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2015

Summer Annual Variety Trial

Heather Darby
University of Vermont, heather.darby@uvm.edu

Sara Ziegler
University of Vermont

Lily Calderwood
University of Vermont

Erica Cummings
University of Vermont

Abha Gupta
University of Vermont

See next page for additional authors

Authors
Heather Darby, Sara Ziegler, Lily Calderwood, Erica Cummings, Abha Gupta, and Julian Post

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Dr. Heather Darby, UVM Extension Agronomist
Sara Ziegler, Lily Calderwood, Erica Cummings, Abha Gupta, and Julian Post
UVM Extension Crops and Soils Technicians
802-524-6501

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University of Vermont Extension
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2015 SUMMER ANNUAL VARIETY TRIAL

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

Warm season grasses, such as sorghum x sudangrass crosses, sudangrass, millet, and teff, can provide quality forage in the hot summer months, when cool season grasses that make up most pastures and hay meadows in the Northeast are not as productive. The addition of summer annuals into a rotation can provide a harvest of high-quality forage for stored feed or grazing. Generally, summer annuals germinate quickly, grow rapidly, are drought resistant, and have high productivity and flexibility in utilization. The UVM Extension Northwest Crops and Soils Program conducted this variety trial to evaluate the yield and quality of warm season annual grasses.

MATERIALS AND METHODS

A trial was initiated at Borderview Research Farm in Alburgh, VT on 7-Jun 2015. General plot management is listed in Table 1. Plots were managed with practices similar to those used by producers in the surrounding area. The previous crop was winter barley. The field was disked and spike tooth harrowed prior to planting. Fourteen varieties of various summer annual species were compared. Plots were seeded with a Great Plains small plot drill at a seeding rate of 50 lbs ac^{-1} for the sorghums, sudangrasses and sorghum x sudangrass crosses, 20 lbs ac^{-1} for the millet, 30 lbs ac^{-1} for the annual ryegrass, and 6 lbs ac^{-1} for the teff. Plots were fertilized with 1000 lbs ac^{-1} ProGro (5-3-4) on 7-Jul and were fertilized again on 2-Aug with 1000 lbs ac^{-1} Pro Booster (10-0-0).

Table 1. General plot management.

Trial Information	Borderview Research Farm-Alburgh, VT
Soil Type	Benson rocky silt loam
Previous crop	Winter barley
Planting date	7-Jun
Fertilizer	1000 lbs ac^{-1} ProGro (5-3-4) on 7-Jul 1000 lbs ac^{-1} Pro Booster (10-0-0) on 2-Aug
First harvest date	29-Jul
Second harvest date	31-Aug
Third harvest date	2-Oct
Seeding rate: Teff	6 lbs $acre^{-1}$
Annual ryegrass	30 lbs $acre^{-1}$
Millet	20 lbs $acre^{-1}$
Sorghum, Sudangrass, and crosses	50 lbs $acre^{-1}$
Tillage methods	Mold board plow, disk, and spike tooth harrow

Plots were harvested with a Carter forage harvester on 29-Jul with a harvest area of 3' x 20', and by hand in a $0.25m^2$ area on 31-Aug and 2-Oct. The species and variety of summer annuals grown are listed in Table 2. Forage quality was analyzed by the University of Vermont Cereal Testing Lab (Burlington, VT) with an FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer. Plot samples were dried, ground and analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and various other nutrients.

Table 2. Summer annual varieties, characteristics, and seed source.

