

# Northern New England Local Bread Wheat Project



## 2011 Maine and Vermont Organic Winter Wheat Variety Trial Results

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Bread wheat has emerged as a new crop for farmers in Northern New England as consumer demand for locally-grown foods increases. In 2010, the University of Vermont and the University of Maine began a series of coordinated trials evaluating varieties of hard red winter wheat to identify those that perform well in northern New England under organic production. This publication presents results for winter wheat varieties trialed in 2011. Separate publications are available for spring wheat varieties and 2010 trials ([www.extension.umaine.edu/localwheat](http://www.extension.umaine.edu/localwheat)).

In Maine, trials were established at two locations: the University of Maine Rogers Farm Forage and Crop Research Facility in Old Town and Nature's Circle Farm, a commercial operation in Houlton. For Vermont, one trial was established at the Borderview Research Farm in Alburgh and one at Cornell University's Willsboro Research Farm in Willsboro, NY. This collaborative work was funded by a grant from the USDA Organic Agriculture Research and Extension Initiative to improve bread wheat production in our region.

### TRIAL DESIGN AND VARIETIES

The experimental design was a randomized complete block with four replications, which means that each variety was planted in four separate plots at each location. The winter wheat varieties that were evaluated are listed in Table 1. All are hard red varieties, with the exception of four hard white and one soft white varieties. Hard wheat varieties are preferred for bread flour.

**Table 1. Winter wheat varieties planted in Maine, New York, and Vermont.**

Winter Wheat Variety	Type <sup>†</sup>	Origin and Year of Release <sup>‡</sup>	Seed Source
AC Morley	HR	Canada	C&M Seed, Canada
Alice	HW	SD, 2006	USDA-ARS, SD
Alliance	HR	NE, 1993	USDA-ARS, NE
Anton	HW	NE, 2008	USDA-ARS, NE
Appalachian White	HW	NC, 2009	USDA-ARS, NC
Arapahoe	HR	NE, 1998	Albert Lea Seed House, MN
Banatka	HR	Heritage var., Hungary, 1800s	Heritage Wheat Conservancy, MA
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.
LP3	HR	WA	Washington State Univ.
Mace	HR	NE, 2008	USDA-ARS, NE
Maxine	HR	Canada, 2001	C&M Seed, Canada
MDM	HW	WA, 2005	Washington State Univ.
Millennium	HR	NE, 1999	USDA-ARS, NE
Overland	HR	NE, 2006	USDA-ARS, NE
NE01643	HR	WA	Washington State Univ.
NuEast	HR	NC, 2009	USDA-ARS, NC
Redeemer	HR	Canada	C&M Seed, Canada
Roughrider	HR	ND, 1975	North Dakota State Univ.
Sherman	SW	OR, 1928	Washington State Univ.
Wahoo	HR	NE, 2000	USDA-ARS, NE
Warthog	HR	Canada	Semican, Canada
Wesley	HR	NE, SD, WY, 2000	USDA-ARS, NE
Zorro	HR	Canada	C&M Seed, Canada

<sup>†</sup> HR = hard red, MHR = medium hard red, HW = hard white, SW = soft white.

<sup>‡</sup> Year of release was not always available.

## WEATHER DATA

Seasonal precipitation and temperature were recorded at each location. The Old Town, Alburgh, and Willsboro locations each had weather stations in close proximity to the trials. The weather data for the Houlton site came from a station 4.5 miles away. Fall 2010 precipitation and temperatures were generally above the 30-year average at all sites. In Houlton, snow cover was inconsistent and temperatures were above normal during the early part of the winter. Spring precipitation was higher than usual at all sites, particularly in Vermont. Vermont spring temperatures were also higher than usual. June and July precipitation levels were close to 30-year averages at all sites except Willsboro, which experienced a substantially drier than usual early summer. Summer temperatures

departed from normal somewhat at each site – Maine sites were slightly cooler than normal, while Vermont sites were slightly warmer than usual.

## CULTURAL PRACTICES

Plots were managed following practices similar to those used by farmers in northern New England (see Table 3).

Rogers Research Farm - Old Town, ME - The trial was conducted on two nearby fields both of which had been in annual crop production for more than 20 years. In early September 2010, the fields were prepared using a moldboard plow and seedbed conditioner. Solid dairy manure was applied at a rate of 22 tons/ac on September 14 and 15 and immediately incorporated with a Perfecta harrow. The plots were

**Table 2. Temperature and precipitation summary for , Houlton, ME, Old Town, ME, South Hero, VT, and Willsboro, NY, 2011.†**

Location	September 2010	October 2010	November 2010	March	April	May	June	July	Total
<b>Houlton, ME</b>									
Total Precipitation (in.)	5.0	3.6	4.9	5.2	3.0	5.9	5.3	4.6	37.4
Departure from Normal	1.6	0.3	1.3	2.4	0.1	2.7	1.6	1.1	11.1
Average Temperature (°F)	58.2	43.6	33.4	25.9	38.2	51.9	60.1	66.4	---
Departure from Normal	4.1	0.6	1.9	0.1	-0.3	0.3	-0.7	0.3	---
Growing Degree Days§	781	372	126	39	205	578	836	1026	3961
<b>Old Town, ME</b>									
Total Precipitation (in.)	4.8	4.7	4.5‡	4.1‡	5.7	3.8	4.2‡	2.1	33.9
Departure from Normal	1.0	1.3	1.0	0.8	2.5	0.5	0.6	-1.3	6.4
Average Temperature (°F)	60.3	46.7	36.3	30.3	41.8	53.9	60.6	69.2	---
Departure from Normal	3.9	1.4	0.8	-0.7	-0.2	0	-2.1	0.8	---
Growing Degree Days§	839	440	165	180	294	680	844	1127	4569
<b>South Hero, VT</b>									
Total Precipitation (in.)	4.3	6.7	2.9	3.4	7.9	8.7	3.5	3.7	41.1
Departure from Normal	0.9	3.8	0.0	1.1	5.0	5.4	0.1	-0.3	16.0
Average Temperature (°F)	64.0	50.6	39.9	32.9	46.6	58.7	67.1	74.4	---
Departure from Normal	3.6	1.8	2.2	2.1	3.1	2.1	1.3	3.3	---
Growing Degree Days§	991	578	243	144	465	826	1088	1314	5649
<b>Willsboro, NY</b>									
Total Precipitation (in.)	2.7	4.1	2.7	1.1	6.6	7.8	2.8	1.8	29.6
Departure from Normal	-0.4	1.1	-0.7	-0.7	5.3	4.6	-5.3	-1.6	2.7
Average Temperature (°F)	62.3	48.7	38.7	30.4	45.7	58.3	66.2	73	---
Departure from Normal	3.4	2.7	3.7	1.4	1.8	3.9	0.9	2.9	---
Growing Degree Days§	909	518	236	104	423	809	1064	1277	5340

† Based on National Weather Service data from cooperative observer stations in close proximity to field trials available at <http://www.ncdc.noaa.gov/crn/report>. Historical averages are for 30 years (1971-2000) available at <http://cdo.ncdc.gov/cgi-bin/climatnormals.pl>

‡ Values are incomplete due to missing or suspect data.

§ Base 32°F ¶ Data not yet available.

seeded with an Almaco Cone Seeder on September 23, 2011 and harvested with a Wintersteiger Classic plot combine on July 25 and 27, 2011. The harvest area was 4' x 34'.

