NORTHWEST CROPS & SOILS PROGRAM

2018 Summer Annual Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2018 SUMMER ANNUAL VARIETY TRIAL

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Warm season grasses, such as Sudangrass, and millet can provide quality forage in the hot summer months, when the cool season grasses enter dormancy and decline in productivity. The addition of summer annuals into a rotation can provide a harvest of high-quality forage for stored feed or grazing during this critical time. 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 8-Jun 2018. Plots were managed with practices similar to those used by producers in the surrounding area (Table 1). The previous crop was winter rye. The field was disked and spike tooth harrowed prior to planting. Fifteen varieties of summer annual species were compared (Table 2). 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 and 20 lbs ac^{-1} for millets.

Table 1. General plot management, 2018.

Trial Information	Borderview Research Farm-Alburgh, VT
Soil Type	Benson rocky silt loam
Previous crop	Winter rye
Planting date	8-Jun
First harvest date	16-Jul
Second harvest date	16-Aug
Third harvest date	5-Oct
Seeding rates: Millet	20 lbs ac^{-1}
Sorghum, Sudangrass, and hybrids	50 lbs ac^{-1}
Tillage methods	Mold board plow, disk, and spike tooth harrow

Plots were harvested with a Carter flail forage harvester on 16-Jul, 16-Aug, and 5-Oct in an area of 3’ x 20’. Forage harvested from each area was collected and weighed. An approximate 1 lb subsample from each plot was collected and dried at each harvest to determine dry matter and calculate dry matter yields. The samples were then ground and analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and 48-hour NDF digestibility (NDFD) at the University of Vermont Cereal Testing Lab (Burlington, VT) with a FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer.

Table 2. Summer annual varieties, characteristics, and seed source, 2018.

Variety	Species	Characteristics	Company
FSG 315	Pearl Millet	BMR, Dwarf	Alta Seeds
Prime 180	Pearl Millet	BMR, Dwarf	King's Agriseed
Prime 360	Pearl Millet	BMR, Dwarf	King's Agriseed
Tifleaf 3	Pearl Millet	Dwarf	Alta Seeds
Wonderleaf	Pearl Millet		Alta Seeds
AS 6401	Sorghum x Sudangrass		Seedway, LLC
Green Grazer V	Sorghum x Sudangrass		Alta Seeds
400x38	Sorghum x Sudangrass		Richardson Seeds
Sugar Pro	Sorghum x Sudangrass	BMR	Seedway, LLC
AS 9301	Sudangrass	BMR	Alta Seeds
AS 9302	Sudangrass	BMR, Dwarf	Alta Seeds
Hayking	Sudangrass	BMR	King's Agriseed
Piper	Sudangrass		Seedway, LLC
ProMax	Sudangrass	BMR	Seedway, LLC
SSG 886	Sudangrass	BMR	Seedway, LLC

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. The portion of the NDF that is digestible within 48 hours is represented by NDFD48. The acid detergent fraction (ADF) is composed of highly indigestible fiber and therefore, is negatively correlated with digestibility. 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 ($p< 0.10$).

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

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 this example, 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.

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 September there was an accumulation of 2298 Growing Degree Days (GDDs) in Alburgh, which is 285 GDDs more than the 30-year average. Rainfall was below average for all months except for June which was approximately normal. Multiple extended periods without rainfall were experienced, the longest of which was more than two weeks. Temperatures, conversely, were above average for Jul-Sep but below average for June. Hot and dry conditions provided ideal growing conditions throughout the year resulting in a third harvest being possible in early October.

Table 3. Seasonal weather data collected in Alburgh, VT, 2018.

Alburgh, VT	June	July	August	September
Average temperature (°F)	64.4	74.1	72.8	63.4
Departure from normal	-1.38	3.51	3.96	2.76
Precipitation (inches)	3.74	2.43	2.96	3.48
Departure from normal	0.05	-1.72	-0.95	-0.16
Growing Degree Days (base 50°F)	447	728	696	427
Departure from normal	-27	88	115	109

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.

