THE UNIVERSITY OF MAINE
Cooperative Extension

2010
Organic Winter Wheat
Variety Trial Results

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2010 MAINE ORGANIC WINTER WHEAT VARIETY TRIAL RESULTS

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In 2010, the University of Maine, in collaboration with the University of Vermont, began an extensive trial evaluating varieties of hard red winter wheat to identify those that perform well in northern New England under organic production. In Maine, this trial was established at two locations, the University of Maine Rogers Farm Forage and Crop Research Facility in Old Town and Sites Farm, a private farm in Athens. The trial was also conducted at two sites in Vermont, results for which are reported in a separate bulletin. 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 averages 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 types except for two hard white and one soft white type. Only the hard red types were included in the statistical analyses. Hard types of wheat are preferred for bread flour.

Table 1. Winter wheat varieties planted in Old Town and Athens, ME.

Winter Wheat Varieties	Type	Seed Source
AC Morley	Hard Red	C&M Seed, Canada
Alliance	Hard Red	USDA-ARS
Arapahoe	Hard Red	Albert Lea Seed House, MN
Bauermeister	Hard Red	Washington State Univ.
Borden	Medium-Hard Red	Semican, Canada
Camelot	Hard Red	USDA-ARS
Expedition	Hard Red	Albert Lea Seed House, MN
Harvard	Hard Red	Agri-Culver Seeds, NY
Jerry	Hard Red	North Dakota State Univ.
Mace	Hard Red	USDA-ARS
Maxine	Hard Red	C&M Seed, Canada
Millennium	Hard Red	USDA-ARS
Overland	Hard Red	USDA-ARS
Redeemer	Hard Red	C&M Seed, Canada
Red Fife	Hard Red	Butterworks Farm, VT
Wahoo	Hard Red	USDA-ARS
Warthog	Hard Red	Semican, Canada
Wesley	Hard Red	USDA-ARS
Zorro	Hard Red	C&M Seed, Canada
Anton†	Hard White	USDA-ARS
MDM†	Hard White	Washington State Univ.
Xerpha†	Soft White	Washington State Univ.

† Variety is not a hard red type.

WEATHER DATA

Seasonal precipitation and temperature recorded at the Rogers Farm Forage and Crop Research Facility are shown in Table 2. Weather data for a site closer to Athens than Old Town was not available. Weather in 2009 and 2010 was ideal for growing wheat. Mild conditions during the winter and an early spring caused the wheat to reach major developmental stages 1-2 weeks earlier than usual. From planting to harvest, there was an accumulation of 3427 Growing Degree Days (GDD) in Old Town.

Table 2. Temperature and precipitation summary for Old Town, ME, 2010.†

Old Town	September 2009	October 2009	March	April	May	June	July
Average Temperature (°F)	55.9	43.0	37.0	46.3	56.1	62.0 ‡	70.5
Departure from Normal	0.5	-2.3	6.0	4.3	2.2	-0.7	2.1
Average Precipitation (inches)	1.4	5.6 ‡	4.6	2.3	1.9	4.0 ‡	2.2
Departure from Normal	-2.5	2.2	1.4	-0.9	-1.5	0.4	-1.2
Growing Degree Days (base 32°F)	700	334	164	426	726	857 ‡	1182

† Based on National Weather Service data from cooperative observer stations in close proximity to field trials. Historical averages are for 30 years (1971-2000). http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl
‡ Values are incomplete due to missing or flagged data.

CULTURAL PRACTICES

Plots were managed following practices similar to those used by farmers in Maine (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. Sweet corn and mixed vegetables were grown on these fields the year prior to planting. In early September 2009, the fields were prepared using a moldboard plow and seedbed conditioner. Solid dairy manure was applied at a rate of 20 tons/ac on September 22 and immediately incorporated with a Perfecta harrow. The plots were seeded with an Almaco Cone Seeder on September 24, 2009 and harvested with an Almaco SPC20 plot combine on July 20, 2010.

Sites Farm - Athens, ME - The field used in the trial in Athens had been in a continual winter rye forage rotation for more than 5 years. In early September 2009, the fields were prepared using a moldboard plow and seedbed conditioner. On September 11, chicken manure (from an egg laying operation) was applied at a rate of 4 tons/ac and then incorporated with a spring-tine harrow on the same day. A spring-tine harrow was used for final seedbed preparation a day before planting. The plots were seeded with an Almaco Cone Seeder on September 25, 2009 and harvested with an Almaco SPC20 plot combine on July 23, 2010.

