NORTHWEST CROPS & SOILS PROGRAM

2019 Legume Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2019 LEGUME VARIETY TRIAL

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In 2017, the University of Vermont Extension Northwest Crops and Soils Team initiated a trial investigating forage yield and quality of varieties of different legume species seeded in monocultures. The species selected were alfalfa, birdsfoot trefoil, red clover, and white clover. These legumes were chosen as they have been shown in previous research to have adequate survivability and forage production in this region. Organic and grass-based dairy systems rely on legumes to help provide balanced nutrition to their animals while also reducing the crop's need for additional nitrogen compared to a pure grass stand. This information therefore, may help enhance forage production and quality, thereby reducing producers' forage and supplemental feed costs. These varieties were selected and seeded in the late summer of 2017 and were ready for harvest in the 2018 growing season. This report reflects data collected in the 2019 growing season.

MATERIALS AND METHODS

Forage species and variety information for the trial initiated in 2017 is summarized in Table 1. Varieties of four legume species were planted in monoculture at Borderview Research Farm in Alburgh, VT at 25 lbs ac^{-1}. The plot design was a randomized complete block with five replications. Treatments were legume varieties which were evaluated for forage yield and quality.

Table 1. Legume species and variety information.

Species	Variety	Source	Type
Alfalfa	FSG 420	Albert Lea	Conventional
	Profusion	King's Agriseed	Organic
	Road Runner	Albert Lea	Non-GMO
	Secure	King's Agriseed	Organic
	Traffic Pro	King's Agriseed	Organic
	Viking 340	Albert Lea	Organic
	Viking 370	Albert Lea	Organic
	Viking 542	Albert Lea	Conventional
Birdsfoot Trefoil	Leo	Oliver Seed	Conventional
	Wellington	King's Agriseed	Conventional
Red Clover	Arlington	Albert Lea	Organic
	Freedom	King's Agriseed	Organic
	Manitoba	Albert Lea	Organic
	Milvus	King's Agriseed	Organic
	Ruby	Albert Lea	Conventional
White Clover	Alice	Albert Lea	Conventional
	Klondike	King's Agriseed	Organic
	Kopu II	Albert Lea	Conventional
	Ladino	Albert Lea	Conventional
	Liflex	King's Agriseed	Organic

The soil type at the Alburgh location was a Benson rocky silt loam (Table 2). The seedbed was moldboard plowed, disked, and finished with a spike tooth harrow. Treatments were seeded on 1-Sep 2017. The previous crop was spring barley. Plots were 5' x 20' and replicated 5 times. In 2019, plots were harvested with a Carter forage harvester in 3' x 20' area on 10-Jun, 19-Jul, and 30-Aug.

Table 2. Perennial forage trial management, Alburgh, VT, 2017-2019.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Spring barley
Tillage operations	Moldboard plow, disk and spike tooth harrow
Planting equipment	Great Plains small plot drill
Treatments	20
Replications	5
Plot size (ft.)	5 x 20
Planting date	1-Sep 2017
Harvest dates (2019)	10-Jun, 19-Jul, and 30-Aug

An approximate 1 lb subsample of the harvested material was collected and dried to calculate dry matter yield. The subsamples were ground using a Wiley and cyclone mill (UDY Corporation) to attain a 1-mm particle size. These samples were then analyzed using NIR (near infrared reflectance spectroscopy) methods at the UVM Cereal Grain Testing Laboratory (Burlington, VT) on a FOSS DS2500 Forage and Feed Analyzer.

In addition to yield and quality, plots were also assessed for severity of damage caused by potato leafhopper (PLH). Plots were assessed visually on 16-Jul, prior to the 2nd harvest, as this is when damage became most apparent in the trial. Plots were assigned a severity rating on a scale from 0-5 where 0 corresponded to no visual evidence of damage and 5 corresponded to leaves being malformed and necrotic around the margin (Images 1-6).

Images 1-6. Potato leafhopper damage severity rating 0-5 (left to right).

Mixtures of true proteins, composed of amino acids, and non-protein nitrogen make up the crude protein (CP) content of forages. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of the plant are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, non-protein nitrogen, fats and other highly digestible compounds; and the less digestible components found in the fiber fraction. The total fiber content of forage is contained in the neutral

detergent fiber (NDF) which includes cellulose, hemicellulose, and lignin. This measure indicates the bulky characteristic of the forage and therefore is negatively correlated with animal dry matter intake. NDF digestibility within 48 hours is represented by 48-hr NDFD. The acid detergent fiber fraction (ADF) is composed of highly indigestible fiber and therefore is negatively correlated with digestibility.

Yield data and stand characteristics were analyzed using the PROC MIXED procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and varieties were treated as fixed. Treatment mean pairwise comparisons were made using the Tukey-Kramer adjustment. Treatments were considered different at the 0.10 level of significance. Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. At the bottom of each table, a level of significance is presented for each variable (i.e. yield). Treatments that differed at a level of significance >0.10 were reported as being not significantly different. Treatments that were not significantly lower in performance than the top performer in a particular column are indicated with an asterisk. In the example, treatment C is significantly different from treatment A but not from treatment B. This means that these hybrids did not differ in yield. The asterisk indicates that treatment B was not significantly lower than the top yielding treatment C, indicated in bold.

Treatment	Yield
A	6.0
B	7.5*
C	**9.0***
Level of significance	<0.05

RESULTS

Weather data was recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 3). In general, the fall of 2018 was slightly cooler than normal with precipitation being approximately normal except for November. This trend continued through the winter months. The spring was cool and wet while the summer continued to be warm and dry. July was particularly hot and dry as much of the rainfall that was accumulated was attributed to a couple of rain events near the end of the month. Over this entire period, growing degree days were 263 below normal.

Table 3. 2018-2019 weather data for Alburgh, VT.