Species Performance Across Cuttings

These grass species are particularly good at withstanding drought conditions and thrive under hot temperatures. Total yields were approximately 4 tons ac^{-1} (Figure 1). Pearl millet produced slightly lower yields than the sorghum x Sudangrass or Sudangrass. However, quality, in terms of protein and NDF digestibility, was about 2% higher in the pearl millet.

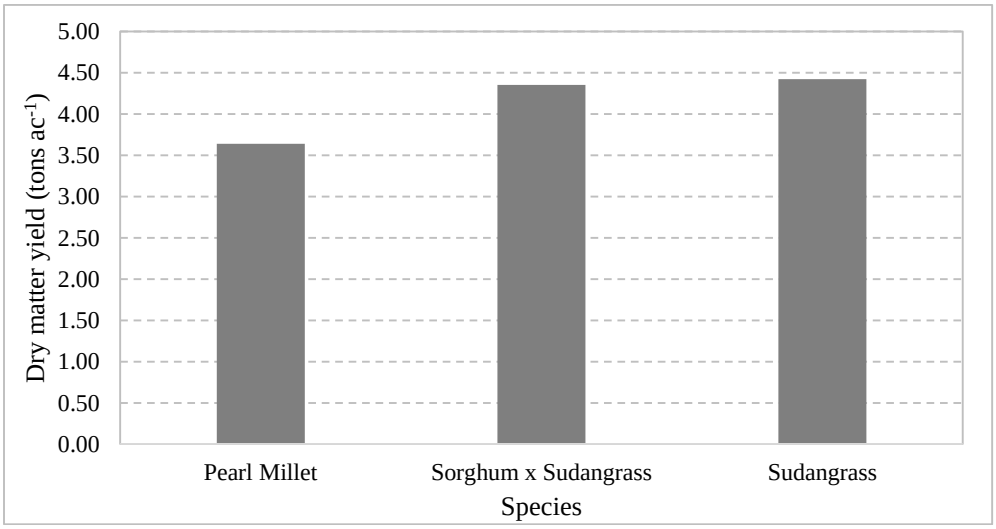

Figure 1. Summer annual total yield across cuttings by species, 2018.

Variety Performance by Cutting

Varieties differed significantly in quality at the first harvest but not in yield (Table 4). Yields averaged 1.67 tons ac^{-1} with the highest yielder, Piper sudangrass, producing 2.09 tons ac^{-1}. This was statistically similar to all other varieties. Crude protein ranged from 18.5 to 24.4%. The variety with the highest protein content was Prime 180 pearl millet, but this was statistically similar to six other varieties. The ADF and NDF concentrations averaged 28.3 and 52.8% respectively. The variety with the lowest ADF and NDF concentrations of 26.2 and 49.2% respectively, were produced by variety FSG 315 pearl millet. These were statistically similar to six and seven other varieties for ADF and NDF, respectively. The lowest lignin content of 2.92% was observed in the variety ProMax sudangrass, which was statistically similar to five other varieties. Finally, varieties also differed significantly in terms of NDF digestibility which ranged from 62.4 to 78.3%. The variety with the highest NDF digestibility was Prime 180 pearl millet, which was statistically similar to seven other varieties. Interestingly, not all the varieties with statistically higher digestibility were BMR varieties. Three varieties, Wonderleaf pearl millet, as well as AS 6401 and 400x38 sorghum x sudangrass, had high digestibility but are not BMR varieties. Similarly, four varieties that are BMR varieties, including Sugar Pro sorghum x sudangrass, as well as AS 9301, Hayking, and ProMax sudangrass, had significantly lower digestibility than the top performers despite their having the BMR trait. The lowest digestibility of 62.4% was produced by Piper sudangrass. This variety has been primarily used for cover cropping and not for animal feed.

Table 4. Yield and quality of 15 summer annual varieties, 1st cut, 2018.

