2016

Organic Winter Wheat Variety Trial

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NORTHWEST CROPS & SOILS PROGRAM

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2016 ORGANIC WINTER WHEAT VARIETY TRIAL

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In 2016, the University of Vermont Extension Northwest Crops and Soils Program evaluated 14 modern hard red winter wheat varieties to determine which varieties thrive in organic production systems. The trial was established at the Borderview Research Farm in Alburgh, Vermont. Several varieties that did not perform well in previous trial years were eliminated from the 2016 variety trial. Newly released varieties were also sought for evaluation.

MATERIALS AND METHODS

In the fall of 2016, a winter wheat variety trial was initiated at Borderview Research Farm in Alburgh. General plot management is listed in Table 1. The experimental design was a randomized complete block with three replicates. Treatments were 14 winter wheat varieties (Table 2). Plots were managed with practices similar to those used by producers in the surrounding area. The previous crop was corn. The field was disked and spike tooth harrowed prior to planting. Plots were seeded with a Great Plains Cone Seeder on 25-Sep 2015 at a seeding rate of 125 lbs ac^{-1}.

During the 2016 growing season, many observations and measurements were recorded on winter wheat development, including winter survival, flowering date, height, lodging and pest and disease prevalence. The flowering date was recorded when at least 50% of the plot was in bloom. Heights and lodging were measured on 19-Jul 2016 before the wheat was harvested. Heights were determined by taking three measurements per plot with a meter stick. Lodging was measured just prior to harvest and was recorded as a percent of plot lodged.

Insect and disease scouting was conducted on 7-Jul. Research technicians looked for the presence of a variety of foliar diseases, including loose smut, powdery mildew, and *Fusarium* head blight (FHB), as well as the presence of mites or insects and evidence of pest damage. Five plants in each plot were examined for disease and pest damage.

Table 1. General plot management, 2016.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Corn
Seeding Rates (lbs ac^{-1})	125 lbs ac^{-1}
Row spacing (in)	6
Replicates	3
Planting date	25-Sep 2015
Harvest date	21-Jul 2016
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, disk & spike tooth harrow

Plots were harvested with an Almaco SPC50 small plot combine on 21-Jul 2016. The harvest area was 5’ x 20’. Grain moisture, test weight, and yield were determined at harvest. Seed was cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN) and a subsample was collected to determine quality characteristics. Samples were ground using the Perten LM3100 Laboratory Mill. Flour was analyzed for protein content using the Perten Inframatic 8600 Flour Analyzer. Most commercial mills target 12-15% protein content. Falling number was measured (AACC Method 56-81B, AACC Intl., 2000) on the Perten FN 1500 Falling Number Machine. The falling number is related to the level of sprout damage in the grain. It is determined by the time it takes, in seconds,

for a stirrer to fall through a slurry of flour and water to the bottom of a test-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), a vomitoxin, was analyzed using Veratox DON 5/5 Quantitative test from the NEOGEN Corp. This test has a detection range of 0.5 to 5 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption. The varieties of heirloom winter wheat grown, and their market class, year, and origin, are listed in Table 2. Results were analyzed with an analysis of variance in SAS using the PROC MIXED procedure with the Tukey-Kramer adjustment, which means that each cultivar was analyzed with a pairwise comparison (i.e. 'Redfield' statistically outperformed 'Wolf', 'Wolf' statistically outperformed 'Cedar', etc.). Relationships between variables were analyzed using the general linear model (GLM) procedure.

Table 2. Winter wheat varietal information, 2016.

