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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

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The UNIVERSITY of VERMONT EXTENSION

**2012 THE EFFECTS OF TOPDRESSING ORGANIC NITROGEN ON HARD RED WINTER WHEAT**

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The demand for local organic food is steadily increasing throughout Vermont and New England. Consumers are asking for bread baked with locally grown wheat; however, bakers have been slow to incorporate local wheat flour because of the challenges associated with obtaining grains that consistently meet bread-baking standards. Addressing the quality issue is essential for expanding the bread flour market in the northeast. One of the major quality factors facing Vermont grain producers is protein content. Much of the winter wheat currently produced in Vermont has protein levels below what most commercial mills would consider suitable for flour production. Commercial mills prefer to buy wheat with crude protein (CP) concentrations of 12-15%. Higher protein levels generally improve baking characteristics. In 2012, the University of Vermont Extension established a trial at Borderview Research Farm in Alburgh, VT to evaluate if winter wheat yield and protein could be improved by topdressing with various organic nitrogen (N) sources at key developmental stages. This trial is one of several in a USDA Organic Research Education Initiative grant focused on the production of high quality organic bread wheat in New England.

## MATERIALS AND METHODS

The seedbed in Alburgh was prepared by conventional tillage methods. All plots were managed with practices outlined in Table 1. The plots were seeded with a Sunflower 9412 no-till planter, 7 inch spacing double disc opener 10 foot grain drill. The plots were seeded with hard red winter wheat (var 'Harvard') on 27-Sep 2011. The prior crop in 2011 was winter wheat. Population and vigor were measured on 26-Oct 2011. Populations were determined by taking three, 0.3 meter counts per plot. Vigor was based on a visual rating with a 0 – 5 scale, where 5 represents excellent stand density, and 0 represents no stand.

**Table 1. General plot management of the winter wheat topdressing trial, Alburgh, VT.**

| Trial Information | Winter Wheat Topdress Trial |
|---|---|
| **Location** | Alburgh, VT<br>Borderview Research Farm |
| **Soil type** | Benson rocky silt loam |
| **Previous crop** | Winter wheat |
| **Row spacing (in.)** | 7 |
| **Seeding rate (lbs ac$^{-1}$)** | 140 |
| **Variety** | Harvard |
| **Replicates** | 4 |
| **Planting date** | 27-Sep 2011 |
| **Harvest date** | 7-Jul 2012 |
| **Harvest area (ft.)** | 5 x 30 |
| **Tillage operations** | Fall plow, disc, & spike-toothed harrow |

The experimental design was a randomized complete block design with ten treatments replicated 4 times. The treatments included an unamended control as well as two rates of fall applied composted cow manure. These treatments represented standard winter wheat production practices of local farms. The composted cow manure was applied on 27-Sep 2011, incorporated immediately; the seedbed was then prepped and the plots planted. The composted cow manure was applied at two rates to provide either 70lbs ac$^{-1}$ or 140lbs ac$^{-1}$of plant available N for the wheat crop. The other treatments included organic N topdress treatments of 'Pro-Booster' (10% N) or 'Chilean Nitrate' (16% N) hand applied at the rates of 35lbs ac$^{-1}$ or 70lbs ac$^{-1}$ of plant available N for the crop. 'Pro-Booster' (PB) is an OMRI approved fertilizer manufactured for North Country Organics in Bradford, VT. The blended fertilizer is composed of vegetable and animal meals and natural nitrate of soda. It has a guaranteed analysis of 10-0-0. Natural Nitrate of Soda, more commonly known as 'Chilean Nitrate' (CN), is an OMRI fertilizer and has a guaranteed analysis of 16-0-0. These organic N topdress treatments were applied at spring green-up (GS25), pre-stem extension (GS30), or at both these growth stages (Table 2). On 12-Apr 2012 the GS25amendments were applied, and the GS30 treatments were applied on 26-Apr.