Variety	Species	Dry matter (DM)	DM yield	Crude protein	ADF	NDF	Lignin	NDFD48
		%	tons ac^{-1}	----------% of DM----------				% of NDF
FSG 315	Pearl Millet	16.2	1.26	24.1*	**26.2**	**49.2**	3.50*	77.7*
Prime 180	Pearl Millet	**16.0**	1.73	**24.4**	26.8*	50.2*	3.88	**78.3**
Prime 360	Pearl Millet	16.8	1.44	23.8*	26.5*	50.2*	3.77	76.9*
Tifleaf 3	Pearl Millet	16.6	1.59	23.1*	27.0*	50.1*	3.81	71.4
Wonderleaf	Pearl Millet	16.4	1.77	23.0*	28.2*	51.4*	4.23	75.6*
AS 6401	Sorghum x Sudangrass	16.4	1.70	20.1	29.1	55.0	3.01*	74.8*
Green Grazer V	Sorghum x Sudangrass	17.7	1.80	20.7	29.0	54.1	3.78	71.9
400x38	Sorghum x Sudangrass	16.5	1.40	28.0*	28.7	53.2	3.53	75.0*
Sugar Pro	Sorghum x Sudangrass	15.9	1.92	20.4	31.0	55.9	4.08	67.1
AS 9301	Sudangrass	15.9	1.94	19.9	30.1	56.0	3.35*	72.6
AS 9302	Sudangrass	17.0	1.56	22.0*	27.3*	53.4	2.96*	76.9*
Hayking	Sudangrass	17.5	1.74	21.4	27.3*	51.5*	3.58	71.2
Piper	Sudangrass	18.9	**2.09**	18.5	31.2	56.5	3.78	62.4
ProMax	Sudangrass	19.4	1.49	20.4	26.9*	51.2*	**2.92**	71.4
SSG 886	Sudangrass	18.7	1.70	20.8	28.7	54.4	3.17*	73.0*
LSD (p = 0.10)		NS	NS	2.41	2.10	2.26	0.595	5.60
First Cut Mean		17.0	1.67	21.7	28.3	52.8	3.56	73.1

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

The second harvest was made 31 days after the 1st harvest. Varieties differed in yield and quality at the second harvest (Table 5). Yields ranged from 1.04 to 2.11 tons ac^{-1}. The highest yielding variety was AS 9301 sudangrass which performed similarly to only three other varieties: AS 6401, Green Grazer V and Sugar Pro sorghum x sudangrass. In terms of quality, none of the top yielding varieties were top performers in terms of protein or ADF concentration. Protein levels ranged from 18.6 to 24.5%. The variety with the highest protein was, as in the 1st harvest, Prime 180 pearl millet. This was similar to all other pearl millet varieties except for Prime 360. The ADF content ranged from 27.5 to 33.7% with the lowest being produced, similarly to the 1st harvest, by FSG 315 pearl millet. This was similar to five other varieties. The NDF content showed a similar trend with the lowest content of 53.8% being from FSG 315 pearl millet which was statistically similar to four other varieties. The NDF digestibility varied significantly from 65.3 to 76.1%. The highest digestibility was again produced by Prime 180 pearl millet, but was similar to seven other varieties. As with the 1st cutting, there were three BMR varieties, Prime 360 pearl millet, ProMax and SSG 886 sudangrass, that actually had significantly lower NDF digestibility than the remaining BMR varieties and two non-BMR varieties. Again the sudangrass variety Piper had the lowest NDF digestibility of 65.3%; all other varieties had NDF digestibility greater than 70.0%.

Table 5. Yield and quality of 15 summer annual varieties, 2nd cut, 2018.

