AIM Trial: **Impact of Rotational Grazing on Potato Yield and Quality (LL-ACS)**
Working Group: Soil Improvement
Crop Year: 2024
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Project Rationale

For many years, forages have been widely grown in PEI potato rotations. Historically this was due in large part to the nature of farms in PEI, many of which were mixed farms, producing cash crops like potatoes as well as livestock, primarily beef and dairy cattle. In the last two decades, there has been a significant drop in beef cattle numbers in the province; as a result, many forage crops are simply mowed or mulched to conserve nutrients and build soil health ahead of a potato crop.

Recently, there has been interest in growing the provincial beef herd once more while finding ways to do so in an economical way. At the same time, the adoption of regenerative agriculture principles is being championed by many potato buyers, and one of those principles is improved livestock integration with crop production.

Therefore, this ACS-Living Labs project was developed to determine if there are benefits in improved soil health and improved potato yield by introducing beef cattle under a managed rotational grazing program for one or two years before potato production.

Project Overview

This project was initiated in two fields prior to the start of the ACS-Living Labs program. One of those fields ended up not having an effective check strip (no grazing), so research was abandoned. The second field trial (BFA24) was set up in 2022. As it has three different crop rotations and was initiated before the new Living Labs program, no grid sampling or greenhouse gas (GHG) sampling was conducted here. The other two field trials (OCF24 and RAY24) were initiated in 2023 and were grid sampled and gas sampled in partnership with Agriculture & Agri-Food Canada.

Each of these fields are being reported on separately, because there are too many variables different between the fields to look at their results in combination.

Bluefield Acres/Kingston View Farms (BFA24)

This trial was established in the spring of 2022, prior to crop planting. In consultation with the land owner and potato grower (Bluefield Acres – Craig McCloskey) and the grazer (Kingston View Farms – Nick Green), we did baseline soil sampling at four representative locations in each of three crop rotation treatment areas. These sites were georeferenced and follow-up soil sampling would be conducted at the same points in 2023 and 2024.

The trial was sited in a large field (> 45 acres) in the North Wiltshire area of Central PEI. All sampling points were located at the southern end of this field. The following crop rotation was installed in this field:

Year	Control Treatment	Graze-Corn	Graze-SSAlf
2022	Barley, underseeded with double cut red clover	Corn, grazed in November	Sorghum sudangrass, underseeded with mix of alfalfa/grass (see below)
2023	Double cut red clover	Annual forage mix consisting of: 28% crimson clover 7% berseem clover 60% annual ryegrass 3% nitro radish 2% hybrid brassica	70% alfalfa 20% timothy 5% tall fescue 3% orchardgrass 3% perennial ryegrass
2024	Potatoes (Alverstone Russet)	Potatoes (Alverstone Russet)	Potatoes (Alverstone Russet)

In 2022, the barley was harvested and straw removed from the field, allowing the underseed to establish in the control treatment. The corn treatment was grazed in November. The cows grazed the majority of the biomass. There were some obvious erosion issues from this treatment the following spring. The sudangrass treatment was grazed twice and then left, allowing the alfalfa/grass underseed to establish.

In 2023, the control treatment was mowed August 12th, 2023 with no biomass removed from the field. The annual forage mix planted after corn was sowed in May 2024. Cattle (18 head) were moved to the field on July 1st, 2023 and removed from the field on November 12th. The two grazing treatments were grazed a total of three times over that time, with cattle grazing in small blocks. The field was moldboard plowed on December 3rd, 2023.

In 2024:

- Soil samples were taken in all sections on May 14th, 2024 before planting potatoes
- Alverstone Russets were planted on May 30th, intended for seed production
- Potato samples were dug on September 24th with six, 10-foot strips dug in each section. These samples were weighed in field, stored and then graded at Central Grading on November 14th.
- Post harvest soil samples were taken on October 17th. Barley had been spread pre-harvest as a cover crop and was incorporated during harvest. Samples were taken at four points in each section of the field at two different depths; 0 – 6 inches and 6 – 12 inches. The samples were tested specifically for nitrates in order to determine if any leaching had occurred post harvest.
- A factor of 13 was used to calculate yield per acre (from lbs per 10 feet).

Soil Tests:

Barley/Red Clover/Potatoes

Year	P_2O_5	K_2O	OM	pH	Active C	Soil Respiration	Aggregate Stability	BNA
	ppm	ppm	%		µg/g	mg/g	%	mg/kg
2022	540	140	2.7	6.6	514	0.36	37	18
2023	525	153	3.2	6.4	434	0.56	47	24
2024	456	105	3.3	6	419	0.43	47	17
p value	0.09	**0.003**	**0.02**	0.2	**0.002**	**0.02**	0.1	0.2

We observed an increase in soil organic matter in this trial from spring 2022 to spring 2024. Interestingly, we saw a decline in active carbon and pH. Aggregate stability improved after the first year (barley) and was the same in 2024 (after plowing). Potassium levels were lower in spring 2024 despite no crop biomass being removed.

