NORTHWEST CROPS & SOILS PROGRAM

2019 Summer Annual Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2019 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 12-Jun 2019. Plots were managed with practices similar to those used by producers in the surrounding area (Table 1). The previous crops were soybeans and hemp. 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, at 20 lbs ac^{-1} for millet, and at 30 lbs ac^{-1} for ryegrass. Plots were 5' x 20'. 50 lbs N ac^{-1} was applied via ProBooster (10-0-0, North Country Organics) following each cutting.

Table 1. General plot management, 2019.

Trial Information	Borderview Research Farm-Alburgh, VT
Soil Type	Benson rocky silt loam, 3-8% slopes
Previous crop	Soybeans, hemp
Planting date	12-Jun
First harvest date	26-Jul
Second harvest date	23-Aug
Seeding rates: Millet	20 lbs ac^{-1}
Sorghum, Sudangrass, and hybrids	50 lbs ac^{-1}
Ryegrass	30 lbs ac^{-1}
Tillage methods	Mold board plow, disk, and spike tooth harrow

Plots were harvested with a Carter flail forage harvester on 26-Jul and 23-Aug 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 30-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. 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.

Table 2. Summer annual varieties, characteristics, and seed sources, 2019.

Variety	Species	Characteristics	Company
KF Prime 180	Pearl Millet	BMR, Dwarf	King Fisher
KF Prime 360	Pearl Millet	BMR, Dwarf	King Fisher
Exceed	Pearl Millet	BMR	Exceed
Wonderleaf	Pearl Millet		Alta Seeds
FSG 114	Forage Sorghum	BMR6	Seedway, LLC
FSG 255C	Grain Sorghum	BMR	Seedway, LLC
KF Sugar Pro 55 SS	Sorghum x Sudangrass	BMR	King Fisher
Green Grazer V	Sorghum x Sudangrass	Green Top	Seedway, LLC
AS 9302	Sorghum x Sudangrass	BMR6, Dwarf	Alta Seeds
FSG 214	Sorghum x Sudangrass	BMR	Seedway, LLC
FSG 215	Sorghum x Sudangrass	BMR	Seedway, LLC
AS 9301	Sudangrass	BMR6	Alta Seeds
Piper	Sudangrass		Seedway, LLC
SSG 886	Sudangrass	BMR	Seedway, LLC
Green Spirit	Italian Ryegrass		King's Agriseeds

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 30 hours is represented by NDFD30. The acid detergent fraction (ADF) is composed of highly indigestible fiber and therefore, is negatively correlated with digestibility. Results were analyzed using a general linear model procedure of SAS (SAS Institute, 2008). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$.

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 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.

Variety	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 a WeatherLink data logger in Alburgh, VT are shown in Table 3. From June through August there was an accumulation of 1730 Growing Degree Days (GDDs) in Alburgh, which is 34 GDDs more than the 30-year average. A cold, wet spring led to fewer GDDs and cooler temperatures in June, which was followed by above average temperatures in July, which had 79 more GDDs than normal. Precipitation was below average June through August, 2.85 inches below the 30-year normal.

Table 3. Seasonal weather data collected in Alburgh, VT, 2019.

Alburgh, VT	June	July	August
Average temperature (°F)	64.3	73.5	68.3
Departure from normal	-1.46	2.87	-0.51
Precipitation (inches)	3.06	2.34	3.50
Departure from normal	-0.63	-1.81	-0.41
Growing Degree Days (base 50°F)	446	716	568
Departure from normal	-29	76	-13

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 3 tons ac^{-1} (Figure 1). Italian ryegrass and pearl millet produced lower yields than the sudangrass and the sorghum x sudangrass. Despite producing the lowest species yield, in terms of quality, Italian ryegrass was the top performer in crude protein and NDF concentration in both harvests. Pearl millet also performed well in terms of quality.