	2018				2019							
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Average temperature (°F)	63.4	45.8	32.2	25.4	15.0	18.9	28.3	42.7	53.3	64.3	73.5	68.3
Departure from normal	2.86	-2.26	-5.79	-0.15	-3.87	-2.48	-2.79	-2.11	-3.21	-1.46	2.87	-0.51
Precipitation (inches)	3.48	3.53	4.50	2.96	1.53	1.70	1.36	3.65	4.90	3.06	2.34	3.50
Departure from normal	-0.18	-0.03	1.38	0.61	-0.47	-0.02	-0.86	0.84	1.51	-0.57	-1.88	-0.41
Growing Degree Days (base 41°F)	671	214	28	20	0	4	41	163	391	700	995	846
Departure from normal	80	-78	-78	-1	-12	-10	-27	-69	-110	-37	88	-9

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

Legume Species Interactions

The only significant interactions observed between cutting and species were for dry matter yield, water soluble carbohydrates (WSC), and milk yield per acre. These interactions indicate that the top performing species changed depending on the cutting.

In terms of dry matter yield, alfalfa was the highest yielding species in the 2nd and 3rd cutting but was third highest in the 1st cutting (Figure 1). The significant interaction between species and cutting for predicted milk yield per acre follows this trend as it reflects the difference in dry matter yield per acre shown in Figure 1. This suggests that all species performed similarly in yield, especially during cool and wet conditions in early summer. However, alfalfa may have been more tolerant to drought conditions that were especially severe during the 2nd cutting, allowing it to outperform the other species.

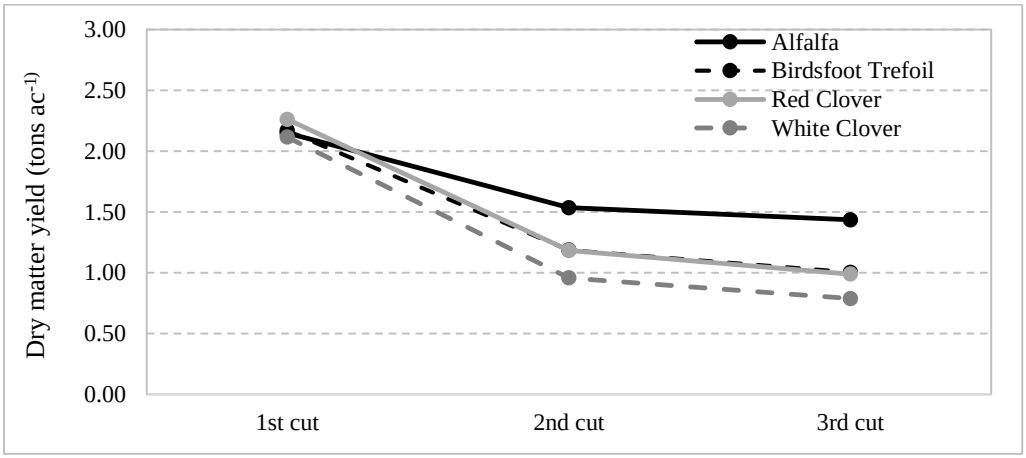

Figure 1. Interaction between species and cutting for dry matter yield.

There was also an interaction between species and cutting for water soluble carbohydrate content (Figure 2). White clover had the highest WSC content in the 1st and 3rd cuttings but in the 2nd cutting, birdsfoot trefoil was highest. This interaction suggests that in the middle of the season, the birdsfoot trefoil maintained a higher WSC content than the other species. However, it also experienced the largest decline following the 2nd cut and was lowest in WSC content in the 3rd cutting.

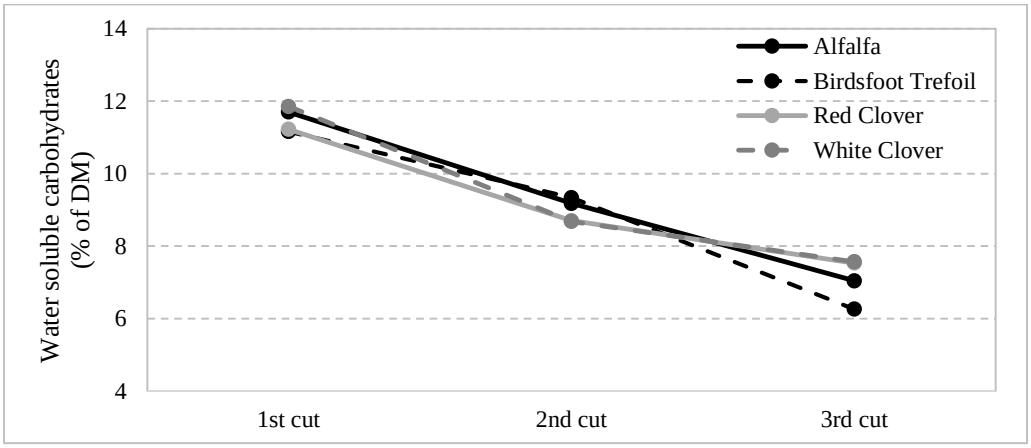

Figure 2. Interaction between species and cutting for water soluble carbohydrate content.

Legume Variety Interactions

There were also several significant interactions between variety and cutting, however, these only occurred within the species birdsfoot trefoil and red clover. For birdsfoot trefoil the significant interaction between variety and cutting occurred for the predicted milk yield per ton of forage (Figure 3).

