2018

Legume Variety Trial

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NORTHWEST CROPS & SOILS PROGRAM

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THE UNIVERSITY OF VERMONT EXTENSION

2018 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.

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 2018, plots were harvested with a Carter forage harvester in 3' x 20' area on 7-Jun, 11-Jul, and 22-Aug.

Table 2. Perennial forage trial management, Alburgh, VT, 2017-2018.

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 (2018)	7-Jun, 11-Jul, and 22-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.

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

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

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.

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 2017 was warmer and drier than normal despite a wetter and cooler summer. Precipitation throughout the winter was below average for all months well into early spring. Throughout the 2018 season, the weather was hotter and drier than normal with many parts of the state experiencing severe drought conditions as only approximately 60% of the typical accumulated rainfall was received. There were only four rain events during this trial's growing season that produced >0.75" of accumulation. These four events constituted approximately 33% of the total rainfall. Therefore, there were extended periods with very little to no rainfall, the longest of which was approximately 25 days with no rainfall >0.25". This period occurred during the regrowth period between the second and third harvests which increased our recovery period by eight days. Furthermore, some plots by this time had not regrown sufficiently to be picked up by the forage harvester and therefore would have required a recovery period likely greater than 50 days.

Table 3. 2017-2018 weather data for Alburgh, VT.

	2017				2018							
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Average temperature (°F)	64.4	57.4	35.2	18.5	17.1	27.3	30.4	39.2	59.5	64.4	74.1	72.8
Departure from normal	3.76	9.16	-2.96	-7.41	-1.73	5.79	-0.66	-5.58	3.10	-1.38	3.51	3.96
Precipitation (inches)	1.84	3.29	2.28	0.78	0.79	1.16	1.51	4.43	1.94	3.74	2.43	2.96
Departure from normal	-1.80	-0.31	-0.84	-1.59	-1.26	-0.60	-0.70	1.61	-1.51	0.05	-1.72	-0.95
Growing Degree Days (base 41°F)	699	516	73	12	14	30	17	118	582	701	1007	974
Departure from normal	111	293	73	12	14	30	17	4	105	-43	89	112

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 Species

Species differed significantly in terms of dry matter yield per acre across the first and third cuts as well as in overall combined yield (Table 4). At the first harvest, red clover was the top performer yielding 0.918 tons ac^{-1}, which was statistically similar to alfalfa that yielded 0.856 tons ac^{-1}. The white clover was the lowest yielding species across all cuts as well as total combined yield. At the second harvest, yields did not differ statistically. However, alfalfa was the top yielding species at this harvest producing 0.803 tons ac^{-1}. At the final harvest, species differed statistically with birdsfoot trefoil producing the highest yield of 0.894 tons ac^{-1}, which was similar to all other species except for white clover. Across the growing season, alfalfa produced a total yield of 2.51 tons ac^{-1}, similar to the trefoil and red cover, with white clover producing significantly less with 1.35 tons ac^{-1}.

Table 4. Dry matter yield across cuts by species, 2018.

Species	Dry matter (DM) yield			
	1st cut	2nd cut	3rd cut	Total yield
	tons ac^{-1}			
Alfalfa	0.856*	**0.803**	0.853*	**2.51**
Birdsfoot Trefoil	0.539	0.754	**0.894**	2.19*
Red Clover	**0.918**	0.705	0.705*	2.31*
White Clover	0.395	0.686	0.276	1.35
p-value	<0.0001	NS	<0.0001	<0.0001
Trial mean	0.725	0.744	0.676	2.14

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**
NS – Not significant.

Legume species also differed in quality characteristics across the three harvests (Tables 5-7). Crude protein content was highest in white clover in the first and third cuts, but lowest in the second cut. Similarly, white clover had the lowest ADF and NDF contents in the first and third cuts. This is likely due to the leafy, prostrate growth habit of white clover compared to the more upright and stemmy growth habit of alfalfa and red clover.

Table 5. Forage quality characteristics by species, 1st cut, 2018.

Species	DM	CP	ADF	NDF	48-hr NDFD
	%		% DM		% NDF
Alfalfa	26.7	20.5*	24.9	35.9	51.9
Birdsfoot Trefoil	23.1*	19.7	23.9*	32.9*	55.8
Red Clover	**21.9**	21.0*	26.2	37.0	49.5
White Clover	22.2*	**21.5**	**22.1**	**32.1**	**61.5**
p-value	<0.0001	<0.05	<0.0001	<0.05	<0.0001
Cut Mean	24.0	20.8	24.4	34.9	54.1

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**

Table 6. Forage quality characteristics by species, 2nd cut, 2018.

