Slutrapport

Strategies for control of root-knot and free living nematodes in crop rotations with potato and root crops

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Introduction

Plant parasitic nematodes (PPN) reduce quality and yield in many crops and are a major threat to world food production. Symptoms constitute root lesions, excessive growth of lateral roots, formation of galls and cysts on the roots (Bridge and Starr, 2007). The destroyed roots can no longer support the plants with water and nutrients and they suffer from deficiencies and water stress. In wounds caused by the feeding of the nematodes, secondary fungi can infect the roots leading to rots. There are no chemical products available for control of PPN and control strategies must include the use of resistent/tolerant crops/varieties and inter crops which are poor or non-hosts. In this project, we have studied host suitability of crops and varieties to *Pratylenchus thornei, P. penetrans* and *Meloidogyne hapla* in bioassays under controlled conditions in WP1, host suitability of inter crops in infested field trials before growing potato, carrot or sugar beet in WP2 and methodology for comparison of host susceptibility in potato varieties to PPN in WP3.

Materials and methods

WP1. Host suitability of main crops. Naturally infested soil (*P. thornei* from Söderslätt, *P. penetrans* from Löddeköpinge*, M. hapla* from Råröd and Gärds köpinge) was mixed and put in 0.5 l pots and sown with ten seeds/pot. The pots were placed in the greenhouse in a randomised block design with one pot per block, 5 blocks. The plants were grown in 16 h day/8 h night cycle, temperature 24°C/19°C for 12 weeks. Nematodes were extracted and the number of juveniles and adults of *P. penetrans* were counted. The reproduction factor (Rf) was calculated as final/initial density (Pf/Pi). The Rf value was also expressed as Rf crop/Rf for susceptible variety, wheat variety Kashmir for *P. thornei* and *P. tanacetifolia* for *P. penetrans*. For *M. hapla*, the number of galls on the roots were counted. In the experiments with artificial inoculation with *P. penetrans* and *M. hapla,* the seeds were sown in a mix with 90% silver sand and 10% Hasselfors peat. Inoculation with 4500 nematodes/pot was done 2 weeks after sowing. Tested crops and varieties are presented in Table 5 for *P. penetrans*. 7 varieties of carrot were tested for sensitivity to *M. hapla*. In 2020, daylight chamber trials were established as a part of a master's project "Cover crops for plant protection", Izabella Lundborg, at SLU-Alnarp assessing sanitation of the plant parasitic nematodes *P. penetrans* and *M. hapla* using cover crops. In the experiments, the plant species blue lupine, *L. angustifolius,* and black oat, *A. strigosa,* were both studied for the respective nematode species. In addition, susceptible tomato, *Solanum lycopersicum* cv. Moneymaker was kept as control treatment for *M. hapla* and phacelia, *P. tanacetifolia* for *P. penetrans*. Host suitability rating was: N = non-host (Rf < 0.1), P = poor host (Rf = 0.1 to 0.9), M = minor host (Rf = 1.0 to 4.9), G = good host (Rf = 5.0 to 9.9) and VG = very good host (Rf ≥ 10.0).

WP2. Sanitation of RKN and FLN using inter crops. The field trials and plans established in this study are presented in table 1-3. At harvest of sugar beet, 20 roots in each plot were evaluated for forking: 1 = no forking, 2 = <5 lateral roots, 3 = 5 – 10 lateral roots and 4 = > 10 lateral roots. A forking index (FI) was calculated: (0*n1+25*n2+50*n3+100*n4)/N, n= the number of plants in each category, N=total number of plants. The clean weight, sugar content and sugar yield was measured. In May 2020, 50 barley plants in DC25-27 were sampled per plot at Segesholm and evaluated for gall formation caused by *Longidorus* spp. In the carrot trials, the roots in each plot were classified at harvest into four categories: 0=marketable, 20-

42 mm in diameter, >12 cm long; 1=to small or to big; 2=2-3 lateral roots, 3=> 3 lateral roots. FI was calculated as above for sugar beet. Marketable yield (ton/ha and %) was calculated. The potatoes were sorted into fractions: 0-20, 20–40, 40–60 and >60 mm. 40 tubers from each plot were evaluated for diseases.