All varieties were harvested on the same day at each site once the latest maturing variety threshed free in hand tests and weather and logistics allowed. Following harvest, the grain from both locations was cleaned with a small Clipper cleaner. Measurements taken include grain yield, moisture, test weight, crude protein, falling number, and DON. Harvest moisture and test weights were determined using a Seedburro GMA 128 grain moisture meter. Subsamples were ground into flour using a Perten LM3100 Laboratory Mill. Flour was then analyzed for crude protein, falling number, and mycotoxin levels. Protein content was determined using a Leco Combustion 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 by 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 greater than 250 seconds indicate low enzymatic activity and sound quality wheat. Falling numbers lower than 200 indicates 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. DON concentrations were determined for the Old Town location only.

All data were analyzed using mixed model Analysis of Variance (ANOVA) in which replicates were considered 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 two locations for most parameters, so results from each location are reported independently.

Table 3. General plot management of the wheat trials.

Trial Information	Winter wheat variety trial	
Location	Rogers Research Farm Old Town, ME	Sites Farm Athens, ME
Soil type	Melrose & Elmwood fine sandy loam	Adams loamy sand
Previous crop	Mixed vegetables / sweet corn	Winter rye sod
Fertility source	Solid dairy manure	Layer chicken manure
Target nitrogen rate (lbs/ac)	70	70
Row spacing (in)	6.5	6.5
Seeding rate (seeds/ft^2)	30	30
Replicates	4	3†
Planting date	9-24-09	9-25-09
Harvest date	7-20-10	7-23-10
Harvest area (ft^2)	4' x 34'	4' x 34'
Tillage operations	Moldboard plow, seedbed conditioner	Moldboard plow, seedbed conditioner

† Four replicates were planted but the fourth block was compromised by soil erosion so results were not included in the analysis.

Summer growth in the Old Town trial.

Harvesting the Old Town trial.

WHAT IS A SIGNIFICANT DIFFERENCE?

Variations in yield and quality can occur not only due to genetics but also due to vaiability 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).

Variety	Yield
A	3161
B	**3886**
C	**4615**
LSD	*889*

RESULTS

Winter Wheat Growth and Development

During the 2010 growing season, several observations were recorded on wheat development. Relative flowering date was recorded for each of the varieties where possible (Table 4). In Old Town, the majority of varieties flowered during the last week of May and beginning of June. All three of the Washington State University varieties, Bauermeister, MDM, and Xerpha, had the latest flowering dates at both sites. Lodging and wildlife damage was minimal at both locations.

After the wheat reached physiological maturity (peak biomass), plant heights, tillering, weed biomass (Table 4) and wheat plant biomass (Table 5) were measured. The biomass was cut one inch above the soil surface. Only tillers with filled grain heads (spikes) were counted. While many things can affect tillering, planting date, weather, and variety choice are probably the most important. Arapahoe and Jerry were two varieties with the highest number of tillers at both locations. It is thought that taller varieties may be more competitive with weeds and therefore better suited for organic production than shorter varieties. A relationship between taller varieties and lower weed biomass was not observed

Zorro in Old Town where clover was not sown but germinated from residual seed in the soil and developed under the wheat.

in our trials. AC Morley, Borden, Red Fife, and Zorro were among the tallest varieties at both locations but did not necessarily have the lowest weed biomass. Other factors, like variable plant stands and spotty weed pressure, also influenced weed biomass in our trials. In general, weed pressure at the Old Town site was very low and consisted almost solely of Shepherd's Purse (*Capsella bursa-pastoris*). Perennial weeds such as quackgrass (*Elytrigia repens*) were a major issue in Athens and contributed to the lower yields at this site. Generally, winter wheat is not prone to summer annual weed problems but is susceptible to perennial weeds. Therefore, site location where perennial weed pressure is low is an important consideration for winter wheat.

Table 4. Estimated wheat flowering date, plant height, number of tillers with spikes, and weed biomass, Old Town and Athens, ME.

