NORTHWEST CROPS & SOILS PROGRAM

2013
The Effects of Topdressing Nitrogen on Hard Red Winter Wheat

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2013 THE EFFECTS OF TOPDRESSING 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 different split N applications at key developmental stages.

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 24-Sep 2012 at a seeding rate of 125 lbs ac^{-1}. The prior crop in 2012 was spring wheat.

Table 1. General plot management of the 2013 winter wheat topdressing trial, Alburgh, VT.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Spring wheat
Row spacing (in.)	7
Seeding rate (lbs ac^{-1})	125
Variety	Harvard
Replicates	4
Manure application date	24-Sep 2012
Planting date	24-Sep 2012
Harvest date	19-Jul 2013
Harvest area (ft.)	5 x 30
Tillage operations	Fall plow, disc, & spike tooth harrow

The experimental design was a randomized complete block design with eight treatments replicated 4 times (Table 2). The treatments included an unamended control as well as two rates of fall applied solid cow manure. These treatments represented standard winter wheat production practices of local farms. The solid cow manure (straw-bedded) was applied on 24-Sep 2012, incorporated immediately; the seedbed was then prepped and the plots planted (Image 1). The cow manure was applied at two rates to provide either 70lbs ac^{-1} or 140lbs ac^{-1} of plant available nitrogen (PAN) for the wheat crop. The other treatments included nitrogen (N) topdress treatments of 'Chilean Nitrate' (16% N) hand applied at the rates of 35lbs ac^{-1} or 70lbs ac^{-1} of plant available N for the crop. 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 N topdress treatments were applied at spring green-up (GS25), pre-stem extension (GS30), or at both these growth stages. On 19-Apr 2013 the GS25 amendments were applied, and on 3-May the GS30 treatments were applied.

Plots were sampled for plant nitrogen concentration prior to N applications and at key developmental stages until the wheat reached physiological maturity. Plant samples were taken to determine total nitrogen concentration by combustion analysis. The tissue samples consisted of 8 rows of wheat top growth, and 6 inches in length selected randomly within each plot. Samples were put into clean paper bags, kept cool, and transported directly to the UVM Horticultural Research Farm where samples were placed in a dryer. Once dried, plant samples were weighed and ground in a Wiley Laboratory Mill, Standard Model No.3. Samples were then sent to Cumberland Valley Analytical Services in Hagerstown, MD for nitrogen 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	0	70
3	70	0	0	70
4	70	0	35	105
5	70	35	0	105
6	70	35	35	140
7	140	0	0	140
8	140	0	35	175

On 19-Apr, the numbers of tillers were counted in eight 12 inch segments randomly selected within each plot in order to determine tiller density (tillers per square foot).

On 9-Jul, after the wheat had reached physiological maturity and was in the process of drying down, the number of spikes were counted from a plant biomass sampling of 8 randomly selected six inch segments per plot.

Plots were harvested with an Almaco SPC50 plot combine on 19-Jul 2013; the harvest area was 5’ x 30’. At the time of harvest, grain moisture, test weight, and plot yields were measured.

Image 1. Spreading manure to the fall applied manure plots, Alburgh, VT.

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.

All data was analyzed using a mixed model analysis where replicates were considered random effects. The Least Significant Difference (LSD) procedure was used to separate cultivar means when the F-test was significant ($P< 0.10$). There were significant differences among the two locations for most parameters, and therefore data from each location is reported independently.

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 and 2013 sites are shown in Table 3. The growing season this year was marked by lower than normal temperatures in April and June and higher than normal rainfall in the months of May and June. In Alburgh, there was an accumulation of 5035 Growing Degree Days (GDDs), which is 5 GDDs below the 30 year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2012 and 2013.

Alburgh, VT	Sep-12	Oct-12	Mar-13	Apr-13	May-13	Jun-13	Jul-13
Average temperature (°F)	60.8	52.4	32.1	43.6	59.1	64.0	71.7
Departure from normal	0.20	4.20	1.00	-1.20	2.70	-1.80	1.10
Precipitation (inches)	5.36	4.13	1.04	2.12	4.79	9.23 ł	1.89
Departure from normal	1.72	0.53	-1.17	-0.70	1.34	5.54	-2.26
Growing Degree Days (base 32°F)	896	652	88.5	348	848	967	1235
Departure from normal	38.0	150	88.5	-35.5	91.4	-47.0	36.8

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.
ł June 2013 precipitation data based on National Weather Service data from cooperative stations in South Hero, VT. (http://www.nrcc.cornell.edu/page_summaries.html)

Wheat Yield and Quality:

Image 2. Harvesting the winter wheat topdress plots, Alburgh, VT.