Table 1. Year for inter crops and main crops in the field trials

Location	**Field trial**	**2019**	**2020**	**2021**
Skåne	Borgeby	Inter crop	Sugar beet	
Skåne	Segesholm	Inter crop	Barley, inter crop	Sugar beet
Skåne	Klagstorp	Inter crop	Sugar beet	
Skåne	Gärds köpinge	-	Inter crop	Sugar beet
Gotland	Ryftes1	Inter crop	Carrots	
Gotland	Ryftes2	-	Inter crop	Carrots
Gotland	Ryftes3	-	Inter crop	Carrots
Skåne	Viby	-	Inter crop	potato
Gotland	När	-	Inter crop	Potato
Gotland	Skags	-	Inter crop	Potato
Gotland	Stora Tollby	-	Inter crop	Potato

Table 2. Trial plans with inter crops 2019

Borgeby, Ryftes, Segesholm	**Klagstorp**
No inter crop	No inter crop
R. sativus var *oleifera* Angus	*R. sativus* var *oleifera* Defender
R. sativus var *oleifera* Contra	*R. sativus* var *oleifera* Angus
R. sativus var *oleifera* Defender	*R. sativus* var *oleifera* Contra
R. sativus var *oleifera* Control	*R. sativus* var *oleifera* Control
Viterra intensiv (*A. strigosa* + *R. sativus* var *oleifera*)	*A. strigosa*
A. strigosa	
Tagetes patula mix	

Table 3. Trial plans 2020 on Gotland and in Skåne

Ryftes2,3; När, Tollby, Viby	**Skags**	**Gärds Köpinge**	**Segesholm**
No inter crop	No inter crop	No inter crop	No inter crop
R. sativus var *oleifera* Defender	*P. tanacetifolia*	*R. sativus* var *oleifera* Angus	*R. sativus* var *oleifera* Angus
R. sativus var *oleifera* Terranova	*R. sativus* var *oleifera* Defender	*R. sativus* var *oleifera* Contra	*R. sativus* var *oleifera* Contra
Viterra intensiv (*A. strigosa* + *R. sativus* var *oleifera*)	Viterra intensiv (*A. strigosa* + *R. sativus* var *oleifera*)	*R. sativus* var *oleifera* Defender	*R. sativus* var *oleifera* Defender
A. strigosa	*A. strigosa*	*R. sativus* var *oleifera* Adventure	*R. sativus* var *oleifera* Control
L. angustifolius + *A. strigosa* + *R. sativus* var *oleifera* Terranova	*Tagetes patula* mix	*R. sativus* var *oleifera* Dracula	Viterra intensiv (*A. strigosa* + *R. sativus* var *oleifera*)
L. angustifolius, var. Boregine		*R. sativus* var *oleifera* Terranova	*A. strigosa*
P. tanacetifolia		Peas	*Tagetes patula* mix

Population dynamics and sampling time. To investigate the importance of sampling time for estimation of nematode populations, five fields were sampled monthly and nematodes species and densities were analysed. The fields were Segesholm, Gärds Köpinge, Borgeby, Löddeköpinge and Råröd.

WP3. Methodology for variety trials in potato on nematode infested soil. In 2020, a demonstration trial with 44 potato varieties were performed in Hasslöv, Halland by the Potato growers association. Soil for analysis of nematodes was sampled from plots with Folva, Queen Anne, King Edward and Bintje. At harvest 40 tubers from each plot were evaluated as described above. In cooperation with SLU, two starch potato trials, Nymö and Kristianstad 2020, where evaluated for differences between varieties (Kuras and Avenue) in susceptibility to nematodes. In 2021, a variety trial including eight potato varieties (Queen Anne, King Edward, Belana, Folva, Melody, Kingsman, Baby Lou and Lucera) was performed in Kristianstad.

Statistical calculations. Normality of nematode densities and number of galls on roots was checked using the method by Shapiro-Wilks. Data not meeting the assumption of normality were transformed using log10(x+1). Differences between crops/varieties in experiements and field trials was analysed with two-way analysis of variance using Sigmaplot 14.5. Multipe pairwise comparisons between treatments were calculated using the Holm-Sidak method. Differences referred to are significant unless otherwise stated, while *p*-values between 0.05 and 0.1 were taken to indicate tendencies.

Results and discussion

WP1. Host suitability of main crops and varieties. There were differences in host suitability to *P. thornei* among varieties of winter wheat. Rf ranged from 2.9 in Memory to 5.2; 14.3 and 11.5 in Kerrin, Kashmir and Elvis, respectively (Table 4). The ranking of winter wheat varieties was similar between the experiments with Kashmir having the highest Rf followed by Kerrin and Memory. Memory is thus a minor host, Kerrin a good host and Kashmir and Elvis very good hosts (Table 4). The varieties of spring wheat, spring and winter barley had Rf <1 indicating that they are poor hosts. Oat had Rf=1.2 and is a minor host. The tested varieties of OSR and sugar beet had Rf <1 and are also poor hosts. Our results on wheat and barley are in line with several earlier studies (Hollaway *et al.,* 2000; Smiley *et al.,* 2014). Hollaway *et al.,* (2000) showed that all wheat cultivars grown in southeastern Australia were susceptible to *P. thornei* while barley cultivars were resistant or moderately resistant. The experiment with *M. hapla* infested soil from Råröd showed that there were few galls on the varieties of OSR (Figure 1). Galls developed on sugar beet but there were no significant differences between the varieties. There was a negative correlation between emergence and number of galls per plant at Råröd (Pearson corr. coeff.=-0.44, p=0.003). The varieties of carrot were all found to be infected by *M. hapla* to various degrees. At Råröd, Romance had more galls/plant and lower emergence than Bolero and Match indicating a higher sensitivity to *M. hapla*. The level of infection of *M. hapla* in the experiment with soil from from Gärds Köpinge was low and galls developed only in carrot and OSR Defender. The occurrence of stubby roots in sugar beet indicate that other FLN may have affected the results in this experiment making the comparison between varieties uncertain.

