



2014 Spring Wheat Crosses Trial



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On-farm wheat breeding began in Vermont, in cooperation with UVM Extension, in 2007 with a USDA SARE grant to build farmer knowledge in plant breeding. The goal of this on-farm breeding trial is to develop spring wheat varieties that are suited for organic management in Vermont soils and climatic conditions. Most commercially available varieties are developed in regions with climates, soils and management techniques that are very different from our own. In addition, those varieties are genetically homogenous and inbred for uniformity. This has often led to rapid breakdown of genetic resistance to local diseases. To address this situation, farmers in Vermont have been gaining the technical skills needed to develop their own varieties by making wheat crosses and selections under organic management.

To acquire hands-on breeding skills, Vermont farmers along with UVM Extension agronomist Heather Darby, attended an intensive short course on wheat breeding at Washington State University. Nineteen modern and heirloom varieties of spring wheat were originally planted in 2007, including three varieties from famed Vermont botanist and wheat breeder, Cyrus Pringle. Of these varieties, a number of crosses were made that have been grown out on farms in Vermont with varying soils and climates for the last 7 years. Farmers continue to grow the crosses and select the best-looking plants, while capturing the genetic diversity from the populations.

MATERIALS AND METHODS

In 2014, five of the top performing spring wheat crosses were planted at two locations: Borderview Research Farm in Alburgh, VT and Butterworks Farm in Westfield, VT. The crosses evaluated include AC Barrie/Red Fife, Champlain/AC Barrie, Champlain/Hope, Champlain/Red Bobs, and Red Fife/Defiance. Parents of the crosses are listed in Table 1.

Both farms are certified organic by Vermont Organic Farmers, LLC. The seedbeds were prepared by conventional tillage methods. See Table 2 for general plot management. Plots were planted with a six-inch Great Plains cone-seeder on 29-Apr in both Alburgh and Westfield. The spring wheat crosses at both locations were planted at 125 lbs acre⁻¹ in 2013 and in 2014, whereas in previous years, they have been planted at 100 lbs acre⁻¹. A lower seeding rate is generally recommended for heirloom varieties to allow for plenty of space for development of each plant and seed head. However, yields had been very low in the past, so we seeded at 125 lbs acre⁻¹ to compare yields and quality with modern varieties of wheat planted at the same seeding rate.

Table 1. Cultivars used as parents in spring wheat breeding project.

Abbreviation	Cultivar	Year	Place of Origin	Pedigree
ACB	AC Barrie	1997	Saskatchewan	Neepawa / Columbus // BW90
Ch	Champlain	1870	Vermont	Black Sea/Gold Drop
D	Defiance	1878	Vermont	Golden Drop/White Hamburg
H	Hope	1927	South Dakota	Yaroslav emmer/Marquis
RB	Red Bobs	1926	Saskatchewan	selection from field of Bobs
RF	Red Fife	1918	Ontario, Canada	information not found
S	Surprise	1909	Vermont	Chile Club/Michigan Club

Populations were determined by making two 1/3 meter counts per plot on 9-Jun at the Alburgh location. Wheat was harvested with an Almaco SPC50 small plot combine on 4-Aug in Alburgh and 20-Aug in Westfield. Grain moisture, test weight and yield were determined at the Westfield location. The grain was cleaned with a Clipper M2B cleaner and dried at 40°C until grain moisture was below 13%. Samples were ground into flour using a Perten LM3100 Laboratory Mill. 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 12-15% protein. Protein was calculated on a 14% moisture basis. Falling number 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) 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. All data was analyzed with an analysis of variance with SAS (Cary, NC). The LSD procedure was used to separate cultivar means when the F-test was significant ($p < 0.10$).

Table 2. General plot management, 2014.

Trial information	Alburgh, VT Borderview Research Farm	Westfield, VT Butterworks Farm
Soil type	Benson rocky silt loam	Colton-Duxbury complex
Previous crop	No-till corn	Dry Beans
Seeding Rate (lbs ac ⁻¹)	125	125
Row spacing (in)	6	6
Replicates	4	4
Planting date	29-Apr	29-Apr
Harvest date	4-Aug	20-Aug
Harvest area (ft)	5 x 20	5 x 20
Tillage operations	Fall plow, spring disk & spike tooth harrow	Fall plow, spring disk & spike tooth harrow

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 (i.e. yield). Least Significant differences (LSD's) at the 10% level of probability are shown. Where the difference between two treatments 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. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. In the example below, A is significantly different from C but not from B. The difference between A and B is equal to 1.5 which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between A and C is equal to 3.0 which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that B was not significantly lower than the top yielding variety.

