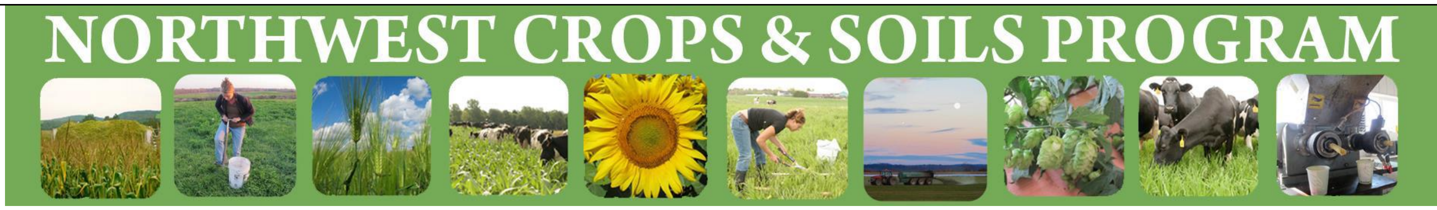

2016 Pasture Productivity Trial

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2016 PASTURE PRODUCTIVITY TRIAL

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Pasture is an essential component of the ration on organic dairy farms. Productivity of pastures is key to ensure the cattle have a plentiful source of high quality feed during the entire grazing season. Optimal management of pastures should include animal, plant, and soil factors. This project aims to identify weak links in the pasture system and evaluate the impact of adopting new strategies to overcome barriers to productivity. In this case, soil fertility was identified as the primary weak link to productivity.

The pasture where this research took place was seeded to grass about 30 years ago and prior to that had been used for corn silage. For the last 10 years, the pasture has been minimally fertilized with a spring or fall manure application at a rate of 3000-4000 gal ac^{-1}. The pasture consisted primarily of grass with low diversity and a very low percentage of legumes. This species scenario substantially increases the pasture demand for nitrogen (N). The long-term strategy to improve yield and quality included over-seeding the pasture to improve species diversity and ultimately provide higher yields and quality, which was done during June 2015. A goal was to increase legume percentage to minimize the need for N in the pasture system.

Our project focused on evaluating N fertility applications for their impact on yield and quality. Sodium nitrate (SN; 16-0-0), pelletized poultry manure (PM; 5-4-3), and a combination of SN and PM were used as fertilizer applications. Sodium nitrate has the advantage of only providing N, where many dairy farmers in Vermont may have fields that are already high in P. In light of water quality regulations, farmers may need to seek ways to fertilize their fields without over-applying P in the form of organic fertilizers (manures, composts). Data was collected throughout the growing season to determine the impact of N fertility management strategies on pasture productivity.

MATERIALS AND METHODS

The project was conducted at Holyoke Farm located in St. Albans, VT. The soil type is a Massena stony loam and the soil test of the field indicated that P was at a medium level and potassium (K) were at a medium soil test level (Table 1).

Table 1. Soil quality characteristics, Holyoke Farm, St. Albans, VT, 2016.

pH	Organic matter	Phosphorus	Potassium	Calcium	Magnesium	Sodium	Aluminum
	%	ppm	ppm	ppm	ppm	ppm	ppm
6.6	6.2	2.64	76.5	1540	138	69.0	52.3

A base fertility application of liquid manure at 4000 gallons ac^{-1} was applied in the fall of 2015. In April, wood ash (5.1% soluble potash) was spread at a rate of 1 ton ac^{-1} over the 18 acre field, contributing 102 lbs ac^{-1} of K.

Two experiments were implemented using a randomized complete block design. The experimental area was within 18 acres of pasture that were grazed by 60 cows using management intensive grazing techniques. Cows were given approximately 1 acre of pasture, representing 1 paddock, for every 24 hours that they grazed. Through the course of the season cows grazed the 18 acres six times. For each experiment, a portion of one paddock was divided into plots 10'x40' in size. In each experiment there were two fertilizer treatments and one un-fertilized control. Experiment one had fertilizer treatments consisting of 1) SN and 2) PM. Experiment two had fertilizer treatments consisting of 1) SN and 2) SN + PM. General plot information is shown in Table 2.

Table 2. General plot management, St. Albans, Vermont, 2016.