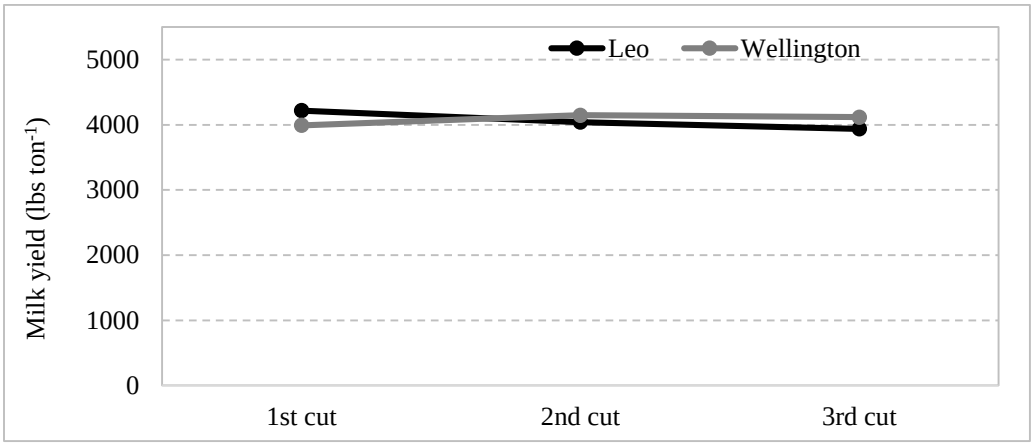

Figure 3. Variety x cutting interaction for milk yield per ton of forage for Birdsfoot Trefoil.

This interaction indicates that these two varieties performed differently in terms of milk yield per ton of forage across the three harvests. As you can see in Figure 3, the variety Leo decreased in milk yield in subsequent harvests while Wellington increased and remained higher than Leo in both the second and third harvests.

The other significant variety x cutting interactions was observed in red clover for milk yield per acre (Figure 4). This interaction indicates that these varieties performed differently in terms of milk yield per acre across the three harvest. As you can see in Figure 4, in general the varieties decline in milk yield as cuttings progress. However, the decline is much greater for the variety Manitoba that saw a reduction by over 6000 lbs ac^{-1} from the first harvest to the second, while the variety Freedom, although lower than Manitoba in the first harvest, only saw a reduction of approximately 2900 lbs ac^{-1} between those harvests. In addition, one variety, Ruby, increased slightly from the second to third harvest while all other varieties decreased.

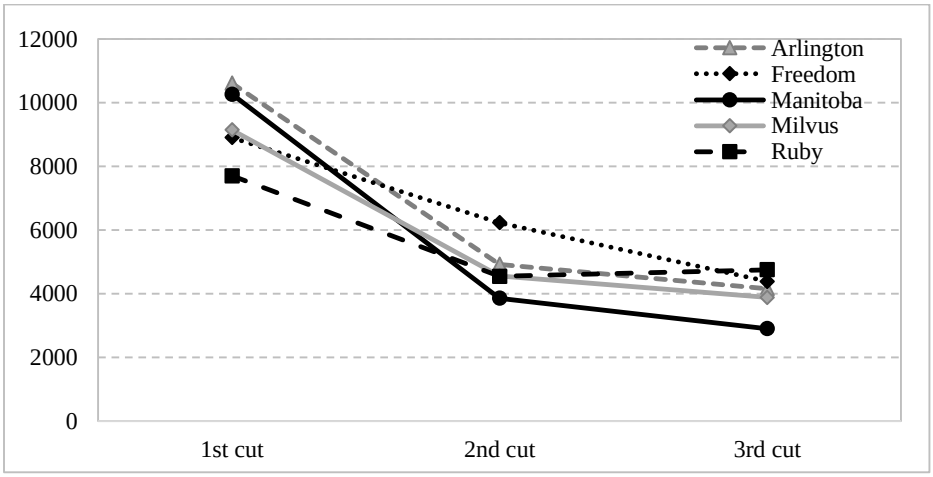

Figure 4. Variety x cutting interaction for milk yield per acre in Red Clover, 2019.

Overall this suggests that a variety like Freedom may be more resilient to drought conditions. These differences are important to highlight as they can provide insight into adaptability to site characteristics and weather and therefore, can help inform producers to their suitability to their particular location.

Impact of Legume Species

Species differed in dry matter yield across the season (Table 4). Alfalfa produced the overall highest biomass of 5.13 tons ac^{-1} and white clover produced the lowest biomass at 3.86 tons ac^{-1}. White clover, being shallow rooted and lower, growing is expected to produce less biomass than a taprooted, upright growing forage like alfalfa that can better withstand drought conditions and is more suitable to mechanical harvest. Dry matter content did not differ by species and averaged 21.8%.

Table 4. Total dry matter yield by legume species, 2019.

Species	Dry matter content (DM) %	Total DM yield tons ac^{-1}
Alfalfa	21.1	**5.13a†**
Birdsfoot Trefoil	**20.0**	4.42ab
Red Clover	20.1	4.50b
White Clover	20.8	3.86b
Level of significance	NS‡	<0.0001
Trial mean	21.8	4.52

†Treatments that share a letter performed statistically similar to one another.
‡NS: Not statistically significant.

In the first cutting, plots were evaluated for species composition as a way to estimate survival and persistence of the legumes. Interestingly, all four species had statistically similar distributions of legume, grass, and weed biomass in the first harvest (Table 5). In this second year of production, all the original monocultures that were planted are now approximately 60% legume. Surprisingly, the birdsfoot trefoil that is notoriously difficult to establish, seems to have established and be persisting as well as the other species despite difficult weather conditions.

Table 5. Botanical composition at 1st cut and potato leafhopper (PLH) severity at 2nd cut, 2019.

Species	Legume	Grass	Weeds	PLH damage
	% of DM			0-5 scale†
Alfalfa	60.7	**30.9**	8.37	2.30b‡
Birdsfoot Trefoil	**61.7**	31.4	**6.93**	**0.200a**
Red Clover	58.7	33.7	7.58	2.24b
White Clover	54.9	33.3	11.7	3.48c
Level of significance	NS¥	NS	NS	<0.0001
Trial mean	58.9	32.3	8.87	2.37

†Potato leafhopper rated on a 0 to 5 scale where 0 indicated no damage and 5 indicated severe damage.
‡Within a column, species with the same letter performed statistically similar to one another. Top performing treatments are indicated in **bold.**
¥NS: not statistically significant.

Prior to the 2nd harvest, plots were assessed for severity of damage caused by potato leafhopper (PLH). Ratings were assigned on a scale from 0-5 where 0 was no damage and 5 was severe damage. Species significantly differed in the severity of PLH damage at this cutting. Birdsfoot trefoil was very much unaffected by PLH and sustained very little damage as a result. Alfalfa and red clover were similar in the damage sustained receiving ratings around 2.25. White clover, however, was much more severely affected averaging a rating of almost 3.5.