Variety	Species	Characteristics	Seeding rate (lbs ac^{-1})	Company
Bruiser	Annual Ryegrass	non-BMR	30	Seedway
Fria	Annual Ryegrass	endophyte-free	30	Seedway
FSG 300	Millet	non-BMR	20	Seedway
Japanese	Millet	non-BMR	20	Seedway
Wonderleaf	Millet	non-BMR	20	Alta Seeds
AF 7101	Sorghum	non-BMR	50	Alta Seeds
AF 7201	Sorghum	non-BMR	50	Alta Seeds
AS 6402	Sorghum x Sudangrass	BMR	50	Alta Seeds
AS 9301	Sorghum x Sudangrass	BMR	50	King's Agriseed
886	Sudangrass	BMR	50	Seedway
AS 9302	Sudangrass	non-BMR	50	Alta Seeds
Hayking	Sudangrass	BMR	50	King's Agriseed
Pro Max	Sudangrass	BMR	50	Seedway
Moxie	Teff	non-BMR	6	Barenbrug

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). Chemically, this fraction includes cellulose, hemicellulose and lignin. The WSC or water soluble carbohydrates include mono-, di-, and oligosaccharides as well as fructans and is considered the best measure of the relevant sugars for ruminant digestion. The measure of sugars refers just to the sugars in the WSC excluding the fructans. Results were analyzed with an analysis of variance in SAS (Cary, NC). The Least Significant Difference (LSD) procedure was used to separate cultivar means when the F-test was significant ($p < 0.10$). The Tukey-Kramer adjustment was made where necessary.

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 varieties 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 (LSD's) at the 10% level of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk.

In the example on right, A is significantly different from C but not from B. The difference between A and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between A and C is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that B was not significantly lower than the top yielding variety.

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

RESULTS

Seasonal precipitation and temperature recorded at a weather station in Alburgh, VT are shown in Table 3. From June through September, there was an accumulation of 2162 Growing Degree Days (GDDs) in Alburgh which is 149 GDDs more than the 30-year average. Rainfall was above average during planting, with over 6 inches of rain in June. This rainy and cool weather in June caused slow establishment allowing grassy weeds to dominate the stands. Nitrogen losses from the abundant rain had the forages looking chlorotic, necessitating the fertilization. The remainder of the growing season had below average precipitation with August being the driest with almost 4 inches less rain than normal. Temperatures during the rest of the season did not drastically fluctuate from the normal with the exception of September, which was on average 4.6 degrees warmer than normal. The warm and dry fall allowed for extra growth of these warm season annuals well into the fall months.

Table 3. Seasonal weather data[1] collected in Alburgh, VT, 2015.

Alburgh, VT	June	July	August	September
Average temperature (°F)	63.1	70.0	69.7	65.2
Departure from normal	-2.7	-0.6	0.9	4.6
Precipitation (inches)	6.42	1.45	0.00	0.34
Departure from normal	2.73	-2.70	-3.91	-3.30
Growing Degree Days (base 50°F)	416	630	624	492
Departure from normal	-58	-10	43	174

[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.

Variety Performance by Cutting

Yield and quality differed significantly by variety across the three harvests. In the first harvest on 29-Jul, the highest yielding variety was Hayking sudangrass which produced 3.14 tons of dry matter per acre (Table 4). However, this did not statistically differ from any of the other varieties in this harvest. Crude protein, ADF, sugars, and WSC (water soluble carbohydrates) statistically differed across varieties in the first harvest. The average protein level in this first cut was 18.2%. The highest protein of 19.7% was found in the sudangrass variety AS 9302 although this did not differ from seven other varieties. The lowest protein of 16.5% was found in the Japanese millet. The ADF concentrations ranged from 32.5% from AS 9302 to 37.2% from ProMax. This result shows the opposite relationship as expected as AS

9302 is a non-BMR variety but had over 5% less lignin than ProMax which is a BMR variety. However, all the other varieties that were statistically similar to AS 9302 in ADF were BMR varieties or other species such as millet and annual ryegrass.

Table 4. Yield and quality of 14 summer annual varieties, first cut, 2015.