Nature's Circle Farm - Houlton, ME - The field used in the trial in Houlton was in potatoes in 2009 and fallowed in 2010. In early September 2010, the fields were prepared using a seedbed conditioner. On September 16, a dehydrated pelletized poultry manure, Nutri-Wave (4-1-2; Envirem Technologies Inc.), was applied at a rate of 750 lbs/ac and then incorporated with a spring-tine harrow on the same day. A spring-tine harrow was used for final seedbed preparation the day before planting. The plots were seeded with an Almaco Cone Seeder on September 22, 2010. On May 23, 2011, a top-dress application of Nutri-Wave™ was applied at a rate of 3,000 lbs/ac. The plots were harvested with a Wintersteiger Classic plot combine on August 6, 2011. The harvest area was 4' x 34'.

Borderview Research Farm - Alburgh, VT - The seedbeds at both the Alburgh and Willsboro locations were prepared by conventional tillage methods (Table 3). The previous crop grown at the Alburgh site was spring wheat. Prior to that, the site had been perennial forages (reed canary and alfalfa) for the previous 10 years. In August 2010, 2 tons/ac of Giroux's composted poultry manure (2-3-2) was applied to the area. The field was then disked and spike tooth harrowed to prepare for planting. Plots were seeded

with a Kincaid Cone Seeder on September 23, 2010. Grain was harvested with an Almaco SP50 plot combine on July 20, 2011. The harvest area was 5' x 20'.

Willsboro Research Farm - Willsboro, NY - At the Willsboro location, planting of the winter wheat followed a 3-year crop of alfalfa/timothy sod. The sod was plowed in August 2009 and fallowed prior to planting. The field was dragged twice during the fallow period to knock down the alfalfa and perennial grasses. The plots were seeded on September 27, 2010 with a custom made eight-row cone planter. Plots were harvested on July 28, 2011 with a Hege plot combine. The harvest area was 4' x 13'.

### MEASUREMENTS AND METHODS

Flowering date was recorded for each variety where possible. At the Houlton and Willsboro sites, which were more remote and visited less frequently, information on the week of flowering is provided rather than the actual day. Once the wheat reached physiological maturity, plant height, number of tillers, wheat and weed above-ground biomass were measured. Only tillers with filled grain heads (spikes) were counted. For biomass, plants were cut one inch above the soil surface. Prior to harvest, the incidence and severity of lodging was noted for each plot.

All varieties were harvested on the same day at each site once the latest maturing variety threshed free in

**Table 3. General plot management of the 2011 winter wheat trials.**

Location	Rogers Research Farm Old Town, ME	Nature's Circle Farm Houlton, ME	Borderview Farm Alburgh, VT	Willsboro Research Farm Willsboro, NY
Soil type	Melrose & Elmwood fine sandy loam	Caribou gravelly loam	Benson rocky silt loam	Kingsbury silt clay loam
Previous crops	Mixed vegetables/ sweet corn	Potato/fallow	Spring wheat	Timothy/Alfalfa Sod
Fertility source	Solid dairy manure	Dehydrated, pellet- ized chicken manure	Composted poultry manure	Plowed in sod
Target nitrogen rate (lbs/ac)	70	70	70	70
Row spacing (in)	6.5	6.5	6	6
Seeding rate (seeds/ft <sup>2</sup> )†	30	30	32	32
Replicates	4	4	4	4
Planting date	9-23-10	9-22-10	9-23-10	9-27-10
Harvest date	7-25-11 & 7-26-11	8-6-11	7-20-11	7-28-10
Harvest area (ft <sup>2</sup> )	4' x 34'	4' x 30'	5' x 20'	4' x 13'
Tillage operations	Moldboard plow, seedbed conditioner	Seedbed conditioner, spring-tine harrow	Fall plow, disc, & spike-toothed harrow	Fall plow, disc, & spike- toothed harrow

† The target seeding rate was calculated to achieve the same plant density for each variety. This translated to 70-140 lbs seed/acre (average 113), and depended on the seed weight of each variety.

## WHAT IS A SIGNIFICANT DIFFERENCE?

Variations in yield and quality can occur not only due to genetics but also due to variability in soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference between two varieties is real or whether it might have occurred due to other variability in the field. The Least Significant Difference (LSD) is the minimum difference needed between two averages to consider them statistically different. LSDs at the 5% level of probability are presented at the bottom of each table for each measure. Where the difference between two varieties within a column is equal to or greater than the LSD value, you can be sure in 19 out of 20 chances that there is a real difference between the two varieties.

In the example below, variety A is significantly different from variety C because the difference between their yields (1454) is greater than the LSD value (889). Variety A is not significantly different from variety B because the difference between their yields (725) is less than the LSD value (889).

Throughout this bulletin, the greatest value at each site for each measure is indicated with an underline and bold type. Varieties that are not significantly different from the greatest value are also in bold type. Using the example below, variety C had the highest measured yield (underlined and bolded) but it was not significantly different than the yield of variety B (bolded).

Example Table

Variety	Yield
A	3161
B	<b>3886</b>
C	<b><u>4615</u></b>
LSD	889

hand tests and weather and logistics allowed. Following harvest, the grain was cleaned with a small Clipper cleaner. Measurements on the harvested grain include yield, moisture, test weight, crude protein, falling number, and mycotoxin levels. Harvest moisture and test weights were determined using a DICKEY-john GAC 2100 moisture meter.

Subsamples were ground using a Perten LM3100 Laboratory Mill. The ground material was then analyzed for crude protein, falling number, and mycotoxin levels. Protein content was determined using a Perten Inframatic 8600 Flour Analyzer. Most commercial mills target 12-15% protein. Falling number was determined on a Perten FN 1500 Falling Number Machine. The falling number is related to the level of sprout damage that has occurred in the grain due to enzymatic activity. It is measured as the time it takes, in seconds, for a plunger to fall through a slurry of flour and water to the bottom of the tube. Falling numbers less than 200 indicate high enzymatic activity and poor quality wheat. Concentrations of deoxynivalenol (DON), a mycotoxin produced by the fungus that causes *Fusarium* head blight, was determined using Veratox DON 2/3 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 (US-FDA 2010, see footnote).

All data were analyzed using mixed model Analysis of Variance (ANOVA) in which replicates were considered

Footnote: U.S. Food and Drug Administration. 2010. Guidance for Industry and FDA: Advisory Levels for Deoxynivalenol (DON) in Finished Wheat Products for Human Consumption and Grains and Grain By-Products used for Animal Feed. Division of Plant and Dairy Food Safety, Center for Food Safety and Applied Nutrition, U.S. Food and Drug Administration. College Park, Maryland.



Harvesting the Alburgh trial.

random effects. The LSD procedure was used to separate variety averages when the ANOVA F-test was significant ( $P < 0.05$ ). There were significant differences between the locations for most parameters, so results from each location are reported independently.

## RESULTS

### Growth and Development

Winter survival was generally good for all varieties except Maxine, which suffered winter injury at the Maine sites. Maxine had good vigor ratings going into the fall (data not shown), but much of its fall topgrowth was killed over the winter. Subsequent biomass production was low compared with other varieties. Winter injury also was observed across many plots in Houlton but was independent of specific varieties. In Alburgh, some areas of the field suffered from erosion and decreased plant vigor due to saturated soils. In general, minimal lodging and wildlife damage was observed at all locations. At the Alburgh site, Sherman partially lodged but it was still harvestable.

Flowering occurred predominately during the second week of June at the Old Town, Alburgh, and Willsboro sites, and during the third and fourth week of June in Houlton (Table 4). Most varieties flowered within a few days of one another. Alliance, Appalachian White, NuEast, and Wesley flowered relatively early at both Old Town and Alburgh, whereas Zorro consistently flowered later than other varieties.

