NORTHWEST CROPS & SOILS PROGRAM

2022 Legume Variety Trial

Dr. Heather Darby, UVM Extension Agronomist
Sara Ziegler, Ivy Krezinski, Laura Sullivan, and Sophia Wilcox Warren
UVM Extension Crops and Soils Technicians
(802) 524-6501

Visit us on the web at http://www.uvm.edu/nwcrops

THE UNIVERSITY OF VERMONT EXTENSION

2022 LEGUME VARIETY TRIAL

Dr. Heather Darby, University of Vermont Extension

heather.darby[at]uvm.edu

In 2020, 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 2020 and were ready for harvest in the 2022 growing season. This report reflects data collected in the 2022 growing season.

MATERIALS AND METHODS

Forage species and variety information for the trial initiated in 2020 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
Alfalfa	Stronghold
	KF Secure BR
	Viking 3200
	4A420P
	KF Enhancer II
Birdsfoot Trefoil	Wellington
	Leo
	Norcen
	Paradee
	Exact
Red Clover	Gallant
	Harmonie
	Freedom
	Starfire II
	Red Wing
White Clover	Domino
	Huia
	Legacy
	Kakariki
	Klondike

The soil type at the Alburgh location was a Benson rocky silt loam (Table 2). The previous crop was hemp. The seedbed was moldboard plowed, disked, and finished with a spike tooth harrow. Treatments were seeded on 3-May 2021. Plots were 5' x 20' and replicated 5 times. During the 2021 season, the plots were mowed occasionally but no data were collected. In 2022, plots were harvested with a Carter forage harvester in a 3' x 20' area on 31-May, 7-Jul, and 19-Aug.

Table 2. Perennial legume trial management, Alburgh, VT, 2021-2022.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	hemp
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	3-May 2021
Harvest dates (2022)	31-May, 7-Jul, and 19-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 E. E. Cummings Crop Testing Laboratory at the University of Vermont (Burlington, VT) on a FOSS DS2500 Forage and Feed Analyzer.

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 2021 was warmer and wetter than normal. However, winter precipitation was below normal through February and temperatures below normal through April. However, these conditions improved in May with warmer weather and normal precipitation allowing for substantial 1st harvests around the region. Wet cool weather returned in June and August. July was particularly hot and dry as much of the rainfall that was accumulated was attributed to a couple of small rain events. During the 2022 growing season, 3477 growing degree days (GDDs) were accumulated, 14 more than normal.

Table 3. 2021-2022 weather data for Alburgh, VT.

	2021				2022							
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Average temperature (°F)	63.1	54.6	37.6	28.6	10.7	20.0	32.3	44.8	60.5	65.3	71.9	70.5
Departure from normal	0.40	4.31	-1.68	0.36	-10.20	-2.93	-0.03	-0.81	2.09	-2.18	-0.54	-0.20
Precipitation (inches)	4.49	6.23	2.26	1.42	0.28	1.14	2.52	5.57	3.36	8.19	3.00	4.94
Departure from normal	0.82	2.40	-0.44	-1.08	-1.85	-0.63	0.28	2.50	-0.40	3.93	-1.06	1.40
Growing Degree Days (base 41°F)	663	441	90	36	0	11	60	201	617	726	953	909
Departure from normal	11	137	9	36	0	11	38	-14	77	-67	-20	-11

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.

Impact of Legume Species

Species differed in dry matter yield across the season (Table 4, Figure 1). Red clover produced the overall highest biomass of 4.99 tons ac^{-1} and white clover produced the lowest biomass at 2.67 tons ac^{-1}. White clover, being shallow rooted and lower growing is expected to produce less biomass than taprooted, upright growing forages like red clover or alfalfa that can better withstand drought conditions and are more suitable to mechanical harvest.

Table 4. Dry matter yields by legume species, 2022.

