Trial Overview: BMP1-Fall Seeded Cover Crops the Year Before Potatoes

Trial Overview:

In the BMP1 trials established in 2020, we examined fall cover crops seeded in early to mid- September the year before planting potatoes. In each field we compared one or more cover crops to a bare check strip; different rates of the same cover crop to a check, or different methods of establishment of the same cover crop to a check. The purpose of the research was to assess how well the crop(s) cover the ground, hold soil to prevent nitrate leaching and erosion, relative to bare ground leading into the winter. Additionally, we are interested in what short-term impact these cover crops have on the resulting potatoes yields and quality the next year.

There were 8 fields set-up in the fall of 2020, including 3 in the Kensington North Watershed region, 2 in East Prince and 3 in the Souris and Area Watershed. They were planted between September 2 - September 24, 2020. The treatment comparisons by trial are outlined below in order from the earliest to latest planting dates:

Trial #1: Diakon Radish (3.2lb/ac)-Brown Mustard (12.8 lb/ac) Mix vs Bare Check (Planted September 2, 2020)

Trial #2: Radish-Mustard Mix (80:20) (22lb/ac) vs Bare Check (Planted September 7, 2020)

Trial #3: Mustard (10 lb/ac) vs Radish (12 lb/ac) vs Bare Check (Planted September 8, 2020)

Trial #4: Oats (180 lb/ac) vs Radish (12 lb/ac) vs Radish/Oats Mix vs Bare Check (Planted September 8 &9, 2020 Respectively)

Trial #5: Spring Barley (130 lb/ac) vs Bare Check (Planted September 11, 2020)

Trial #6: Spring Barley (200 lb/ac) vs Bare Check (Planted September 24, 2020)

Trial #7: Hay Ground vs Tillage Radish (10 lb/ac) vs Bare Check (Planted October 5-7, 2020)

Trial #8: Oats (90-150 lb/ac range) vs Bare Check (Planted October 13, 2020)

Note: Trial #4 and Trial #6 had complicating factors that have led us to remove them from potato yield analysis. Trial #4 had a severe issue with wireworm which was not equally distributed over the field, and this field did not historically have a wireworm issue. Trial #6 had unexpected and repeated traffic over the trial area during the fall of 2020 and winter of 2021, potentially creating significant compaction issues that are not crop-related.

Methods:

Fall soil sampling was conducted for chemical nutrient analysis, the soil health package, root lesion nematodes (RLN), and *Verticillium dahliae* (Vd) in the fall of 2020. The soil chemistry and health samples were analyzed by staff at the PEI Analytical Labs in Charlottetown. The RLN samples were analyzed by staff at the Potato Quality Institute (PQI). The Vd samples were sent to Fredericton, NB to the Agricultural Certification Services (ACS) lab for analysis.

A subset of the trials were selected in the fall of 2020 for soil erosion testing with splash pans based on topography and consistency between treatment areas. Soil sampling was done at three time points in the

fall each spaced roughly 2 weeks apart, spanning October and November for soil nitrates to 3 depths, including 0-6", 6-12" and 12-18". The nitrate analysis was done by staff at the PEI Analytical Laboratories. The Canopeo phone app was used to take and analyze replicate ground cover photos in each treatment at 3 time points over the fall, each spaced roughly 2 weeks apart. Photos were taken at the same waist height each time, pointed directly overtop of the cover crop. These results from the first season in the fall of 2020 were previously compiled in other reports both collectively across trials, and individually for each trial and shared individually with the respective grower in 2021 as initial feedback on the results, before preceding with follow-up 2021 growing season data collection. Soil penetrometer values were only collected in the spring of 2021 before primary tillage events because fall measurements are less reliable given more recent physical soil disturbance events.

