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Profitable break crop options for managing root lesion nematode (*Pratylenchus neglectus*)

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Key messages

- Legume break crops reduced populations of RLN (*Pratylenchus neglectus*) in the soil while canola increased the population.
- *Rhizoctonia solani* AG8 inoculum decreased under serradella but had a mixed response to canola and legume break crops.
- Wheat and oats are susceptible to RLN and Rhizoctonia and facilitated their multiplication following all break crops.
- A single break crop year in the rotation may be insufficient to effectively reduce disease inoculum beyond the season following the break crop.

Background

Root lesion nematode (RLN) is a soil-borne parasite that feeds on plant roots. It reduces plants' ability to uptake water and nutrients, thus limiting growth and lowering plant tolerance to other stresses. Growing susceptible crops in consecutive seasons enables RLN populations to build up in the soil. Management options include sowing resistant break crops and varieties and keeping paddocks clean over summer. Lupins, faba beans and serradella are resistant to *P. neglectus*, but they are not suited to all rainfall zones and soil types. Canola is a susceptible host to *P. neglectus*, meaning it enables populations to build up in the root zone. Therefore, analysis of break crop options is warranted to understand the best break crop for managing RLN.

Activity objectives

The aim of this field experiment was to compare the viability of different break crop options for the management of RLN (*P. neglectus*) and Rhizoctonia. This involved monitoring the RLN population in response to different break crops in the break crop year (2018), as well as under susceptible cereal crops in following years (wheat 2019 and oats 2020).

Methods

A paddock was selected near Dumbleyung with a high RLN burden and sown to wheat in 2017. In 2018 a small plot field trial was established to evaluate the effects of different break crops on the disease risk profile. Sixteen plots were arranged in a randomised block design, including four crop types (Bonito canola, Samira faba bean, Jurien lupin and Cadiz serradella) replicated four times, in two banks. The paddock surrounding the trial was sown to lupins.

Legumes were inoculated as required and all crops received superphosphate at seeding. Canola was top-dressed with 60kg/ha urea in-season. In 2019 the site was blanket-sown to Scepter wheat on 22 May with 40kg/ha nitrogen in the sowing fertiliser. On 25 April 2020, the site was blanket-sown to Bannister oats to monitor population recovery under a second susceptible host crop. The trial received approx. 65kg/ha nitrogen over the season (46 units at seeding in compound and banded liquid N, 10 units liquid N top-dressed at 3-4 leaf, and 9 units liquid N top-dressed at F-1, i.e. GS33). All inputs were grower managed in 2019 and 2020.

Data collection

In all three years PredictaB testing was carried out prior to seeding, during the growing season (August) and after plots were harvested. Yield loss risk categories for *P. neglectus* and *R. solani* AG8 were assigned according to Table 1. The sowing (baseline) pathogen levels (Pi) of *P. neglectus* and *R. solani* (AG8) (untransformed data) were compared to harvest (final) populations (Pf) to determine multiplication factors (M), where;

M = (Pf + 1) / (Pi + 1)

Break crop growth, nitrogen fixation and yield was monitored in 2018. In 2019 (wheat) and 2020 (oats), yield and grain quality was analysed to compare nitrogen contributions from the previous break crops.

Table 1. Western region yield loss risk categories for *Pratylenchus neglectus* and *Rhizoctonia solani* AG8 (% yield loss refers to intolerant wheat varieties under conducive seasonal conditions).

Level	*P. neglectus* RLN/g soil	Potential yield loss (%) (*P. neglectus*)	*R. solani* AG8 log(pgDNA+1) /g soil	Potential yield loss (%) (*R. solani*)
Below detection	<0.1	0	<0.5	<5
Low	0.1–5	0–5	0.5–<1.5	0–10
Medium	6–25	5–20	1.5–<2.0	5–25
High	>25	20–40	≥2.0	20–50

Results and discussion

The soil is a loamy sand with no obvious chemical constraints identified down to 40cm (Table 2). In 2018 however, the serradella plots received a pre-emergent spray with imazethepyr 700g/ha (as 100g/ha Spinnaker). This herbicide failed to break down over the 2018/2019 summer (due to insufficient rainfall) and the residual chemical significantly stunted wheat growth in 2019.

Table 2. Trial site soil physical and chemical description. Sampled prior to seeding trial in 2018.

