2012

Summer Annual x Fertility Rate Trial

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NW CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES

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The UNIVERSITY of VERMONT EXTENSION

2012 SUMMER ANNUAL X FERTILITY RATE TRIAL

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Warm season grasses are high yield and quality forages best grown during the hot and dry summer months. They can provide quality pasture in the summer months when common cool season grasses are not as productive. Warm season grasses can also be harvested for stored feed. As with any crop though, summer annuals have their advantages and disadvantages. Some advantages include fast germination/emergence, rapid growth, high productivity and flexibility in utilization. Some disadvantages include high cost of annual establishment and high nitrogen (N) requirements. Summer annuals such as sorghum, sudangrass, sorghum x sudangrass and millets are heavy N feeders and require up to 150 lbs of N per season. Supplying high levels of N fertility in organic systems can be difficult. The primary source of N is manure on most farms. Timing manure application to coincide with crop N demand can be difficult as N mineralization rate is impacted by many environmental factors. Lack of N can also lead to lower protein and FA concentrations in forage. The goal of this study was to determine manure application rate appropriate to meet the N requirements of two summer annuals grown in Vermont.

MATERIALS AND METHODS

A trial was initiated at Borderview Research Farm in Alburgh, VT to determine the impact of a high and low manure application rate on yield and quality of millet and sudangrass. All plots were managed with conventional tillage practices, including moldboard plow, disking and field finishing with a drag harrow. The experimental design was a randomized complete block with split plots. Two commercially available summer annual grasses comprised the main treatment (Table 1). Subplots consisted of three manure-N rate applications 0, 35, and 70 lbs. per acre of estimated plant-available nitrogen (PAN) (Table 2). Plots were seeded with a Sunflower grain drill on 12-Jun. The plots were 10'x 25' and replicated four times. The summer annuals were harvested two times during the season on 25-Jul and 30-Aug.

Table 1. Summer annual varieties trialed at Borderview Research Farm in Alburgh, VT.

Type	Variety	Seed source	Characteristics
Sudangrass	HayKing BMR hybrid sudangrass	Alta Seeds	BMR-6
Millet	Summer Feast mix: 86% Wonderleaf hybrid pearl millet, 12% T-raptor rape	Kings Agriseed	Non-BMR

Table 2. Agronomic and trial information for summer annual variety x fertility rate trial, 2012.

	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Spring wheat
Tillage operations	Fall plow, disc, spike-toothed harrow
Plot area (ft.)	10 x 25
Fertilizer (lbs. ac-1)	0, 35, 70
Seeding rate (lbs. ac-1)	50
Replicates	4
Planting date	12-Jun
1st harvest	25-Jul
2nd harvest	30-Aug

All plots were harvested with a BCS sickle bar mower. Once the plots were harvested, all plant material was collected and weighed on a platform scale. A subsample was taken to determine moisture and quality. All data were analyzed using a mixed model analysis where replicates were considered random effects. Silage quality was analyzed by Cumberland Valley Analytical Forage Laboratory in Hagerstown, Maryland. Plot samples were dried, ground and analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and various other nutrients. The nonstructural carbohydrates (NSC) and total digestible nutrients (TDN) were calculated from forage analysis data. Performance indices such as net energy for lactation (NEL) were calculated to determine forage value. 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 NSC or non-fiber carbohydrates (NFC) include starch, sugars and pectins.

