NORTHWEST CROPS & SOILS PROGRAM

2015 Vegetable Fertility Management Trial

Dr. Heather Darby, UVM Extension Agronomist
Abha Gupta, Lily Calderwood, Erica Cummings, Julian Post, and Sara Zieglar
UVM Extension Crops and Soils Technicians
802-524-6501

Visit us on the web: http://www.uvm.edu/extension/cropsoil

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2015 VEGETABLE FERTILITY MANAGEMENT TRIAL

Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

INTRODUCTION

Many organic vegetable producers have been relying heavily on livestock composts as a source of fertility on farm. Often, high rates of compost are applied to meet the nitrogen (N) needs of crops. When this strategy is implemented it can lead to over application of phosphorus (P) and potassium (K). As an example, a grower may apply poultry manure at 6 tons ac^{-1} for 3 consecutive years. This contributes 225 lbs ac^{-1} of P per year, where vegetable crop removal of P ranges from 10-80 lbs ac^{-1} per season. In this scenario, there is an over application of P, leading to an excess of 900 lbs ac^{-1} in 3 years in cases where the soil already had sufficient P levels. After multiple seasons of using composts, P levels may accumulate in the soil to the point where applying additional P poses an environmental risk to nearby waterways. Phosphorus loading and associated risk depends on soil type, slope, and proximity to water. However, with impending water quality regulations, farmers will be required to account for their nutrient balance.

There are few alternative fertilizer options for organic growers that primarily provide N with limited P and K. Sodium nitrate (SN), also known as Chilean nitrate, is a high N fertilizer that is mined from natural deposits of caliche ore found in the Atacama Desert of northern Chile. Organic growers have been attracted to SN because its N is 100% plant available, even in cold, early season soils, which makes SN especially desirable in regions with cool spring weather, like Vermont. There are few alternative, organic options that can quickly provide N to plants.

SN has been a highly valued fertilizer for organic growers, however, it may be less available as an organic option in the future. The goal of this research project was to evaluate the advantages of using SN and blood meal, another organic-approved N fertilizer alternative, in cool, early season soils for heavy N feeding vegetable crops. The two crops studied were sweet corn and cabbage. Sweet corn was chosen because it has difficulty germinating in cold soils without threat of fungal damage. Cabbage was chosen since many organic vegetable producers grow it as an early season, spring planted crop.

MATERIALS AND METHODS

The trial was conducted at Borderview Research Farm in Alburgh, VT. The experimental design was a randomized complete block with four replications for both crops. The cabbage variety, ‘Farao,’ was transplanted on 7-May. The sweet corn variety, ‘My Fair Lady,’ was seeded on 29-May. Plots were 5’ x 10’ for the cabbage and 10’ x 20’ for the sweet corn. Cabbage was spaced 30” between rows and 12” within the row. Sweet corn was thinned to 22,000 seeds/acre. The previous crop was flax. The field was rototilled prior to planting using a skid steer. General plot management is listed in Table 1.

Main plots were fertilizer treatments of 1) SN (16-0-0) as starter fertilizer to meet 20% of the N needs and Kreher’s poultry manure (5-4-3) to meet the remaining 80% of the N needs, 2) blood meal (12-0-0) as starter fertilizer to meet 20% of the N needs and Kreher’s poultry manure to meet the remaining 80% of the N needs, and 3) a control of Kreher’s composted poultry manure alone to meet 100% of the N needs (see Tables 2 and 3 for fertilizer rates). The third treatment was considered a grower control, representing poultry manure application rates commonly used on organic vegetable operations in VT. Poultry manure was applied and incorporated on 5-May. SN and blood meal starter fertilizer was incorporated around the base of each plant during cabbage transplant (7-May) and at the V1 stage for sweet corn (15-Jun). Fertilizer rates were adjusted based off of estimated plant available N (PAN) rates at 70 days, which were determined from a lab incubation study. Blood meal has 53.2% PAN, SN has 84.1% PAN, and Kreher’s composted poultry manure has 23.4% PAN at 70 days after incorporation.

