NW CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES

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 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. 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.

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	Semican
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 White	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	Soft White	Washington State Univ.
Zorro	Hard Red	C&M Seed

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 warn spring the wheat got off to an early start and continued to be at least a week early in reaching major developmental stages. 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 accumulated GDDs had 454 more GDDS than the long term average.

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 Alburgh site had been perennial forages (reed canary and alfalfa) for the previous 10 years. In the spring of 2009 the area was moldboard plowed. In August, the field was disked and spike tooth harrowed to prepare for planting the winter wheat. The plots in Alburgh were seeded with a Kincaid Cone Seeder on September 26th, 2010. Grain plots were harvested with an Almaco SP50 plot combine on July 21st, 2010.

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 on September, 25th with a custom made eight-row cone planter and harvested on July 26th, 2010 with a Hege plot combine.

Following harvest, seed was cleaned with a small Clipper cleaner. 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 14-15% 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 Quantitaive 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 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 3. General plot management of the wheat trials.

Trial Information	**Winter wheat variety trial**	
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 (lbs ac^{-1})	150	150
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 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

<u>Winter Wheat Growth and Development</u>:

During the 2010 growing season several observations and measurements were recorded on wheat development. Relative flowering date was recorded for each of the varieties (Table 4 and 5). At both locations the majority of varieties flowered during the second week of June. However, all three of the Washington State University varieties, MDM, Bauermeister, and Xerpha, had the latest flowering dates. Lodging and bird damage was minimal at both locations. Loose smut caused by the fungus, *Ustilago tritici*, was observed at both locations. Two varieties Wesley and Anton showed signs of loose smut 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 (Image 3). The spores are dispersed by the wind during wheat flowering and can infect healthy plants.

Image 3. Loose smut infected wheat

Table 4. Relative flowering date of wheat, Alburgh.

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. Relative flowering date of wheat, Willsboro

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. Plant heights and weed biomass are reported in Table 6. Borden, AC Morley, and Roughrider were amoung the tallest varieties for both locations. In general we observed that the shorter and less vigorous varieties had higher weed preassures. The taller, or earlier developing varieties overall had less weed biomass. In general, there was low weed pressure in the winter wheat variety trials.

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

Table 6. Plant heights & weed biomass, Alburgh and Willsboro

Alburgh		
Variety	**Plant height**	**Weed biomass**
	inches	lbs ac^{-1}
AC Morley	43.0*	0.0
Alliance	33.8	0.0
Anton	33.2	37.8
Arapahoe	35.6	0.0
Bauermeister	33.9	208.3
Borden	**44.9***	11.0
Camelot	33.3	53.3
Expedition	31.9	20.0
Harvard	34.6	161.8
HR9711J	31.5	137.3
HR9712J	36.3	163.8
HR9713J	29.6	367.5
HW45-104J	28.1	**553.5***
Jerry	40.3	155.0
Mace	31.8	51.0
Maxine	31.6	20.0
MDM	31.9	0.0
Millenium	36.8	0.0
Overland	34.5	75.3
Redeemer	35.9	113.0
Roughrider	44.6*	0.0
Wahoo	35.9	228.0
Warthog	37.5	0.0
Wesley	30.5	168.3
Xerpha	30.3	35.5
Zorro	37.9	157.3
Trial Mean	*35.0*	*104.5*
LSD (0.10)	*3.6*	*NS*