Variety	Species	DM Yield	Crude protein	ADF	NDF	NDFD	Sugars	WSC
		tons ac^{-1}	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Bruiser	Annual Ryegrass	2.80	19.0*	34.5*	60.9	48.2	2.28	3.36
Fria	Annual Ryegrass	1.67	19.6*	33.6*	**57.7**	**52.6**	2.38	3.71
FSG 300	Millet	2.31	18.5*	34.3*	59.9	48.0	3.05*	4.25*
Japanese	Millet	2.02	16.5	35.7	61.9	48.6	2.92*	4.36*
Wonderleaf	Millet	2.40	16.8	34.4*	61.4	50.1	**3.41***	**4.77***
AF 7101	Sorghum	2.54	17.1	35.3	62.4	48.9	2.78*	3.96*
AF 7201	Sorghum	2.37	17.9*	36.9	63.0	47.7	1.89	2.66
AS 6402	Sorghum x Sudangrass	2.41	17.6	34.4*	60.9	49.0	2.90*	4.12*
AS 9301	Sorghum x Sudangrass	2.40	19.5*	32.6*	58.4	51.9	2.82*	4.07*
886	Sudangrass	2.56	17.6	35.7	63.2	47.4	2.50	3.33
AS 9302	Sudangrass	2.08	**19.7***	**32.5***	60.0	51.1	2.84*	3.97*
Hayking	Sudangrass	**3.14**	18.8*	34.8*	60.9	47.5	2.38	3.31
Pro Max	Sudangrass	2.45	17.2	37.2	63.2	49.7	1.64	2.58
Moxie Teff	Teff	2.39	19.0*	35.1	61.4	46.8	1.58	2.44
LSD (p = 0.10)		NS	2.1	2.6	NS	NS	0.81	1.03
Cut Mean		2.40	18.2	34.8	61.1	49.1	2.53	3.63

Treatments with an asterisk* were statistically similar.
The treatment in **bold** was the top performer for that variable.
NS – No significant difference.

Although NDF and NDFD did not statistically differ across variety, Fria annual ryegrass had the lowest NDF of 57.7% and the highest NDFD of 52.6% compared to the average for the cut of 61.1% and 49.1% respectively. Sugars and WSC also differed significantly by variety. Sugars ranged from 1.58% to 3.41% with the highest sugar content produced from the millet variety Wonderleaf. Wonderleaf performed statistically similarly to six other varieties. Water soluble carbohydrates were also highest in Wonderleaf at 4.77%, which also was statistically similar to six other varieties.

After high rainfall and cool temperatures in June, the plots were fertilized with the product ProGro (5-3-4) at a rate of 1000 lbs ac^{-1} on 7-Jul shortly after the first harvest. About a month later on 2-Aug, the plots were again fertilized with the product ProBooster (10-0-0) at a rate of 1000 lbs ac^{-1}. The second harvest occurred on 31-Aug and is summarized below in Table 5. For the second cut, all yield and quality parameters varied statistically by variety. Teff was not harvested in this cut due to poor and patchy regrowth after the first cut and would have not been an accurate representation of this species.

Table 5. Yield and quality of 13 summer annual varieties, second cut, 2015.

Variety	DM Yield	Crude protein	ADF	NDF	NDFD	Sugars	WSC
	ton ac^{-1}	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Bruiser	0.96	**23.4***	**25.1***	**49.7***	55.5*	6.11*	7.87*
Fria	1.18	17.4	29.8	54.9	48.6	**6.71***	**8.87***
FSG 300	1.19	18.5	30.3	57.0	48.3	5.61*	7.68*
Japanese	1.35	14.5	34.4	61.7	41.9	4.79	6.91
Wonderleaf	1.12	20.9*	27.2*	54.1	52.8*	6.19*	8.13*
AF 7101	1.31	17.7	30.4	57.2	**55.6***	5.68*	7.73*
AF 7201	1.45	19.6	29.2	55.9	53.7*	5.52	7.52
AS 6402	1.08	18.4	30.2	56.8	54.2*	5.55	7.26
AS 9301	1.42	16.8	31.3	57.9	54.6*	5.59*	7.48
886	1.82*	20.7*	28.0	55.0	54.8*	5.74*	7.59*
AS 9302	1.83*	20.7*	28.8	56.4	53.0*	4.87	6.62
Hayking	2.38*	17.2	31.3	58.1	49.1	6.42*	8.58*
Pro Max	**3.37**	15.6	32.6	60.3	47.2	5.97*	8.08*
LSD (p = 0.10)	***	3.10	2.10	2.50	4.30	1.12	1.31
Cut Mean	1.58	18.6	29.9	56.5	51.5	5.75	7.72

Treatments with an asterisk* were statistically similar.
The treatments in **bold** was the top performer for that variable.
The Tukey-Kramer adjustment was used for yield and was significant at the .001 level (***).

