2013

Organic Winter Wheat Planting Date Trial

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UNIVERSITY OF VERMONT EXTENSION
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2013 ORGANIC WINTER WHEAT PLANTING DATE TRIAL

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In 2013, the University of Vermont Extension Northwest Crops and Soils Program conducted a winter wheat planting date trial. As the demand for local organic wheat has risen over the last few years, UVM Extension has been trying to determine the best agronomic practices for wheat production in the problematic Northeastern climate. Traditionally, producers have planted winter wheat after the Hessian fly free date, 15-Sep. Producers are interested in knowing how late they can plant their wheat in order to plan rotations and maximize yield.

MATERIALS AND METHODS

The trial was conducted in 2013 at Borderview Research Farm in Alburgh, VT. The experimental design was a randomized complete block design with split plots replicated four times. Main plots were planting date and subplots were varieties (Table 1, 2). Planting dates were initiated on 12-Sep 2012 and continued approximately every week for 7 weeks (Table 2). Three hard red spring wheat varieties were selected to represent varieties of varying heights, maturities, and quality (Table 1).

Table 1. Seed varieties and seed sources for the winter wheat planting date trial at Borderview Research Farm in Alburgh, VT.

Winter Wheat Varieties	Type	Origin	Seed Source
Harvard	Hard red winter wheat	Canada	saved seed-VT
Morley (AC)	Hard red winter wheat	Canada	Bramhill Seeds, Canada
Redeemer	Hard red winter wheat	Canada	Bramhill Seeds, Canada

Table 2. Winter wheat planting and harvest dates at Borderview Research Farm in Alburgh, VT.

Planting date	Plant emergence date	Harvest date
12-Sep 2012	20-Sep 2012	22-Jul 2013
20-Sep 2012	25-Sep 2012	22-Jul 2013
26-Sep 2012	11-Oct 2012	22-Jul 2013
5-Oct 2012	18-Oct 2012	22-Jul 2013
11-Oct 2012	25-Oct 2012	22-Jul 2013
18-Oct 2012	1-Nov 2012	22-Jul 2013
25-Oct 2012	9-Nov 2012	Not harvestable

The soil type at the project site was a Benson rocky silt loam. The seedbed was prepared by fall plow, followed by disk and spike tooth harrow. All plots were managed with practices similar to those used by producers in the surrounding areas (Table 3).

Table 3. Winter wheat planting date trial specifics in Alburgh, VT, 2013.

Trial information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Spring wheat
Row spacing (in)	6
Seeding rate (lbs ac^{-1})	125
Replicates	4
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, disk, and spike tooth harrow

Winter survival and vigor were measured on 19-Apr 2013. Winter survival was based on a visual estimate of percent survival and vigor was rated using a 0 – 5 scale, where 5 represents excellent stand density, and 0 represents no stand. Populations were measured on 1-May 2013 by taking two, 0.3 meter counts per plot.

Grain plots were harvested on 22-Jul 2013 with an Almaco SPC50 plot combine, the harvest area was 5' x 20'. At the time of harvest plant heights were measured, excluding awns, and the severity of lodging was recorded based on a visual rating with a 0 – 5 scale, where 0 indicates no lodging and 5 indicates severe lodging and a complete crop loss. In addition, grain moisture, test weight, and yield were calculated.

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.

Data was analyzed using mixed model analysis using the mixed 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 ($p<0.10$)

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. 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 4. 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 4. Temperature, precipitation, and growing degree days (GDDs) data by month for Alburgh, VT, 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)

Planting Date x Variety Interactions

There was a significant interaction between planting date and variety for winter wheat plant heights, harvest moisture, test weight, crude protein, falling number, and DON concentrations. These interactions indicate that winter wheat varieties respond differently across planting dates. All three hard red winter wheat varieties (Morley (AC), Harvard, and Redeemer) were tallest when planted on the first planting date 12-Sep 2012 and decreased in height as the planting dates became later (Figure1). The heights of the variety Harvard decreased more gradually until the sixth planting date 18-Oct when the height increased.

The lowest Deoxynivalenol (DON) concentration for both Redeemer and Harvard was the first planting date of 12-Sep (Figure 2). The DON levels for these varieties gradually increased as the planting dates extended into October. Morley (AC) was the opposite; the highest level was on the first planting date and decreased across planting dates.