Corn/Annual Forage & Legume Mix/Potatoes

Year	P_2O_5	K_2O	OM	pH	Active C	Soil Respiration	Aggregate Stability	BNA
	ppm	ppm	%		µg/g	mg/g	%	mg/kg
2022	626	126	3.1	6.1	501	0.29	35	19
2023	668	191	3.4	6.1	438	0.6	37	20
2024	536	122	3.2	6.1	389	0.36	49	19
p value	0.3	**0.003**	**0.004**	0.9	**<0.001**	**0.01**	**0.01**	0.99

There was relatively no change in soil organic matter or pH in this treatment after two years of grazing. Active carbon also decreased (as in the control treatment). Biological nitrogen availability (BNA) was remarkably constant (in line with consistent soil OM), while soil respiration was more variable.

Sorghum/Alfalfa/Potatoes

Year	P_2O_5	K_2O	OM	pH	Active C	Soil Respiration	Aggregate Stability	BNA
	ppm	ppm	%		µg/g	mg/g	%	mg/kg
2022	685	144	3.2	6.5	453	0.31	40	18
2023	699	191	3.3	6.2	474	0.48	30	25
2024	588	137	3.4	6.1	426	0.42	42	21
p value	**<0.001**	0.3	0.1	0.2	0.2	**0.02**	**0.004**	**<0.001**

There was a slight increase in soil organic matter (0.2%) over the grazing period, and active carbon did not decline as much in this treatment than in the other two; however, it started at a relatively lower level. pH declined similarly to the control treatment and other soil health metrics were variable in response. Interestingly, this treatment has the lowest aggregate stability in spring 2024, despite the presence of aggregate building crops like alfalfa and grasses.

Potato Quality and Yield:

Treatment	Total Yield	Smalls	>10 oz.	Total Defects	M. Yield	Payout
	cwt/ac	%			cwt/ac	$/ac
Control	355	18.0	0	0.7	291	5121
Graze-Corn	350	21.0	1.8	0.3	276	4899
Graze-SSAlf	304	18.5	1.0	0.3	248	4376
p value	0.09	0.73	0.41	0.76	0.25	0.25

There appears to have been a slight reduction in yield in the Graze-SSAlf treatment area compared to the other two treatments. This was at first surprising, as this part of the field was noticeably greener/healthier in late August when visiting the field. However, it should be noted that this side of the field was top-killed a few days earlier than the rest of the field (in early September); additionally, the extra nitrogen likely to be been mineralized by the alfalfa in this treatment area may have delayed maturation of the potato crop, delaying tuber bulking compared to the other two treatment areas.

Post Harvest Soil Nitrates

	Graze-SSAlf	Graze-Corn	Control	p value
Depth (in.)	**Nitrates (ppm)**			
0-6”	5.2	5.7	11.4	0.14
6-12”	10.4	11.7	18.2	0.10

Somewhat surprisingly, residual nitrate levels were highest at both depths in the control treatment, despite it having a high total yield. Differences were not significant, but there was a trend toward lower residual nitrates in the two grazed treatment areas.

Key Observations:

- There were few obvious trends related to soil health metrics between any of the treatments.
- Organic matter increased in the control and the Graze-SSAlf treatment, and remained constant in the Graze-Corn area.
- Yields were slightly lower in the Graze-SSAlf treatment area in 2024; however, this may be a result of excess nitrogen availability and a slight difference in top-kill date.
- Residual nitrate levels were lower following potatoes in both of the grazed areas compared with the control.

Rayner Farms (RAY24):

This trial was established in the summer of 2024. A first cut of hay was removed from the entire field (4 round bales per acre) in July. Most of the field was then grazed by 60 cows and 40 calves starting August 4th. Cows were moved frequently, resulting the field being grazed three times before cows were removed in November. In the non-grazed control treatment, no mowing was done due to lack of regrowth. Baseline soil sampling was performed prior to grazing in the summer

of 2023, with follow-up testing in May 2024 prior to potato planting. Also prior to potato planting, beef manure (field stored) was spread on most of the field. An area of the field that included both the grazed and non-grazed treatments had no manure spread.

Potatoes were planted on May 31st, 2024, with the variety being Yellow Star (a creamer variety for seed). Due to lack of moisture during the summer of 2024, the Yellow Star potatoes began to desiccate early and were killed on August 30th. On September 20th, twelve, ten-foot samples were dug from both the grazed and check sections of the field (6 each from the manure-applied and no-manure areas of the field). These samples were weighed in field, stored and later graded at AAFC based on a seed grading standard. A factor of 13 was used to calculate yield in cwt/acre (from lbs/10 feet of row).