Trial Information	Holyoke Farm St. Albans, VT
Soil type	Massena stony loam 0-3% slope
Previous crop	Permanent pasture
Plot size (ft)	10 x 40
Grazing cycles	May – October, six cycles
Fertilizer application dates	9-May 5-Aug

The application rate of SN and PM was based on crop removal rates of the pasture. Nitrogen was applied based off of crop removal rates for intensively managed grass pasture, which is 145 lbs N ac^{-1}. Organic standards only allow using SN to meet 20% of crop N removal rates, at most, which equaled to 29.0 lbs N ac^{-1} or a total of 181 lbs ac^{-1} of SN product. The rate of PM application was matched to the crop removal rate of P (57.5 lbs P ac^{-1}). This was to replicate scenarios where over-application of P is of strong concern, and equaled to 1438 lbs ac^{-1} of PM. An overview of all treatments used in both experiments is shown in Table 3.

Table 3. Pasture productivity trial treatments, St. Albans, Vermont, 2016.

Treatment	Total product applied	Nitrogen rate	Phosphorus rate	Potassium rate
	lbs ac^{-1}	lbs ac^{-1}	lbs ac^{-1}	lbs ac^{-1}
Sodium nitrate 16-0-0	181	29.0	0	0
Kreher's poultry manure 5-4-3	1438	71.9	57.5	43.1
Sodium nitrate 16-0-0 **AND** Kreher's poultry manure 5-4-3	181 1438	29.0 71.9	0 57.5	0 43.1
Control	None	None	None	None

Fertilizer treatments were split over two applications. Applications were done prior to the first cycle of grazing on 9-May and the fourth cycle of grazing on 5-Aug. Fertilizers were broadcast by hand.

Soil nitrate-N samples were taken prior to the first, fourth, and sixth grazing cycle. Rising plate meter measurements were recorded before and after each grazing cycle in order to evaluate the quantity of pasture grazed. Pasture plots were sampled by clipping the contents within two 0.5 m^2 quadrats per plot just before each grazing cycle to determine biomass yield and quality. Samples were dried until they reached a stable weight and then sent to Dairy One Forage Laboratory (Ithaca, NY) for wet chemistry analysis of crude protein (CP), net energy lactation (NE_L), relative feed value (RFV), and neutral detergent fiber (NDF), and calcium, phosphorus, magnesium, potassium, and sodium concentrations on a dry matter basis.

The bulky characteristics of forage come from fiber. Forage relative feeding values (RFV) are negatively associated with fiber since the less digestible portions of plants 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). This fraction includes cellulose, hemicellulose, and lignin. Because these components are associated with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows.

Net energy of lactation (NE_L) is calculated based on concentrations of NDF and acid detergent fiber. NE_L can be used as a tool to determine the quality of a ration. However, it should not be considered the sole indicator of the quality of a feed as NE_L is affected by the quantity of a cow's dry matter intake, the speed at which her ration is consumed, the contents of the ration, feeding practices, the level of her production, and many other factors.

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 ($p< 0.10$).

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 p-value is presented for each variable (i.e. yield). The p-value represents the probability that there was an effect from the treatment. The lower the p-value, the greater the probability that the treatment had an effect on the variable (i.e. yield).

Also 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 following 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 AND DISCUSSION

Seasonal precipitation and temperature were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT. The growing season was dryer than normal with May-September getting 7.27 fewer inches of precipitation as compared to historical averages (Table 4). Temperatures in June-July were comparable to normal averages, while May and August-October were at least 1.8 degrees warmer than normal, per month. Overall, there were an accumulated 5754 GDDs at base 32°F this season, approximately 291 more than the historical average.

Table 4. Seasonal weather data collected in Alburgh, VT, 2016.

Alburgh, VT	May	June	July	August	September	October
Average temperature (°F)	58.1	65.8	70.7	71.6	63.4	50.0
Departure from normal	1.80	0.00	0.10	2.90	2.90	1.90
Precipitation (inches)	1.50	2.8 0	1.80	3.00	2.50	5.00
Departure from normal	-1.92	-0.88	-2.37	-0.93	-1.17	1.39
Growing Degree Days (base 32°F)	803	1017	1201	1224	949	559
Departure from normal	50	3	4	84	92	58

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.

Trial 1 – Impact of N Fertility from SN or PM on Pasture Yield and Quality

With the exception of CP concentration, there were no significant differences between treatments (Table 5). The small amount of N added may not have been enough to boost yields or other quality parameters above the control. The season tended to be dry and the lack of moisture may have prevented the fertilizers from becoming plant-available. Moisture is needed for microbial communities to be able to break down organic fertilizers, such as PM, to a plant-available form and for already plant-available fertilizers, such as SN, to become absorbed.

