NORTHWEST CROPS & SOILS PROGRAM

# 2013 Vermont
# On-Farm Spring Wheat Breeding Trials

Dr. Heather Darby, UVM Extension Agronomist
Susan Monahan, Conner Burke, Erica Cummings, and Hannah Harwood
UVM Extension Crops and Soils Technicians
802-524-6501

Visit us on the web: http://www.uvm.edu/extension/cropsoil

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

**2013 ON-FARM SPRING WHEAT BREEDING TRIALS**

Dr. Heather Darby, University of Vermont Extension
Heather.Darby[at]uvm.edu

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 climactic 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 6 years. Farmers continue to grow the crosses and select the best-looking plants, while capturing the genetic diversity from the populations. In 2010, a second set of crosses were made to begin selections from new populations. In 2013, we were able to continue this organic plant breeding project thanks to funding from the Nell Newman Foundation.

## MATERIALS AND METHODS

### Spring Wheat Crosses: The First Set

In 2013, 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. The spring wheat crosses grown at Alburgh in 2013 had been planted in Bridport and Shoreham, VT in prior years. Due to low germ and high weed pressure, the crosses were not able to be harvested in 2012, therefore, the seed planted in Alburgh was from a previous generation, harvested in 2011 (and is one generation behind the crosses planted in Westfield).

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 Kincaid cone-seeder on 22-Apr in Alburgh and 1-May in Westfield. The spring wheat crosses at both locations were planted at 125 lbs acre$^{-1}$ in 2013, 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 22-May (and 4-Jun in Westfield). Lodging was determined by a visual observation of the percent of the plot lodged made on the day of harvest, and severity was recorded from 0-5, where 5 meant the wheat had fallen over completely. Wheat was harvested with an Almaco SPC50 small plot combine on 5-Aug in Alburgh and 20-Aug in Westfield. Grain moisture, test weight and yield were determined. The grain was cleaned with a Clipper M2B cleaner and dried at 40$^{o}$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.**

| Trial Information | Borderview Research Farm, Alburgh, VT | Butterworks Farm, Westfield, VT |
|---|---|---|
| Soil type | Benson rocky silt loam | Dixfield sandy loam |
| Previous crop | Corn | Sunflowers |
| Seeder | Kincaid cone-seeder | Kincaid cone-seeder |
| Planting date | 22-Apr | 1-May |
| Harvest Date | 5-Aug | 20-Aug |
| Seeding rate | 125 lbs/acre | 125 lbs/acre |
| Plot size (ft) | 7’ x 20’ | 7’ x 20’ |
| Tillage methods | fall plow, disk, and spike tooth harrow | fall plow, tandem disk, and field cultivate |

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 temperature recorded at weather stations in Alburgh and in close in proximity to Westfield are reported in Table 3. There were a total of 4510 Growing Degree Days (GDDs) from April to August in Alburgh, 18 GDDs more than the 30-year average. In Westfield, there was a total of 4031 GDDs from April to August, 85 GDDs less than the 30-year average. Average monthly temperatures were less than normal in April, June and August, while May and June (and July in Westfield) saw much more rain than the historical normal.

**Table 3. Seasonal weather data collected near Alburgh and Westfield, VT.**

| Alburgh, Vermont | April | May | June | July | August |
|---|---|---|---|---|---|
| Average Temperature (F) | 43.6 | 59.1 | 64 | 71.7 | 67.7 |
| Departure from Normal | -1.2 | 2.7 | -1.8 | 1.1 | -1.1 |
| | | | | | |
| Precipitation (inches) | 2.12 | 4.79 | 9.23 | 1.89 | 2.41 |
| Departure from Normal | -0.7 | 1.34 | 5.54 | -2.26 | -1.5 |
| | | | | | |
| Growing Degree Days (base 32) | 348 | 848 | 967 | 1235 | 1112 |
| Departure from Normal | -36 | 91 | -47 | 37 | -27 |