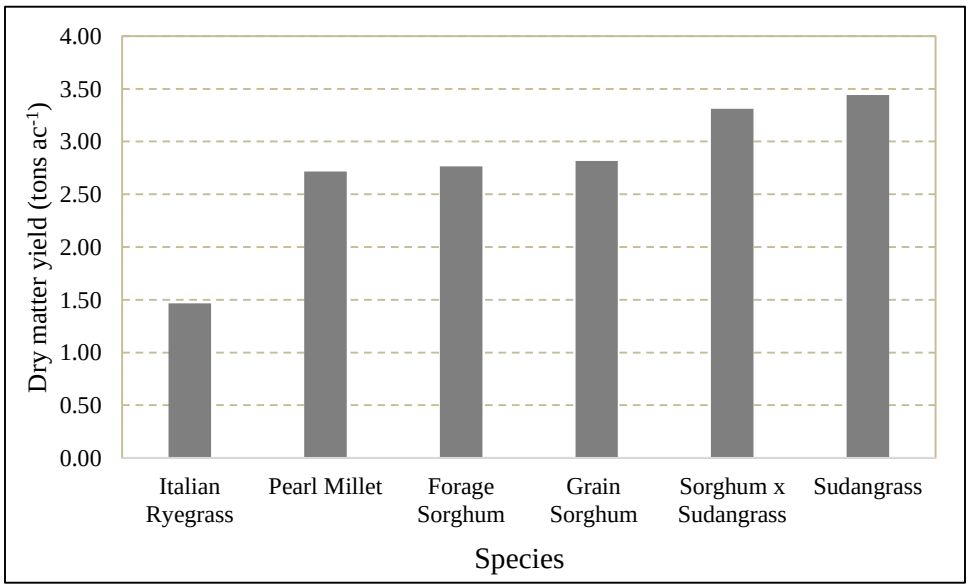

Figure 1. Summer annual total yield across cuttings by species, 2019.

Variety Performance by Cutting

Varieties differed significantly in quality and yield at the first harvest (Table 4). Yields averaged 1.39 tons ac^{-1} with the top performer, Piper sudangrass, producing 1.96 tons ac^{-1}. This was statistically similar to six other varieties: the sorghum x sudangrass varieties FSG 214, KF Sugar Pro 55 SS, FSG 215, and Green Grazer V, and the sudangrass varieties AS 9301 and SSG 886. While Piper sudangrass was the top yielding variety, the variety was not a top performer in forage quality, nor was it statistically similar to the top performers in quality. Crude protein ranged from 14.2% to 23.9%. The variety with the highest protein content was Green Spirit Italian ryegrass, which was statistically similar to KF Prime 360 pearl millet. The ADF and NDF concentrations averaged 31.7% and 56.3% respectively. The variety that produced the lowest ADF concentration, 27.9%, was KF Prime 180 pearl millet, which was statistically similar to five other varieties. Green Spirit Italian ryegrass produced the lowest NDF concentration, 42.4%, and was statistically different from all other varieties. The lowest lignin content of 3.77% was observed in the AS 9301 sudangrass, which was statistically similar to ten other varieties. NDF digestibility ranged from 69.6% to 82.9%. The KF Prime 360 pearl millet produced the highest NDF digestibility, and was statistically similar to KF Prime 180 pearl millet, and Exceed pearl millet. Besides all being pearl millets, these top three performers were all BMR varieties. The lowest digestibility was produced by the grain sorghum variety FSG 255C.

Table 4. Yield and quality of 15 summer annual varieties, 1st cut, 2019.