Species	1st cut	2nd cut	3rd cut	Season yield
		Dry matter tons ac^{-1}		
Alfalfa	1.49b†	**1.68a**	**1.30a**	4.47b
Birdsfoot Trefoil	0.993c	1.58a	1.23a	3.80c
Red Clover	**2.43a**	1.38b	1.17a	**4.99a**
White Clover	0.386d	1.33b	0.962b	2.67d
LSD (p = 0.10) ‡	0.208	0.114	0.142	0.259
Trial mean	1.33	1.49	1.17	3.98

†Within a column, species with the same letter performed statistically similar to one another.
‡LSD; Least Significant Difference at p=0.10 level.

Legume species also differed in forage quality parameters (Table 5). Forages averaged 19.3% crude protein, 35.3% NDF, and 9.88% WSC. The alfalfa was the lowest performing species for each of these parameters while the white clover was the top performer. White clover also had the highest digestibility of 73.6%. These quality difference coalesce into the predicted milk yield per ton of forage which was at least 300 lbs higher for the white clover than any other treatment.

Table 5. Forage quality characteristics by legume species, 2022.

Species	CP	NDF	WSC	30-hr NDFD	Milk yield
		% DM		% NDF	lbs ton^{-1}
Alfalfa	18.2c†	39.2b	8.62c	57.1c	3614c
Birdsfoot Trefoil	18.9bc	37.1b	8.71c	61.2b	3745b
Red Clover	19.1b	33.4a	10.6b	56.9c	3711bc
White Clover	**20.9a**	**31.5a**	**11.6a**	**73.6a**	**4069a**
LSD (p = 0.10) ‡	0.894	2.4	0.474	2.11	110
Trial mean	19.3	35.3	9.88	62.2	3785

†Within a column, species with the same letter performed statistically similar to one another.
Top performing treatments are indicated in **bold.**
‡LSD; Least Significant Difference at p=0.10 level.

However, while on a dry matter basis the white clover may appear to produce the highest quality forage, it yields significantly less dry matter than the other species. Therefore, if we consider the yield of these quality components and the resulting milk, the performance looks a bit different (Table 6). Due to the low dry matter yields of white clover, it produces the least protein, digestible fiber, and water-soluble carbohydrates per acre compared to the other legume species. This ultimately results in a lower predicted milk yield per acre as well. While alfalfa produced the highest digestible NDF yield, the overall higher yield of the red clover ultimately produced more protein, WSC, and milk per acre.

Table 6. Forage quality component yields by legume species, 2022.

Species	CP	30-hr digestible NDF	WSC	Milk yield
		tons ac^{-1}		
Alfalfa	0.814b†	**1.09a**	0.383b	8.06b
Birdsfoot Trefoil	0.694c	0.913b	0.317c	6.89c
Red Clover	**0.934a**	0.970b	**0.540a**	**9.04a**
White Clover	0.542d	0.630c	0.290c	5.24d
LSD (p = 0.10)‡	0.060	0.096	0.0332	0.519
Trial mean	0.746	0.901	0.383	7.31

†Within a column, species with the same letter performed statistically similar to one another.
‡LSD; Least Significant Difference at p=0.10 level.
Top performing treatments are indicated in **bold.**

Impact of Variety-Alfalfa

Alfalfa varieties did not differ statistically in yield or quality even when considering yield of overall dry matter, protein, digestible NDF, WSC or predicted milk on a per acre basis (Table 7). All of the varieties trialed produced over four tons of dry matter per acre with approximately 18% protein, 57% NDF digestibility, 8.6% WSC, and a predicted milk yield of 3600 lbs/ton. These equated to the quality component and milk yields on a per acre basis in Table 7.

Table 7. Total dry matter and quality component yields of alfalfa varieties, 2022.