Species	Dry matter	CP	ADF	NDF	48-hr NDFD
	%		% DM		% NDF
Alfalfa	28.0	22.7*	25.9	36.2	49.1
Birdsfoot Trefoil	**24.5**	22.2*	**25.1**	**33.3**	51.9
Red Clover	25.0*	**22.8**	26.2	36.8	49.1
White Clover	26.3*	21.8	26.3	35.8	**57.3**
p-value	<0.05	<0.05	NS	<0.05	<0.0001
Cut Mean	26.5	22.4	26.0	36.0	51.4

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**
NS – Not significant.

Furthermore, the decline in quality observed in white clover between the first and second harvests could be explained by maturity as it was noted that the white clover was just beginning to bloom at the first harvest but was in full bloom at the second harvest. However, NDF digestibility was consistently highest in the white clover across all cuts. This indicates that, although the NDF content increased from the first to the second harvest, that fiber fraction remained more digestible than the other species at that harvest.

Table 7. Forage quality characteristics by species, 3rd cut, 2018.

Species	Dry matter	CP	ADF	NDF	48-hr NDFD
	%		% DM		% NDF
Alfalfa	28.2	24.1	25.3	34.9	51.5
Birdsfoot Trefoil	**25.3**	22.6	26.8	34.0*	54.9
Red Clover	29.3	21.6	31.4	41.9	49.9
White Clover	27.0*	**25.3**	**22.3**	**31.1**	**61.6**
p-value	<0.05	<.0001	<0.0001	<0.0001	<0.0001
Cut Mean	27.9	23.6	26.2	35.6	53.8

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**

Impact of Variety

Significant varietal differences were not observed for yield or quality parameters across all cuttings for birdsfoot trefoil. However, some differences were observed for the other species. For alfalfa, varieties differed only in NDF digestibility at the 1st harvest (Table 8). The highest NDF digestibility of 53.9% was produced by Viking 340. This was statistically similar to all except for three varieties for this harvest.

Table 8. Forage quality characteristics by variety for alfalfa, 1st cut, 2018.

Variety	Dry matter	CP	ADF	NDF	48-hr NDFD
	%		% DM		% NDF
FSG 420	28.2	21.3	24.3	34.5	50.6
Profusion	25.9	21.1	24.0	34.5	51.8*
Road Runner	25.9	19.5	26.6	37.5	49.9
Secure	25.9	20.4	25.9	36.8	49.8
Traffic Pro	27.8	20.7	24.3	35.6	52.7*
Viking 340	27.3	19.3	26.3	38.8	**53.9**
Viking 370	26.1	20.1	24.9	36.7	53.2*
Viking 542	26.2	21.6	22.7	33.0	53.7*
LSD (*p* = 0.10)	NS	NS	NS	NS	2.83
Cut Mean	26.7	20.5	24.9	35.9	54.1

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**
NS – Not significant.

For red clover, varieties only differed in dry matter, crude protein, and NDF digestibility in the 1st harvest (Table 9). The variety Manitoba had the highest quality in terms of CP, ADF, NDF and NDF digestibility at this harvest. This was likely due to Manitoba blooming later than the other varieties. This is consistent with the observation that Milvus was in full bloom at this harvest and therefore was lower quality.

Table 9. Forage quality characteristics by variety for red clover, 1st cut, 2018.

Variety	Dry matter	CP	ADF	NDF	48-hr NDFD
	%		% DM		% NDF
Arlington	21.7	20.4	26.3	37.3	49.3
Freedom	22.0	21.4*	26.1	36.1	47.8
Manitoba	**19.6**	**22.5**	**24.8**	**34.9**	**51.6**
Milvus	22.7	20.0	27.0	38.1	48.5
Ruby	23.8	20.7	26.9	38.4	50.3*
LSD (*p* = 0.10)	1.65	1.2	NS	NS	2.10
Cut Mean	21.9	21.0	26.2	37.0	54.1

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**
NS – Not significant.

White clover varieties also differed significantly in quality across the season (Tables 10-12). In general, the variety Liflex was the lowest quality at all harvests while Kopu II retained high quality. Liflex was starting to bloom in the first cut which may have contributed to its lower quality, especially NDF digestibility.

Table 10. Forage quality characteristics by variety for white clover, 1st cut, 2018.