Plots were sampled for soil nitrates and plant nitrogen concentration prior to organic N applications and at key developmental stages until the wheat reached physiological maturity (Image 1). From each plot a composite of 10 soil cores (1 inch dia., 12 inch depth) was taken, placed on ice, and transported to the testing laboratory on the day of sampling. Soil nitrates were measured using flow injection analysis. Plant samples were taken to determine total nitrogen concentration by combustion analysis at the same time as soil sampling. The tissue samples consisted of 4 rows of wheat top growth, 12 inches in length selected randomly within each plot. Samples were put into clean paper bags, placed on ice, and transported directly to the laboratory for analysis. All soil was analyzed at University of Vermont's Agricultural and Environmental testing laboratory in Burlington, VT. Plant samples were sent to Cumberland Valley Analytical Services in Hagerstown, MD for analysis.

**Table 2. Application rates and timings of organic N amendments and total amount of N applied, Alburgh, VT.**

| Treatments | Pre-plant Manure | Spring greenup (GS25) | Pre-stem extension (GS30) | Total N applied |
|---|---|---|---|---|
| | lbs ac$^{-1}$ | lbs ac$^{-1}$ | lbs ac$^{-1}$ | lbs ac$^{-1}$ |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 70(CN) | 0 | 70 |
| 3 | 70 | 0 | 0 | 70 |
| 4 | 70 | 0 | 35(CN) | 105 |
| 5 | 70 | 35(CN) | 0 | 105 |
| 6 | 70 | 35(CN) | 35(CN) | 140 |
| 7 | 70 | 35(PB) | 0 | 105 |
| 8 | 70 | 0 | 35(PB) | 105 |
| 9 | 140 | 0 | 0 | 140 |
| 10 | 140 | 0 | 35(CN) | 175 |

**Image 1. Plant and soil sampling, Alburgh, VT.**

On 16-Apr, the numbers of tillers were counted in two 12 inch segments randomly selected within each plot in order to determine tiller density (tillers per square foot).

On 2-Jul, after the wheat had reached physiological maturity and was in the process of drying down, plant heights were measured excluding the awns and the number of spikes counted from a plant biomass sampling of 4 randomly selected 12 inch segments per plot.

Plots were harvested with an Almaco SPC50 plot combine on 11-Jul; the harvest area was 5' x 30'. At the time of harvest, grain moisture, test weight, and plot yields were measured (Image 2).

Following harvest, seed was cleaned with a small Clipper cleaner (A.T. Ferrell, Bluffton, IN). An approximate one pound subsample was collected to determine quality. Quality measurements included standard testing parameters used by commercial mills. Test weight was measured by the weighing of a known volume of grain. Generally the heavier the wheat is per bushel, the higher baking quality. The acceptable test weight for bread wheat is 56-60 lbs per bushel. Once test weight was determined, the samples were then ground into flour using the Perten LM3100 Laboratory Mill. At this time flour was evaluated for its protein content, falling number, and mycotoxin levels. Grains were analyzed for protein content using the Perten Inframatic 8600 Flour Analyzer. Grain protein affects gluten strength and loaf volume. Most commercial mills target 12-15% protein. The determination of falling number (AACC Method 56-81B, AACC Intl., 2000) was measured on the Perten FN 1500 Falling Number Machine. The falling number is related to the level of sprout damage that has occurred in the grain. It is measured by the time it takes, in seconds, for a stirrer to fall through a slurry of flour and water to the bottom of the tube. Falling numbers greater than 350 indicate low enzymatic activity and sound quality wheat. A falling number lower than 200 indicates high enzymatic activity and poor quality wheat. Deoxynivalenol (DON) analysis was analyzed using Veratox DON 5/5 Quantitative test from the NEOGEN Corp. This test has a detection range of 0.5 to 5 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption.