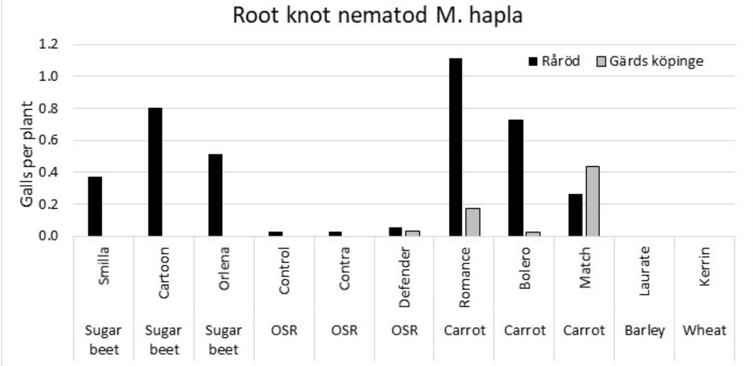


Figure 1. The number of galls formed by M. hapla on varieties of sugar beet, oil seed radish and carrot Råröd and Gärds köpinge. The figure shows LSmeans. p (Råröd) =0.014, p (Gärds köpinge) <0.001.

In the experiment with artifical inoculation with J2 of *M. hapla*, all varieties (Romance, Nerac, Darina, Favorit and Charisma) developed galls and there were no differences in number of galls per plant or emergence between the varieties.

There were differences between species and varieties tested for host suitability to *P. penetrans* (Table 5). The highest Rf was found for *L. angustifolius* Regent (1.59, minor host). The varieties of OSR were either poor or non-hosts. *P. tanacetifolia* was a poor host.

Table 4. Reproduction factor (Rf), host suitability rating (HS) and Rf crop/Rf Kashmir grown in experiment 1 and 2 with soil naturally infected with Pratylenchus thornei

		Rf / HS rating**		Rf/Rf Kashmir	
		Exp 1*	**Exp 2***	**Exp 1**	**Exp 2**
Winter wheat	Elvis	11.48 VG	-	0.86	-
	Kashmir	14.33 VG	0.88	1.00	1.00
	Kerrin	5.23 G	0.41	0.38	0.56
	Memory	2.93 M	0.09	0.25	0.29
	Stinger	-	2.43	-	2.00
Spring wheat	Quarna	-	0.92	-	1.96
Spring barley	Planet	0.07 N	0.21	0.01	0.29
	Laurate	0.28 P	0.18	0.02	0.43
Winter barley	Wallace	0.77 P	0.10	0.05	0.21
	Flair	-	0.22	-	0.30
R. sativa var. oleifera	Defender	0.34 P	0.39	0.03	0.72
	Terranova	0.17 P	0.10	0.01	0.26
	Angus	0.23 P	0.19	0.01	0.25
Tagetes	Ground control	0.34 P	0.24	0.00	0.29
Sugar beet	Cartoon	0.53 P	0.34	0.04	0.45
	Smilla	0.43 P	0.44	0.03	0.87
	Orlena	0.35 P	-	0.02	-
	Daphna	-	0.21	-	0.09
Oat	Symphony	-	1.26	-	1.21
Phacelia tanacetofolia		-	0.92	-	1.17
	P (treatm)	*<0.001*	*<0.001*	*0.013*	*0.042*

*Pi exp 1 = 22 ind/250 g soil, exp 2 = 18 ind/250g soil.

