2016 Summer Annual Forage Mixtures Trial

Dr. Heather Darby, UVM Extension Agronomist
Sara Ziegler, Nate Brigham, and Julija Cubins
UVM Extension Crops and Soils Technicians
(802) 524-6501

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Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

In 2016, the University of Vermont Extension Northwest Crops and Soils Program evaluated yield and quality of six summer annual forage species and five mixtures at Borderview Research Farm in Alburgh, VT. In the Northeast, cool season grasses dominate the pastures and hay meadows farmers rely on throughout the season. With the onset of hot summer weather, these grasses enter dormancy and slow in production leading to what is generally referred to as the "summer slump". In addition to this loss in production, organic producers must provide animals with 30% of their dry matter intake (DMI) from pasture over at least 120 days of the year. These constraints, in combination with variable weather, can make it very difficult to produce adequate forage from these cool season perennial grasses alone to meet the farmer's needs. Summer annual species thrive in hot weather and can be grazed to help reach the pasture requirement or can be used as stored feed to supplement other sources. Recently, there has been a growing interest in utilizing multiple species to maximize forage yield and quality. In 2015, we trialed three- and five-way mixtures of various summer annual grass, legume, and forb species. We found it very difficult to establish a well-balanced mixture as the grasses tended to outcompete the other species. In 2016, we simplified the project to examine seeding rates of summer annual legumes and grasses to better understand how to establish mixtures of these species and be able to benefit from both species. While the information presented can begin to describe the yield and quality performance of these forage mixtures in this region, it is important to note that the data represent results from only one season and one location.

MATERIALS AND METHODS

In 2016, 13 annual forage mixtures were evaluated at Borderview Research Farm in Alburgh, VT. The plot design was a randomized complete block with four replications. The soil type at the Alburgh location was a Benson rocky silt loam (Table 1).

Table 1. Annual forage trial management, Alburgh, VT, 2016.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Corn silage
Tillage operations	Chisel plow, disk and spike tooth harrow
Planting equipment	Cone Seeder
Treatments (species/mixtures)	12
Replications	4
Plot size (ft)	5 x 20
Planting date	6-Jun
Harvest dates	3-Aug and 30-Aug

The seedbed was chisel plowed, disked, and finished with a spike tooth harrow. The previous crop was corn silage. Plots were 5’ x 20’ and replicated 4 times. The trial was planted with a cone seeder on 6-Jun. Plots were harvested with the carter forage harvester in a 3’ x 20’ area on 3-Aug. Due to uneven emergence, some plots were hand harvested in a 0.25m^2 area. After harvest, all the remaining plots were mowed to the same height. Plots were again harvested on 30-Aug. Due to poor regrowth, some plots were not harvested a second time.

Treatments were summer annual forages species alone or in mixtures (Table 2). An approximate 1 lb subsample of the harvested material was collected, dried, ground, and then analyzed at the University of Vermont’s Testing Laboratory, Burlington, VT, for forage quality. Dry matter yields were calculated.

Table 2. Summer annual forage species and mixtures evaluated in Alburgh, VT.

Treatment	Species	Variety	Seeding Rate lbs. ac^{-1}
MC1	Millet	Wonderleaf	10
	Berseem Clover	Frosty	10
MC2	Millet	Wonderleaf	14
	Berseem Clover	Frosty	6
SC1	Sudangrass	Hayking	25
	Berseem Clover	Frosty	25
SC2	Sudangrass	Hayking	35
	Berseem Clover	Frosty	15
MV1	Millet	Wonderleaf	10
	Chickling Vetch	AC Greenfix	10
MV2	Millet	Wonderleaf	14
	Chickling Vetch	Wonderleaf	6
SV1	Sudangrass	Hayking	25
	Chickling Vetch	AC Greenfix	25
SV2	Sudangrass	Hayking	35
	Chickling Vetch	AC Greenfix	15
Pollinator	Peas & Oats	Stockade and	26
	Hairy vetch	Purple bounty	16
	Crimson clover	VNS	16
	Buckwheat	VNS	16
	Rape	Trophy	10.5
	Berseem clover	VNS	10.5
	Sunflower	Wildlife blend	10.5
Berseem	Berseem clover	Frosty	15
Millet	Pearl Millet	Wonderleaf	20
Sudangrass	Sudangrass	Hayking	50
Vetch	Chickling vetch	AC Greenfix	60

Forage quality was analyzed using the FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer. Dried and coarsely-ground plot samples were brought to the lab where they were reground using a cyclone sample mill (1mm screen) from the UDY Corporation. The samples were then analyzed using the FOSS NIRS DS2500 for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), 30-hour digestible NDF (NDFD), and total digestible nutrients (TDN).