	Estimated Flowering Date		No. of Tillers with Spikes		Plant Height		Weed Biomass	
Variety	Old Town	Athens	Old Town	Athens	Old Town	Athens	Old Town	Athens
			no./ft^2	no./ft^2	inches	inches	lbs/ac	lbs/ac
AC Morley	1-June	< 9-June	30	31	36	31	130	530
Alliance	27-May	< 9-June	35	**44**	27	23	63	1019
Arapahoe	28-May	< 9-June	**45**	**49**	29	27	**44**	1352
Bauermeister	10-June	10-June	**39**	**39**	31	23	**36**	606
Borden	30-May	< 9-June	28	36	36	31	**45**	805
Camelot	29-May	< 9-June	**39**	34	29	27	**34**	1334
Expedition	26-May	< 9-June	**38**	**43**	29	27	**126**	550
Harvard	28-May	< 9-June	30	36	30	30	**64**	860
Jerry	1-June	< 9-June	**48**	**41**	33	26	85	817
Mace	1-June	< 9-June	35	33	25	20	**80**	1005
Maxine	30-May	< 9-June	22	30	28	24	229	808
Millennium	29-May	< 9-June	35	34	28	26	**33**	763
Overland	29-May	< 9-June	36	29	30	25	**48**	1103
Redeemer	31-May	< 9-June	28	34	30	29	**42**	748
Red Fife	3-June	< 9-June	26	21	**43**	**39**	127	1082
Wahoo	29-May	< 9-June	35	**38**	28	25	**58**	675
Warthog	31-May	< 9-June	29	28	33	24	121	1030
Wesley	27-May	< 9-June	38	**43**	25	22	**48**	706
Zorro	2-June	< 9-June	27	24	37	32	**26**	707
Anton‡	29-May	< 9-June	29	33	28	23	42	698
MDM‡	10-June	11-June	35	34	30	22	49	1099
Xerpha‡	6-June	10-June	29	31	27	24	45	1056
Trial Average	---	---	*34*	*33*	*31*	*26*	*76*	*873*
LSD (0.05)	---	---	*10*	*11*	*1*	*4*	*11*	*NS* §

† 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 and was not included in statistical analyses.

§ No significant difference among varieties.

Winter Wheat Yield

Overall, yields were much higher in Old Town than in Athens (2785 vs. 1610 lbs/ac; Table 5, Fig. 1 & 2). Weeds, weather, and background fertility contributed to these differences. The highest yielding varieties were, in Old Town, Jerry at 3469 lbs/ac, and in Athens, Harvard at 2409 lbs/ac. Varieties that yielded well at both sites were Borden, Camelot, Harvard, Jerry, and Zorro. Red Fife is considered a spring type wheat but sowing it in the fall as a winter wheat has gained interest in our region. In this winter wheat trial Red Fife was the lowest yielding variety in Old Town and the third lowest in Athens. The lowest yielding variety in Athens was Mace. Varieties with the highest grain moisture tended to be those with the latest flowering dates (e.g. Bauermeister and MDM) and lower test weight.

Table 5. Wheat plant biomass, grain moisture at harvest, test weight, and yield of winter wheat, Old Town and Athens, ME.

	Wheat Plant Biomass		Grain Moisture at Harvest†		Test Weight		Yield at 13.5% Moisture	
Variety	**Old Town**	**Athens**	**Old Town**	**Athens**	**Old Town**	**Athens**	**Old Town**	**Athens**
	lbs/ac	lbs/ac	%	%	lbs/bu	lbs/bu	lbs/ac	lbs/ac
AC Morley	6855	5141	21	14	58	**56‡**	**2746**	1635
Alliance	5357	4282	22	14	57	**56**	2667	1769
Arapahoe	6926	5856	21	14	56	**55**	2515	1853
Bauermeister	7663	5312	25	15	54	50	2656	1185
Borden	6736	6159	20	14	55	53	**3344**	**2127**
Camelot	7785	5465	22	14	57	**55**	**2887**	**1962**
Expedition	6783	6246	22	14	58	**56**	2656	**2371**
Harvard	6853	7605	19	15	58	**56**	**3247**	**2409**
Jerry	8764	5850	21	14	57	**55**	**3469**	**1897**
Mace	5393	3365	20	14	57	53	2384	762
Maxine	5679	3104	19	14	59	**55**	2388	1788
Millennium	5944	5634	22	14	58	**56**	2511	1521
Overland	6757	4337	22	15	57	**55**	**3001**	1645
Redeemer	5973	6238	19	13	59	**56**	2652	**1905**
Red Fife	6741	4245	20	13	58	**56**	1923	1313
Wahoo	6423	5076	21	14	56	55	**2797**	1724
Warthog	6851	4374	20	13	58	55	**3387**	1444
Wesley	6457	5909	21	14	57	54	2679	1676
Zorro	7215	5611	19	14	59	**55**	**3145**	**2091**
Anton§	6265	5091	21	14	58	55	2637	1574
MDM§	6985	4325	27	15	56	47	2830	843
Xerpha§	6833	5505	22	14	54	53	3496	1530
Trial Average	*6692*	*4755*	*21*	*14*	*57*	*55*	*2785*	*1610*
LSD (0.05)	*NS ¶*	*NS ¶*	---	---	---	*2*	*695*	*539*