Mixed-model analysis was calculated using PROC MIXED procedure of SAS. Mean separation among treatments involving fertilizer source and timing of application were obtained using the LSMEANS procedure when the F-test was 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 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 (e.g. yield). Least Significant Differences at the 10% level of probability are shown. Where the difference between two varieties 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. Wheat varieties that were not significantly lower in performance than the highest variety in a particular column are indicated with an asterisk. In the example below, variety A is significantly different from variety C but not from variety B. The difference between A and B is equal to 725 which is less than the LSD value of 889. This means that these varieties did not differ in yield. The difference between A and C is equal to 1454 which is greater than the LSD value of 889. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that variety B was not significantly lower than the top yielding variety.

| Variety | Yield |
|---|---|
| A | 3161 |
| B | 3886* |
| C | **4615*** |
| **LSD** | **889** |

## RESULTS

Seasonal precipitation and temperature recorded at weather stations in close proximity to the 2012 site are shown in Table 3. This year's growing season was marked by higher than normal temperatures and less than normal rainfall, starting in the fall of 2011 and continuing through the harvest in July of 2012. From planting to harvest in Alburgh, there was an accumulation of 5732 Growing Degree Days (GDD), which is 692 GDDs higher than the 30 year average.

**Table 3. Temperature and precipitation summary for Alburgh, VT, 2011 and 2012.**

| Alburgh, VT | Sept. 2011 | Oct. 2011 | Nov. 2011 | Mar. 2012 | Apr. 2012 | May 2012 | June 2012 | July 2012 |
|---|---|---|---|---|---|---|---|---|
| Average Temperature (F) | 62.8 | 50.1 | 43.4 | 39.7 | 44.9 | 60.5 | 67.0 | 71.4 |
| Departure from Normal | 2.20 | 1.90 | 5.20 | 8.60 | 0.10 | 4.10 | 1.20 | 0.80 |
| | | | | | | | | |
| Precipitation (inches) * | 5.56 | 3.52 | 1.41 | 1.46 | 2.64 | 3.90 | 3.22 | 3.78 |
| Departure from Normal | 1.92 | -0.08 | -1.71 | -0.75 | -0.18 | 0.45 | -0.47 | -0.37 |
| | | | | | | | | |
| Growing Degree Days (base 32) | 932 | 578 | 344 | 331 | 396 | 884 | 1046 | 1221 |
| Departure from Normal | 74.0 | 76.0 | 142 | 205 | 12.0 | 128 | 32.0 | 23.0 |

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 June-September 2012 is based on Northeast Regional Climate Center data from an observation station in Burlington, VT.

**<u>Soil & Plant Nitrogen</u>:**

Soil and plant biomass nitrogen analysis have yet to be completed. The samples are currently at the lab and data will be completed by the termination of this project.

## **Wheat Yield and Quality**:

The treatments differed significantly in yield (Table 4; Figure 1). The highest yielding treatment was 70lbs $ac^{-1}$ of Chilean Nitrate applied at spring greenup (GS25) with 3845lbs $ac^{-1}$. The unamended control treatment (2244lbs $ac^{-1}$) yielded less than Chilean Nitrate treatments applied at GS30 GS25 at the 70 and 35 lbs $ac^{-1}$. Interestingly, there were no significant differences in grain moisture and test weight. The treatments differed in protein concentration (Table 4; Figure 2). 'Pro-Booster' treatments and Chilean Nitrate applied at both GS25& GS30 stages had the highest protein levels. Fall manure applications and the unamended control treatments did not differ in CP concentrations. Interestingly, the protein level of 'Chilean Nitrate' applied at GS25was not significantly different than the fall applied manure or the unamended control plots. The average protein level was 11.5%. Treatments did not differ significantly in falling number or DON.