For both crops, soil nitrate samples were taken every two weeks until harvest. Soil temperature was continuously measured after seeding and transplanting and soil moisture was measured weekly. The cupping date for cabbage (start of head formation) was 12-Jun (Table 2). The middle four heads of cabbage per plot were harvested by hand on 2-Jul. At harvest, the following quality standards were measured: uniformity was measured visually over the entire plot to estimate whether all the heads were maturing at the same time and whether there were abnormalities, using a 1 (low uniformity) - 9 (high uniformity) scale; head solidity was measured visually and by touch over the four middle heads, using a 1 (less solid) – 9 (more solid) scale; weight of each head harvested was measured; leaf thickness of the outer, wrapper leaf was measured for each harvested head using a digital caliper; tipburn was measured by cutting each head longitudinally and examining the young, inner leaves for necrotic margins and noted as either present or absent; and percent moisture was measured by sampling approximately 1 cup of each of the four heads harvested, chopping the cabbage in a food processor, and then taking approximately ½ cup of the chopped cabbage to weigh before and after drying in an oven.

The corn tasseling date was 31-Jul and the silking date was 2-Aug for sweet corn in all treatments (Table 3). Just prior to harvest, populations were counted and plant height and ear height were measured from the middle two rows only. Sweet corn was harvested by hand on 24-Aug from the middle two rows. At harvest, stalk nitrate was measured by taking 8" stalk samples 6" above the ground level. Samples were sent to Dairy One laboratory for analysis. Percent moisture was measured by shaving kernels off of 3 ears per plot, making a slurry of the kernels in a food processor, and then taking approximately ¼ cup of the slurry to weigh before and after drying in a microwave. The number of ears in the middle two rows of corn was recorded. Also, the ear length, ear diameter, length of unfilled tip, husked corn ear weight, and unhusked corn ear weight were measured for 10 randomly selected ears from the middle two rows of corn per plot. Northern corn leaf blight and rust were measured visually over the middle two rows of corn and rated on a 0-5 disease severity scale.

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 ($p < 0.10$).

Table 1. General plot management, 2015.

Trial Information	Borderview Research Farm Alburgh, VT
Soil Type	Nellis silt loam 3-8% slope Covington silty clay loam 0-3% slope
Previous crop	Flax
Tillage methods	Rototiller

Table 2. Cabbage plot information, 2015.

Cabbage Information	Borderview Research Farm Alburgh, VT
Variety	Farao
Nutrient requirements	160 lbs ac^{-1} nitrogen
Fertilizer Treatments	Treatment 1: Sodium nitrate as a starter fertilizer Sodium nitrate (16-0-0) 237.8 lbs ac^{-1} Poultry manure (5-4-3) 10940.2 lbs ac^{-1} Boron: 2 lbs ac^{-1} Treatment 2: Blood meal as a starter fertilizer Blood meal (12-0-0) 501.3 lbs ac^{-1} Poultry manure (5-4-3) 10940.2 lbs ac^{-1} Boron: 2 lbs ac^{-1} Treatment 3: No starter fertilizer Poultry manure (5-4-3) 13675.2 lbs ac^{-1} Boron: 2 lbs ac^{-1}
Planting dates	7-May
Fertilizer dates	5-May poultry manure 7-May blood meal, sodium nitrate, boron
Cupping date	12-Jun
Harvest date	2-Jul
Plant spacing	30" x 12"

Table 3. Sweet corn plot information, 2015.

Sweet Corn Information	Borderview Research Farm Alburgh, VT
Variety	My Fair Lady
Nutrient requirements	115 lbs ac^{-1} nitrogen
Fertilizer Treatments	Treatment 1: Sodium nitrate as a starter fertilizer Sodium nitrate (16-0-0) 170.9 lbs ac^{-1} Poultry manure (5-4-3) 7863.2 lbs ac^{-1} Treatment 2: Blood meal as a starter fertilizer Blood meal (12-0-0) 360.3 lbs ac^{-1} Poultry manure (5-4-3) 7863.2 lbs ac^{-1} Treatment 3: No starter fertilizer Poultry manure (5-4-3) 13675.2 lbs ac^{-1}
Planting dates	7-May, reseeded 29-May
Fertilizer dates	5-May poultry manure 15-Jun blood meal, sodium nitrate, boron
Tasseling date	31-Jul
Silking date	2-Aug
Harvest date	24-Aug
Plant spacing	22,000 seeds ac^{-1}

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 the example below, 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

The soil where this experiment took place had a pH of 7.8, organic matter at 4.0%, an optimum level of P at 5.8 ppm, and a medium level of K at 77 ppm.