The number of spikes per unit area is influenced by tillering and tiller survival, which in turn is influenced by

planting date, weather, and variety. The Alburgh and Willsboro sites, with the greatest number of growing degree days, had the greatest number of spikes per square foot, on average 60 and 53 spikes per square foot, respectively, compared with 39 and 38 spikes per square foot in Old Town and Houlton, respectively (Table 4). Arapahoe, Jerry, and Mace had the greatest number of spikes per unit area across locations. While the average number of spikes at each site appears related to the average site yields, within a site we found only weak correlations between spike number and plant biomass, or spike number and yield.

Plant height ranged from 23 to 50 inches (Table 4). Tall varieties included AC Morley, Banatka, Borden, Sherman, Roughrider, and Zorro and short ones included Alice, LP3, Mace, and Wesley. Taller varieties are more susceptible to lodging but, as noted above, lodging was not an issue at any site this year. It is thought that taller varieties may be more competitive with weeds but winter wheat in general is very competitive. Weed pressure was low and nonuniform at all of the locations (Table 5), making it difficult to properly evaluate the relationship between plant height and weed competitiveness. In Maine, however, where weed biomass was collected, no correlation was found between plant height and weed biomass. The tallest varieties (AC Morley, Banatka, Borden, Sherman, and Zorro) did not necessarily have the lowest weed biomass (Table 5). A similar observation was made in 2010.

Total wheat plant biomass was measured at the grain soft dough stage when plants are considered to have accumulated their greatest biomass (i.e. “peak biomass” stage). It is a stage when cereals are sometimes harvested for animal forage. Overall, the Alburgh and Willsboro sites recorded the highest peak biomass with site averages of 9,463 and 7,757 lbs/acre, respectively (Table 5). Among the varieties, AC Morley and Zorro produced the greatest biomass at three of the four locations. Other top biomass producing varieties included Banatka, Borden, and Warthog. Wheat plant biomass did not correlate strongly with final grain yield, but it may be a good indicator of potential straw yield.

Leaf disease were prevalent in 2011 at some sites. In Old Town, powdery mildew and rust were noted in the fall. In early spring before stem extension, Anton and Mace appeared to be the most infected by these



Photo by Ellen Mallory

Harvesting the Old Town trial.

**Table 4. Estimated wheat flowering date, number of spikes, and plant height, ME, NY, and VT.**

Variety	Estimated Flowering Date (day or week of June)				No. of Spikes (no./ft <sup>2</sup> )				Plant Height (inches)			
	Old Town	Houlton	Alburgh	Willsboro	Old Town	Houlton	Alburgh	Willsboro	Old Town	Houlton	Alburgh	Willsboro
	ME	ME	VT	NY	ME	ME	VT	NY	ME	ME	VT	NY
AC Morley	June 10	June 22	June 9	2nd wk	41	32	57	56	40	<b><u>37</u></b>	45	<b>39</b>
Alice‡	---	---	June 7	1st wk	---	---	<b>68</b>	52	---	---	33	27
Alliance	June 8	< June 22	June 7	2nd wk	37	38	<b>75</b>	<b>67</b>	28	26	39	31
Anton‡	June 10	June 22	June 7	2nd wk	31	37	60	38	28	26	34	29
App. White‡	June 8	< June 22	June 7	2nd wk	<b>48</b>	38	54	55	29	26	35	30
Arapahoe	June 9	< June 22	June 7	2nd wk	<b>45</b>	<b>45</b>	<b>81</b>	<b>66</b>	32	29	41	35
Banatka	June 10	---	---	---	<b>44</b>	---	---	---	<b>49</b>	---	---	---
Borden‡	June 10	< June 22	June 10	2nd wk	34	39	66	40	39	<b>36</b>	<b>50</b>	37
Camelot	June 9	< June 22	June 10	2nd wk	39	36	63	52	31	27	36	31
Expedition	June 8	< June 22	June 8	2nd wk	<b>45</b>	<b>44</b>	58	<b>61</b>	30	28	38	31
Harvard	June 9	< June 22	June 8	2nd wk	31	27	49	42	33	29	39	34
Jerry	June 10	< June 22	June 9	2nd wk	<b>52</b>	<b>50</b>	62	<b>68</b>	31	31	41	36
LP3	---	---	June 9	2nd wk	---	---	57	45	---	---	29	25
Mace	June 10	< June 22	June 9	2nd wk	<b>45</b>	<b>43</b>	<b>68</b>	52	26	25	32	27
Maxine	June 9	< June 22	June 7	2nd wk	26	21	41	26	28	26	35	30
MDM‡	---	---	June 22	2nd wk	---	---	NA	NA	---	---	37	33
Millennium	June 9	< June 22	June 9	2nd wk	39	<b>46</b>	57	57	29	28	38	31
NE06143	---	---	June 7	2nd wk	---	---	55	59	---	---	38	31
NuEast	June 8	< June 22	June 7	2nd wk	<b>46</b>	<b>48</b>	47	53	29	27	36	33
Overland	June 9	< June 22	June 9	2nd wk	36	<b>44</b>	67	<b>77</b>	30	27	38	34
Redeemer	June 10	< June 22	June 7	3rd wk	40	<b>43</b>	45	48	33	33	41	33
Roughrider	---	---	June 9	2nd wk	---	---	<b>92</b>	<b>62</b>	---	---	47	38
Sherman‡	---	---	June 10	2nd wk	---	---	52	50	---	---	<b>49</b>	<b>42</b>
Wahoo	June 9	June 22	June 8	2nd wk	26	27	55	54	29	26	38	31
Warthog	June 10	< June 22	June 7	2nd wk	<b>45</b>	38	49	43	36	33	40	30
Wesley	June 8	< June 22	June 7	2nd wk	37	37	49	57	25	23	34	29
Zorro	June 11	June 22	June 10	2nd wk	41	32	<b>68</b>	55	38	33	45	<b>39</b>
<i>Site Average</i>	---	---	---	---	39	38	60	53	32	29	39	33
<i>LSD (0.05)</i>	---	---	---	---	8	8	24	17	2	2	3	4

† For all measures, bolded values are not significantly different from the highest value, which is indicated with underline.

‡ Variety is not a hard red type.

diseases. Subsequent infection of the flag leaf was most notable for Alliance, Expedition, and Mace. In Vermont and New York, the wet spring created the ideal environment for growth of fungal pathogens including *Ascochyta* leaf spot. At both the Alburgh and Willsboro locations all varieties exhibited signs of this fungus, but Redeemer appeared to be particularly susceptible. *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). Over time these spots spread out over the leaf and the centers turn a grayish 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. In general, *Ascochyta* leaf spot is not usually considered a significant problem in the major wheat producing countries. However, its distribution and impact may be greater than originally thought, because *Ascochyta* species are found on most cereals