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.
June 2013 precipitation data based on National Weather Service data from cooperative stations in South Hero, VT. (http://www.nrcc.cornell.edu/page_summaries.html)

| Westfield,* Vermont | April | May | June | July | August |
|---|---|---|---|---|---|
| Average Temperature (F) | 39.4 | 55.7 | 62.2 | 69.3 | 64.6 |
| Departure from Normal | -3.2 | 0.9 | -1.6 | 1.3 | -1.5 |
| | | | | | |
| Precipitation (inches) | 2.78 | 6.53 | 7.08 | 7.29 | 2.78 |
| Departure from Normal | -0.03 | 2.86 | 3.12 | 2.96 | -1.83 |
| | | | | | |
| Growing Degree Days (base 32) | 221 | 736 | 906 | 1156 | 1012 |
| Departure from Normal | -102 | 26 | -48 | 84 | -45 |

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

In Alburgh, ACB/RF yielded the highest of the F5 crosses with 1339 lbs acre$^{-1}$ (Table 4). AC Barrie/Red Fife also had better standability than the other crosses with only 22.5% of the plot lodged. All of the crosses were very tall varieties, measuring over 46 inches tall. With the excessive rain received during the growing season, it is not surprising that the tall wheat became lodged from heavy rain events. Crude protein levels were high, ranging between 13.3-14.9% (Figure 1). Interestingly the crosses that included the parent Champlain always had higher CP than other crosses. Falling number was over 250 seconds for all crosses. The cross ACB/RF had the highest falling number indicating less susceptibility to pre-harvest sprouting. All of the DON levels were over 1 ppm and considered un-suitable for human consumption—although two crosses, Ch/ACB and Ch/H had DON levels significantly lower than the other crosses (Table 4).

**Table 4. Growth characteristics and harvest data from F5 spring wheat crosses grown in Alburgh, VT, 2013.**

| Cross | Height inches | Lodging % | Yield lbs ac$^{-1}$ | Moisture % | Test weight lbs bu$^{-1}$ | CP 14% moisture % | Falling number seconds | DON ppm |
|---|---|---|---|---|---|---|---|---|
| ACB/RF | 47.1 | 22.5 | **1339*** | 11.2 | 54.3 | 13.5 | **337*** | 4.7 |
| Ch/ACB | 47.4 | 52.5 | 1031 | 11.4 | 53.0 | **14.9*** | 282 | **3.3*** |
| Ch/H | 46.5 | 57.5 | 1011 | 10.0 | 52.5 | 14.2* | 300 | 4.4* |
| Ch/RB | 49.7 | 35.0 | 1076 | 9.7 | 53.3 | 14.4* | 290 | 5.1 |
| RF/D | 47.6 | 46.3 | 867 | 10.2 | 54.1 | 13.3 | 299 | 5.9 |
| Trial Mean | 47.7 | 42.8 | 1065 | 10.5 | 53.4 | 14.1 | 301 | 4.7 |
| LSD (p<0.10) | NS | NS | 201 | NS | NS | 0.872 | 18.3 | 1.26 |

*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.