Seasonal precipitation and temperature was recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT. June was a wet month with 2.73 more inches of precipitation than normal (Table 4, Figure 2). The remainder of summer was relatively dry with 6.61 fewer inches of precipitation than normal over July and August. Temperature varied with May being much warmer than the 30 year average. Overall, there were an accumulated 2053 Growing Degree Days (GDDs) April – August (Figure 1), approximately 159 more than the historical average.

Table 4. Seasonal weather data[1] collected in Alburgh, VT, 2015.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	43.4	61.9	63.1	70.0	69.7
Departure from normal	-1.4	5.5	-2.7	-0.6	0.9
Precipitation (inches)	0.09	1.94	6.42	1.45	0.00
Departure from normal	-2.73	-1.51	2.73	-2.70	-3.91
Growing Degree Days (base 50°F)	22	376	399	630	626
Departure from normal	22	177	-75	-10	45

[1]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.

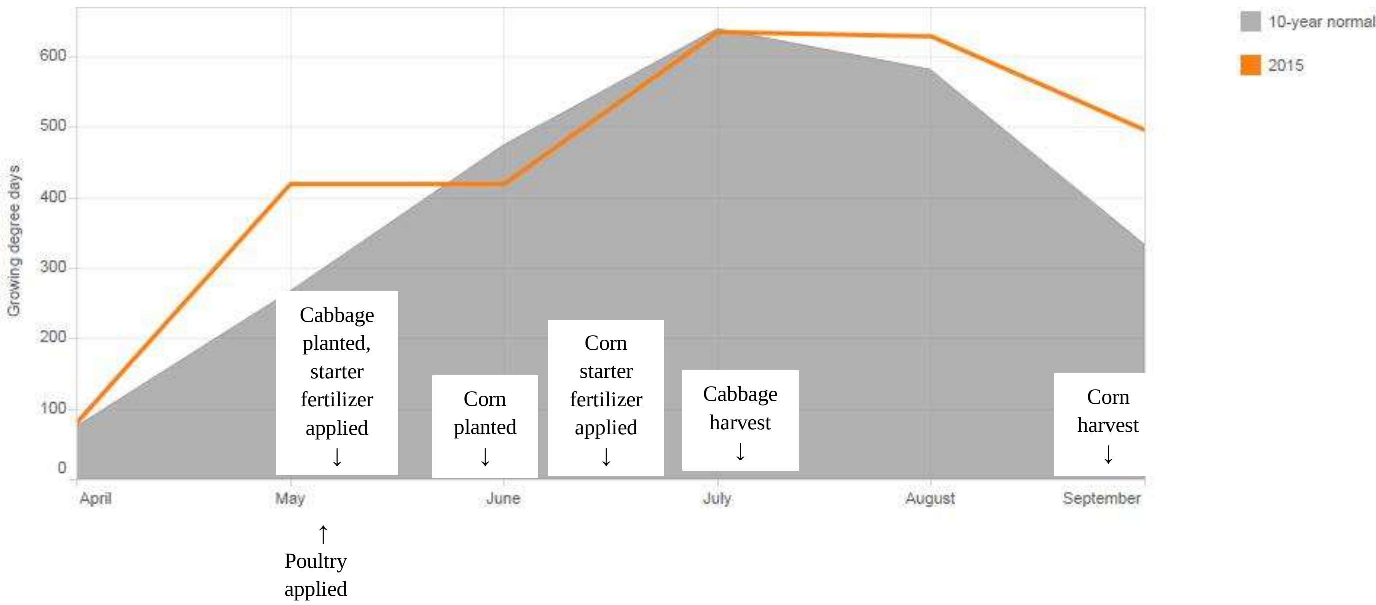

Figure 1. Growing degree day information, Alburgh, VT, 2015.