Variety	Species	Dry matter (DM)	DM yield	Crude protein	ADF	NDF	Lignin	NDFD30
		%	tons ac^{-1}	----------% of DM----------				% of NDF
KF Prime 180	Pearl Millet	23.4	0.52	17.9	**27.9**	56.0	3.85*	80.8*
KF Prime 360	Pearl Millet	25.1	0.72	22.3*	29.0*	52.9	6.94	**82.9**
Exceed	Pearl Millet	25.6	1.02	19.9	28.0*	53.8	7.39	79.4*
Wonderleaf	Pearl Millet	24.2	1.23	18.7	30.7*	57.4	4.38*	75.5
FSG 114	Forage Sorghum	23.2	1.33	15.6	33.7	58.6	5.22*	74.4
FSG 255C	Grain Sorghum	25.6	1.47	15.9	33.4	60.8	4.31*	69.6
KF Sugar Pro 55 SS	Sorghum x Sudangrass	23.6	1.85*	16.0	31.9	59.7	4.33*	73.4
Green Grazer V	Sorghum x Sudangrass	23.0	1.76*	15.6	34.1	57.0	5.28*	70.7
AS 9302	Sorghum x Sudangrass	22.4	1.44	17.7	33.1	60.1	4.26*	75.5
FSG 214	Sorghum x Sudangrass	23.5	1.88*	14.2	33.7	57.8	5.97*	73.1
FSG 215	Sorghum x Sudangrass	21.2	1.82*	16.3	34.2	59.1	4.07*	76.6
AS 9301	Sudangrass	22.9	1.62*	15.4	33.2	58.6	**3.77**	76.4
Piper	Sudangrass	24.7	**1.96**	18.5	33.0	54.4	6.36	72.0
SSG 886	Sudangrass	20.5	1.89*	15.5	31.1*	56.0	4.59*	73.9
Green Spirit	Italian Ryegrass	**27.8**	0.34	**23.9**	28.0*	**42.4**	8.59	76.6
LSD (p = 0.10)		NS	0.43	3.62	3.24	4.30	2.28	3.91
1st Cut Mean		23.8	1.39	17.6	31.7	56.3	5.29	75.4

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

The second harvest was made 28 days after the first harvest. Varieties differed in yield and quality at the second harvest (Table 5), with the exception of ADF and lignin concentrations. Yields ranged from 1.13 to 2.35 tons ac^{-1}. The highest yielding variety was Wonderleaf pearl millet which was statistically similar to Piper sudangrass. These two top yielding varieties were not top performers in quality. Crude protein ranged from 17.8% to 26.8%. Green Spirit Italian ryegrass had the highest crude protein, as it did in the first harvest, and was not statistically similar to any other varieties in the second harvest. The top performer in ADF and lignin concentrations was KF Prime 180 pearl millet, although there were no significant differences between varieties. Similar to the first harvest, the lowest NDF content was 47.6% produced by Green Spirit Italian ryegrass, and it was significantly lower than all other varieties. The NDF digestibility varied from 68.3% to 79.2%. The highest digestibility was produced by Exceed pearl millet, which was statistically similar to KF Prime 180 and KF Prime 360 pearl millets as in the first harvest, but this time it was also similar to AS 9301 sudangrass and Green Spirit Italian ryegrass. With the exception of Green Spirit Italian ryegrass, these varieties were BMR varieties. Again, the grain sorghum variety FSG 255C had the lowest NDF digestibility of 68.3%. The FSG 255C grain sorghum, Green Grazer V sorghum x sudangrass, and Piper sudangrass were the only varieties with NDF digestibility less than 70%.

Table 5. Yield and quality of 15 summer annual varieties, 2nd cut, 2019.