Fatty acid content and profile of the feed samples were analyzed using a modified version of the direct transesterification method developed by Sukhija and Palmquist (1988). In brief, 1 mL of internal standard (1 mg C13:0 TAG/mL acetone), 2 mL of toluene, and 2 mL of 2% methanolic H_2SO_4 acid were added to 500 mg of ground feed composites samples. The solution was heated at 50°C overnight. After cooling the samples to room temperature, 5 mL of 6% $KHCO_3$ solution and 1 mL of hexane were added. The samples were mixed and centrifuged at 500 x *g* for 5 min. The resulting hexane layer was dried and cleaned over a mixture of Na_2SO_4 and charcoal. An aliquot of the solution, containing the fatty acid methyl esters (FAME), was taken for GLC analysis. The analysis of FAME extracts was performed on a GC-2010 gas chromatograph (Shimadzu, Kyoto, Japan) equipped with a split injector, a flame ionization detector, an autosampler (model AOC-20s; Shimadzu), and a 100 m CP-Sil 88 fused-silica capillary column (100 m × 0.25 mm i.d. × 0.2 μm film thickness; Varian Inc., Palo Alto, CA) The injector and detector were both maintained at 250°C. Hydrogen was used as carrier gas at a linear velocity of 30 cm/sec. The sample injection volume was 1 μL at a split ratio of 1:50. The oven program used was: initial temperature of 45°C held for 4 min, programmed at 13°C/min to 175°C held for 27 min, then programmed at 4°C/min to 215°C held for 35 min. Integration and quantification was based on the FID response and achieved with GC solution software (version 2.30.00, Shimadzu, Kyoto, Japan). Identification of FAME was accomplished by comparison of relative retention times with commercial FAME standards. Total fatty acid content was determined using C13:0 as an internal standard. The fatty acid results were expressed as percentages (weight/weight) of fatty acids detected with a chain length between 10 and 24 carbon atoms. The lowest level of detection was <0.001g/100g fatty acids and is reported as not detectable (ND).

Data were analyzed using mixed model analysis procedure of SAS (SAS Institute, 1999). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

LEAST SIGNIFICANT DIFFERENCE (LSD)

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. Least Significant Differences (LSDs) at the 0.10 level of significance are shown. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). 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 that for 9 out of 10 times, there is a real difference between the two treatments. Treatments that were not significantly lower in performance than the highest hybrid in a particular column are indicated with an asterisk. In the example below, 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

Weather data is based on data from an onsite Davis Instruments Vantage Pro2 with Weatherlink data logger at Borderview Research Farm in Alburgh, VT, and on National Weather Service data from cooperative observer stations in close proximity to Borderview Research Farm. Historical averages are for 30 years of data (1981-2010). In mid-summer 2012, drought-like conditions were experienced, leading to a total of 3.1 fewer inches of precipitation than the 30 year average (Table 3). Although summer annuals are relatively drought tolerant, growers should work to recognize and prevent nitrate poisoning (which is considered relatively safe for feed up to 5000 ppm). The summer annual growing season experienced 1948 GDD's, which was 253 GDD's more than the 30 year average.

Table 3. Weather data for summer annual variety x fertility rate trial in Alburgh, VT, 2012.

Alburgh, VT	Jun	Jul	Aug
Average temperature (°F)	67.0	71.4	71.1
Departure from normal	1.2	0.8	2.3
Precipitation* (inches)	3.2	3.8	2.9
Departure from normal	-0.5	-0.4	-1.0
Growing Degree Days (base 50°F)	539	721	688
Departure from normal	65	81	107

Based on weather data from Davis Instruments Vantage Pro2 with Weatherlink data logger.
Historical averages for 30 years of NOAA data (1981-2010).
*Precipitation data from is based on Northeast Regional Climate Center data from an observation station in Burlington, VT.

Fertilizer Rate x Species Interactions

There were few statistically significant interactions between fertilizer rate and summer annual. This indicates that the summer annuals responded similarly across the 3 nitrogen rates. The only statistically significant interactions occurred in crude protein (CP) and acid detergent fiber (ADF) in the second harvest (Figure 1, Figure 2). In both cases, millet appeared to respond more favorably to the higher PAN rate of 70 lbs per acre.

