



# 2010 Winter Wheat Variety Trial



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# 2010 VERMONT WINTER WHEAT VARIETY PERFORMANCE TRIALS

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In 2010, the University of Vermont Extension in collaboration with the University of Maine began an extensive organic variety trial of 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. This trial is one of several in a USDA OREI grant focused on the production of high quality organic bread wheat in New England.

## WINTER WHEAT VARIETY TRIALS

The experimental plot designs at both locations were 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.**

Species		Seed Source
Winter Wheat Varieties	Type	
AC Morley	Hard Red	C&M Seed
Alliance	Hard Red	USDA-ARS
Anton	Hard Red	USDA-ARS
Arapahoe	Hard Red	Albert Lea Seed House
Bauermeister	Hard Red	Washington State Univ.
Borden	Medium-Hard Red	Butterworks Farm
Camelot	Hard Red	USDA-ARS
Expedition	Hard Red	Albert Lea Seedhouse
Harvard	Hard Red	Agriculver/ Seedway
HR9711J	Hard Red	JGL, Inc.
HR9712J	Hard Red	JGL, Inc.
HR9713J	Hard Red	JGL, Inc.
HW45-104J	Hard White	JGL, Inc.
Jerry	Hard Red	North Dakota State Univ.
Mace	Hard Red	USDA-ARS
Maxine	Hard Red	C&M Seed
MDM	Hard Red	Washington State Univ.
Millenium	Hard Red	USDA-ARS
Overland	Hard Red	USDA-ARS
Redeemer	Hard Red	C&M Seed
Roughrider	Hard Red	North Dakota State Univ.
Wahoo	Hard Red	USDA-ARS
Warthog	Hard Red	Semican
Wesley	Hard Red	USDA-ARS
Xerpha	Hard Red	Washington State Univ.
Zorro	Hard Red	Washington State Univ.

## WEATHER DATA

Seasonal precipitation and temperature recorded at weather stations in close proximity to the 2010 sites are shown in Table 2. This growing season's weather was ideal for growing wheat. Due to the early season warmth the wheat got off to an early start and continued to be a couple weeks ahead of what we have experienced in the past. From planting to harvest in Alburgh there was an accumulation of 5094 Growing Degree Days (GDD), 273 GDDs higher than the 30 year average. Willsboro, with 5187 GDDs, had a higher than average accumulation too, up 454 GDDs.

**Table 2. Temperature and precipitation summary for Alburgh, VT and Willsboro, NY, 2010.**

South Hero (Alburgh)	September 2009	October 2009	March	April	May	June	July
Average Temperature (F)	57.7	44.1	37.8	49.3	59.6	66.0	74.1
Departure from Normal	-2.7	-4.7	7.0	5.8	3.0	0.2	3.0
Precipitation (inches)	4.01	5.18	2.79	2.76	0.92	4.61	4.30
Departure from Normal	0.55	0.79	0.73	0.25	-2.01	1.40	0.89
Growing Degree Days (base 32)	771	395.5	229.4	520.5	854.1	1018.5	1305.1
Departure from Normal	-81.0	-125.3	113.3	175.5	91.5	4.5	94.6

Willsboro, NY	September 2009	October 2009	March	April	May	June	July
Average Temperature (F)	60.0	47	38.5	49.8	60.2	65.5	73.8
Departure from Normal	0.6	-0.7	9.5	7.8	5.8	0.2	3.7
Precipitation (inches)	0.46	1.63	3.38	2.11	1.08	4.84	2.38
Departure from Normal	-3.37	-1.49	1.53	0.79	-2.12	1.50	-1.00
Growing Degree Days (base 32)	815.5	426.7	238.7	532.5	875.8	1003.5	1294.3
Departure from Normal	-6.5	-58.5	120.9	189.0	116.3	-4.5	7.7

\*Based on National Weather Service data from cooperative observer stations in close proximity to field trials. Historical averages are for 30 years of data (1971-2000)

## CULTURAL PRACTICES

The seedbed 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 3).

The plots in Alburgh were seeded with a Kincaid Cone Seeder. Grain plots were harvested with an Almaco SP50 plot combine.

At the Willsboro location planting of the winter wheat followed 3 years of alfalfa/timothy sod. The sod was plowed in August 2008 and fallow prior to planting. The field was dragged twice during the fallow period to knock down out the alfalfa and perennial grasses. The plots were seeded with a custom made eight row cone planter and harvested with a Hege plot combine.