Legume species also differed in some forage quality parameters (Table 6). Forages averaged 22.7% crude protein (CP), 30.5% ADF and 44.4% NDF. Red clover had the lowest lignin content of 7.55%, which was statistically similar to white clover with 7.61%. A similar trend was observed with NDF digestibility, which would be expected based on the lignin contents, with white clover having the highest digestibility of 66.7%, which was statistically similar to red clover with 66.1%. The significant differences in dry matter yield discussed previously and these quality differences, species also differed in predicted milk yield per acre with alfalfa producing the most milk at 6939 lbs ac^{-1} followed by red clover with 6053 lbs ac^{-1}.

Table 6. Forage quality characteristics by legume species, 2019.

Species	CP	ADF	NDF	Lignin	WSC	48-hr NDFD	NE_L	RFQ	Milk yield	
			% DM			% NDF	Mcal lb^{-1}		lbs ton^{-1}	lbs ac^{-1}
Alfalfa	22.2	32.4	47.8	8.21b†	7.87	63.3b	0.576	144	3963	**6939a**
Birdsfoot Trefoil	22.6	32.1	**46.5**	8.30ab	7.48	64.1ab	**0.583**	149	3954	5843bc
Red Clover	**22.7**	**31.8**	49.1	**7.55a**	7.72	66.1a	0.578	141	4005	6053b
White Clover	22.3	32.1	48.5	7.61a	**7.93**	**66.7a**	0.580	**151**	**4014**	5242c
Level of significance	NS‡	NS	NS	0.009	NS	0.009	NS	NS	NS	<0.0001
Trial mean	22.7	30.5	44.4	7.83	9.25	65.2	0.608	167	4108	6184

†Within a column, species with the same letter performed statistically similar to one another. Top performing treatments are indicated in **bold.**

‡NS- not statistically significant.

Impact of Cutting

Forage yield and quality was also significantly impacted by cutting (Tables 7 and 8). Dry matter yield was highest in the 1st cutting averaging 2.22 tons ac^{-1} and lowest in the third harvest averaging half as much at 1.11 tons ac^{-1}. Crude protein ranged from 19.8% in the second harvest up to 25.8% in the third. Water soluble carbohydrates were highest at 10.0% in the first cutting compared to only 5.67% in the third cutting. Fiber digestibility ranged from 61.7% in the third cutting to 67.4% in the second cutting. This was surprising as the second cutting took place during hot and dry conditions that typically induce lignification and therefore lower digestibility in forages. Overall, relative forage quality (RFQ) ranked the third cut the highest quality at a score of 158, closely followed by the first harvest with 154. A score of 150 is considered of adequate quality for lactating cattle. The second harvest fell significantly lower in quality at 127. Despite the higher digestibility, overall NDF content was 51.8% and likely contributed to the lower quality rating. Overall, predicted milk yields were highest in the first cutting at 4001 lbs ton^{-1} and 8867 lbs ac^{-1} respectively. However, milk yield per ton did not differ statistically and the difference observed in milk production per acre is due to the difference in dry matter yield, not quality.

Table 7. Dry matter content, yield, and milk yield by cutting, 2019.

Cutting	Dry matter	DM yield	Milk yield	
	%	tons ac^{-1}	lbs ton^{-1}	lbs ac^{-1}
1st cut	18.4a†	2.22a	**4001**	**8867a**
2nd cut	25.6b	1.27b	3973	4915b
3rd cut	**18.0a**	1.11c	3979	4276c
Level of significance	<0.0001	<0.0001	NS‡	<0.0001
Trial mean	21.8	2.17	4108	6184

†Within a column, treatments with the same letter performed statistically similarly.
The top performing treatment is indicated in **bold**.
‡NS; Not statistically significant.

Table 8. Dry matter yield and quality by cutting, 2019.

Cutting	CP	ADF	NDF	Lignin	WSC	48-hr NDFD	NE_L	RFQ
			% DM			% NDF	Mcal lb^{-1}	
1st cut	21.6b†	**31.2a**	47.5b	**6.89a**	10.0a	66.1a	**0.603a**	154a
2nd cut	19.8c	31.4a	51.8c	7.62b	7.54b	**67.4a**	0.574b	127b
3rd cut	**25.8a**	33.7b	**44.6a**	9.23c	5.67c	61.7b	0.562c	**158a**
Level of significance	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Trial mean	22.7	30.5	44.4	7.83	9.25	65.2	0.608	167

†Within a column, treatments with the same letter performed statistically similarly. The top performing treatment is indicated in **bold**.

Impact of Variety-Alfalfa

Alfalfa varieties did not differ statistically in terms of yield or botanical composition at 1st cut (Table 9). All varieties produced yields over 4.5 tons with Traffic Pro producing nearly 5.5 tons ac^{-1}. Varieties averaged approximately 60% legume, 31% grass, and 9% weeds in the 1st cutting indicating about 30% stand loss since the original planting.

Table 9. Total dry matter yield, botanical composition, and PLH damage by variety for alfalfa, 2019.

Variety	Total DM yield	Legume	Grass	Weeds	PLH damage
	tons ac^{-1}		% of DM		0-5 scale†
FSG420	4.84	57.1	34.8	8.15	2.00ab‡
Profusion	5.22	**75.1**	**20.8**	4.08	2.80b
Road Runner	4.92	61.4	34.2	4.45	2.60b
Secure	5.34	66.1	30.5	**3.47**	2.20ab
Traffic Pro	**5.47**	61.8	28.0	10.2	2.60b
Viking340	5.14	55.5	35.4	9.12	2.20ab
Viking370	4.88	62.3	28.8	8.93	2.60b
Viking542	4.73	46.7	34.8	18.6	**1.40a**
Level of significance	NS¥	NS	NS	NS	0.006
Trial mean	5.07	60.7	30.9	8.37	2.30

†Potato leafhopper rated on a 0 to 5 scale where 0 indicated no damage and 5 indicated severe damage.
‡Within a column, treatments with the same letter performed statistically similarly. The top performing treatment is indicated in **bold**.
¥NS; Not statistically significant.