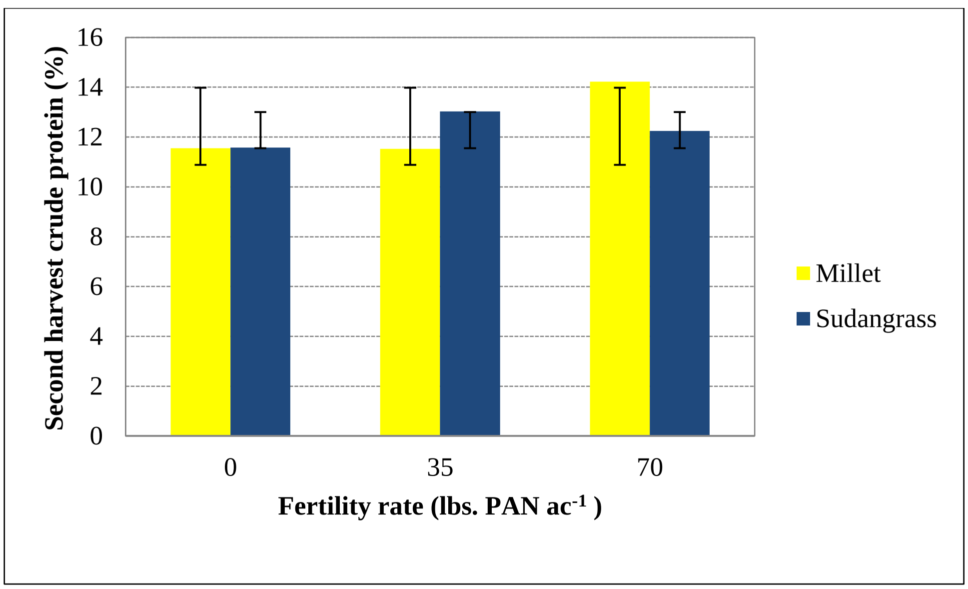

Figure 1. Impact of fertility rate on crude protein for sudangrass and millet, second harvest, 2012.
Vertical bars represent +/- one standard deviation.

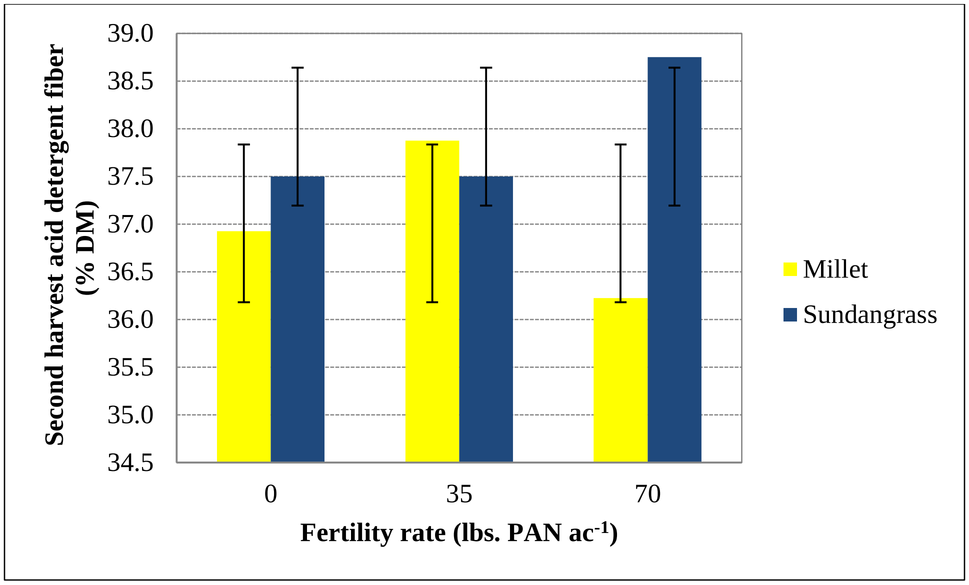

Figure 2. Impact of fertilizer on acid detergent fiber for sudangrass and millet, second harvest, 2012. Vertical bars represent +/- one standard deviation.

Impact of Fertility Rate

At the first harvest on 25-Jul, fertility rate did not significantly impact forage yields (Table 4). Crude protein was highest when 70 lbs. PAN per acre was applied (15.8%), although this was not statistically different than when 35 lbs. PAN per acre was applied. With respect to fertility rate at the first harvest, there was no statistical significance between fertility rates for plant height, ADF, NDF and dNDF parameters.

Table 4. Impact of fertility rate on forage yield and quality of summer annuals, first harvest, 2012.

Fertility rate	Plant height	DM	DM yield	CP	ADF	NDF	dNDF	TDN	NEL	NFC	NSC
lbs. PAN ac^{-1}	cm	%	lbs ac^{-1}	% of DM	% of DM	% of DM	% of NDF	% of DM	Mcal lb^{-1}	% of DM	% of DM
0	42.8	**18.0***	**4400**	14.9*	**37.3**	**58.7**	**61**	**60.2***	**0.61***	**16.7***	**10.0***
35	43.1	17.2	4202	14.2	38.2	59.6	60.1	58.6	0.60	15.5*	9.4*
70	**44.5**	15.7	3336	**15.8***	37.4	59	**61**	59.1	0.60	14.4	8.6
LSD (0.10)	NS	0.8	NS	0.9	NS	NS	NS	0.8	0.09	1.2	0.6
Trial mean	43.4	17	3979	15	37.6	59.1	60.7	59.3	0.6	15.5	9.3

NS – No statistical significance was determined between varieties.
*Varieties that did not perform significantly lower than the top performing treatment (in **bold**) in a particular column are indicated with an asterisk.

