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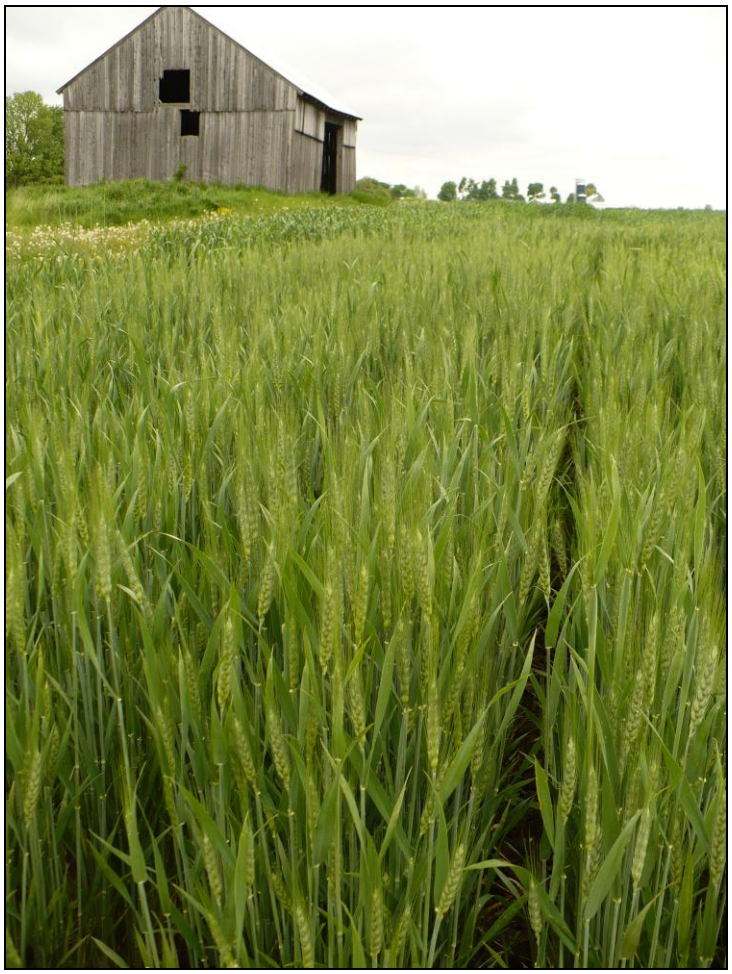
2012
Winter Wheat Variety Trial



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The UNIVERSITY of VERMONT EXTENSION

2012 WINTER WHEAT VARIETY TRIAL

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In 2012, the University of Vermont Extension, in collaboration with the University of Maine, began the third year of extensive organic variety trials evaluating hard red winter wheat in order to determine which varieties thrive in our northern climate. The trials were established at the Borderview Research Farm in Alburgh, Vermont and at Cornell University's Willsboro Research Farm in Willsboro, New York. In the 2012 varietal selection process, varieties that in previous trial years had not performed well were eliminated. 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 experimental plot design at both locations was a randomized complete block with four replications. Wheat varieties evaluated are listed in Table 1.

Table 1. Winter wheat varieties planted in Alburgh, VT and Willsboro, NY.

Winter Wheat Varieties	Type†	Origin and Year of Release‡	Seed Source
AC Morley	HR	Canada	Bramhill Seeds, Canada
Alice	HW	SD, 2006	USDA-ARS, SD
Appalachian White	HW	NC, 2009	USDA-ARS, NC
Arapahoe	HR	NE, 1998	Albert Lea Seed House, MN
Borden	MHR	Canada, 1983	Semican, Canada
Camelot	HR	NE, 2008	USDA-ARS, NE
Expedition	HR	SD, 2002	Albert Lea Seed House, MN
Harvard	HR	Canada	Agri-Culver Seeds, NY
Jerry	HR	ND, 2001	North Dakota State Univ.
Maxine	HR	Canada, 2001	C&M Seed, Canada
Millennium	HR	NE, 1999	USDA-ARS, NE
NuEast	HR	NC, 2009	USDA-ARS, NC
Overland	HR	NE, 2006	USDA-ARS, NE
Redeemer	HR	Canada	Bramhill Seeds, Canada
Roughrider	HR	ND, 1975	North Dakota State Univ.
Sherman	SW	OR, 1928	Washington State Univ.
Warthog	HR	Canada	Semican, Canada
Zorro	HR	Canada	C&M Seed, Canada

† HR = hard red, MHR = medium hard red, HW = hard white, SW = soft white.

‡ Year of release was not always available.