Soil sampling was performed in the spring of 2021 in each treatment area for soil nutrient analysis, the soil health package, root lesion nematodes (RLN), and *Verticillium dahliae* (Vd). In the fall of 2021, four (4) potato yield strip samples (each 10 ft long) were collected in each treatment area. These potato samples were temporarily stored either at Agriculture and Agri-Food Canada cold storage facilities in Charlottetown or at grower farmyard warehouses until grading at Cavendish Farms Central Grading in New Annan, PEI. They were graded to evaluate total yields, percent defects, percent smalls, percent of potatoes over 10-ounce size, specific gravity, marketable yields, and crop value in $/acre. Statistical analysis was done using ANOVA with a confidence interval of 95% (α=0.05) as a baseline and Multiple Means Comparisons if applicable to determine treatment differences. If significance was borderline, it was also assessed at a=0.1. Additional analysis was done comparing all grain cover crops against check strip treatments all Brassica crops against check strips, and all cover crops against check strips.

Results- Soil Health:

Table 1: Soil respiration (mg/g) across trials over 2020-2021 sampling

		Soil Respiration (mg/g)		
Trial: Treatment	Fall 2020 (Composite)	Spring 2021 (Treatment)	Spring 2021 (Control)	Spring 2021 (Difference)
Field 1: Rad-Mus*	0.4	0.31	0.4	-0.09
Field 2: Rad-Mus	0.46	**0.63**	**0.41**	**+0.22**
Field 3: Mustard	0.7	0.54	0.53	+0.01
Field 3: Radish		0.44	0.53	-0.09
Field 4: Oats	0.5	0.3	0.43	-0.13
Field 4: Radish		0.3	0.43	-0.13
Field 4: Oats-Radish		0.48	0.43	+0.05
Field 5: Spring Barley	0.7	**0.72**	**0.34**	**+0.38**
Field 6: Spring Barley	0.62	0.35	0.32	+0.03
Field 7: Hay	1.09	0.35	0.45	-0.10
Field 7: Tillage Radish		0.55	0.45	+0.10
Field 8: Oats	0.93	**0.74**	**0.59**	**+0.15**
Average	0.68	0.48	0.44	+0.03

Note: Abbreviations=> Rad-Mus*= Radish-Mustard Mix. Values highlighted yellow and red indicate Medium and especially Low ratings respectively, according to the scoring function for the Soil Health test. Bolded values in the same row represent the most noticeable differences between treatments in the spring of 2021.

Soil Health Observations:

During spring 2021 soil sampling, there were 3 trials showing average soil organic matter (SOM) levels less than 2.0%, another 4 trials showing levels between 2.0-3.0%, and the remaining trial (Trial #8) having greater than 3.0% SOM. Throughout the duration of these trials, the general trend showed that active carbon and soil aggregate stability remained low irrespective of treatment. The soil respiratory activity was more variable by site, in which some trials had treatment crops with higher respiration than their corresponding checks, and others did not. In two of the trials measured in the spring of 2021, the soil respiration was especially low in the check strips, but medium in the treatment crop areas (Trials #2 and #5), as highlighted in Table 1. Another field (Trial #8) showed high soil respiratory activity in the oats treatment compared to more medium levels under bare ground. Looking at overall averages, the spring 2021 soil respiration was slightly higher in the treatment crops compared to the check.

Two trials showed some differences in soil biological nitrogen availability (BNA) during spring 2021 sampling, including Trial #5 and #8 both having higher levels in the treatment crops (barley and oats respectively) compared to the bare check strips. However, there were no clear trends in the BNA data across sites.

Results- Soil Compaction:

Table 2: Soil compaction values (psi) at 3 depths across 7 trials by treatment in spring 2021

		Depth (Inches)		
Treatment	# Treatments	6"	9"	12"
Bare Soil Check	7	**41 b**	129	**274 a**
Radish	3	85	141	236
Radish-Mustard	2	39	93	219
Oats	2	84	156	263
Oats-Radish	1	50	87	206
Spring Barley	1	33	47	124
Mustard	1	49	179	286
Hay	1	73	155	285
Average of Treatments		**59 a**	123	**231 b**
Difference (Crop-Check)		+18	-6	-43

Compaction Observations:

Looking at treatments comparisons across trials, the general trend showed that the cover crops had lower compaction than the bare check strips, particularly at the 12 inch depth. Statistics were run at each depth comparing all cover crops vs checks, which showed significantly higher compaction in the cover crops at the 6” depth at α=0.05, no statistical differences between covers and checks at 9”, and then significantly higher compaction in the checks at the 12” depth at α=0.1 Statistics were also run on the data at 12” individually between treatments in each trial. There were only two significant differences detected for individual trials, including Trial #4’s spring barley, which had significantly lower compaction than its corresponding check strip, and Trial #5’s radish that actually had significantly higher soil compaction than its check strip.