Table 5. Trial 1 – Pasture yield and quality comparing fertilizer treatments, across all grazing cycles, St. Albans, Vermont, 2016.

Fertility treatment	Yield	CP		NDF	NE_L	RFV
	lbs ac^{-1}	% of DM	Rank	% of DM	Mcal lb^{-1}	
SN	1290	**21.3***	**A**	50.8	0.619	119
PM	1440	20.7*	A	49.9	0.600	115
Control	1230	19.0	B	53.4	0.599	113
p-value	0.255	0.004		0.139	0.272	0.315
LSD	NS	1.10		NS	NS	NS
Trial mean	1320	20.3		51.4	0.606	116

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10).
Treatments with the same letter did not perform statistically different from each other.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

Rising plate meter measurements were recorded before and after each grazing cycle in order to evaluate the quantity of pasture grazed. The dairy cattle grazed more from the plots where SN and PM treatments had been applied, which may show some preferential grazing for the tastes of these amendments (Table 6).

Table 6. Trial 1 – Quantity of pasture grazed, across all grazing cycles, St. Albans, VT, 2016.

Fertility treatment	Quantity grazed†		Height difference‡	
	lbs ac^{-1}	Rank	cm	Rank
SN	**1770***	**A**	**6.04***	**A**
PM	1710	B	5.85*	A
Control	1540	B	5.08	B
p-value	0.086		0.094	
LSD	178		0.763	
Trial mean	0.835		5.66	

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10).
Treatments with the same letter did not perform statistically different from each other.
NS – There was no statistical difference between treatments in a particular column (p=0.10).
†Quantity grazed refers to the amount of pasture consumed, measured before and after grazing.
‡Height difference refers to the difference in pasture height, measured before and after grazing.

There was not a consistent impact from the fertilizer treatments on pasture nutrient concentration (Table 7). The amendments applied, especially the SN, were geared towards adding N and so the increase in other nutrients should have been minimal. However, the sodium content of the forages was significantly increased. The SN treatment increased the sodium by 64.7% compared to the control and 37.6% over the PM treatment. Increase in sodium concentration is associated with improvements in pasture palatability.

Table 7. Trial 1 – Pasture nutrient concentration comparing fertilizer treatments, across all grazing cycles, St. Albans, VT, 2016.

Treatment	Calcium	Phosphorus	Magnesium	Potassium	Sodium	
	% of DM	% of DM	% of DM	% of DM	% of DM	Rank
SN	0.784	0.398	0.311	1.99	**0.219***	**A**
PM	0.760	0.394	0.292	2.07	0.183*	A
Control	0.739	0.415	0.296	1.93	0.133	B
p-value	0.601	0.375	0.335	0.559	0.015	
LSD	NS	NS	NS	NS	0.048	
Trial mean	0.761	0.402	0.300	2.00	0.178	

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10). Treatments with the same letter did not perform statistically different from each other. NS – No statistical difference.

Trial 1 – Impact of Grazing Cycle on Pasture Yield and Quality

The highest pasture quality occurred during the 4th and 5th cycles of grazing, 5-Aug thru 6-Oct (Table 8). This also may have been due to dry and hot weather during May and July reducing pasture performance earlier in the season. The first cycle of grazing, 1-May – 10-Jun had the highest yield, however, that sampling of grass was given at least 1.5 more weeks to grow compared to the other cycles, which were generally around 4 weeks, and was hayed rather than grazed because it was too tall for the cattle to eat.

Table 8. Trial 1 – Pasture yield & quality comparing grazing cycles, across all treatments, St. Albans,VT2016.

Grazing cycle	Yield		CP		NDF		NE_L		RFV	
	lbs ac^{-1}	Rank	% of DM	Rank	% of DM	Rank	Mcal lb^{-1}	Rank		Rank
1-May – 10-Jun	**3000*†**	A	13.3	E	60.4	A	0.501	C	85.3	C
11-Jun – 3-Jul	No sample received									
4-Jul – 4-Aug	785	C	21.4	C	51.6	B	0.615	B	117	B
5-Aug – 6-Sep	1190	B	23.2	B	46.5*	C	0.650*	A	132 *	A
7-Sep – 6-Oct	804	C	**24.9 ***	A	**45.8***	C	**0.655***	A	**133 ***	A
7-Oct – 1-Nov	806	C	18.7	D	52.5	B	0.608	B	111	B
p-value	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001	
LSD	172		1.42		3.88		0.030		8.62	
Trial mean	1320		20.3		51.4		0.606		116	

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10). Treatments with same letter did not perform statistically different from each other. † First graze was harvested for hay instead of pasture.