There were no significant interactions between variety and planting date for winter wheat populations, winter survival, vigor, and yield.

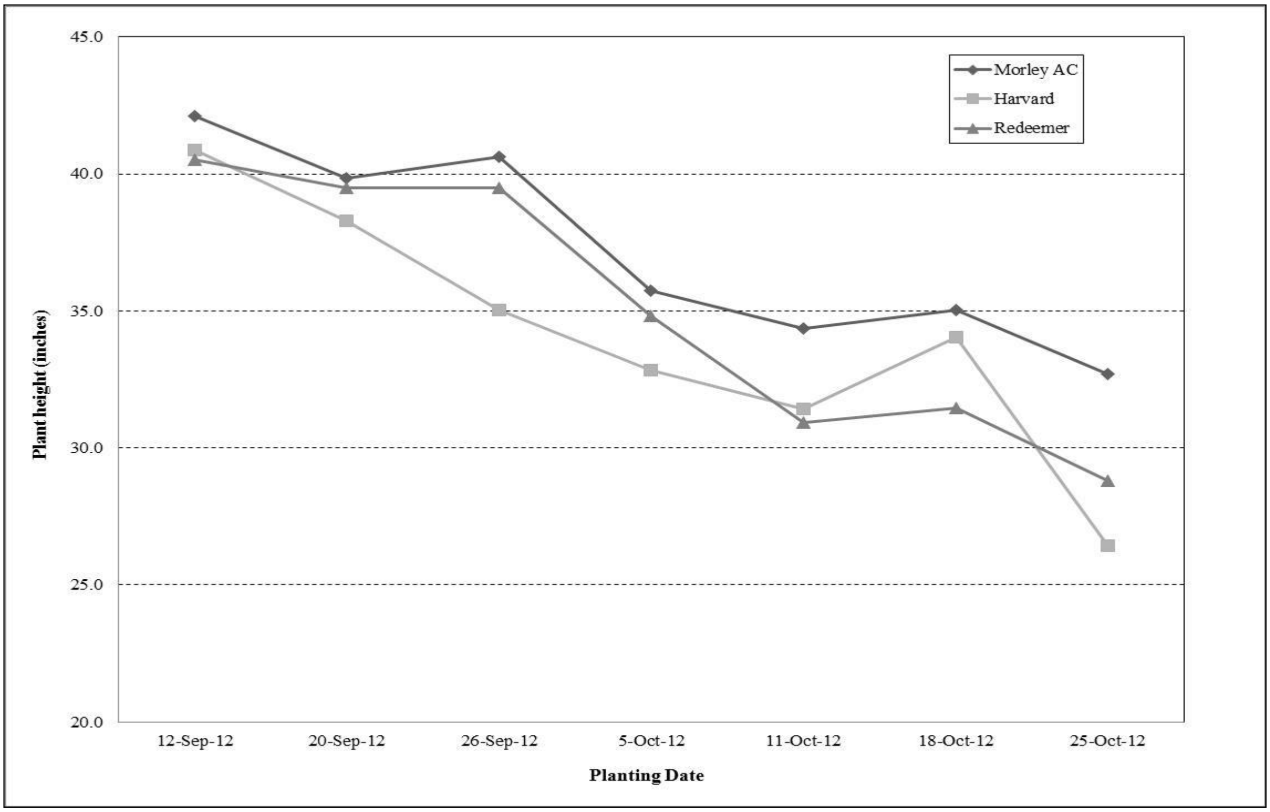

Figure 1. Planting date by variety interaction of plant heights.