Willsboro		
Variety	**Plant height**	**Weed biomass**
	inches	lbs ac^{-1}
AC Morley	**39.7***	197.0
Alliance	31.9	212.5
Anton	29.4	119.8
Arapahoe	32.4	139.5
Bauermeister	38.3*	338.8
Borden	39.3*	102.0
Camelot	32.3	108.5
Expedition	31.9	28.8
Harvard	34.3	97.5
HR9711J	31.0	146.3
HR9712J	37.2*	108.8
HR9713J	29.0	580.3*
HW45-104J	32.6	438.5
Jerry	35.7*	77.5
Mace	33.5	316.5
Maxine	30.9	626.8*
MDM	33.9	**752.8***
Millenium	33.4	146.0
Overland	32.9	210.5
Redeemer	33.2	159.5
Roughrider	37.1*	57.5
Wahoo	33.8	48.8
Warthog	33.8	263.3
Wesley	30.7	257.0
Xerpha	31.6	232.8
Zorro	38.9*	274.5
Trial Mean	*33.8*	*232.4*
LSD (0.10)	*4.3*	*289.0*

* 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

Winter Wheat Yield:

Exceptional weather in 2009 and 2010 lead to what most farmers exclaimed as the best winter wheat crop in years. The highest yielding variety at both the Alburgh, 4615 lb ac^{-1}, and Willsboro, 4657 lb ac^{-1}, locations was Borden (Tables 7, 8 and Figures 1, 2). Other top yielding varieties at both locations included Jerry, Alliance, Arapahoe, Millennium, Overland, and Wahoo. Varieties that yielded well at both locations indicate a variety's ability to adapt to various soil and climatic conditions. In Alburgh, the lowest yielding variety was MDM with 2606 lb ac^{-1} while HR9713J was the lowest yielding variety at the Willsboro location with 1887 lb ac^{-1}.

Redeemer had the highest test weight at the Alburgh site with 57.3 lbs bu^{-1}. The varieties Xerpha, MDM, and Bauermesiter had the lowest test weights. In Willsboro Expedition had the highest test weight of 60.3 lbs bu^{-1} and Xerpha had the lowest test weight at 49.5 lbs bu^{-1}. In general, most varieties reached the optimal 55 to 60 lb bu^{-1} test weight for wheat.

Table 7. Yield of winter wheat, Alburgh

Variety	Harvest moisture	Test weight	Yield @13.5% moisture
	%	lbs bu^{-1}	lbs ac^{-1}
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	**17.3***	50.5	3176
Borden	15.2	54.4	**4615***
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	**57.3***	3886*
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
Trial Mean	14.9	55.2	3647
LSD (0.10)	1.5	1.3	889

Table 8. Yield of winter wheat, Willsboro

Variety	Harvest moisture	Test weight	Yield @13.5% moisture
	%	lbs bu^{-1}	lbs ac^{-1}
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	**4657***
Camelot	11.2	58.9*	4121
Expedition	12.0*	**60.3***	4173
Harvard	**14.0***	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	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
Trial Mean	10.6	57.7	3707
LSD (0.10)	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.