Varieties also differed significantly in PLH damage. The variety Viking 542 had the lowest damage rating of 1.40 which was statistically similar to three other varieties, while the highest ratings of 2.60 and 2.80 were observed in the varieties Viking 370, Traffic Pro, Road Runner, and Profusion. Viking 542 is a leafhopper resistant variety and although all varieties yielded statistically similarly, in a year with higher PLH pressure, selecting varieties with pest resistance may save yield and quality. Alfalfa varieties also did not differ statistically in terms of forage quality characteristics (Table 10). Overall, alfalfa varieties averaged over 22.5% protein, 63.6% NDF digestibility, and 0.606 Mcal lb^{-1}, leading to a relative forage quality (RFQ) rating of 166. Predicted milk yield averaged 4086 lbs ton^{-1} and 6939 lbs ac^{-1}. The differences observed in these quality parameters were not statistically significant, indicating that all eight alfalfa varieties produced similar forage quality in 2019.

Table 10. Forage quality characteristics by variety for alfalfa, 2019.

Variety	CP	ADF	NDF	Lignin	WSC	48-hr NDFD	NEL	RFQ	Milk yield	
	% DM					% NDF	Mcal lb^{-1}		lbs ton^{-1}	lbs ac^{-1}
FSG420	21.6	30.7	44.8	**7.54**	9.24	62.8	0.602	163	4002	6984
Profusion	22.7	30.9	43.6	7.65	9.49	63.7	0.611	167	4051	6995
Road Runner	22.5	30.6	44.6	7.83	9.19	65.1	0.606	164	4131	6768
Secure	22.7	30.7	44.1	8.26	9.09	62.5	0.600	160	4069	7222
Traffic Pro	22.8	30.4	43.0	8.56	9.09	63.1	**0.618**	**174**	**4150**	**7465**
Viking340	21.7	31.4	45.5	8.28	9.17	63.4	0.595	164	4055	6918
Viking370	22.7	31.2	43.6	8.52	**9.71**	**65.6**	0.604	170	4142	6731
Viking542	**23.4**	**30.0**	**42.6**	8.51	9.49	62.7	0.611	164	4091	6426
Level of significance	NS†	NS	NS	NS	NS	NS	NS	NS	NS	NS
Species Mean	22.5	30.7	44.0	8.14	9.31	63.6	0.606	166	4086	6939

The top performing treatment is indicated in **bold**.
†NS; Not statistically significant.

Impact of Variety-Birdsfoot Trefoil

Birdsfoot trefoil varieties did not differ statistically in total dry matter yield or botanical composition at 1st cut (Table 11). Both varieties produced over 4 tons of dry matter over the course of the season. Despite birdsfoot trefoil typically being difficult to establish and have persist, especially in a monoculture, both these varieties have maintained a stand of approximately 60% trefoil since planting. The two varieties also did not differ in the severity of PLH damage and were both very low averaging a rating of 0.200.

Table 11. Total dry matter yield and botanical composition by variety for birdsfoot trefoil, 2019.

Variety	Total DM yield	Legume	Grass	Weeds	PLH damage
	tons ac^{-1}	% of DM			0-5 scale†
Leo	4.19	**63.0**	**1.10**	35.9	0.200
Wellington	**4.52**	60.4	12.8	**26.8**	0.200
Level of significance	NS‡	NS	NS	NS	NS
Species Mean	4.36	61.7	31.4	6.93	0.200

†Potato leafhopper damage (PLH) was rated on a 0 to 5 scale where 0 was no damage and 5 was severe damage.
‡NS- Not significant. The top performing treatment is indicated in **bold**.

Birdsfoot trefoil varieties also did not differ significantly in forage quality characteristics (Table 12). Both trefoil varieties produced forage with approximately 23% protein, 64.3% NDF digestibility, and 6.13 Mcal lb^{-1} leading to a RFQ rating of 170. Predicted milk yield averaged 4077 lbs ton^{-1} and 5843 lbs $ac^{-1.}$ The differences observed in these quality parameters were not statistically significant, indicating that both of the birdsfoot trefoil varieties included in this trial produced similar forage quality in 2019.

Table 12. Forage quality characteristics by variety for birdsfoot trefoil, 2019.

Variety	CP	ADF	NDF	Lignin	WSC	48-hr NDFD	NE_L	RFQ	Milk yield	
	% DM					% NDF	Mcal lb^{-1}		lbs ton^{-1}	lbs ac^{-1}
Leo	23.2	30.8	42.1	**8.26**	8.85	63.3	0.618	171	4068	5525
Wellington	**22.8**	**30.1**	**43.3**	8.20	8.99	65.4	0.609	170	4086	6162
Level of significance	NS†	NS	NS	NS	NS	NS	NS	NS	NS	NS
Species Mean	23.0	30.5	42.7	8.23	8.92	64.3	0.613	170	4077	5843

†NS; Not statistically significant. The top performing treatment is indicated in **bold**.

Impact of Variety-Red Clover

Red clover varieties did not differ statistically in dry matter yield across the season or botanical composition at 1st cut (Table 13). All red clover varieties produced over 4 tons ac^{-1} across the three harvests. In addition, the red clovers have maintained stands of 50-60% since being planted. Red clover varieties also differed significantly in PLH damage. The varieties Milvus and Manitoba had significantly higher severity ratings of 3.20 compared to the other three varieties. Ruby had the lowest rating of 1.00, but this was statistically similar to Freedom and Arlington.

Table 13. Total dry matter yield and botanical composition by variety for red clover, 2019.