Variety	Market class	Seed source
10007W	HRWW	Seedway, NY
112313W	HRWW	Seedway, NY
Brome	HRWW	Semican, Canada
Byrd	HRWW	Arrow Seeds, NE
WB-Cedar	HRWW	Arrow Seeds, NE
Expedition	HRWW	Albert Lea Seed House, MN
Fredrick	SWWW	Lakeview Oragincs, NY
WB-Grainfield	HRWW	Arrow Seeds, NE
Overland	HRWW	Albert Lea Seed House, MN
Redeemer	HRWW	C&M Seed, Canada
Redfield	HRWW	Albert Lea Seed House, MN
Warthog	HRWW	Seedway, NY
Winterhawk	HRWW	Arrow Seeds, NE
Sy Wolf	HRWW	Arrow Seeds, NE

HRWW – Hard Red Winter Wheat; SWWW – Soft White Winter Wheat

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 p value is presented for each variable (i.e. yield). A small p-value indicates strong statistical differences between varieties. A large p value indicates weak statistical differences between varieties. A p value of 0.10 indicates that the differences between varieties are significant at 10% level of probability. Where the p value is 0.10, you can be sure in 9 out of 10 chances that there is a real difference between the varieties. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk.

RESULTS AND DISCUSSION

Seasonal precipitation and temperature recorded at a weather station in Alburgh, VT are shown in Table 3. Temperatures were average or above for most of the growing season, with the exception of a colder than normal April. The 2015-2016 growing season could be characterized as being drier than normal with 10.9 inches of precipitation less than normal. While a few months were warmer than average, overall temperatures were very mild and resulted in 5324 growing degree days (GDDs) at a base temperature of 32°F through the growing season, 278 GGDs more than the 30 year average. Many of the varieties in the trial were developed in environments much different than New England. Hence, it is important to evaluate the varieties for tolerance to our climate. All varieties were able to survive the winter despite the lack of protective snow cover.

Table 3. Seasonal weather data collected in Alburgh, VT, 2015 and 2016.

Alburgh, VT	Sep-15	Oct-15	Nov-15	Mar-16	Apr-16	May-16	Jun-16	Jul-16
Average temperature (°F)	65.2	46.5	42.2	33.9	39.8	58.1	65.8	70.7
Departure from normal	4.7	-1.6	4.0	2.9	-4.9	1.8	0.0	0.1
Precipitation (inches)	0.3	2.5	1.8	2.5	2.6	1.5	2.8	1.8
Departure from normal	-3.3	-1.1	-1.3	0.3	-0.3	-1.9	-0.9	-2.4
Growing Degree Days (base 32°F)	1010	464	329	209	291	803	1017	1201
Departure from normal	154	-37	117	85	-98	50	3	4

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

Winter survival, flowering date, and height are reported in Table 4. The majority (11 varieties) of winter wheat varieties were flowering by 6-Jun and all varieties were flowering by 12-Jun. In organic systems, taller plants are generally desired for their ability to shade out competing weeds, although tall wheat may be prone to lodging depending on many factors such as stalk strength and over-fertilization. 'Brome' was the tallest wheat variety at 92 cm (36.2 inches) (Table 4). This was not significantly taller than any varieties except 'WB-Cedar,' the shortest wheat at 60.4 cm (23.8 inches). Lodging was minimal and only present in two plots in the trial (data not shown).

Table 4. Growing season measurements winter wheat varieties in Alburgh, VT, 2016.

Variety	Winter survival	Flowering date	Height @ harvest
	%		cm
10007W	92.6*	4-Jun	65.4
112313W	**98.6***	4-Jun	69.9
Brome	76.7*	12-Jun	**92.2***
Byrd	98.0*	4-Jun	70.9
WB-Cedar	89.3*	9-Jun	60.4
Expedition	86.0*	6-Jun	69.8
Fredrick	88.3*	4-Jun	87.8*
WB-Grainfield	90.0*	7-Jun	67.1
Overland	62.7	6-Jun	62.1
Redeemer	91.7*	6-Jun	73.9
Redfield	85.0*	6-Jun	69.9
Warthog	93.7*	6-Jun	73.1
Winterhawk	95.3*	5-Jun	74.9
Sy Wolf	91.0*	5-Jun	69.4
LSD (p = 0.10)	22.7	NS	14.6
Trial Mean	88.5	6-Jun	71.9

*Varieties with an asterisk are not significantly different than the top performer in **bold**.
NS – No significant difference amongst varieties.