At the second harvest on 30-Aug, plant height varied significantly by fertility rate (Table 5). The tallest plants were in plots amended with manure. Dry matter levels were not impacted by fertility rate, but averaged 17.5%. Fertility amendment significantly impacted yields. The greatest yield was observed with 70 lbs. PAN per acre, though this was not a significantly greater yield than 35 lbs. PAN per acre. A fertility rate of 70 lbs. PAN per acre produced the highest protein content (13.2%), although this was not statistically different then when 35 lbs. of PAN was applied. The highest NFC (18.7%) occurred in the lowest fertility rate of 0 lbs. PAN per acre.

NSC was also the highest in 0 lbs. of PAN per acre at 12.6% of dry matter. With respect to fertility rate on the second harvest, there was no statistical significance between fertility rates for ADF, NDF, dNDF, TDN and NEL parameters.

Table 5. Impact of fertility rate on forage yield and quality of summer annuals, second harvest, 2012.

Fertility rate lbs. PAN ac^{-1}	Plant height cm	DM %	DM yield lbs ac^{-1}	CP % of DM	ADF % of DM	NDF % of DM	dNDF % of NDF	TDN % of DM	NEL Mcal lb^{-1}	NFC % of DM	NSC % of DM
0	46	**17.7**	2828	11.6	**37.2**	62.1	**67.3**	**59.2**	**0.61**	**18.7***	**12.6***
35	52.0*	17.2	3573*	12.3*	37.7	62.2	66.7	58.4	0.6	17.1	11.7
70	**56.3***	17.6	**4422***	**13.2***	37.5	**61.6**	65.7	58.2	0.6	16.1	11.2
LSD (0.10)	4.5	NS	1002	1.1	NS	NS	NS	NS	NS	1.2	0.6
Trial mean	51.4	17.5	3608	12.4	37.5	62	66.6	58.6	0.6	17.3	11.8

NS – No statistical significance was determined between varieties.
*Varieties that did not perform significantly lower than the top performing treatment (in **bold**) in a particular column are indicated with an asterisk.

Overall forage yield and quality (combined harvests) did not vary significantly by fertility rate (Table 6).

Table 6. Impact of fertility rate on overall yield and quality of summer annuals, 2012.

Fertility rate lbs. PAN ac^{-1}	Total yield lbs ac^{-1}	CP lbs ac^{-1}	NDF lbs ac^{-1}	TDN lbs ac^{-1}	NSC lbs ac^{-1}
0	7228	991	**4342**	4324	792
35	**7776**	1049	4729	**4555**	**812**
70	7758	**1105**	4705	4539	780
LSD (0.10)	NS	NS	NS	NS	NS
Trial mean	7587	1048	4592	4473	795

NS – No statistical significance was determined between varieties.
Bold- Indicates the top performing variety.

Impact of Species

There was no difference in yield between sudangrass and millet in the first harvest (Table 7). Species selection impacted forage quality characteristics in the first harvest. Overall the forage millet produced the higher quality feed.

Table 7. Impact of summer annual species on forage yield and quality, first harvest, 2012.

Species	Plant height	DM	DM yield	CP	ADF	NDF	dNDF	TDN	NEL	NFC	NSC
				% of DM	% of DM	% of DM	% of NDF	% of DM	Mcal lb^{-1}	% of DM	% of DM
	cm	%	lbs ac^{-1}								
Sudangrass	**52.8***	16.8	3890	14.5	38.9	60.3	55.2	58.5	**0.61***	15.3	9.1
Millet	34.1	**17.1**	**4069**	**15.4***	**36.4***	**58.0***	**66.2***	**60.1***	0.60*	**15.8**	**9.6***
LSD (0.10)	1.9	NS	NS	0.7	0.8	1.1	0.7	0.7	0.1	NS	0.5
Trial mean	43.5	17.0	3980	15.0	37.7	59.2	60.7	59.3	0.6	15.6	9.4

NS – No statistical significance was determined between varieties.
*Varieties that did not perform significantly lower than the top performing treatment (in bold) in a particular column are indicated with an asterisk.