Table 5. Reproduction factor (Rf) and reproduction factor Rf crop/ Rf for P. tanacetifolia for crops/varieties grown in experiment with soil naturally infected with P. penetrans

Species	**Variety**	**Rf / HS rating****	**Rf/Rf Phacelia**
Phacelia tanacetifolia		0.82 P	1.00
Raphanus sativa var. oleifera	Defender	0.12 P	0.66
	Contra	0.07 N	0.09
	S103g	0.35 P	1.28
	Adventure	0.44 P	0.36
	Doublet	0.07 N	0.18
	Terranova	0.14 P	0.84
Tagetes		0.02 N	0.00
Avena strigosa	Bristol	0.08 N	0.29
Lupinus angustifolius	Regent	1.59 M	3.83
	Mirabor	0.76 P	1.74
	P (treatm)	*<0.001*	*0.003*

The analysis of variances among the treatments in the *M. hapla* experiment within the master thesis revealed a difference (Kruskal-Wallis, p <0.001, df=2) in disease severity among the three treatments, *S. lycopersicum*, *A. strigosa* and *L. angustifolius.* The root gall indices (RGI) regarding the specific treatments were 0.82, 0 and 0.71 respectively. *L. angustifolius* was found to be susceptible to *M. hapla.* The analysis of variance revealed that *A. strigosa, P. tanacetifolia* and *L. angustifolius* tested within the master thesis had a significant impact on the amount of *P. penetrans* in the soil (ANOVA, p<0.001, df= 3). Moreover, the reproduction factor Pf/Pi of *P. penetrans* differed based on the treatments (ANOVA, p<0.001, df= 2). Multi comparison performed by Tukey's test of nematode counts and Pf/Pi showed that *L. angustifolius* had higher Pf/Pi than *A. strigosa* and *P. tanacetifolia*.

WP2. Sanitation of RKN and FLN using inter crops. At Ryftes1, there were differences between the inter crops in number of stubby root nematodes found in the spring 2020 before sowing carrots (Figure 2). OSR Defender (p=0.027) had higher density of stubby root nematodes than *A. strigosa*. There were no differences in marketable yield or FI. At Ryftes3 2021, the mix with *L. angustifolius, A. strigosa* and OSR had higher FI than the control without inter crop and *P. tanacetifolia* (p=0.039) (Table 6). There was also a tendency for low marketable yield (%) in this mix (p=0.089). This indicates that mixes with inter crops can multiply several species of nematodes.

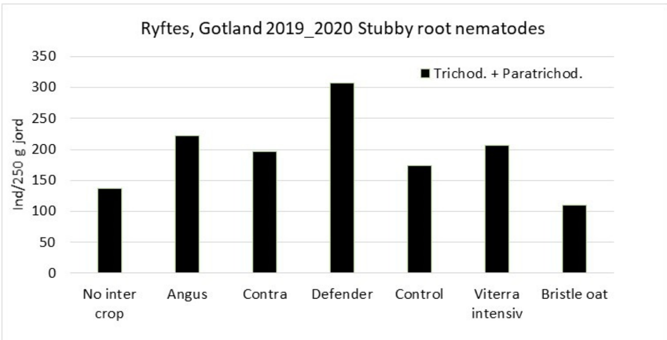


Figure 2. The total number of stubby root nematodes (Trichodorus + Paratrichodorus) before sowing carrots at Ryftes1 in the spring 2020. p=0.031.

Table 6. Marketable yield (ton/ha, %) and forking index (FI) at Ryftes 2 and 3 2021

	Ryftes2 Marketable yield		**FI**	**Ryftes3 Marketable yield**		**FI**
	ton/ha	%	0-100	ton/ha	%	0-100
No inter crop	26.61	80.62	9	36.20	62.26	21
Defender	34.88	67.04	12	30.21	53.47	27
Terranova	37.46	81.87	8	32.21	60.43	24
Viterra intensiv	25.56	78.58	8	31.35	56.17	27
A. strigosa	29.59	73.74	10	28.39	56.45	28
L. angustifolius, A. strigosa, *R. sativus* v. *oleifera*	33.01	69.26	13	27.05	50.58	32
L. angustifolius	28.98	74.97	10	27.98	54.34	22
P. tanacetifolia	35.79	76.70	10	37.16	66.45	20
P (treatm)	*ns*	*ns*	*ns*	*ns*	*0.052*	*0.021*

At Klagstorp, there were fewer individuals of *P. neglectus* after unfertilized OSR (Defender, Angus, Contra and Control) and OSR Defender + *A. strigosa* than in the control. There were no differences in sugar yield or FI with or without fertilization. Sugar beet is a poor host to *P. neglectus* and the yield has not been shown to be affected in previous trials at NBR (Olsson and Persson, Betodlaren 4, 2018).

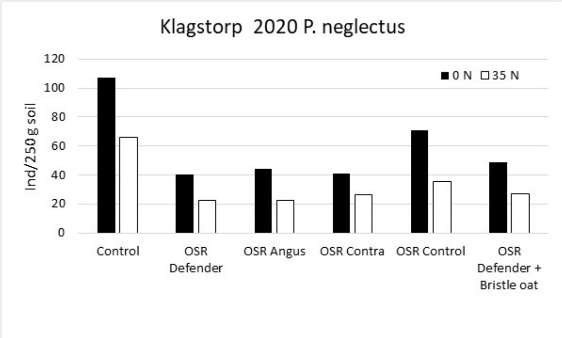


Figure 3. The number of root lesion nematodes P. neglectus after growing OSR at Klagstorp 2020. p (0 N) = 0.036; p (35 N) = ns.