Table 5. Disease and pest damage in winter wheat varieties, 2016

Variety	Foliar disease	Arthropod damage
	% leaf affected	% leaf damaged
10007W	**0.26***	5.26
112313W	1.93*	**1.13***
Brome	1.46*	9.47
Byrd	2.73*	1.87*
WB-Cedar	5.00	3.67*
Expedition	4.47*	5.53
Fredrick	4.40*	4.47*
WB-Grainfield	1.47*	1.20*
Overland	1.33*	2.13*
Redeemer	7.80	2.47*
Redfield	7.60	2.3*
Warthog	0.40*	3.53*
Winterhawk	0.67*	1.47*
Sy Wolf	0.67*	2.80*
LSD (p = .10)	4.69	4.21
Trial Mean	2.87	3.40

*Varieties with an asterisk are not significantly different than the top performer in **bold**.

Five plants in each plot were examined for disease and pest damage, and are shown in Table 5 as the average percent of each leaf that was affected by either arthropod damage or foliar disease.

The most common arthropods affecting the winter wheat trials were mites and thrips. Mites are very small arthropods that feed on the sap of leaves of wheat and other grain crops. Leaves affected by mites may appear yellowish or silvery in early stages of infestation and later take on a scorched appearance. Injury caused by mites can result in stunted plants. Some degree of mite damage was observed in all plots. Thrips are small insects with fringed wings that feed on a variety of plants by puncturing the cells and sucking up the contents. Damage caused by thrips includes discoloration and leaf scarring, reduced growth of the plant, and they can also act as a disease vector. Thrips damage was observed in more than half of the winter wheat trial plots. Cereal leaf beetle damage and European corn borer damage were also observed in a few scattered plots. '112313W' was least susceptible to arthropod damage, with only 1.10% of leaf surface displaying pest damage. This was statistically similar to the arthropod damage sustained by 'Grainfield,' 'Winterhawk,' 'Byrd,' 'Overland,' 'Redeemer,' 'Redfield,' 'Wolf,' 'Warthog,' 'Cedar,' 'Fredrick,' and '10007W.' The varieties with the highest levels of arthropod damage were Brome (9.50% of the leaf damaged) and 'Expedition' (5.50% leaf damage).

Several foliar diseases were observed during wheat development, including powdery mildew, leaf rust, and tan spot. Foliar diseases reduce photosynthetic leaf area, use nutrients, and increase respiration and transpiration within colonized host tissues. The diseased plant typically exhibits reduced vigor, growth and seed fill. The earlier occurrence, greater degree of host susceptibility, and longer duration of conditions favorable for disease development will increase the yield loss. Tan spot, caused by the fungus *Pyrenophora tritici-repenti,* was also very prevalent and affected all varieties and more than 75% of plots. Powdery mildew (caused by the fungus *Erysiphe graminis f. sp. Tritici*) and leaf rust were less prevalent than leaf spot. 10007W had the least presence of foliar disease, with 0.30% of leaf surface displaying foliar disease. Warthog, Wolf, and Winterhawk also all had foliar disease on less than 1.00% of leaf surface. Redeemer was the most prone to foliar disease (lesions covering 7.80% of the leaf surface on average), followed by Redfield with 7.60% of leaf surface affected and Cedar with 5.00% of leaf surface affected.

Fusarium head blight (FHB) is a foliar disease of particular concern to wheat growers. In the Northeast, FHB is predominantly caused by the species *Fusarium graminearum*. This disease is very destructive and causes yield loss, low test weights, and low seed germination. It is of particular concern due to contamination of grain with mycotoxins. A vomitoxin called deoxynivalenol (DON) is considered the primary mycotoxin associated with FHB.