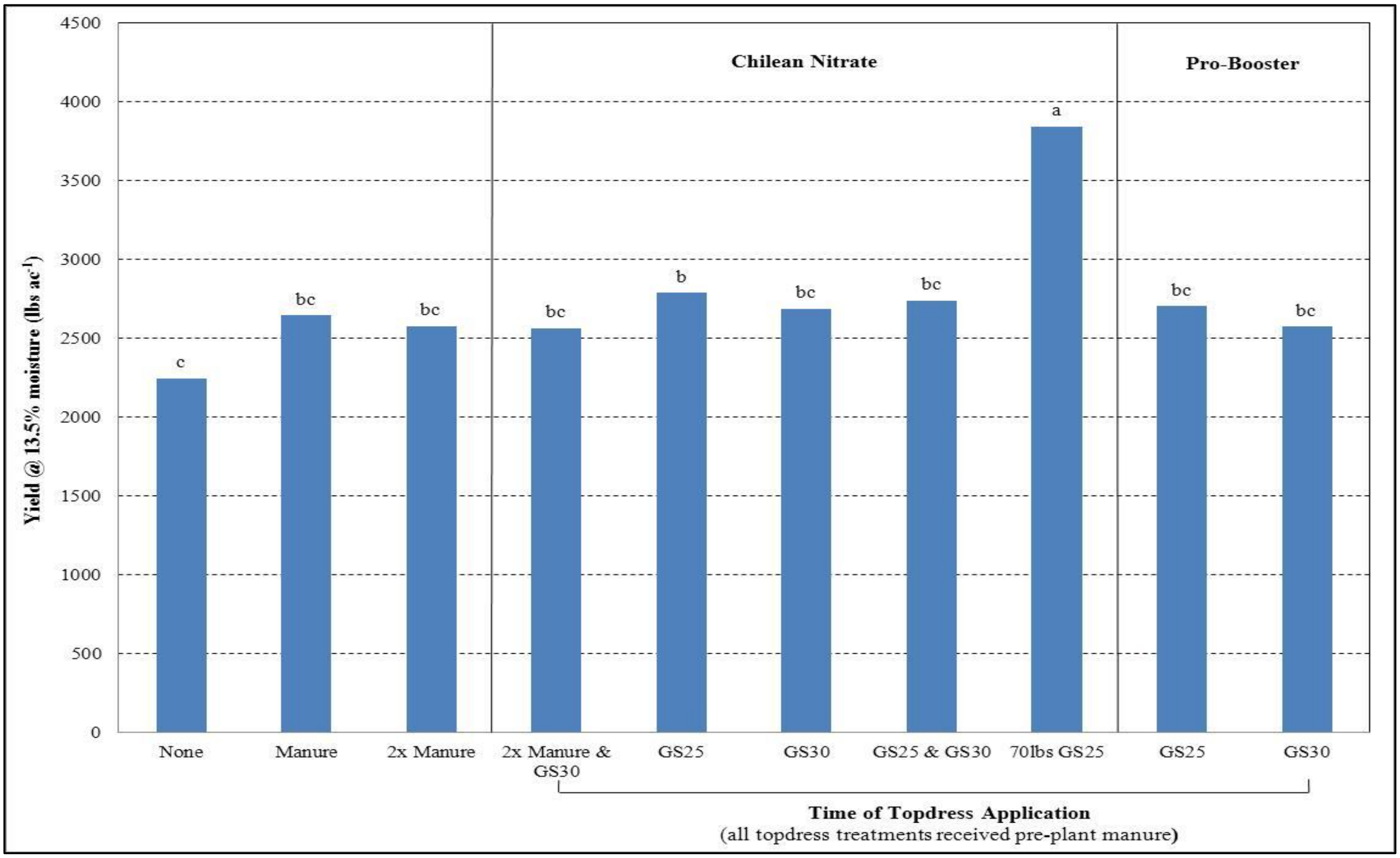
**Image 2. Winter wheat N topdress trial harvest, Alburgh, VT.**