This trial evaluated wheat quality based on standard testing parameters used by commercial mills. Yield, moisture, and test weight were recorded at both locations during harvest. 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. 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. We analyzed grains for protein content by using the Perten

Inframatic 8600 Flour Analyzer. Grain protein affects gluten strength and loaf volume (Wall, 1979). Most commercial mills target 14-15% protein. The falling number is related to the level of sprout damage that has occurred in the grain. It is measured by of time it takes, in seconds, for a stirrer to fall through a flour and water slurry to the bottom of the tube. High 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. The determination of falling number (AACC Method 56-81B, AACC Intl., 2000) was measured on the Perten FN 1500 Falling Number Machine. Deoxynivalenol (DON) analysis was done using Veratox DON 5/5 Quantitative test from the NEOGEN Corp. This test has a detection range of 0.5 to 5 ppm. DON values greater than 1 ppm are considered unsuitable for human consumption (FDA, 1993).

All data was analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate cultivar means when the F-test was significant ( $P < 0.10$ ).

**Table 3. General plot management of the wheat trials.**

Trial Information	Winter wheat variety trial	
	Alburgh, VT Borderview Farm	Willsboro, NY Willsboro Research Farm
Location	Alburgh, VT Borderview Farm	Willsboro, NY Willsboro Research Farm
Soil type	Benson rocky silt loam	Kingsbury silt clay loam
Previous crop	Sod	Fallow
Row spacing (in.)	6	6
Seeding rate	150 lbs/acre	150 lbs/acre
Replicates	4	4
Planting date	9-26-09	9-25-09
Harvest date	7-21-10	7-26-10
Harvest area (ft.)	5x20	4x13.5
Tillage operations	Fall plow, disc, & spike-toothed harrow	Fall plow, disc, & spike-toothed harrow



**Image 1. Planting the Alburgh trial**



**Image 2. Fall emergence**

## 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 (LSD's) 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*
<b>LSD</b>	<b>889</b>

## WINTER WHEAT RESULTS

During the 2010 growing season several observations and measurements were recorded on wheat development. In Tables 4 and 5 we noted when each of the varieties flowered. At both the Alburgh and Willsboro locations the majority of the trialed varieties flowered during the second week of June. However, all three of the Washington State University varieties, MDM, Bauermeister, and Xerpha, at both sites, had the latest flowering dates. These same three varieties had the highest mycotoxin (DON) levels (Tables 9 & 10). In the Northeast, *Fusarium* head blight 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, >1ppm, poses a health risk to both humans and livestock. Bird damage was minimal at both locations. There was one plot of Roughrider at the Alburgh site where 50% lodging was recorded; otherwise lodging was not an issue. Loose smut caused by the fungus, *Ustilago tritici*, was observed at both locations. Infected heads were found in four varieties in Alburgh: Wesley, Roughrider, Wahoo, and Anton. Willsboro also had four varieties in which infected heads were found: Wesley, Overland, Maxine, and Anton. 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 with a dusty black appearance of diseased heads. Usually, all the glumes and grain in a smutted head are entirely transformed into black powder. This sooty mass is composed almost entirely of millions of microscopic smut spores (Image 3). The spores are swiftly dispersed by the wind



**Image 3. Loose smut infected wheat**

during wheat flowering and can infect healthy plants. As more farmers save their seed the potential for yield losses due to the

spread of loose smut contaminated grain has become a major concern, especially for organic producers where there are limited treatments for infected seed.

**Table 4. Alburgh wheat flowering**

Variety	Early	Mid	Late
	1st Wk June	2nd Wk June	3rd Wk June
AC Morley		X	
Alliance	X		
Anton		X	
Arapahoe		X	
Bauermeister			X
Borden	X		
Camelot	X		
Expedition	X		
Harvard	X		
HR9711J		X	
HR9712J		X	
HR9713J		X	
HW45-104J		X	
Jerry		X	
Mace		X	
Maxine	X		
MDM			X
Millenium		X	
Overland		X	
Redeemer		X	
Roughrider		X	
Wahoo		X	
Warthog		X	
Wesley	X		
Xerpha			X
Zorro		X	