Results- Soil Pathogens:

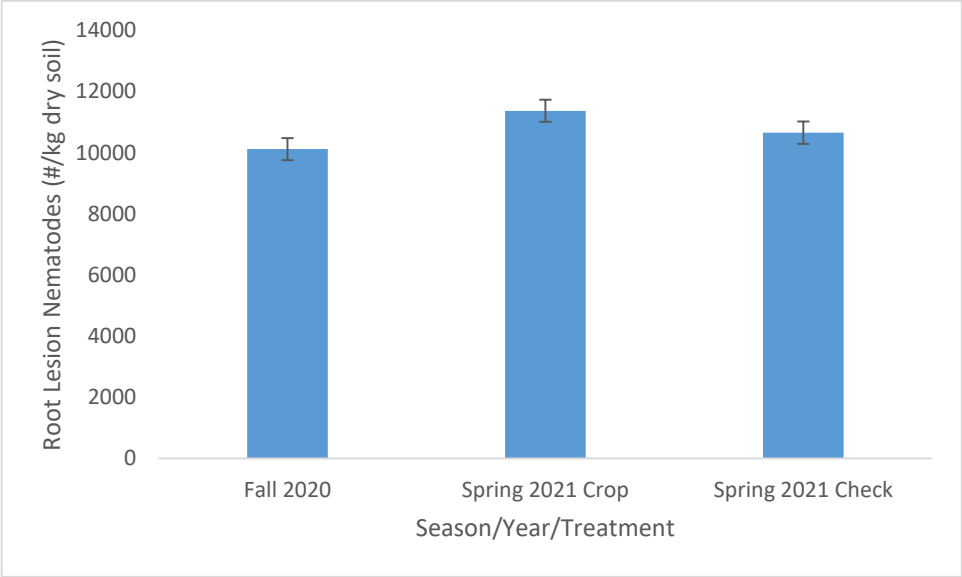

Figure 1: Root lesion nematodes (RLN) levels in fall 2020 and spring 2021 by treatment

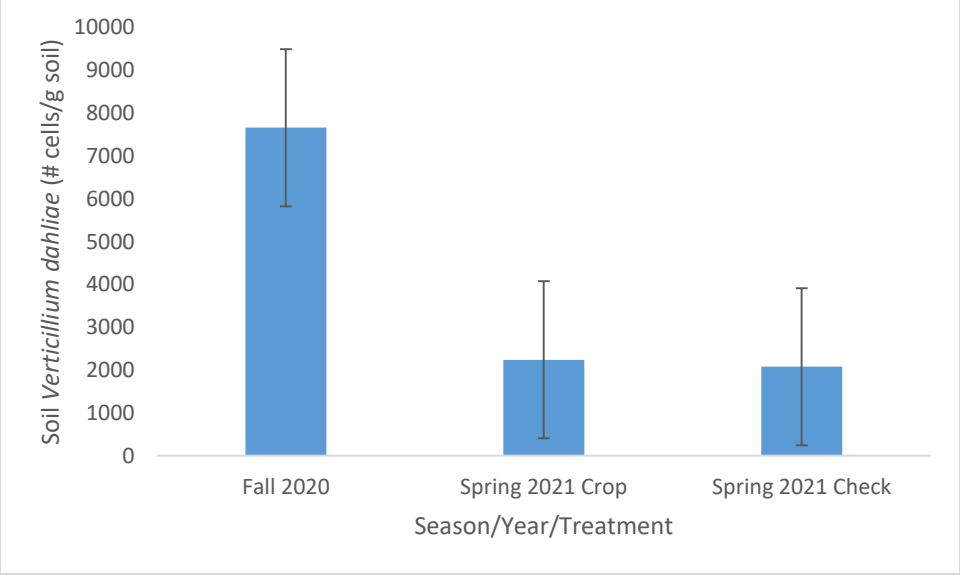

Figure 2: *Verticillium dahliae* levels in fall 2020 and spring 2021 by treatment

As shown in Figure 1 and 2, starting values of both RLN and Vd were quite variable by field. Six of the eight fields had starting RLN counts higher than 5000/kg of dry soil, which has been used as the threshold value for Russet Burbanks from previous research with this sampling method. There is also significant variability in the starting values for Vd, though a threshold value for Vd using this testing method has not yet been established.