The seedbeds at both the Alburgh and Willsboro locations were prepared by conventional tillage methods. All plots were managed with practices similar to those used by producers in the surrounding areas (Table 2). The previous crop planted at the Alburgh site was spring wheat and prior to that, the site had been organic corn. The field was then disked and spike-toothed harrowed to prepare for planting. The plots in Alburgh were seeded with a Kincaid Cone Seeder on 21-Sep 2011.

At the Willsboro location, planting of the winter wheat followed a three year crop of alfalfa/timothy hay. The field was moldboard plowed, disked, and dragged with a spring-toothed harrow prior to seeding. The plots were seeded on 27-Sep 2011 with a custom made eight-row cone planter.

Population and vigor were measured on 24-Oct 2011 in Alburgh and 26-Oct 2011 in Willsboro (Image 1). 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. On 11-Apr 2012 at the Alburgh site and 13-Apr 2012 at the Willsboro site, winter survival was measured on a 0 - 5 scale with the same procedure as above. At the Alburgh location, plots were top-dressed by hand on 3-May 2012 with 500 lbs per acre each of Pro-Booster and Pro-Gro. 'Pro-Booster' and 'Pro-Gro' are Organic Materials Review Institute (OMRI) approved fertilizers manufactured for North Country Organics in Bradford, VT. They are blended fertilizers composed of vegetable and animal meals and natural nitrate of soda. 'Pro-Booster' has a guaranteed analysis of 10-0-0 and 'Pro-Gro' has a guaranteed analysis of 5-3-4. There was no amendments applied at the Willsboro location.

Image 1. Counting wheat populations, Willsboro, NY.

Flowering dates of the wheat were recorded when at least 50% of the spikes were in bloom. At the Willsboro site, flowering dates were approximated to the week of flowering because daily observations could not be recorded due to location. Throughout the growing season, other pertinent observations such as disease and wheat development were recorded.

Grain plots were harvested at the Alburgh site with an Almaco SPC50 plot combine on 11-Jul 2012, the harvest area was 5' x 20' (Image 2). In Willsboro, plots were harvested on 20-Jul 2012 with a Hege plot combine; the plot area harvested was 4'x 13'. 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 – 4 scale, where 0 indicates no lodging and 4 indicates severe lodging and a complete crop loss. In addition, grain moisture, test weight, and yield were calculated.

Image 2. Winter wheat harvest, 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.

Table 2. General plot management of the 2012 winter wheat trials.

Trial Information	Winter wheat variety trial	
Location	Alburgh, VT Borderview Research Farm	Willsboro, NY Willsboro Research Farm
Soil type	Benson rocky silt loam	Kingsbury silt clay loam
Previous crop	Spring wheat	Timothy/Alfalfa Sod
Row spacing (in)	6	6
Seeding rate (live seed/m^2)	350	350
Replicates	4	4
Planting date	21-Sep 2011	27-Sep 2011
Harvest date	11-Jul 2012	20-Jul 2012
Harvest area (ft)	5x20	4x13
Tillage operations	Fall plow, disk, & spike-toothed harrow	Fall plow, disk, & spring-toothed harrow
Spring-applied fertilizer (1000 lbs ac^{-1})	Pro-Booster (10-0-0-) and Pro-Gro (5-3-4)	None

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 2011and 2012 sites are shown in Table 3. The growing season this year was marked by higher than normal temperatures and less than normal rainfall especially in the months of June and July. In Alburgh, there was an accumulation of 5732 Growing Degree Days (GDD), which is 692 GDDs higher than the 30 year average. Willsboro, with 6004 accumulated GDDs had 964 more GDDs than the long-term average.

Table 3. Temperature and precipitation summary for Alburgh, VT and Willsboro, NY, 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.

Willsboro, NY	Sept. 2011	Oct. 2011	Nov. 2011	Mar. 2012	Apr. 2012	May 2012	June 2012	July 2012
Average Temperature (F)	64.1	50.1	43.3	43.2	46.1	61.6	67.8	73.0
Departure from Normal	3.50	1.90	5.10	12.10	1.30	5.20	2.00	2.40
Precipitation (inches)	6.10	3.50	1.40	1.00	2.80	4.40	3.20	3.80
Departure from Normal	2.50	-0.10	-1.70	-1.20	0.00	0.90	-0.50	-0.40
Growing Degree Days (base 32)	964	566	368	411	435	917	1072	1271
Departure from Normal	106	64.0	166	285	51.0	161	58.0	73.0

Based on Northeast Region Climate Center data from observation stations in Burlington, VT.
Historical averages for 30 years of NOAA data (1981-2010).

Winter Wheat Growth and Development:

Image 3. Flowering wheat, Willsboro, NY.