† All varieties at each site were harvested on the same day.

‡ 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 and was not included in the statistical analyses.

¶ No significant difference among varieties.

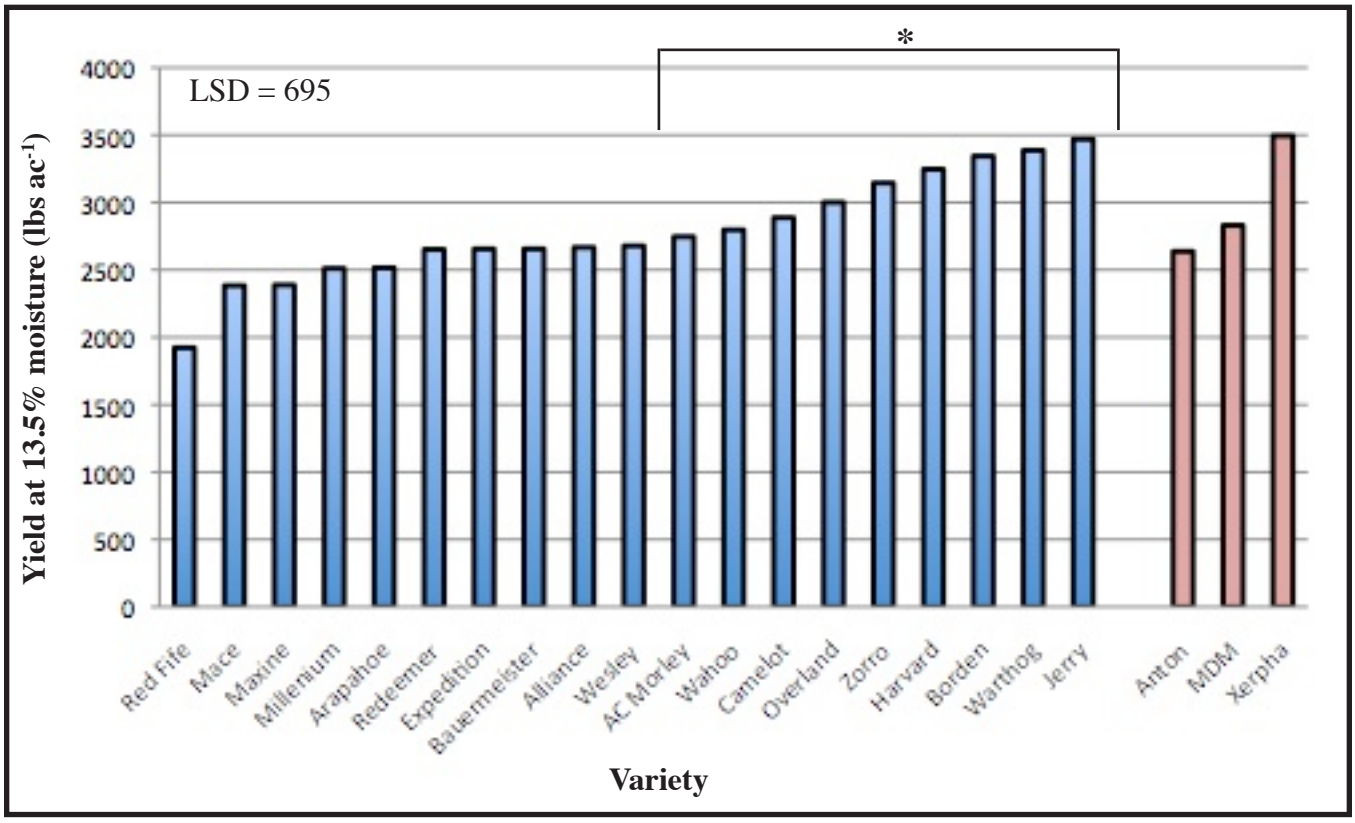

Figure 1. Yield of 22 winter wheat varieties, Old Town, ME.

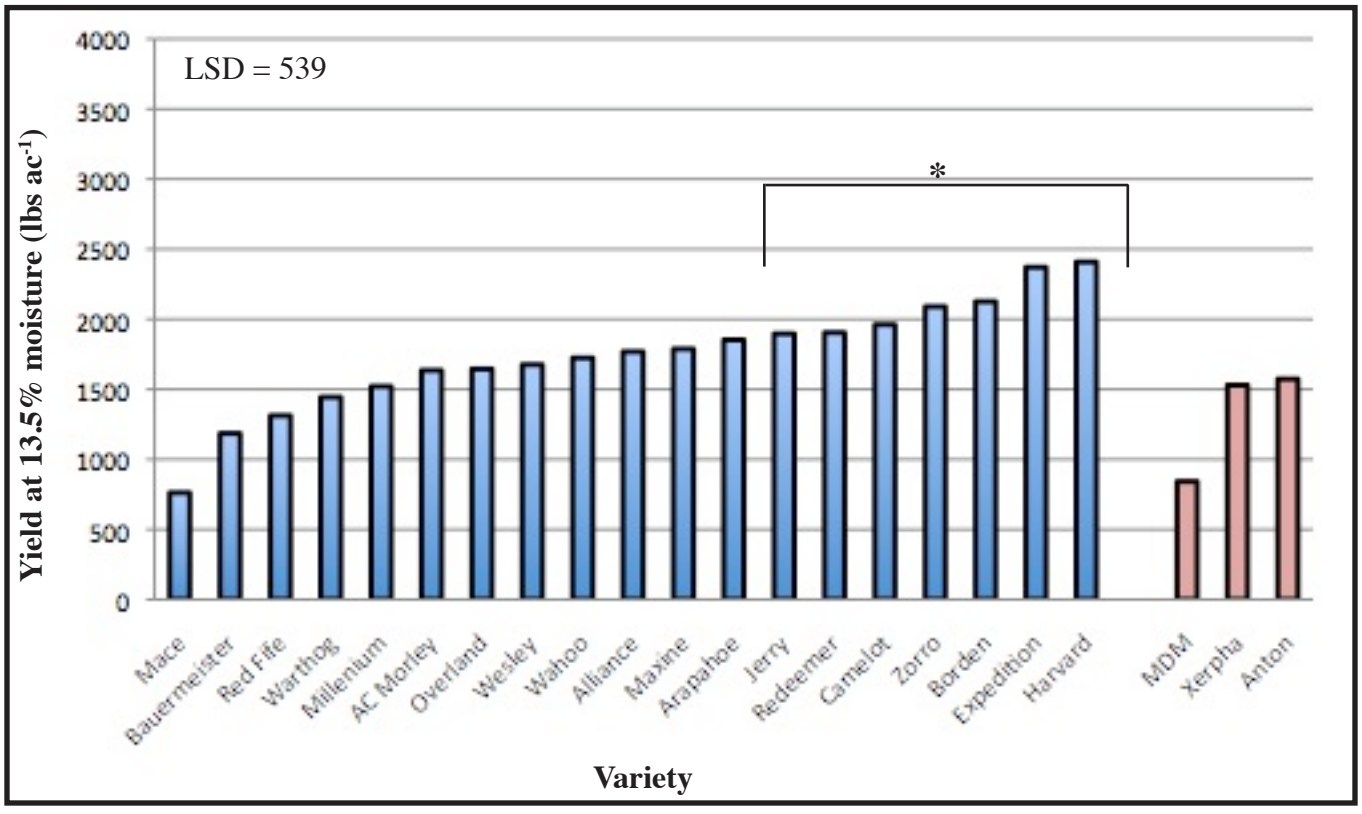

Figure 2. Yield of 22 winter wheat varieties, Athens, ME.