Depth	Gravel	Texture	OC	NH_4^+ N	NO_3^- N	Colwell P	Colwell K	S	EC	pH	PBI
cm	%		%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	dS/m	$CaCl_2$	
0-10	0	Loamy sand	2	3	21	66	183	11.9	0.097	5.9	41.9
10-20	5	Loamy sand	1.07	2	8	36	80	7.2	0.040	5.6	37.7
20-30	5	Loam	0.88	< 1	8	24	61	5.4	0.035	5.7	35.9
30-40	5	Loam	0.65	1	4	16	47	5.2	0.031	5.8	37.2

Pathogen and pest levels

Predicta B soil testing (pre-seeding 2018) gave background indications of yield loss risk categories. Results indicated a medium risk of yield loss associated with *P. neglectus* (average 13 RLN/g soil), shown in Table 3. *P. quasitereoides* (formerly *P. teres*) was not detected. Many plots had a high risk of yield loss from Rhizoctonia bare patch (*Rhizoctonia* *solani* AG8) at over 2.3 log pgDNA/g soil, as in Table 4, though the average level fell in medium yield loss risk category (1.9 log pgDNA/g soil).

Table 3. RLN (*P. neglectus*) numbers (per gram soil) for each plot under different break crops (2018), wheat (2019), and oats (2020) determined by PredictaB analysis. Yield loss risk (%) is indicated by colour coding. Times of sampling: S=seeding, M=mid-season, H=harvest.

	2018 Break crop			2019 Wheat			2020 Oats		
2018 break crop	S	M	H	S	M	H	S	M	H
Canola	13	13	23	22	5	20	13	10	10
	13	18	21	13	3	30	8	6	17
	11	12	27	20	4	28	15	16	13
	10	18	31	27	6	36	20	13	21
Faba beans	19	9	5	5	2	8	6	7	7
	10	2	4	3	2	11	9	6	9
	11	7	4	3	3	10	9	5	14
	15	8	7	5	4	9	8	7	23
Lupins	15	8	5	7	3	8	12	9	12
	11	6	4	3	2	6	8	6	10
	9	5	7	3	3	10	14	4	9
	11	20	4	4	6	12	7	7	14
Serradella	18	9	8	8	4	15	8	1	7
	14	9	6	6	3	19	9	7	10
	15	10	8	9	2	16	12	3	17
	11	11	2	8	3	16	8	4	14

Break crop year (2018)

In 2018, Predicta B sampling from pre-seeding to harvest indicated that faba bean, lupin, and serradella reduced numbers of *P. neglectus* (Table 3). In contrast, canola increased *P. neglectus* numbers and levels stayed high into the start of 2019. RLN multiplication over the 2018 season under the different crops is represented in Figure 1a. Canola was associated with a RLN multiplication factor over 2 and was significantly greater than all other break crops. Faba bean, serradella and lupin had multiplication factors <1, thus they reduced RLN numbers (Fig. 1a).

Rhizoctonia levels displayed much greater variability across break crops and over the season (Table 4), though on average levels increased under canola, faba beans and lupins (Fig. 1b). Serradella was the only break crop which decreased inoculum levels with a multiplication factor <1, with relatively low variability (Fig. 1b). To successfully reduce Rhizoctonia levels in soil, break crops must be free of grass weeds. The elimination of grasses in the serradella plots may have been a highly effective break for Rhizoctonia, similar to a fallow effect. In both diseases, harvest levels from 2018 were similar to those measured just prior to seeding in 2019, suggesting populations were reasonably stable over the dry summer months (Dumbleyung summer rainfall decile 4).

Table 4. Rhizoctonia (*R. solani* AG8) levels in soil for each plot under different break crops (2018) and under wheat (2019), determined by Predicta B analysis. Values are log transformed (Log10(pgDNA+1)). Yield loss risk (%) is indicated by colour coding. Times of sampling: S=seeding, M=mid-season, H=harvest.

