2023 Summer Annual Seeding Rate Trial

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THE UNIVERSITY OF VERMONT EXTENSION

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Warm season grasses, such as sudangrass, and millet can provide quality forage in the hot summer months, when cool season grasses enter dormancy and decline in productivity. Varieties of these species can differ widely in their growth characteristics such as stem width and leaf to stem ratio, which influences their quality potential. Additional traits such as brown mid-rib (BMR) can further increase the quality of these species through improved fiber digestibility. However, seed costs for these improved varieties can be considerable. With seeding rate recommendations varying between seed company, extension, and literature, it can be difficult for a farmer to ensure they're using a cost-effective rate. To better understand the yield and quality tradeoffs and accompanying costs of various seeding rates and types of summer annual grasses, the UVM Extension Northwest Crops and Soils Program initiated a field trial in 2023.

MATERIALS AND METHODS

A trial was initiated at Borderview Research Farm in Alburgh, VT on 31-May. Sixteen treatments consisted of two species and eight seeding rates, which were replicated four times (Table 1). Prior to planting, starter fertilizer (7-18-36) was applied at a rate of 200 lbs ac^{-1}. Plots were 5' x 20' and were seeded with a Great Plains cone seeder. Approximately 50 lbs N was applied in the form of urea (46-0-0) on 12-Jul.

Table 1. General plot management, 2023.

Trial Information	Borderview Research Farm-Alburgh, VT
Soil Type	Benson rocky silt loam
Previous crop	No-till soybeans with winter rye cover crop
Starter fertilizer	200 lbs ac^{-1} 7-18-36, 9-May
Topdress fertilizer	100 lbs ac^{-1} 46-0-0, 12-Jul
Species/type treatments	BMR sudangrass (variety: AS 9301) BMR sorghum x sudangrass (variety: SSA 251)
Seeding rate treatments (thousand seeds ac^{-1})	450 500 550 600 650 700 750 800
Planting date	31-May
First harvest date	12-Jul
Second harvest date	17-Aug
Tillage methods	Pottinger TerraDisc®

Plots were harvested with a Carter flail forage harvester to a height of approximately 4" on 12-Jul and 17-Aug. Plot yields were recorded and a subsample collected to determine dry matter content and forage quality. The samples were ground to 2mm using a Wiley sample mill and then to 1mm using a UDY cyclone mill. Samples analyzed at the E. E. Cummings Crop Testing Laboratory at the University of Vermont (Burlington, VT) via near infrared reflectance spectroscopy (NIR) techniques using a FOSS 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. 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 fraction that is estimated to be digestible after 30 hours of fermentation in rumen fluid is represented by the 30- hour NDF digestibility. Ethanol soluble carbohydrates (ESC) are simple sugars found in grasses. Water soluble carbohydrates (WSC) include simple sugars as well as fructose polymers called fructans. Several quality metrics are combined to predict net energy needed for lactation (NEL), milk yield per ton of forage, and relative forage quality (RFQ).

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 between varieties is likely attributable to the treatment or random variation. At the bottom of each table, an LSD value may be presented. 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 treatments. 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 treatments 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 treatments were significantly different from one another. The asterisk indicates that B was not significantly lower than the top yielding treatment.

Treatment	**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 2. The beginning of the season was cooler with average precipitation. Temperatures continued to be relatively cool through the rest of the season, but rainfall increased substantially in July and August. Over 10 inches of rain fell in July, almost 7 inches above normal. Over 70% of that rain came in >1 inch rain events throughout the month. Several additional large rain events were experienced in August, with over 6 inches of rain and very cool temperatures. These warm season annual species, much like corn, perform best in hot conditions and typically tolerate dry conditions better than the perennial forage species that predominate the region. The cool temperatures contributed to a total of 1435 Growing Degree Days (GDDs) accumulated over the trial period. This was 328 fewer than last year's trial and 125 below the 30-year normal for these months.

Table 2. Seasonal weather data collected in Alburgh, VT, 2023.

Alburgh, VT	June	July	August
Average temperature (°F)	65.7	72.2	67.0
Departure from normal	-1.76	-0.24	-3.73
Precipitation (inches)	4.40	10.8	6.27
Departure from normal	0.14	6.69	2.73
Growing Degree Days (base 50°F)	483	712	540
Departure from normal	-41	17	-101

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of NOAA data (1991-2020) from Burlington, VT.

Dry matter yields were statistically similar at both harvests for all seeding rates regardless of species (Table 3). Dry matter yields in each cutting ranged from approximately 1.10 tons to 1.70 tons ac^{-1} and did not consistently increase or decrease with increasing seeding rate.

Table 3. Dry matter yields by treatment, 2023.