Mixtures of true proteins, composed of amino acids, and non-protein nitrogen make up the CP content of forages. The CP content of forages is determined by measuring the amount of nitrogen and multiplying by 6.25. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of plants 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). Chemically, this fraction includes cellulose, hemicellulose, and lignin. Because of these chemical components and their association with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows. Evaluation of forages and other feedstuffs for NDF digestibility (NDFD) is being conducted to aid prediction of feed energy content and animal performance. Research has demonstrated that lactating dairy cows will eat more dry matter and produce more milk when fed forages with optimum NDFD. Forages with increased NDFD will result in higher energy values and, perhaps more importantly, increased forage intakes. Forage NDFD can range from 20 – 80% NDF. The results presented in this report represent 48-hr NDFD.

Yield data and stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and mixtures were treated as fixed. Treatment mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

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 hybrids is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. Where the difference between two hybrids within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two hybrids. Hybrids that were not significantly lower in performance than the highest hybrid in a particular column are indicated with an asterisk. In this example, hybrid C is significantly different from hybrid A but not from hybrid B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

Hybrid	Yield
A	6.0
B	7.5*
C	**9.0***
LSD	2.0

RESULTS

Seasonal precipitation and temperatures recorded with a Davis Instruments Vantage Pro 2 weather station with WeatherLink data logger in Alburgh, VT are shown in Table 3. From June through August there was an accumulation of 1784 Growing Degree Days (GDDs) in Alburgh, which is 90 GDDs more than the 30-

year average. Rainfall was below normal at planting by almost an inch. Slow and patchy emergence of the crop was a result of dry soil conditions.

Table 1. Seasonal weather data[1] collected in Alburgh, VT, 2016.

Alburgh, VT		June	July	August
Average temperature (°F)		65.8	70.7	71.6
Departure from normal		0.00	0.10	2.90
Precipitation (inches)		2.80	1.80	3.00
Departure from normal		-0.88	-2.37	-0.93
Growing Degree Days (base 50°F)		481	640	663
Departure from normal		7	1	82

[1]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.

These droughty conditions persisted through the growing season with the driest month being July, which was almost 2.5" below normal. Temperatures during the season were approximately normal with the exception of August, which was about 3 degrees above normal. These warm dry conditions continued into September causing poor regrowth and no third harvest.

Table 4. Yield and quality of 13 summer annual forage treatments 1st cut, 2016.

Summer annual	Dry Matter (DM) %	DM Yield tons ac^{-1}	Crude Protein % of DM	ADF % of DM	NDF % of DM	NDFD % of NDF
MC1	15.8	1.54	17.3bc	30.9b	51.3de	68.3abc
MC2	16.5	0.982	19.4abc	26.6ab	45.3cde	**70.7a**
SC1	**22.9**	**2.79**	16.3bc	32.7b	53.7e	62.3
SC2	21.7	1.15	15.2c	32.7b	54.0e	63.8bc
MV1	21.6	1.06	20.5ab	25.2ab	42.9bcd	69.8ab
MV2	16.6	1.01	18.1bc	29.4b	48.3de	68.5ab
SV1	15.9	1.03	17.4bc	32.1b	50.6de	53.0bc
SV2	18.1	0.954	17.9bc	29.5b	48.4de	64.4abc
Pollinator	15.7	1.40	17.8bc	26.7ab	37.2abc	62.9bc
Berseem Clover	21.5	0.829	23.1a	**21.1a**	**30.0a**	48.9d
Chickling Vetch	17.3	0.613	**23.8a**	25.8ab	34.4ab	60.6b
Millet	21.1	1.67	16.0bc	30.5b	50.8de	69.1ab
Sudangrass	18.0	1.48	18.4bc	30.9b	51.4de	64.7abc
Probability level	NS	NS	***	***	***	***
Trial Mean	18.6	1.29	18.3	30.7	48.6	61.1

Treatments in **bold** indicate the top performer for that parameter.
In a column, treatments with the same letter are not statistically different.
NS-Not statistically significant.
*, **, *** treatments varied significantly to the .1, .05, and .001 level of significance respectively.