Variety	Species	Dry matter (DM)	DM yield	Crude protein	ADF	NDF	Lignin	NDFD48
		%	tons ac^{-1}	----------% of DM----------				% of NDF
FSG 315	Pearl Millet	18.2	1.04	23.3*	**27.5**	**53.8**	3.76	75.3*
Prime 180	Pearl Millet	17.3	1.41	**24.5**	28.5*	55.6*	3.53	**76.1**
Prime 360	Pearl Millet	17.8	1.09	20.9	29.3*	56.6	3.94	73.2
Tifleaf 3	Pearl Millet	16.4	1.37	23.8*	29.0*	55.4*	4.07	74.7*
Wonderleaf	Pearl Millet	16.3	1.62	22.9*	29.2	55.7*	4.07	72.4
AS 6401	Sorghum x Sudangrass	**13.4**	1.92*	19.6	33.5	59.9	3.43	72.3
Green Grazer V	Sorghum x Sudangrass	15.9	1.88*	19.9	30.1	55.4*	3.62	72.5*
400x38	Sorghum x Sudangrass	15.6	1.71	21.9	30.4	57.4	3.92	72.4
Sugar Pro	Sorghum x Sudangrass	14.9*	1.75*	20.3	32.5	60.1	3.39	73.0*
AS 9301	Sudangrass	15.5	**2.11**	19.9	31.2	58.6	3.57	74.4*
AS 9302	Sudangrass	16.5	1.52	22.3	28.4*	56.6	3.36	74.9*
Hayking	Sudangrass	17.7	1.61	20.7	28.3*	55.7	2.86	75.5*
Piper	Sudangrass	17.3	1.68	18.6	33.7	60.3	4.32	65.3
ProMax	Sudangrass	17.2	1.72	19.6	30.2	57.5	**3.33**	70.7
SSG 886	Sudangrass	16.4	1.61	20.1	31.0	58.1	3.39	72.1
LSD (p = 0.10)		1.49	0.368	2.06	2.37	2.67	NS	3.62
First Cut Mean		16.4	1.60	21.2	30.2	57.1	3.64	73.0

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

Due to warm weather persisting into the fall, a third harvest was made. However, due to very dry conditions during this period, this harvest was not made until early October, 50 days after the 2nd harvest. Yield and quality differed significantly at this harvest as well (Table 6). Yields ranged from 0.521 to 1.11 tons ac^{-1}.

The highest yielding variety was Piper sudangrass which performed similarly to five other varieties. Protein also varied widely from 14.9 to 20.0%. The variety with the highest protein once again was Prime 180 pearl millet which was similar to four other varieties. Interestingly, three of the pearl millet varieties, Prime 360, Tifleaf 3, and Wonderleaf, dropped to below 18.0% protein while the other two varieties remained close to 19.0 and 20.0%. The ADF and NDF contents also differed significantly. The ADF ranged from 28.0 to 33.3% while NDF ranged from 55.2 to 61.0%. The variety with the lowest ADF was AS 9302 sudangrass which performed similarly to three other varieties. The variety with the lowest NDF was Prime 180 pearl millet which was similar to nine other varieties. The NDF digestibility ranged from 59.8 to 71.3%. Sugar Pro sorghum x sudangrass had the highest NDF digestibility which was similar to only three other varieties. Interestingly, at this harvest the varieties with the highest NDF digestibility were all sudangrasses or sorghum x sudangrasses, whereas in the previous cuttings the millet varieties were top performers. All of these varieties contain the BMR trait. Again, the lowest digestibility was observed in the variety Piper sudangrass with less than 60% digestibility. Overall, yield and quality of this third harvest was significantly reduced from the previous two. In most years, a third harvest is not obtained in this region.

Table 6. Yield and quality of 15 summer annual varieties, 3rd cut, 2018.