During the 2012 growing season, several observations and measurements were recorded on wheat development. The flowering date was recorded when approximately 50% of the plot was in bloom for each of the varieties (Table 4). In Alburgh most varieties were in full bloom by 1-Jun (Image 3), and in Willsboro, the majority of the varieties bloomed the first week of June. In general, lodging and bird damage were minimal at both locations. Appalachian White and Sherman, at the Alburgh location, partially lodged but not so severely that it couldn't be harvested. Loose smut caused by the fungus, *Ustilago tritici*, was observed at both locations. The loose smut fungus is carried as dormant mycelium within healthy-looking seed and is spread by planting infected seed. A smut-infected seed or plant cannot be distinguished from an uninfected one until the head starts to emerge. The disease is most obvious just after the time of heading by the characteristic dusty black appearance of diseased heads. The spores are dispersed by the wind during wheat flowering and can infect healthy plants. Ascochyta leaf spot was not prevalent on any of the wheat varieties this year as it was in 2011. Ascochyta leaf spot initially appears on lower leaves. The first visual symptoms are chlorotic (yellow) flecks, which turn into distinct oval or round spots (lesions). Overtime these spots spread out over the leaf and the centers turn a gray brown (necrotic). Fungal structures (pycnidia) look like little black dots within the necrotic spots. The spores can overwinter on crop residues or be blown in on the prevailing winds.

Prior to harvest, plant heights were measured (Table 5 and Image 4). Borden and Sherman were among the tallest varieties for both locations. In general, we observed that the shorter and less vigorous varieties had higher weed pressures. The taller, or earlier developing varieties overall had less weed presure. In general, there was low weed pressure in the winter wheat trials at both locations.

Table 4. The approximate winter wheat flowering dates in Alburgh, VT and Willsboro, NY.

Variety	Alburgh, VT **Flowering Date**	Willsboro, NY **Flowering Date**
AC Morley	1-Jun	4-Jun
Alice	1-Jun	4-Jun
Appalachian Wht.	1-Jun	4-Jun
Arapahoe	1-Jun	4-Jun
Borden	1-Jun	4-Jun
Camelot	4-Jun	4-Jun
Expedition	1-Jun	4-Jun
Harvard	1-Jun	4-Jun
Jerry	1-Jun	4-Jun
Maxine	1-Jun	4-Jun
Millennium	1-Jun	4-Jun
NuEast	4-Jun	4-Jun
Overland	1-Jun	4-Jun
Redeemer	1-Jun	4-Jun
Roughrider	1-Jun	4-Jun
Sherman	1-Jun	6-Jun
Warthog	1-Jun	4-Jun
Zorro	1-Jun	4-Jun

Table 5. Plant heights in Alburgh, VT and Willsboro, NY.

Variety	Alburgh, VT **Plant height**	Willsboro, NY **Plant height**
	inches	inches
AC Morley	47.5*	40.3
Alice	35.5	29.1
Appalachian Wht.	35.6	31.1
Arapahoe	40.2	33.9
Borden	48.1*	43.9*
Camelot	38.7	31.6
Expedition	38.8	36.0
Harvard	41.1	34.8
Jerry	46.0*	39.4
Maxine	38.7	33.0
Millennium	40.9	35.3
NuEast	38.1	31.2
Overland	41.8	34.8
Redeemer	41.2	38.3
Roughrider	45.5*	37.7
Sherman	**49.1***	**46.8***
Warthog	44.1	37.9
Zorro	45.2*	40.9
LSD (0.10)	4.09	4.04
Trial Mean	42.0	36.4

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.

Image 4. Winter wheat prior to harvest, Alburgh, VT

Winter Wheat Yield:

The yields at the Willsboro location were not significantly different. The highest yielding variety at the Alburgh site was AC Morley (5507lbs ac^{-1}), and Expedition (5073 lbs ac^{-1}) in Willsboro (Tables 6, 7 and Figures 1, 2). Varieties that yielded over 2 tons ac^{-1} at the Alburgh site were; Alice, Appalachian White, Camelot, Expedition, Harvard, Millennium, NuEast, Overland, Redeemer, and Warthog. The varieties Expedition, Appalachian White, Overland, Camelot Millennium, NuEast and Warthog yielded well at both trial locations. Varieties that yielded well at both locations indicate a variety's ability to adapt to various soil and climatic conditions. The lowest yielding varieties at both locations were Sherman, Roughrider, and Zorro.

Test weight is the measure of grain density determined by weighing a known volume of grain. Generally, the heavier the wheat is per bushel, the higher baking quality. Every variety at the Alburgh location, and all except for Borden at the Willsboro location, reached or exceeded the optimal 56 to 60 lbs bu^{-1} test weight for wheat.