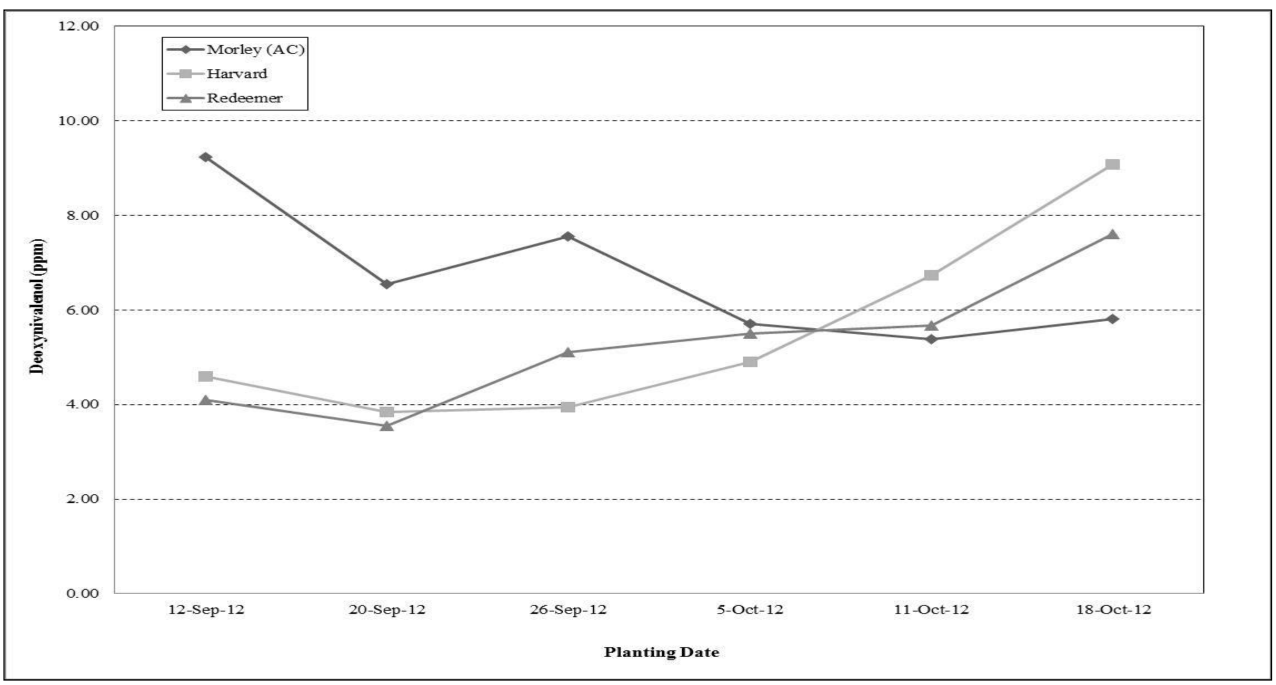

Figure 2. Planting date by variety interaction of deoxynivalenol (DON) concentrations.

Impact of Planting Date

There was significant difference in spring plant population, winter survival, vigor, and plant height by planting date (Table 5). The first planting date (12-Sep) had the highest plant population (25.0 plants per 0.33 meter), winter survival (93.3%), vigor (4.92), and plant height (41.2 inches). The last planting date of 25-Oct had the lowest spring plant population (3.63 plants per 0.33 meter), winter survival (14.6%), vigor (1.25), and plant height (29.3 inches).

Table 5. Winter wheat plant measurements by planting date, 2013.

Planting Date	Plant population	Winter survival	Vigor	Plant heights
	0.33 meter	%	(1-5)	inches
12-Sep 2012	**25.0***	**93.3***	**4.92***	**41.2***
20-Sep 2012	20.5	88.3*	4.58*	39.2*
26-Sep 2012	18.0	83.8	3.92	38.4
5-Oct 2012	12.6	85.0	3.42	34.5
11-Oct 2012	11.8	63.8	2.17	32.2
18-Oct 2012	8.63	52.5	2.00	33.5
25-Oct 2012	3.63	14.6	1.25	29.3
LSD (0.10)	2.32	7.63	0.35	2.37
Trial Mean	14.3	68.8	3.18	35.5

* Treatments that did not perform significantly lower than the top-performing treatment (in **bold**).

Planting date did significantly impact grain yield, moisture, test weight, crude protein, falling number, and DON concentrations (Table 6, Figure 3). The first planting date (12-Sep) had the highest yield at 3529 lbs ac^{-1} and the last planting date (18-Oct) yielded the lowest 1242 lbs ac^{-1}. The lowest harvest moistures occurred at September planting dates. All of the grains harvested from the October planting dates had to be dried down to below 14% moisture, necessary for optimal grain storability. Earlier planting dates from 12-Sep to 5-Oct had test weights that met the industry standard of 56 lbs bu^{-1}.

Table 6. Winter wheat harvest and quality results by planting date, 2013.