Variety	Species	Dry matter (DM)	DM yield	Crude protein	ADF	NDF	Lignin	NDFD48
		%	tons ac^{-1}	----------% of DM----------				% of NDF
FSG 315	Pearl Millet	20.0	0.676	18.7*	29.7*	56.2*	4.48	66.1
Prime 180	Pearl Millet	19.5	0.741	**20.0**	28.4*	**55.2**	4.68	66.0
Prime 360	Pearl Millet	22.1	0.655	15.5	30.8	58.3	4.37	64.8
Tifleaf 3	Pearl Millet	20.9	0.732	17.4	30.0	57.0*	4.77	63.0
Wonderleaf	Pearl Millet	19.7	0.595	17.8	29.9	55.6*	5.06	63.8
AS 6401	Sorghum x Sudangrass	**18.6**	0.792	16.4	31.9	57.2*	3.80*	68.2
Green Grazer V	Sorghum x Sudangrass	19.5	0.963*	17.1	31.8	58.0	4.24	64.0
400x38	Sorghum x Sudangrass	20.0	0.521	19.4*	30.0	56.0*	4.18	66.1
Sugar Pro	Sorghum x Sudangrass	19.9	1.04*	17.0	29.6*	55.7*	3.63*	**71.3**
AS 9301	Sudangrass	19.3	1.06*	17.7	30.1	56.8*	3.63*	70.1*
AS 9302	Sudangrass	19.7	1.04*	19.8*	**28.0**	55.9*	3.94	69.3*
Hayking	Sudangrass	20.4	0.984*	18.8*	30.6	57.7	4.31	63.4
Piper	Sudangrass	21.7	**1.11**	14.9	33.3	61.0	4.77	59.8
ProMax	Sudangrass	21.8	0.798	17.2	31.3	58.4	4.09	64.0
SSG 886	Sudangrass	20.0	0.771	17.0	29.5	56.5*	**3.46**	70.5*
LSD (p = 0.10)		NS	0.244	2.10	1.72	1.95	0.410	2.23
First Cut Mean		20.2	0.830	17.7	30.3	57.0	4.23	66.0

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

Variety Performance Across Cuttings

Variety performance in terms of yield and quality across all cuttings is summarized in Figure 2. Overall, yields ranged from 2.97 to 5.10 tons ac^{-1}. The variety that produced the highest total yield was AS 9301

sudangrass. Three other varieties produced yields over 4.5 tons ac^{-1} including Piper sudangrass, and Sugar Pro and Green Grazer V sorghum x sudangrass. The lowest yielding varieties were FSG 315 and Prime 360 pearl millet which produced less than 3.5 tons ac^{-1}. In terms of quality, Prime 180 pearl millet consistently had very high protein and low ADF and NDF contents, even into the late harvest. It remained high in quality at this late harvest better than the other millet varieties except for FSG 315. Figure 2 is divided into four quadrants by dotted lines signifying the average total yield and relative forage value (RFV) for the trial across the three cuttings. Varieties that land in the top left quadrant are those that produced above average yields but below average quality. Varieties in the bottom right quadrant produced above average quality but below average yields. Varieties in the top right quadrant produced above average yield and quality. The varieties that produced both high yield and quality over all three cuttings were Hayking and AS 9302 sudangrass. Wonderleaf and Prime 180 millet were close but yielded slightly less overall. However, RFV is a calculation based on ADF and NDF content and does not take other aspects of quality into consideration. Of particular importance is the portion of NDF that is digestible. Figure 3 shows yield and NDF digestibility of the treatments. When we compare Figure 2 and 3, you can see that some treatments, AS 9301, and AS 6401, appeared lower in quality in terms of RFV but had above average NDF digestibility.