Variety	Total DM yield	CP	30-hr digestible NDF	WSC	Milk yield
			tons ac^{-1}		
4A420P	**4.71**	**0.867**	1.08	**0.406**	**8.45**
KF Enhancer II	4.30	0.756	1.09	0.373	7.71
KF Secure BR	4.26	0.762	**1.12**	0.365	7.68
Stronghold	4.55	0.845	1.07	0.391	8.28
Viking 3200	4.54	0.838	1.09	0.378	8.17
LSD (p = 0.10)‡	NS†	NS	NS	NS	NS
Trial mean	4.47	0.814	1.09	0.383	8.06

†NS; Not statistically significant.
‡LSD; Least Significant Difference at p=0.10 level.
Top performing treatments are indicated in **bold.**

Impact of Variety-Birdsfoot Trefoil

Birdsfoot trefoil varieties did not differ statistically in yield or quality even when considering yield of overall dry matter, protein, digestible NDF, WSC or predicted milk on a per acre basis (Table 8). All of the varieties trialed produced over three tons of dry matter per acre with approximately 19% protein, 62% NDF digestibility, 8.7% WSC, and a predicted milk yield of 3700 lbs/ton. These equated to the quality component and milk yields on a per acre basis in Table 8.

Table 8. Total dry matter and quality component yields of birdsfoot trefoil varieties, 2022.

Variety	Total DM yield	CP	30-hr digestible NDF	WSC	Milk yield
			tons ac^{-1}		
Exact	4.01	0.659	0.73	0.333	6.67
Leo	3.72	0.703	0.96	0.322	7.01
Norcen	**4.17**	**0.771**	**1.06**	**0.352**	**7.62**
Pardee	3.78	0.741	0.96	0.308	7.14
Wellington	3.34	0.594	0.86	0.271	6.03
LSD (p = 0.10)‡	NS†	NS	NS	NS	NS
Species mean	3.80	0.694	0.91	0.317	6.89

†NS- Not significant

‡LSD; Least Significant Difference at p=0.10 level.

Top performing treatments are indicated in **bold**.

Impact of Variety-Red Clover

Red clover varieties differed statistically in some forage quality characteristics and quality component yields but did not differ in dry matter yield alone (Table 9). Red clover varieties produced over four and five tons of dry matter per acre with approximately 19% protein, 57% NDF digestibility, 10.6% WSC, and a predicted milk yield of 3700 lbs per ton of feed. Due to the variety Gallant's high dry matter yield and high protein content of almost 20%, the protein yield on a per acre basis was statistically higher than the varieties Harmonie or Starfire II. However, the overall predicted milk yield on a per acre basis did not differ statistically.

Table 9. Total dry matter and quality component yields of red clover varieties, 2022.

Variety	Total DM yield	CP	30-hr digestible NDF	WSC	Milk yield
			tons ac^{-1}		
Freedom	5.17	0.986ab†	1.05	0.584	9.46
Gallant	5.15	**1.02a**	1.00	0.563	9.54
Harmonie	4.44	0.846bc	0.91	0.512	8.77
Red Wing	**5.31**	0.989ab	**1.06**	**0.594**	**9.61**
Starfire II	4.84	0.827c	0.86	0.447	7.82
LSD (p = 0.10)¥	NS‡	0.148	NS	NS	NS
Species mean	4.99	0.934	0.97	0.540	9.04

†Within a column, species with the same letter performed statistically similar to one another.

Top performing treatments are indicated in **bold**.

‡NS- Not significant

¥LSD; Least Significant Difference at p=0.10 level.

Impact of Variety-White Clover

White clover varieties differed statistically in some yield and quality characteristics (Table 10). While yields at the first harvest differed statistically across the varieties, the overall season yields did not. This may suggest differences in early season vigor and height. Varieties Legacy and Kakariki produced approximately 0.7 tons ac^{-1} during the 1st harvest, which was approximately 0.5 tons ac^{-1} more than all other varieties. For the season, all varieties produced more than 2.5 $tons^{-1}$ ac. In addition, white clover varieties differed in average protein content, NDF digestibility, and predicted milk yield per ton of forage fed. Again, varieties Legacy and Kakariki produced forage with protein contents over 23%, which was approximately 4% higher than all other varieties. Fiber digestibility ranged from 68.4% to 78.5% with Legacy and Kakariki producing the most digestible fiber along with Domino. Because of these differences in average forage quality, the varieties differed statistically in predicted milk yield per ton of forage fed which ranged from 3775 to 4383 lbs ton^{-1}.