Interestingly, species had little effect on forage yield and quality in the second harvest (Table 8). Overall, the millet was slightly higher in forage quality when compared to the sudangrass. The ADF of millet (37.0%) was significantly lower than the sudangrass. Millet also outperformed the sudangrass with great digestible fiber and NSC.

Table 8. Impact of summer annual species forage yield and quality, second harvest, 2012.

Species	Plant height	DM	DM yield	CP	ADF	NDF	dNDF	TDN	NEL	NFC	NSC
				% of DM	% of DM	% of DM	% of NDF	% of DM	Mcal lb^{-1}	% of DM	% of DM
	cm	%	lbs ac^{-1}								
Sudangrass	**59.5***	16.7	3561	12.3	37.9	62.3	62.4	**58.6**	**0.61**	**17.7**	11.2
Millet	43.4	**18.3**	**3655**	**12.4**	**37.0***	**61.7**	**70.7***	58.6	0.60	16.9	**12.4***
LSD (0.10)	3.7	NS	NS	NS	0.9	NS	1.4	NS	NS	NS	0.5
Trial mean	51.5	17.5	3608	12.4	37.5	62.0	66.6	58.6	0.6	17.3	11.8

NS – No statistical significance was determined between varieties.
*Varieties that did not perform significantly lower than the top performing treatment (in **bold**) in a particular column are indicated with an asterisk.

For combined results of both harvests, there was no significant difference between species for yield and quality measurements (Table 9).

Table 9. Impact of summer annual species on overall forage yield and quality, 2012.

Species	Total yield	CP	NDF	TDN	NSC
	lbs ac^{-1}	lbs ac^{-1}	lbs ac^{-1}	lbs ac^{-1}	lbs ac^{-1}
Sudangrass	7451	1006	**4562**	4365	755
Millet	**7723**	**1091**	4622	**4580**	**835**
LSD (0.10)	NS	NS	NS	NS	NS
Trial mean	7587	1049	4592	4473	795

NS – No statistical significance was determined between varieties.
*Varieties that did not perform significantly lower than the top performing treatment (in **bold**) in a particular column are indicated with an asterisk.

Fatty Acid Results

The fatty acid profile and concentration of millet and sudangrass at different rates of nitrogen applications are presented in Tables 10 and 11. There were no interactions between species and fertility rate and harvest time. There were few significant differences of fatty acids by species and fertility rate (Table 10). Overall, the addition of nitrogen fertilizer did not increase the Omega 3 fatty acids or the total fatty acid concentration of the forage.

Table 10. Average fatty acid profile (%- in grey) and concentration ($mg\ g^{-1}$-in white) of summer annuals fertilized at three different rates of nitrogen.

	Millet-0	Millet-35	Millet-70	Sudan-0	Sudan-35	Sudan-70	Trial Mean	LSD
SFA (%)	40.1	40.3	38.8	39.5	39.0	39.2	39.5	NS
SFA ($mg\ g^{-1}$)	5.0	4.6	4.7	4.5	4.9	5.1	4.8	NS
C16 (%)	27.1*	27.2*	27.0*	26.9*	26.3	26.8*	26.9	0.4988
C16 ($mg\ g^{-1}$)	3.4	3.1	3.3	3.0	3.3	3.5	3.3	NS
MUFA (%)	3.7	4.4*	3.8	4.3*	4.1*	4.3*	4.1	0.4274
MUFA ($mg\ g^{-1}$)	0.4	0.5	0.5	1.2	0.5	0.6	0.6	NS
PUFA (%)	56.2	55.3	57.3	56.3	56.8	56.5	56.4	NS
PUFA ($mg\ g^{-1}$)	7.2	6.5	7.2	5.8	7.4	7.5	6.9	NS
C18:2 LA (%)	16.3	17.2	16.4	16.5	16.3	16.1	16.5	NS
C18:2 LA ($mg\ g^{-1}$)	1.6	2.0	2.0	1.9	2.1	2.1	1.9	NS
C18:3 LNA (%)	39.6	37.8	40.6	39.3	40.1	39.9	39.5	NS
C18:3 LNA ($mg\ g^{-1}$)	5.2	4.5	5.1	3.9	5.2	5.3	4.8	NS
Omega 3 FA (%)	39.6	37.8	40.6	39.3	40.1	39.9	39.5	NS
Omega 3 ($mg\ g^{-1}$)	5.2	4.5	5.1	3.9	5.2	5.3	4.9	NS
Omega 6 (%)	16.6	17.5	16.7	16.9	16.7	16.6	16.8	NS
Omega 6 ($mg\ g^{-1}$)	1.6	2.0	2.0	1.9	2.1	2.1	1.9	NS
Total FA ($mg\ g^{-1}$)	12.6	11.6	12.4	11.5	12.9	13.1	12.3	NS
Ratio Omega6: Omega3	0.34	0.48	0.42	0.43	0.41	0.41	0.42	NS