**Table 5. Weed and wheat plant biomass, ME, NY, and VT.**

Variety	Weed Biomass (lbs/acre)		Wheat Plant Biomass (lbs/acre)			
	Old Town	Houlton	Old Town	Houlton	Alburgh	Willsboro
	ME	ME	ME	ME	VT	NY
AC Morley	119	<b>125<sup>†</sup></b>	<b>8469</b>	<b>7263</b>	9675	<b>12291</b>
Alice‡	---	---	---	---	9313	6618
Alliance	363	176	4710	4230	9692	7223
Anton‡	218	<b>135</b>	5483	5576	9106	7462
App. White‡	219	<b>124</b>	6759	5043	5951	9081
Arapahoe	95	<b>106</b>	6730	5159	10120	<b>10578</b>
Banatka	<b>69</b>	---	<b>9136</b>	---	---	---
Borden‡	162	<b>112</b>	7262	<b>7571</b>	<b>14390</b>	7670
Camelot	127	215	6453	5094	9287	7905
Expedition	213	192	6478	5565	9072	6680
Harvard	57	<b>102</b>	6888	5370	10585	8505
Jerry	117	<b>161</b>	7327	<b>7669</b>	9905	8108
LP3	---	---	---	---	8928	5509
Mace	232	196	5903	4941	8336	5907
Maxine	253	275	5846	3778	8975	4512
MDM‡	---	---	---	---	---	NA
Millennium	184	<b>172</b>	5828	<b>6277</b>	8632	7860
NE01643	---	---	---	---	8483	6678
NuEast	204	<b>96</b>	6903	5858	7564	8033
Overland	188	<b>136</b>	5442	5187	7841	<b>9430</b>
Redeemer	191	<b>21</b>	7047	<b>8978</b>	8564	6303
Roughrider	---	---	---	---	<b>12727</b>	7442
Sherman‡	---	---	---	---	9954	8451
Wahoo	332	355	4914	4628	8496	7373
Warthog	78	<b>101</b>	<b>8798</b>	<b>7129</b>	9325	6868
Wesley	111	526	5975	4761	8120	7603
Zorro	76	<b>94</b>	<b>8513</b>	5659	<b>13055</b>	<b>9831</b>
Site Average	176	175	6687	5814	9463	7757
LSD (0.05)	NS§	131	1492	1508	3629	3102

† For all measures, bolded values are not significantly different from the highest value, which is indicated with underline. For weed biomass, the lowest values are indicated.

‡ Variety is not a hard red type.

§ No significant difference among varieties.

and grasses throughout the world. Powdery mildew was observed on several varieties at the Alburgh location in areas where there was poor drainage.

### Yield

Yields for 2011 are presented in Table 6, as well as in Figure 1 in graphical form to easily compare varieties. Two-year averages (2010 and 2011) also are presented in Table 6 for three of the sites to provide information for how the varieties perform over different seasons. For instance, while higher than average rainfall created challenges for the 2011 season, the 2010 season was ideal for growing winter wheat, with mild winter conditions, an early spring, and dry conditions at harvest. This difference between the years is reflected in the fact that site average yields were lower for 2011 than the 2-year average for all sites.

The 2-year average yields also show that overall, the Alburgh and Willsboro sites have had better growing conditions than the Old Town site, most likely due to the greater number of growing degree days and a more tempered winter climate at the Vermont sites. The 2-year site averages for yield were 3,662, 3,095, and 2576 lbs/acre for the Alburgh, Willsboro, and Old Town sites, respectively. The Houlton site, used for the first time in 2011, had a site average yield similar to Old Town's.

Leaf diseases such as tan spot, rust, and powdery mildew were prevalent in 2011 trials.



Photo by Ellen Mallory

In 2011, hard wheat varieties that were among the top yielding at all locations were AC Morley, Harvard, Warthog, and Zorro. Borden, a medium hard red type, and Banatka, a heritage land race, also had relatively high yields. Varieties that yielded well at multiple sites over the two years include AC Morley,

Borden, Harvard, Jerry, Overland, Redeemer, Warthog, and Zorro. Test weights were within the accepted range of 55 to 60 lbs/bu at all but the Houlton site. In Houlton, poor winter conditions, lower heat units, and possibly inadequate fertility may have contributed to low test weights.