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

Winter Wheat Quality

Commercial mills use a variety of measurements to determine if a particular lot of wheat grain is suitable for bread flour, including grain protein, falling number, test weight, and mycotoxin (DON) concentration. Overall, crude protein was higher in Athens than in Old Town (12.0% vs. 10.7%; Table 6, Fig. 3 & 4). The varieties with the highest crude protein levels at the Old Town site were Red Fife, Maxine and Redeemer. There were no statistically significant differences among the crude protein levels at the Athens site. Falling number results are not available yet. There were few signs of *Fusarium* head blight at either site, and DON levels measured for the varieties grown at Old Town were all under the 1.0 ppm limit for human consumption. The fungus that causes *Fusarium* head blight and produces DON infects the plants through the flower. Conditions were dry just before and during flowering which would have prevented innoculum from building up and infecting plants.

Table 6. Quality of winter wheat, Old Town and Athens, ME.

	Crude protein at 12% moisture		Falling number at 14% moisture	DON
Variety	**Old Town**	**Athens**	**Old Town**	**Old Town**
	%	%	seconds	ppm
AC Morley	10.8	12.1	†	< 0.5
Alliance	10.4	11.5	†	< 0.5
Arapahoe	11.0	12.0	†	< 0.5
Bauermeister	10.1	11.8	†	< 0.5
Borden	10.1	11.6	†	< 0.5
Camelot	10.7	11.9	†	< 0.5
Expedition	10.2	12.1	†	< 0.5
Harvard	9.6	11.3	†	< 0.5
Jerry	10.9	12.1	†	< 0.5
Mace	10.8	12.0	†	< 0.5
Maxine	**11.7**‡	12.3	†	< 0.5
Millennium	10.8	12.1	†	< 0.5
Overland	10.5	12.1	†	< 0.5
Redeemer	**11.5**	12.0	†	< 0.5
Red Fife	**11.7**	12.3	†	< 0.5
Wahoo	10.1	11.9	†	< 0.5
Warthog	10.7	12.1	†	< 0.5
Wesley	10.6	12.5	†	< 0.5
Zorro	10.6	11.8	†	< 0.5
Anton§	10.9	11.9	†	0.5
MDM§	10.5	12.7	†	< 0.5
Xerpha§	10.0	11.9	†	0.8
Trial Average	*10.7*	*12.0*	†	---
LSD (0.05)	*0.7*	*NS* ¶	†	---

† Samples are still being processed and results are pending.

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

§ Varieties are not hard red types and were not included in the analyses.

¶ No significant difference between varieties.