At the first harvest, dry matter content and dry matter yields did not differ statistically (Table 4). Dry matter ranged from 15.7 to 22.9% with an average of 18.6% across the trial. The pollinator mixture, MC1, and SV2 mixtures had the lowest dry matter contents while the SC1, SC2, and MV1 treatments had the highest. Yields ranged from 0.613 to 2.79 tons per acre. Due to high variation, likely caused by germination and establishment issues associated with dry weather, yields were not statistically different across treatments. However, quality parameters did statistically differ across summer annual treatments. The addition of an annual legume to grass mixture did not significantly increase the crude protein concentration of the forage. Similar trends were observed for all other quality parameters. The statistical differences observed are between the legume and the summer annual grass, which is to be expected as these two crops are known to differ in quality from one another considerably. Although not statistically different, the protein level in the MV1 mixture was 4.5% higher than the millet alone. This large of a difference may have not been detected as a significant difference due to high variation. The pollinator mixture performed statistically similarly to the mixtures and grasses alone in terms of protein and ADF. In terms of NDF, the pollinator mixture was similar to the legumes alone having a considerably lower NDF than the grasses and any of the mixes with sudangrass. Interestingly, the pollinator mixture had a similar NDF to the MC2 mixture although it was not similar to the millet and this mixture had a higher proportion of millet. In general, these mixtures still produced considerable biomass of high quality during this incredibly dry period in the summer.

Table 5. Yield and quality of 13 summer annual forage treatments 2nd cut, 2016.

Abbreviation	Dry Matter (DM)	DM Yield	Crude Protein	ADF	NDF	NDFD
	%	tons ac^{-1}	% of DM	% of DM	% of DM	% of NDF
MC1	15.8ab	0.613	**22.7**	32.1	51.0	**69.3**
MC2	17.3b	0.826	19.0	**31.9**	**49.8**	64.2
SC1	14.3a	0.656	18.6	35.7	55.5	58.9
SC2	14.7ab	0.842	18.5	34.6	54.5	60.9
MV1	16.4ab	0.797	19.8	32.3	50.9	64.7
MV2	15.2ab	0.618	20.1	32.0	50.7	67.4
SV1	14.2a	**0.847**	20.7	34.8	56.4	66.2
SV2	14.5a	0.743	19.3	34.6	54.5	60.5
Pollinator	-	-	-	-	-	-
Berseem Clover	-	-	-	-	-	-
Chickling Vetch	-	-	-	-	-	-
Millet	15.7ab	0.664	20.2	32.0	50.6	65.9
Sudangrass	**13.8a**	0.665	19.6	35.1	55.1	59.0
Probability level	*	NS	NS	NS	NS	NS
Trial Mean	15.2	0.727	19.8	33.5	52.9	63.7

Treatments in **bold** indicate the top performer for that parameter.
In a column, treatments with the same letter are not statistically different.
NS-Not statistically significant.
*, **, *** treatments varied significantly to the .1, .05, and .001 level of significance respectively.

Dry weather continued after the first harvest significantly reducing regrowth. Both legume treatments alone as well as the pollinator mixture virtually did not regrow at all by the time the other treatments were harvestable again. This may have been due, not only to dry weather, but to limited regrowth potential of these species. All treatments yielded under 1 ton of dry matter per acre but were not statistically different from one another. The average dry matter yield was 0.727 tons ac^{-1}. Treatments did differ statistically in terms of dry matter content. The MC2 treatment had a higher dry matter content than the sudangrass treatments, except for the SC2 treatment. Quality parameters did not statistically differ in the second harvest (Table 5).

