NORTHWEST CROPS & SOILS PROGRAM

2019 Spring Wheat Crosses Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2019 SPRING WHEAT CROSSES TRIAL

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The goal of this project is to develop new spring wheat varieties that are suited for organic management in Northeast soils and climatic conditions. Most commercially available varieties are developed in regions with climates, soils, and management techniques that are very different from northern New England. These modern varieties are also genetically homogenous and inbred for uniformity, sometimes resulting in rapid breakdown of genetic resistance to local diseases.

Eight crosses were developed by Dr. Stephen Jones of Washington State University, including crosses of two varieties bred by famed Vermont botanist and wheat breeder, Cyrus Pringle. Of these varieties, a number of crosses were made that have been grown out on farms with varying soils and climates for several years. Farmers have continued to grow the crosses, select the best-looking plants, and capture the genetic diversity from the populations.

MATERIALS AND METHODS

The top performing spring wheat crosses have been grown out at four locations across New England and New York state. Seed was collected and trialed at Borderview Research Farm in Alburgh, Vermont. The crosses evaluated include Defiance/Otis, Faller/Tigre, Kelse/AC Walton, Kelse/Helios, Kingsey/Tigre, Surprise/Macon, Surprise/Otis, and Tigre/Faller. Top performing crosses selected by local farmers were evaluated for yield and quality. Parents of the crosses are listed in Table 1. Five varieties of modern and heirloom wheats (AC Barrie, Glenn, ND VitPro, Oland, and Tom) were cultivated as controls.

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

Cultivar	Market Class	Year	Place of Origin	Pedigree
AC Walton	HRSW	1995	Prince Edward Island	Nobeoka Bozu/2/Kolibri/Janus/3/Opal/Glenlea
Defiance	SWSW	1878	Vermont	White Hamburg/Golden Drop
Faller	HRSW	2007	North Dakota	Amidon/Stoa/Kitt/Sumai3
Helios	HRSW	2006	Saskatchewan	BW674/AC Cadillac/AC Barrie
Kelse	HRSW	2008	Washington	Westbred 906R / PI520542 // Scholar
Kingsey	HRSW	2011	Quebec	
Macon	HRSW	2003	Washington	Serra/Westbred-926//TanagerR-S(PI-519878)/(PI-519819)Pewee-S
Otis	HWSW	2005	Washington	Idaho 377s/3/Tanager S/Torim 73//Spillman
Surprise	SWSW	1875	Vermont	Chile Club/Michegan Club
Tigre	HW facultative	2015	France	

The seedbeds were prepared by conventional tillage methods (Table 2). Plots were planted with a six-inch Great Plains cone-seeder on 29-Apr. The spring wheat crosses were planted at 125 lbs ac^{-1}.

Populations were determined on 21-May by counting two one-foot sections of row in each plot. Flowering date was recorded when at least 50% of the plot was flowering. Disease and arthropod damage were assessed on 10-Jul. The top two leaves from three plants per plot were examined and the extent of foliar damage due to plant diseases or arthropod pests was estimated on a percent cover basis. Lodging was visually assessed prior to harvest on 5-Aug as a percent of each plot that was too lodged to harvest.

Wheat was harvested with an Almaco SPC50 small plot combine on 5-Aug. Grain moisture, test weight and yield were determined with a Dickey-John mini-GAC meter and pound scale. The grain was cleaned with a Clipper M2B cleaner and dried at 40° C until grain moisture was below 14%. 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 12% 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 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.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 1999). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$.

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 (e.g. yield). Least Significant Differences at the 10% level of probability are shown. Where the difference between two varieties 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. In the accompanying example, variety A is significantly different from variety C, but not from variety B. The difference between A and B is equal to 725, which is less than the LSD value of 889. This means that these varieties did not differ in yield. The difference between A and C is equal to 1454, which is greater than the LSD value of 889. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that variety B was not significantly lower than the top yielding variety.

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

Table 2. General plot management, 2019.

Trial Information	Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Corn
Seeding Rate (lbs ac^{-1})	125
Row spacing (in)	6
Replicates	4
Planting date	29-Apr
Harvest date	5-Aug
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, spring disk & spike tooth harrow

RESULTS AND DISCUSSION

Seasonal precipitation and temperature recorded at a weather station at Borderview Research Farm are shown in Table 3. April, May and June were all colder than normal. April and May had higher precipitation than the 30-year average, while June was somewhat drier. July was both hotter and drier than the 30-year average. From April through July, there was an accumulation of 3261 Growing Degree Days (GDDs), 91 GDDs below the 30-year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2019.