Table 10. Forage yield and quality characteristics of white clover varieties, 2022.

Variety	1st cut DM yield	Total DM yield	CP	WSC	30-hr digestible NDF	Milk yield
	tons ac^{-1}		% of DM		% of NDF	lbs ton^{-1}
Domino	0.222b†	2.55	19.3b	11.7	74.5a	4015ab
Huia	0.159b	2.65	19.4b	10.5	69.5b	3838b
Kakariki	0.696a	2.70	**23.8a**	**12.5**	**78.5a**	**4383a**
Klondike	0.120b	2.67	19.0b	10.9	68.4b	3775b
Legacy	**0.735a**	**2.81**	23.3a	12.2	77.0a	4335a
LSD (p = 0.10)¥	0.272	NS‡	2.89	NS	4.30	370
Species mean	0.386	2.67	20.9	11.6	73.6	4069

†Within a column, species with the same letter performed statistically similar to one another.

Top performing treatments are indicated in **bold**.

‡NS- Not significant.

¥LSD; Least Significant Difference at p=0.10 level.

Despite these differences, the resulting yield of these quality fractions throughout the season provides a slightly different perspective (Table 11). Kakariki produced the highest protein yields per acre followed closely by Legacy. However, when we consider the dry matter productivity and NDF digestibility throughout the season, Klondike and Domino produced more tons of digestible NDF per acre than the other varieties. This was due to higher yields in 2nd and 3rd harvests and maintaining relatively high NDF digestibility. Conditions turned hot and dry following the first harvest. The varieties that produced significant biomass at the first harvest may have suffered from these conditions more than the ones that had not grown tall enough to have much biomass removed. Overall, however, predicted milk yields on a per acre basis for the whole season did not differ statistically between varieties.

Table 11. Yield of quality components for white clover varieties, 2022.

Variety	CP	30-hr digestible NDF	WSC	Milk yield
		tons ac^{-1}		
Domino	0.474c†	0.741a	0.272	4.93
Huia	0.518bc	0.664ab	0.265	5.01
Kakariki	**0.634a**	0.479b	**0.327**	**5.81**
Klondike	0.484c	**0.776a**	0.273	4.86
Legacy	0.600ab	0.490b	0.314	5.58
LSD (p = 0.10)¥	0.0904	0.222	NS‡	NS
Species mean	0.542	0.630	0.290	5.24

†Within a column, species with the same letter performed statistically similar to one another.
Top performing treatments are indicated in **bold**.
‡NS- Not significant.
¥LSD; Least Significant Difference at p=0.10 level.

DISCUSSION

The growing seasons of 2021 and 2022 presented challenging weather conditions for perennial forage species in the northeast. Prolonged periods of very cold weather and little snow cover in the winter combined with dry conditions at various points through the season challenged legume productivity and persistence. During this first season of data collection, differences in species and varietal performance in terms of yield and quality were observed. While alfalfa is often thought of as the primary forage legume, red clover performed very well producing similar yields with higher fiber digestibility. While the white clovers and birdsfoot trefoils are less drought tolerant, including them in pastures and mixed grass-legume hay fields can help provide nitrogen and high-quality forage throughout the summer. As this trial matures, we will continue to evaluate these 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.

ACKNOWLEDGEMENTS

UVM Extension would like to thank Roger Rainville and his staff at Borderview Research Farm in Alburgh for their generous help with the trials. We would like to acknowledge funding for this research provided through USDA OREI project #(2018-51300-28515). We would also like to acknowledge Anna Brown, John Bruce, Catherine Davidson, Hillary Emick, Laura Sullivan, and Sophia Wilcox-Warren for their assistance with data collection and entry. The information is presented with the understanding that no product discrimination is intended and no endorsement of any product mentioned or criticism of unnamed products is implied.

UVM Extension helps individuals and communities put research-based knowledge to work.