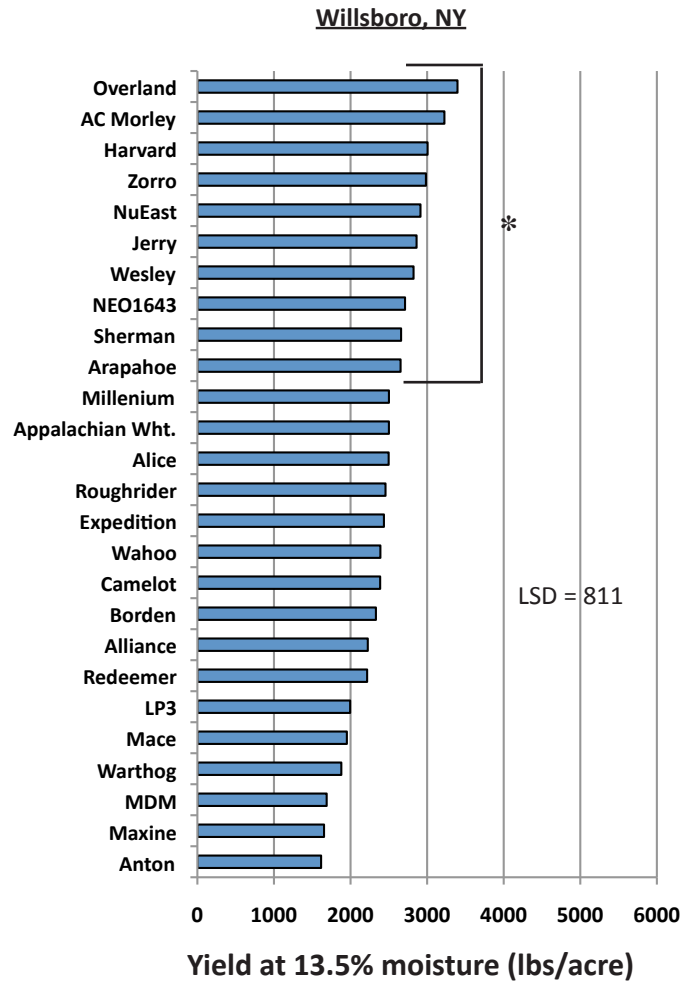
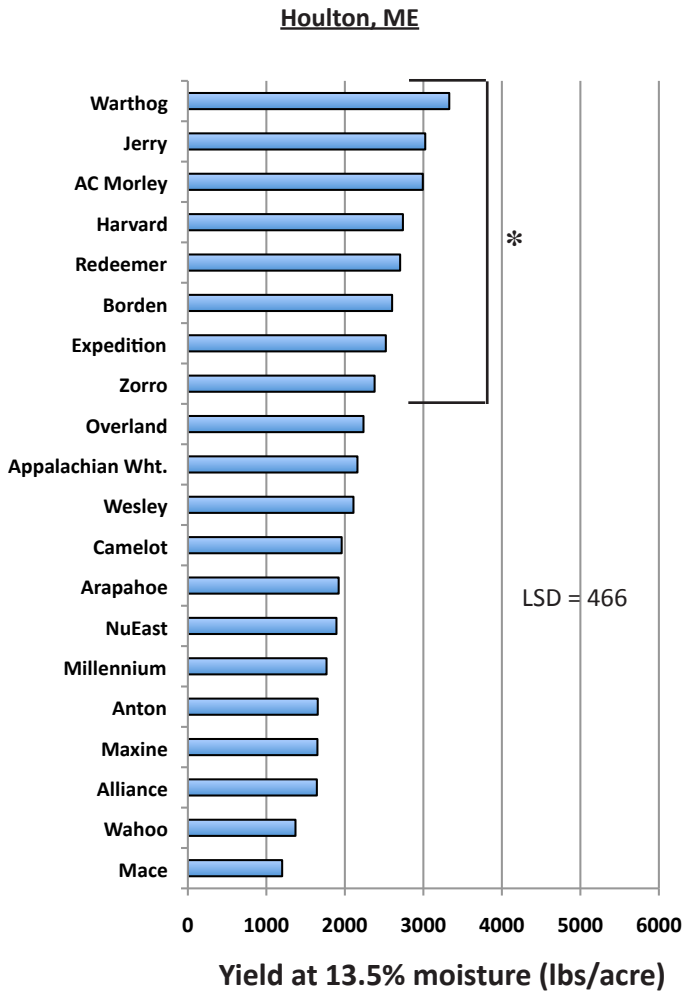
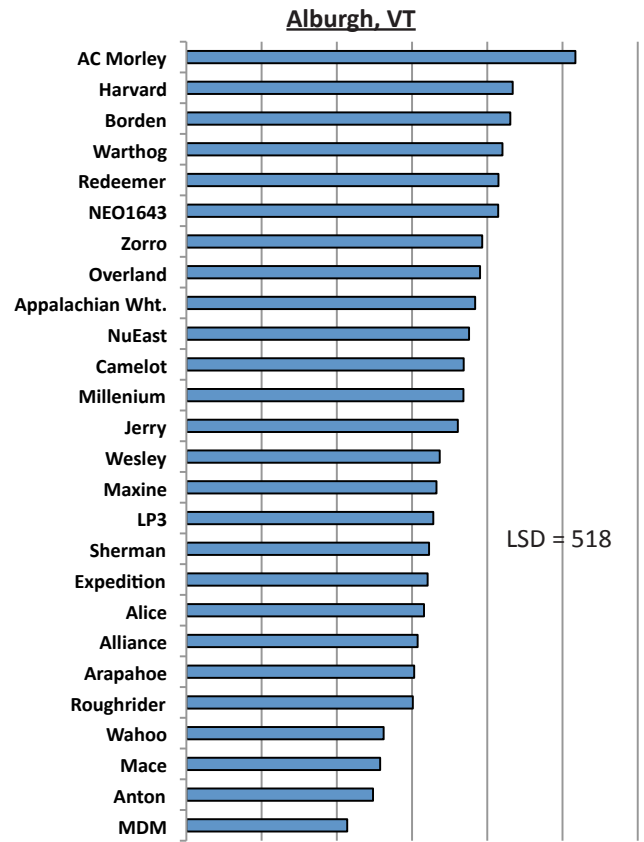
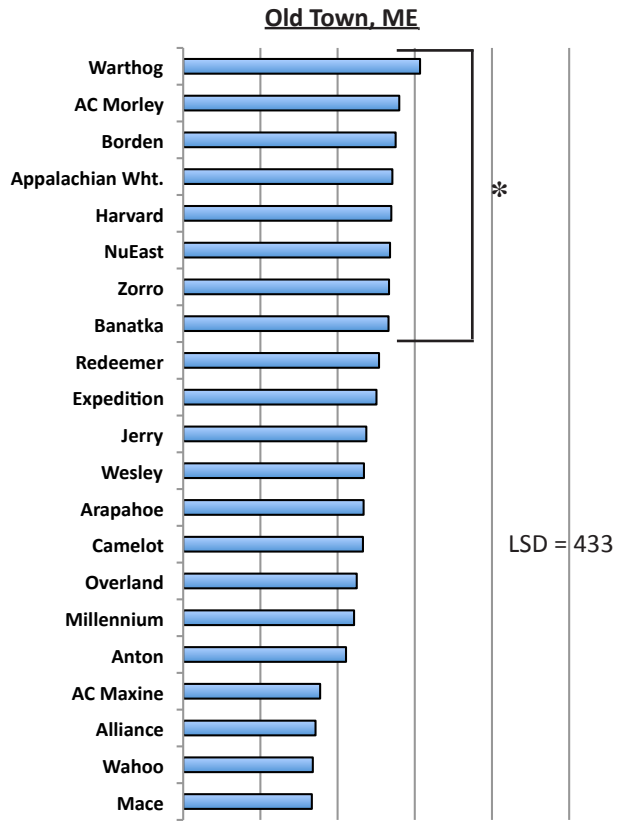
**Table 6. Yield and test weight of winter wheat in ME, NY, and VT.**

Variety	Yield at 13.5% Moisture (lbs/acre)							Test Weight (lbs/bu)			
	2011				2 yr averages (2010-2011)			2011			
	Old Town ME	Houlton ME	Alburgh VT	Willsboro NY	Old Town ME	Alburgh VT	Willsboro NY	Old Town ME	Houlton ME	Alburgh VT	Willsboro NY
AC Morley	<b>2799</b>	<b><u>2993</u></b>	<b><u>5171</u></b>	<b>3226</b>	<b>2773</b>	<b><u>4866</u></b>	<b>3886</b>	61	57	65	<b>60</b>
Alice‡	---	---	3159	2498	---	---	---	---	---	64	58
Alliance	1714	1643	3074	2225	2191	3543	2944	61	54	63	57
Anton‡	2109	1655	2481	1616	2373	3001	<b>3048</b>	<b>63†</b>	53	64	57
App. White‡	<b>2710</b>	2160	3839	2501	---	---	---	62	51	66	<b>59</b>
Arapahoe	2337	1921	3028	<b>2653</b>	2426	3535	<b>3299</b>	62	56	65	58
Banatka	<b>2660</b>	---	---	---	---	---	---	62	---	---	---
Borden‡	<b>2752</b>	<b>2602</b>	4306	2331	<b>3032</b>	<b>4461</b>	2971	58	53	65	55
Camelot	2332	1960	3687	2387	2610	3659	<b>3189</b>	<b>63</b>	53	63	58
Expedition	2504	<b>2522</b>	3207	2436	2580	3337	<b>3308</b>	62	57	63	<b>59</b>
Harvard	<b>2696</b>	<b>2740</b>	4338	<b>3006</b>	<b>2971</b>	4153	<b>3515</b>	62	57	65	59
Jerry	2372	<b>3024</b>	3609	<b>2862</b>	<b>2921</b>	4008	<b>3361</b>	61	55	64	58
LP3	---	---	3282	1806	---	---	---	---	---	64	58
Mace	1667	1201	2576	1952	2025	3115	2579	61	50	65	57
Maxine	1774	1651	3324	1654	2081	3509	2936	61	56	63	58
MDM‡	---	---	2138	1688	---	2372	2885	---	---	54	53
Millennium	2214	1767	3683	2501	2362	4001	<b>3064</b>	62	55	64	58
NE01643	---	---	4145	<b>2712</b>	---	---	---	---	---	65	58
NuEast	<b>2680</b>	1893	3758	<b>2913</b>	---	---	---	<b>64</b>	56	64	<b>60</b>
Overland	2248	2237	3904	<b><u>3397</u></b>	2625	4056	<b><u>4023</u></b>	60	55	62	59
Redeemer	2537	2704	4149	2217	2594	4018	<b>3172</b>	62	<b><u>58</u></b>	65	58
Roughrider	---	---	3010	2457	---	3217	<b>3179</b>	---	---	64	<b>59</b>
Sherman‡	---	---	3226	<b>2660</b>	---	---	---	---	---	<b><u>66</u></b>	59
Wahoo	1679	1371	2622	2390	2238	3252	<b>3192</b>	61	52	65	58
Warthog	<b><u>3068</u></b>	<b>3330</b>	4202	1691	<b><u>3228</u></b>	4103	2770	60	56	64	58
Wesley	2342	2110	3368	2823	2510	3515	2984	61	55	65	58
Zorro	<b>2667</b>	<b>2379</b>	3933	<b>2984</b>	<b>2906</b>	3718	<b>3514</b>	62	56	63	58
Site Average	2371	2220	3509	2470	2576	3662	3095	61	55	64	58
LSD (0.05)	433	466	518	811	567	642	995	0.9	0.7	---	1.6

† For all measures, bolded values are not significantly different from the highest value, which is indicated with an underline.