For RLN, we can see in Figure 1 that there was not much average difference in nematode counts from fall 2020 to the spring of 2021. Likewise, there is very little difference in nematode numbers between the

average of cover crops and the average of the no-cover check strips. This is similar to data we've found in related projects.

A different trend is evident from the Vd data. All 2021 values are noticeably lower than the starting values we found in fall 2020. There is a small numeric difference between the check strips and the cover crop treatments in the spring of 2021, however, given the field-to-field variability as well as the standard error levels in the Vd testing, it's not possible to say with certainty whether the cover crop treatments had higher Vd readings than the no cover checks. The fact the average of all 2021 tests were substantially lower than in 2020 is very much in line with results we found in BMP3 and in other recent trials looking at Vd populations over time.

Table 3: Soil root lesion nematode (RLN) and *Verticillium dahliae* (Vd) populations in spring 2021 by treatment

		RLN (#/kg dry soil)			Vd (cells/g soil)		
Treatment	**# Treatments**	**Check**	**Crop**	**Difference**	**Check**	**Crop**	**Difference**
Radish	3	11379	14399	3020	3629	2520	-1109
Radish-Mustard	2	10682	7423	-3259	1758	2217	459
Oats	2	14214	15,011	797	2631	2050	-581
Spring Barley	2	10524	8083	-2441	1111	357	-754
Radish-Oats	1	7087	4697	-2390	5262	5304	42
Mustard	1	9672	6401	-3271	436	1006	570
Hay	1	17377	21,106	3729	5190	3748	-1442
Median		10682	8083	-2390	2631	2217	-581
Mean		11562	11017	-545	2860	2457	-402

Note: Differences were calculated subtracting Check values from the cover crop treatment in each row of the table.

When it comes to assessing different cover crops species of mixtures against no cover treatments, there is considerable variability between the different cover crops for changes in RLN counts. Across all comparisons, the level of nematodes is quite high. At these high levels, it may be difficult to truly assess the relative impact of cover crops on RLN populations. The treatments with mustard (either alone or in a mix) appeared to have the greatest reduction in RLN counts.

As noted, spring 2021 Vd counts were comparatively lower and less variable than the RLN counts. The relative difference between cover crop species is well within the error range for Vd testing.

Results- Soil Erosion:

Table 4: Average soil accumulation (g) by date and total accumulation over fall season of 2020

	Date			
Treatment	Mid-October 2021	Early November 2021	Late November 2021	Total Soil Accumulation (g)
Trial 1: Check	20.8	14.3	5.9	123
Trial 1: Rad-Mus	7.2	9.9	3.5	61.6
Difference	**-13.6**	**-4.4**	**-2.4**	**-61.4**
Percent Reduction (%)	**-65.4**	**-30.8**	**-40.7**	**-49.9**
Trial #4: Check	78.4	36.6	37.5	457.6
Trial #4: Oats	49.9	15.5	10.1	226.8
Trial #4: Radish	53.8	12.9	16.9	250.7
Difference (Oat-Check)	**-28.5**	**-21.1**	**-27.4**	**-230.8**
Difference (Radish-Check)	**-24.6**	**-23.7**	**-20.6**	**-206.9**
Percent Reduction (%) (Oat-Chk)	**-36.4**	**-57.7**	**-73.1**	**-50.4**
Percent Reduction (%) (Rad-Chk)	**-31.4**	**-64.8**	**-54.9**	**-45.2**

Soil Erosion Observations:

There were 2 trials from this set tested for soil erosion potential in the fall of 2020, including Trial #1 and Trial #4. Across both trials, given the negative difference values in the table, it was clearly evident that the check strips had greater soil accumulation in the splash pans than the cover crops at all 3 dates of collections in the fall as well as in total accumulation over the fall season. In both fields where splash pans were situated, total accumulated soil in the splash pans was 45-50% less in the cover crop treatments than in the no cover crop check strips. There was a big difference in the scale of the soil accumulated between these trials. This is likely due to the fact that Trial #1 was a somewhat sheltered field where a chisel plough was used as the primary tillage implement. Conversely, Trial # 4 was in a more exposed location close to the north shore, and a moldboard plough was used for fall tillage.