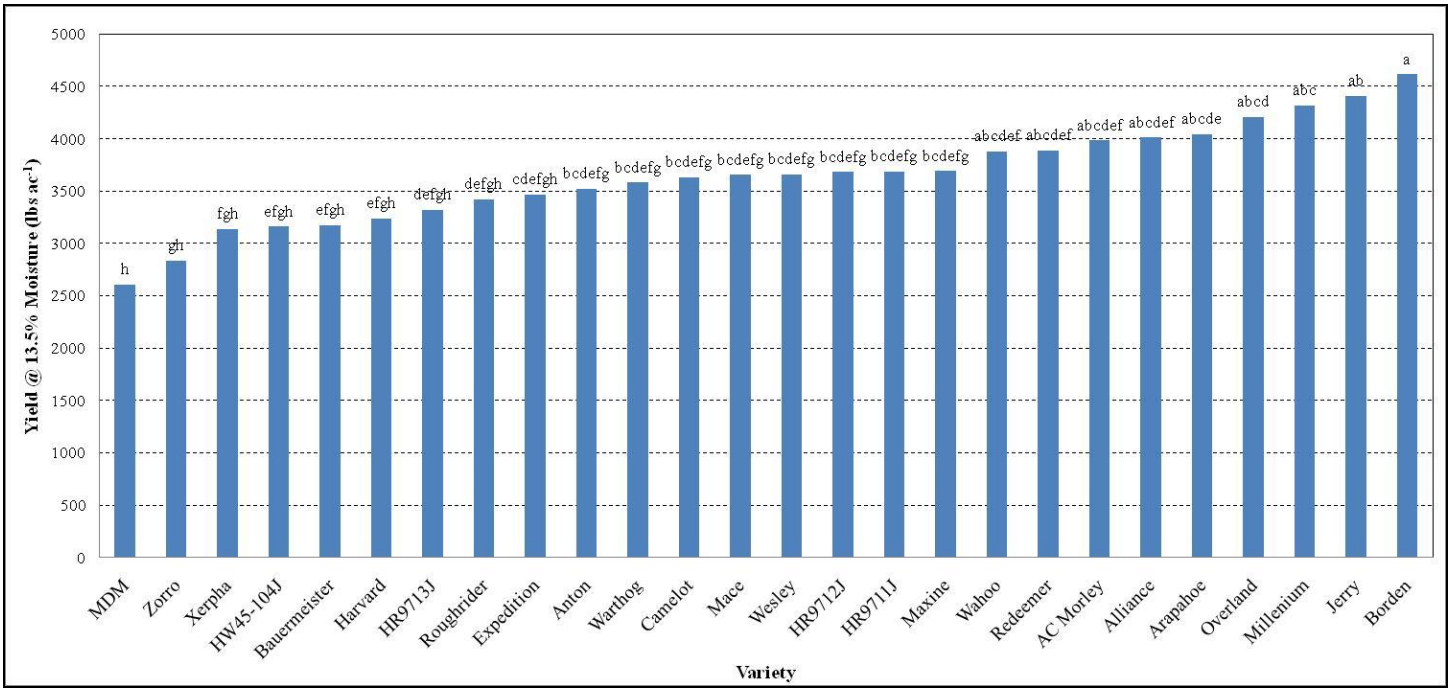

Figure 1. Yield of 26 winter wheat varieties, Alburgh, VT
*Varieties with the same letter did not differ significantly in yield.