The spores are usually transported by air currents and can infect plants at flowering through grain fill. Eating contaminated grain greater than 1ppm poses a health risk to both humans and livestock. In the 2016 trial, seven of the 14 varieties (Brome, Byrd, Expedition, Fredrick, Overland, Redfield, and Wolf) displayed bleached grain heads which are associated with the presence of *Fusarium* head blight. Byrd, Expedition, and Wolf displayed bleached heads in two out of three replicates (bleaching was only observed in one plot out of the three replicates in the other four varieties.) However, DON levels (Table 6) for all wheat plots were far below the 1 ppm threshold for human consumption.

Loose smut was observed in all plots of Fredrick wheat but in no other winter wheat varieties. Loose smut in wheat is caused by *Ustilago tritici* and can destroy large portions of grain crops. Loose smut replaces grain heads with masses of spores (smut) which infect the open flowers of healthy plants and grow into the seed. Seeds appear healthy and only when they reach maturity the following season is it clear that they were infected.

Table 6. Yield and quality of winter wheat varieties, Alburgh, VT, 2016.

Variety	Yield @ 13.5% moisture	Moisture	Test weight	Crude protein @ 12% moisture	Falling number	DON
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm
10007W	3507*	**15.1***	62.5*	11.9	281	0.17
112313W	**4336***	16.2*	58.8	10.0	330	0.13
Brome	3484*	20.8	59.7	12.1	336	0.13
Byrd	4090*	16.1*	62.5*	11.6	353	0.20
WB-Cedar	3524*	15.3*	61.5*	13.3*	**404***	0.10
Expedition	2194	15.7*	**62.8***	13.2*	375*	**0.00**
Fredrick	3411*	15.5*	62.3*	12.7	272	0.23
WB-Grainfield	2515	15.6*	62.7*	12.6	355	0.10
Overland	3312*	16.9	61.5*	13.5*	396*	0.00
Redeemer	3323*	15.9*	62.5*	**14.2***	388*	0.17
Redfield	3339*	16.3*	61.7*	12.3	399*	0.07
Warthog	3382*	16.7	62.0*	12.2	387*	0.17
Winterhawk	3616*	17.4	61.7*	13.0*	399*	0.23
Sy Wolf	3257*	17.1	62.5*	12.7	298	0.13
LSD (p = 0.10)	1303	1.17	1.46	1.37	33.8	NS
Trial Mean	3378	16.5	61.8	12.5	355	0.13

*Varieties with an asterisk are not significantly different than the top performer in **bold**.
NS – No significant difference amongst varieties.

Winter wheat heirloom varieties had an average yield of 3378 lbs ac^{-1}. Two varieties yielded over two tons per acre (112312W at 4336 lbs ac^{-1} and Byrd at 4090 lbs ac^{-1}). This was statistically similar to the varieties 10007W, Brome, Cedar, Fredrick, Overland, Redeemer, Redfield, Warthog, Winterhawk, and Wolf.

Harvest moisture below 16% is desirable for growers for grain storage. Wheat above this moisture content has to be dried down postharvest at additional time and cost to farmers. Despite the dry season, high humidity at harvest time resulted in relatively high moisture content in the wheat harvest. The varieties 10007W, Cedar, Expedition, Fredrick, Grainfield, and Redeemer had moisture content below 16% while all others had to be dried down for storage and processing.

Test weight is the measure of grain density. It is determined by weighing a known volume of grain. Generally, the heavier the wheat is per bushel, the higher baking quality. Expedition had the highest test weight at 62.8 lbs bu^{-1}. This was statistically similar to all varieties except 112313W and Brome. All varieties in the 2016 winter wheat trials meet the industry standard of 56-60 lbs bu^{-1}.

Only one winter wheat variety, Redeemer, had crude protein levels above the industry minimum of 14%. There is often an inverse relationship seen between yield and protein, and this was somewhat true of the winter wheat varieties assessed in 2016, with the highest yielding variety 112312W having the lowest crude protein level at 10.0% crude protein (Figure 1). Falling numbers for all varieties were above 200 seconds, indicating sound quality wheat (Table 6). DON levels for all varieties were below the FDA threshold of 1 ppm which is considered safe for human consumption (Table 6).