**Table 5. Willsboro wheat flowering**

Variety	Early	Mid	Late
	1st Wk June	2nd Wk June	3rd Wk June
AC Morley	X		
Alliance		X	
Anton		X	
Arapahoe		X	
Bauermeister			X
Borden	X		
Camelot		X	
Expedition		X	
Harvard		X	
HR9711J		X	
HR9712J		X	
HR9713J	X		
HW45-104J		X	
Jerry		X	
Mace		X	
Maxine		X	
MDM			X
Millenium		X	
Overland		X	
Redeemer	X		
Roughrider		X	
Wahoo		X	
Warthog		X	
Wesley		X	
Xerpha			X
Zorro		X	

After the wheat reached physiological maturity plant heights were measured. In Table 6 we compare the plant heights to the weed biomass subsampled from each of the plots. At the Alburgh location Borden was the tallest variety at 44.9 inches, the shortest variety was HW45-104J at 28.1 inches. In Willsboro Ac Morley was the tallest variety at 39.7 inches, the shortest at 29 inches was HR9713J. In general we observed that the shorter, or more slowly growing varieties had higher weed pressures. The taller, or earlier developing varieties overall had less weeds.



**Image 4. Winter wheat variety trial in Alburgh, note the hieght differences**

**Table 6. Plant hieghts and weed biomass from both locations**

Alburgh			Willsboro		
Variety	Plant Height	Weed Biomass	Variety	Plant Height	Weed Biomass
	inches	lbs/acre		inches	lbs/acre
AC Morley	43.0*	0.0	AC Morley	<b>39.7*</b>	197.0
Alliance	33.8	0.0	Alliance	31.9	212.5
Anton	33.2	37.8	Anton	29.4	119.8
Arapahoe	35.6	0.0	Arapahoe	32.4	139.5
Bauermeister	33.9	208.3	Bauermeister	38.3*	338.8
Borden	<b>44.9*</b>	11.0	Borden	39.3*	102.0
Camelot	33.3	53.3	Camelot	32.3	108.5
Expedition	31.9	20.0	Expedition	31.9	28.8
Harvard	34.6	161.8	Harvard	34.3	97.5
HR9711J	31.5	137.3	HR9711J	31.0	146.3
HR9712J	36.3	163.8	HR9712J	37.2*	108.8
HR9713J	29.6	367.5	HR9713J	29.0	580.3*
HW45-104J	28.1	<b>553.5</b>	HW45-104J	32.6	438.5
Jerry	40.3	155.0	Jerry	35.7*	77.5
Mace	31.8	51.0	Mace	33.5	316.5
Maxine	31.6	20.0	Maxine	30.9	626.8*
MDM	31.9	0.0	MDM	33.9	<b>752.8*</b>
Millenium	36.8	0.0	Millenium	33.4	146.0
Overland	34.5	75.3	Overland	32.9	210.5
Redeemer	35.9	113.0	Redeemer	33.2	159.5
Roughrider	44.6*	0.0	Roughrider	37.1*	57.5
Wahoo	35.9	228.0	Wahoo	33.8	48.8
Warthog	37.5	0.0	Warthog	33.8	263.3
Wesley	30.5	168.3	Wesley	30.7	257.0
Xerpha	30.3	35.5	Xerpha	31.6	232.8
Zorro	37.9	157.3	Zorro	38.9*	274.5
<i>Trial Mean</i>	<i>35.0</i>	<i>104.5</i>	<i>Trial Mean</i>	<i>33.8</i>	<i>232.4</i>
<i>LSD (0.10)</i>	<i>3.6</i>	<i>NS</i>	<i>LSD (0.10)</i>	<i>4.3</i>	<i>289.0</i>

\* Wheat that did not perform significantly lower than the top performing variety in a particular column are indicated with an asterisk.

NS - None of the varieties were significantly different from one another.



Image 5. Alburgh trial harvest



Image 6. Willsboro trial harvest

The highest yielding variety at both the Alburgh, 4615 lb ac<sup>-1</sup>, and Willsboro, 4657 lb ac<sup>-1</sup>, locations was Borden (Tables 7 & 8 and Figures 1 & 2). In Alburgh, the lowest yielding variety was MDM with 2606 lb ac<sup>-1</sup> while HR9713J was the lowest yielding variety at the Willsboro location with 1887 lb ac<sup>-1</sup>. Redeemer had the highest test weight at the Alburgh site with 57.3 lbs/bu. Two of the three Washington State University varieties, Bauermeister and MDM, had the lowest test weights of 50.5 lbs/bu. In Willsboro Expedition had the highest test weight of 60.3 lbs/bu and Xerpha, the third Washington State variety, had the lowest test weight at 49.5 lbs/bu. The variety with the highest moisture content at harvest in Alburgh was Bauermeister with a moisture of 17.3%. There were two varieties in Alburgh, Xerpha and Mace with the lowest moisture content of 11.9%. Harvard had the highest moisture content at 14% and Xerpha had the lowest at 7.0% moisture in Willsboro.