Planting Date	Yield	Harvest Moisture	Test weight	Quality		
				Crude protein @ 12% moisture	Falling number	DON
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm
12-Sep 2012	**3529***	13.0*	57.0*	13.0	377*	5.98
20-Sep 2012	2976	**12.5***	**57.3***	12.5	375*	**4.65***
26-Sep 2012	2839	13.6*	56.4*	12.7	388*	5.53*
5-Oct 2012	2460	15.3	56.5*	12.3	**389***	5.37*
11-Oct 2012	1622	19.3	54.5	13.0	380*	5.93
18-Oct 2012	1242	21.1	53.0	**13.9***	361	7.49
LSD (0.10)	381	1.89	1.21	0.48	15.8	1.17
Trial Mean	2444	15.8	55.8	12.9	378	5.82

*Treatments that did not perform significantly lower than the top-performing treatment (in **bold**).

The sixth planting date had the highest protein level (13.9 %) and was likely related to severely depressed yields at this date. The protein levels from all of the planting dates met industry standards of 12-15% protein. All of the falling numbers for each of the planting dates were higher than 350 seconds indicating little or no sprout damage.

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 this year. All of the planting dates were above the FDA's 1ppm limit. The lowest DON level was the 20-Sep planting date (4.65 ppm).

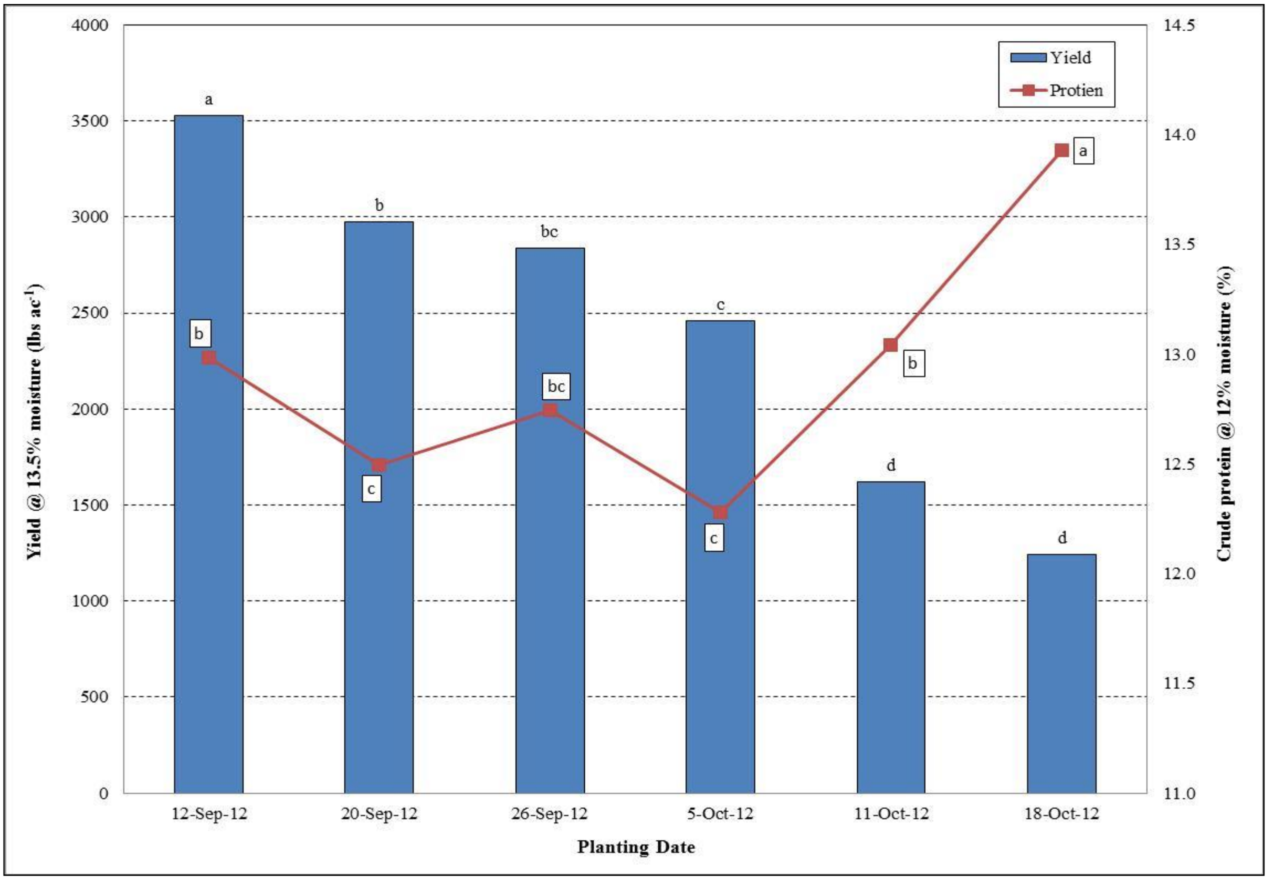

Figure 3. Yield and protein comparison between planting dates across hard red winter wheat varieties in Alburgh, VT, 2013. Treatments that share a letter did not differ significantly by planting date.

Impact of Variety

Plant population, winter survival, and vigor were not significantly different between the three winter wheat varieties Morley (AC), Harvard, and Redeemer (Table 7). Morley (AC) was the tallest variety (37.2 inches) and Harvard was the shortest (34.1 inches).

Table 7. Winter wheat plant measurements by variety, 2013.

Winter Wheat Variety	Plant population	Winter survival	Vigor	Plant heights