Table 6. Yield results of 18 winter wheat varieties, Alburgh, VT.

Variety	Harvest moisture	Test weight	Yield @13.5% moisture
	%	lbs bu^{-1}	lbs ac^{-1}
AC Morley	15.3	61.5	**5507***
Alice	**10.8***	60.6	4224
Appalachian Wht.	11.3*	61.9	4648
Arapahoe	12.1*	60.3	3948
Borden	11.1*	58.9	3872
Camelot	10.9*	61.1	4824
Expedition	11.5*	63.1*	4748
Harvard	14.5	59.6	4221
Jerry	12.0*	59.0	3816
Maxine	13.5	60.1	4839
Millennium	12.7	60.3	4585
NuEast	13.2	**64.3***	5210*
Overland	12.5	62.3	4983
Redeemer	14.9	61.0	4159
Roughrider	12.7	62.8*	3650
Sherman	13.9	61.8	3043
Warthog	14.1	59.1	4437
Zorro	15.6	58.8	3553
LSD (0.10)	1.3	1.86	451
Trial Mean	12.9	60.9	4348

Table 7. Yield results of 18 winter wheat varieties, Willsboro, NY.

Variety	Harvest moisture	Test weight	Yield @13.5% moisture
	%	lbs bu^{-1}	lbs ac^{-1}
AC Morley	14.0	59.5*	3887
Alice	13.3	59.3*	3966
Appalachian Wht.	13.2	58.3	4376
Arapahoe	13.5	58.0	4261
Borden	12.4*	55.8	3766
Camelot	14.0	59.5*	4175
Expedition	14.1	60.0*	**5073**
Harvard	13.7	59.0	3708
Jerry	13.0*	57.5	3740
Maxine	13.2	58.8	4198
Millennium	14.6	58.8	4591
NuEast	14.2	59.5*	4128
Overland	14.1	57.8	4229
Redeemer	**11.8***	59.0	3958
Roughrider	13.7	**60.8***	3212
Sherman	13.1	58.8	3396
Warthog	14.5	59.0	4440
Zorro	**11.8***	59.0	3320
LSD (0.10)	1.23	1.67	NS
Trial Mean	13.4	58.8	4023

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.