Table 7. Alburgh harvest results

Variety	Harvest Moisture	Test Weight	Yield @13.5% Moisture
	%	lbs/bu	lbs/ac
AC Morley	16.8*	57.0*	3985*
Alliance	13.1	55.5	4011*
Anton	14.4	55.6	3521
Arapahoe	14.0	55.3	4041*
Bauermeister	<b>17.3*</b>	50.5	3176
Borden	15.2	54.4	<b>4615*</b>
Camelot	15.8*	56.0*	3631
Expedition	15.8*	56.3*	3466
Harvard	16.0*	55.6	3237
HR9711J	15.6	56.6	3686
HR9712J	15.7	55.9	3682
HR9713J	15.2	55.8	3321
HW45-104J	14.0	54.9	3161
Jerry	15.2	55.5	4408*
Mace	11.9	53.8	3653
Maxine	14.9	56.9*	3692
MDM	15.3	50.5	2606
Millenium	15.6	56.4*	4319*
Overland	15.5	55.6	4208*
Redeemer	15.2	<b>57.3*</b>	3886*

Table 8. Willsboro harvest results

Variety	Harvest Moisture	Test Weight	Yield @13.5% Moisture
	%	lbs/bu	lbs/ac
AC Morley	10.8	59.0*	3798
Alliance	11.2	58.6	4390*
Anton	10.6	58.8*	3413
Arapahoe	10.7	59.3*	4439*
Bauermeister	10.5	55.5	3146
Borden	9.1	57.6	<b>4657*</b>
Camelot	11.2	58.9*	4121
Expedition	12.0*	<b>60.3*</b>	4173
Harvard	<b>14.0*</b>	59.5*	4303*
HR9711J	10.3	57.6	3288
HR9712J	10.5	59.0*	4438*
HR9713J	11.7*	53.0	1887
HW45-104J	9.0	57.3	3290
Jerry	9.9	58.6	4432*
Mace	10.2	56.9	3337
Maxine	11.2	57.6	2822
MDM	9.7	55.9	3315
Millenium	10.6	58.9*	4397*
Overland	10.7	59.1*	4372*
Redeemer	11.5*	58.1	3043



Roughrider	15.2	57.0*	3423
Wahoo	14.4	55.1	3881*
Warthog	16.5*	56.6*	3580
Wesley	12.3	55.3	3661
Xerpha	11.9	50.8	3135
Zorro	15.1	56.0*	2836
<i>Trial Mean</i>	14.9	55.2	3647
<i>LSD (0.10)</i>	1.5	1.3	889

Roughrider	10.1	59.5*	3798
Wahoo	10.0	58.9*	4451*
Warthog	11.4*	58.4	3178
Wesley	9.0	56.6	4054
Xerpha	7.0	49.5	2095
Zorro	12.7*	59.0*	3746
<i>Trial Mean</i>	10.6	57.7	3707
<i>LSD (0.10)</i>	2.6	1.5	468

\* Wheat that did not perform significantly lower than the top performing variety in a particular column are indicated with an asterisk.