Soil Tests

Baseline: **Spring 2023**

	NO_3 (mg/kg)		Soil OM %	pH	Active C	Soil Respiration	Aggregate Stability	BNA
	0-15	**15-30**	**0-15**		**µg/g**	**mg/g**	**%**	**mg/kg**
Grazed	7.8	6.9	2.70	6.4	359.1	0.47	77.9	19.6
Non-Grazed	7.3	5.9	2.24	6.1	279.0	0.39	71.0	14.9

There was a wide range of soil carbon (converted to soil organic matter using factor of 1.724) across the field; however, yield samples for the grazed treatment were located next to the non-grazed section and differences in soil attributes were smaller. Differences in BNA and Active C are likely to also be reflected in this across-field variability.

Nitrates: October 2023

	NO_3 (mg/kg)
	0-15
Grazed	9.9
Non-Grazed	15.6

Soil nitrates were slightly lower in October (after most grazing was completed) in the grazed treatment area than in the non-grazed control treatment. This is curious, as some additional nitrogen in the form of manure from the cattle would have been deposited on the field.

Spring 2024: May 2

	NO_3 (mg/kg)		Soil OM %	pH	P_2O_5	K_2O	Active C	Soil Resp	Agg Stab	BNA
	0-15	15-30	0-15		ppm	ppm	µg/g	mg/g	%	mg/kg
Grazed	5.8	6.5	2.56	6.5	382.5	189.2	373.5	0.52	58.1	20.1
Non-Grazed	6.2	8.6	2.48	6.2	396.0	161.3	325.0	0.5	57.5	18.6

Compared to the baseline testing in 2023, organic matter was slightly lower in the grazed area and slightly higher in the non-grazed control, which is the opposite of what was expected. Metrics for soil respiration, aggregate stability and BNA are very comparable between the treatments. Active C was similar for the grazed area compared to the baseline sampling, while it improved noticeably in the non-grazed check.

Potato Yield and Quality

Treatment	<1.5”		1.5-2.5”		>2.5”		Offtype/Culls		Total Yield	
	cwt/ac.	#	cwt/ac.	#	cwt/ac.	#	cwt/ac.	#	cwt/ac.	#
Graze	32.1	56	176.5	113	17.4	5	4.8	3	230.7	177
Non-Grazed	29.6	53	167.4	110	18.9	5	2.7	2	218.5	169
Difference	2.5	3	9.1	3	-1.5	0	2.1	1	12.2	8
p value	0.6	0.7	0.4	0.6	0.9	1	0.2	0.3	0.5	0.5

There were no significant differences in yield and size profile between the grazed and non-grazed treatments. There is a numerical difference of 12.2 cwt/ac as well as a slightly higher number of tubers per sample for the grazed treatment, but these are not statistically significant.

Treatment	<1.5”		1.5-2.5”		>2.5”		Offtype/Culls		Total Yield	
	cwt/ac.	#	cwt/ac.	#	cwt/ac.	#	cwt/ac.	#	cwt/ac.	#
Manure	32.0	56	184.5	119	21.4	6	3.7	2	241.5	182
No Manure	29.7	52	159.4	104	14.8	4	3.7	2	207.6	163
Difference	2.3	4	25.1	15	6.6	2	0	0	33.9	19
p value	0.6	0.7	0.02	0.01	0.5	0.5	0.99	0.5	0.05	0.05

There was a significant difference in tuber number per sample and total yield between the parts of the field where manure was applied compared to the non-manure applied section. This field was significantly impacted by drought, so the extra water-holding capacity of the organic matter from

the manure may have made a difference. The majority of the increase in yield was in the prime seed size category of 1.5 to 2.5 inch diameter.

Post-Harvest Nitrates: September 20

	Depth	Manure	No Manure
Grazed	**0-15**	11.3	20.0
	15-30	20.2	44.2
Non-Grazed	**0-15**	17.5	35.6
	15-30	28.5	50.7

Following potato harvest, there still appeared to be slightly lower residual nitrates in the grazed treatment area compared to the non-grazed control. Residual nitrates were higher in the no manure section of the field, which is likely reflected by the reduced yield (and reduced N export) seen in this section of the field.

Key Observations:

- The presence of manure had a significant impact on potato yield.
- There was no significant difference in yield between the grazed and non-grazed treatments.
- There was no obvious difference in soil health metrics between grazed and non-grazed.
- Residual nitrates were lower in the grazed area than in the non-grazed area, both after grazing and after potatoes in the year after grazing.
- While no data was collected on this, the research team noticed that weed density appeared to be lower in the grazed area of the field.