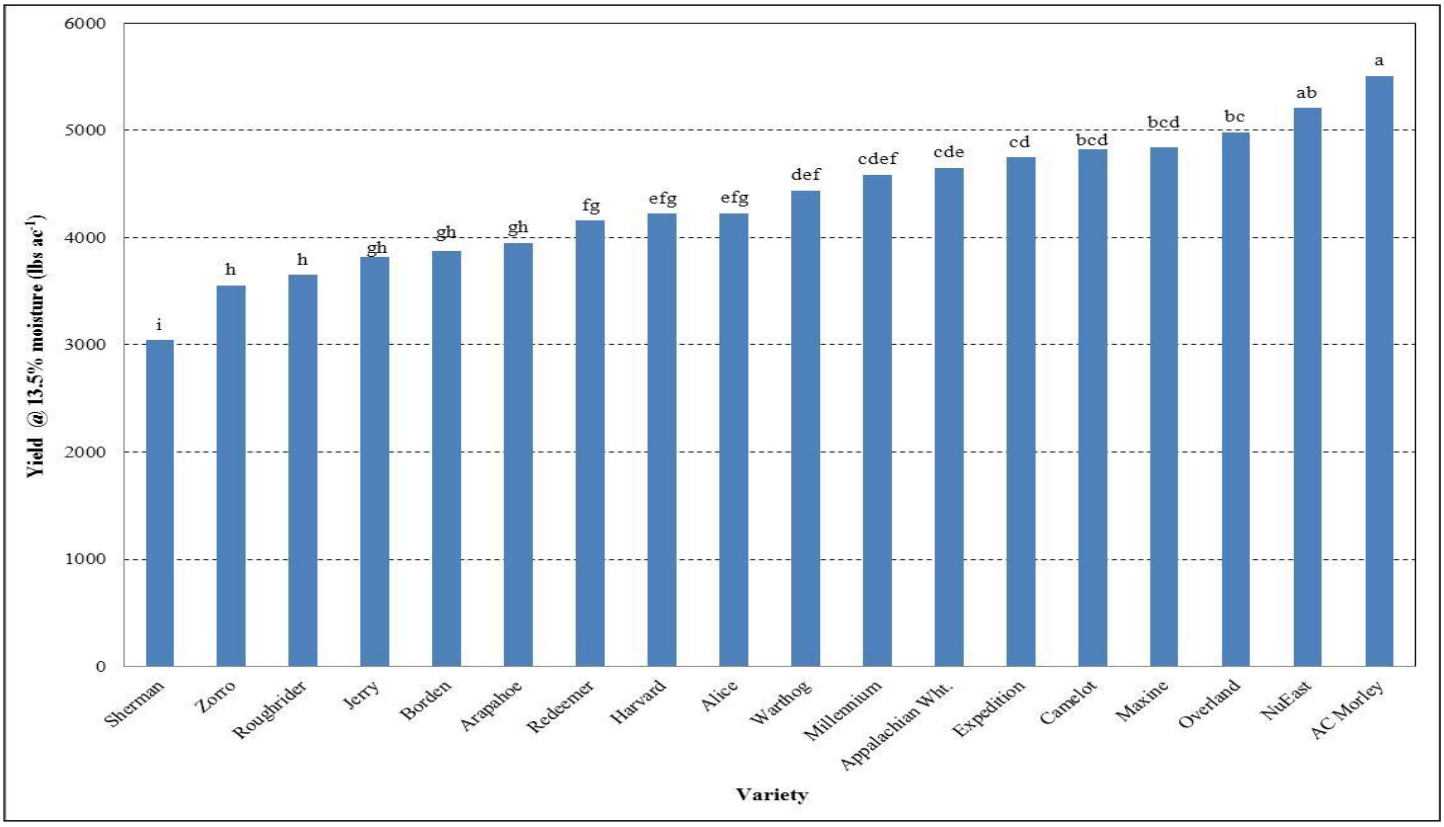

Figure 1. Yield of 18 winter wheat varieties, Alburgh, VT.