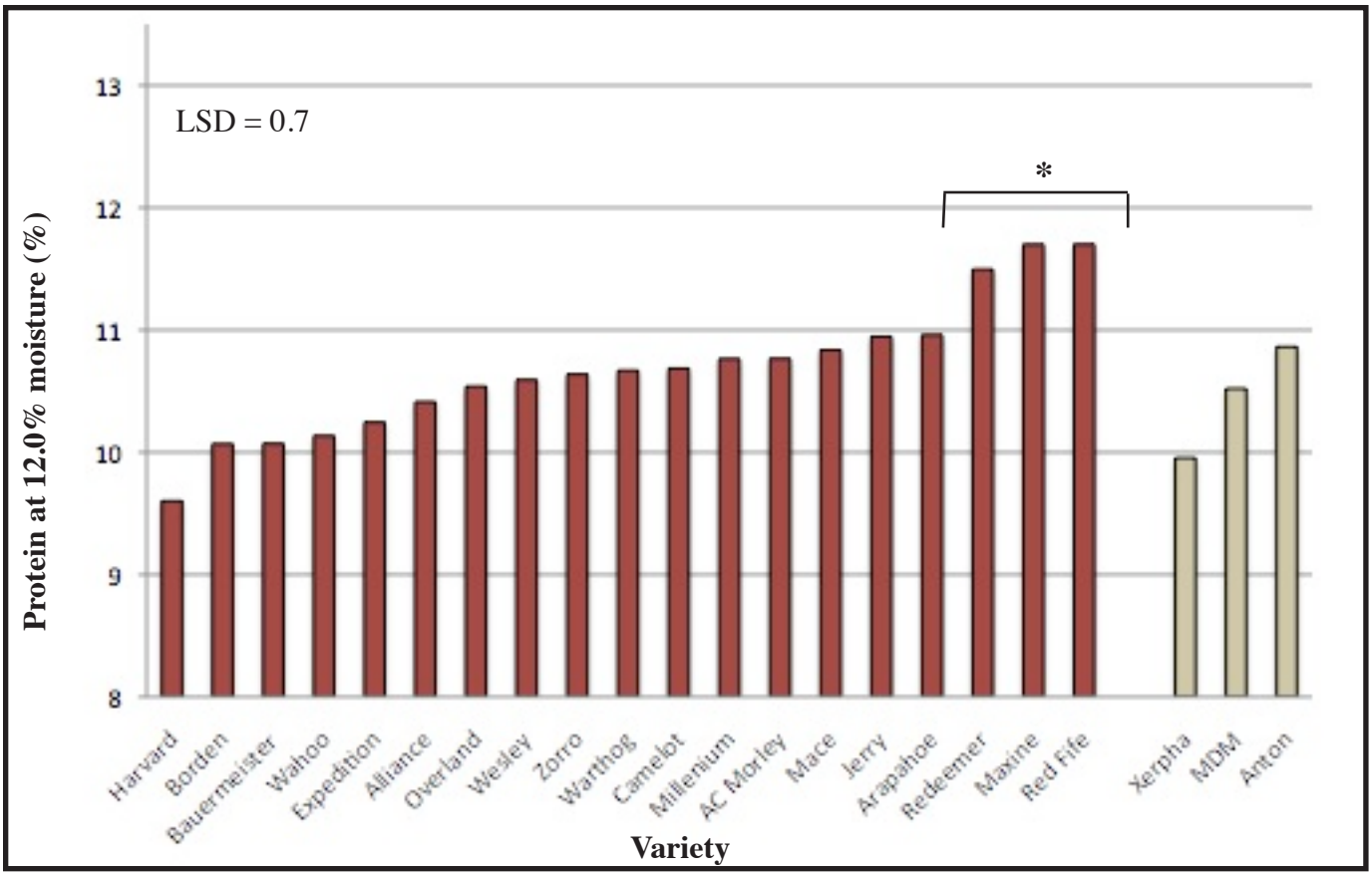

Figure 3. Protein concentration in 22 winter wheat varieties, Old Town, ME.