Variety	Yield
A	6.0
B	7.5*
C	9.0*
LSD	2.0

RESULTS AND DISCUSSION

Seasonal precipitation and temperatures were recorded with a Davis Instruments Vantage Pro2 with Weatherlink data logger on site in Alburgh, VT (Table 3). The spring wheat growing season this year experienced lower than normal temperatures in April, July and August with above average temperatures in May and June. Alburgh experienced above average rainfall. From April to August there was an accumulation of 4439 Growing Degree Days (GDDs) in Alburgh, VT, which is 52 GDDs lower than the 30 year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2014.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	43	57.4	66.9	69.7	67.6
Departure from normal	-1.8	1	1.1	-0.9	-1.2
Precipitation (inches)	4.34	4.9	6.09	5.15	3.98
Departure from normal	1.5	1.5	2.4	1	0.1
Growing Degree Days (base 32°F)	330	789	1041	1171	1108
Departure from normal	-54	33	27	-27	-31

Based on weather data from Davis Instruments Vantage Pro2 with Weatherlink data logger.
Historical averages for 30 years of NOAA data (1981-2010).

Seasonal precipitation and temperature was recorded at a weather station in close proximity to the Westfield site and is shown in Table 4. Westfield experienced below average temperatures and above average rainfall during the spring wheat growing season. From April to August there was an accumulation of 3922 Growing Degree Days (GDDs) in Westfield, VT, which is 194 GDDs lower than the 30 year average.

Table 4. Temperature and precipitation summary for Westfield, VT, 2014.

Westfield, VT	April	May	June	July	August
Average temperature (°F)	39.4	53.6	62.9	67.2	64.6
Departure from normal	-3.2	-1.2	-0.9	-0.8	-1.5
Precipitation (inches)	3.0	5.4	4.5	5.9	4.8
Departure from normal	0.2	1.7	0.5	1.5	0.2
Growing Degree Days (base 32°F)	222	670	927	1091	1012
Departure from normal	-101	-40	-27	19	-45

*Data compiled from Northeast Regional Climate Center data from Newport, VT. Historical averages for 30 years of NOAA data (1981-2010).

In Alburgh, there was severe bird damage just prior to harvest leading to reduced yields at this location. In Alburgh, Champlain/AC Barrie yielded the highest of the F6 crosses with 417 lbs acre⁻¹ (Table 5). This was not significantly different from the other crosses. All of the crosses were very tall, measuring over 90 cm in height. With the excessive rain received during the growing season, it is not surprising that the tall wheat became lodged from heavy rain events. Surprise/Red Bobs was the tallest variety (104.4 cm) and had one of the lowest yields (212 lbs acre⁻¹). The greatest population was found in the Champlain/AC Barrie cross which also had the highest yield (417 lbs acre⁻¹). However, the population of this cross was not significantly different than three of the other four crosses. Because of the low yields in the F6 crosses at the Alburgh location, it was decided that the seed should be saved for planting next year, and quality was not tested.

Table 5. Growth characteristics from F6 spring wheat crosses grown in Alburgh, VT, 2014.

Variety	Height cm	Yield lbs ac ⁻¹	Population plants m ⁻²
AC Barrie/Red Fife	99.3	202	253
Champlain/AC Barrie	95.9	417	357
Defiance/AC Barrie	97.3	281	287
Hope/Champlain	93.7	225	325
Surprise/Red Bobs	104.4	212	283
LSD (0.10)	NS	NS	NS
Trial Mean	98.1	268	301

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

Yields of the crosses grown in Westfield were higher than those grown in Alburgh and ranged from 1278-1866 lbs acre⁻¹ (Table 6 and Figure 1). The highest yielding spring wheat cross was Defiance/AC Barrie. This was not significantly different than three of the other four crosses. Crude protein levels were high, ranging from 14.1-15.5%. The highest crude protein level was found in Champlain/AC Barrie but this was not significantly different than Hope/Champlain. Figure 1 shows the direct relationship between higher yield and lower crude protein. Falling numbers ranged from 187-236 seconds, indicating a high level of sprout damage. Additionally, all of the crosses grown in Westfield had DON levels less than 1 ppm and are considered safe for human consumption.

Table 6. Harvest data from F7 spring wheat crosses grown in Westfield, VT, 2014.