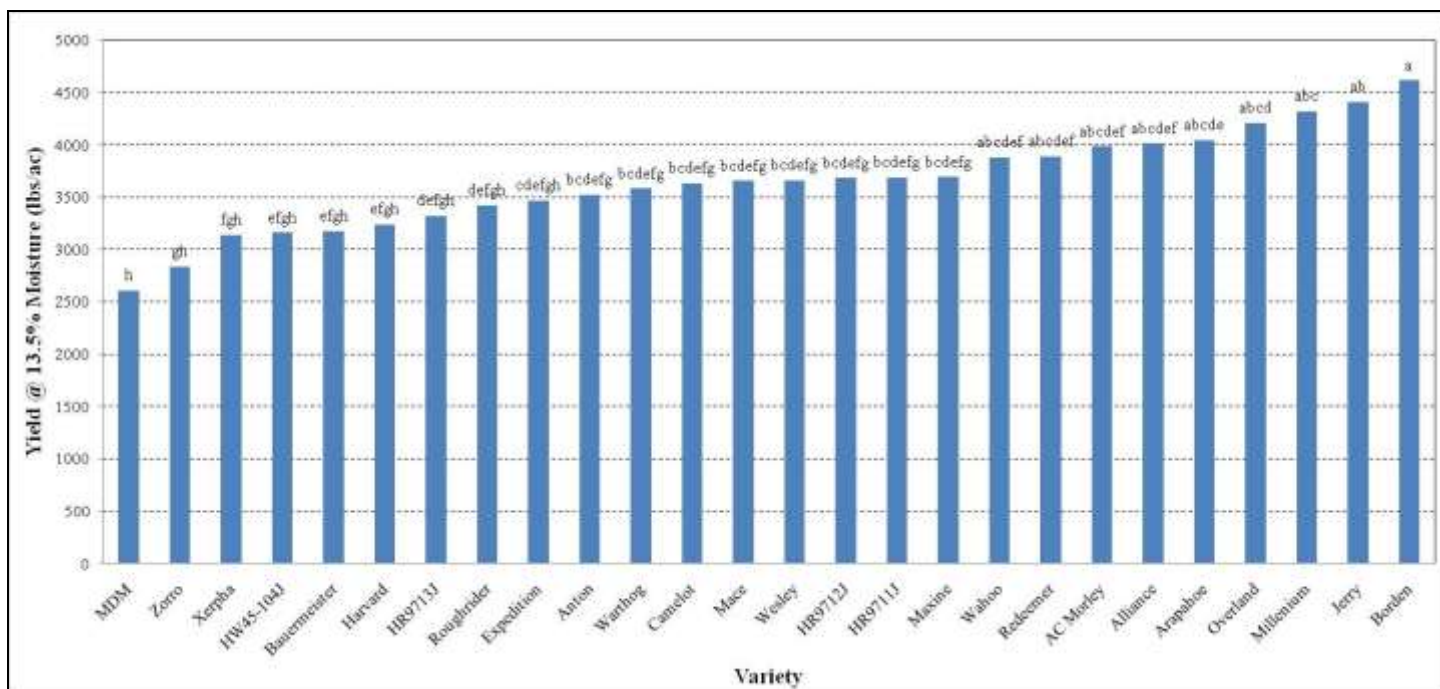


Figure 1. Winter wheat yields of 26 varieties, Alburgh, VT

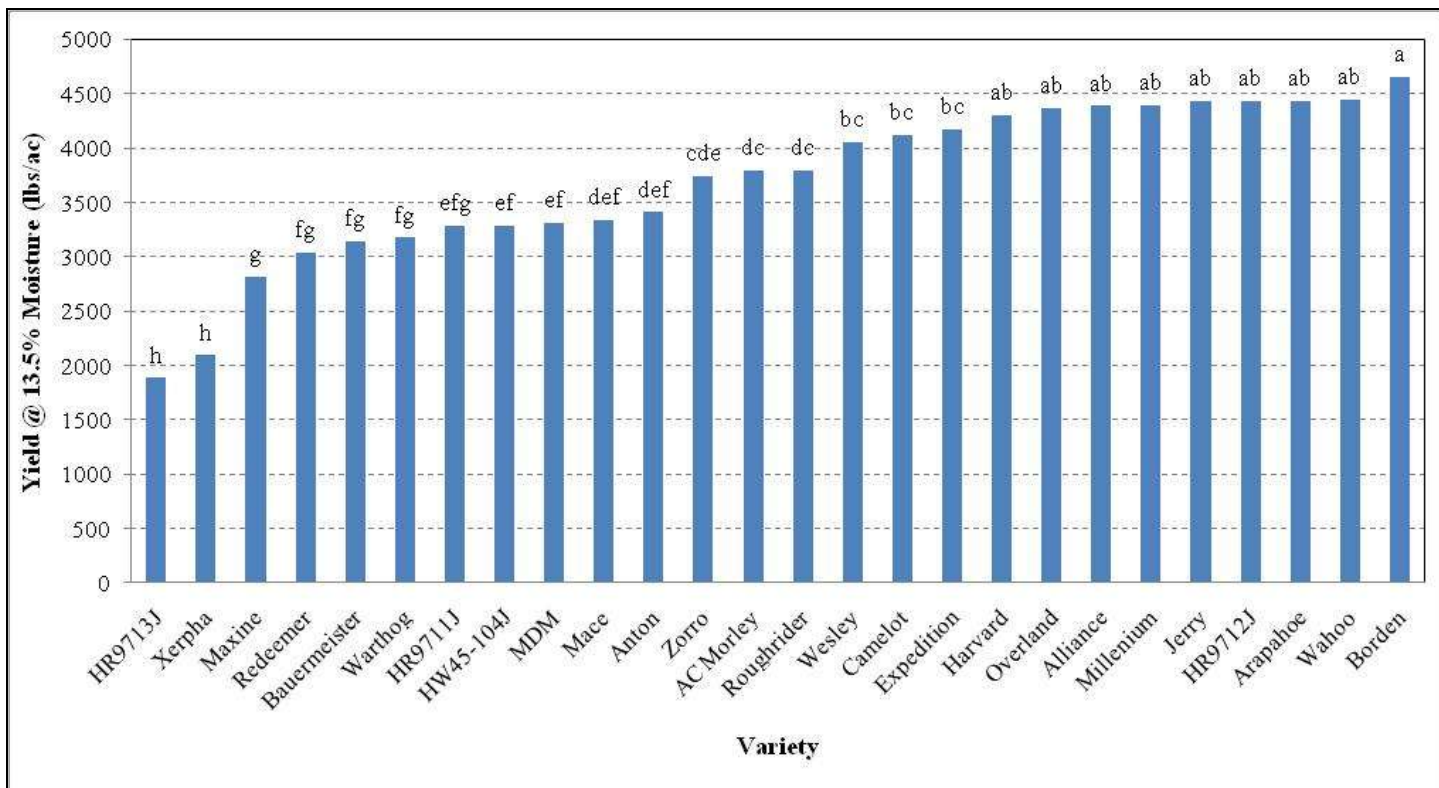


Figure 2. Winter wheat yields of 26 varieties, Willsboro, NY

The common measures used by commercial mills to evaluate wheat quality are: grain protein, falling number, test weight, and mycotoxin (DON) content. The variety with the highest protein content at both locations was HR9713J, with 13.2% in Alburgh and 14.7% in Willsboro. The varieties Overland and Wahoo had the lowest proteins at 9.3% in Alburgh, while the variety with the lowest protein content at the Willsboro site was Borden with a protein of 11.8% (Tables 9 & 10 and Figures 3 & 4). In Alburgh the variety with the highest falling

number was Redeemer with 421 seconds, Xerpha had the lowest with 211 seconds. The highest falling number in Willsboro was Warthog with a Falling Number of 422 seconds, the variety with lowest falling number at this location was HW45-104J, it took the plunger just 197 seconds to hit bottom of the tube. The variety with the highest DON value at both locations MDM, in Alburgh there was 9.2 ppm and in Willsboro the amount was 10.10 ppm. The variety with the lowest concentration of DON was Borden, 0.38 ppm, in Alburgh. At the Willsboro site Jerry had the lowest DON value with a concentration of 0.15 ppm.

Table 9. Alburgh quality results

Variety	Crude Protein @14% Moisture	Falling Number @14% Moisture	DON
	%	seconds	ppm
AC Morley	11.8	368	0.63
Alliance	9.7	346	0.35
Anton	11.3	355	1.75
Arapahoe	10.9	396	0.60
Bauermeister	11.1	380	5.55
Borden	9.5	364	0.38

Table 10. Willsboro quality results

Variety	Crude Protein @14% Moisture	Falling Number @14% Moisture	DON
	%	seconds	ppm
AC Morley	12.8	349	0.65
Alliance	12.1	333	0.40
Anton	13.4	236	2.38
Arapahoe	12.7	400*	0.60
Bauermeister	13.2	375	4.20
Borden	11.8	361	0.50