The highest yielding variety in the second cut was ProMax with 3.37 tons of dry matter per acre. This was statistically similar to Hayking, AS 9302, and 886. These four varieties interestingly are all sudangrasses. The highest protein, as well as the lowest ADF and NDF were produced by the annual ryegrass variety Bruiser. The protein of 23.4% was similar to three other varieties statistically. The lowest protein level of 14.5% was observed in the Japanese millet treatment. Wonderleaf millet had the lowest fiber concentrations of all other annual grasses. The highest NDFD of 55.6% was observed in the sorghum variety AF 7101, however, this was statistically similar to seven other varieties. Surprisingly, AF 7101 is a non-BMR variety whereas some of the BMR varieties such as Hayking and ProMax had much lower NDFD. Sugar and WSC also varied across variety. The highest sugars and WSC were found in the annual ryegrass variety Fria at 6.71% and 8.87%.

The third harvest occurred on 2-Oct. Yield was not impacted by variety in this harvest, however, all quality parameters listed were (Table 6). The Japanese millet plots were not harvested in this cut due to patchy, variable regrowth and to avoid misrepresenting the variety.

Table 6. Yield and quality of 13 summer annual varieties, third cut, 2015.

Variety	DM Yield	Crude protein	ADF	NDF	NDFD	Sugars	WSC
	ton ac^{-1}	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Bruiser	0.75	**23.1***	**22.0***	**43.1***	**60.4***	9.16	12.6
Fria	0.91	17.8	25.0*	45.8*	58.3*	**11.2***	**15.4***
FSG 300	0.71	19.3	29.6	55.7	50.8	5.58	7.87
Wonderleaf	0.41	21.1*	25.9	50.8	52.2	7.47	10.2
AF 7101	1.22	17.6	31.0	56.4	54.7	5.42	8.07
AF 7201	0.83	20.9*	26.8	51.1	53.1	6.72	9.31
AS 6402	0.55	18.7	29.6	54.7	59.5*	5.90	7.91
AS 9301	0.80	17.7	30.4	55.5	56.9*	5.85	8.00
886	0.85	20.3	28.4	53.9	53.9	5.85	8.15
AS 9302	0.73	21.4*	29.1	51.9	56.4*	6.35	8.34
Hayking	0.82	20.4*	28.5	52.5	54.3	6.21	8.37
Pro Max	0.95	19.3	29.4	54.4	53.9	5.91	8.04
Moxie	0.67	20.7*	27.2	55.0	46.5	6.56	8.65
LSD (p = 0.10)	NS	2.8	3.1	3.1	4.4	1.17	1.44
Cut Mean	0.78	19.9	27.9	52.4	54.7	6.78	9.30

Treatments with an asterisk* were statistically similar.
The treatments in **bold** was the top performer for that variable.
NS- No significant difference.

Yields were much lower in the third cut with only one variety, AF 7101, producing over 1 ton of dry matter per acre. These yields, however, were not statistically different. The highest protein and NDFD, as well as the lowest ADF and NDF, were produced by the annual ryegrass variety Bruiser. The protein of 23.1% was similar to five other varieties. The ADF and NDF of 22.0% and 43.1% respectively were both similar to the other annual ryegrass variety Fria. Fria also had the highest sugar and WSC contents of 11.2% and 15.4% respectively. These were not similar to any other variety.