Variety	Dry matter	CP	ADF	NDF	48-hr NDFD
	%		% DM		% NDF
Alice	22.7*	22.0*	21.8	32.3	61.8*
Klondike	21.4*	21.5*	22.6	33.2	61.3*
Kopu II	21.7*	22.3*	**20.5**	**28.8**	61.7*
Ladino	**20.6**	**22.5**	20.7	29.7	**64.2**
Liflex	24.4	19.3	25.0	36.2	58.7
LSD (*p* = 0.10)	2.20	1.96	NS	NS	3.14
Cut Mean	22.2	21.5	22.1	32.1	54.1

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**
NS – Not significant.

Table 11. Forage quality characteristics by variety for white clover, 2nd cut, 2018.

Variety	Dry matter	CP	ADF	NDF	48-hr NDFD
	%		% DM		% NDF
Alice	**24.0**	22.1*	25.0*	34.7*	57.8
Klondike	24.1	**22.7**	25.8*	35.0*	**58.2**
Kopu II	28.1	22.3*	**24.5**	**32.8**	56.9
Ladino	27.6	21.5	27.0	36.7	57.7
Liflex	27.6	20.3	29.4	39.9	56.1
LSD (*p* = 0.10)	NS	0.978	2.32	3.17	NS
Cut Mean	26.3	21.8	26.3	35.8	51.4

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**
NS – Not significant.

Table 12. Forage quality characteristics by variety for white clover, 3rd cut, 2018.

Variety	Dry matter	CP	ADF	NDF	48-hr NDFD
	%		% DM		% NDF
Alice	26.6	24.7	22.6	31.7	60.7
Klondike	25.8	26.2*	21.5*	30.4	61.6
Kopu II	**25.5**	**26.9**	19.9*	**27.0**	62.4
Ladino	28.5	26.8*	**19.9**	27.7*	**63.7**
Liflex	28.4	22.0	27.6	38.9	59.3
LSD (*p* = 0.10)	NS	1.69	2.31	3.01	NS
Cut Mean	27.0	25.3	22.3	31.1	54.0

Treatments with an asterisk* performed statistically similar to the top performer in **bold.**
NS – Not significant.

DISCUSSION

Red clover and birdsfoot trefoil yielded just as well as alfalfa and often-produced higher quality forage, even during drought conditions (Figures 1-3). Alfalfa and birdsfoot trefoil maintained quality across the harvests better than red and white clover. Typically, we would expect alfalfa and red clover, forage species with deep taproots, to fare better in drought conditions than shallow-rooted birdsfoot trefoil and white clover. However, for the two varieties of birdsfoot trefoil in this trial that was not the case. In general, alfalfa yields were maintained across the various soil conditions found in this trial (Figure 1). Greater yield declines were observed from birdsfoot trefoil between favorable and excessively dry and stony conditions. Furthermore, varietal differences in yield were observed for alfalfa and white clover as great as 1 ton ac^{-1}. These differences highlight the importance of varietal selection to maximize yield and quality under variable weather and soil conditions. We will continue to monitor these stands for winter survival, yield, and stand longevity in the future to better understand varietal performance and potential in this region.