Variety	Species	Dry matter (DM)	DM yield	Crude protein	ADF	NDF	Lignin	NDFD30
		%	tons ac^{-1}	----------% of DM----------				% of NDF
KF Prime 180	Pearl Millet	18.3	1.58	20.4	**31.2**	59.7	**4.30**	79.0*
KF Prime 360	Pearl Millet	16.7	1.73	21.2	34.2	59.6	5.02	76.3*
Exceed	Pearl Millet	18.0	1.71	20.9	32.3	60.5	4.97	**79.2**
Wonderleaf	Pearl Millet	16.7	**2.35**	19.4	34.8	60.8	5.08	72.7
FSG 114	Forage Sorghum	16.0	1.43	17.8	33.7	61.3	4.43	73.4
FSG 255C	Grain Sorghum	18.8	1.35	19.8	33.6	62.8	4.95	68.3
KF Sugar Pro 55 SS	Sorghum x Sudangrass	15.7	1.86	19.9	34.3	59.4	5.37	72.7
Green Grazer V	Sorghum x Sudangrass	15.7	1.50	18.7	34.9	61.6	5.71	68.6
AS 9302	Sorghum x Sudangrass	16.9	1.46	19.5	33.0	61.8	5.03	75.5
FSG 214	Sorghum x Sudangrass	15.8	1.52	19.6	36.3	61.9	4.93	73.2
FSG 215	Sorghum x Sudangrass	15.1	1.47	20.2	33.8	58.5	6.00	74.8
AS 9301	Sudangrass	14.9	1.40	22.0	35.7	60.6	6.47	77.9*
Piper	Sudangrass	16.1	2.01*	20.8	36.1	61.2	5.81	69.1
SSG 886	Sudangrass	16.7	1.44	18.7	34.1	58.0	5.36	73.5
Green Spirit	Italian Ryegrass	15.6	1.13	**26.8**	32.0	**47.6**	6.74	78.7*
LSD (p = 0.10)		NS	0.42	3.37	NS	2.10	NS	2.95
2nd Cut Mean		16.5	1.60	20.4	34.0	59.7	5.34	74.2

*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 Figures 2 and 3. Overall, yields ranged from 1.46 to 3.97 tons ac^{-1}. Piper sudangrass produced the highest total yield. This was followed by KF Sugar Pro 55 SS sorghum x sudangrass, Wonderleaf pearl millet, FSG 214 sorghum x sudangrass, SSG 886 sudangrass, FSG 215 sorghum x sudangrass, and Greengrazer V sorghum x sudangrass, which all produced yields above 3.25 tons ac^{-1}. Only Piper sudangrass, KF Sugar Pro 55 SS sorghum x sudangrass, and Wonderleaf pearl millet yielded more than 3.5 tons ac^{-1}. The lowest yielding variety was Green Spirit Italian ryegrass which only produced 1.46 tons ac^{-1}. While it yielded the least, Green Spirit Italian ryegrass had above average quality in terms of crude protein and NDF in both harvests, and average RFV and 30-hr NDF digestibility. In addition, unlike the other warm season grasses, the Italian ryegrass continued to grow well into the fall. It could have been harvested a 3rd time and potentially even a 4th time depending on the fall weather. Although Piper sudangrass was the top performer in yield, it performed below average in terms of quality. This is not entirely surprising as this variety is primarily used for cover cropping. Figure 3 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 only variety to have both high yield and quality was SSG 886 sudangrass. However, RFV is a calculation based on ADF and NDF content and does not take other aspects of quality into consideration.