**Table 4. The results of fertility type and application timing on wheat harvest and quality.**

| Fertility Type | Time of Application | | | | Quality | | | |
|---|---|---|---|---|---|---|---|---|
| | | Yield | Moisture | Test weight | Crude protein @ 12% moisture | Crude protein @ 14% moisture | Falling number | DON |
| | | lbs $ac^{-1}$ | % | bu $ac^{-1}$ | % | % | seconds | ppm |
| 35lbs $ac^{-1}$ Chilean Nitrate | GS30 | 2686 | 15.8 | **60.1** | 11.3 | 11.1 | 323 | **0.28** |
| 35lbs $ac^{-1}$ Chilean Nitrate | GS25 | 2787 | 16.0 | 59.0 | 11.2 | 11.0 | 325 | 0.30 |
| 35lbs $ac^{-1}$ Chilean Nitrate | Both (GS25 & GS30) | 2738 | 15.5 | 58.3 | 12.2* | 11.9* | **338** | 0.33 |
| 35lbs $ac^{-1}$ Pro-Booster | GS30 | 2573 | 16.3 | 58.5 | **12.7*** | **12.4*** | 332 | 0.38 |
| 35lbs $ac^{-1}$ Pro-Booster | GS25 | 2702 | 16.9 | 59.0 | 12.1* | 11.8* | 334 | 0.35 |
| 70 lbs $ac^{-1}$ Chilean Nitrate | GS25 | **3845** | **15.0** | 58.1 | 11.8 | 11.6 | 316 | 0.38 |
| 2x Manure & 35lbs $ac^{-1}$ Chilean Nitrate | Fall 2011 & GS30 | 2562 | 15.6 | 58.3 | 11.8 | 11.5 | 324 | **0.28** |
| 2x Manure | Fall 2011 | 2575 | 15.3 | 59.5 | 10.8 | 10.5 | 320 | 0.35 |
| Manure | Fall 2011 | 2644 | 15.4 | 59.8 | 10.6 | 10.4 | 307 | 0.30 |
| None | Control | 2244 | 16.0 | 58.9 | 10.6 | 10.4 | 312 | 0.40 |
| *LSD (0.1)* | | 502 | NS | NS | 0.65 | 0.63 | NS | NS |
| *Trial means* | | 2735 | 15.8 | 58.9 | 11.5 | 11.2 | 323 | 0.33 |