These results support the use of fall seeded cover crops the year before planting potatoes for control of soil erosion. These results are in agreement with the majority of our previous Living Labs BMP1 trials that have showed overall lower soil accumulation in the cover crops treatments than in the check strips.

Results- Potato Yield and Quality:

Table 5: Potato yield and quality data for trial and treatment from fall 2021 graded samples

Trial: Treatment	Total Yields (cwt/ac)	% Total Defects	%Smalls	%> 10 oz	Specific Gravity	Marketable Yields (cwt/ac)	Crop Value ($)
1: Check	299.8	20	9	**13.2 b****	1.100	217.7	2853
1: Radish-Mustard	340.0	22	6.6	**28.9 a****	1.083	253.6	3299
2: Check	314.4	**6.1 b****	6.1	24.6	1.08	286.7	3495
2: Radish-Mustard	319.5	**13.3 a****	7.2	25.9	1.082	268.2	3332
3: Check	335.5	2.8	6.4	14.1	1.091	307.2	4065
3: Radish	317.1	5.1	7.6	8.3	1.089	278.8	3698
3: Mustard	335.8	4	7.5	14.59	1.089	299.8	3949
5: Check	**312.5 b****	**0.4 b****	12.1	10.9	1.078	**273.7 b****	**3377 b****
5: Spring Barley	**382.8 a****	**3.2 a****	9.2	11.9	1.081	**341.7 a****	**4271 a****
7: Check	327.4	30.9	11.9	**19.4 b***	1.086	**190.1 c****	**2534 b****
7: Radish	322.5	10.4	7.3	**18.6 b***	1.09	**276.8 ab ****	**3641 a****
7: Hay	330.1	16.2	6.6	**26.6 a***	1.088	**261.5 b****	**3516 a***
8: Check	**245.8 b***	8.2	**7.6 b****	26.6	**1.072 b****	**210.2 b***	**2515 b***
8: Oats	**328.5 a***	7.3	**10.7 a****	22.6	**1.079 a****	**275.5 a***	**3416 a***

Note: Treatments with significant differences are bolded, and as indicated by different letter groupings. Those including one * asterisk are statistically significant at α=0.1, and those with two ** asterisks are statistically significant at α=0.05.

Potato Yield and Quality Observations:

Looking at the fields individually, we observed the following statistically significant differences between cover crops and no cover check strips:

- Trial #1: The radish/mustard cover crop had higher % 10 ounce than the no cover check. There were numerical differences in yield and crop value favouring the cover crop but were not significant at $p < 0.1$.

- Trial #2: The percentage of total defects was higher in the radish/mustard treatment than in the no cover check.

- Trial #5: We found significant differences between the spring barley cover and the no cover check for total yield, percentage total defects, marketable yield and crop value.

- Trial #7: Marketable yield and crop value was significantly higher for both the radish cover crop and the non-tilled hay stubble compared with the no cover, tilled check. There was no significant difference between the radish cover and the non-tilled hay treatment.

- Trial #8: There were significant increases in favour of the cover crop treatment for total yield, marketable yield, crop value, and specific gravity. There was also a significantly greater percentage of smalls in the cover crop treatment.