	0.33 meter	%	(1-5)	inches
Morley (AC)	14.0	70.0	3.2	**37.2***
Harvard	14.2	67.5	3.2	34.1
Redeemer	14.7	68.8	3.1	35.1
LSD (0.10)	NS	NS	NS	1.55
Trial Mean	14.3	68.8	3.18	35.5

*Treatments that did not perform significantly lower than the top-performing treatment (in **bold**) in a particular column are indicated with an asterisk.
NS-Treatments were not significantly different from one another.

Grain yields were not significantly different by variety (Table 8, Figure 4). Morley (AC) yielded the highest (2604 lbs ac^{-1}) and Redeemer the lowest (2302 lbs ac^{-1}). All of the winter wheat varieties had harvest moistures greater than 14%, the optimum moisture for grain storability, and therefore had to be dried down. Redeemer had the lowest harvest moisture out of the three varieties (14.7 %). Redeemer had the highest test weight (56.7 lbs bu^{-1}), protein concentration (14.4%), and falling number (403 seconds). All three varieties had falling numbers above the industry standard of 350 seconds. The DON levels were extremely high this year. All of the varieties had DON levels above the FDA's 1ppm limit. The lowest DON level was Redeemer (5.25 ppm).

Table 8. Winter wheat harvest and quality results by variety, 2013.

Winter Wheat Variety	Yield	Harvest Moisture	Test weight	Quality		
				Crude protein @ 12% moisture	Falling number	DON
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm
Morley (AC)	**2604**	16.4	55.4	11.8	369	6.70
Harvard	2427	16.3	55.2	12.5	363	5.51*
Redeemer	2302	**14.7***	**56.7***	**14.4***	**403***	**5.25***
LSD (0.10)	NS	1.34	0.86	0.34	11.2	0.83
Trial Mean	2444	15.8	55.8	12.9	378	5.82

*Treatments that did not perform significantly lower than the top-performing treatment (in **bold**) in a particular column.
NS-Treatments were not significantly different from one another.