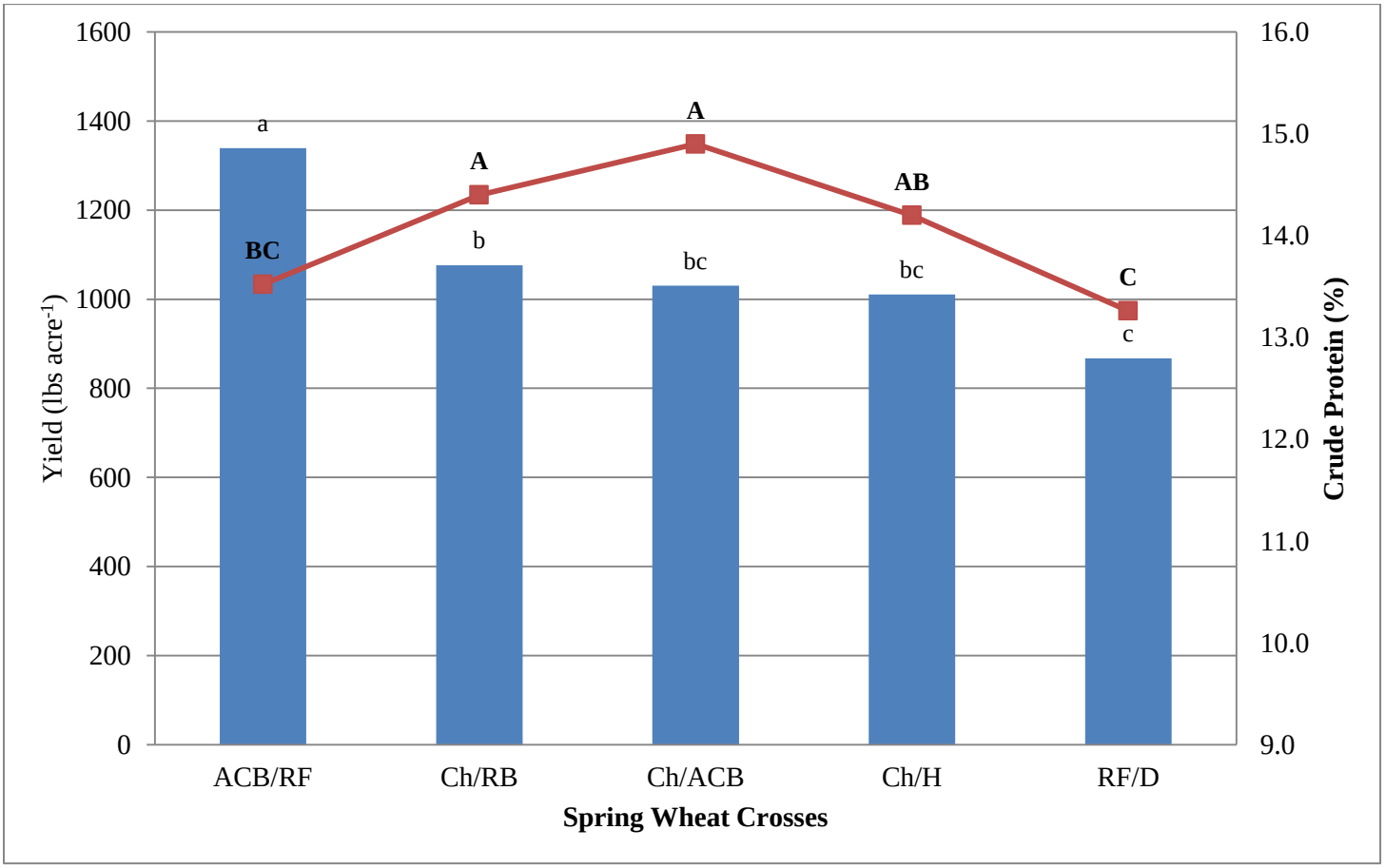


**Figure 1. Yield and protein of F5 spring wheat crosses grown in Alburgh, VT, 2013.**

Yields of the crosses grown in Westfield were lower than those grown in Alburgh and ranged from 571-745 lbs acre$^{-1}$ (Table 5 and Figure 2). Low yields were likely a result of competition from mustard in the early growing season. Hand weeding was performed to reduce overall pressure. Crude protein levels were high, ranging from 13.0-14.2%. Falling numbers ranged from 200-250 seconds, indicating some sprout damage. ACBarrie/Red Fife and Ch/ACB had significantly higher falling numbers (indicating less sprout damage) than the other crosses. These same crosses had higher falling numbers at the Alburgh site as well. This consistency suggests that the variety will respond similarly across environments. Additionally, all of the crosses grown in Westfield had DON levels less than 1 ppm and are considered safe for human consumption. Less rain during flowering resulted in lower DON numbers than the Alburgh site.

**Table 5. Growth characteristics and harvest data from F6 spring wheat crosses grown in Westfield, VT, 2013.**

| Cross | Population plants m$^2$ | Yield lbs acre$^{-1}$ | Moisture % | CP % | FN sec | DON ppm |
|---|---|---|---|---|---|---|
| ACB/RF | 288 | 745 | 16.6 | 13.3 | **250*** | 0.6 |
| Ch/ACB | 357 | 695 | 14.5* | 14.0 | 245* | 0.5 |
| D/ACB | 327 | 624 | 16.2 | 14.2 | 216 | 0.4 |
| H/Ch | 300 | 571 | 15.8 | 13.7 | 200 | 0.4 |
| S/RB | 359 | 617 | **13.4*** | 13.0 | 210 | 0.6 |
| Trial Mean | 326 | 651 | 15.3 | 13.6 | 224 | 0.5 |
| LSD (p<0.10) | NS | NS | 1.9583 | NS | 20.364 | NS |

*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.