	2018 Break crop			**2019 Wheat**			**2020 Oats**		
2018 Break crop	**S**	**M**	**H**	**S**	**M**	**H**	**S**	**M**	**H**
Canola	1.5	1.9	2.2	2.3	2.5	2.4	2.3	3.1	2.9
	1.2	1.5	2.2	1.8	2.5	2.3	2.0	2.8	2.8
	1.9	1.2	1.1	1.6	0.9	0.8	0.0	1.1	2.2
	2.3	1.0	1.4	1.5	1.3	1.7	1.8	2.2	1.8
Faba beans	0.8	1.0	2.0	1.5	2.5	2.3	1.7	2.9	2.5
	1.0	1.0	2.4	2.1	2.6	2.6	1.9	2.3	2.0
	1.4	0.0	0.9	1.5	1.3	1.5	1.4	1.8	2.1
	2.3	0.7	1.4	1.0	0.7	1.6	1.3	1.3	2.4
Lupins	0.9	1.4	2.0	2.1	1.3	2.1	1.7	2.6	2.3
	0.8	0.0	0.9	1.8	0.8	1.8	1.4	2.4	2.4
	2.0	0.4	1.1	0.0	0.5	0.8	0.8	1.9	2.0
	2.5	1.1	1.5	1.9	0.4	2.2	1.2	2.1	2.4
Serradella	1.9	1.8	1.8	2.0	2.1	1.9	1.0	2.5	2.4
	2.2	1.2	1.3	1.4	1.4	1.5	0.9	1.9	2.1
	1.5	1.5	0.6	1.2	1.7	2.7	2.3	2.1	2.6
	2.3	1.1	0.0	0.7	1.8	1.0	0.9	1.8	2.0

Wheat year (2019)

Dumbleyung experienced decile 4 growing season (April to October 230mm). After a season of Scepter wheat, *P. neglectus* populations increased across the site from seeding to harvest levels (Table 3). All treatments on average had multiplication factors >1, meaning pathogen populations increased under wheat (Fig 2.a).

Despite multiplication factors, plots that had a lupin, faba bean or serradella break crop all had medium risk levels of *P. neglectus* by the end of the season, while those that had a canola break crop had high risk levels of nematodes by the end of 2019 (Table 3). Thus the high nematode population established under canola carried over for a second season under a susceptible crop.

Rhizoctonia levels multiplied across the site under wheat by factors of 3-4 on average, however variability within treatments was also high (Fig. 2b). Average disease risk levels were high for all treatments based on harvest sampling. These inoculum levels did reduce over summer and were lower for seeding in 2020 (Dumbleyung summer rainfall decile 5).

Oats year (2020)

Dumbleyung experienced a decile 2 growing season (April to October 197mm). Under Bannister oats sown in 2020, numbers of *P. neglectus* increased on average but were stable over the season, at moderate risk levels (Table 3; Figure 3a). *R. solani* inoculum level increased in all plots over the season and was at a high risk level at harvest (Table 4; Figure 3b). Rhizoctonia multiplication rates were among the highest from the whole experiment under oats. Plots that grew serradella and lupins in 2018 had average multiplication rates of 12.