Alburgh, VT	April	May	June	July
Average temperature (°F)	42.7	53.3	64.3	73.5
Departure from normal	-2.11	-3.11	-1.46	2.87
Precipitation (inches)	3.65	4.90	3.06	2.34
Departure from normal	0.83	1.45	-0.63	-1.81
Growing Degree Days (32-95°F)	346	660	970	1286
Departure from normal	-38	-96	-44	88

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

Agronomic data were collected through the growing season (Table 4). Populations were lower than the target population of 350 plants m^{-2}, likely due to very cold weather in the early spring. The highest population was the Essex Surprise/Otis, with 341 plants m^{-2}. Other crosses with populations over 300 include Butterworks Surprise/Macon, Essex Kelse/Helios, and Grange Corner Faller/Tigre. Flowering date for the crosses ranged from 26-Jun to 30-Jun.

There was moderate disease pressure in the spring wheat crosses trial. Several foliar diseases were observed during wheat development, including powdery mildew, leaf rust, and several diseases causing lesions and spotting to the leaf, including septoria 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. The trial average was 7.43% of the foliar surface affected by foliar disease. The most common symptoms were lesions and spotting of the leaf that could be caused by a variety of viral, fungal, and bacterial infections. 76.0% of plants scouted had some degree of leaf spots, with an average of 4% of the foliar surface impacted in affected plants. Leaf rust was noted on 18.0% of plants scouted and powdery mildew was noted on 7.00% of plants scouted, both at an average of 3.00% of foliar surface affected in infected plants. The cultivar with the lowest total disease burden was Essex Faller/Tigre, with an average of 3.97% of the foliar surface affected by disease. The cultivar with the highest disease burden was Adirondack Kelse/Helios, with an average of 11.7% of the foliar surface affected by disease.

Overall, damage from pests and disease was low in the spring wheat crosses. 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. 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. Mites affected 15.0% of all plants scouted (average 4% foliar surface damaged) and thrips affected 39.0% of all plants scouted (average 3.00% foliar surface area damaged). Other common pests were cereal leaf beetle (12.0% of plants were affected at an average of 6.00% damage per plant), slugs (11.0% of plants affected at an average of 5.00% per plant), aphids (4.00% of plants affected at an average of 3.00% per plant), and corn borer (1.00% of plants affected at an average of 3.00% per plant). The cross with the best overall pest rating was Butterworks Surprise/Otis (1.69% of the foliar surface damaged by arthropod pests). Most other crosses had less than 5.00% of the foliar surface damaged by pests. Butterworks Surprise/Macon had the most arthropod damage, with 11.0% of the foliar surface damaged by pests.

Lodging was a problem for several of the crosses. While most crosses had no lodging or lodging less than 5.00%, several crosses had lodging impacting yields. The most lodged crosses were Butterworks Surprise/Macon (11.3%) and Grange Corner Surprise/Otis (11.3%).

Table 4. Agronomic Characteristics of Spring Wheat Crosses, Alburgh, VT, 2019.