Variety	Total DM yield	Legume	Grass	Weeds	PLH damage
	tons ac^{-1}	% of DM			0-5 scale†
Arlington	**4.94**	55.5	39.3	5.19	2.00a§
Freedom	4.42	51.9	43.4	**4.74**	1.80a
Manitoba	4.17	60.7	29.8	9.52	3.20b
Milvus	4.40	59.3	31.7	9.06	3.20b
Ruby	4.23	**66.3**	**24.3**	9.39	**1.00a**
Level of significance	NS‡	NS	NS	NS	<0.0001
Species Mean	4.43	58.7	33.7	7.58	2.24

†Potato leafhopper damage (PLH) was rated on a 0 to 5 scale where 0 was no damage and 5 was severe damage.
§ Within a column, treatments with the same letter performed statistically similarly. The top performing treatment is indicated in **bold**.
‡NS; Not statistically significant.

Red clover varieties did differ statistically in a couple of quality characteristics (Table 14). Varieties differed in 48-hr NDF digestibility ranging from 63.8% to 70.3% with Ruby producing the most digestible fiber. The varieties Manitoba and Milvus produced the least digestible fiber. Similarly, due to this difference of forage quality, predicted milk yield per ton was highest for Ruby and Freedom which differed from the other three varieties. Varieties performed similarly for all other quality parameters.

Table 14. Forage quality characteristics by variety for red clover, 2019.

Variety	CP	ADF	NDF	Lignin	WSC	48-hr NDFD	NEL	RFQ	Milk yield	
	% DM					% NDF	Mcal lb^{-1}		lbs ton^{-1}	lbs ac^{-1}
Arlington	22.3	29.9	46.6	7.20	9.08	65.9bc†	0.602	151	4091b	**6564**
Freedom	23.2	30.2	46.4	7.16	8.91	67.9ab	0.611	157	4200a	6505
Manitoba	23.2	30.8	44.8	7.87	9.09	63.8c	0.601	159	4048b	5673
Milvus	23.0	30.2	43.6	**7.58**	9.19	64.1c	**0.618**	164	4089b	5860
Ruby	**23.4**	**30.0**	**45.3**	7.58	**9.49**	**70.3a**	0.607	**180**	**4212a**	5665
Level of significance	NS‡	NS	NS	NS	NS	0.005	NS	NS	0.047	NS
Species Mean	23.0	30.2	45.3	7.48	9.15	66.4	0.608	162	4128	6053

†Within a column, treatments with the same letter performed statistically similarly. The top performer is indicated in **bold.**
‡NS; Not statistically significant.

Impact of Variety-White Clover

White clover varieties did not differ statistically in dry matter yield across the season or botanical composition at 1st cut (Table 15). All white clover varieties produced over 3 tons ac^{-1} across the three harvests. Two varieties, Ladino and Klondike, produced yields of over 4 tons ac^{-1} however, these were not statistically different from any of the other varieties. On average, white clovers have maintained stands of approximately 50% since being planted. Although Ladino displayed a composition of over 60% legume, this was not statistically different from the other varieties. The white clover varieties also did not differ statistically in terms of PLH damage severity. All varieties had ratings of over 3.00 indicating moderately severe damage characterized by prominent leaf chlorosis with some leaves beginning to show cupping.

Table 15. Total dry matter yield and botanical composition by variety for white clover, 2019.

Variety	Total DM yield	Legume	Grass	Weeds	PLH damage
	tons ac^{-1}	% of DM			0-5 scale†
Alice	3.93	48.1	49.1	**2.73**	3.40
Klondike	4.05	53.4	37.4	9.13	3.60
Kopu II	3.12	52.1	27.2	20.7	3.80
Ladino	**4.17**	**61.8**	**25.6**	12.6	**3.20**
Liflex	3.70	59.2	27.3	13.5	3.40
Level of significance	NS‡	NS	NS	NS	NS
Species Mean	3.79	54.9	33.3	11.72	3.48

†Potato leafhopper damage (PLH) was rated on a 0 to 5 scale where 0 was no damage and 5 was severe damage.
‡NS-Not statistically significant. The top performer is indicated in **bold.**

White clover varieties did not differ significantly in forage quality characteristics (Table 16). The five white clover varieties produced forage with approximately 22.6% protein, 67.0% NDF digestibility, and 0.610 Mcal lb^{-1} leading to a RFQ rating of 173. Predicted milk yield averaged 4137 lbs ton^{-1} and 5242 lbs ac$^{-1.}$ The differences observed in these quality parameters were not statistically significant indicating that the five white clover varieties included in this trial produced similar forage quality in 2019.

Table 16. Forage quality characteristics by variety for white clover, 2019.

Variety	CP	ADF	NDF	Lignin	WSC	48-hr NDFD	NEL	RFQ	Milk yield	
	% DM					% NDF	Mcal lb^{-1}		lbs ton^{-1}	lbs ac^{-1}
Alice	21.8	**29.6**	46.4	**7.00**	9.63	66.0	0.611	171	4165	5448
Klondike	23.3	30.4	45.4	7.48	**9.79**	67.7	0.609	**177**	4163	**5520**
Kopu II	22.4	31.6	44.1	7.05	9.55	67.4	**0.618**	173	4110	4408
Ladino	22.4	30.8	**43.5**	8.24	8.82	64.7	0.608	166	4072	5881
Liflex	**23.5**	30.0	43.9	7.90	9.05	**68.9**	0.606	175	**4173**	4954
Level of significance	NS†	NS	NS	NS	NS	NS	NS	NS	NS	NS
Species Mean	22.6	30.5	44.7	7.54	9.37	67.0	0.610	173	4137	5242

The top performer is indicated in **bold.**

†NS; Not statistically significant.