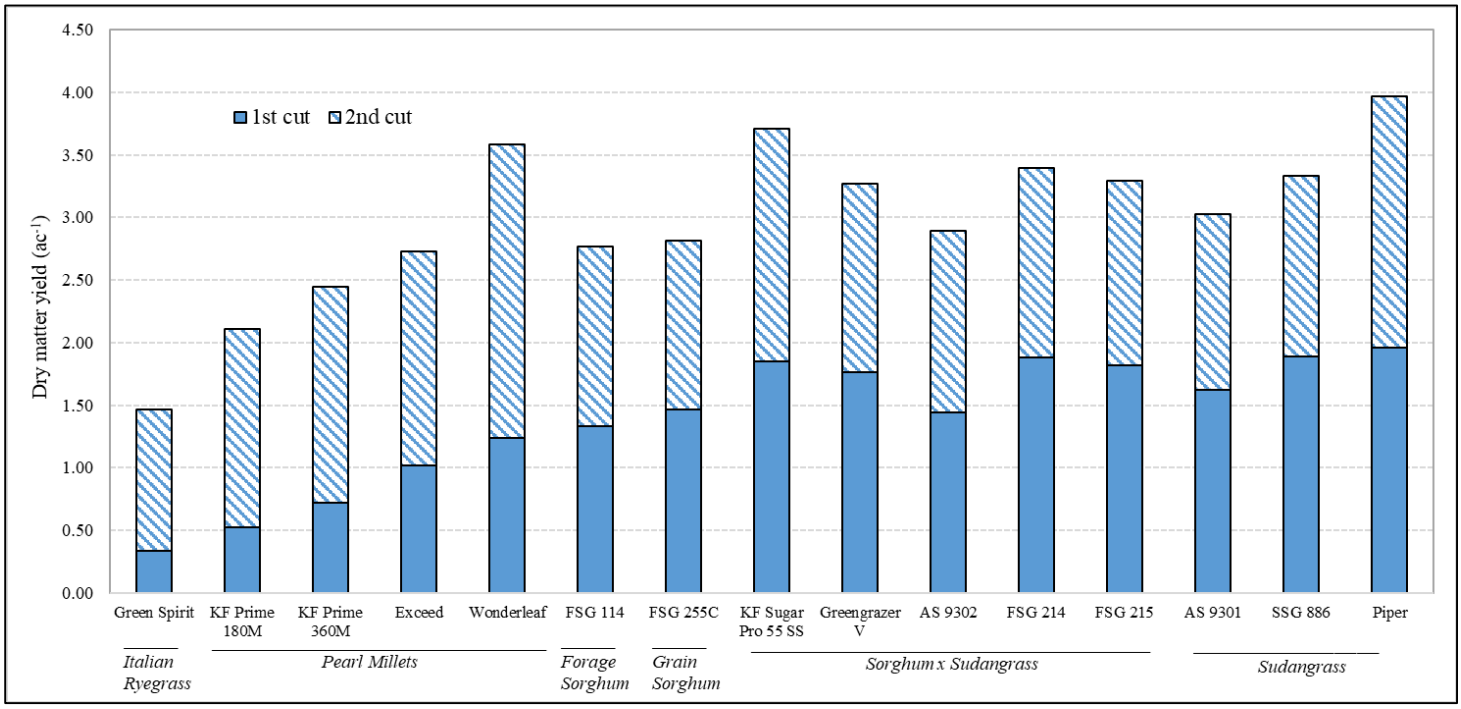

Figure 2. Total yield of 15 summer annual varieties across harvests, 2019.