Variety	Population	Flowering date	Foliar disease	Arthropod damage	Lodging
	plants m^{-2}	Date	%	%	%
Adirondack Faller/Tigre	251$^{c-e\dagger}$	26-Jun^{d}	9.88^{a-e}	2.25^{d}	0.00^{c}
Adirondack Kelse/AC Walton	244^{c-e}	26-Jun^{d}	8.11^{a-f}	3.13^{cd}	0.00^{c}
Adirondack Kelse/Helios	276^{a-e}	26-Jun^{d}	11.73^{a}	3.08^{cd}	0.00^{c}
Adirondack Surprise/Macon	283^{a-e}	26-Jun^{d}	10.4^{a-c}	3.00^{cd}	6.25^{a-c}
Adirondack Tigre/Faller	233de	27-Jun^{cd}	7.91^{a-f}	4.63^{b-d}	2.50^{bc}
Butterworks Defiance/Otis	287^{a-e}	28-Jun^{bc}	6.02^{b-f}	3.29^{cd}	6.25^{a-c}
Butterworks Kelse/AC Walton	276^{a-e}	27-Jun^{cd}	4.89^{ef}	3.83^{cd}	0.00^{c}
Butterworks Kingsey/Tigre	242^{c-e}	26-Jun^{d}	10.6^{ab}	4.67^{b-d}	0.00^{c}
Butterworks Surprise/Macon	301^{a-d}	27-Jun^{cd}	6.23^{b-f}	11.00^{a}	11.3^{ab}
Butterworks Surprise/Otis	255^{c-e}	27-Jun^{cd}	8.54^{a-f}	1.69^{d}	2.50^{bc}
Butterworks Tigre/Faller	262^{b-e}	27-Jun^{cd}	6.85^{a-f}	4.54^{b-d}	6.25^{a-c}
Essex Faller/Tigre	269^{a-e}	26-Jun^{d}	3.97^{f}	4.39^{b-d}	1.25^{bc}
Essex Kelse/AC Walton	283^{a-e}	27-Jun^{cd}	6.73^{a-f}	5.63^{bc}	0.00^{c}
Essex Kelse/Helios	316^{a-c}	27-Jun^{cd}	4.87^{ef}	2.88^{cd}	1.25^{bc}
Essex Kingsey/Tigre	292^{a-e}	26-Jun^{d}	9.40^{a-e}	3.04^{cd}	0.00^{c}
Essex Surprise/Otis	341^{a}	27-Jun^{cd}	7.44^{a-f}	4.69^{b-d}	1.25^{bc}
Grange Corner Faller/Tigre	303^{a-d}	27-Jun^{cd}	7.17^{a-f}	4.06^{b-d}	0.00^{c}
Grange Corner Kelse/AC Walton	296^{a-e}	27-Jun^{cd}	7.20^{a-f}	2.42^{cd}	0.00^{c}
Grange Corner Kingsey/Tigre	231de	26-Jun^{d}	6.40^{b-f}	4.19^{b-d}	2.50^{bc}
Grange Corner Surprise/Macon	262^{b-e}	26-Jun^{d}	10.0^{a-d}	3.17^{cd}	8.75^{a-c}
Grange Corner Surprise/Otis	275^{a-e}	30-Jun^{ab}	5.52^{b-f}	3.04^{cd}	11.3^{ab}
AC Barrie	251^{c-e}	26-Jun^{cd}	5.42^{c-f}	3.75^{cd}	0.00^{c}
Glenn	283^{a-e}	26-Jun^{d}	7.65^{a-f}	4.44^{b-d}	0.00^{c}
ND VitPro	316^{a-c}	26-Jun^{d}	5.73^{b-f}	7.38^{b}	0.00^{c}
Oland	337^{ab}	1-Jul^{a}	8.64^{a-f}	4.50^{b-d}	10.0^{a-c}
Tom	335^{ab}	26-Jun^{d}	5.93^{b-f}	1.67^{d}	0.00^{c}
LSD (p=0.10)	76	<1 day	5.03	3.37	10.53
Trial Mean	281	26-Jun	7.43	4.01	2.74

†Within a column, crosses with the same letter are statistically similar at p=0.10.

Moisture content below 14% is desirable for long term storage. Most varieties had to be dried down for long term storage (Table 5). 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. None of the crosses met the desired standard of 60 lbs bu^{-1}. The cross with the highest test weight was Grange Corner Faller/Tigre (59.8 lbs bu^{-1}).

The average yield for the trial was 2861 lbs ac^{-1}. Six crosses had yields above 3000 lbs ac^{-1}: Adirondack Kelse/AC Walton (3574 lbs ac^{-1}), Essex Kingsey/Tigre (3515 lbs ac^{-1}), Butterworks Kingsey/AC Walton (3412 lbs ac^{-1}), Grange Corner Faller/Tigre (3354 lbs ac^{-1}), Essex Faller/Tigre (3343 lbs ac^{-1}) and Grange Corner Kingsey/Tigre (3047 lbs ac^{-1}).

Table 5. Yield and Quality of Spring Wheat Crosses, Alburgh, VT, 2019.

