Mirka			
	control		nematicide		control		nematicide	
	total	*R. solani*	total	*R. solani*	total	*R. solani*	total	*R. solani*
P	35	4	30	10	33	22	39	25
MP	12	2	16	5	3	4	15	14
SP	26	3	20	4	14	3	22	14

[a] For explanation: see Table 1.

was initially attack by the root-knot nematodes. They were the dominant nematodes in this experiment (Leijdens & Hofmeester, 1986). Cyst nematodes could not be detected. Root-knot nematodes occurred in all rotations, but most were found in P and SP. Population densities were much lower in MP than in P and SP, and the yield reduction in MP was initially low compared with MSBBP. The higher dry matter content in the haulm in the short rotations and on untreated plots was a consequence of a reduced uptake of water. In 1986, uptake of minerals was also reduced (data not shown), but the mineral content of plants in the short rotations was the same as in MSBBP.

A small part of the reduced growth in the short rotations in the first part of the growing season can be ascribed to *R. solani*, especially in P. Severe attacks on stems and stolons by this fungus reduce plant growth (Scholte, 1989b).

In the second half of the growing season yield depressions increased in the short rotations, mainly because of the fast development of wilt symptoms in the leaves caused by *V. dahliae* (Scholte, 1989c). This resulted in a lower level of light interception (data not shown) and a shortening of the growing season. Multiple linear regression analyses showed that *V. dahliae* was the biggest yield-reducing factor for cv. Element in the short rotations, followed by *Meloidogyne* spp. *R. solani* accounted for a small part of these yield reductions. This fact was confirmed by calculations about the contribution of *R. solani* to the yield depressions (Table 6).

Potatoes yielded less in the five-year rotation MSBBP than after eight years of cereals (RB_7P). This difference in yield can mainly be ascribed to differences in soil infestation with *V. dahliae* (Scholte, 1989c). Thus, in 1986 the difference in yield between the two cropping systems was greater for cv. Element (which is very susceptible to *V. dahliae*) than for cv. Mirka (which is highly tolerant to it). The positive effect of nematicides in MSBBP and RB_7P is probably mainly caused by the control of root-knot nematodes, in MSBBP accompanied by a retardation of the *V. dahliae* infection and in RB_7P possibly by a control of the high population density of *Tylenchorhynchus dubius* (Bütschli) Filipjev. The population of root-knot nematodes occurring in RB_7P was probably mainly *M. chitwoodi*, because barley is a non-host for *M. hapla* and a suitable host for *M. chitwoodi*.

'Mirka' appeared to be very susceptible to *R. solani* (Scholte, 1989b). This explains why the application of nematicides had no positive effect on the yields of this cultivar in P, MP and SP in 1986 (Table 3). Nematicides greatly increased the *R. solani* attack on stems and stolons. Thus the positive effects of nematode control were cancelled by an increase in *R. solani,* which contributed to the yield depressions of cv. Mirka in short rotations (Table 6 and results of multiple linear regression analyses).

The stimulatory effect of granular nematicides on *R. solani* was found by Hofman (1988) to be primarily caused by reduced grazing by mycophagous soil fauna (nematodes, springtails and mites) on the pathogen in nematicide-treated fields.

Another effect of nematicides was observed in this experiment in that they retarded *V. dahliae* infection (Scholte, 1989b). Endoparasitic nematodes such as *M. hapla* promote infection by *V. dahliae,* so the increased duration of the growing season after application of nematicides can be explained at least partly by their retarding effect on *V. dahliae.*

Another synergistic interaction between soil pathogens may have occurred in this experiment. Scholte & s'Jacob (1989) showed a synergistic interaction between *V. dahliae* and *R. solani* in the presence of *Meloidogyne* spp. All these pathogens occurred in high densities in the experiment.

As well as yield, tuber quality was also affected by short rotations. An increase in mis-shapen tubers resulted from the increased activity of *R. solani* in these rotations (Scholte, 1989b).

Tuber quality was also affected by common scab. However, there was no relation between the cropping frequency and the incidence of common scab. It differs in this aspect from netted scab (Scholte, 1989a; Scholte & Labruyère, 1985).