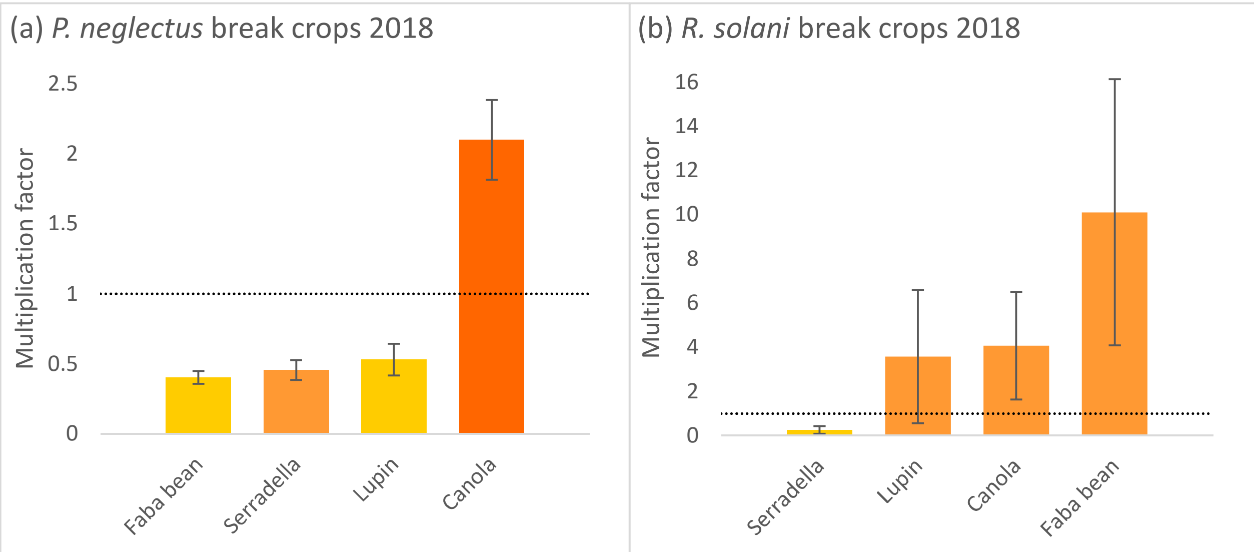

Figure 1. Multiplication factor (Pi/Pf) of (a) *P. neglectus* and (b) *R. solani* AG8 from seeding levels (Pi) to end of season (Pf) in 2018 at Dumbleyung, under different break crops. M=1 represents no change in soil pathogen level. Columns are coloured according to yield loss risk category at end of season (yellow=low, orange=medium, red=high). Error bars show one standard error of the treatment means.

Figure 2. Multiplication factor (Pi/Pf) of (a) *P. neglectus* and (b) *R. solani* AG8 from seeding levels (Pi) to end of season (Pf) in 2019 at Dumbleyung, under Scepter wheat. Different break crops sown in 2018 are shown on the x axis. M=1 represents no change in soil pathogen level. Columns are coloured according to yield loss risk category at end of season (orange=medium, red=high). Error bars show one standard error of the treatment means.

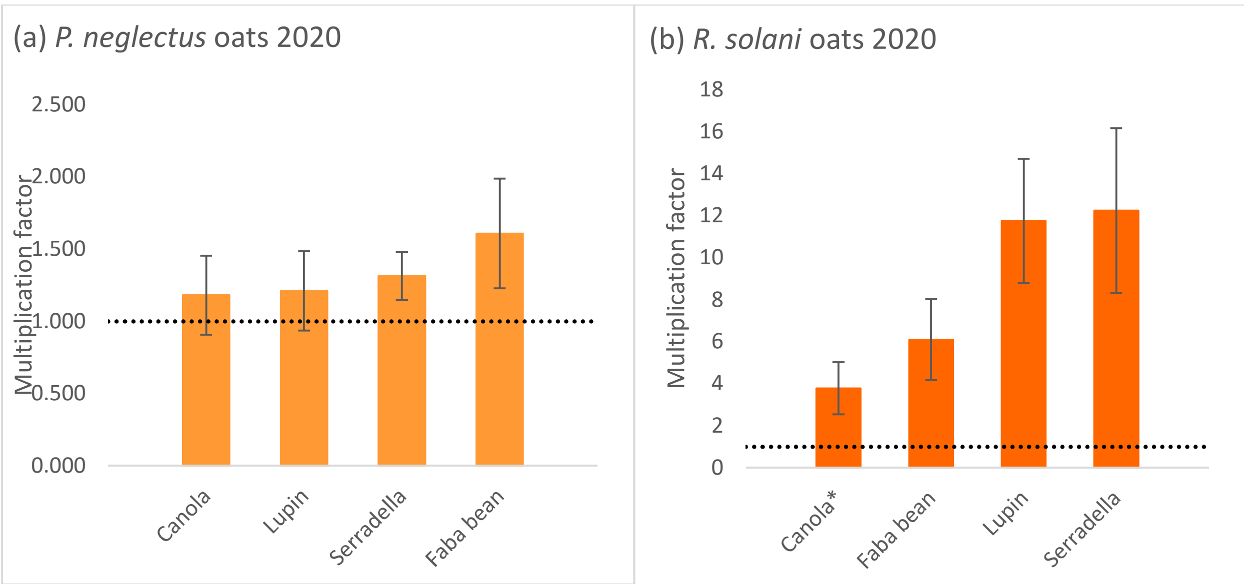

Figure 3. Multiplication factor (Pi/Pf) of (a) *P. neglectus* and (b) *R. solani* AG8 from seeding levels (Pi) to end of season (Pf) in 2020 at Dumbleyung, under Bannister oats. Different break crops sown in 2018 are shown on the x axis. M=1 represents no change in soil pathogen level. Columns are coloured according to yield loss risk category at end of season (orange=medium, red=high). Error bars show one standard error of the treatment means. Canola* excludes plot 2003 data (zero).

Yields

Soil samples (0-10cm) were collected in May 2019 prior to seeding to compare nitrogen contributions from break crops. Soil mineral nitrogen expressed as kg/ha was estimated by adding ammonium nitrogen and nitrate nitrogen and multiplying by a factor of 1.5 (Table 5). Table 5 suggests that serradella and faba beans had significantly more mineral N in the soil (56kg/ha and 51kg/ha respectively) than canola (39kg/ha) and lupins (33kg/ha) ($p<0.05$).