SFA Saturated Fatty Acids, MUFA mono-unsaturated fatty acids, PUFA poly-unsaturated fatty acids, LA linoleic acid, LNA linolenic acid.
* Varieties with an asterisk indicate that it was not significantly different than the top performer in row.

There were many differences in the fatty acid profile and concentration of the summer annuals between first and second cut (Table 11). First cut had higher levels of poly-unsaturated fatty acids (PUFAs), Omega 3s, and total fatty acids. First cut also had the lowest ratio of omega 6 to omega 3 fatty acids. Second cut had a larger profile of saturated fats, C16:0, mono-unsaturated fatty acids (MUFAs), and omega 6s. First cut forage may have been leafier and resulted in higher omega-3 concentrations.

Table 11. Average fatty acid profile (%- in grey) and concentration (mg g^{-1}-in white) of summer annuals at two harvests.

	First Cut	Second Cut	Trial Mean	LSD
SFA (%)	38.4	40.6*	39.5	0.5971
SFA (mg g^{-1})	4.9	4.7	4.8	NS
C16 (%)	26.2	27.7*	26.9	0.2880
C16 (mg g^{-1})	3.3	3.2	3.3	NS
MUFA (%)	3.6	4.6*	4.1	0.2467
MUFA (mg g^{-1})	0.7	0.5	0.6	NS
PUFA (%)	57.9*	54.8	56.4	0.7772
PUFA (mg g^{-1})	7.3*	6.5	6.9	0.7452
C18:2 LA (%)	14.8	18.2*	16.5	0.6781
C18:2 LA (mg g^{-1})	1.8	2.1*	1.9	0.2221
C18:3 LNA (%)	42.8*	36.1	39.5	1.2900
C18:3 LNA (mg g^{-1})	5.4*	4.3	4.8	0.6352
Omega 3 FA (%)	42.8*	36.1	39.5	1.2900
Omega 3 (mg g^{-1})	5.4*	4.3	4.9	0.6357
Omega 6 (%)	15.1	18.6*	16.8	0.7159
Omega 6 (mg g^{-1})	1.8	2.1*	1.9	0.2225
Total FA (mg g^{-1})	12.9*	11.7	12.3	0.9443
Ratio Omega6: Omega3	0.32	0.52*	0.42	0.0501

SFA Saturated Fatty Acids, MUFA mono-unsaturated fatty acids, PUFA poly-unsaturated fatty acids, LA linoleic acid, LNA linolenic acid.

* Varieties with an asterisk indicate that it was not significantly different than the top performer in row.

DISCUSSION

In looking at the impact of fertility rate on summer annual yield and quality, additional fertilizer did not affect most quality parameters, with the exception of crude protein, where additional fertilizer resulted in higher protein content at both harvest dates. At both harvests, the effects of fertility rate were similar on the summer annual species. The first harvest likely benefitted from good soil fertility, while the second harvest benefitted from the slow release of fertilizer. In combining both harvests, there was no significant difference in yield and quality by fertility rate. In looking at the impact of species choice, millet had slightly higher yields and higher overall quality. The addition of either of these species would allow for production of a high-yielding crop when other crops in this region are experiencing a lull during hot and dry summer months. However, according to these results, it is not conclusive that higher fertility rates would be cost effective, as forage quality varies little by fertility rate. Additional years of research should be conducted to get a better handle on nitrogen rates for summer annuals.

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ACKNOWLEDGEMENTS

UVM Extension would like to thank Roger Rainville of Borderview Research Farm in Alburgh, VT, for hosting this trial and Organic Valley for their financial assistance. We would also like to thank Katie Blair, Chantel Cline, and Savanna Kittell-Mitchell for their assistance with data collection and entry. 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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