DISCUSSION

In 2018, red clover and birdsfoot trefoil yielded just as well as alfalfa and often-produced higher quality forage, even during drought conditions. In 2019, however, alfalfa out yielded all other species producing over 5 tons ac^{-1} from only three harvests. However, difficult conditions in the fall/winter of 2018 followed by drought conditions in 2019 lead to overall low persistence of the legume monocultures as most had declined to 60% or less. In addition, with high variability across the entire trial due to weather and soil conditions and insect pressure, very few varietal differences arose to the level of statistical significance. That being said, differences in yield, quality, and persistence were observed, highlighting the importance of varietal selection to maximize yield and quality under variable weather and soil conditions. Looking just at the 2^{nd} cut yields, the harvest that experienced the most severe drought conditions, we definitely see differences across species with alfalfa being more widely adapted and able to tolerate droughty soils better than white clover (Figure 5). But within these species there also appear to be some varietal differences (Figures 6-8). These differences were not statistically significant as we did not observe significant variety x cutting interactions for yield, however, they do indicate the importance of varietal selection for adaptability to specific site conditions. We will continue to evaluate legume species and varieties for persistence, pest and disease resistance, yield, and forage quality in the future to better understand varietal performance and potential in this region.

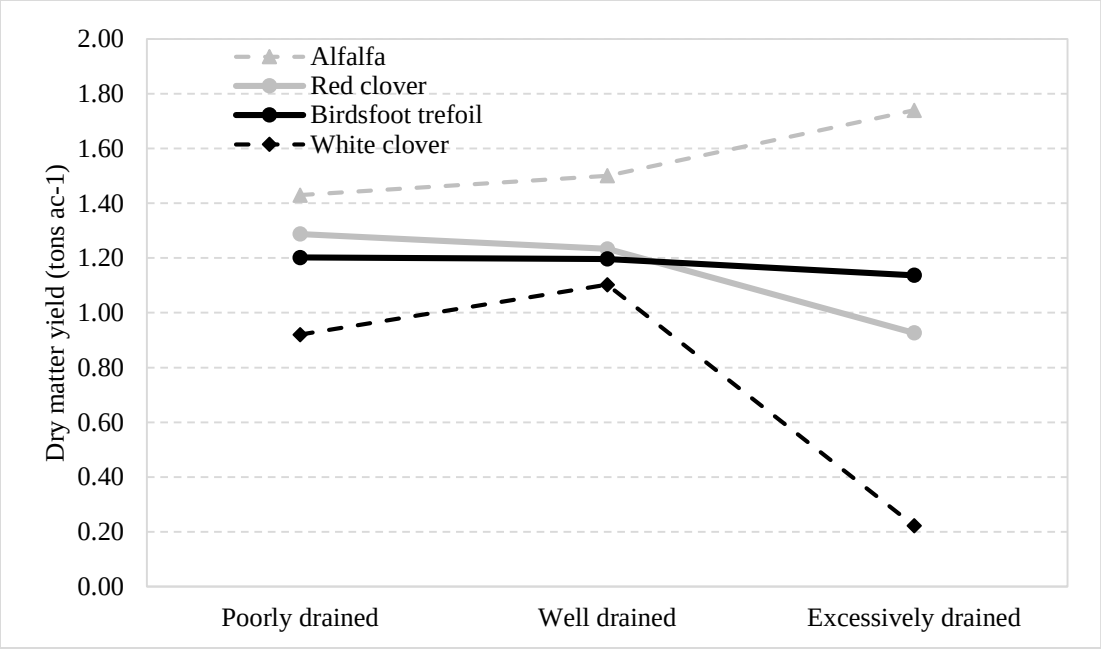

Figure 5. 2nd cut dry matter yield by legume species across soil drainage class, 2019.

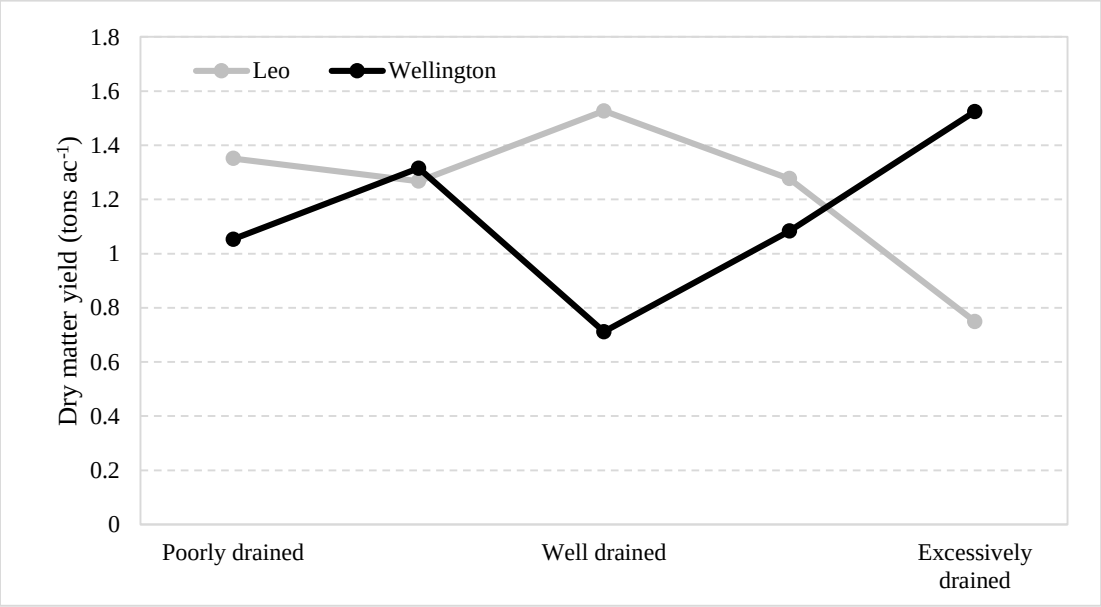

Figure 6. 2nd cut dry matter yield by variety for birdsfoot trefoil across soil drainage class, 2019.