Table 5. Soil mineral nitrogen (0-10cm) estimated from soil ammonium nitrogen and nitrate nitrogen levels after different break crops. Soil samples were taken in May following the break crops. SE=standard error. Different letters indicate significant difference (α=0.05).

	Ammonium nitrogen (mg/kg)		Nitrate nitrogen (mg/kg)		Estimated mineral N (kg/ha)		
Break crop	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	
Canola	2.75	1.49	23.50	1.89	39.38	2.96	*a*
Faba bean	4.25	1.49	29.50	2.33	50.63	5.46	*b*
Lupin	0.75	0.48	21.25	0.63	33.00	0.61	*a*
Serradella	4.00	1.08	33.25	2.29	55.88	5.03	*b*

In 2019, observations were made with regards to stunting and lack of vigour in wheat plants growing on serradella plots. This was attributed to residual herbicide activity from imazethepyr these plots received in 2018. Plant establishment was not significantly lower in serradella plots, but plants had fewer tillers so yield was significantly reduced (Table 6). Wheat yield across the trial site was on average 2.56t/ha. On average, yields from faba bean plots were highest with 3.02t/ha, however this was not significantly greater than yields from canola or lupin plots (Table 6). Wheat sown on serradella plots yielded 1.54t/ha which was significantly less than all other plots. Protein levels in wheat were significantly higher in faba bean and serradella treatments (Table 6). This mirrors the starting soil mineral N levels in Table 5, therefore it is inferred that faba bean and serradella fixed more nitrogen than canola and lupins.

Table 6. 2019 wheat yields and protein after different break crops. Different letters indicate significant difference (α=0.05).

Break crop	Plants/m^2		Mean yield (t/ha)		Mean protein (%)	
Canola	88	*a*	2.77	*b*	9.10	*a*
Faba bean	73	*a*	3.02	*b*	9.63	*b*
Lupin	68	*a*	2.91	*b*	9.23	*a*
Serradella	75	*a*	1.54	*a*	9.63	*b*
p-value	*0.31*		*<0.05*		*<0.05*	
LSD	*21*		*0.32*		*0.26*	

In 2020, dry matter was calculated from calibrated NDVI measurements in August (R^2=0.885). Average dry matter at GS33 (third node) was 3.5t/ha. Faba bean and serradella treatments had less biomass measured in August, however there was no significant difference in oat grain yield at harvest (Table 7). The protein level in the serradella treatments was higher than other treatments, but the effect is practically insignificant. There was likely more residual soil nitrogen in the serradella plots due to reduced wheat growth and low wheat yields in 2019.

Table 7. 2020 oat yields and protein after different break crops. Different letters indicate significant difference (α=0.05).

Break crop	Mean Aug DM (t/ha)		Mean yield (t/ha)		Mean protein (%)	
Canola	3.56	*b*	3.14	*a*	9.12	*a*
Faba bean	3.34	*a*	3.29	*a*	9.46	*a*
Lupin	3.65	*b*	3.27	*a*	9.75	*a*
Serradella	3.46	*ab*	3.09	*a*	10.05	*b*
p-value	*<0.05*		*0.62*		*<0.05*	
LSD	*0.15*		*0.39*		*0.65*	

Conclusions

The aim of this three-year trial was to compare the viability of different break crop options for the management of RLN and Rhizoctonia. Pathogen populations were monitored in the break crop year in 2018 and under susceptible cereal crops in 2019 and 2020. Legume break crops reduced populations of RLN (*P. neglectus*) in the soil, while canola increased the population. After one season of wheat, RLN populations multiplied across the site, reaching levels that posed a medium risk of yield loss for the 2020 season. Over the 2020 season under oats, RLN numbers increased or stayed about the same. However, Rhizoctonia levels were variable in and limited conclusions can be drawn from break crop treatments. Serradella appeared to suppress Rhizoctonia effectively in the season it was grown, however levels multiplied rapidly under wheat. Under oats, Rhizoctonia increased to high-risk levels across the trial site.

At the end of this three-year rotation, RLN levels returned to similar levels that were present before the trial was sown (moderate risk of yield loss), while Rhizoctonia levels were uniformly higher (high risk of yield loss). These results suggest a single break crop is insufficient to reduce disease inoculum in some cases for more than one season and more work into the viability of a double RLN break crop (not canola) is warranted.

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