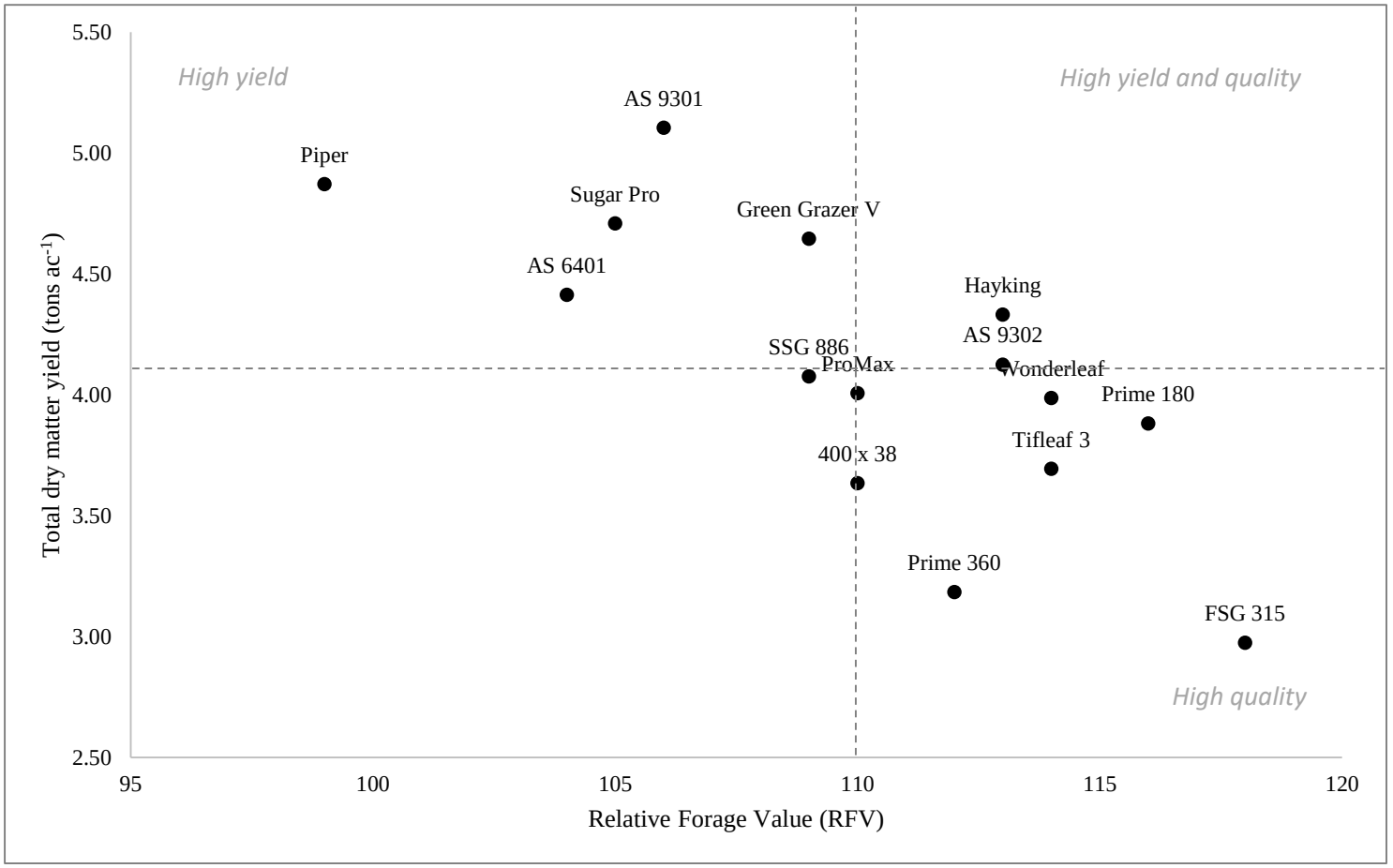

Figure 2. Total yield and average relative forage value (RFV) of 15 summer annual varieties across three harvests, 2018.