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

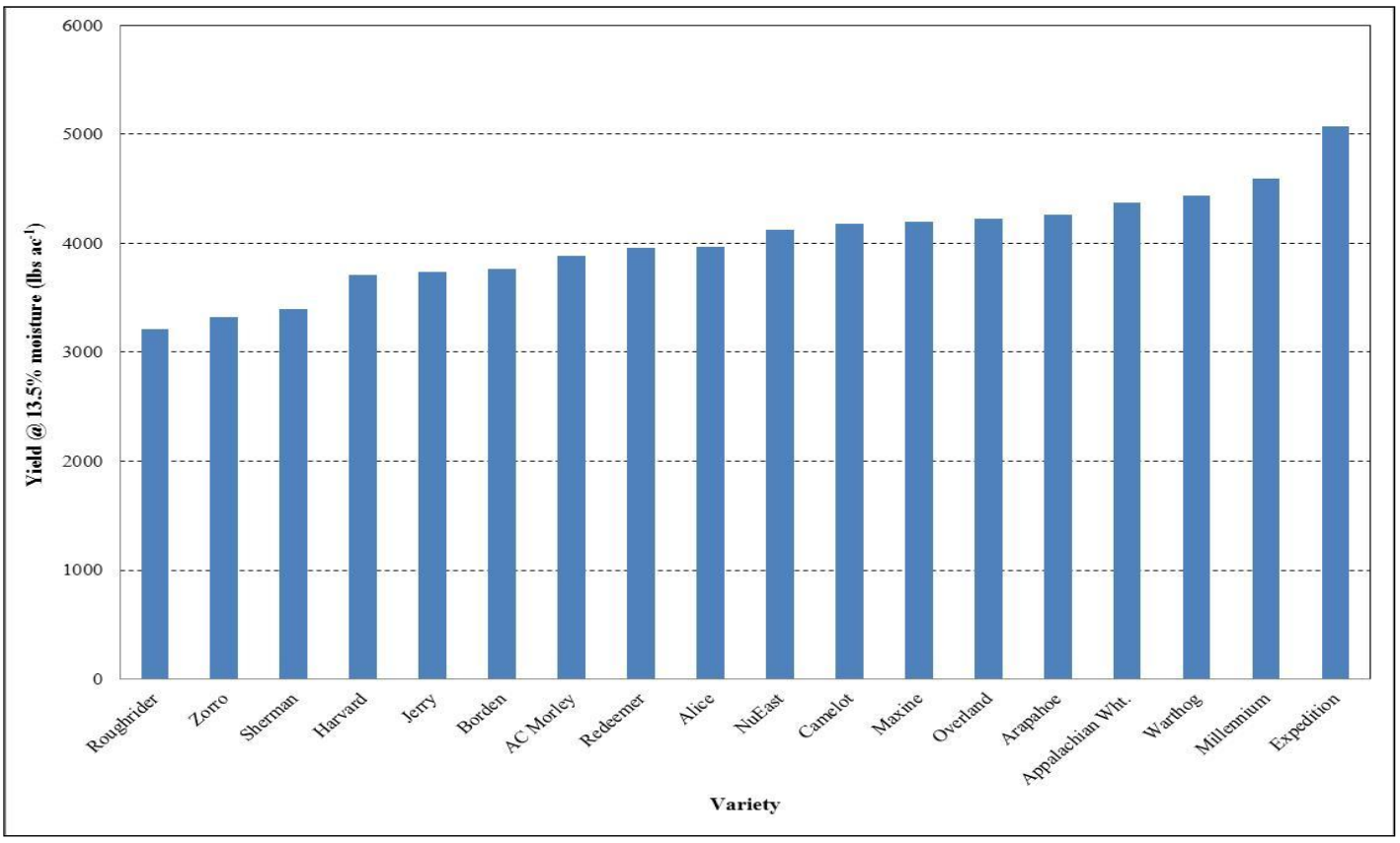

Figure 2. Yield of 18 winter wheat varieties, Willsboro, NY.

Winter Wheat Quality:

The common measures used by commercial mills to evaluate wheat quality are grain protein, falling number, test weight, and mycotoxin (DON) content (Table 8, 9; Fig. 3, 4). The varieties with the highest protein content at both locations were Redeemer and Sherman. The varieties with low protein concentrations at both locations included Millennium, Overland, and Expedition. Every variety had acceptable falling number levels based on mill standards. 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. All varieties from both trial locations were below the 1 ppm FDA threshold.

Table 8. Quality of 18 winter wheat varieties, Alburgh, VT.

Variety	Crude protein @ 12% moisture	Crude protein @ 14% moisture	Falling number @ 14% moisture	DON
	%	%	seconds	ppm
AC Morley	10.8	10.5	377	0.18
Alice	10.9	10.7	**416***	0.28
Appalachian Wht.	11.6	11.3	392*	0.15
Arapahoe	11.0	10.7	404*	0.30
Borden	10.5	10.3	354	0.14
Camelot	10.5	10.3	402*	0.20
Expedition	10.7	10.4	405*	**0.08**
Harvard	11.6	11.3	337	0.15
Jerry	11.4	11.2	413*	0.30
Maxine	11.9	11.6	391*	0.28
Millennium	9.95	9.70	397*	0.50
NuEast	10.3	10.0	403*	0.28
Overland	10.2	9.93	382	0.10
Redeemer	12.8*	12.5*	407*	0.18
Roughrider	10.9	10.7	369	0.25
Sherman	**13.0***	**12.7***	399*	0.35
Warthog	11.3	11.1	388*	0.18
Zorro	12.3	12.0	372	0.25
LSD (0.10)	0.56	0.55	30.2	NS
Trial Mean	11.2	10.9	389	0.23

Table 9. Quality of 18 winter wheat varieties,Willsboro. NY.

Variety	Crude protein @ 12% moisture	Crude protein @ 14% moisture	Falling number @ 14% moisture	DON
	%	%	seconds	ppm
AC Morley	9.69	9.46	354	0.20
Alice	9.47	9.26	402	0.43
Appalachian Wht.	10.2	10.0	408*	0.78
Arapahoe	9.37	9.16	394	0.49
Borden	9.50	9.29	377	0.30
Camelot	9.27	9.07	405	0.68
Expedition	8.71	8.52	395	0.60
Harvard	10.7	10.5	361	0.45
Jerry	9.94	9.73	386	0.63
Maxine	10.5	10.2	405	0.48
Millennium	9.37	9.16	390	0.43
NuEast	9.43	9.22	396	0.58
Overland	8.41	8.22	384	0.20
Redeemer	**11.4***	**11.1***	**439***	0.30
Roughrider	10.5	10.3	387	0.30
Sherman	11.3*	11.0*	411*	**0.15**
Warthog	10.5	10.2	435*	0.30
Zorro	11.2*	11.0*	351	0.40
LSD (0.10)	0.64	0.63	33.0	0.31
Trial Mean	10.0	9.7	393	0.43

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.