At Segesholm, there were no differences between the inter crops in Pi of *Trichodorus* spp. or *Longidorus* spp. analysed in the spring 2020 before sowing barley. Pearson correlation analysis showed that there was a tendency for higher plant weight of barley when the density of *Longidorus* spp. was low (p=0.0769). *Longidorus* spp. has a wide host range and poor growth and yield loss has been seen in strawberry, carrot, red clover and cereals. In combination with stubby root nematodes, sugar beets may also respond with severe yield loss. *Longidorus* spp. attack plants near the root tip and the growing point is destroyed. The tip of the root becomes typically hook formed. There is little information on how *Longidorus* populations develop under different inter crops. In 2021, there were no difference between the inter crops for Pi of *Longidorus* spp. before drilling sugar beet. However, there was a tendency that forking of the sugar beet roots differed between the inter crops (p=0.078). The highest FI was found after Control (FI=40) and the lowest after Tagetes (FI=20) suggesting that Tagetes may have a reducing effect on *Longidorus* spp. This is currently being further investigated in field trials in a recently approved research project (Påverkan av växtskadliga nematoder i ekologiska odlingssystem, Ekhagastiftelsen).

At Gärds köpinge, there were differences between the varieties of OSR in Pi of stubby root nematodes in the spring 2021 (p=0.025). Adventure had more individuals than Contra and a tendency to more individuals than Angus (p=0.083) and the control without inter crop (p=0.080). There were no differences in sugar yield or FI.

Phacelia tanacetifolia is frequently grown as an inter crop in many fields. It is not related to most of our main crops and are easily established after cereal harvest. In the trial at Viby, populations of *P. neglectus* were increased by *P. tanacetifolia* compared to varieties of OSR, *A. strigosa* and *L. angustifolius,* alone and in mixture. *Pratylenchus neglectus* is a serious pathogen on cereals causing severe yield reductions in many countries (Smiley *et al*., 2005). *Phacelia tanacetifolia* is therefore not recommended on fields infested with *P. neglectus*.

Multiresistant varieties of OSR combine resistences to many nematodes for example *Heterodera schachtii*, the beet cyst nematode and RKN, *M. chitwoodi* and/or *M. hapla*. The effect of OSR varieties on other nematodes such as stubby root nematodes and root lesion nematodes is less known. In this study, we found differences between inter crops in the trial at Viby (Table 7) infested with stubby rooot nematodes. OSR Terranova increased the number of stubby root nematodes compared to *P. tanacetifolia* and the control without inter crop.

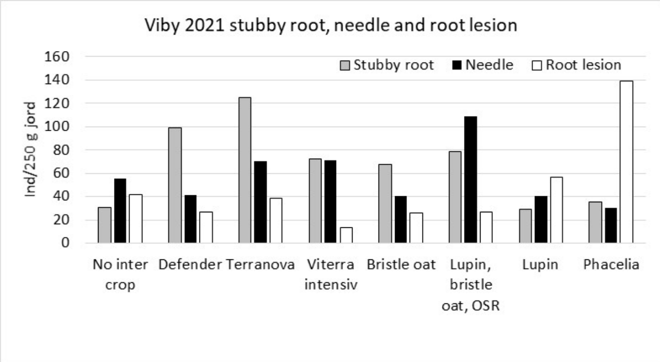


Figure 4. The number of needle, stubby root and root lesion nematodes prior to sowing potato at Viby in the spring 2021. p (needle) =ns; p (stubby root) = 0.006; p (root lesion) <0.001.

In the trial at Ryftes 2020 (Figure 2) Defender had the highest number of stubby root nematodes followed by Angus, Contra and Control. In contrast, in the trial at Klagstorp 2020, Defender, Angus, Contra and Control decreased the number of *P. neglectus* individuals compared to the control without inter crop. Moreover, Defender, Terranova and Angus where poor hosts to *P. thornei*. Among the varieties of OSR tested for host suitability to *P. penetrans*, Contra and Doublet where non-hosts and Defender and Terranova poor hosts.