Variety Performance across Cuttings

The yields across the season indicate that species and variety selection are critical to maximize yields. From Table 8 you can see that of the annual ryegrasses, Bruiser yielded almost a ton per acre more than the variety Fria. Both of these varieties exhibited excellent forage quality. Of the three millet varieties, the Japanese millet yielded the lowest, about 1 and 0.5 tons less than FSG 300 and Wonderleaf respectively. The Wonderleaf variety not only yielded well but also stood out as having high forage quality, The sorghum and sorghum x sudangrass hybrid varieties yielded similarly to one another. Of the four sudangrass varieties, ProMax and Hayking produced about 2 tons more per acre than AS 9302 and about 1 ton more than 886.

Table 7. Heights by variety, 2015.

Variety	Species	Height (cm) 2nd cut	3rd cut
Bruiser	Annual Ryegrass	69.0	46.5
Fria	Annual Ryegrass	83.3	52.0
FSG 300	Millet	63.3	68.8
Japanese	Millet	81.3	-
Wonderleaf	Millet	70.5	67.0
AF 7101	Sorghum	63.3	59.8
AF 7201	Sorghum	69.5	64.7
AS 6402	Sorghum x Sudangrass	61.7	53.0
AS 9301	Sorghum x Sudangrass	82.8	62.8
886	Sudangrass	81.8	62.8
AS 9302	Sudangrass	75.0	58.3
Hayking	Sudangrass	**120***	**70.3**
Pro Max	Sudangrass	118*	69.8
Moxie	Teff	-	46.0
Probability level		***	NS
Cut mean		79.9	60.1

Heights were not measured for all varieties in the first cut so statistics were not performed.
The Tukey-Kramer adjustment was used and was significant at the .001 level (***)
NS-Not significant

These species and varieties also differed in height which may be a management concern for some growers depending on how the crop is intended to be utilized (Table 7). The tallest variety was Hayking sudangrass at 120 cm, which was statistically similar to ProMax at 118 cm. It is interesting to note that the sudangrasses 886 and AS 9302 were much shorter than Hayking and ProMax reaching only about 80 cm in comparison. It is also interesting that the annual ryegrass variety Fria was almost 20 cm taller than Bruiser but lower yielding. In the third cut, the tallest variety was still Hayking at 70.3 cm. The difference between the other sudangrass varieties was much smaller in the third cut as 886 and AS 9302 reached about 60 cm in comparison. The difference between the two annual ryegrass varieties was also much smaller in the third cut as Fria and Bruiser reached 52.0 and 46.5 cm respectively. These differences may be helpful if considering grazing these summer annuals as managing their heights is quite different between species and some varieties.

To have a better idea of the distribution of dry matter yield throughout the season, Figure 1 displays the yield of each variety by cut in a stacked bar graph.