The treatments differed significantly in yield (Table 4, Figure 1). The highest yielding treatment was manure applied at a rate of 70lbs ac^{-1} of plant available N in the fall of 2012 with (4973lbs ac^{-1}) (Image 2). Interestingly, the lowest yielding treatment was manure applied at a rate of 140 lbs ac^{-1} of plant available N in the fall of 2012 (3741 lbs ac^{-1}). There were no significant differences in grain moisture and test weight.

The treatments differed in protein concentration (Table 4, Figure 2). Chilean Nitrate (35 lbs ac^{-1} PAN) applied at both GS25& GS30 stages had the highest protein content (13.5%). Other treatments with high protein content include; the 2x manure (140 lbs ac^{-1} PAN) and 35 lbs ac^{-1} Chilean Nitrate applied at GS30 treatment (13.2%), 70lbs ac^{-1} PAN of Chilean Nitrate applied at GS25 (13.0%), and the fall applied manure (70 lbs ac^{-1} PAN) (12.9%). All of the treatments had higher protein levels than the unamended control (11.4%). The protein content of all the treatments, except for the unamended control, met industry standards of 12-15% protein.

In the Northeast, *Fusarium* head blight (FHB) is predominantly caused by the species *Fusarium graminearum*. This disease is very destructive and causes yield loss, low test weights, low seed germination and contamination of grain with mycotoxins. A vomitoxin called deoxynivalenol (DON) is considered the primary mycotoxin associated with FHB. The spores are usually transported by air currents and can infect plants at flowering through grain fill. Eating contaminated grain greater than 1ppm poses a health risk to both humans and livestock. The DON levels were extremely high in 2013. All treatments had DON levels greater than the FDA's 1ppm limit. Treatments did not differ significantly in falling number or DON.

Table 4. The results of fertility type and application timing on hard red winter wheat harvest and quality.

Fertility Type	Time of Application	Total N applied	Yield	Moisture	Test weight	Quality		
						Crude protein @ 12% moisture	Falling number	DON
		lbs ac^{-1}	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm
None	Control	0	3939	17.8	53.8	11.4	**412**	**3.58**
Manure	Fall 2012	70	**4973***	**17.4**	54.8	12.9*	390	4.10
2x Manure	Fall 2012	140	3741	17.9	54.0	12.5	366	5.45
70 lbs ac^{-1} Chilean Nitrate	GS25	70	3767	17.8	53.8	13.0*	377	5.40
Manure & 35lbs ac^{-1}Chilean Nitrate	Fall 2012 & GS25	105	3817	18.0	53.8	12.7	395	4.68
Manure & 35lbs ac^{-1} Chilean Nitrate	Fall 2012 & GS30	105	3801	**17.4**	53.8	12.9	380	4.93
2x Manure & 35lbs ac^{-1} Chilean Nitrate	Fall 2012 & GS30	175	4470*	17.6	**55.3**	13.2*	400	4.95
Manure & 35lbs ac^{-1} Chilean Nitrate	Fall 2012, GS25, & GS30	140	4119	17.9	53.8	**13.5***	375	5.33
LSD (0.1)			745	NS	NS	0.58	NS	NS
Trial means			4078	17.7	54.1	12.8	387	4.80

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.