Camelot	10.9	395	0.58
Expedition	9.9	388	0.58
Harvard	9.5	374	1.93
HR9711J	11.0	400*	2.13
HR9712J	9.9	335	0.60
HR9713J	<b>13.2*</b>	361	1.10
HW45-104J	10.4	282	1.53
Jerry	10.5	381	2.10
Mace	11.3	388	0.93
Maxine	10.5	385	0.48
MDM	11.3	272	<b>9.20*</b>
Millenium	9.8	376	0.45
Overland	9.3	382	0.75
Redeemer	12.6*	<b>421*</b>	0.40
Roughrider	11.3	399*	0.60
Wahoo	9.3	377	1.95
Warthog	10.9	412*	0.95
Wesley	10.6	382	0.68
Xerpha	10.8	211	7.50
Zorro	11.9	370	0.85
<i>Trial Mean</i>	10.7	365	1.71
<i>LSD (0.10)</i>	1.2	22	1.69

Camelot	12.8	386	0.43
Expedition	12.8	363	0.80
Harvard	11.9	363	0.63
HR9711J	12.6	372	2.33
HR9712J	12.2	331	0.70
HR9713J	<b>14.7*</b>	255	2.40
HW45-104J	12.9	197	1.33
Jerry	12.4	376	0.15
Mace	12.6	387	0.88
Maxine	13.3	375	0.83
MDM	13.3	224	<b>10.10*</b>
Millenium	12.5	378	1.00
Overland	12.5	399*	0.40
Redeemer	14.0*	420*	0.40
Roughrider	13.2	365	0.78
Wahoo	12.8	379	0.88
Warthog	12.8	<b>422*</b>	0.93
Wesley	12.5	377	1.35
Xerpha	13.0	209	8.85*
Zorro	12.8	342	0.86
<i>Trial Mean</i>	12.8	345	1.72
<i>LSD (0.10)</i>	0.9	23	1.29

\* Wheat that did not perform significantly lower than the top performing variety in a particular column are indicated with an asterisk.