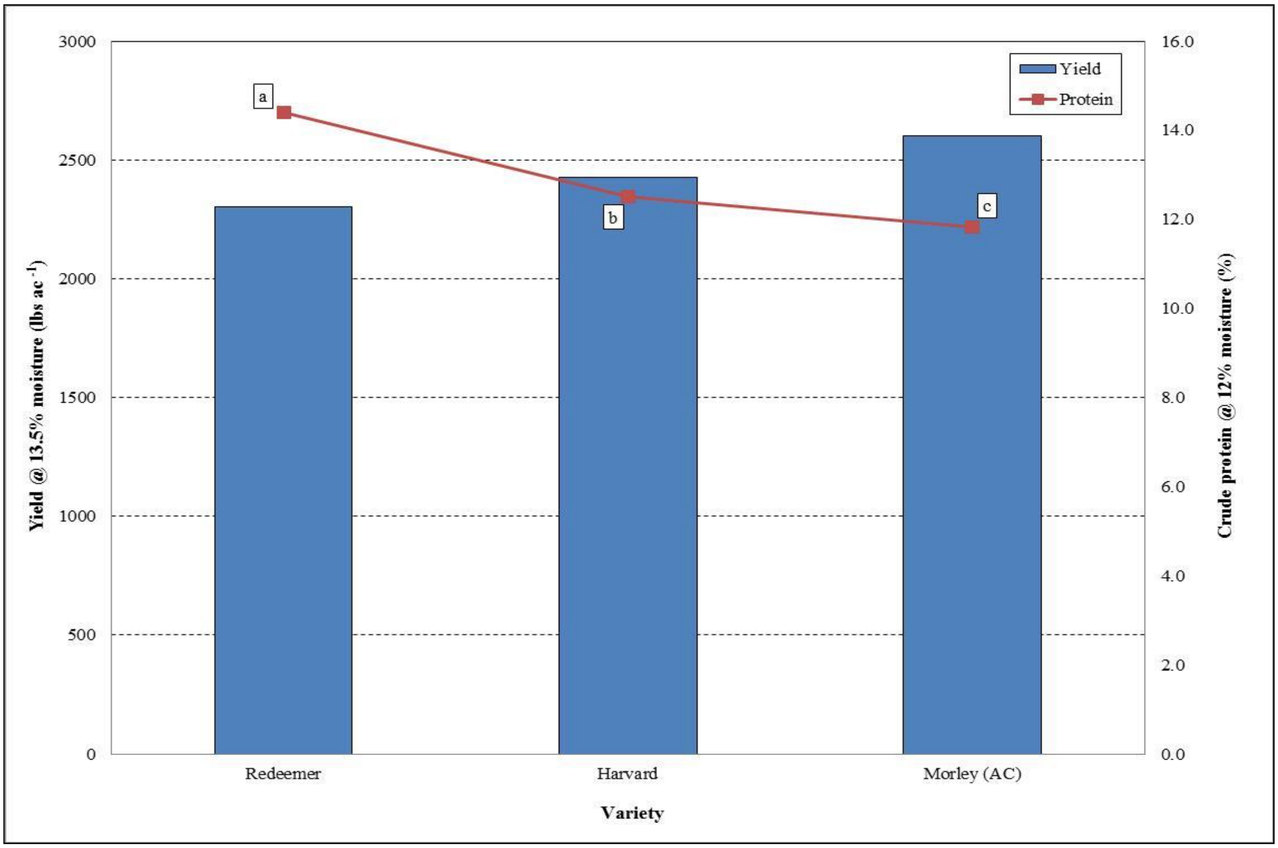

Figure 4. Yield and protein comparison between hard red winter wheat varieties across all planting dates in Alburgh, VT, 2013. Treatments that share a letter did not differ significantly by variety.

DISCUSSION

It is important to remember that the results only represent one year of data. 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 7 inches of rain to the area. The rains started soon after spring green up which saturated the plots impacting wheat development. This could explain the increase in weed pressure observed especially in the later planting dates. The seventh planting date could not be harvested due to excessively high weed pressure. The increased weed pressure could also help explain the overall decrease in yields. The mean yield in 2013 was 2444 lbs ac^{-1}, 1325 lbs ac^{-1} lower than the 2012 mean yield.

The continuous rains and cool temperatures during flowering also provided the perfect conditions for Fusarium head blight (FHB) (*Fusarium graminearum*) to thrive. The infection resulted in some of the highest levels of the mycotoxin deoxynivalenol (DON) seen to date. Redeemer and Harvard DON levels were lowest on the first planting date and gradually increased across planting dates. Morley (AC) was the reverse; the highest level was on the first planting date and decreased as the planting dates extended into mid-October. Interestingly, all three varieties are stated to have moderate to excellent resistance to FHB.

This study indicates that winter wheat planted during mid-September will result in higher yields and quality. In general, as yields increase the protein concentrations decrease. Earlier planting dates produced taller wheat across all varieties and may play a role in suppressing weeds during the growing season. The last harvested planting date (18-Oct) had the lowest yield, the highest harvest moisture, the lowest test weight, the lowest falling number and the highest amounts of DON. This indicates that planting wheat in mid-October will produce a crop, but could result in reduced yields and quality. Overall, planting winter wheat early, allowing for six to eight weeks of growth before the soil freezes, will provide the best chances of high yield and quality winter wheat

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