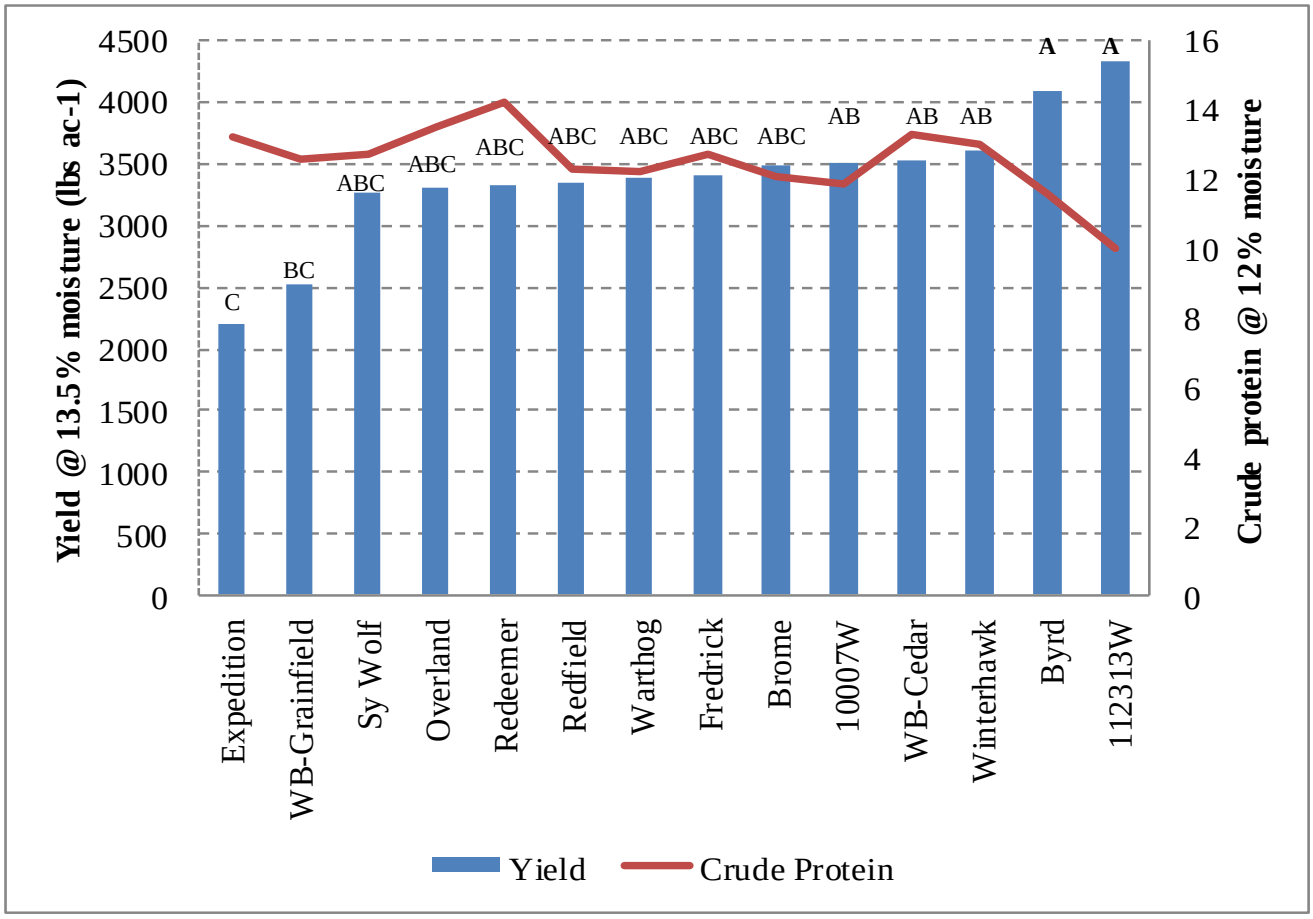

Figure 1. Yield and crude protein of winter wheat varieties, Alburgh, VT, 2016. *For yield, varieties with the same letter are not significantly different from one another.*

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