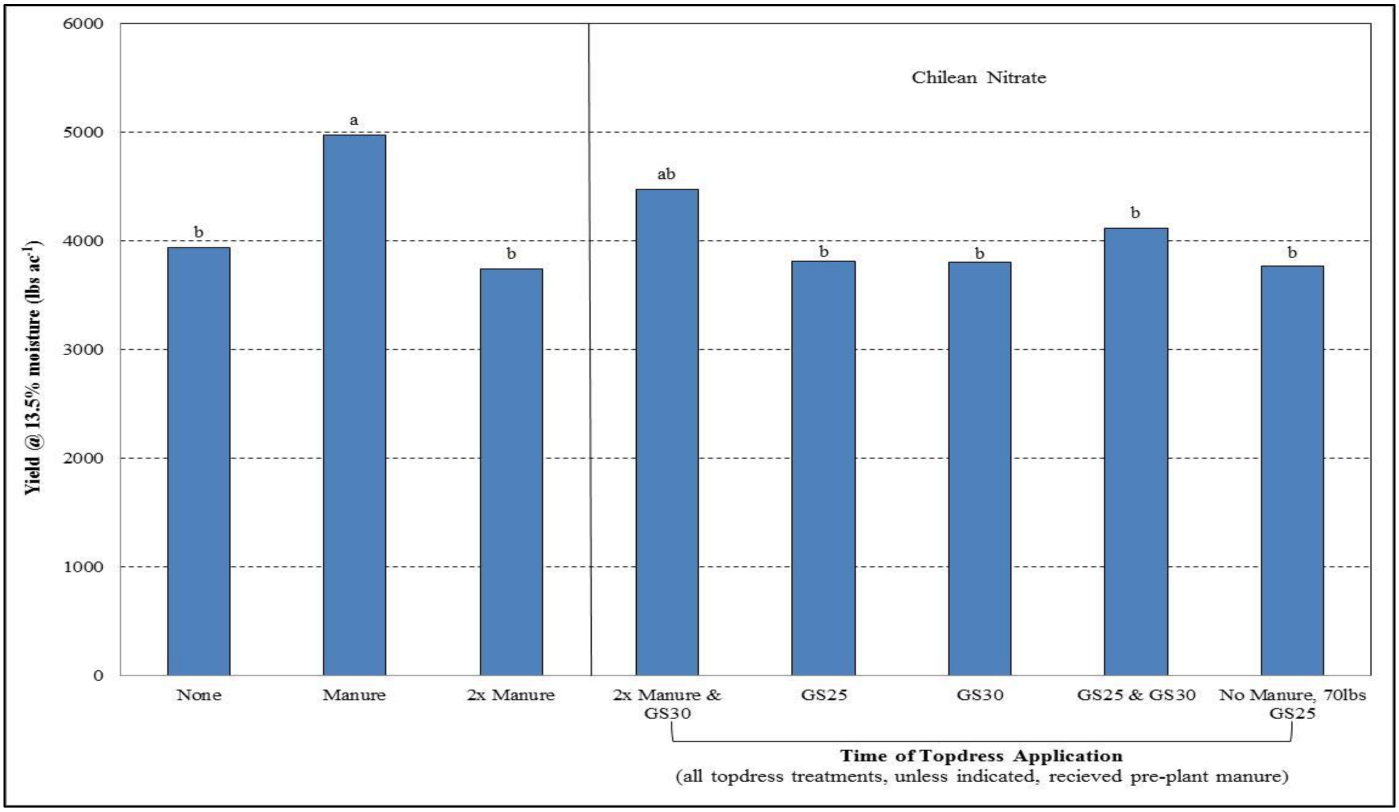

Figure 1. Yield impact of topdressing organic N sources at critical wheat developmental stages, Alburgh, VT.
Varieties with the same letter did not differ significantly in yield.