Table 7. Means for reproductive factor (Rf) of inter crop/ Rf for control without inter crop in the field trial at Viby infected with P. neglectus and stubby root nematodes

	Rf / no inter crop at Viby	
Inter crop	*P. neglectus*	Stubby root nematodes
No inter crop	1.00	1.00
OSR Defender	0.90	3.74
OSR Terranova	2.26	4.24
Viterra intensiv (*A. strigosa* + OSR)	0.39	2.88
A. strigosa	1.26	2.60
L. angustifolius + *A. strigosa* + OSR Terranova	1.49	3.30
L. angustifolius, var. Boregine	3.81	1.08
P. tanacetifolia	4.97	1.26
(P treatm)	*0.034*	*0.012*

<u>Interactions between nematodes and Rhizoctonia.</u> At Skags, Pearson correlation analysis showed that there was a positive correlation between *P. crenatus* and the percentage of surface area on tubers with black scurf (corr. coeff = 0.443, p=0.030). There were no differences in potato yield. At När, Pearson correlation analysis showed that there was a negative correlation with *Longidorus* spp. for percent tubers with symptoms of *R. violacea* (corr. coeff = -0.456, p=0.009) and surface are on tubers (corr. coeff = -0.480, p=0.005). There were no differences between the treatments in initial nematode densities in the spring 2021 or potato yield (40-60 mm, >60 mm and total yield).

<u>Population dynamics.</u> Nematodepopulations vary in size over the year due to changes in temperature, soil moisture and crops grown on the field. When a non-host is grown, populations are effectively reduced whereas a good host may lead to high multiplication. The populations of the most serious root lesion nematode *P. penetrans* increased to high numbers during the summer when a susceptible host was grown. Shortly after harvest, the populations declined but not below the damage threshold even when the field was ploughed. To reduce the populations below the damage threshold active sanitation using OSR or Tagetes is required. Populations of *M. hapla* where often high during January to May, low or absent during the summer and high again in early autumn. In the spring, juveniles are hatched from eggs and these enter into roots where they start to feed and develop into mature females. In

early autumn, the second generation are hatched. To minimize the risk of missing this nematode in the field, soil should be sampled in the autumn before harvest or in early spring when new individuals start to hatch in the warmer soil. Sampling in the summer between the first and second generation is not recommended. Inspection of roots may instead reveal galls formed by the root knot nematodes.

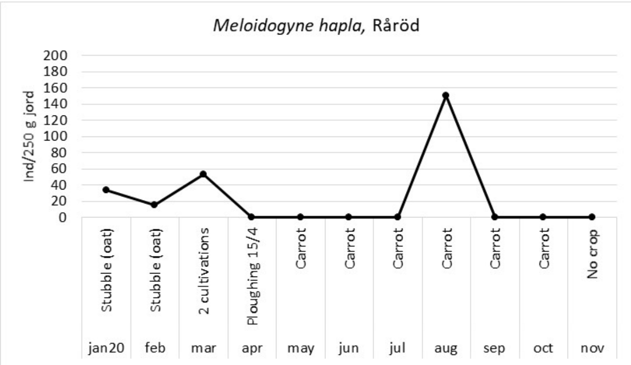


Figure 5. Population dynamics for M. hapla at Råröd from January to November 2020

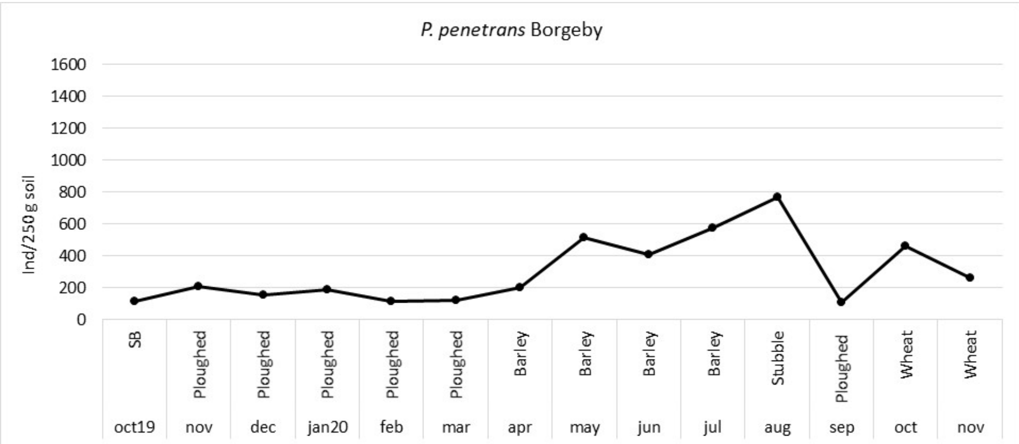
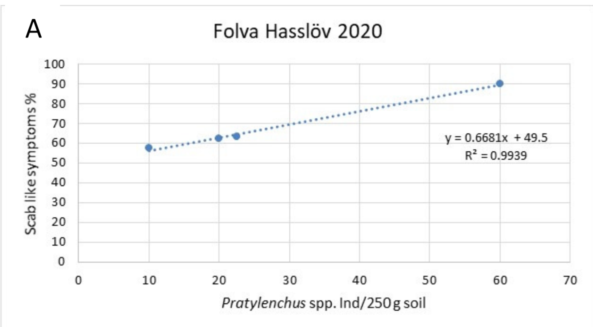


Figure 6. Population dynamics for P. penetrans at Borgeby from October 2019 to November 2020. SB = sugar beet

<u>WP3. Methodology for variety trials in potato on nematode infested soil.</u> The trial field at Hasslöv, Halland was severly infested with *P. penetrans*. The correlation between number of individuals at planting to the percentage of area on the tubers with skin lesions at harvest was strong for the variety Folva, R^2 =0.99. (Figure 7). The percentage of tubers with skin-lesions was 68 for Folva compared to 29% for Queen Anne.