‡ Variety is not a hard red type.





**Figure 1. Yield of winter wheat varieties.**

\* Varieties under this bar did not perform significantly lower than the top performing variety.

## Wheat Quality

Commercial mills use a variety of measurements to determine if a particular lot of wheat is suitable for bread flour, including grain protein, falling number, test weight, and mycotoxin (DON) concentration. Site average protein levels were lower in 2011 than the 2-year averages, which might reflect nitrogen loss from leaching or volatilization due to higher than

usual spring precipitation. In general, protein levels have been lower in Maine than in Vermont and New York over the two years of the trial. Interestingly, at the Willsboro site, protein levels weren't lower in 2011 compared to 2010. This could be attributed to the higher level of organic N in the soil from the plow down sod compared to composted poultry manure applied in Alburgh. However, heavy rains in Willsboro caused soil erosion and compaction which contribut-

**Table 7. Protein concentration and falling number of winter wheat, ME, NY, and VT.**

Variety	Crude Protein at 12% Moisture (%)							Falling Number at 14% Moisture (seconds)			
	2011				2 yr averages (2010-2011)						
	Old Town ME	Houlton ME	Alburgh VT	Willsboro NY	Old Town ME	Alburgh VT	Willsboro NY	Old Town ME	Houlton ME	Alburgh VT	Willsboro NY
AC Morley	8.4	8.2	9.6	10.6	9.6	10.8	11.9	463	345	370	402
Alice‡	---	---	9.8	11.3	---	---	---	---	---	401	393
Alliance	8.9	8.7	8.8	9.9	9.6	9.4	11.1	431	336	381	400
Anton‡	<b>10.4†</b>	<b>10.3</b>	10.4	12.1	<b>10.6</b>	10.9	<b>12.9</b>	483	172	<b>404</b>	375
App. White‡	8.9	9.2	9.9	11.5	---	---	---	486	75	395	367
Arapahoe	9.8	8.4	9.6	10.6	10.3	10.4	12.1	478	328	<b>429</b>	420
Banatka	<b>10.2</b>	---	---	---	---	---	---	469	---	---	---
Borden‡	8.2	8.4	9.7	9.8	9.1	9.7	11.0	396	386	402	408
Camelot	8.9	9.4	9.2	11.4	9.7	10.2	12.3	464	462	393	421
Expedition	8.6	8.4	9.4	10.7	9.3	9.7	11.9	453	340	391	412
Harvard	8.9	8.9	9.7	11.2	9.2	9.7	11.9	411	331	349	389
Jerry	9.6	8.5	10.4	11.5	10.2	10.6	12.1	486	290	<b>416</b>	423
LP3	---	---	10.4	12.5	---	---	---	---	---	383	414
Mace	9.8	<b>11.1</b>	10.2	11.2	10.2	10.8	12.1	497	374	<b>410</b>	427
Maxine	<b>10.6</b>	<b>10.4</b>	10.3	12.7	<b>10.8</b>	10.5	<b>13.2</b>	477	410	<b>412</b>	367
MDM‡	---	---	10.7	12.0	---	11.1	12.8	---	---	380	393
Millennium	9.2	8.7	9.8	10.9	9.9	9.9	11.8	460	257	391	419
NE01643	---	---	9.4	10.5	---	---	---	---	---	<b>405</b>	<b>431</b>
NuEast	8.9	8.8	8.6	11.1	---	---	---	518	441	<b>410</b>	<b>440</b>
Overland	8.4	8.2	9.7	11.9	9.4	9.6	11.8	484	396	<b>404</b>	426
Redeemer	<b>10.5</b>	<b>10.4</b>	<b>12.3</b>	<b>13.0</b>	<b>10.9</b>	<b>12.6</b>	<b>13.6</b>	499	322	<b>428</b>	<b>452</b>
Roughrider	---	---	10.3	11.7	---	10.8	12.6	---	---	<b>412</b>	<b>432</b>
Sherman‡	---	---	<b>11.8</b>	<b>13.5</b>	---	---	---	---	---	<b>410</b>	400
Wahoo	9.3	8.9	9.7	10.4	9.6	9.6	11.7	450	349	392	399
Warthog	8.8	8.8	10.0	12.0	9.7	10.5	12.6	463	413	<b>413</b>	<b>466</b>
Wesley	9.4	9.8	10.5	11.8	9.9	10.7	12.3	440	395	387	384
Zorro	9.7	8.6	11.0	11.3	10.1	<b>11.5</b>	12.2	469	283	397	429
Site Average	9.3	9.1	10.1	11.4	10.0	10.5	12.3	465§	335¶	398	411
LSD (0.05)	0.5	0.9	0.9	0.7	---	1.2	0.8	---	---	27	35

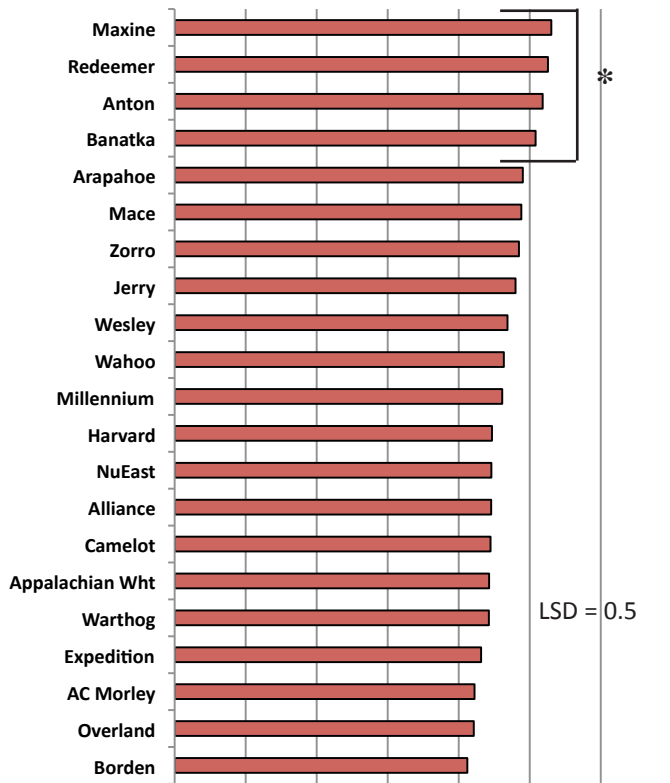
† For all measures, bolded values are not significantly different from the highest value, which is indicated with an underline.

‡ Variety is not a hard red type.