Variety	Harvest moisture	Test weight	Yield @ 13.5% moisture	Crude Protein @ 12% moisture	Falling number
	%	lbs bu^{-1}	lbs ac^{-1}	%	seconds
Adirondack Faller/Tigre	12.9^{gh†}	57.9^{a-e}	2801^{b-f}	12.8^{d-h}	411^{ab}
Adirondack Kelse/AC Walton	14.2^{d-h}	59.1^{a-d}	3574^{a}	12.8^{d-h}	353^{f-i}
Adirondack Kelse/Helios	15.5^{c-g}	58.3^{a-e}	2893^{a-e}	15.1^{a}	379^{b-g}
Adirondack Surprise/Macon	14.7^{c-h}	57.2^{a-f}	2738^{c-f}	12.3^{gh}	336^{i-k}
Adirondack Tigre/Faller	12.7^{h}	58.8^{a-d}	2154^{f}	12.5^{f-h}	390^{a-e}
Butterworks Defiance/Otis	14.7^{c-h}	55.5^{c-f}	2419^{ef}	12.7^{e-h}	349^{g-j}
Butterworks Kelse/AC Walton	15.5^{c-g}	56.8^{a-f}	3412^{a-c}	14.0^{a-d}	352^{f-j}
Butterworks Kingsey/Tigre	13.6^{f-h}	57.5^{a-f}	2786^{c-f}	12.3^{gh}	364^{d-i}
Butterworks Surprise/Macon	14.7^{c-h}	55.1^{d-f}	2869^{a-f}	12.7^{e-h}	303^{kl}
Butterworks Surprise/Otis	14.9^{c-h}	55.7^{b-f}	2682^{d-f}	12.8^{d-h}	319^{j-l}
Butterworks Tigre/Faller	14.2^{d-h}	54.6^{ef}	2749^{c-f}	12.4^{f-h}	415^{a}
Essex Faller/Tigre	13.7^{e-h}	58.7^{a-d}	3343^{a-d}	13.8^{b-e}	395^{a-d}
Essex Kelse/AC Walton	16.6^{b-d}	56.4^{a-f}	2839^{b-f}	13.2^{c-h}	390^{a-e}
Essex Kelse/Helios	13.7^{e-h}	58.2^{a-e}	2621^{ef}	12.9^{d-h}	361^{e-i}
Essex Kingsey/Tigre	16.1^{b-f}	56.4^{a-f}	3515^{ab}	13.2^{c-h}	358^{e-i}
Essex Surprise/Otis	16.2^{b-f}	57.4^{a-f}	2786^{c-f}	12.6^{f-h}	367^{d-i}
Grange Corner Faller/Tigre	15.4^{c-g}	59.8^{ab}	3354^{a-d}	13.8^{b-e}	378^{b-g}
Grange Corner Kelse/AC Walton	17.3^{a-c}	56.3^{a-f}	2861^{a-f}	13.5^{c-f}	340^{h-j}
Grange Corner Kingsey/Tigre	13.1^{gh}	57.5^{a-f}	3047^{a-e}	12.8^{d-h}	384^{a-f}
Grange Corner Surprise/Macon	12.5^{h}	57.2^{a-f}	2702^{c-f}	12.2^{h}	375^{c-g}
Grange Corner Surprise/Otis	19.1^{ab}	53.5^{f}	2735^{c-f}	12.6^{f-h}	312^{j-l}
AC Barrie	12.7^{h}	53.8^{f}	2701^{c-f}	13.1^{c-h}	405^{a-c}
Glenn	13.7^{e-h}	59.3^{a-c}	2970^{a-e}	13.1^{c-h}	411^{ab}
ND VitPro	13.3^{gh}	59.9^{a}	2683^{d-f}	14.3^{a-c}	391^{a-e}
Oland	13.7^{e-h}	57.4^{a-f}	2505^{ef}	13.1^{c-h}	396^{a-d}
Tom	16.3^{b-e}	59.8^{a}	3127^{a-e}	13.4^{c-g}	403^{a-c}
LSD (p=0.10)	2.72	4.1	715	1.2	33.3
Trial Mean	14.7	57.2	2861	13.1	369

†Within a column, crosses with the same letter are statistically similar at p=0.10.

Only two crosses had crude protein levels above the desired industry minimum of 14% (Adirondack Kelse/Helios at 15.1% and Butterworks Kelse/AC Walton at 14.0%). There is often an inverse relationship seen between yield and protein. This did not appear to hold true for the spring wheat crosses assessed in 2019, with some of the highest yielding crosses also having good crude protein (Table 5, Figure 1).

Falling numbers for all crosses were above 200 seconds, indicating sound quality wheat. Only one replicate per variety was tested for deoxynivalenol (DON) vomitoxin, and all were below the FDA threshold of 1 ppm which is considered safe for human consumption (data not shown).