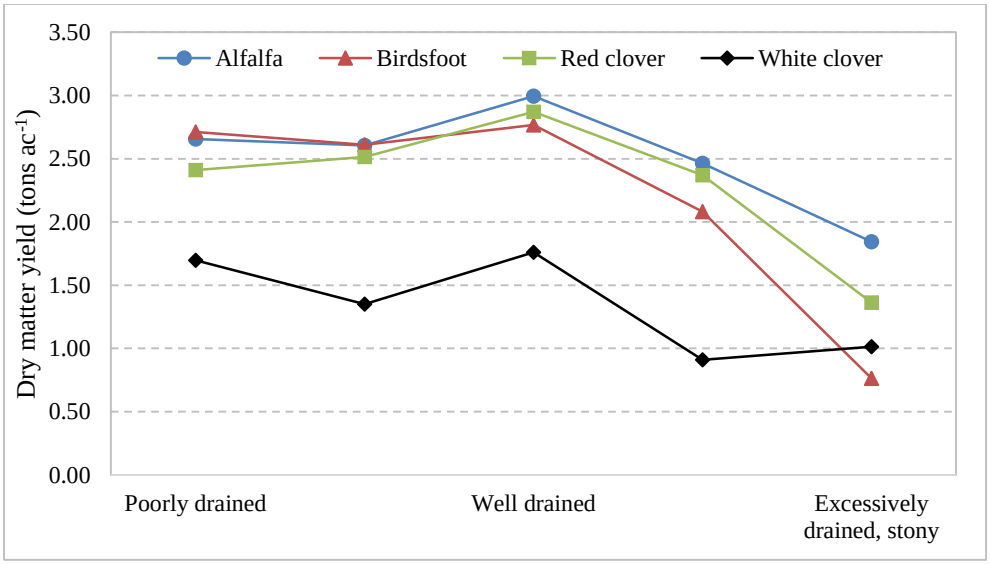

Figure 1. Dry matter yield by legume species across soil textures and drainage class, 2018.

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 thank Organic Valley Farmers Advocating for Organic grant program for supporting this research. We would like to acknowledge Erica Cummings, Catherine Davidson, Amanda Gervais, Haley Jean, and Rory Malone 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.

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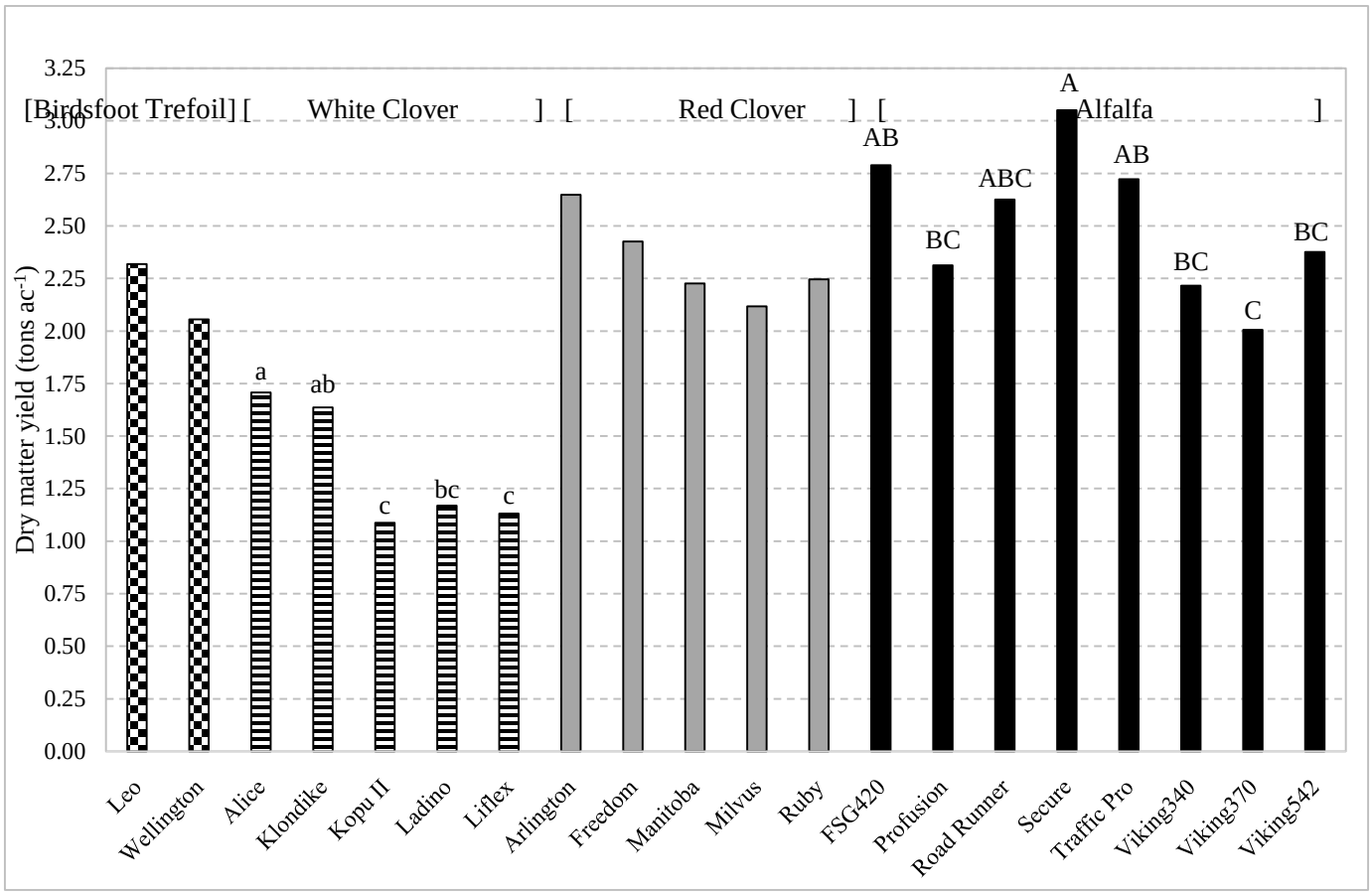

Figure 2. Total dry matter yield by variety within species, 2018.
Treatments that share letters performed statistically similar to one another.