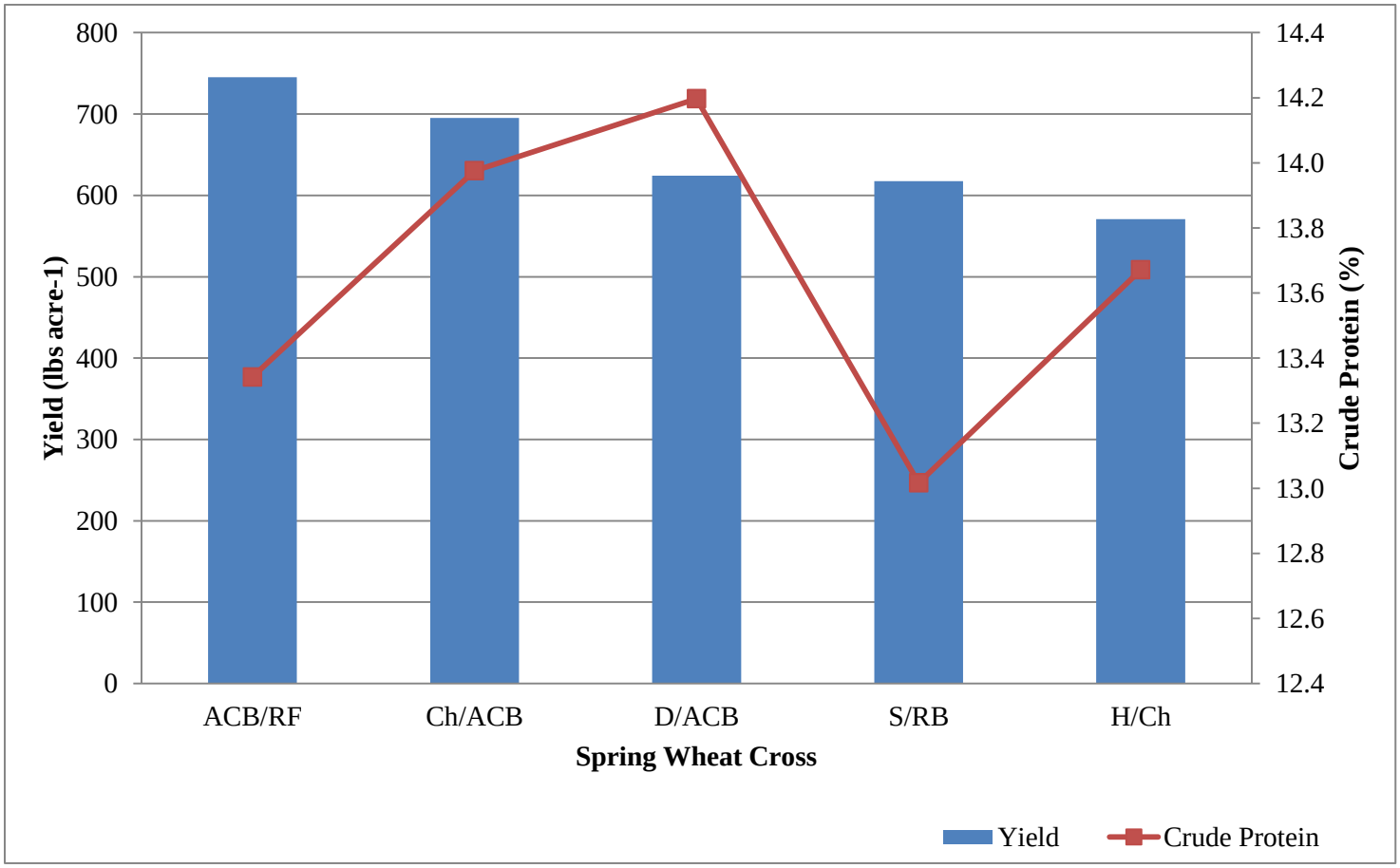


**Figure 2. Yield and protein of F6 spring wheat crosses grown in Westfield, VT, 2013.**

## Spring Wheat Crosses: The Second Set

We have been trialing a "second set" of spring wheat crosses, also made by Dr. Stephen Jones of Washington State University. The second set of eight crosses was planted on 23-Apr at Borderview Research Farm. All other plot management was the same as the F5s planted at Borderview Research Farm. Growth, yield and quality characteristics were statistically analyzed with a tukey-kramer test in SAS (Cary, NC).

**Table 6. Parent cultivars for the "second set" of spring wheat crosses.**

| Cultivar | Yea | Market Class | Place of Origin | Pedigree |
|---|---|---|---|---|
| Defiance | 1878 | SWSW | Vermont | White Hamburg / Golden Drop |
| Otis | 2005 | HWSW | Washington | Idaho 377s/3/Tanager S/Torim 73//Spillman |
| Faller | 2007 | HRSW | North Dakota | ND2857/ND2814 |
| Tigre | | HW facultative | France | |
| Kelse | 2008 | HRSW | Washington | Westbred 906R / PI520542 // Scholar |
| AC Walton | 1995 | HRSW | PEI | |
| Helios | 2006 | HRSW | Saskatchewan | BW674 / AC Cadillac // AC Barrie |
| Kingsey | | | Canada | |
| Surprise | 1875 | SWSW | Vermont | Chile Club / Michegan Club |
| Macon | 2003 | HWSW | Washington | Serra/Westbred-926//TanagerR-S(PI-519878)/(PI-519819)Pewee-S |