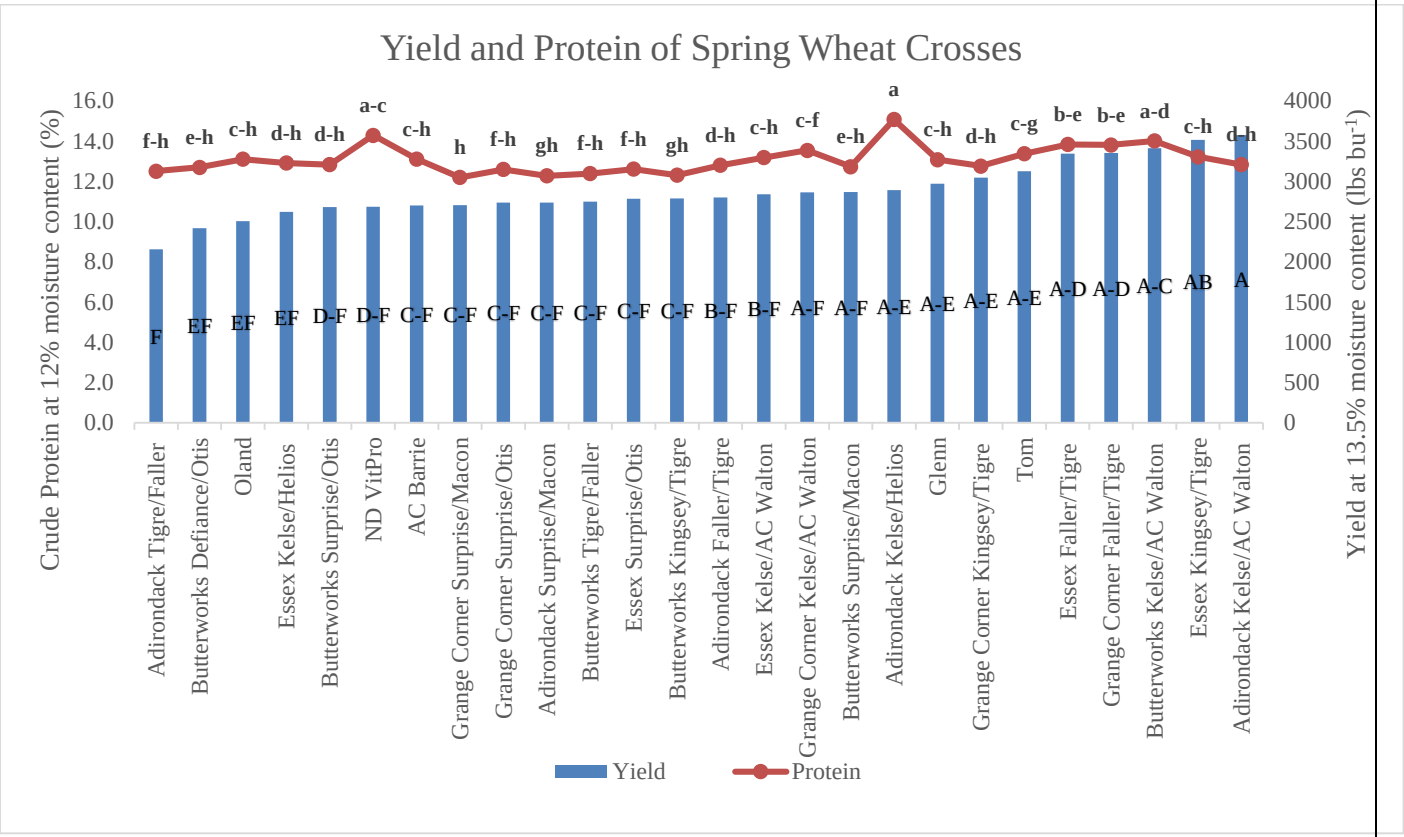

Figure 1. Yield and protein of spring wheat crosses, Alburgh, VT. Varieties with the same capital letter did not differ significantly in yield. Varieties with the same lower-case letter did not differ significantly by crude protein concentration.

DISCUSSION

Overall, 2019 was an exceptional year from small grain production. The average yield and quality for the spring crosses compares favorably with the results from the 2019 spring wheat variety trial and 2019 heirloom spring wheat variety trial (Table 6), indicating that the spring wheat crosses have potential as new cultivars. The variety trial reports are available on our website - https://www.uvm.edu/extension/nwcrops/research.

Table 6. Yield and Quality Means of Spring Wheat Trials, Alburgh, VT, 2019.

		Spring Wheat Crosses	Spring Wheat Variety Trial	Heirloom Spring Wheat Variety Trial
Trial Means	Yield at 13.5% moisture content (lbs bu^{-1})	2861	2950	1936
	Crude Protein at 12% moisture content (%)	13.1	13.1	13.1
	Falling Number (sec)	369	404	387

We intend to continue evaluating these crosses with the goal of releasing top performing crosses as new cultivars.

ACKNOWLEDGEMENTS

The UVM Extension Crops and Soils Team would like to thank Borderview Research Farm and their staff in Alburgh. Thanks to Catherine Davidson, Scott Lewins, Shannon Meyler, Lindsey Ruhl, and Sara Ziegler for their assistance with data collection and entry. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

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