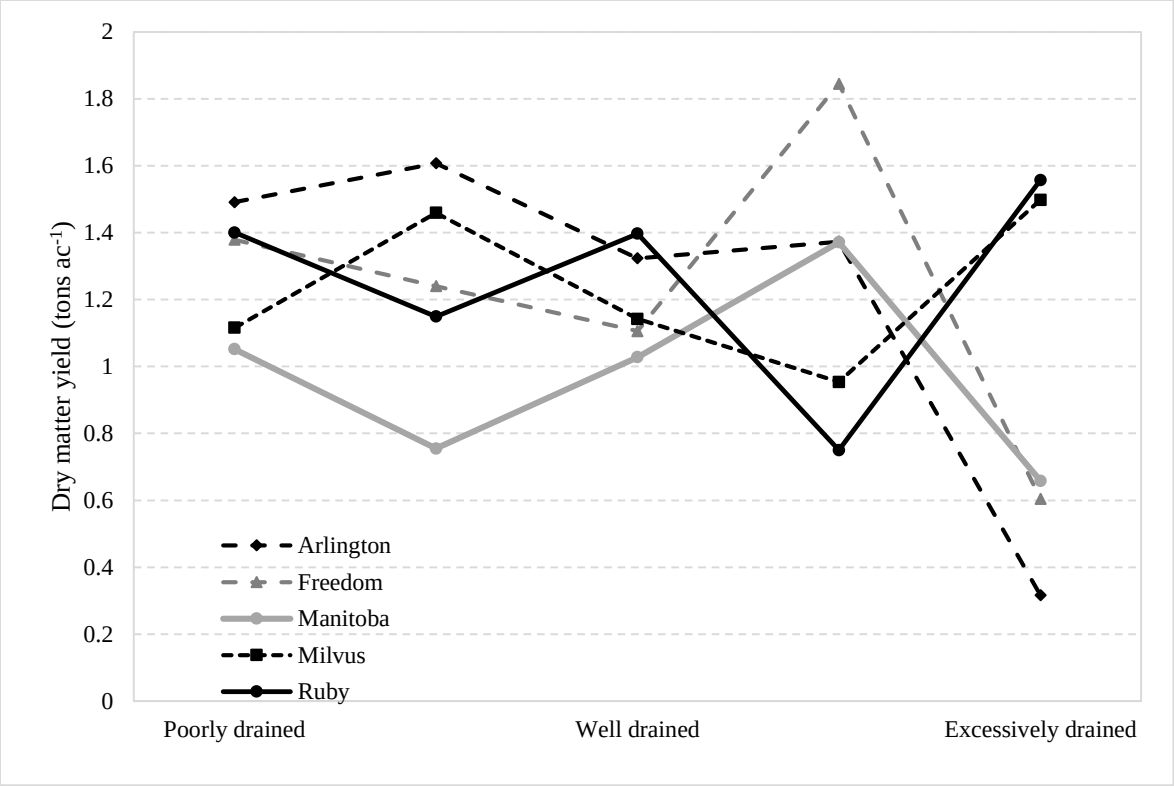

Figure 7. 2nd cut dry matter yield by variety for red clover across soil drainage class, 2019.

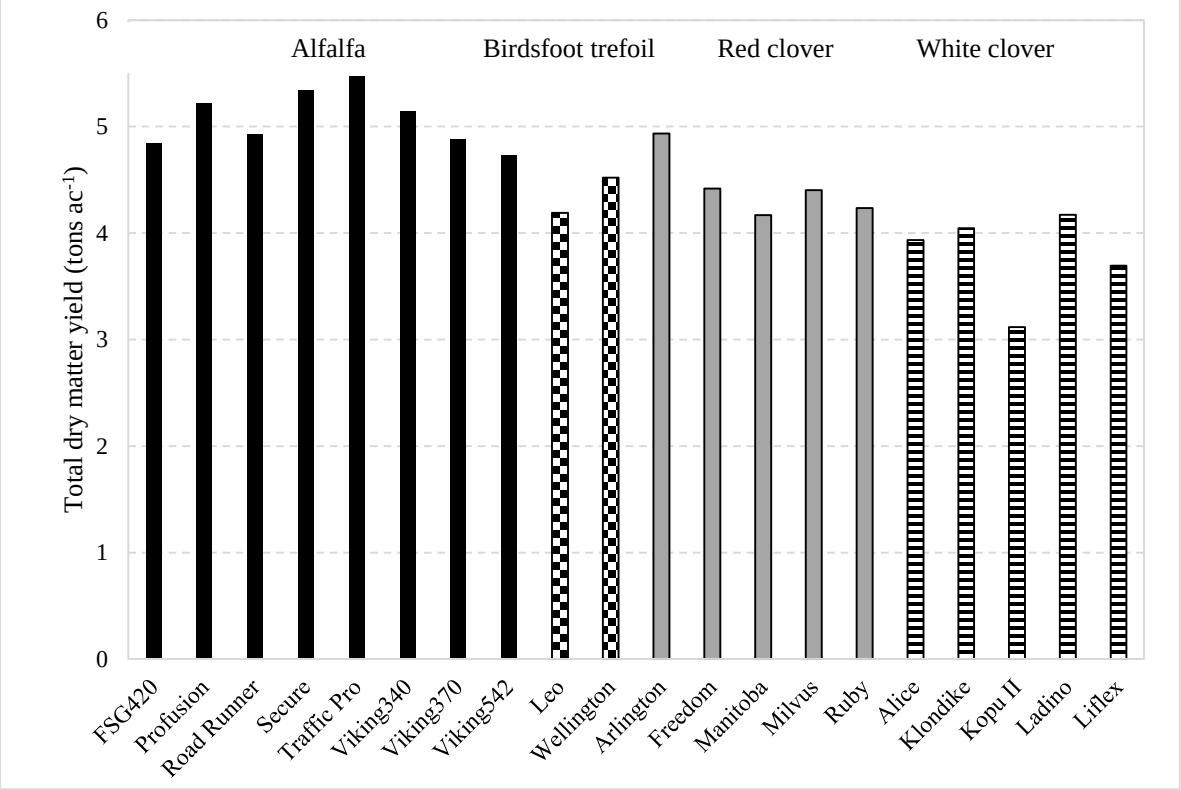

Figure 8. Total dry matter yield by variety within species, 2019.

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