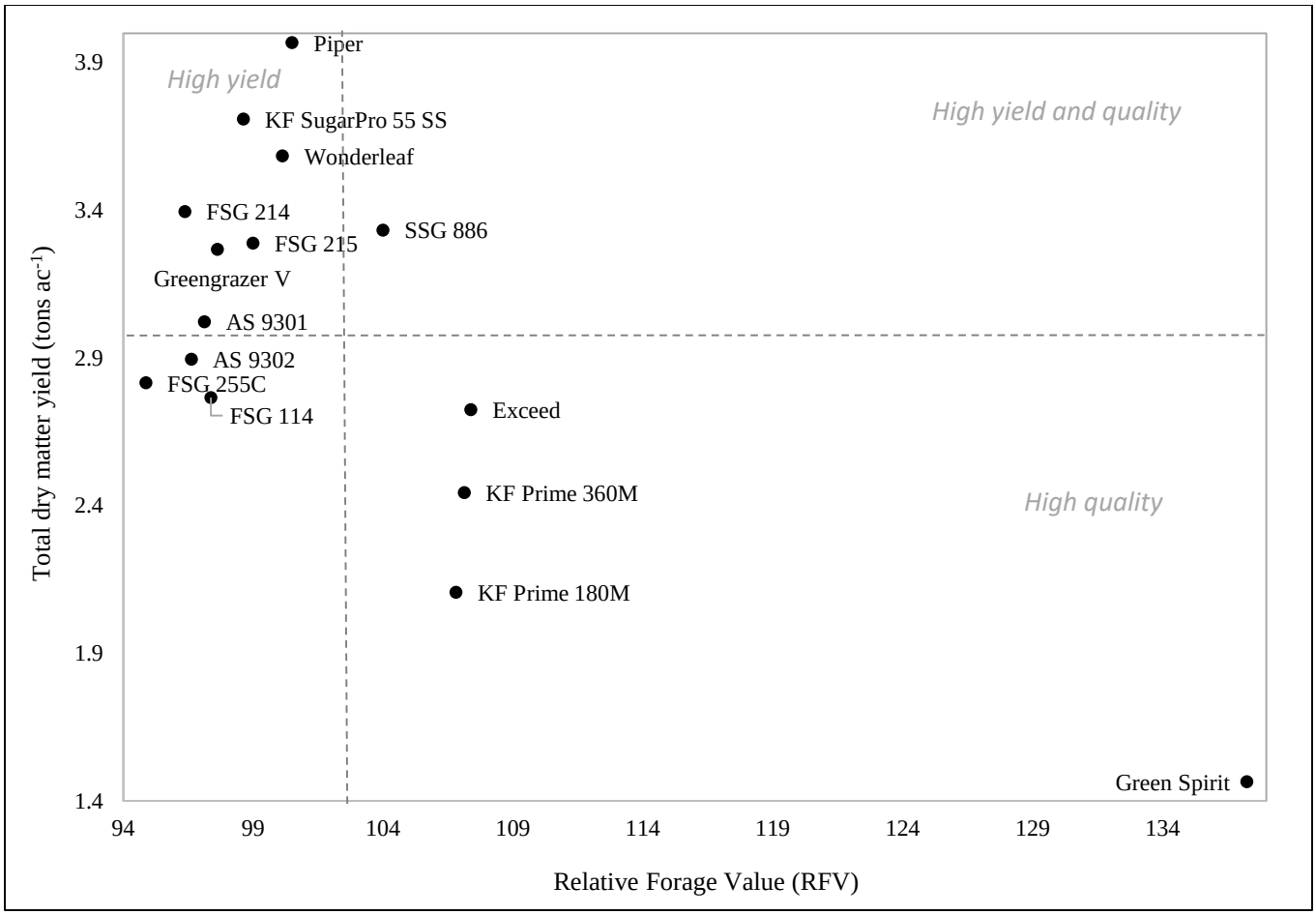

Figure 3. Total yield and average relative forage value (RFV) of 15 summer annual varieties across harvests, 2019.

Of particular importance is the portion of NDF that is digestible. Figure 4 shows yield and NDF digestibility of the varieties. When we compare Figures 3 and 4, you can see that some treatments, AS 9301, AS 9302, and FSG 215, appeared lower in quality in terms of RFV but not in terms of 30-hr NDF digestibility.