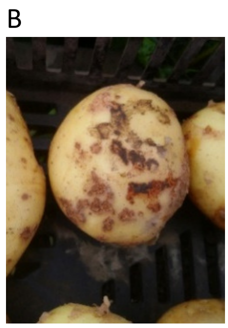


Figure 7 A. Correlation between number of individuals at planting to the percentage of surface area with skin lesions on the tubers. Demonstration trial at Hasslöv, Halland 2021. B. Skin lesions on the variety Folva.

The field trial at Nymö 2020 was infested with *P. penetrans*. The two starch varieties Avenue and Kuras, differed in number of tubers with skin-lesions caused by *P. penetrans*. More than 70% of the tubers of Avenue had skin-lesions whereas Kuras only had 39%. Root lesion nematodes also occurred in the variety trial in Kristianstad but the species was *P. neglectus* which is mainly a pathogen on cereals but also oil seed rape (Table 8). Skin-lesions (%) on both varieties were much lower in this trial compared to in the trial at Nymö but the percentage of skin-lesions was again higher in Avenue compared to Kuras, 21 and 2% respectively. The varieties also differed in the percentage of tubers with black scurf at Nymö. 65% of the tubers of Kuras was attacked compared to 39% for Avenue. There were no differences between the varieties in percentage of tubers attacked by brown rot.

Table 8. Initial nematode densities (Pi) and percentage of tubers infected with black scurf, with skin lesions and brown rot at Nymö and Kristianstad 2020

		Pi ind/250 g soil			**Tubers (%)**		
		P. penetrans	Stubby-root	Root-knot	Black scurf	With skin-lesions	Brown rot
Nymö	Avenue	17	4	2	39	71	7
	Kuras	14	3	2	65	39	8
	P (treatm)				*0.037*	*0.012*	*ns*
Kristianstad	Avenue	0	4	0	3	21	70
	Kuras	0	1	0	7	2	78
	P (treatm)				*ns*	*0.007*	*ns*

Table 9. Initial nematode densities (Pi), emergence, height of foliage, plants per ha at harvest and total yield in the variety trial in Kristianstad

	Pi *Longid.*	Pi Stubby root	Pi *P. neglectus*	Emergence (%) in June	Height foliage (cm) in June	Plants/ha at harvest	Total yield ton/ha
Queen Anne	35	3	116	97	34	52500	64928
King Edward	31	9	140	95	43	51944	51942
Belana	28	9	136	91	21	50972	27049
Folva	48	10	116	97	58	52222	59346
Melody	55	8	160	96	40	51250	65308
Kingsman	19	6	88	95	38	51389	64474
Baby Lou	30	3	89	98	35	52639	44721
Lucera	33	10	158	93	38	48334	76486
P (treatm)				*0.023*	*<0.001*	*0.006*	*<0.001*

Table 10. Percentage of tubers and surface area on tubers with skin lesions and black scurf in the potato variety trial in Kristianstad 2021

	Tubers with skin lesions (%)	Surface area with skin lesions (%)	Tubers with black scurf (%)	Surface area with black scurf (%)
Queen Anne	29	3	11	70
King Edward	34	6	15	93
Belana	11	1	24	92
Folva	51	8	9	76
Melody	37	4	9	74
Kingsman	35	5	15	84
Baby Lou	38	4	9	78
Lucera	17	2	13	83
P (treatm)	*0.002*	*0.008*	*<0.001*	*0.037*

The variety trial in Kristianstad (Table 8-9) showed differences between the varieties for emergence, height of foliage, plants/ha and total yield. There were also differences between the varieties in percentage of tubers with skin lesions (p=0.002) and attacked surface area (p=0.008) (Table 10). More than 50% of the tubers of Folva had skin lesions compared to Lucera with 17%. In summary, the results from the variety trials in potato showed that there were differences between the varieties for most of the assessed variables (Pi, emergence, plant height, diseases on tubers after harvest) and densities of *P. penetrans* could be related to percentage of tubers with skin-lesions in both food and starch potato.