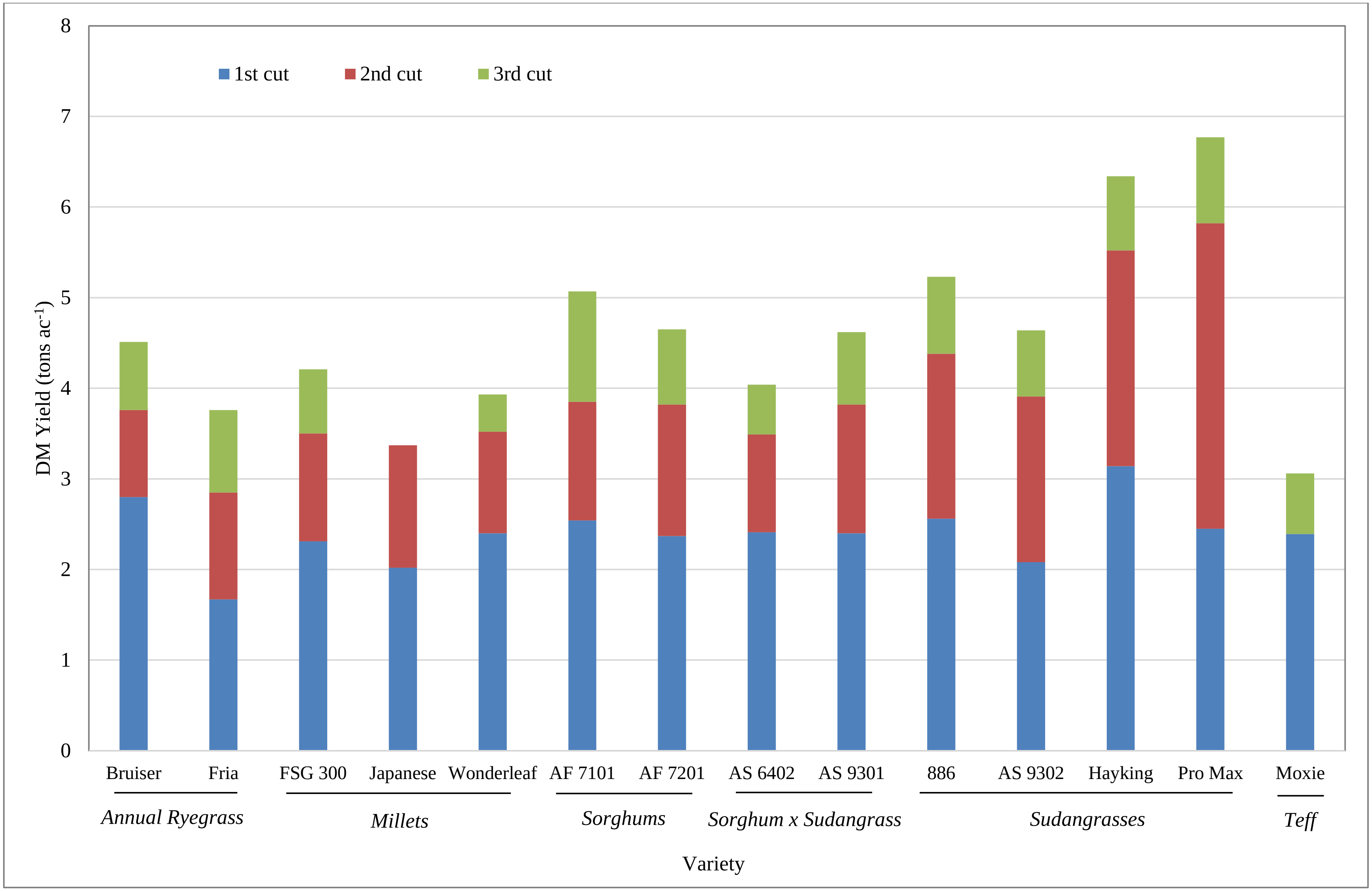

Figure 1. Yield across three cuts by variety, 2015.

From Figure 1, you can see that most varieties and species produce most of their total biomass in the first cut. The forage sorghum variety AF 7101 and the sudangrass varieties Hayking and ProMax produced more evenly distributed amounts of dry matter between the 2nd and 3rd cuts (AF 7101) and between the 1st and 2nd cuts (Hayking and ProMax). Japanese millet and Moxie teff were more adversely affected by the weather which allowed for increased weed pressure as they were not harvested at all three harvests due to an uneven distribution of weeds which would have been a misrepresentation of the varieties.

Another consideration is the price of seed. Table 8 shows the cost per acre of seeding each variety as well as (based on the cost, seeding rate, and yields observed) the cost per ton of dry matter.

Table 8. Cost of seed per acre and cost per dry matter ton by variety, 2015.