Results- Differences in Potato Yield and Quality:

Table 6: Differences between cover crops and checks for potato yield and quality measurements in fall 2021 harvest samples

Trial: Treatment	Total Yields (cwt/ac)	Specific Gravity	% > 10 oz	%Total Defects	%Smalls	Marketable Yields (cwt/ac)	Payables ($)
1: Rad-Mus	40.1	-0.001	**+15.7****	2.1	-2.4	35.9	446
2: Rad-Mus	5.1	0.001	1.3	**+7.2****	1	-18.5	-163
3: Mustard	0.3	-0.003	0.5	1.3	1.1	-7.5	-116
3: Radish	-18.4	-0.002	-5.8	2.4	1.3	-28.5	-366
5: Spring Barley	**+70.3****	0.003	1.0	**+2.9****	-2.9	**+68****	**+894****
7: Tillage Radish	-4.9	0.003	-0.8	-20.5	-4.7	**+86.7****	**+1107****
8: Oats	**+82.7***	**+0.007****	-4	-0.9	**+3.1****	**+65.3***	**+901***
Averages:	**+25.0**	**+0.001**	**+1.1**	**-0.8**	**-0.5**	**+28.8**	**+386**

Note: Rad-Mus= Radish-Mustard mix**.** Differences were determined by subtracted Check values from Cover Crop values. The bolded differences represent treatments where significant differences were detected at α=0.1 if including an * or at α=0.05 with two asterisks **.

Table 6 shows the differences between the cover crop treatments and the no cover check in each field. As noted before, we have omitted two fields from yield analysis due to factors out of the research team's control, including severe and uneven wireworm damage as well as traffic over the research area prior to potato planting.

In three trials, we saw a statistically significant increase in marketable yield and crop value in favour of the cover crop treatment. The other four comparisons were statistically non-significant. One of these was numerically positive for marketable yield and crop value, while the other three were slightly negative.

In general, there doesn't appear to be much difference in quality attributes between cover crop and no-cover checks, but there may be a trend toward increased yield for the cover crop treatments. Therefore, we ran an ANOVA comparing data from all cover crop treatments with all no cover checks (Table 7), all grain covers vs no cover checks (Table 8) and all Brassica crops vs no cover checks (Table 9).

Table 7: ANOVA output across 6 trials comparing all cover crops against check strips

	# Trt.	Total Yields (cwt/ac)	Specific Gravity	% > 10 oz	% Total Defects	%Smalls	Marketable Yields (cwt/ac)	Crop Value ($)
Check	6	**305.9 b****	1.082	18.1	11.4	8.9	**247.6 b****	**3140 b****
Cover	7	**335.2 a****	1.085	18.7	9.3	8.0	**284.9 a****	**3658 a****
Difference	0	+29.3	+0.003	+0.6	-2.1	-0.9	+37.3	+518

Note: The values within the same column not sharing a letter grouping are significantly different from each other, as bolded in the table. Differences were detected at α=0.1 if including an * or at α=0.05 with two asterisks **.

Table 8: ANOVA output across two trials directly comparing grain cover crops against check strips

	# Trt.	Total Yields (cwt/ac)	Specific Gravity	% > 10 oz	%Total Defects	%Smalls	Marketable Yields (cwt/ac)	Crop Value ($)
Check	2	**279.1 b****	**1.075 b****	18.7	4.3	9.8	**242.0 b****	**2946 b****
Grains	2	**355.7 a****	**1.080 a****	17.2	5.3	9.9	**308.6 a****	**3844 a****
Difference	0	**+76.6**	**+0.005**	-1.5	+1.0	+0.1	**+66.6**	**+898**

Note: Trt= Treatments. The values within the same column not sharing a letter grouping are significantly different from each other, as bolded in the table. Differences were detected at α=0.1 if including an * or at α=0.05 with two asterisks **.

Table 9: ANOVA output across 4 trials directly comparing brassica cover crops against check strips

	# Trt.	Total Yields (cwt/ac)	Specific Gravity	% > 10 oz	%Total Defects	%Smalls	Marketable Yields (cwt/ac)	Payables ($)
Check	4	319.3 a	1.085 a	17.8 a	14.9 a	8.4 a	250.4 a	3237 a
Brassicas	5	327.0 a	1.086 a	19.3 a	11.0 a	7.2 a	275.4 a	3584 a
Difference	0	NS	NS	NS	NS	NS	NS	NS

Note: NS= Not Significant

From this analysis, it appears to confirm the trends evident from Table 6: while differences in quality metrics are not significantly different, there does appear to be a significant difference in total yield, marketable yield, and crop value in favour of the cover crop treatments.

We then wanted to see whether there was any difference in how grain cover crops (ie. oats, spring barley) performed compared with brassica species (mustard, radish) as cover crops. In the fields where grain species were used alone as cover crops, they produced significantly higher total yields, marketable yield, specific gravity, and crop value in comparison with the no cover check strips.

When comparing the fields that had brassica species as cover crop treatments compared with a no-cover check, there are some small numerical advantages to the benefit of the brassica covers, but none of these differences were statistically significant. It may be that there was insufficient time for these brassica cover crops to fully establish following tillage, compared with the relatively fast growing grain species. Earlier establishment dates may result in different observations.

Summary:

Below are the key messages regarding these sites established in 2020:

- Two trials were removed from yield analysis in this report because there were mitigating circumstances that we felt made the data non-representative.
- Most of the soil health indicators were low across trials when measured in the spring of 2021, with the exception of Trial #8, which showed medium soil organic matter levels and active carbon in both treatments, but high soil respiratory activity and biological nitrogen availability in the oats relative to medium levels in the check strip.
- The average spring 2021 soil compaction values tended to be lower in the cover crops than the checks, but only a few individual trials showed significant differences between treatments at 12".
- Examining across all trials by treatment, the covers had significantly higher soil compaction than the checks at 6" depth in soil profile. There were no significant differences detected between treatments at the 9" depth. The check had significantly higher soil compaction at 12" depth compared to cover crops.
- Average root lesion nematode populations were higher across all samples in the spring of 2021 compared with the fall of 2021; however, there appears to be a trend for slightly reduced level of increase in the cover crop treatments than in the no-cover check strips.
- *Verticillium dahliae* counts were on average much lower in the spring of 2021 compared to the fall of 2020. There was not a great deal of difference between cover crop treatments and no-cover check strips.
- For both of the fields where splash pans were installed to measure the likelihood of soil erosion, the presence of a cover crop reduced soil accumulation in the pans by 45-50%, indicating that the cover crops did a good job at reducing the risk of soil erosion.
- Rainfall was abundant during the 2021 growing season helping to support a high yield potential
- Trials #5, 7, and 8 showed significantly higher total, marketable yields and payout in their cover crop treatment areas relative to a bare check.
- Grains crops and overall usage of a cover crop resulted in significantly higher total and marketable yields as well as crop value. The Brassica species did not result in significantly higher potato yield and quality data from the checks, but the average values were numerically higher for marketable yield and crop value. The 2020-2021 yield results are in a similar range to what we found in the 2019-2020 fields in the same study.
- Following the completion of this project later in 2022, we will hopefully have enough site-years for some of these soil-building crops to get a truer picture as to the effects of individual cover crops as well as cover crops in general on soil health, soil-borne pathogens, and marketable yield.

Despite still being in the midst of a global pandemic, we have been able to continue with all the Living Labs fall cover cropping research work with some adaptations. The pandemic has reduced our ability to visit with growers more frequently in person or hold meetings in person to discuss trial details and results

on a more on-going basis, but we feel more of those opportunities will open up soon. Online meetings are still possible, but we prefer to do them in person where possible because they tend to be more interactive.

Acknowledgements:

Thank you to the following groups/people:

- Potato Quality Institute (PQI) staff for letting us store samples in a freezer at their facility
- Agriculture and Agri-Food Canada Scientist Dr. Judith Nyiraneza for her collaboration on statistical analysis of our research data
- East Prince Agri-Environmental Association contacts with Living Labs: Andrea McKenna and John Phillips
- Staff from Kensington North Watershed Association, Souris & Area Wildlife Branch, and Bedeque Bay Environmental Management Association (BBEMA) for help with various field tasks

Thank you to the farms who participated in trials with us in 2020-2021, in no particular order, including:

- R.A. Rose & Sons,
- Arthur Mooney & Sons,
- Ching Bros Ltd.,
- Indian River Farms,
- Arthur Cousins & Sons,
- Country View Farms,
- Dunk River Farms and
- Klondike Farms.

Submitted by: Morgan McNeil and Ryan Barrett **Date:** February 10, 2022