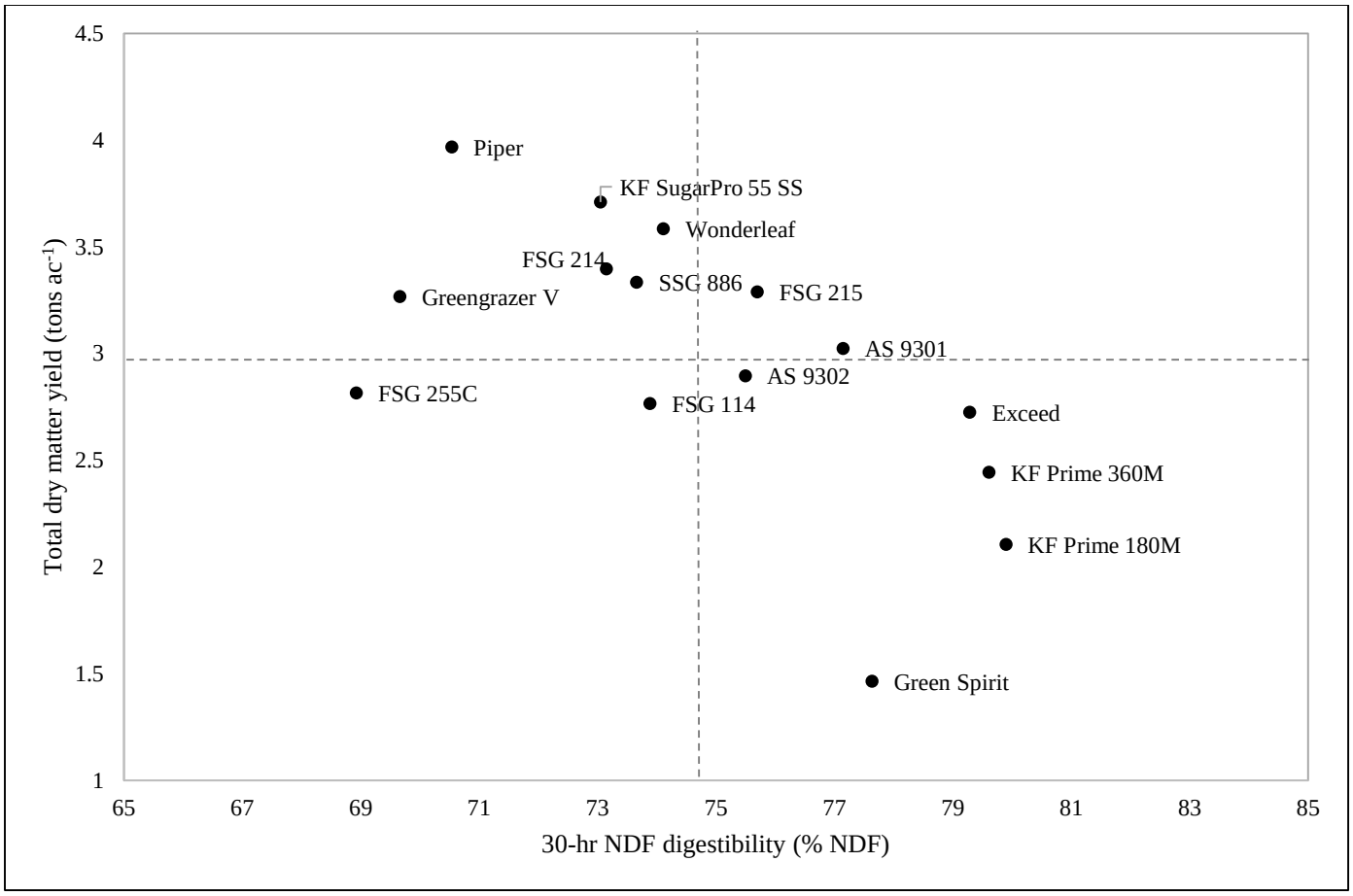

Figure 4. Total yield and average 30-hr NDF digestibility of 15 summer annual varieties across harvests, 2019.

DISCUSSION

These data demonstrate the value of integrating summer annual forages into forage production systems in the Northeast. In a year with precipitation below and July temperatures above the 30-year normal, summer annuals produced on average 2.99 tons ac^{-1} high quality forage. In terms of 30-hr NDF digestibility, all varieties resulted in NDF digestibility greater than 65%. 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. In contrast to Piper sudangrass, Green Spirit Italian ryegrass was a top performer in quality but produced the lowest yields. The pearl millets KF Prime 180, KF Prime 360, and Exceed also produced higher quality forage despite lower yields. 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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