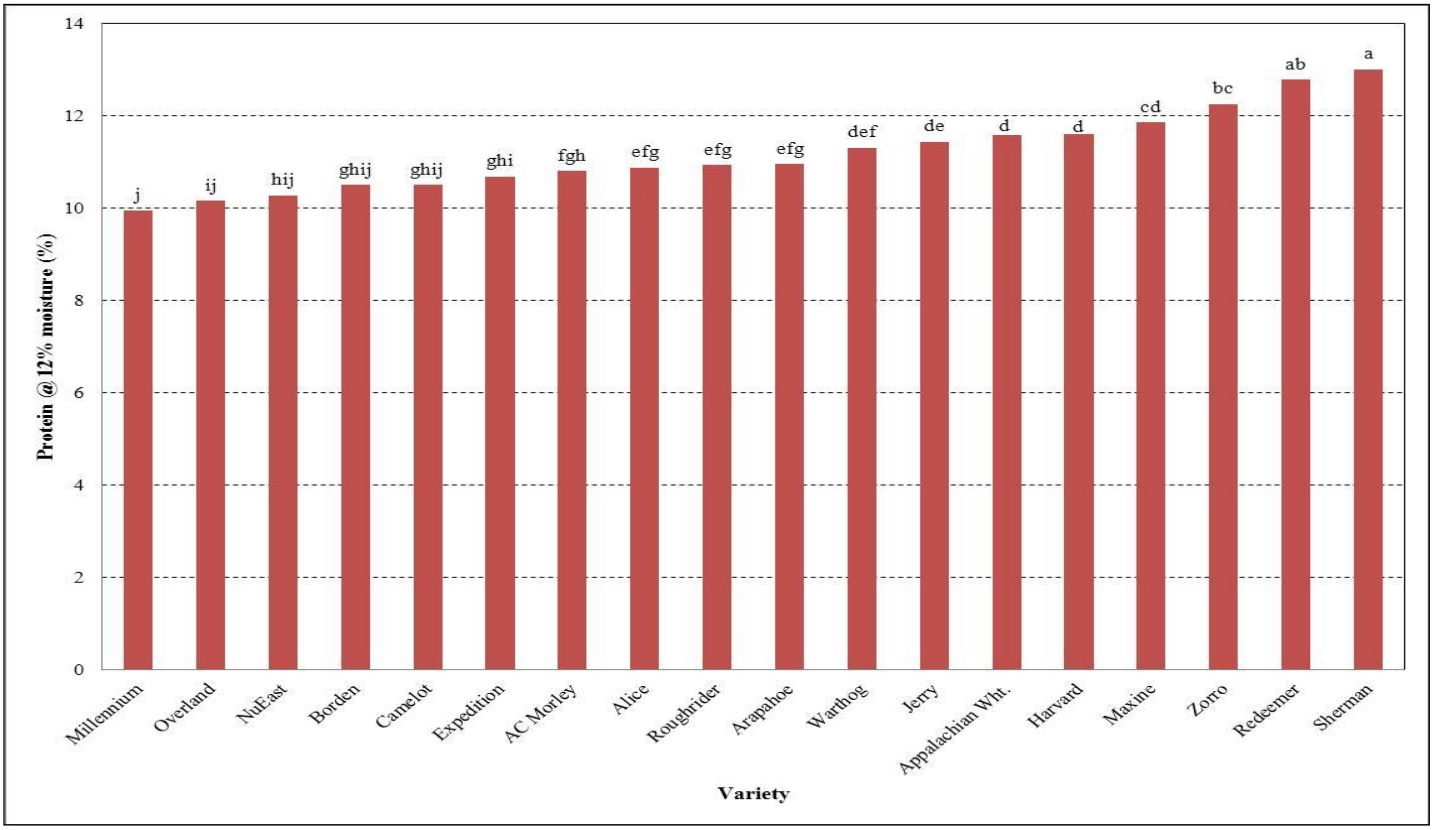

Figure 3. Protein concentration of 18 winter wheat varieties, Alburgh, VT.
*Varieties with the same letter did not differ significantly in protein content.