Similarly, pasture nutrient concentration was generally best during the 5th grazing cycle, and again this may have been due to relatively more precipitation and cooler temperatures (Table 9).

Table 9. Trial 1 – Pasture nutrient concentration comparing grazing cycles, across all treatments, St. Albans, Vermont, 2016.

Grazing cycle	Calcium		Phosphorus		Magnesium		Potassium	Sodium	
	% of DM	Rank	% of DM	Rank	% of DM	Rank	% of DM	% of DM	Rank
1-May – 10-Jun	0.600	B	0.277	D	0.194	C	1.89	0.121	B
11-Jun – 3-Jul	No sample received								
4-Jul – 4-Aug	**0.881***	A	0.402	B	0.333*	A	1.94	0.180*	AB
5-Aug – 6-Sep	0.790*	A	0.495	A	0.339*	A	2.08	0.225*	A
7-Sep – 6-Oct	0.840*	A	**0.478***	A	**0.340***	A	2.17	**0.238***	A
7-Oct – 1-Nov	0.694	B	0.358*	C	0.293	B	1.91	0.125	B
p-value	<0.0001		<0.0001		<0.0001		0.354	0.004	
LSD	0.096		0.034		0.029		NS	0.062	
Trial mean	0.761		0.402		0.300		2.00	0.178	

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10).
Treatments with the same letter did not perform statistically different from each other
NS – There was no statistical difference between treatments in a particular column (p=0.10).

Trial 2 – Impact of N Fertility from SN or SN + PM on Pasture Yield and Quality

The SN + PM treatment yielded significantly more than the SN alone or control treatment. This is likely due to the fact that the SN + PM treatment consisted of a higher N application rate than the other treatments. Essentially, these plots received double the N rate compared to the SN treatment alone. There were few quality differences between the fertility treatments (Table 10).

Table 10. Trial 2 – Pasture yield and quality comparing fertilizer treatments, across all grazing cycles, St. Albans, Vermont, 2016.

Treatment	Yield		CP	NDF		NE_L	RFV	
	lbs ac^{-1}	Rank	% of DM	% of DM	Rank	Mcal lb^{-1}		Rank
SN	1180	B	22.2	**47.8***	B	0.623	**123***	A
SN + PM	**1390***	A	21.5	52.0	A	0.613	115	B
Control	1140	B	21.2	49.3*	B	0.631	**123***	A
p-value	0.002		0.260	0.006		0.354	0.045	

LSD	121	NS	2.11	NS	5.67
Trial mean	1240	21.6	49.7	0.623	120

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10).
Treatments with the same letter did not perform statistically different from each other
NS – There was no statistical difference between treatments in a particular column (p=0.10).

There was a significant interaction between treatment and grazing cycle for CP (p-value = 0.108) (Figure 1). The SN treatment alone was the top performer for the 3rd and 4th month of grazing, which was statistically significant. However, during the 3rd month of grazing, results were comparable to the control.

The SN and SN + PM treatments may have performed better than the control during the 4th month (26-Jul – 23-Aug) because fertilizer treatments were applied during that cycle, on 5-Aug. The month of August received 3.0 inches of rainfall and that additional moisture is needed by microbial communities for decomposing organic forms of fertilizer, such as the PM. The SN is already plant available, however, that fertilizer needs moisture to become accessible by plants. Therefore, the increased moisture in August may have aided in making the fertilizers more plant available and affected the CP quality. The fertilizers would have provided N, which is directly needed in protein.