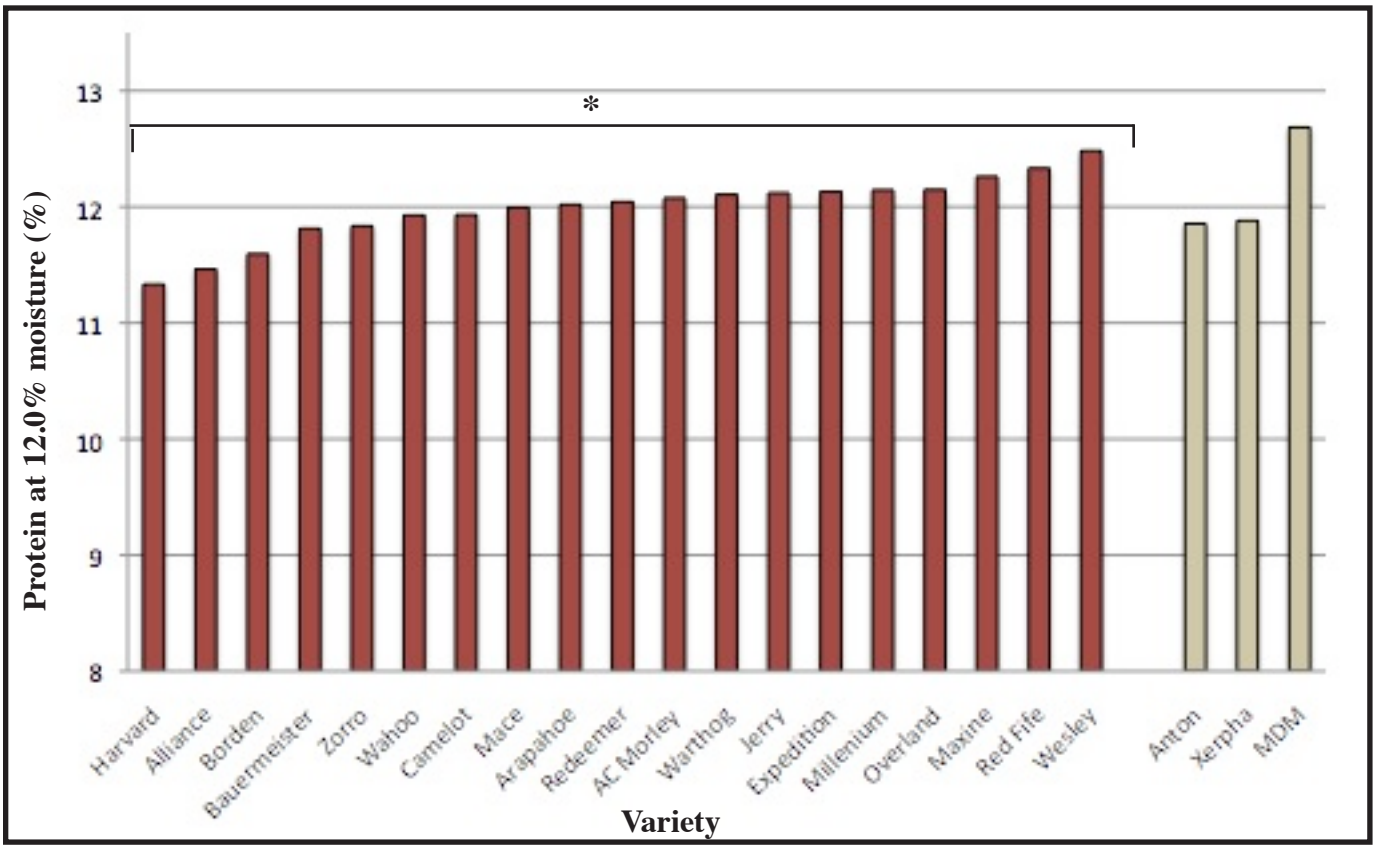

Figure 4. Protein concentration in 2 winter wheat varieties, Athens, ME.

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

DISCUSSION

It is important to note that the results presented in this report are from just one year of data, and do not necessarily reflect how the varieties would perform in different years. We will repeat this trial in 2011. However, some observations are worth noting at this point. The relative performance of each variety was not always consistent across locations, due likely to differences in growing conditions and soil type. The average yield in Old Town (2785 lbs/ac) was much higher than that in Athens (1610 lbs/ac). Historical yields for organic hard red winter wheat grown in Maine over the last 10 years are estimated to be 2500 lbs/ac (personal communiation, Matt Williams, 2011). Weed pressure and low background fertility contibuted to poorer growing conditions at the Athens site. A few varieties that were in the top yielding group in Old Town, yielded relatively poorly in Athens (ex. Warthog); and others that were top yielders in Athens were not in the top group in Old Town (ex. Expedition). Some varieties performed consistently well at both sites, in particular Borden, Camelot, Harvard, Jerry, and Zorro.

Crude protein levels were highest at the Athens site, with nearly all varieties at or above 12%, the standard cutoff for good baking characteristics. High yields are often associated with lower protein as seen at the Old Town site. Maxine and Redeemer, however, yielded close to the historical level in Old Town and also had relatively high grain protein values.

One variety new to the Northeast that showed promise is Jerry. While not always the top performer for each measurement, Jerry was among the top yielders at both sites and had good grain protein in Athens. It performed similarly in Vermont. We're looking forward to seeing how it performs next year.

Results from the sites in Vermont are available in a separate publication that can be found at www.extension.umaine.edu/localwheat. As well, it may be helpful to compare these results 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.

Visitors tour the winter wheat variety trial at the 2010 University of Maine Sustainable Agriculture Field Day at Rogers Research Farm. Photo by Eric Gallandt.

Photos by Ellen Mallory unless otherwise noted.

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