NORTHWEST CROPS & SOILS PROGRAM

2020 Organic Spring Wheat Crosses Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2020 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 crosses include Defiance/Otis, Faller/Tigre, Kelse/AC Walton, Kelse/Helios, Kingsey/Tigre, Surprise/Macon, Surprise/Otis, and Tigre/Faller. Parents of the crosses are listed in Table 1. Two modern varieties were planted in the trial as checks, this were Glenn and Tom, both are hard red spring wheat.

The trial was initiated in April of 2020 at Borderview Research Farm in Alburgh. Plots were managed with practices similar to those used by producers in the surrounding area. Agronomic information is displayed in Table 2. The experimental design was a randomized complete block with four replicates. The previous crop was corn silage. The field was disked and spike tooth harrowed prior to planting. The field was fertilized with 19-19-19 at a rate of 300 lbs ac^{-1} prior to seeding. Plots were seeded in 5' x 20' plots with a Great Plains Cone Seeder on 8-Apr at a seeding rate of 350 live seeds m^{-2}. Field season data were collected on all varieties. Heights were determined on 21-Jul by taking three measurements per plot.

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
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	
Surprise	SWSW	1875	Vermont	Chile Club/Michigan Club
Tigre	HW facultative	2015	France	

Table 2. Trial agronomic information, Alburgh, VT, 2020.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Covington silty clay loam, 0 to 3 percent slopes
Previous crop	Corn silage
Seeding rate	350 live seeds m^{-2}
Row spacing (in)	6
Replicates	4
Planting date	8-Apr 2020
Harvest date	31-Jul 2020
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, disk & spike tooth harrow

Populations were determined on 12-May by counting two one-foot sections of row in each plot. Disease and arthropod damage were assessed on 8-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 on 21-Jul as a percent of each plot that was lodged.

Plots were harvested with an Almaco SPC50 small plot combine on 31-Jul. 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. Grain quality was determined at UVM Extension's Northwest Crop and Soils Quality Testing Laboratory (Burlington, Vermont). 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 for bread wheat. Falling number was measured (AACC Method 56-81B, AACC Intl., 2000) on the Perten FN 1500 Falling Number Machine. The falling number indicates the level of enzymatic activity 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 between 300-350 indicate low enzymatic activity and sound quality wheat. A falling number lower than 200 indicates high enzymatic activity and poor quality wheat, typically as a result of pre-harvest sprouting damage in the grain. Falling number above 400 is suitable but may retard fermentation when used for baking. 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. One sample of each variety was run and all tested well below the threshold for human consumption (data not shown).

Stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within the trial were treated as random effects, and treatments were treated as fixed. Treatment mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

Variations in project results can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments 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 (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 values. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. In the previous example, treatment A is significantly different from treatment C but not from treatment B. The difference between A and B is equal to 200, which is less than the LSD value of 300. This means that these treatments did not differ in yield. The difference between A and C is equal to 400, which is greater than the LSD value of 300. This means that the yields of these treatments were significantly different from one another.

Treatment	Yield
A	**2100***
B	1900*
C	1700
LSD	300

RESULTS

Seasonal precipitation and temperature recorded at Borderview Research Farm in Alburgh, VT are displayed in Table 3. An early period of dry weather allowed for early planting at the beginning of April. Cooler than average spring, but warmer and drier summer led to 3433 Growing Degree Days (GDDs) accumulated April to July, which was 55 GDDs above the 30-year average. Precipitation from April to July was 3.81 inches below normal.

Table 3. Seasonal weather data collected in Alburgh, VT, 2020.

	Apr	May	Jun	Jul
Average temperature (°F)	41.6	56.1	66.9	74.8
Departure from normal	-3.19	-0.44	1.08	4.17
Precipitation (inches)	2.09	2.35	1.86	3.94
Departure from normal	-0.72	-1.04	-1.77	-0.28
Growing Degree Days (32°-95°F)	315	746	1046	1326
Departure from normal	-99	-13	35	132

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) for Burlington, VT.

There was low disease pressure in the spring wheat crosses trial (Table 4). 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. On 77.5% of plants scouted leaf spots were present, with an average of 2.3% of the

foliar surface impacted in affected plants. Leaf rust was noted on 1.5% of plants scouted and powdery mildew was noted on 5.5% of plants scouted, both at an average of less than 1.0% of foliar surface affected in infected plants. The cultivar with the lowest total disease burden was Grange Corner Kelse/AC Walton with an average of 1.5% of the foliar surface affected by disease. The cultivar with the highest disease burden was Butterworks Kelse/AC Walton, with an average of 2.6% of the foliar surface affected by disease.