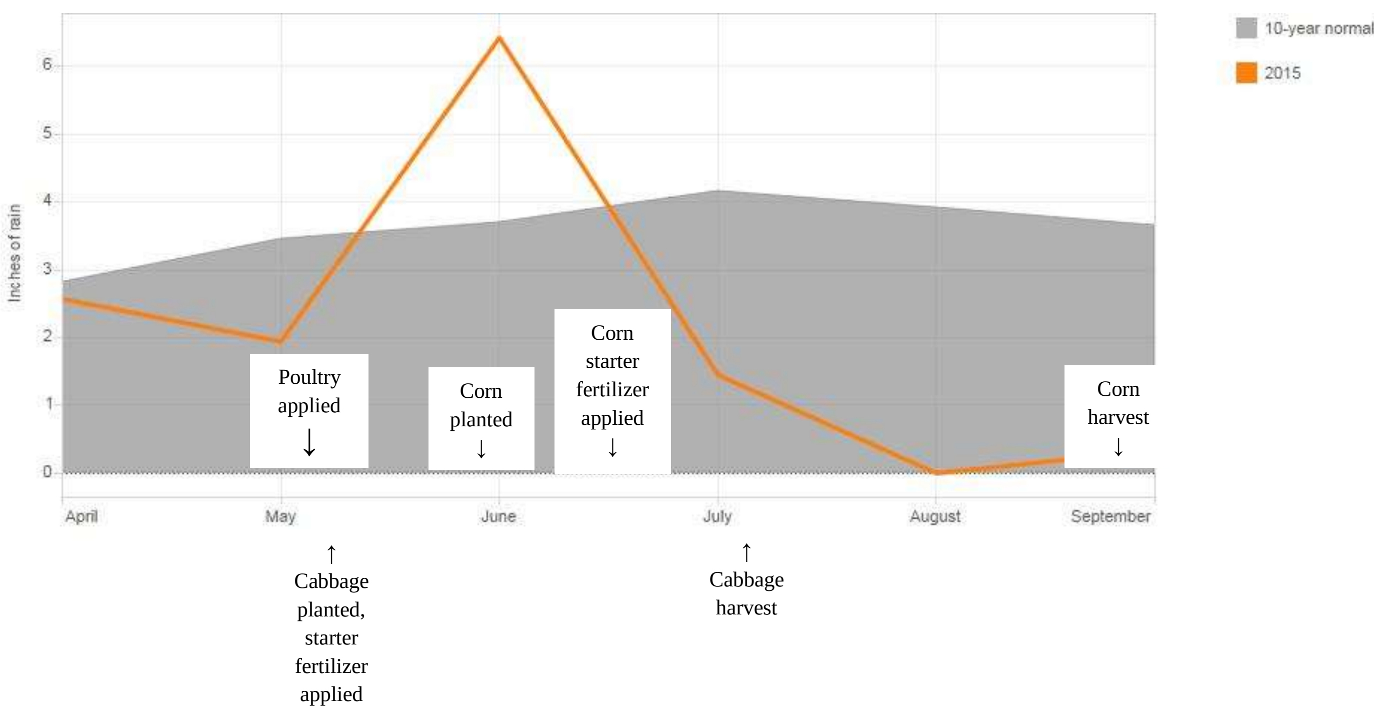

Figure 2. Seasonal precipitation information, Alburgh, VT, 2015.

Cabbage Trial

Uniformity, tipburn, solidity, percent moisture, and average leaf thickness showed no significant difference between treatments (Table 5). The fertility treatments did not significantly impact cabbage yield (Table 6).

Table 5. Cabbage harvest quality data, Alburgh, VT, 2015.

Treatment	Uniformity 1= low, 9= high	Tipburn 1= present, 0= absent	Solidity 1= less dense, 9= more dense	Moisture %	Leaf thickness micrometer
1	7.5	0.00	6.0	85.7	219
2	7.5	0.06	6.0	85.5	219
3	7.3	0.00	5.5	85.2	219
p-value	0.87	0.44	0.88	0.59	0.56
LSD (0.10)	NS	NS	NS	NS	NS

NS – There was no statistical difference between treatments in a particular column (p=0.10).