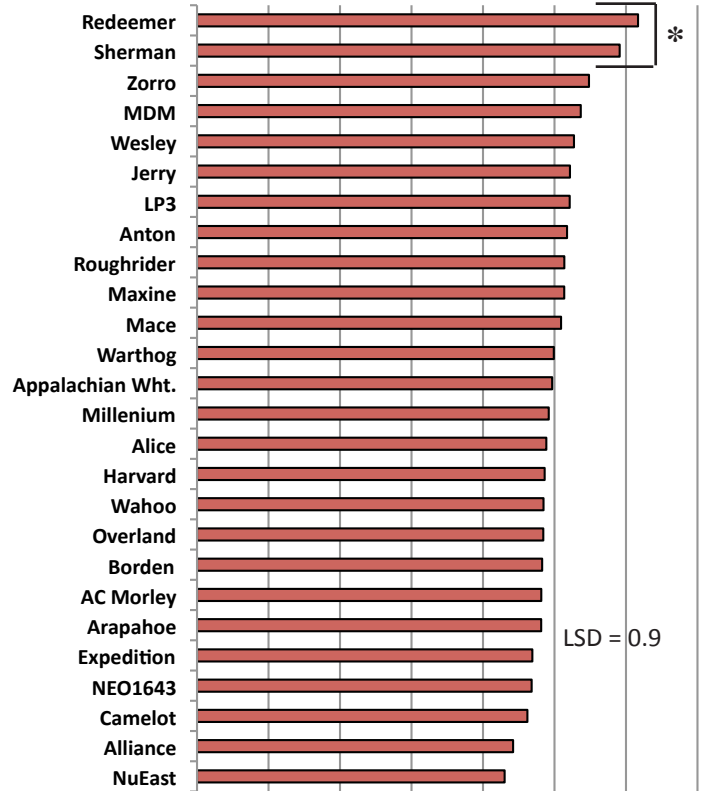
§ Average value taken from two samples per variety instead of four.

¶ Average value taken from one sample per variety instead of four.

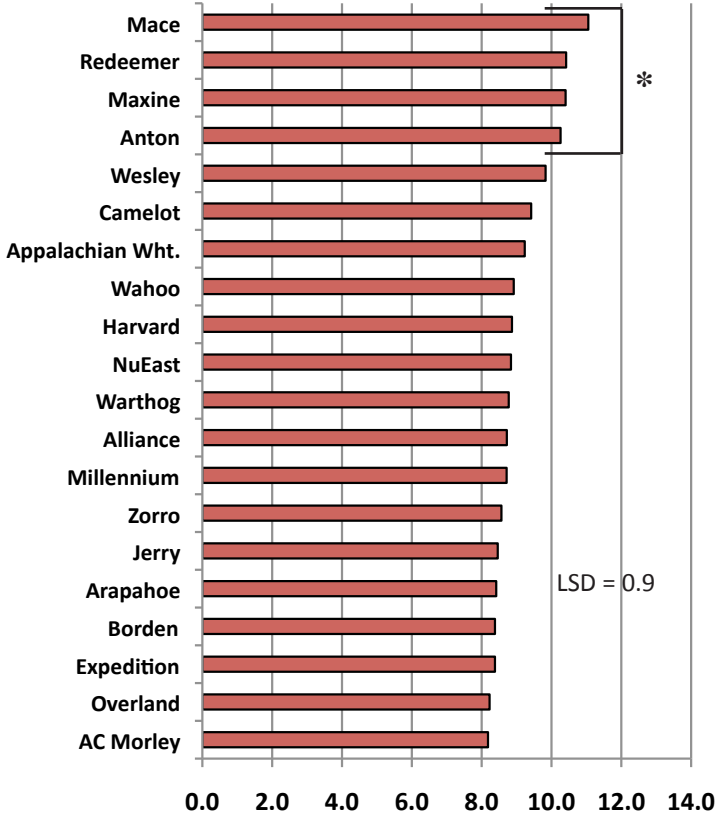
**Old Town, ME**



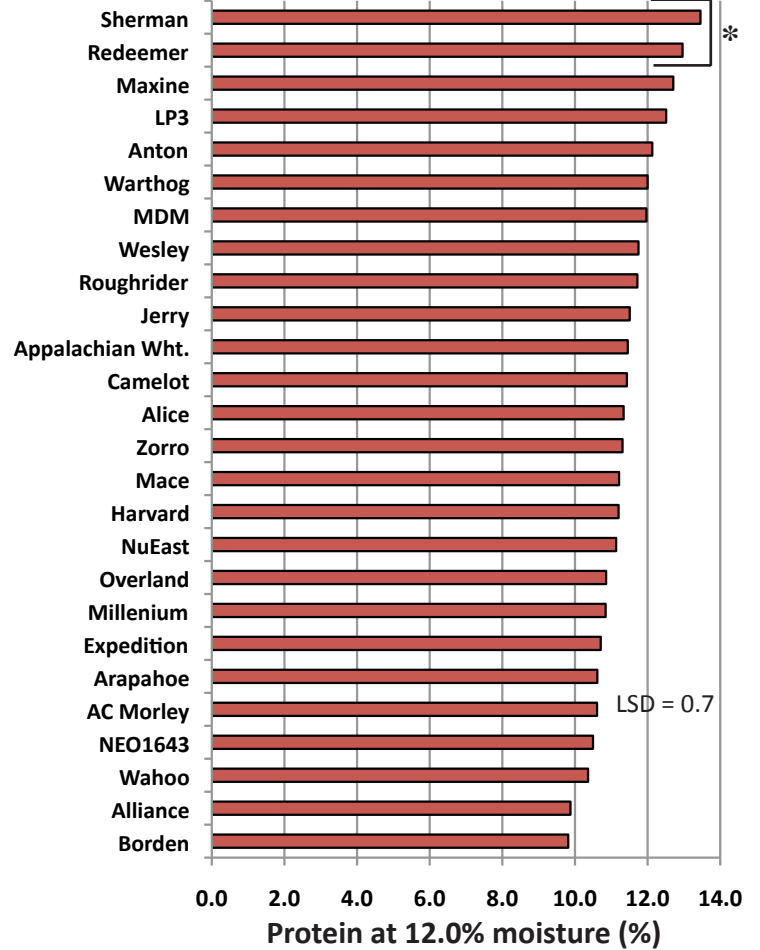
**Alburgh, VT**



**Houlton, ME**



**Willsboro, NY**



**Figure 2. Protein concentration in winter wheat varieties.**

\* Varieties under this bar did not perform significantly lower than the top performing variety.

ed to reduced yields. The fertility program for Old Town has been a preplant application of solid dairy manure at a target rate of 70 lbs of available nitrogen per acre. We suspect some of this nitrogen has been lost over the winters, and that actual available nitrogen was probably 55 to 60 lbs per acre. In Houlton, a split application of dehydrated pelletized chicken manure, with 20% was applied preplant and 80% was applied as topdress. However, the spring application didn't occur

until late May because of wet conditions. Low protein levels at this site suggest inadequate availability from the mid-season surface application.

In 2011, hard red varieties that had high protein levels across sites were Anton, Maxine, and Redeemer (protein ranged from 10.3 to 13.0% among these varieties). Banatka, Mace, and Sherman (a soft white) also had relatively high protein levels.