Different crops in a rotation react differently to *Meloidogyne* spp. The host ranges of *M. hapla* have been studied by Faulkner & McElroy (1964) and those of *M. chitwoodi* by O'Bannon et al. (1982) and Mojtahedi et al. (1988). Host crop suitability also depends on the cultivar used, but in general the potato is an excellent host for both *M. hapla* and *M. chitwoodi.* Sugar beet is considered a moderately suitable host for both nematode species, whereas maize is a non-host for *M. hapla* and a suitable host for *M. chitwoodi.* Thus, maize enhances *M. chitwoodi* and therefore this nematode met less competition with *M. hapla* in MP than in P and SP. The optimum temperature for *M. chitwoodi* is lower than for *M. hapla* (O'Bannon & Santo, 1984) and consequently it completes more generations within a season. These facts explain why in 1983 the percentage of tubers with galls was higher in MP than in other short rotations.

Conclusions

1. On sandy soils the yield of potato depends greatly on the cropping frequency of that crop and also on the crops in rotation with it.
2. *V. dahliae, R. solani* and *Meloidogyne* spp. are important yield-reducing pathogens in short rotations on sandy soils.
3. The cultivars used in a crop rotation experiment greatly influence the results.
4. Root galls induced by root-knot nematodes increase the root weight.
5. The incidence of common scab on tubers is not affected by the cropping frequency of the potato or the application of granular nematicides.
6. The fresh weight percentage of mis-shapen tubers increases with increasing cropping frequency and after application of granular nematicides.

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References

Faulkner, L. R. & F. D. McElroy, 1964. Host range of northern root-knot nematode on irrigated crop plants and weeds in Washington. *Plant Disease Reporter* 48: 190–193.

Hofman, T. W., 1988. Effects of granular nematicides on the infection of potatoes by *Rhizoctonia solani*. Thesis, Wageningen Agricultural University: pp. 1–123.

Leijdens, M. B. & Y. Hofmeester, 1986. Population fluctuations of some nematodes on potato and sugar beet in relation to different crop rotations. *Mededelingen Faculteit Landbouwwetenschappen der Rijksuniversiteit Gent* 51/3b: 1279–1286.

Mojtahedi, H., G. S. Santo & J. H. Wilson, 1988. Host tests to differentiate *Meloidogyne chitwoodi* races 1 and 2 and *M. hapla*. *Journal of Nematology* 20: 468–473.

O'Bannon, J. H., G. S. Santo & A. P. Nyczepir, 1982. Host range of the Columbia root-knot nematode. *Plant Disease* 66: 1045--1048.

O'Bannon, J. H. & G. S. Santo, 1984. Effect of soil temperature on reproduction of *Meloidogyne chitwoodi* and *M. hapla* alone and in combination on potato and *M. chitwoodi* on rotation plants. *Journal of Nematology* 16: 309–312.

Scholte, K., 1987. The effect of crop rotation and granular nematicides on the incidence of *Rhizoctonia solani* in potato. *Potato Research* 30: 187–199.

Scholte, K., 1989a. The effect of netted scab. (*Streptomyces* spp.) and *Verticillium dahliae* on growth and yield of potato. *Potato Research* 32: 65–73.

Scholte, K., 1989b. Effects of soil-borne *Rhizoctonia solani* Kühn on yield and quality of ten potato cultivars. *Potato Research* 32: 367–376.

Scholte, K., 1989c. Effects of crop rotation and granular nematicides on the incidence of *Verticillium dahliae* Kleb. and *Colletotrichum coccodes* (Wallr.) Hughes, in potato. *Potato Research* 32: 377–385.

Scholte, K. & J. J. s'Jacob, 1989. Synergistic interactions between *Rhizoctonia solani* Kühn, *Verticillium dahliae* Kleb., *Meloidogyne* spp. and *Pratylenchus neglectus* (Rensch) Chitwood & Oteifa, in potato. *Potato Research* 32: 387–395.

Scholte, K. & R. E. Labruyère, 1985. Netted scab: a new name for an old disease in Europe. *Potato Research* 28: 443–448.

Scholte, K., J. W. Veenbas-Rijks & R. E. Labruyère, 1985. Potato growing in short rotations and the effect of *Streptomyces* spp., *Colletotrichum coccodes, Fusarium tabacinum* and *Verticillium dahliae* on plant growth and tuber yield. *Potato Research* 28: 331–348.