Table 6. Cabbage harvest yield data, Alburgh, VT, 2015.

Treatment	Average head weight lbs	Yield wet tons ac^{-1}
1	3.8	26.5
2	4.0	27.8
3	3.4	23.7
p-value	0.14	0.14
LSD (0.10)	NS	NS

NS – There was no statistical difference between treatments in a particular column (p=0.10).

Sweet Corn Trial

Husked/unhusked weight per ear, ear length, ear height, ear diameter, unfilled tip length, plant height, percent moisture, uniformity, rust, and Northern corn leaf blight showed no significant difference between treatments (Tables 7 & 8). The number of harvested ears and yield did not differ significantly between fertilizer treatments in the sweet corn (Table 9). The population per acre was significantly lower for treatment 1, using sodium nitrate, and closer to the targeted 22000 seeds ac-1, as compared to the blood meal (treatment 2) and control (treatment 3) (Table 9). The corn stalk nitrate in the blood meal was significantly lower than the control, however, the control did not differ significantly from the SN treatment (Table 9, Figure 3).

Table 7. Sweet corn harvest quality data, Alburgh, VT, 2015.

Treatment	Husked weight per ear lbs	Unhusked weight per ear Lbs	Ear length cm	Ear height cm	Ear diameter cm	Unfilled tip cm
1	0.69	0.52	18.6	51	4.6	1.9
2	0.71	0.54	18.8	56	4.6	2.0
3	0.72	0.55	18.9	53	4.6	2.1
p-value	0.43	0.54	0.43	0.68	0.97	0.64
LSD (0.10)	NS	NS	NS	NS	NS	NS

NS – There was no statistical difference between treatments in a particular column (p=0.10).

Table 8. Sweet corn harvest quality data, continued, Alburgh, VT, 2015.

Treatment	Plant height cm	Moisture %	Uniformity 1= low, 9= high	Rust 0=less severe, 5=more severe	Northern corn leaf blight 0=less severe, 5=more severe
1	211	69.5	4.8	1.0	0.3
2	205	70.1	4.5	1.0	0.0
3	209	69.1	5.3	1.3	0.0
p-value	0.67	0.88	0.83	0.44	0.44
LSD (0.10)	NS	NS	NS	NS	NS

NS – There was no statistical difference between treatments in a particular column (p=0.10).

Table 9. Sweet corn harvest data, Alburgh, VT, 2015.

Treatment	Harvested ears plot^{-1}	Harvest population ac^{-1}	Yield tons ac^{-1}	Stalk nitrate ppm
1	32	20909	4.5	1796
2	38	27878	5.8	1250
3	41	26354	6.3	2490
p-value	0.27	0.09	0.16	0.04
LSD (0.10)	NS	5349	NS	718

NS – There was no statistical difference between treatments in a particular column (p=0.10).