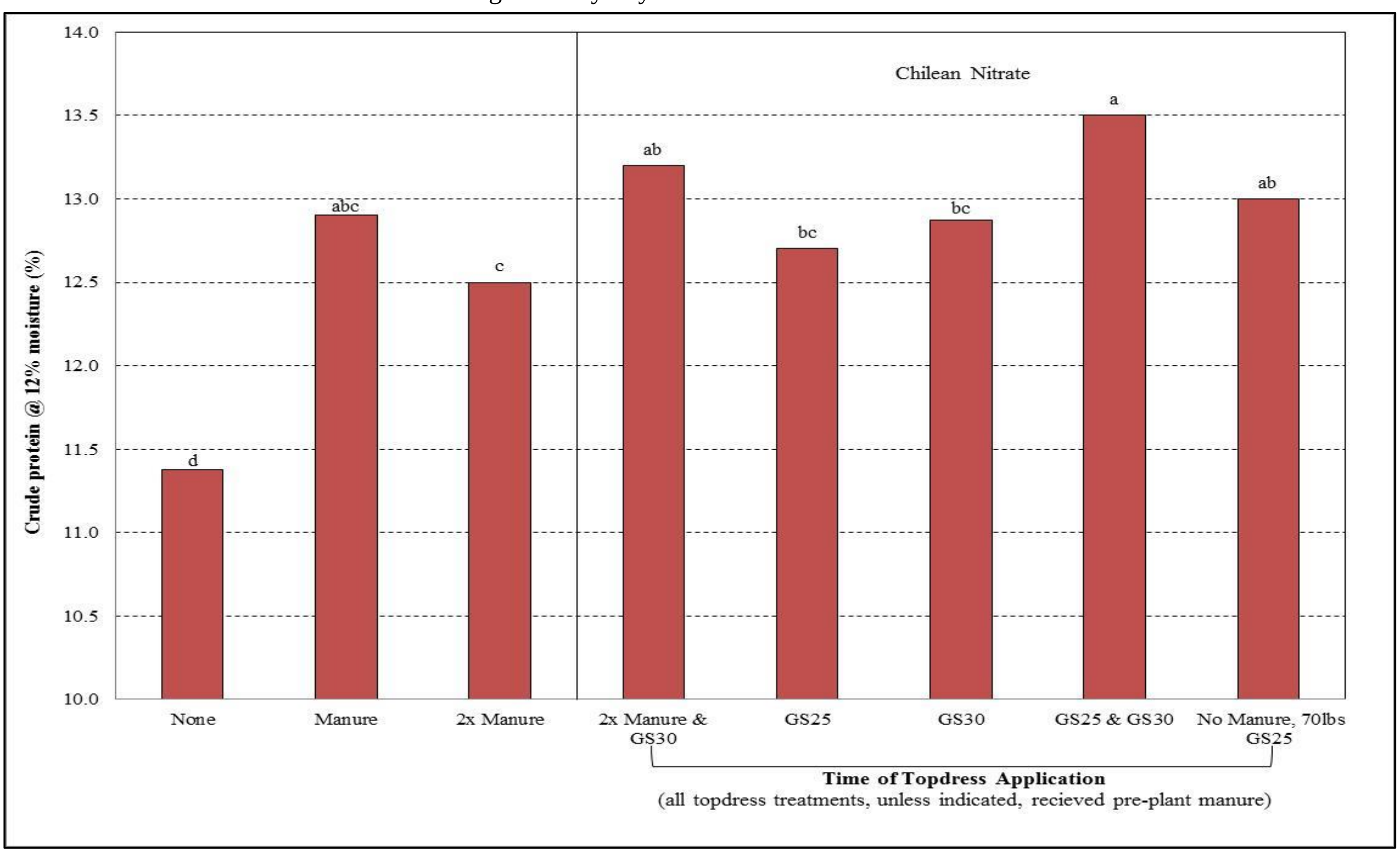

Figure 2.The impact of topdressing organic N sources at critical wheat developmental stages on crude protein concentrations, Alburgh, VT.
Varieties with the same letter did not differ significantly in protein concentration.

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 results indicate that Chilean Nitrate can be applied to increase protein levels but not yields. The 2013 growing season was by far one of the most challenging in recent history due to the excessive rains during key periods of wheat development. The wet weather in May and June brought an excess of 9 inches of rain to the area. The spring was also cooler than normal and likely led potentially slower mineralization of N from the manure. Interestingly, the 140 lb acre of manure application rates had the lowest yield and protein of all N treatments. The higher rate of manure may have led to nitrogen immobilization due to the elevated levels of straw in the application rate. The rains started two months after the GS25 and one month after the GS30 Chilean nitrate application. Hence, the topdress applications of Chilean nitrate were likely taken up by the plant prior to the significant rainfall in late May and June. Interestingly, Chilean nitrate applications in combination with the low rate of manure did not significantly boost protein concentration of the wheat. However, addition of Chilean nitrate with the high rate of manure application did help boost protein of the wheat. It is likely that the additional N may have helped overcome some of the immobilization from the straw. All of the treatments had higher protein levels than the unamended control indicating validity to applying additional N to the wheat crop to improve both yield and quality. In this experiment, Chilean nitrate was used to serve as an example of a quick release nutrient source. Currently, it is approved for use up to 20% of a crops nitrogen needs on organic farms. However, it is slated for removal from the OMRI approved list of soil amendments.

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