Figure 1 below summarizes the dry matter yields of the 13 different treatments across the two cuttings. The overall average dry matter yield for the season was 1.77 tons ac^{-1}. The highest yielding treatment, although not statistically different from all other treatments, was the SC1 mixture of sudangrass and berseem clover both seeded at 25 lbs ac^{-1}. These yields were substantial considering the extreme drought conditions over the season. Although we did not investigate the cost of implementing these mixtures, having over 1.5 tons of extra dry matter during this point in the season to supplement declines in perennial pastures could be extremely beneficial.

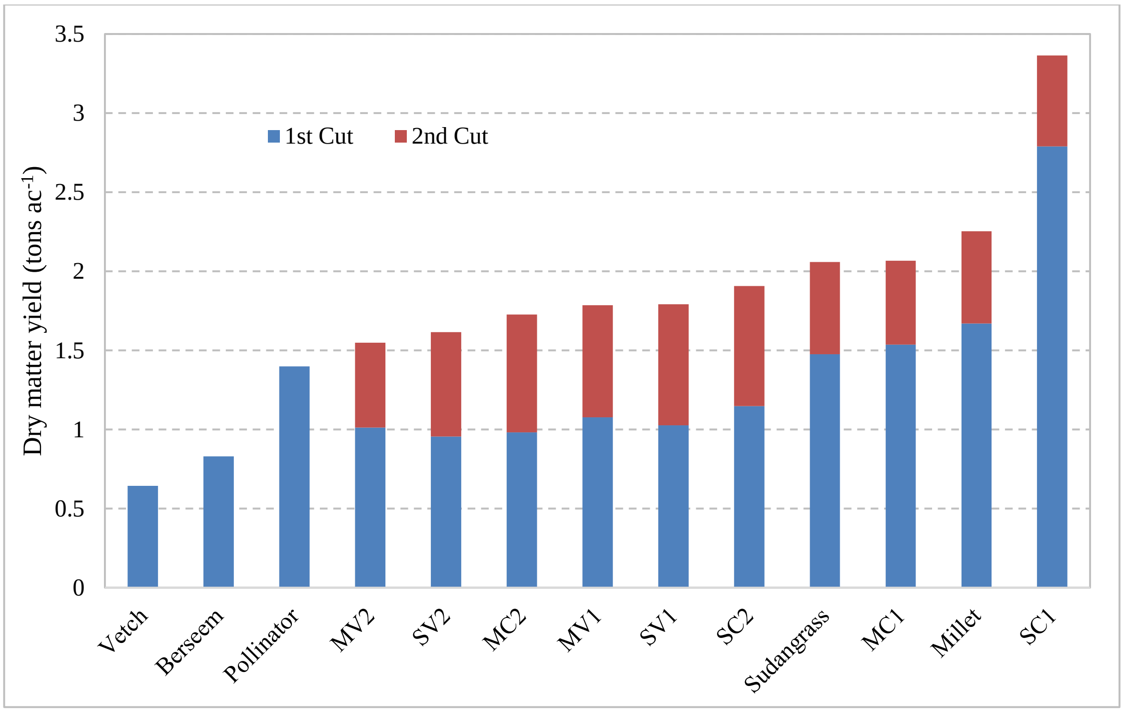

Figure 1. Summary of the dry matter yields of the 13 different treatments across the two cuttings.

DISCUSSION

Challenging weather conditions at the time of planting and continuing through the summer led to patchy establishment and high variability in the trial. We did not observe many differences between the two proportions of grass and legume or between the types of grasses and legumes combined. Some of these differences may have been overshadowed by the high variability. The legumes and the pollinator mixture had little to no regrowth following the first harvest. No differences in yield or quality were observed in the second harvest. Further research is needed to develop recommendations for establishing summer annual grass and legume forage mixtures that produce high yields and quality forage 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 also like to acknowledge Erica Cummings, Kelly Drollette, Hillary Emick, Abha Gupta, Julian Post, Lindsey Ruhl, and Xiaohe "Danny" Yang for their assistance with data collection and entry. This project was made possible by funding through a USDA CARE grant. 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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