Relevance and recommendations

Decision on crops to be grown in the rotation must be based on the nematode species occurring in the specific soil. Knowledge on host suitability in crops and varieties is therefore very important and offers new possibilities to control FLN and minimize yield and quality losses. The results from this study showed that there are variations in host suitability to *P. thornei* among the varieties of wheat grown in Sweden which is very promising and offers new options for control of this nematode. However, more trials and experiments are needed to test more and new varieties. The tested varieties of carrrot were found to be more or less sensitive to *M. hapla*. Control of *M. hapla* must therefore be done by using non host crops or resistent inter crops in the rotation. Among the inter crops, *P. tanacetifolia* was found to a good host to *P. neglectus* and is not recommended on infested fields to prevent yield losses in cereals. OSR may increase stubby root nematodes and is not recommended on infested fields before sensitive crops. In contrast, OSR are poor hosts to most root lesion nematodes and can be grown on infested fields. Tagetes can effectively reduce the number of root lesion nematodes. This requires a growing period of at least three months and that weeds are controlled. It should be noted that Tagetes has no effect on stubby root nematodes or RKN. Bristle oat was found to be a poor host to stubby root nematodes and can be recommended as an inter crop on infested fields. Blue lupin was found to be susceptible both to *P. penetrans* and *M. hapla*. The tested methodology for variety trials in potato revealed differences in host suitability and damage to FLN among potato varieties. Varieties were found to differ in percentage of skin lesions that severly lowers quality and yield.

Conclusions

- Wheat varieties differ in host suitability to *P. thornei* which is an important yield reducing root lesion nematode. This offers new options for control by choosing varieties with low reproduction factor.
- The tested varieties of carrot did not show any differences in sensitivity to *M. hapla* and control must be done with growing non hosts or resistent crops in the rotation.
- *Phacelia tanacetifolia* is a good host to the root lesion nematode *P. neglectus* and should be avoided on infested fields to reduce yield losses in cereals.
- Varieties of oil seed radish increase stubby root nematodes but are poor hosts to root lesion nematodes. Bristel oat are more suitable on fields infested with stubby root nematodes.
- Tagetes sanitate root lesion nematodes but not stubby root- or root knot nematodes.
- Susceptibility in potato varieties to FLN can be evaluated in field trials and would be a valuable tool for growers to avoid yield losses and to control FLN within IPM.

2022-12-20/Åsa Olsson Nyström

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Smiley, R. W., Yan, G. P., and Gourlie, J. A. 2014. Selected Pacific Northwest crops as hosts of Pratylenchus neglectus and P. thornei. Plant Dis. 98:1341-1348.

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Del 3: Resultatförmedling

Ange resultatförmedling av projektet, inklusive titel, referens, datum, författare/talare, och länk till presentation eller publikation om tillämpligt. Planerade publiceringar (med preliminära titlar) ska ingå i tabellen. Ytterligare rader kan läggas till i tabellen.

Vetenskapliga publiceringar	Control of plant parasitic nematodes with inter crops. Påbörjas januari 2023.
	Population dynamics and damage thresholds for free living nematodes in carrot, sugar beet and potato. Påbörjas januari 2023.
Övriga publiceringar	Frilevande nematoder i rot- och knölgrödor – försök med olika sorter. Planeras till Viola potatis våren 2023.
	Frilevande nematoder i betor. Betodlaren våren 2023.
	Book chapter: In: *Nematode Diseases of Crops and Their Sustainable Management (To be published 2023, by Elsevier).* **Chapter 22: Nematode problems in sugarcane and sugar beet and their sustainable management.** Dr. B. B. Westerdahl, University of California, USA; Prof. M. R. Khan, Aligarh Muslim University, India; Dr. Åsa Olsson Nyström, Agri Science Sweden AB, Sweden; Dr. Irfan Ahmad, Aligarh Muslim University, India.
Muntlig kommunikation	Så hanterar du rotgall och frilevande nematoder i odling av rot- och knölgrödor. Gröna möten 2021-03-10. Åsa Olsson Nyström.
	Strategier för kontroll of rotgall- och frilevande nematoder i växtföljder med potatis och rotgrödor SLF 2019-2021. Kurs IPM växtskydd rotfrukter 2021-02-17. HIR Skåne. Åsa Olsson Nyström.
	Strategier för kontroll av nematoder. Potatismöte med odlare och rådgivare. Mullsjö 2021-12-08. Åsa Olsson Nyström.
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Studentarbete	Mellangrödor i syfte för växtskydd. Mellangrödor för kontroll av rot patogena *Plasmodiophora brassicae* och rot parasitära *Pratylenchus penetrans och Meloidogyne hapla.* Master's project (30 hp). Swedish University of Agricultural Sciences, SLU Department of Plant Protection Biology, Horticultural science Alnarp 2022. Izabella Lundborg.

Övrigt	Control of free living nematodes using inter crops. Poster 78th congress 2022. Mons, Belgium. Å. Olsson, L. Persson.