The F3 crosses had yields that ranged from 1060 to 2155 lbs acre$^{-1}$ (Table 7 and Figure 3). There was much less lodging in the F3 crosses than in the F5s. Crude protein levels were very high, ranging from 13.4 to 15.6%. Kelse/AC Walton, Kelse/Helios, Surprise/Otis, and Tigre/Faller had significantly higher protein levels than the other crosses. Like the other wheat varieties grown in Alburgh, all the crosses had DON levels over 1 ppm, but Tigre/Faller had the lowest DON of any cross, at 5 ppm. Top performers from 2013 will be distributed for further selection by farms throughout the Northeast.

**Table 7. Growing characteristics, yield and quality of the "second set" of spring wheat crosses, Alburgh, VT, 2013.**

| Cross | Population plants m$^{-2}$ | Lodge % | Yield lbs acre$^{-1}$ | Moisture % | Test Weight lbs acre$^{-1}$ | Protein % | DON ppm |
|---|---|---|---|---|---|---|---|
| Defiance/Otis | 240 | 25 | 1060 | 16.3 | 50.5 | 14.3 | 11.0 |
| Faller/Tigre | 303 | 20 | 1810* | 12.2* | 52.6 | 13.9 | 8.0 |
| Kelse/AC Walton | 233 | 0 | **2155*** | 15.4 | 51.9 | 15.0* | 7.4* |
| Kelse/Helios | 293 | 0 | 1730* | **11.2*** | **55.3*** | **15.6*** | 7.2* |
| Kingsey/Tigre | 290 | 1 | 1665* | 12.8* | 51.5 | 13.4 | 9.5 |
| Surprise/Macon | 317 | 8 | 1457 | 11.5* | 52.5 | 14.3 | 10.4 |
| Surprise/Otis | 293 | 39 | 1116 | 15.5 | 50.3 | 14.9* | 11.6 |
| Tigre/Faller | 261 | 0 | 1829* | 11.6* | 53.8* | 14.6* | **5.0*** |
| Trial Mean | 279 | 11.6 | 1603 | 13.3 | 52.3 | 14.5 | 8.8 |