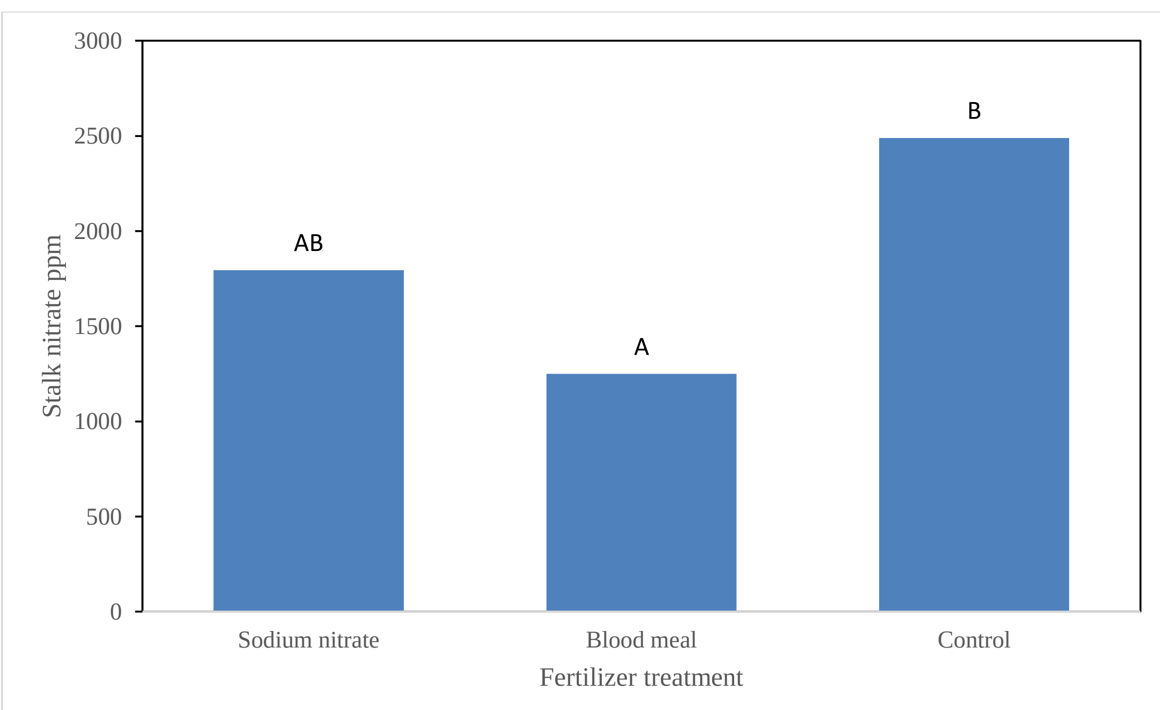

Figure 3. Sweet corn stalk nitrate, Alburgh, VT.
Treatments with the same letter did not differ significantly from each other.

Trial results were likely affected by unseasonal weather conditions. A goal of this research was to trial SN as an early season fertilizer, in cool, spring soils, however, with May experiencing 177 more growing degree days than the historical average, those conditions were not met. June experienced nearly 3 inches more rain than the historical average, while the rest of the season was dry. Heavy rainfall in June likely led to the loss of some N from all treatments but likely more so from the SN that was applied during this month.

Poultry manure was used as the base fertilizer in the SN and blood meal treatments and as the total source of fertility for the control treatment in order to replicate the fertility management strategy many organic vegetable producers use. See Table 10 for overall nutrient information per treatment. It is important to note that using poultry manure may not be the best fertility choice, considering it may provide excess K and P, which may in turn lead to environmental damage. Also, it is important to consider the cost of fertilizers on a price per pound of N basis (Table 11). SN provides the biggest economical advantage as a N source. Growers may find that organic fertilizers that are concentrated in N, without additional nutrients, will be a good fit for their crop and land needs as well as being able to meet environmental goals and regulations. Future research will be geared towards defining fertility strategies that allow farmers to balance nutrient needs of their crops with environmental goals set forth by state regulations and the USDA NOP.

Table 10. Nutrient rates in the three fertilizer treatments, Alburgh, VT, 2015.

Treatments	Total nitrogen	Plant available nitrogen*	Phosphorus	Potassium
	lbs ac^{-1}	lbs ac^{-1}	lbs ac^{-1}	lbs ac^{-1}
Cabbage				
1	583	160	436	327
2	605	160	436	327
3	684	160	547	410
Sweet Corn				
1	420	115	314	236
2	436	115	314	236
3	491	115	392	295

*Estimated plant available nitrogen rates were determined from a lab incubation study.

Table 11. Cost of each of the three fertilizers based on total nitrogen.

Fertilizer	Per pound of product	Per pound of nitrogen
	$	$
Sodium nitrate	0.53	3.31
Blood meal	1.60	13.33
Poultry manure	0.25	5.00

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank the SQM Company for funding this research. Special thanks to Roger Rainville and the staff at Borderview Research Farm for their generous help with the trials. We would like to acknowledge Julija Cubins, Hillary Emick, Lindsey Ruhl, and Dan Ushkow for their assistance with data collection and entry. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

UVM Extension helps individuals and communities put research-based knowledge to work.