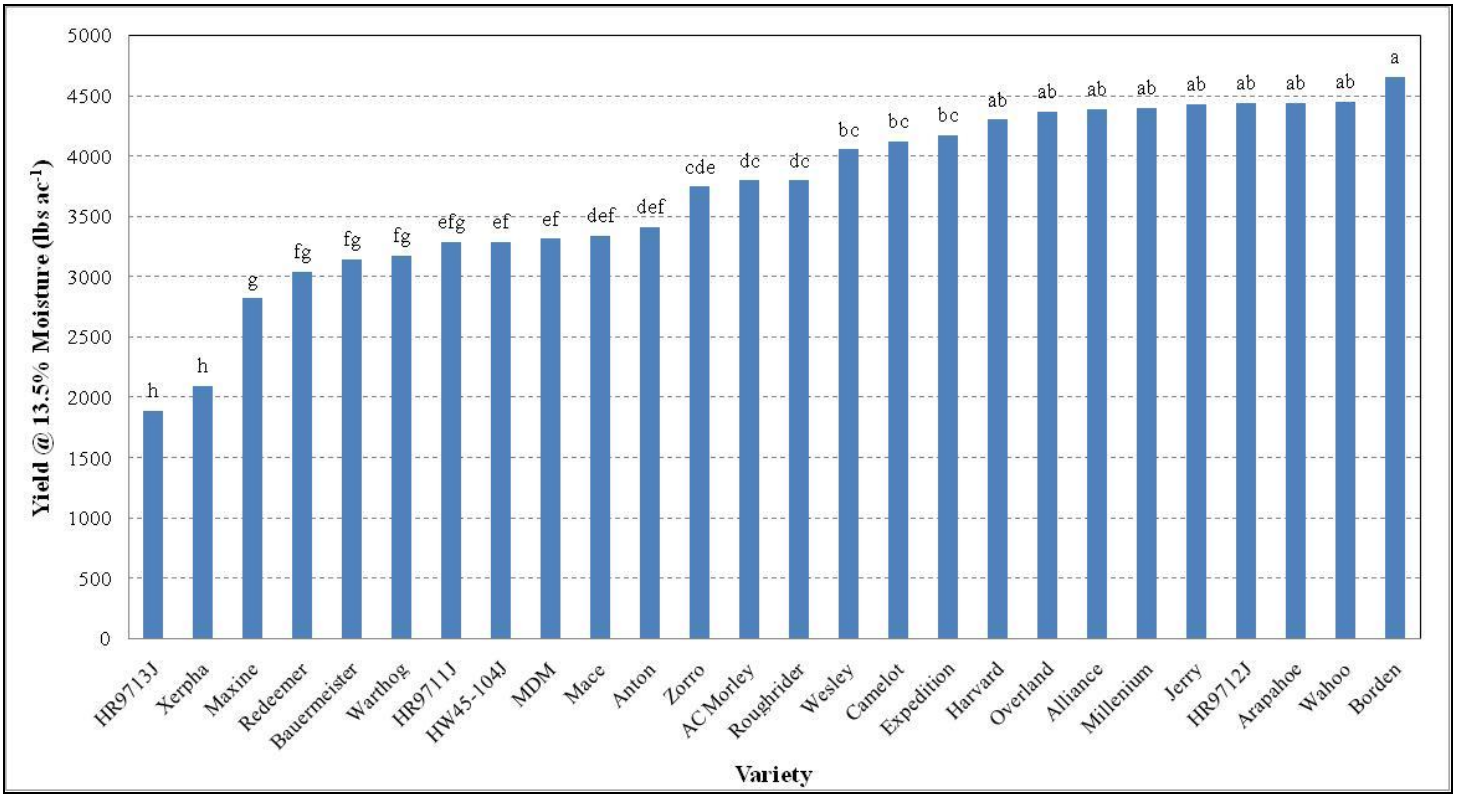

Figure 2. Yield of 26 winter wheat varieties, Willsboro, NY
*Varieties with the same letter did not differ significantly in yield.

Winter Wheat Quality:

The common measures used by commerial mills to evaluate wheat quality are: grain protein, falling number, test weight, and mycotoxin (DON) content. The varieties with the highest protein content at both locations was HR9713J and Redeemer. Redeemer and Warthog had high falling numbers at both locations. Almost every variety had acceptable falling number levels based on mill standards. There were just a few varieties that performed poorly and included Xerpha, MDM, and HW45-104J. These varieties MDM and Xerpha are both Washington developed varieties. Since Fusarium head blight is not a major disease for that area these vareities may be more susceptible. In general there was low DON concentrations in winter wheat this season. It was a relatively dry season, especially during flowering and grain development stages. 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. Interestingly, there were a few varieties that had extremely high DON concentrations.

Table 9. Quality of 26 winter wheat vareities, Alburgh

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
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	**13.2***	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	**9.20***
Millenium	9.8	376	0.45
Overland	9.3	382	0.75
Redeemer	12.6*	**421***	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
Trial Mean	10.7	365	1.71
LSD (0.10)	1.2	22	1.69

Table 10. Quality of 26 winter wheat varieties,Willsboro

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	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	**14.7***	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	**10.10***
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	**422***	0.93
Wesley	12.5	377	1.35
Xerpha	13.0	209	8.85*
Zorro	12.8	342	0.86
Trial Mean	12.8	345	1.72
LSD (0.10)	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.

