

AIM Research Trial Report: **Effect of Legume Species on Potato Early Dying Complex**
Working Group: Soil Improvement
Crop Year: 2021
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Project Rationale:

There have been many questions from potato producers regarding how different species of forage legumes may differentially host *Verticillium dahliae* and root lesion nematodes, causal agents of potato early dying (PED) complex. Past research in PEI has indicated that red clover is a preferred host for both of these pathogens. However, there is little research on other forage legumes like alfalfa and white clover in comparison with grass species.

Project Overview:

In the spring of 2019, two fields in Western Prince Edward Island were planted with strips of the following forage species: double cut red clover (RC), alfalfa and timothy (ALF), white clover and festolium grass (WC), birdfoot trefoil (TR), and grass as a non-legume check. Participating growers were Wallace Properties (WP) with a field in Alma, and Dock Corner Farms (DCF) with a field in Huntley.

Festolium grass was planted at both sites, but did not establish well at the Wallace Properties site in Alma, so the comparison was done using Italian ryegrass which was planted in the same field directly next to the festolium strip.

In the DCF field, the birdsfoot trefoil did not establish well. It was not evident in 2019, with some volunteer clover and grass being most evident. Trefoil was more evident in 2020, with considerably more biomass in the treatment strip. Trefoil was not evident at all in the Wallace Properties field. Therefore, this strip was excluded from analysis in this report for both fields.

Both fields were planted with the same grain drill on the same day in May 2019 using the same seeding rates. Each strip is four widths of the grain drill, except for the festolium strips that were 2 widths of the seeder. Each strip was also planted with barley at approximately 40 lbs per acres as a nurse crop.

Soil chemical, *Verticillium* and nematode testing was completed at planting in the spring of 2019. It was then completed again in the fall of 2019, spring of 2020, fall of 2020, and spring of 2021. Samples were taken using dutch augers with multiple auger samples per strip, mixed and submitted as a composite sample for each treatment strip.

Both fields were planted to potatoes in 2018. Both fields were planted to potatoes in 2021. Mountain Gem Russets were planted at the Wallace Properties field, while Prospect was planted at the Dock Corner Farms field. Four 10 foot strips were harvested in each treatment with a consistent number of plants per strip, depending on variety. Harvest samples were then graded at Cavendish Farms Central Grading.



Alfalfa/timothy treatment on the left, double cut red clover on the right in the Wallace Properties field in June 2020. Photo by Ryan Barrett

Results:

Soil Fertility Properties:

For the Dock Corner Farms (DCF) field, pH remained relatively consistent, with most measurements ranging between 5.8 and 6.2. Soil organic matter percentages showed very little difference observed over the 3 years; however, composite samples were repeated only over time, not within each sample date. From the soil test data, soil OM percentages repeatedly appeared to be slightly lower in the white clover/grass treatment compared with the other treatments.

Measurements for soil nutrients were somewhat variable. Phosphorus (P_2O_5) ppm ranged from 327 to 643 in the spring of 2021, with the lowest P levels evident in the alfalfa/timothy treatment; however, all P levels were rated as High. Potassium (K_2O) ppm ranged from 94 to 215 in the spring of 2021, with the highest values evident in the red clover and alfalfa treatments. It should be noted that these two treatments were tilled with vertical tillage in the fall of 2020, compared with the other treatments being inadvertently moldboard ploughed. However, the full 25 cm soil depth was sampled consistently across all treatments. The difference for other nutrients was negligible.

For the Wallace Properties (WP) field, pH again remained remarkably consistently ranging between 6.2 and 6.5 across treatments in the spring of 2021 and without much change from 2019 to 2021. There was also not much difference in soil organic matter over time. Differences between treatments for individual soil nutrients was negligible in the spring of 2021, with ratings of High+ for both P and K. For both fields, micronutrients including B, Zn, and Cu were generally rated as Low, and Sulfur levels were also low (11-14 ppm).

For all treatments across the two fields, soil nitrate was assessed in the spring of 2021. Readings were non-detectable (< 5 ppm) in all but one treatment. There did not appear to be much free nitrate in the soil in advance of potato planting in May 2021.

We also tested both fields for soil compaction in May 2021 using a hand-held needle penetrometer. The results from the DCF field are somewhat compromised, as there were two different tillage practices used in the fall of 2020 in the field. This resulted in compaction readings not being truly comparable. At the WP site, the results were as follows, averaged over 10 penetrometer readings per treatment:

Treatment	6 inches (psi)	9 inches (psi)	12 inches (psi)
Alfalfa/Timothy	25.5	79.5	227.5
DC Red Clover	23.5	119	317
White Clover/ Festolium	32	96	246
Ryegrass	23	67.5	256

As you can see, there is a noticeably lower level of compaction at 12 inches for the alfalfa/timothy treatment than the red clover treatment, and marginally lower than the other two treatments. It was also easier to get the penetrometer to penetrate deeper than 12 inches on the alfalfa/timothy strip, while in the other strips, it was often difficult to even get to 12 inches of depth in many places.