Variety	Yield @ 13.5% moisture lbs/ac	Moisture %	Test weight lbs/bu	Crude protein @ 12% moisture %	Falling number seconds	DON ppm
AC Barrie/Red Fife	1815*	17.8	55	14.1	236	0.27
Champlain/AC Barrie	1523*	17.9	54	15.5*	201	0.22
Defiance/AC Barrie	1866*	17.6	54	14.3	220	0.23
Hope/Champlain	1278	17.5	53	14.9*	187	0.40
Surprise/Red Bobs	1733*	17.7	55	14.1	212	0.38
LSD (0.10)	368	NS	NS	0.7	NS	NS
Trial Mean	1643	17.7	54	14.6	211	0.30

*Varieties with an asterisk indicate that it was not significantly different than the top performer in column (in bold).

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

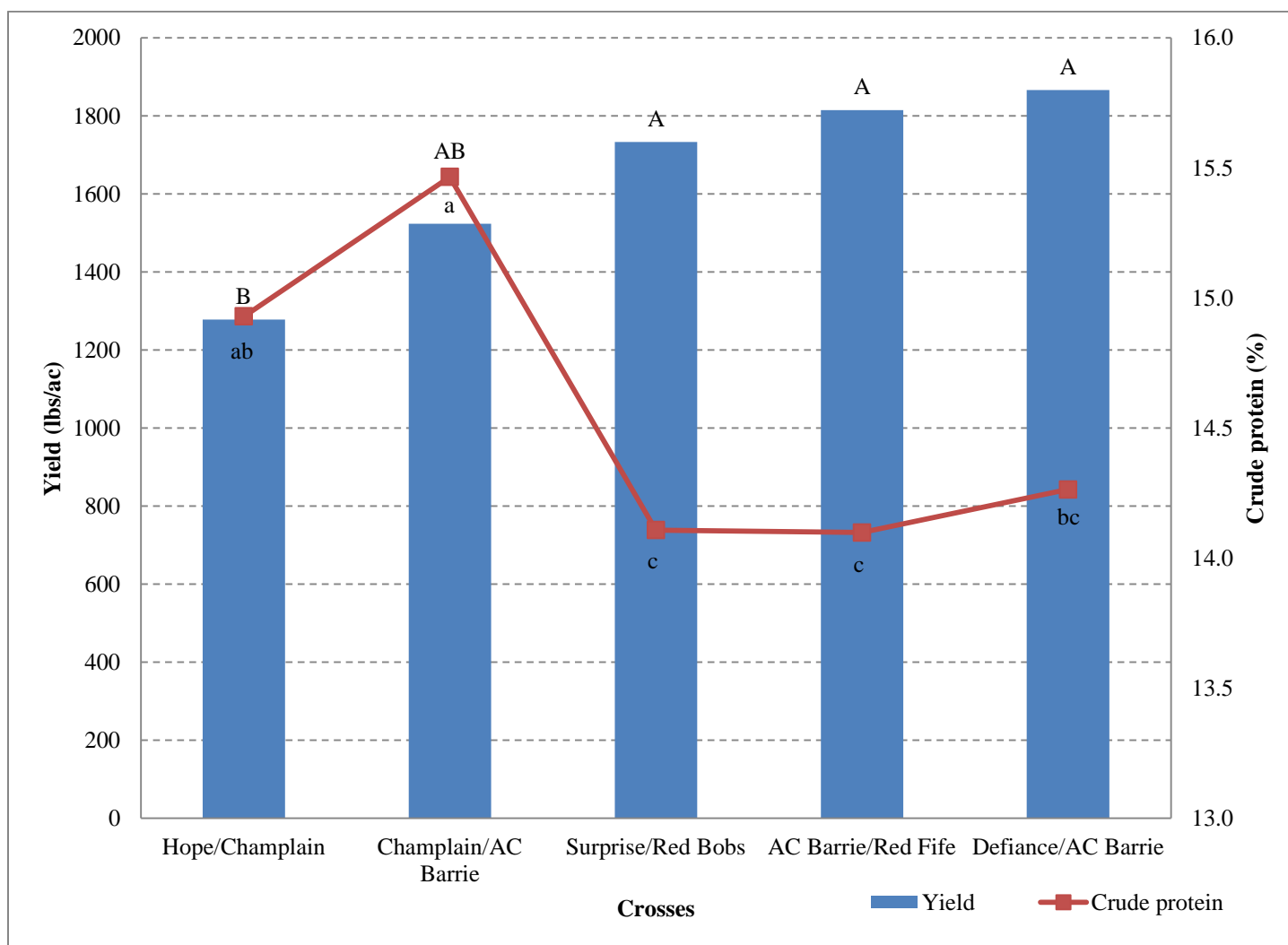


Figure 1. Yield and protein of F7 spring wheat crosses grown in Westfield, VT, 2014.

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