Overall, damage from pests was low in the spring wheat crosses. The most common arthropods affecting the 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 88.5% of all plants scouted (average 6.9% foliar surface damaged) and thrips affected 95.5% of all plants scouted (average 3.7% foliar surface area damaged). Other common pests were cereal leaf beetle (18.5% of plants were affected at an average of 2.70% damage per plant), slugs (4% of plants affected at an average of 0.6% per plant), and corn borer (21.5% of plants affected at an average of 2.3% per plant). The cross with the best overall pest rating was Essex Kingsey/Tigre (2.0% of the foliar surface damaged by arthropod pests). All other crosses had less than 5.00% of the foliar surface damaged by pests. Glenn, the commercial check variety, had 5.2% of the foliar surface damaged by pests. Essex Kelse/AC Walton was the cross that had the most arthropod damage, with 3.9%% of the foliar surface damaged by pests.

Table 4. Pest and disease pressure in Spring Wheat Crosses, Alburgh, VT, 2020.

Variety	Powdery Mildew	Leaf spots	Rust	Physical damage	Thrips	Mites	Beetle	Borer	Slug	Weeds
	% of leaf area impacted by pest									
Adirondack Kelse/AC Walton	0.5*‡	2.6*	**0.0**	3.4*	3.4*	9.5	4.4*	1.0*	**0.0**	16.3*
Adirondack Kelse/Helios	**0.0**	2.7*	**0.0**	4.8*	5.0	8.2*	1.6*	2.5*	**0.0**	23.8
Butterworks Kelse/AC Walton	0.3*	2.2*	**0.0**	7.9	3.4*	3.9*	0.5*	3.2*	**0.0**	**7.5**
Essex Kelse/AC Walton	0.3*	2.5*	**0.0**	3.7*	4.0*	9.9	3.4*	2.3*	**0.0**	16.3*
Essex Kelse/Helios	1.0*	1.7*	0.3*	5.4*	2.9*	6.3*	3.1*	2.1*	1.3*	18.8*
Essex Kingsey/Tigre	0.9*	2.4*	**0.0**	**3.3**	3.0*	**3.4**	**0.0**	2.3*	1.5*	21.3
Glenn	0.5*	2.9	0.3*	**3.3**	4.8	8.4*	7.6	3.9	1.5*	16.3*
Grange Corner Faller/Tigre	**0.0**	3.1	**0.0**	4.6*	4.6	7.1*	3.0*	**0.5**	1.0*	18.8*
Grange Corner Kelse/AC Walton	1.0*	1.6*	**0.0**	**3.3**	3.8*	7.3*	0.5*	4.3	0.5*	15.0*
Tom	0.3*	**1.5**	0.3*	4.1*	**2.4**	4.8*	2.9*	1.0*	0.3*	**7.5**
LSD (p=0.10)	1.1	1.3	0.3	3.7	1.9	5.1	4.7	2.8	1.8	11.8
Mean	0.5	2.3	0.1	4.4	3.7	6.9	2.7	2.3	0.6	16.1

‡* Varieties with an asterisk are not significantly from the top performer in **bold**.

Agronomic data were collected through the growing season (Table 5). All crosses in the trial had populations over 300 plants m^{-2}. The highest population was the Glenn and Essex Kelse/AC Walton with 360 plants m^{-2}. Six varieties had populations that were lower than the target population of 350 plants m^{-2}.

Table 5 shows heights, lodging and harvest data for the spring wheat crosses trial. Varieties had an average yield of 2760 lbs ac^{-1} adjusted for 13.5% moisture. The top yielding variety was Essex Kingsey/Tigre, at 3161 lbs ac^{-1}. Every variety in the trial yielded above 2000 lbs ac^{-1}. Grange Corner Faller/Tigre had the highest average plant height at 97 cm and Adirondack Kelse/Helios the lowest at 78 cm.

Harvest moisture below 14% is desirable for grain storage. Wheat above this moisture content must be dried down after harvest, adding time and cost to farmers. Every variety in this trial had moistures above 14% and required drying before storage. Grange Corner Faller/Tigre had the lowest harvest moisture at 19.0% and Essex Kelse/AC Walton had the highest at 20.3%. Test weight is the measure of grain density, which is determined by weighing a known volume of grain. Industry standard for wheat is 60 lbs bu^{-1}. None of the varieties in this trial met the industry standard, Adirondack Kelse/AC Walton had the highest test weight at 55.4 lbs bu^{-1}.

Table 5. Spring wheat harvest data, Alburgh, VT, 2020.