Soil Health Metrics:

Table 1: Soil Health metrics from Wallace Properties field from May 2021

	Active Carbon		Soil Respiration		Aggregate Stability		Bio. N Availability	
	Result µg/g	Score (/100)	Result mg/g	Score (/100)	Result %	Score (/100)	Result mg/kg	Score (/100)
Alfalfa/Timothy	365	21	0.41	14	22.3	7	17.6	29
DC Red Clover	372	22	0.41	14	22.5	7	22.9	47
White Clover/ Festolium	285	11	0.21	0	19.3	4	10.7	10
Festolium	284	11	0.46	28	24.9	11	16.9	27

With regards to soil health metrics, there was very little difference across the treatments, with scores generally low across the board.

Table 2: Soil Health metrics from Wallace Properties field from May 2021

	Active Carbon		Soil Respiration		Aggregate Stability		Bio. N Availability	
	Result µg/g	Score (/100)	Result mg/g	Score (/100)	Result %	Score (/100)	Result mg/kg	Score (/100)
Alfalfa/Timothy	310	14	0.47	31	18.4	3	21.8	44
DC Red Clover	295	12	0.53	46	22.1	7	19.0	33
White Clover/ Festolium	312	14	0.60	60	17.7	3	34.6	81
Italian Ryegrass	361	20	0.57	55	29.5	20	24.6	53

In the WP field, there was very little difference across treatments for Active Carbon and Aggregate Stability. There did seem to be a slight improvement in Soil Respiration for the White Clover/Festolium

and Ryegrass treatments. There was also a notably higher level of Biological Nitrogen Availability in the White Clover/*Festolium* treatment, compared with the other three treatments.

***Verticillium* populations:**

Table 3: *Verticillium dahliae* populations by treatment at Dock Corner Farms (DCF) field from 2019 to 2021, expressed in cells per gram of soil.

Treatment	May 2019	October 2019	May 2020	October 2020	May 2021
Red Clover	9395	9748	4271	6962	2109
Alfalfa/Timothy		8593	3169	10866	3202
White Clover/ Festolium		9311	8958	7195	1310
Festolium		7244	5136	3500	1326

In the DCF field, there was a general trend for a reduction in *V. dahliae* spores over time, as we get further away from the last potato year (2018). While *V. dahliae* populations appeared to decrease less over time in the alfalfa/timothy treatment, the range of error in testing makes it difficult to say with any certainty that there is an observable difference between treatments ahead of potato planting in 2021.

Table 4: *Verticillium dahliae* populations by treatment at Wallace Properties (WP) field from 2019 to 2021, expressed in cells per gram of soil.

Treatment	May 2019	October 2019	May 2020	October 2020	May 2021
Red Clover	7489	9405	5716	5727	1125
Alfalfa/Timothy		9444	8444	8686	3636
White Clover/ Festolium		6185	6176	5089	1854
Italian Ryegrass		6582	10048	8738	3465

For *V. dahliae* populations in the WP field, there was a similar reduction in spores over time. Again, it appeared from the raw numbers that the amount of reduction was slightly less in the alfalfa/timothy treatment than for the white clover and red clover treatments; however, the same provisos related to sampling error make it difficult to state that there is any tangible difference between the treatments for *V. dahliae*. What is important to note is that in none of the treatments did the amount of *V. dahliae* not decrease substantially from the spring of 2019 (following potatoes).

Root Lesion Nematode Populations:

Table 5: Root lesion nematode populations by treatment in Dock Corner Farms field from 2019 to 2021, expressed in nematodes per kg of soil.

Treatment	May 2019	October 2019	May 2020	October 2020	May 2021
Red Clover	5855	10494	12669	23611	7070
Alfalfa/Timothy		5816	1740	14399	17651
White Clover/ Festolium		5816	1727	11735	7932
Festolium		9614	3444	7637	12902

For the DCF field, there is a significant degree of volatility in the results obtained between treatments on individual sampling dates as well as across years. Following the first year of forage establishment, it appeared that RLN populations were much higher for the red clover treatment than for the other treatments. Following the 2020 crop, RLN numbers increased significantly in the other treatments while the RLN numbers in the red clover treatment were noticeably lower in the spring of 2021. It is hard to draw any firm conclusions from this data, aside from the fact that RLN populations were the same or higher in 2021 than following the 2018 potato crop, contrary to what was observed in for *V. dahliae* in this field.

Table 6: Root lesion nematode populations by treatment in Wallace Properties field from 2019 to 2021, expressed in nematodes per kg of soil.

Treatment	May 2019	October 2019	May 2020	October 2020	May 2021
Red Clover	1742	19931	848	9661	3110
Alfalfa/Timothy		2319	2257	2061	2957
White Clover/ Festolium		5653	6296	6765	3994
Italian Ryegrass		14568	5847	7820	7077

The starting population of RLN for the Wallace Properties field was comparatively low (at 1742 per kg of soil). It may be that our sample did not reflect the true population of RLN. Once again, there was a considerable degree of volatility in RLN tests over time. In this field, RLN numbers remained consistently lowest in the alfalfa/timothy treatment. Over the two years of sampling, RLN populations appeared to be slightly higher in the Italian ryegrass treatment than in the legume-heavy treatments. Nonetheless, RLN populations were considerably lower for the Wallace Properties field than for the Dock Corner Farms field, and generally RLN numbers were higher in the grass treatments than the legume treatments.