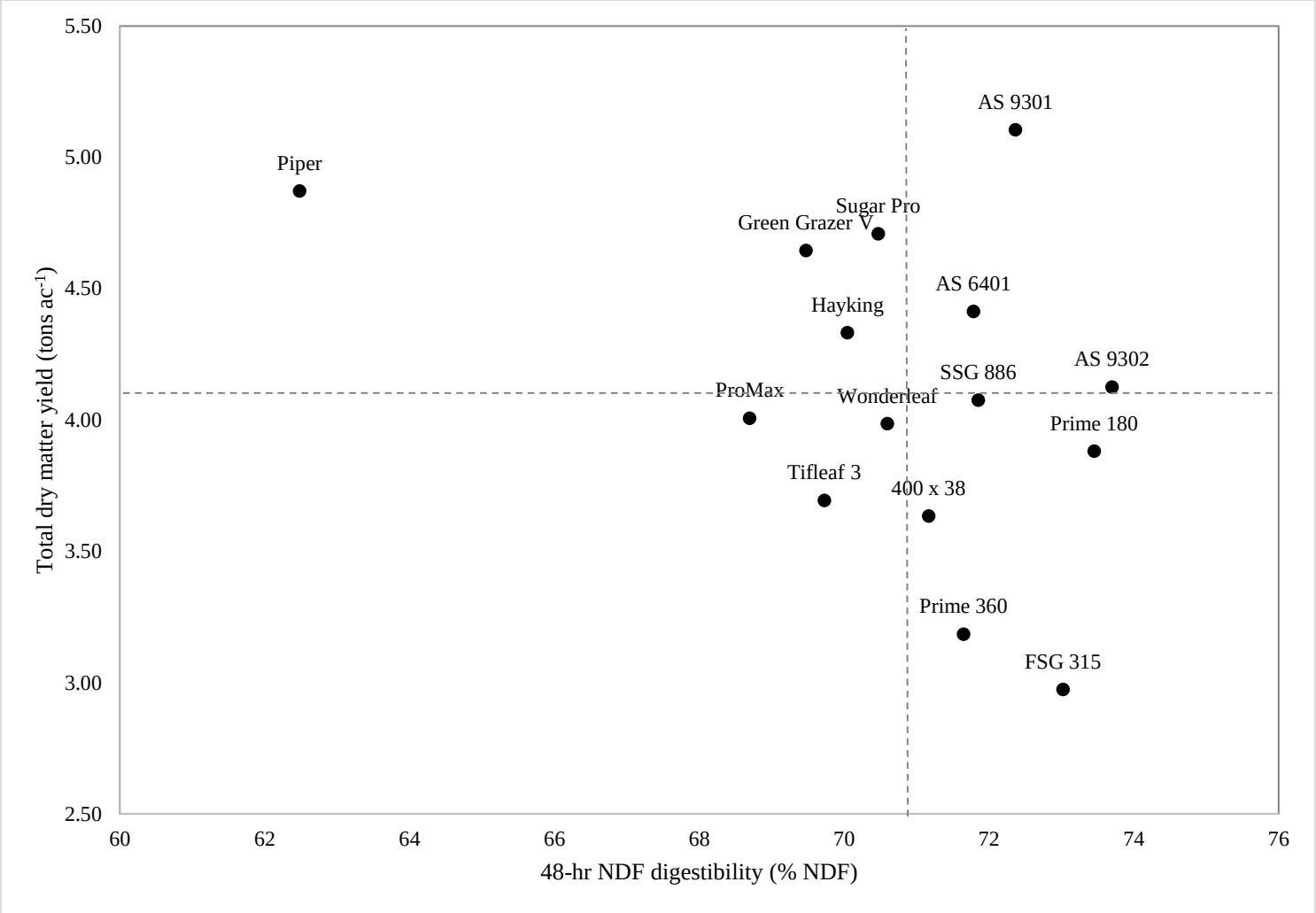

Figure 3. Total yield and average 48-hr NDF digestibility of 15 summer annual varieties across three harvests, 2018.

DISCUSSION

These data demonstrate the value of integrating summer annual forages into forage production systems in the Northeast. In a year where drought conditions diminished the yield and quality of perennial pastures and hay fields, summer annuals produced on average 4.10 tons ac^{-1} of high quality forage. Varietal selection is important as varieties differ in performance in terms of yield and quality. Piper sudangrass, for example, was one of the highest yielding varieties in the trial. However, its quality was substantially lower than all the other varieties. Piper is sold primarily as a summer cover crop. Purchasing improved forage varieties, despite potentially higher costs or lower yields, is important if your goal is to produce high quality forage.

With growing summer annuals, it is important to also be aware of the risk of nitrate accumulation and the presence of prussic acid. 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, sudangrasses, and hybrids may contain prussic acid, which can be toxic. To avoid prussic acid poisoning from summer annuals:

Graze when the grasses 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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