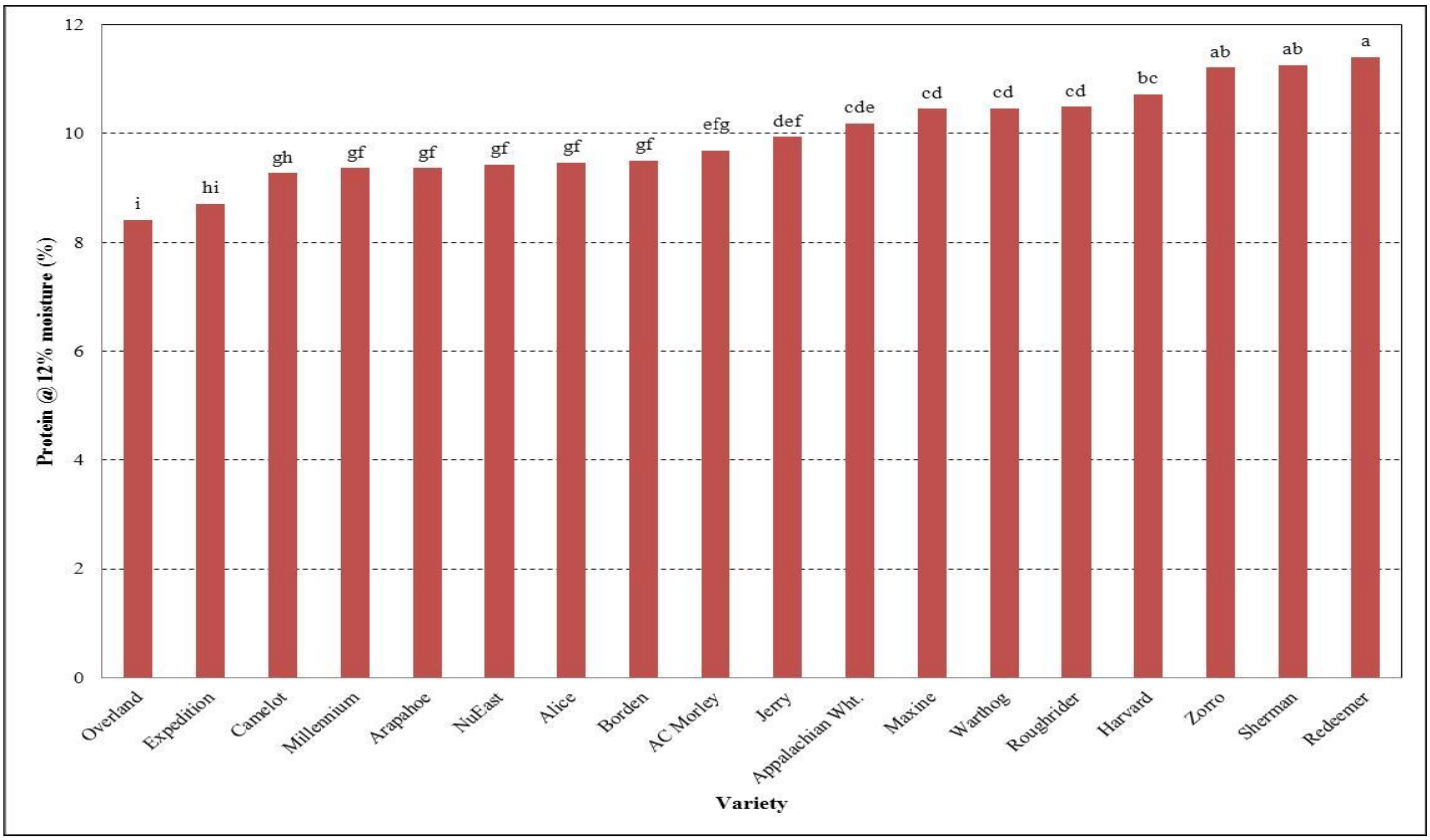

Figure 4. Protein concentration of 18 winter wheat varieties, Willsboro, NY.
*Varieties with the same letter did not differ significantly in protein content.

DISCUSSION

The 2012 growing season, similar to 2011, was all about the weather. However, where 2011 was marked by extremely wet conditions, 2012 was essentially ideal weather for growing wheat. Spring growth started early with the warm temperatures in March. As a result, the wheat flowered and matured earlier and therefore the trials were harvested a week before they had been in 2011. Yields were higher in both trial locations as well. The average yield in Alburgh was 800 lbs more than in 2011, and in Willsboro the difference was over 1500 lbs higher. Part of this large difference can be explained by the elimination of several low performing varieties. However, most of the 2012 varieties grown yielded higher than in 2011 at both of the trial sites. AC Morley continues to be the top yielding variety in Alburgh with 3 tons to the acre; unfortunately, the protein levels continue to be considerably lower than the industry standards. The protein levels at the Alburgh location were substantially higher than 2011 levels. Sherman had a protein level of 13% and Redeemer was a close second at 12.8%. The overall higher protein levels in Alburgh may be partially attributed to the lack of snow and rain during the growing season which decreased nutrient leaching. In addition, the wheat plots at this location were top-dressed in early May because plants were showing signs of nitrogen deficiency. The protein levels at the Willsboro location were similar to those in 2011. Redeemer continues to be a favorite among bakers for its high protein and baking characteristics. Producers however, are finding it difficult to grow due to disease challenges. Redeemer, though high in quality, appears to be especially susceptible to leaf diseases like Ascochyta leaf spot. In general, there was very little plant disease observed during the growing season. This can be explained by the lack of moisture necessary for the typical fungal pathogens (Loose smut, *Fusarium* head blight, and Ascochyta leaf spot) to thrive.

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