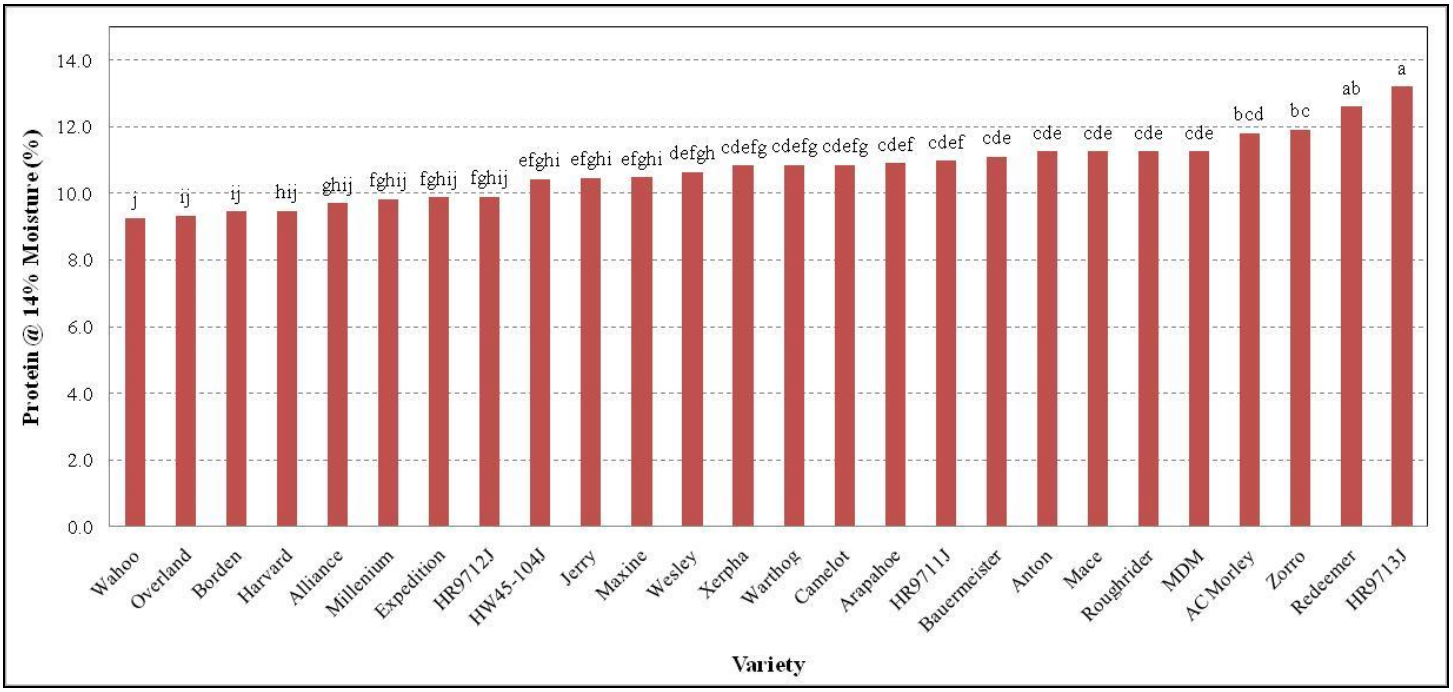

Figure 3. Protein concentration of 26 winter wheat varieties, Alburgh, VT
*Varieties with the same letter did not differ significantly in protein content.

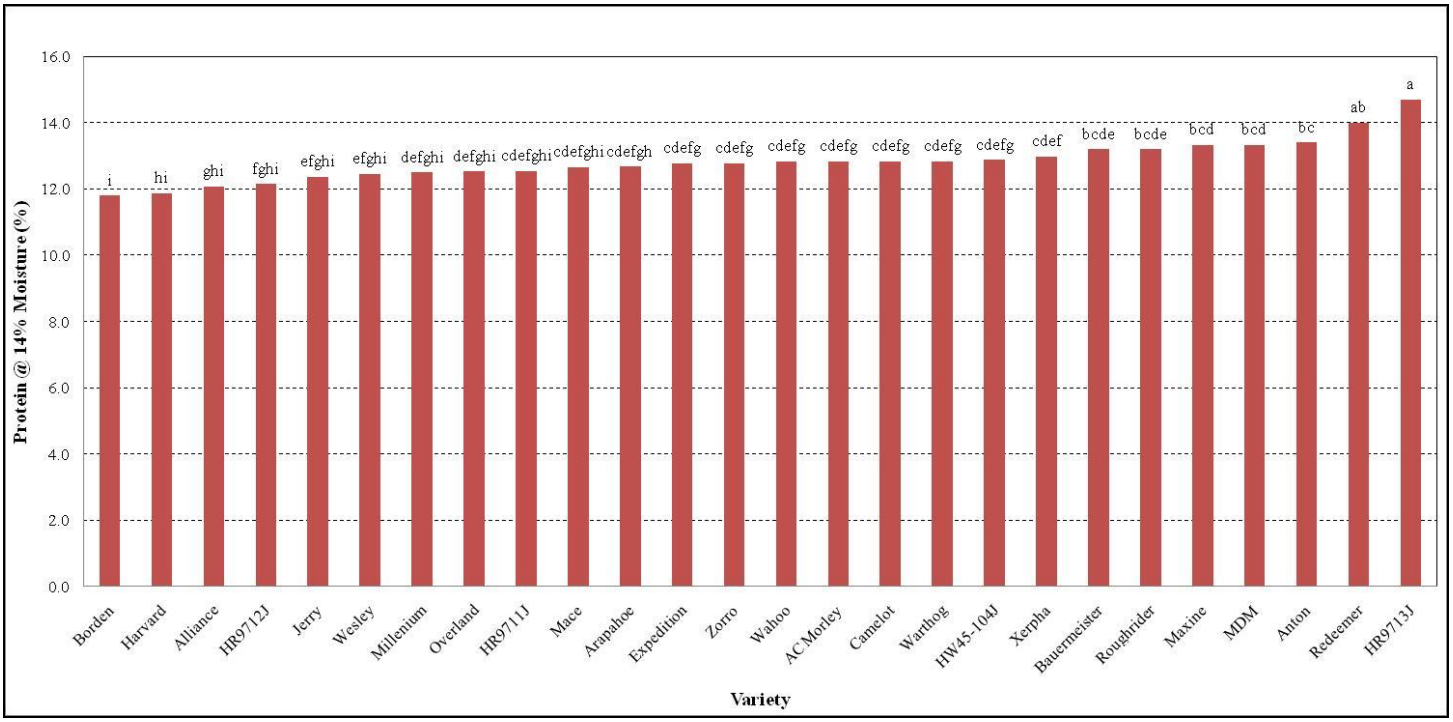

Figure 4. Protein concentration of 26 winter wheat varieties, Willsboro, NY
*Varieties with the same letter did not differ significantly in protein content.

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. First it appears that varieties from Eastern Washington may not be suitable for production in our climate. These varieties especially Xerpha and MDM performed well below average in yields and quality. Conditions in these wheat growing regions are much more arid than the temperate climate of the Northeast. Varieties developed in these areas would not be subject to the same diseases and climatic regimes and hence much less adaptable. The variety Redeemer has consistently shown high quality at multiple locations, however yields were variable depending on the site. This is similar to farmer observations reported for this variety. Local bakers that have baked with Redeemer find it superior to other varieties that we have trialed. However, farmers have reported that Redeemer grows better on well-drained soils than heavy textured soils. This is similar to our observations where Redeemer was a top-yielder at the Alburgh site (silt loam) and yielded lowest at the Willsboro site (clay soil). It is important, as you make variety choices on your farm, that you evaluate data from test sites that are as similar to your region as possible.

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 OREI grants program for their financial support. Any reference to commercial products, trade names, or brand names is for information only, and no endorsement or approval is intended.

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