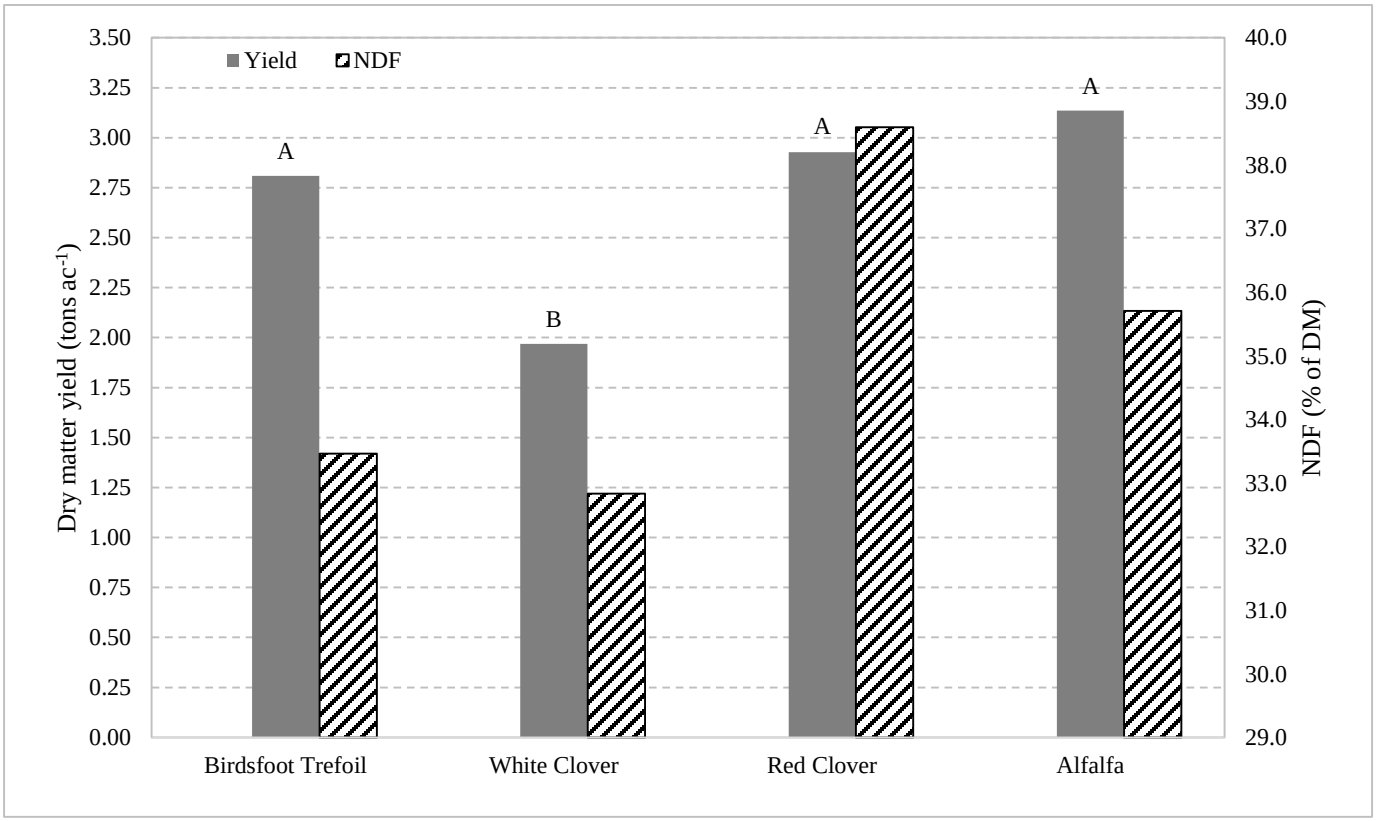

Figure 3. Total dry matter yield and NDF content by variety within species, 2018.
Treatments that share letters performed statistically similar to one another.