Variety	Species	DM Yield tons ac^{-1}	Cost Dollars ac^{-1}	Cost Dollars DM ton^{-1}
Bruiser	Annual Ryegrass	4.51	20.40	4.52
Fria	Annual Ryegrass	3.76	20.40	5.43
FSG 300	Millet	4.21	26.00	6.18
Japanese	Millet	3.37	15.60	4.63
Wonderleaf	Millet	3.93	30.00	7.63
AF 7101	Sorghum	5.07	132.00	26.04
AF 7201	Sorghum	4.65	127.00	27.31
AS 6402	Sorghum x Sudangrass	4.04	83.50	20.67
AS 9301	Sorghum x Sudangrass	4.62	130.00	28.14
886	Sudangrass	5.23	82.00	15.68
AS 9302	Sudangrass	4.64	104.50	22.52
Hayking	Sudangrass	6.34	94.00	14.83
Pro Max	Sudangrass	6.77	87.00	12.85
Moxie	Teff	3.06	18.96	6.20
Trial Mean		4.59	69.38	14.32

The cost of seed varies widely from 18.96 to 132.00 per acre. The most expensive are the forage sorghums and some of the sorghum x sudangrass and sudangrass varieties. However, as yields varied so widely by variety, if we compare cost per ton of dry matter, a better comparison can be made for the return on investment. The least expensive varieties were the annual ryegrasses, the teff, and the millets with the most expensive of those being under $8.00 per dry matter ton while the most expensive sorghum x sudangrass hybrid was $28.14 per dry matter ton.

DISCUSSION

Despite poor weather in the beginning of the summer that slowed growth and allowed for increased weed competition, overall the summer annual varieties trialed performed quite well and produced a large quantity of quality biomass throughout the three cuts. However, in addition to differences between these varieties there seemed to be differences between the species as well. Table 9 below illustrates the total dry matter produced per acre for each of the species, combining the three cuts and the varieties within a species. Overall, the sudangrasses produced over 5.75 tons of dry matter per acre over the three harvests while the teff only produced 3.06 tons. Annual ryegrasses and the sorghum x sudangrass hybrids produced about 4 tons per acre. Species and variety selection will be critical decision making factors to make sure the yield and quality are maximized from these annual forages.

Table 9. Yield by species, 2015.

Species	DM Yield tons ac^{-1}
Annual Ryegrass	4.14
Millet	3.84
Sorghum	4.86
Sorghum x Sudangrass	4.33
Sudangrass	5.75
Teff	3.06
Trial Mean	4.70

Table 9. Yield by variety, 2015.

Variety	DM Yield tons ac^{-1}
Bruiser	4.51
Fria	3.76
FSG 300	4.21
Japanese	3.37
Wonderleaf	3.93
AF 7101	5.07
AF 7201	4.65
AS 6402	4.04
AS 9301	4.62
886	5.23
AS 9302	4.64
Hayking	6.34
Pro Max	6.77
Moxie	3.06
Trial Mean	4.70

There is a benefit of utilizing summer annual species to extend grazing periods and increase the production of quality forage throughout the entire season. It is important to consider all of the variables that can influence both yield and quality and how different species and varieties within those species may respond to these variables. Annual ryegrass appeared to produce a relatively large quantity of very high quality forage for a very low cost. The height of the plant would have made it more conducive to grazing operations. Sudangrasses can produce a significant amount of biomass of decent quality but cost significantly more and may be less utilized by grazing animals.

It is important to be aware of the risk of nitrate accumulation and the presence of prussic acid when growing summer annuals. Nitrates are considered relatively safe for feed up to 5000 ppm, however there is a risk of excessive nitrate accumulation under excessive fertility and immediately after a drought stressed crop receives rainfall. Additionally, sorghums and sudangrasses may contain prussic acid which is toxic when present. To avoid prussic acid poisoning:

- Graze sorghum or crosses when they are at least 18 inches tall.
- Do not graze plants during and shortly after drought periods when growth is severely reduced.
- Do not graze wilted plants or plants with young tillers.
- Do not graze after a non-killing frost; regrowth can be toxic.
- Do not graze after a killing frost until plant material is dry (the toxin usually dissipates within 48 hours).
- Do not graze at night when frost is likely. High levels of toxins are produced within hours after frost occurs.
- Delay feeding silage six to eight weeks following ensiling.

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