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

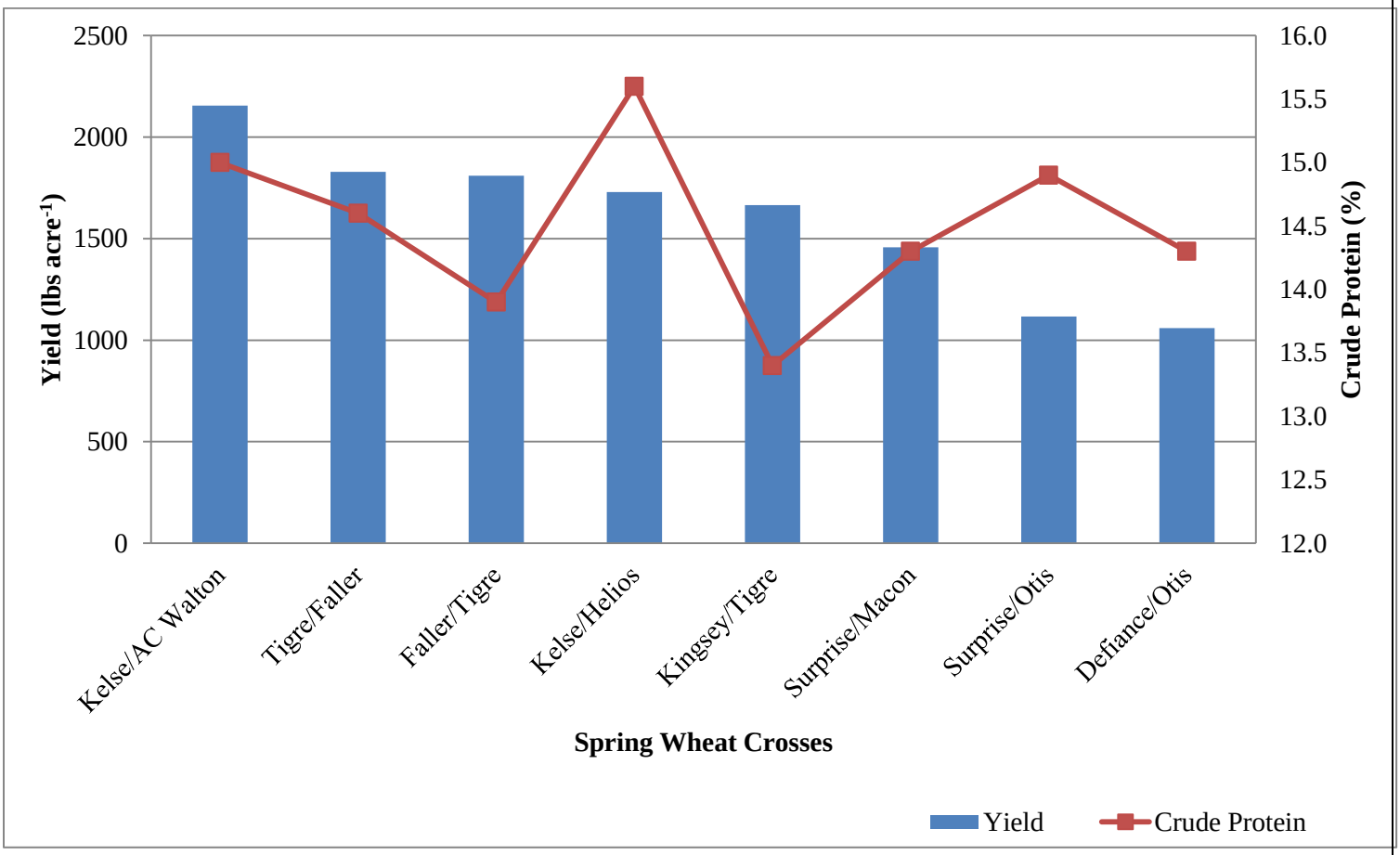


**Figure 3. Yield and protein of F3 "second set" of spring wheat crosses grown in Alburgh, VT, 2013.**

## ACKNOWLEDGEMENTS

UVM Extension would like to thank Borderview Research Farm and Butterworks Farm for hosting these trials, and Dr. Stephen Jones and the staff from Washington State University breeding program for making the original crosses. We would also like to thank the Nell Newman Foundation for funding this trial. Any reference to commercial products, trade names, or brand names is for information only, and no endorsement or approval is intended.

*UVM Extension helps individuals and communities put research-based knowledge to work.*

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES