Living Labs Atlantic – Final Report

BMP2: Use of fall seeded cover crop following potato harvest

Report by Ryan Barrett, Prince Edward Island Potato Board

Project Rationale:

There has been considerable research conducted in recent years on the merits of fall cover crops in a variety of cropping systems. The use of fall cover crops are associated with a number of benefits, including reduced soil erosion, conservation of soil nutrients, improving soil organic carbon, improving soil health, and, in some cases, improving yields in subsequent crops. Research in potato cropping systems has been more limited. On-farm research in the United Kingdom (reference) showed a trend toward improved potato yields following a fall cover crop compared to a no cover control across multiple site-years of data. Plot-scale research in Southern Ontario (reference) in a field tomato crop rotation showed significant increases in both marketable yield as well as soil organic matter when post-harvest cover crops were employed in six out of eight years in a four-year cash crop rotation.

The majority of potatoes grown in Prince Edward Island are harvested in the month of October. This means that there is a relatively narrow window post-harvest to establish a cover crop before soil temperatures and weather conditions make cover crop establishment difficult. While there are a substantial amount of acres being cover-cropped post-harvest in PEI (40-50% of potato acres, according to annual PEI Potato Board grower surveys), there are a lot of questions from producers on best management practices, including species selection, establishment method, and seeding rates.

In this project, it was our goal to work with producers doing on-farm trials to assess a range of cereal cover crops after potato harvest for both best agronomic practices but also for their impact on soil erosion and soil nitrates.

Project Overview:

In 2019, the Prince Edward Island Potato Board was selected to lead a project under the Living Labs Atlantic initiative to investigate the use of fall planted cover crops following potato harvest. For four years (2019-2022), a number of field-scale trials were established on participating farms. Each field trial included a no cover crop control treatment compared with one or more cover crop treatments. Some field trials compared multiple cover crop species, while others compared different methods of establishment, different seeding rates, or different seeding dates.

Table 1 describes the nature of data collection in these research fields.

Table 1: Description of data collected in BMP1 field trials over three-year period.

Tests Performed	Variables	Timing of Collection	Sampling Intensity
Soil Chemistry, analyzed at PEI Soil Lab (2019 only)	Organic Matter %, pH, individual nutrients	1. Before or immediately after cover crop establishment	One composite sample per treatment.
Soil Health, analyzed at PEI Soil Health Lab (2019 only)	Active Carbon, Aggregate Stability, Soil Respiration, Biological Available Nitrogen	1. Before or immediately after cover crop establishment	One composite sample per treatment
Soil Erosion, with soil weights analyzed at PEI Soil Lab	Accumulated soil (grams)	Multiple times over fall after cover crop planting	Subset of fields per year 2 or 3 splash pans installed per field
Soil Nitrates, analyzed by PEI Soil Lab	Soil Nitrate (ppm)	Following cover crop establishment	3 depths (0-6, 6-12, 12-18 inches), one composite sample per treatment Two or three sampling dates (early October to mid November)
Above Ground Biomass, analyzed using digital photos and Canopeo app	Percent Green Cover	Following cover crop establishment	Two or three sampling dates (early October to mid November)

There were seven fields established in 2019, eight established in 2020, six established in 2021, and one established in 2022 in this project. Fields were located in the three primary watershed areas participating in the Living Labs initiative: Kensington North, Dunk River, and Souris & area. Project staff worked collaboratively with the participating producers to select the cover crops to be evaluated, the timing and method of establishment, and the layout of the trial in the field. The reason why only one field was established in 2022 was due to operational challenges following Hurricane Fiona for many producers, as well as a change in project staff that limited the ability to conduct sampling.

In 2019, seven fields were established between Sept 26th and Oct 14th. Comparisons included:

- 2 fields comparing oats versus check
- 2 fields comparing spring barley versus check
- 2 fields comparing two rates of spring barley versus check
- 1 field comparing fall rye versus check
- 1 field comparing fall rye, spring barley, and check

In 2020, eight fields were established with fall cover crops between September 22nd and October 12th. Comparisons included:

- 2 fields comparing winter barley with spring barley and bare check
- 2 fields comparing different cover crop rates (one with 3 rates of barley, one with 2 rates of oats) versus bare check
- 1 field comparing winter barley with winter wheat and bare check
- 1 field comparing winter barley with fall rye and bare check
- 1 field comparing two methods of establishment with fall rye versus bare check

- 1 field comparing fall rye with bare check

In 2021, six fields were established with fall cover crops between October 1st and October 12th. Comparisons included:

- 2 fields comparing winter barley, winter wheat and bare check
- 1 field comparing winter wheat with a bare check
- 1 field comparing spring barley with a bare check
- 1 field comparing 3 rates of oats with a bare check
- 1 field comparing winter barley, fall rye, and bare check

In 2022, one field was established on September 30th with winter barley, winter wheat, and a bare check. As noted previously, challenges due to human resources and Hurricane Fiona limited the ability to establish trials.

In looking at groupings of trials:

- 8 fields with winter barley
- 4 fields with oats
- 8 fields with spring barley
- 6 fields with fall rye
- 5 fields with winter wheat
- 5 fields doing seeding rate comparisons
- 1 field with different methods of establishment

Above Ground Biomass:

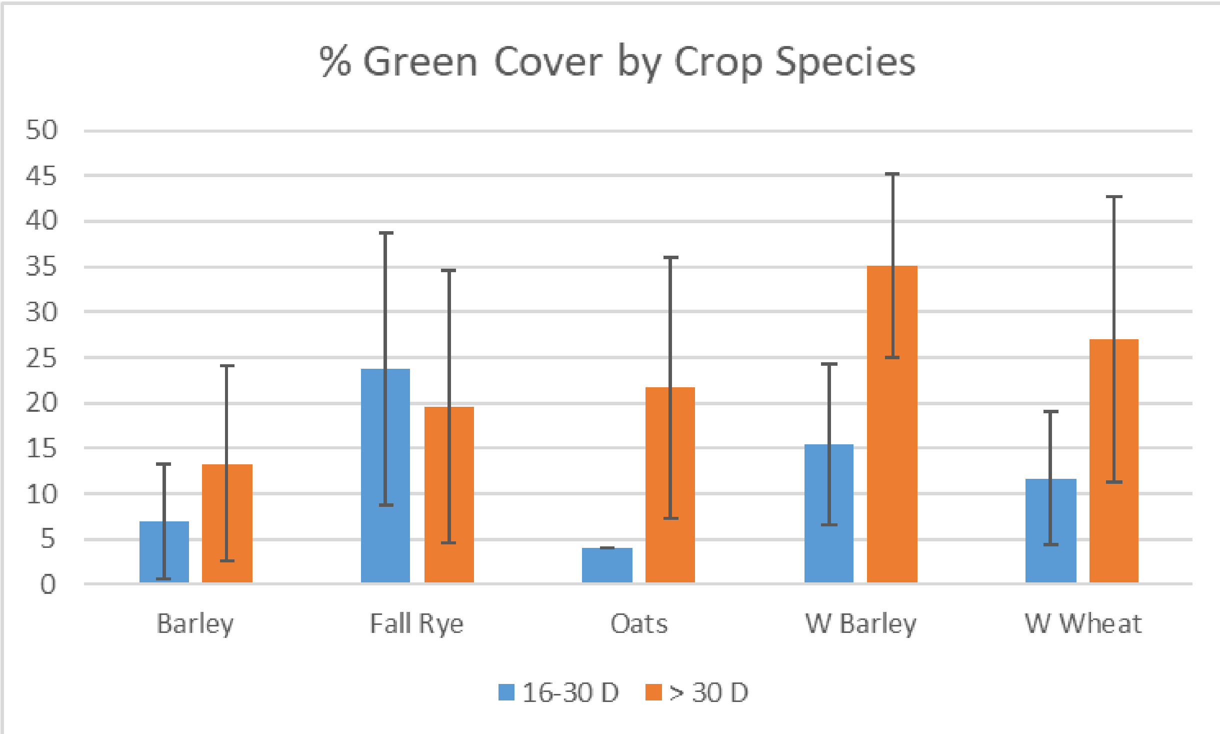
Unsurprisingly, the average percentage of green cover for the cover crop treatments (17.8%, averaged across all dates) was significantly higher ($p < 0.001$) than for the no cover crop treatments (1.0%). When broken down by cover crop, results are as follows:

Table 2: Percent green cover across all observation dates by cover crop species from 2019 to 2022.

Treatment	# of observations	Percentage Green Cover
Barley	21	10.2
Check	53	1.0
Fall Rye	16	20.7
Oats	13	20.3
Winter Barley	21	22.6
Winter Wheat	12	16.4

In breaking out these percentages by days after planting:

Figure 1: Percent green cover across all observation dates for cover crop species sorted by days after planting (DAP) from 2019 to 2022.



From this table, it appears that winter barley and winter wheat had the best percentage of green cover late in the fall in this trial, followed by fall rye and oats. One piece of context that should be added is that the winter barley and winter wheat was primarily planted in late September or early October, while several of the fall rye fields were planted in mid-October. Nonetheless, the fast emergence and good growth of the winter barley was particularly interesting in this trial, as winter barley has not been often grown in Prince Edward Island previously. However, when we followed up with the fields where winter barley the following spring, the majority of these fields had a significant amount of winter dying of the cover crop. Only two of the eight winter barley fields in the study were eventually harvested as a cash crop, and only one of these had what the producer would categorize as a satisfactory yield (greater than 2 MT/acre). Therefore, winter barley planted after potato harvest appears to do well as a fall cover but does not hold the same potential as winter wheat to be harvested the next year. Future trials could examine if winter barley planted earlier in the fall (mid-September) had better winter hardiness. If a producer had the ability to produce their own winter barley seed for cover crop purposes, it may have potential as a good fall cover crop that largely self-terminates. Currently, winter barley seed is much more expensive than other winter cereal options, so adoption is likely to be limited.

In looking at the four trials where we compared different seeding rates, the table below compares percent green cover at the latest measurement date.

Table 3: Percent green cover (measured by Canopeo) in mid to late November at different seeding rates.

	Check	Low Rate	Medium Rate	High Rate
2019 Barley (85, 125 lbs/ac)	0.3	4.2		8.9
2020 Oats (140, 200 lbs/ac)	1.8	41.3		51.0
2020 Barley (90, 120, 150 lbs/ac)	0.4	3.6	4.0	4.6
2021 Oats (90, 120, 150 lbs/ac)	1.1	11.4	11.3	14.8

It was clear that percent green cover was influenced more by the planting date (the 2020 oats trial was planted in late September, versus an October planting date for the other three trials) than by the seeding rate. In two trials, a 33 or 66% increase in seed cost very marginally improved percent cover, if at all. This would lead us to recommend a lighter seeding rate for these spring cereals but with as early of a seeding date as possible. Lowering the cost may help with improving the level of adoption for this practice. In future studies, more could be done to further narrow in the optimum seeding rate for multiple species, including winter cereals.

In the one trial where there was a difference in seeding dates/method of establishment, there was approximately a 50% increase in the percentage of green cover when broadcasting fall rye immediately before the potato harvester compared with broadcasting fall rye after harvest, followed by a levelling tillage pass. Once again, these trial results indicate that the earlier that producers can seed cover crops, the better the cover will be.

Soil Erosion:

Due to limitations in the number of splash pans available, only a subset of fields across the three years of study had splash pans installed to measure the potential for soil erosion caused by dislodging of soil by rainfall or wind from the soil surface.

In 18 splash pans where no cover crop was planted, we saw an average soil accumulation throughout the season of 31.8 g, compared to 24.8 g in the cover crop treatments (total of 23 splash pans). While this was not statistically significant ($p = 0.159$), there is an encouraging trend (22.2% reduction). There was a high degree of variability between fields and between years. In fact, there was a significant difference in accumulated soil between years, with 2019 (42.5 g) and 2020 (36.9 g) have much more soil accumulated in the splash pans than 2021 (17.2 g).

Efforts to use erosion pins to observe differences in soil erosion were fraught with multiple issues, including installation error and frost heaving. For future studies, we would recommend finding alternative methods to measure soil erosion which better account for both dislodging of particles at point of impact on the soil surface but also for the movement of water and wind longitudinally across the field.

Soil Nitrates:

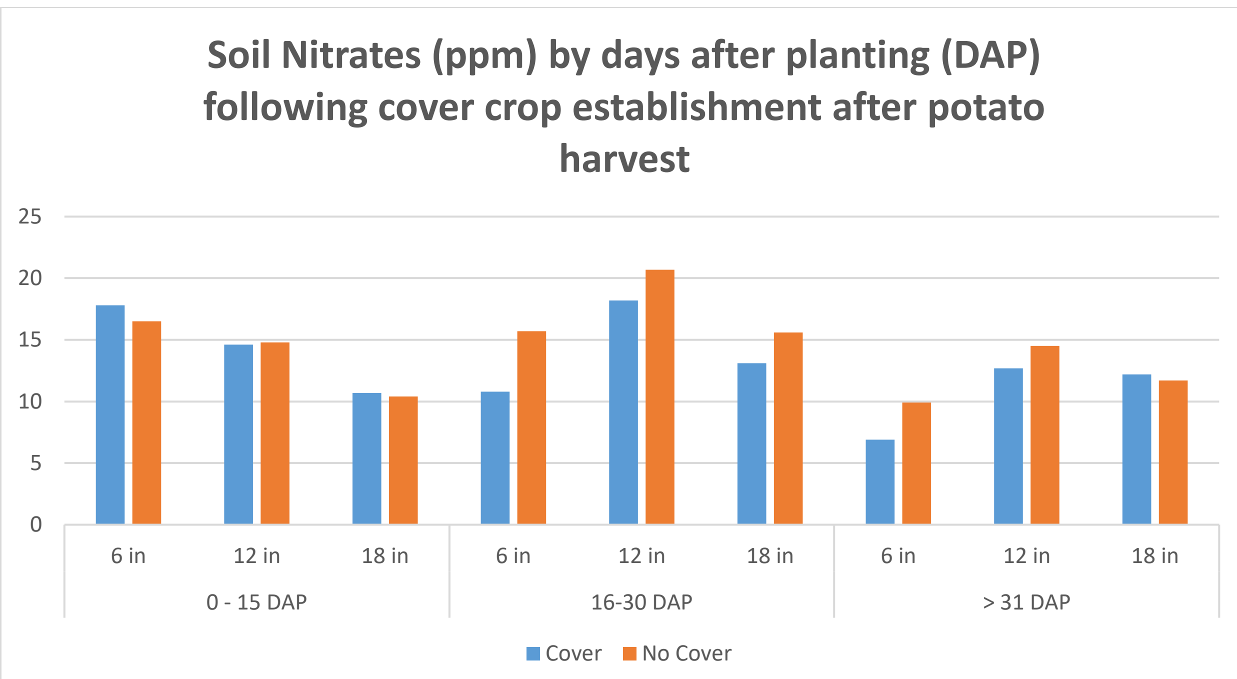
Table 4: Soil nitrate concentrations (in ppm) at three depths and at different days after planting (DAP following cover crop establishment after potato harvest in 2019-2021.

	0-6 inches	**6-12 inches**	**12-18 inches**
Cover Crop	10.2	14.4	12.1
No Cover Crop	13.0	16.3	12.6
Difference	-2.8	-1.9	-0.5
p value	0.112	0.222	0.644

Differences in soil nitrate concentrations were non-significant at each of the three depths when comparing cover crops with no cover crop treatments. While there was a trend toward a reduction (especially at the first two depths), it is statistically not significant.

We wanted to explore whether there may be greater difference seen at later days after planting:

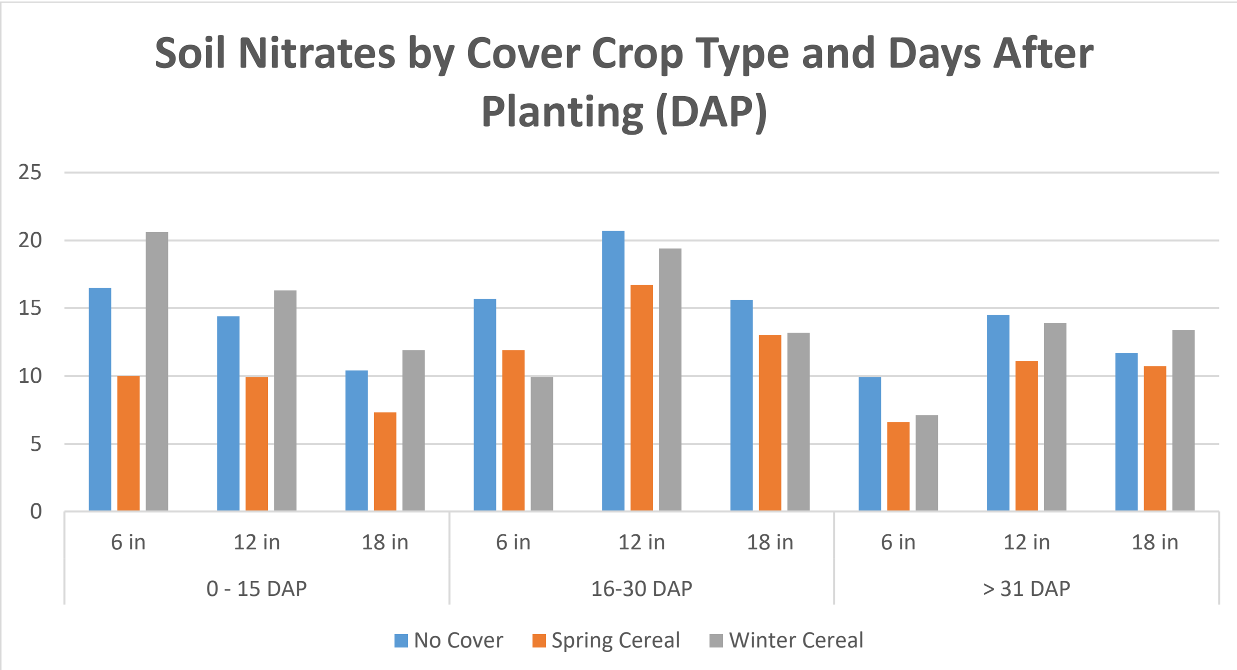
Figure 2: Soil nitrates (ppm) by days after planting (DAP) following cover crop establishment after potato harvest.



At 0-15 DAP, there is no difference at all in soil nitrate levels. It is likely that the cover crop has not had an opportunity to uptake much soil nitrate in this short period of time. In the 16 to 30 days after planting grouping, there does appear to be a trend toward lower soil nitrate levels in the cover crop treatments, though these differences are not statistically different at p = 0.05. This trend also appears to continue for dates greater than 31 days after planting; however, the difference continues to be non-significant. The greatest reduction appears to be in the 0-6 inch soil depth, which is largely where the majority of roots are for the cover crop in the relatively short period for growth after potato harvest that we had in this trial.

We wanted to break out these nitrate results by cover crop type (spring cereals and winter cereals) as well as by days after planting (DAP):

Figure 3: Soil nitrates (ppm) results grouped by cover crop type and by days after planting following establishment of cover crops after potato harvest from 2019 to 2021.



This figure aggregates all data from all trials, so there is not an equal number of observations for each crop and each date category. As well, only a subset of trials compared a winter cereal and a spring cereal in the same field, so it is difficult to draw any direct conclusions from these comparisons. However, it does not appear that there is any substantial difference in nitrate uptake between the spring cereal and winter cereals after 15 days after planting. The spring cereals may have taken up soil nitrates at a faster rate before 15 days after planting; however, this is a relatively small number of fields, and some of the fields that had winter cereals planted had higher starting levels of soil nitrate. Therefore, no firm conclusions are obvious from this data, and none of the p-values from ANOVAs are less than 0.05.

Soil Nutrients and Soil Health:

In the fall of 2019, soil chemistry and soil health testing was completed for project fields, based on the expectation that follow-up soil sampling would be completed the following spring. It was decided to not continue this soil sampling due to the logical assumption that 30-60 days worth of cover crop growth would not make enough of a difference to change soil chemical or soil health metrics given the relatively low density of sampling that was performed.

Discussion and Next Steps:

One of the limitations of this trial that we acknowledged from the beginning was that growers are very busy during harvest, and it can be challenging to propose and implement multiple treatments (different species, different seeding rates, and different seeding dates). Growers were more willing to entertain comparing different species or different rates than different seeding dates, as that would require a second trip to the field. For many producers, the biggest barrier to getting cover crops established is not cost or willingness; rather, it is a lack of available labour and/or equipment. Therefore, we were not able to do the full suite of comparisons envisioned in this project. That said, we feel that we were still able to generate some useful data to help producers refine and improve best management practices.

For some producers, there is a reluctance to use fall rye as a winter cover crop. Because of its hardy nature, it almost always survives the winter in PEI and will need to be managed the following spring. The grand majority of cereal rye in PEI is not managed to be harvested, rather, it is terminated before planting another crop. This is less of an issue ahead of a glyphosate tolerant crop like corn or soybeans or a full season cover crop, but more of an issue ahead of barley or oats. Our data has shown in this project that fall rye will establish reliably in most years until October 15th; in some warm falls, it has successfully established up to October 31st. However, the producer needs to have a management plan to deal with that fall rye cover crop the next spring, depending on the projected crop rotation. Some producers are also hesitant to use glyphosate to manage cover crops; instead, they would rather the cover crop to winter kill and avoid using herbicide. While this saves an expense, it reduces the potential to mitigate soil erosion and nitrate leaching and also reduces the potential to increase soil carbon. Better understanding the trade-offs and economics in managing cover crops in potato rotations should be a focus of future research or on-farm demonstrations.

Winter barley did not reliably over-winter in most of the trial fields in this project. It appears that seeding winter barley following potato harvest in late September or early October is too late for reliable over-wintering and production of a harvestable crop. Perhaps seeding in early or mid-September may provide sufficient time for winter barley to establish and fortify itself for acceptable survival the following spring. In all of our trial where winter wheat was planted, there was an acceptable level of winter survival and those fields were eventually harvested as a cash crop. Ideally, maximizing the number of acres in Prince Edward Island that are planted with a fall cover crop that will also most often be harvested as a cash crop is in the best interest of both the profitability of producers as well as the long-term health of soils. Future research into the successful planting window for winter wheat (and other vernal species), particularly given the changing nature of our climate, is warranted. If there was a greater market for rye as a cash crop, there is considerable potential to increase acreage of this cover crop.

One of the true take home messages from this project was demonstrating that after the first days of October the ability for spring cereals like barley or oats to reach the desired level of cover is limited. Where possible, producers are recommended to prioritize winter cereals after the first days of October in most years. Barley and oats are better than nothing as a fall cover, winter cereals will establish better in colder soils and will continue to regrow in the spring, further protecting soils from erosion.

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- Murray Farms, Bedeque
- Monaghan Farms, Norboro
- Townshend Potato Co., Rollo Bay West
- MacSull Farms, Graham's Road
- Mull Na Bienne Farms, Graham's Road
- Oyster Cove Farms, Hamilton
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