**Table 8. DON levels for winter wheat, ME, NY, and VT.**

Variety	DON (ppm)						
	2011				2 yr averages (2010-2011)		
	Old Town ME	Houlton ME	Alburgh VT	Willsboro NY	Old Town ME	Alburgh VT	Willsboro NY
AC Morley	< 0.5	< 0.5	< 0.5	0.6	< 0.5	0.7	0.8
Alice‡	---	---	1.0	1.3	---	---	---
Alliance	< 0.5	< 0.5	0.8	0.8	< 0.5	0.7	0.7
Anton‡	< 0.5	< 0.5	<b><u>&gt; 5.0</u></b> †	<b>4.8</b>	< 0.5	<b>3.4</b>	<b>3.1</b>
App. White‡	< 0.5	< 0.5	2.0	2.0	---	---	---
Arapahoe	< 0.5	< 0.5	1.3	0.9	< 0.5	0.9	0.8
Banatka	< 0.5	---	---	---	---	---	---
Borden‡	< 0.5	< 0.5	0.6	0.5	< 0.5	0.6	0.7
Camelot	< 0.5	< 0.5	1.8	1.5	< 0.5	1.2	1.1
Expedition	< 0.5	< 0.5	1.3	1.2	< 0.5	1.0	1.1
Harvard	< 0.5	< 0.5	0.6	1.1	< 0.5	1.1	0.9
Jerry	< 0.5	< 0.5	0.8	0.8	< 0.5	1.4	0.6
LP3	---	---	3.0	2.2	---	---	---
Mace	< 0.5	< 0.5	1.8	1.0	< 0.5	1.4	1.0
Maxine	< 0.5	< 0.5	1.0	1.2	< 0.5	0.9	1.1
MDM‡	---	---	2.2	0.7	---	---	---
Millennium	< 0.5	< 0.5	1.5	1.2	< 0.5	1.0	1.2
NE01643	---	---	1.0	1.2	---	---	---
NuEast	< 0.5	< 0.5	1.2	2.4	---	---	---
Overland	< 0.5	< 0.5	1.6	1.3	< 0.5	1.2	0.9
Redeemer	< 0.5	< 0.5	0.4	0.7	< 0.5	0.5	0.7
Roughrider	---	---	0.6	< 0.5	---	0.6	0.7
Sherman‡	---	---	0.6	0.6	---	---	---
Wahoo	< 0.5	< 0.5	2.1	0.7	< 0.5	1.9	0.8
Warthog	< 0.5	< 0.5	0.7	0.8	< 0.5	0.9	0.9
Wesley	< 0.5	< 0.5	2.7	<b>3.0</b>	< 0.5	1.7	2.2
Zorro	< 0.5	< 0.5	1.0	< 0.5	< 0.5	0.9	0.7
<i>Site Average</i>	<i>&lt; 0.5</i>	<i>&lt; 0.5</i>	<i>1.4</i>	<i>1.3</i>	<i>&lt; 0.5</i>	<i>1.3</i>	<i>1.5</i>
<i>LSD (0.05)</i>	<i>NS§</i>	<i>NS§</i>	<i>0.5</i>	<i>---</i>	<i>NS§</i>	<i>---</i>	<i>---</i>

† For all measures, bolded values are not significantly different from the highest value, which is indicated with an underline.

‡ Variety is not a hard red type.

§ No significant difference among varieties.

Redeemer stands out as a variety with consistently high protein levels, across sites and years. Two-year average protein levels were 10.9, 12.6, and 13.6% for Old Town, Alburgh, and Willsboro, respectively. Other varieties with high 2-year average protein levels at multiple sites include Anton, Arapahoe, Jerry, Maxine, and Zorro. Falling number values were well above the acceptable level (250 seconds) for almost all of the varieties. The exceptions were Appalachian White and Anton at the Houlton site (Table 7).

*Fusarium* head blight (FSB), which produces the mycotoxin deoxynivalenol (DON), is a disease of major concern for wheat growers in northern New England. It primarily infects the plant during flowering and is favored by cool, humid weather. The United States Food and Drug Administration has established a maximum DON guidelines of 1 ppm for finished hu-



Photo by Ellen Mallory

Old Town variety trial

man products. Millers may accept grain with slightly higher DON levels because they can remove some of the infected grain and reduce DON levels through cleaning. In Maine, despite wet weather during flowering at both locations, DON levels were all below the detectable limit of 0.5 ppm (Table 8). In contrast, the Vermont locations had measurable amounts of DON, with site averages of 1.4 ppm for Alburgh and 1.3 ppm for Willsboro. A similar trend was observed in 2010, as reflected in the 2-year averages. Seventeen of the varieties in Alburgh and 14 of the varieties in Willsboro exceeded the 1 ppm standard. Anton, LP3, and Wesley had the highest levels at both locations. Anton and Wesley also had high DON levels in 2010 at sites where DON was a concern.

Wheat grain sold for bread flour can receive up to twice the pay price as grain sold for livestock feed,

but the grain must meet higher quality standards. Therefore, when choosing which varieties to plant it is important to consider their potential to produce grain with acceptable protein, test weight, falling number, and DON levels, as well as their yield potential.

The 2011 growing season provided a good opportunity to evaluate the winter wheat varieties under somewhat challenging growing conditions. In particular, all sites experienced above average rainfall in the fall 2010 and early part of the 2011 season (April and May). Poor snow cover affected the Houlton site with some areas of the field suffering from winter damage. In Alburgh, heavy rain caused standing water in some poorly drained plot areas. Leaf diseases were prevalent early in the season, and in Vermont *Fusarium* head blight pressure was high. All sites produced lower yields and protein levels than in 2010.

Most commercial mills want a minimum of 12% grain protein for winter bread wheat, although some local buyers have accepted a minimum of 10.5 to 11% when supplies of locally-grown wheat are limited. In our trials, site average protein levels have been below 12% except at the Willsboro site. Within a site, however, protein levels for individual varieties ranged 1.0 to 3.7 percentage points, and at every site at least one individual variety met the lower limit of 10.5% protein. This illustrates that variety choice is the key strategy to use when trying to achieve adequate protein levels for bread wheat. Another key strategy is fertility. Achieving high protein levels is difficult in winter wheat because much of the nitrogen in preplant applications can be lost over the winter, or slow to mineralize in the spring. At the Willsboro site protein levels have been consistently higher than any of the other trial locations. This could be attributed to the higher level of organic N in the soil from the plow down sod compared to composted poultry manure applied in Alburgh. To increase protein levels, growers should consider using a higher preplant manure application rate or applying additional nitrogen in the spring as a topdress application. Note that topdress nitrogen sources must be consistent with organic certification and food safety standards (for instance, no manure within 120 days of harvest) and should be in a readily available form.

There are currently no varieties that are resistant to *Fusarium* head blight but some varieties are more tolerant than others to the disease, resulting in lower

DON levels. In Maine, DON levels were not a concern, with all varieties testing below 0.5 ppm, but in Alburgh and Willsboro, 17 and 14 of the varieties, respectively, tested above 1 ppm, with Anton, Appalachian White, LP3, and Wesley testing above 2 ppm at both locations. Over the 2 years of the trial, Anton and Wesley consistently have had high DON levels at sites where DON was a concern and should be avoided for production in northern New England.

Choosing bread wheat varieties is difficult due to the common tradeoff between maximizing yields and maximizing the quality parameters required by millers and bakers, particularly protein. AC Morley, Harvard, and Warthog have been among the highest yielding varieties in these trials, but their protein levels have been relatively low. In contrast, Anton, Mace, and Maxine have consistently had among the highest protein levels, but the yields for these varieties have been below average. Arapahoe and Zorro are in the middle of these extremes with medium protein,

low DON, and average to above-average yields. One variety in particular, Redeemer, stands out from the others as scoring high in all categories. It has shown consistently high protein levels, low DON levels, and average to above-average yields. Redeemer does appear to be more susceptible to leaf disease, specifically *Ascochyta* leaf spot, under extremely wet conditions as Vermont experienced in 2011, but on lighter soils or with more typical rainfall, it has performed well.

Full reports of the 2010 results are available as a separate publication that can be found at [www.extension.umaine.edu/localwheat](http://www.extension.umaine.edu/localwheat) and [www.uvm.edu/extension/cropsoil](http://www.uvm.edu/extension/cropsoil). It also may be helpful to compare these results from Maine and Vermont to variety trials from other regions. Ultimately, though, it is important to evaluate data from test sites that are similar to your farm and region when deciding which varieties to grow.



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