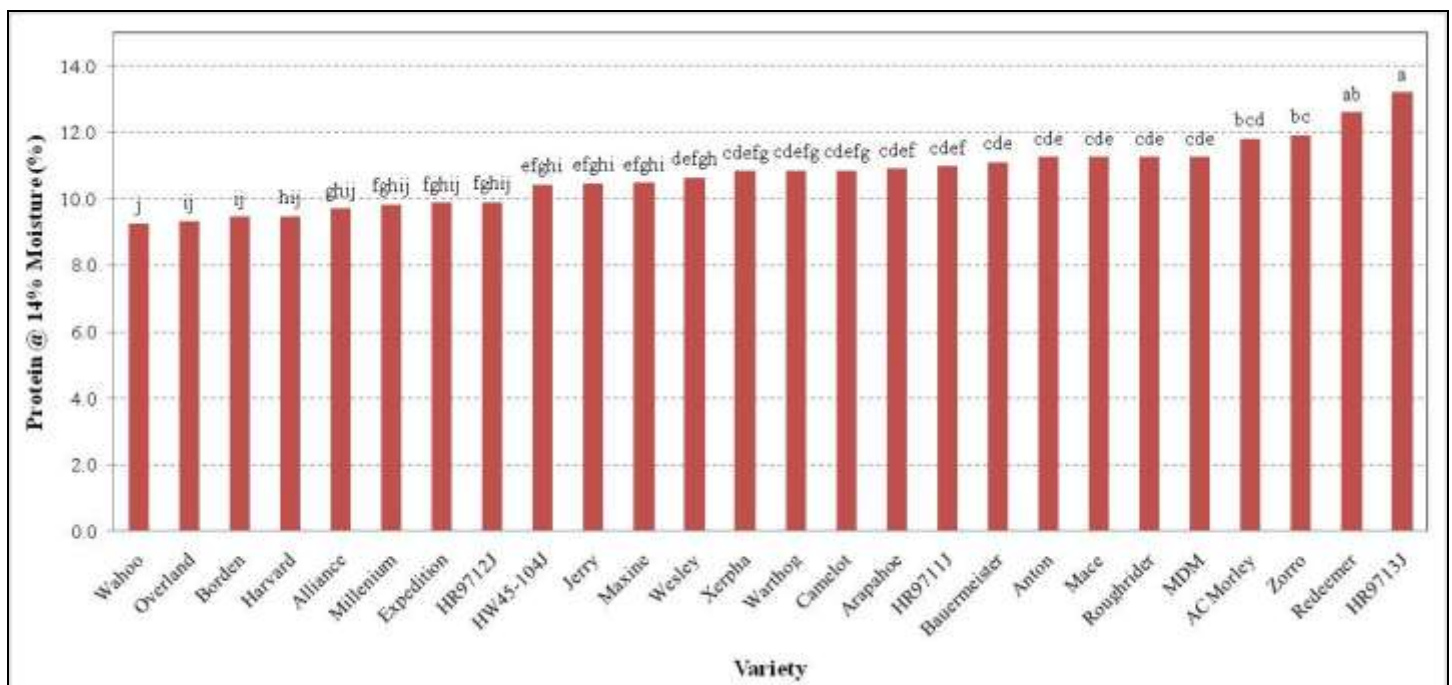
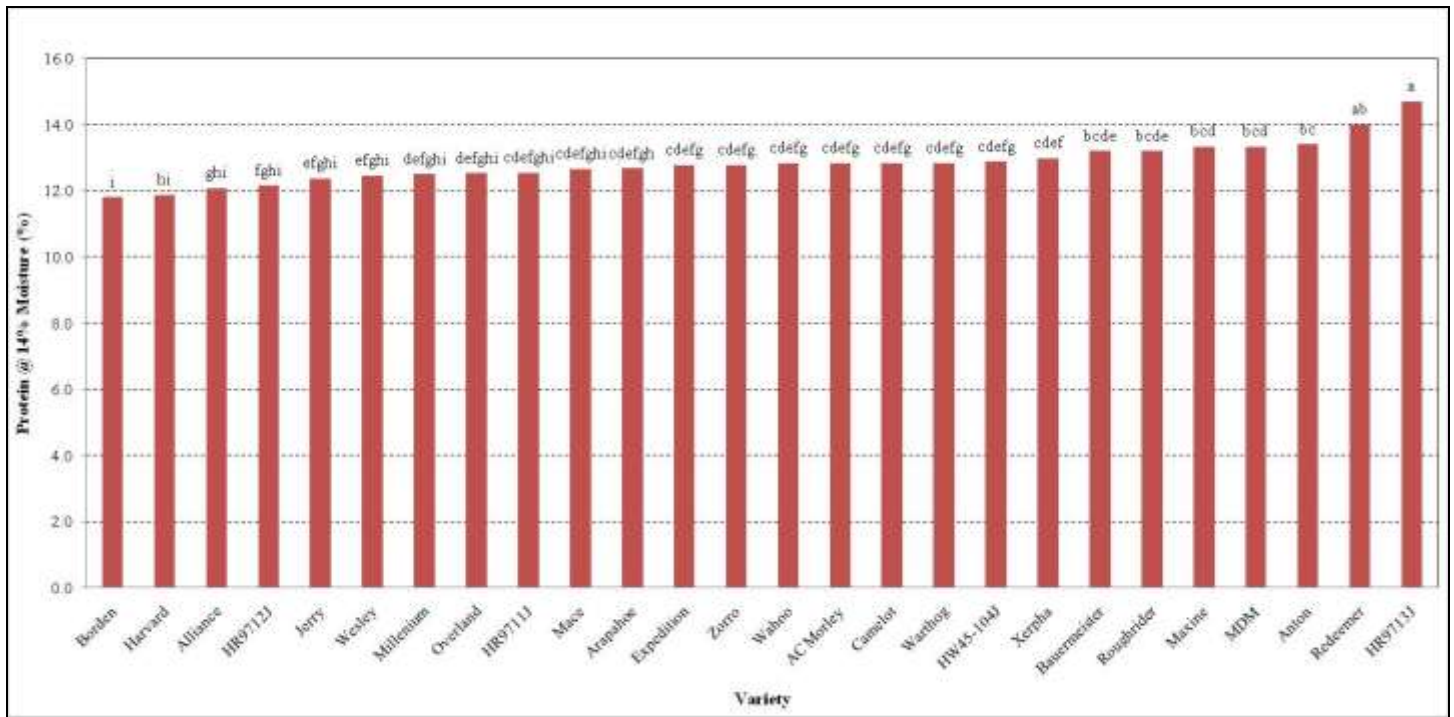


Figure 3. Winter wheat grain proteins of 26 varieties, Alburgh, VT



**Figure 4. Winter wheat grain proteins of 26 varieties, Willsboror, NY**

The UVM Extension Crops and Soils Team would like to thank the Borderview Research Farm and the Willsboro Research Farm for their generous help with the trials and acknowledge the USDA for their financial support.

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