Species treatment	Seeding rate treatment	Dry matter yield (tons ac^{-1})		
	thousand seeds ac^{-1}	1st cut	2nd cut	Total
Sorghum x sudangrass	450	1.41	1.20	2.61
	500	**1.77**	1.29	3.06
	550	1.40	1.25	2.65
	600	1.24	1.40	2.65
	650	1.07	1.33	2.40
	700	1.43	**1.71**	3.14
	750	1.36	1.33	2.69
	800	1.54	1.24	2.78
Sudangrass	450	1.40	1.28	2.67
	500	1.45	1.20	2.65
	550	1.11	1.46	2.57
	600	1.16	1.17	2.33
	650	1.28	1.24	2.52
	700	1.32	1.13	2.46
	750	1.20	1.25	2.45
	800	1.58	1.64	**3.22**
LSD (p = 0.10) †		NS‡	NS	NS
Trial mean		1.36	1.32	2.68

Top performer treatments are in **bold.**
†LSD; least significant difference at the p=0.10 level.
‡NS; not statistically significant.

Total season yields ranged from approximately 2.40 to 3.20 tons ac^{-1} and again did not differ across increasing seeding rates. The two species performed similarly across these seeding rates. These data suggest that exceeding the seeding rate of 450,000 seeds ac^{-1} with either a sorghum x sudangrass or sudangrass provides no additional dry matter yield benefit. The same trends were observed in 2022. However, given both seasons' unusually wet and cool conditions, these trends may have been different if optimal summer annual growing conditions were experienced.

In changing seeding rates of these grasses, it is plausible that the quality of the resulting forage may be impacted as leaf-stem ratios or other differences may be influenced by planting density. The average forage quality resulting from each treatment across the season is summarized in Table 4. Water soluble carbohydrate content was the only statistically significant difference observed.

Table 4. Average forage quality across two harvests by treatment, 2023.

Species treatment	Seeding rate treatment	CP	WSC	30-hr NDF digestibility	NEL	RFQ	Milk yield
	thousand seeds ac^{-1}	% of DM		% of NDF	Mcal lb^{-1}		lbs ton^{-1}
Sorghum x sudangrass	450	17.4	8.14cde†	72.9	0.560	127	3436
	500	17.0	8.10cde	71.0	**0.588**	132	3442
	550	16.6	9.03abcd	72.5	0.564	133	3470
	600	16.5	8.33bcde	72.3	0.582	132	3515
	650	15.1	9.63abc	72.4	0.552	138	3431
	700	17.3	6.73e	71.2	0.548	134	3316
	750	14.7	9.35abcd	71.9	0.534	134	3353
	800	14.3	9.58abc	71.9	0.547	135	3353
Sudangrass	450	17.0	9.93ab	73.1	0.583	143	**3525**
	500	18.0	7.81cde	72.3	0.585	**149**	3442
	550	15.8	9.83ab	72.6	0.558	133	3440
	600	15.6	9.11abcd	72.9	0.564	131	3443
	650	**18.1**	8.40bcd	**74.2**	0.568	137	3460
	700	15.5	**10.24a**	72.4	0.585	135	3512
	750	16.8	8.81abcd	72.9	0.583	130	3499
	800	17.6	7.93cde	72.2	0.581	129	3456
LSD (p = 0.10) ‡		NS§	1.62	NS	NS	NS	NS
Trial mean		16.5	8.81	72.4	0.568	135	3443

†Treatments that share a letter performed share a letter performed statistically similarly to one another. Top performer treatments are in **bold.**
‡LSD; least significant difference at the p=0.10 level.
§NS; not statistically significant.

However, to better understand the impacts of yield and quality differences in combination, the yield of quality components on a per acre basis can be compared (Table 5). No statistical differences were observed in the yield of any quality components indicating that seeding rate and species did not impact forage quality.

Table 5. Yield of quality components per acre by treatment, 2023.

Species treatment	Seeding rate treatment	CP	WSC	30-hr digestible NDF	Milk yield
	thousand seeds ac^{-1}	lbs ac^{-1}		tons ac^{-1}	cwt ac^{-1}
Sorghum x sudangrass	450	942	412	1.02	89.7
	500	1063	482	1.13	106
	550	904	466	1.02	92.1
	600	891	432	1.01	93.6
	650	729	454	0.962	82.4
	700	1091	416	1.21	104
	750	798	506	1.08	90.3
	800	814	519	1.13	93.0
Sudangrass	450	930	517	1.01	94.5
	500	938	421	0.965	90.8
	550	804	**520**	1.01	88.4
	600	749	398	0.910	80.0
	650	915	406	0.960	86.8
	700	797	481	0.947	86.6
	750	843	406	0.939	85.2
	800	**1122**	517	**1.24**	**111**
LSD (p = 0.10) †		NS‡	NS	NS	NS
Trial mean		896	460	1.03	92.2

Top performer treatments are in **bold.**
†LSD; least significant difference at the p=0.10 level.
‡NS; not statistically significant.

DISCUSSION

These data suggest that no yield or quality benefit is observed by exceeding a seeding rate of 450,000 seeds ac^{-1} regardless of summer annual grass species. Depending on the size of the seed, which can vary widely between species and varieties, this may equate to 25-35 lbs ac^{-1}. Due to the below average temperatures and excessive rainfall for much of the summer, these results may have differed if conditions were optimal for these summer annual species. Similar trends were observed in 2022 which, while not as wet as 2023, experienced similar growing conditions. These results represent only one location and growing season and should not be used alone to make management decisions.

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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