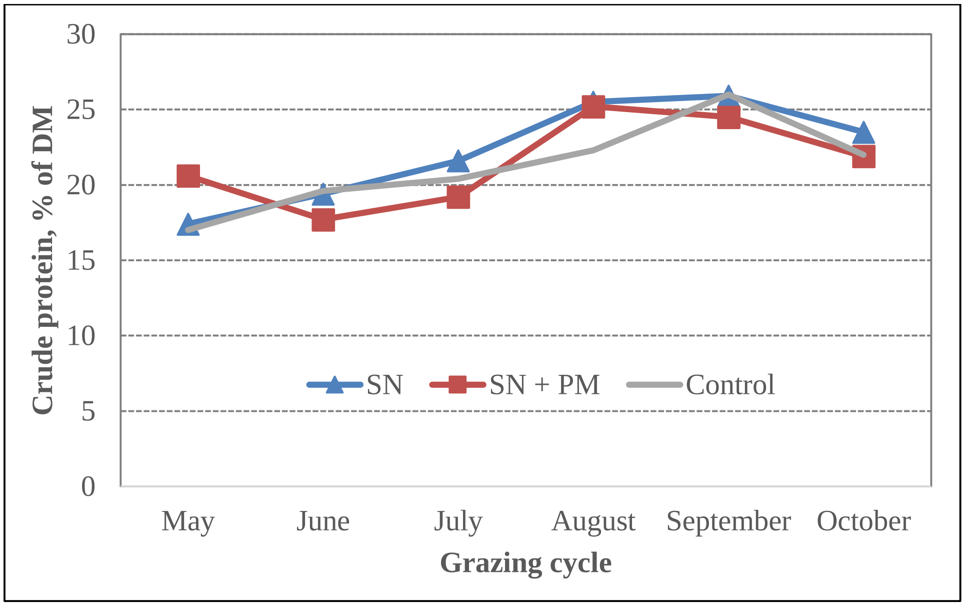

Figure 1. Trial 2 – The effect of fertilizer treatment and grazing cycle on crude protein (significantly different in July and August, p=0.10), St. Albans, VT, 2016.

It was possible that the dairy cattle would have preferentially grazed the plots containing SN, as they may have been attracted to the salt, however, there was no significant difference in quantity grazed between treatments (Table 11).

Table 11. Trial 2 – Quantity of pasture grazed, across all grazing cycles, St. Albans, VT, 2016.

Grazing cycle	Quantity grazed†	Height difference‡
	lbs ac^{-1}	cm
SN	612	2.69

SN + PM	466	1.96
Control	558	2.45
p-value	0.456	0.347
LSD	NS	NS
Trial mean	546	2.37

NS – There was no statistical difference between treatments in a particular column (p=0.10).
†Quantity grazed refers to the amount of pasture consumed, measured before and after grazing.
‡Height difference refers to the difference in pasture height, measured before and after grazing.

The fertilizer treatments did not consistently outperform the control for pasture nutrient concentrations (Table 12). Again the treatments were primarily applied to meet N needs of the pasture so an increase in other nutrients would not be expected. Interestingly the sodium content of SN treatments was significantly higher than the other treatments.

Table 12. Trial 2 – Pasture nutrient concentration comparing fertilizer treatments, across all grazing cycles, St. Albans, Vermont, 2016.

Treatment	Calcium		Phosphorus		Magnesium	Potassium	Sodium	
	% of DM	Rank	% of DM	Rank	% of DM	% of DM	% of DM	Rank
SN	0.817*	A	0.362	B	0.308	2.33	**0.119***	A
SN + PM	0.717	B	0.387	B	0.289	2.47	0.090	B
Control	**0.835***	A	**0.427***	A	0.305	2.38	0.070	B
p-value	0.010		0.0003		0.260	0.267	0.008	
LSD	0.067		0.025		NS	NS	0.026	
Trial mean	0.790		0.392		0.301	2.39	0.093	

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10).
Treatments with the same letter did not perform statistically different from each other
NS – There was no statistical difference between treatments in a particular column (p=0.10).

Trial 2 – Impact of Grazing Cycle on Pasture Yield and Quality

The pasture tended to improve in quality such that the best pasture performance was generally during the 5^{th} cycle of grazing, 24-Aug – 28-Sep (Table 13). During that time, pasture performed well for protein, NDF, NE_L, and yield compared to earlier in the season. May and July tended to be dry, which may have contributed to lower productivity and performance. The pasture may have improved by August and September because of a combination of increased rainfall and cooler weather. A fertility treatment was applied following the 4^{th} cycle of grazing and could have attributed to this increase in yield and quality. Also, it is possible that fertility applications that included PM had started to mineralize and have an impact on the yield and quality of the crop.

Table 13. Trial 2 – Pasture yield and quality comparing grazing cycles, across all treatments, St. Albans, VT, 2016.

Grazing cycle	Yield	CP	NDF	NE_L	RFV
	lbs ac^{-1}	% of DM	% of DM	Mcal lb^{-1}	
1-May – 1-Jun	1770	18.3	52.3	0.570	105
2-Jun – 23-Jun	1190	18.9	54.8	0.593	105
24-Jun – 25-Jul	876	20.4	50.3	0.625	121
26-Jul – 23-Aug	1020	24.3*	48.5	0.639*	123
24-Aug – 28-Sep	**2070***	**25.5***	46.8*	0.650*	129
29-Sep – 30-Oct	567	22.5	**45.2***	**0.659***	**138***
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
LSD	172	1.44	2.98	0.030	8.01
Trial mean	1240	21.6	49.7	0.623	120

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10).