Oyster Cove Farms (OCF24):

This field in Hamilton, PEI was baseline soil sampled in June 2023, prior to cattle grazing the field. The majority of the field was rotationally grazed, with a section of the field fenced off as a non-grazed control. The non-grazed control was mowed twice throughout the summer to mimic standard practice. The forage mixture in the field was nominally 60% alfalfa, 10% alsike clover and 30% tall fescue, orchard grass and timothy; however, the section of the field where potatoes were planted in 2024 had a higher percentage of grass than legume.

Cattle were moved to the field on June 5th, 2023 and a total of 38.5 animal units grazed the entire field four times before removal in the fall. The field was rotationally grazed, with animals moved frequently into small strips. The field was plowed (moldboard plow) in April prior to potato planting. Only a small portion of the larger field was planted to potatoes in 2024.

Alverstone Russets were planted on May 25th for processing. On September 23rd, 2024, after top kill, six, ten-foot strips were dug in both the grazed and check sections of the field. These potato samples were weighed in the field, stored and graded at Central Grading on November 14. A factor of 13 was used to calculate yield in cwt/acre (from lbs/10 feet of row)

Soil Tests

Baseline Samples: Spring 2023

	NO_3 (mg/kg)		Soil OM	pH	Active C	Soil Respiration	Aggregate Stability	BNA
	0-15	15-30	%		µg/g	mg/g	%	mg/kg
Grazed	14.2	9.6	2.82	6.6	404.8	0.71	79.4	28.6

Spring 2024: April 29

	NO_3 (mg/kg)		Soil OM	pH	P_2O_5	K_2O	Active C	Soil Resp	Agg Stab	BNA
	0-15	15-30	%		ppm	ppm	µg/g	mg/g	%	mg/kg
Grazed	9.1	7.5	2.75	6.6	275.7	184.1	436.1	0.69	66.1	33.7

***only one point in check**

Due to the small size of the non-grazed check (it only included on point on the baseline sampling map), it was not possible to compare grazed with non-grazed for soil attributes. When comparing year-over-year data, we observed an increase in active carbon and biological nitrogen availability following grazing in the year previous. A relative decrease in aggregate stability may be impacted by the fact that this sampling was done after plowing. There did not appear to be much difference in soil organic matter, and any differences could be masked by differences in time of sampling

Post Harvest Nitrate Samples: September 23

	NO_3	
	0-15 cm	15-30 cm
	mg/kg	
Grazed	9.8	8.3
Non-Grazed	6.5	7.9
Difference	3.3	0.4

Differently than the other two 2024 trials, nitrate levels were higher in the grazed area than the non-grazed control following potato harvest. However, it should be noted that these levels of residual N are comparatively low.

Potato Yield and Quality

Treatment	Total Yield	Smalls	>10 oz.	Total Defects	M. Yield	Payout
	cwt/ac	%			cwt/ac	$/acre
Grazing	285.8	25.7	0	4.7	204.3	3603.43
Non-Grazed	288.8	22.3	0.5	10.3	198.0	3517.73
Difference	-3	3.4	0.5	-5.6	6.3	85.7
p value	0.9	0.58	0.34	0.27	0.87	0.90

There was no significant difference in yield between the two treatments. There was a higher level of

total defects observed in the non-grazed control (largely common scab) but it's not possible to attribute that to the treatment, particularly given the small size of the non-grazed area.

Key Observations:

- There were no obvious trends identified with regards to soil health metrics or potato yield between the two treatments.
- This field was impacted by drought conditions in 2024, and potato yields were below budget from what the producer was expecting.
- Spring plowing ahead of potatoes had a negative impact on the crop, with lots of lumps/clods and some weed pressure.
- The small size of the non-grazed control made it difficult to make comparisons on soil attributes.

Summary Points:

- This rotational grazing project experienced some hiccups in the first trial fields, including the impact of dry weather and the size and layout of non-grazed control strips. It is difficult to set aside non-grazed portions of fields in representative areas of the field (or with replication) because it adds significant labour and management to grazing and it can lead to cattle breaking through fences to get into non-grazed areas. While all participants worked hard to ensure the integrity of each trial, challenges from the first iteration of this project will inform future years of study.
- Both the BFA24 and RAY24 fields are planned to go into rotational grazing for additional years before potatoes are planted again in 2027. The status of the OCF24 field is uncertain, given that we may no longer have a non-grazed check in the part of the field that was not potatoes in 2024 (and that was grazed).
- So far, no obvious trends in potato yield improvement or soil health metrics have been detected. More time and more replications may be needed to observe true impacts of these practices.
- At the same time, there were no observed detrimental effects of grazing on these fields. This alone may prove valuable to potato producers who have an opportunity to rent land for grazing or who choose to graze their own animals.
- Greenhouse gas emission data is not included in this report but was collected by AAFC.
- Two additional fields will be in potatoes in 2025 that were grazed in 2024.

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