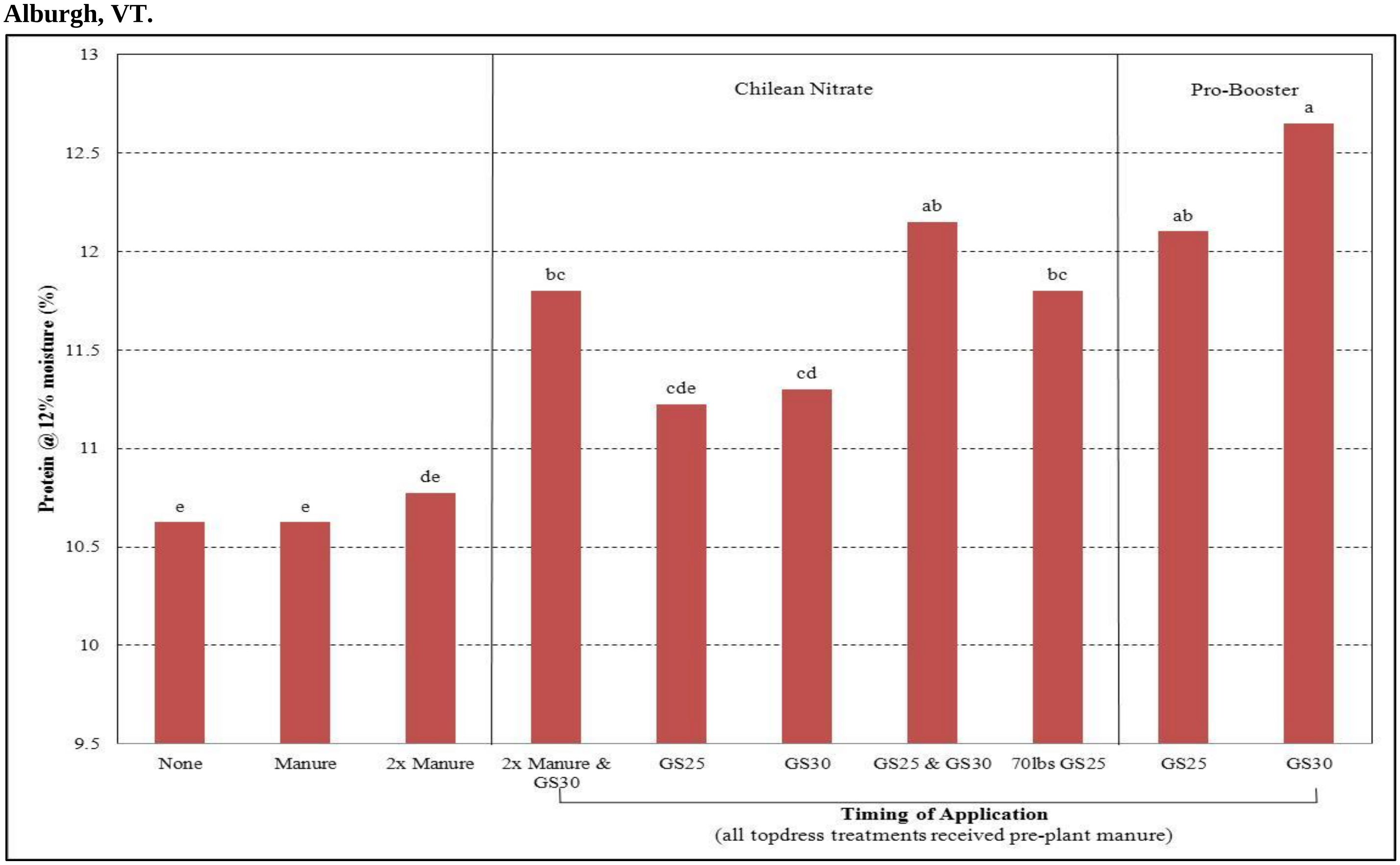
Values shown in bold are of the highest value or top performing.
* Wheat that did not perform significantly lower than the top performing variety in a particular column is indicated with an asterisk.
NS - None of the varieties were significantly different from one another.

**Figure 1. Yield impact of topdressing organic N sources at critical wheat developmental stages, Alburgh, VT.**




Varieties with the same letter did not differ significantly in yield.

**Figure 2.The impact of topdressing organic N sources at critical wheat developmental stages on crude protein concentrations, Alburgh, VT.**




Varieties with the same letter did not differ significantly in protein concentration.

# DISCUSSION

It is important to remember that the results only represent one year of data. However, a few generalizations can be made from this past season. Overall the winter wheat topdress trial results indicate that organic certified N amendments can be applied to increase both yield and protein levels. The 2012 yields were surprisingly lower than what we have observed in other trial years. This could be attributed to the lack of moisture restricting the mineralization of amendments. In addition, the extremely hot dry conditions could have stressed the wheat and reduced tiller formation. The GS25 applied Chilean Nitrate at a rate of 70 lbs $ac^{-1}$ produced the highest yield as compared to all other treatments. This indicates that an early application of 70 lbs of nitrogen per acre can increase yields. However, this treatment did not increase protein content as compared to the unamended control. This is a typical response seen in wheat where early applications of nitrogen boost yield and later applications boost protein. Nitrogen sources such as 'Pro-Booster' with both soluble and slow release N sources may more easily meet the N needs of the plant. In this experiment 'Pro-Booster' applied at either stage increase protein concentrations. In the case of soluble N products such as 'Chilean Nitrate' application time will need to be applied at the time of rapid uptake. In this experiment, a split nitrogen application of 70 lbs $ac^{-1}$at GS25 and GS30 resulted in a significant increase in protein as compared to the unamended control. In this experiment 'Chilean Nitrate' was used to serve as an example of a quick release nutrient source. Currently, it is approved for use on organic farms. However, it is slated for removal from the approved list of soil amendments.

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