The pasture's nutrient content was also generally the best for the 5th cycle of grazing from 24-Aug – 28-Sep (Table 14). Again this could have been due to better environmental conditions during that part of the season. Interestingly, sodium content of the forage was higher following addition of SN after the first and 4th grazing cycles.

Table 14. Trial 2 – Pasture nutrient concentration comparing grazing cycles, across all treatments, St. Albans, VT, 2016.

Grazing cycle	Calcium		Phosphorus		Magnesium		Potassium		Sodium	
	% of DM	Rank	% of DM	Rank	% of DM	Rank	% of DM	Rank	% of DM	Rank
1-May – 1-Jun	0.580	D	0.309	D	0.191	D	2.41	B	0.074	B
2-Jun – 23-Jun	0.894*	AB	0.368	C	0.290	C	2.37	BC	0.092*	AB
24-Jun – 25-Jul	**0.902***	A	0.353	C	**0.345***	A	2.26	BC	0.068	B
26-Jul – 23-Aug	0.738	C	0.425	B	0.329*	AB	2.18	C	0.087*	AB
24-Aug – 28-Sep	0.803	BC	**0.473***	A	0.338*	AB	**2.79**	A	0.114*	A
29-Sep – 30-Oct	0.823*	ABC	0.424	B	0.312	BC	2.33	BC	**0.123***	A
p-value	<0.0001		<0.0001		<0.0001		0.0001		0.086	
LSD	0.095		0.036		0.028		0.202		0.036	
Trial mean	0.790		0.392		0.301		2.39		0.093	

*Treatments marked with an asterisk were not statistically different than the top performing treatment shown in **bold** (p=0.10).
Treatments with the same letter did not perform statistically different from each other

The crop nutrient recommendations based on the soil test appear in Table 15. In general, the highest amount of N applied came from the SN+PM treatment. It should be noted that although the PM application contained 71 lbs ac^{-1} of actual N, only roughly one third of that total would be plant available in the first year. Hence, the crop likely received approximately 60 additional lbs of N ac^{-1}. This was still double that applied as SN or PM alone. It makes sense that this combined treatment would likely provide a yield and quality boost to the pasture.

Table 15. Nutrient balance from the sodium nitrate treatment, St. Albans, Vermont, 2016.

		Nitrogen	Phosphorus	Potassium
		lbs ac^{-1}	lbs ac^{-1}	lbs ac^{-1}
Soil test recommendation	**Pasture, intensive grazing**	100	25	140
Nutrients supplied	**SN treatment**	29.0	0	0
Nutrient balance	**SN treatment**	-71.0	-25	-140
Nutrients supplied	**PM treatment**	71.9	57.5	43.1
Nutrient balance	**PM treatment**	-28.1	+22.5	-96.9
Nutrients supplied	**SN + PM treatment**	100.9	57.5	43.1
Nutrient balance	**SN + PM treatment**	+0.9	+22.5	-96.9

With pelletized PM priced at \$0.25 lb^{-1} and SN priced at \$0.53 lb^{-1}, the price to fertilize per acre is listed in Table 16. The cost per pound of applied N is \$3.31 for SN, \$5.00 for PM, and \$4.51 for SN+PM. Some of these fertilizer treatments may be feasible for pasture-based dairy farmers, however, one also needs to consider the amount of time taken to apply the fertilizer and one would want to verify the potential benefit of the application.

Table 16. Costs for each fertilizer treatment, St. Albans, Vermont, 2016.

Treatment	Product applied	Cost
	lbs ac^{-1}	\$ ac^{-1}
Sodium nitrate (SN) 16-0-0	181	96.1
Kreher's poultry manure (PM) 5-4-3	1438	360
Sodium nitrate (SN) 16-0-0 **AND** Kreher's poultry manure (PM) 5-4-3	181 1438	455

These results only represent one year of data at one location. Because the growing season was generally dry, this may have largely affected results of the study. This trial aimed to evaluate improving pasture productivity by targeting soil fertility, while avoiding an over-application of P. The cost of purchased N sources in organic systems may outweigh the benefit realized from the application. In this study, a small increase was seen in yield and quality compared to no additional N amendments (outside of farm manure). The most cost effective way to improve pasture yields and reduce N requirements of pasture is to maintain legumes in the pasture mix. More research is needed to evaluate best fertility management strategies for this situation.

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