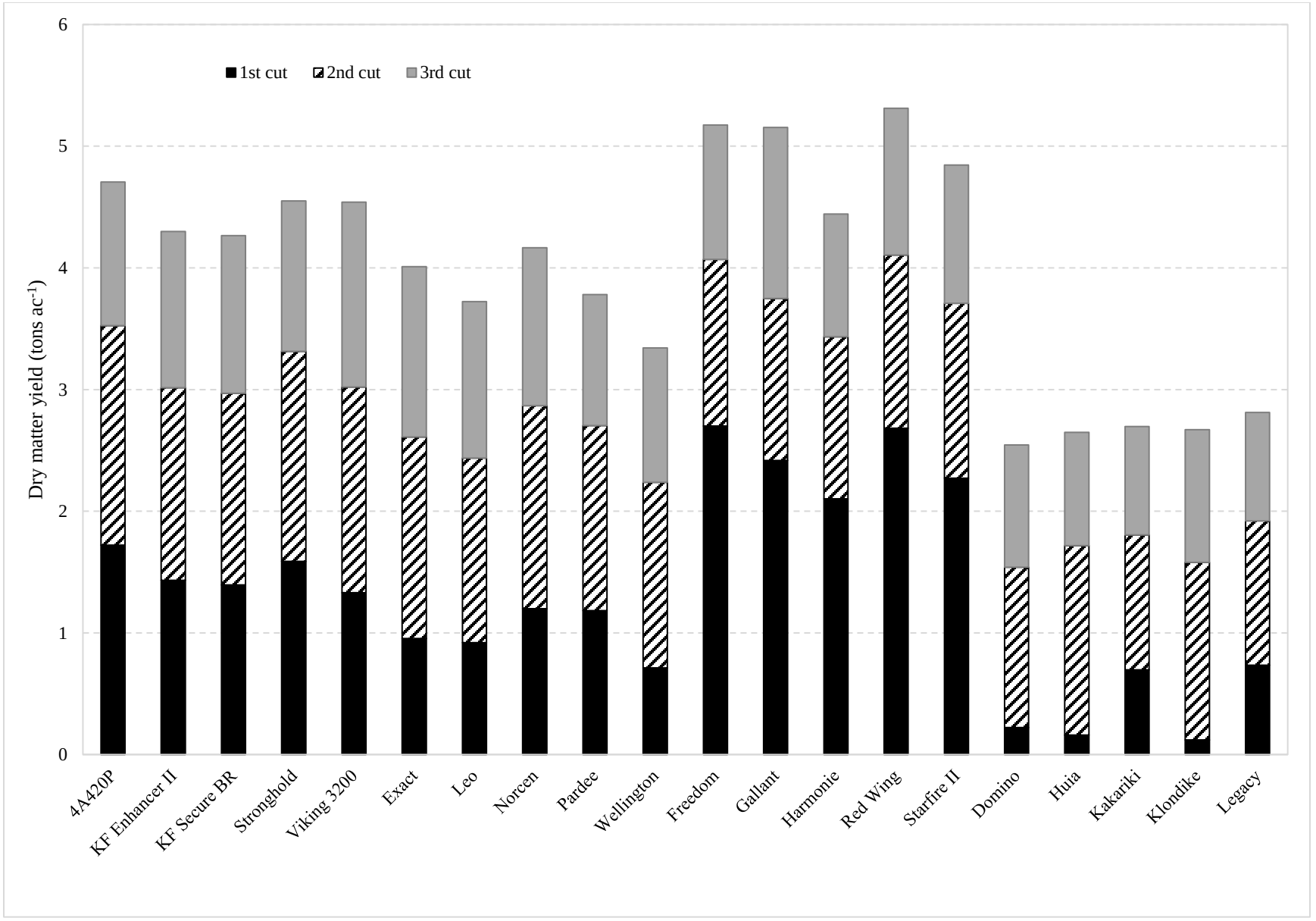

Figure 1. Dry matter yield by cutting for 20 perennial legume varieties, 2022.