Yield Data:

Table 7: Yield and quality for Prospects in the Dock Corner Farms field in 2021.

Treatment	Total Yield cwt/ac	Smalls %	> 10 oz %	Total Defects %	Specific Gravity	M. Yield cwt/ac	Payout \$/acre
DC Red Clover	340.9 ab	0.9	35.1	9.0	1.077	310.1	3683 ab
Alfalfa/Timothy	354.6 b	2.3	49.0	2.8	1.076	337.4	4060 b
White Clover/Festolium	280.2 a	2.0	31.4	3.6	1.078	268.5	3225 a
Festolium	297.6 a	1.5	29.6	2.8	1.078	285.0	3379 ab

In the DCF field, both the red clover and alfalfa/timothy treatments have larger total yields and crop values than the white clover/festolium and festolium treatments. It should be noted that there was an unexpected difference in tillage between these sides of the field, with the red clover and alfalfa/timothy treatments getting vertical tillage while the white clover/festolium and festolium treatments were moldboard ploughed. It is not possible to tell whether the difference in yield is more related to the tillage difference or the difference in forage crops. In comparing alfalfa/timothy directly with red clover, there does not appear to be a significant difference ($p < 0.1$) for marketable yield and greater than 10 ounce percentage favouring alfalfa/timothy, but there is trend favouring alfalfa. There was no difference in the percentage of small tubers or specific gravity across the treatments.

Table 8: Yield and quality for Mountain Gem Russets in the Wallace Properties field in 2021.

Treatment	Total Yield cwt/ac	Smalls %	> 10 oz %	Total Defects %	Specific Gravity	M. Yield cwt/ac	Payout \$/acre
DC Red Clover	295.5	5.5	27.2	0.1	1.086	279.2	3682
Alfalfa/Timothy	357.2	3.7	31.1	3.6	1.082	336.7	4270
White Clover/Festolium	294.8	7.8	31.3	3.4	1.086	266.7	3548
Italian Ryegrass	297.8	5.2	22.4	3.0	1.085	275.8	3570

In the WP field, there was no significant differences at $p < 0.1$; however, there is again a trend toward a higher total yield, marketable yield, and crop value for the alfalfa/timothy treatment than the other three treatments. In general, quality and size distribution was similar across the treatments. Yields were comparable between the two fields, despite the difference in variety.

Summary:

Some key observations from this trial:

- There was no identifiable trend for an increase or decrease in pH, soil organic matter, or soil nutrient concentration between the different forage treatments. Following two years of forages, pH and soil organic matter levels were mostly unchanged, regardless of treatment. Both fields in the study had acceptable pH levels and were generally strong for macronutrients, while ranking somewhat lower for soil organic matter percentage and most micronutrients.

- In the Wallace Properties field, there is evidence of reduced soil compaction in the alfalfa/timothy treatment.
- Levels of *Verticillium dahliae* were lower across all treatments in the spring of 2021 compared to samples in the spring of 2019 immediately following potatoes in 2018. It is difficult to say whether there is a difference in *V. dahliae* population between the different forage treatments.
- Root lesion nematode populations were more inconsistent across years and treatments, as well as from field to field. In the DCF field with a higher starting population of nematodes, populations fluctuated substantially, with populations prior to potato planting considered high across all treatments. In the WP field, with a lower starting population, RLN counts were a bit more consistent from year to year, with three of the four treatments having counts less than 5000 per kg of soil (considered a threshold for damage in Russet Burbank by Dr. Kimpinski, AAFC). In the WP, the alfalfa/timothy treatment has consistently lower RLN counts.
- In both fields, the alfalfa/timothy treatment had the highest total yield and marketable yields. In the Wallace Properties field, this was significantly different than the three other treatments. For the Dock Corner Farms field, alfalfa/timothy yields were significantly different than only the white clover/festolium and festolium treatments.
- Differences in tuber size and quality variables was largely insignificant across treatments.
- From this study, it is difficult to make any conclusive statements regarding the effect of these different forage species or mixes on potato early dying (PED), as both *Verticillium dahliae* and root lesion nematode levels were quite variable between fields and between testing dates. After the first year of forages, both fields had lower root lesion nematodes following alfalfa/timothy than the other treatments, but this advantage was not sustained in the DCF field in 2020. Nematode number did appear to be generally higher in the grass only treatments in both fields compared with the legume treatments, but with large differences from field to field.
- It is difficult to isolate the reason for the improved yields in the alfalfa/timothy treatments in both fields. While suppression of potato early dying could be one factor, additional factors that may come into play include additional nitrogen supply (although this was not demonstrated in soil health tests) or reduced soil compaction. Nonetheless, the alfalfa/timothy treatment did show a marked improvement in yield in both fields.
- Crop value was the highest for the alfalfa/timothy treatment in both fields; however, this difference was only statistically significant in the DCF field.

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