Variety	Populations	Height	Lodging	Test weight	Moisture	Yield 13.5% moisture
	plants m^{-2}	cm	%	lbs bu^{-1}	%	lbs ac^{-1}
Adirondack Kelse/AC Walton	340*‡	87	12.5*	**55.4**	19.9	3020*
Adirondack Kelse/Helios	340*	78	**4.00**	54.7*	19.4*	2454
Butterworks Kelse/AC Walton	350*	90	8.80*	53.8	19.5*	2555
Essex Kelse/AC Walton	**360**	94	12.8*	53.9	20.3	2757*
Essex Kelse/Helios	340*	88	38.8	53.2	20.0	2743
Essex Kingsey/Tigre	320	94	12.5*	53.5	19.6	**3161**
Glenn	**360**	91	37.8	53.2	19.9	2744
Grange Corner Faller/Tigre	340*	**97**	4.30*	53.2	**19.0**	2587
Grange Corner Kelse/AC	340*	90	21.3	54.1*	19.6	2692
Tom	350*	82	**4.00**	54.2*	19.2*	2889*
LSD (p=0.10)	30	2	13.8	1.4	0.5	406
Trial mean	340	89	15.7	53.9	19.6	2760

‡*Varieties marked with an asterisk are not significantly different from the top performer in **bold**.

All varieties tested above 12% protein (Table 6), adjusted for 12.5% moisture, which is within the range for high quality bread flour. The ideal range for bread wheat is 12-15% crude protein, though some artisan bread bakers have found success working with wheat in the 10-12% range, depending on the end-product. The Cross with the highest protein level was Adirondack Kelse/Helios at 15.5%, the highest protein in the trial was the commercial variety Tom at 16.5%. The trial mean is 14.9% protein and 3 varieties tested above 15%.

Falling number measures viscosity by recording the time in seconds it takes for a plunger to fall through a slurry to the bottom of a test tube. The viscosity is an indicator of enzymatic (alpha-amylase) activity in the kernel which most often results from pre-harvest sprouting in the grain. Low falling number indicates high enzymatic activity, or more pre-harvest sprouting damage. This is most common if there are rain events as the grain is ripening prior to harvest. Low falling number, below 250, has a negative impact on bread quality and can lead to lower prices paid for the wheat or possible rejection at the mill. The ideal range for wheat is 250-350. High falling numbers, over 400 seconds, can potentially lead to slower fermentation, poorer loaf volume and drier bread texture, depending on the end product. The falling number mean was 369 seconds. Essex Kingsey/Tigre had the lowest falling number at 280, well within the ideal range for bread baking. The highest falling number was Tom at 465. Glenn was the only other variety testing above 400. Each of the other varieties in the trial tested in the 300s which is an acceptable range for bread wheat.

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).

Table 6. Spring wheat quality data, Alburgh, VT, 2020.

Variety	Crude protein @ 12.5% moisture	Falling Number
	%	second
Adirondack Kelse/AC Walton	14.0	345
Adirondack Kelse/Helios	15.5*‡	375
Butterworks Kelse/AC Walton	14.3	388
Essex Kelse/AC Walton	14.9	374
Essex Kelse/Helios	14.4	330
Essex Kingsey/Tigre	14.7	280
Glenn	14.8	409
Grange Corner Faller/Tigre	14.4	374
Grange Corner Kelse/AC Walton	15.1	349
Tom	**16.5**	**465**
LSD (p=0.10)	1.0	29
Trial mean	14.9	369

‡*Varieties marked with an asterisk are not significantly different from the top performer in **bold**.

DISCUSSION

The 2020 growing season was warmer and drier than the 30-year average. This allowed for early planting in April and quality targets within ideal ranges across the grain trials at Borderview Research Farm. Warm, dry weather during grain dry down is favorable for most cereal grain crops. Spring wheat yields were high in 2020, though the Spring Wheat Crosses trial average was slightly lower (by 421 bu ac^{-1}) than the Spring Wheat Variety trial. Early planting and relatively cool weather during the vegetative phase of cereal grain development helped to promote high yields. Protein was over 14% for every spring wheat

cross planted, all well within the ideal range for bread baking, the most common end-use for hard red spring wheat. Falling numbers were all within an acceptable range, indicating low pre-harvest sprouting damage, a result of little to no rainfall in the days leading up to harvest. DON levels were very low, again likely due to dry growing conditions during the heading/flowering susceptibility window. Overall, several of the spring wheat crosses were similar to or exceeded the performance of the check varieties.

It is important to remember that this only represents one year of data. The weather this growing season was challenging for many crops at Borderview Research Farm, and across much of Vermont and New England, in 2020. The hot and dry weather led to drought stress, disease and pest pressures in many crops. However, the cereal grains performed well overall. They are better adapted to these types of conditions than the cooler and wetter weather that is more typical for this region. Though spring wheat was high yielding and most quality targets were met or exceeded this year, many years can be challenging for this crop in New England. It is important, as you make variety choices on your farm, that you evaluate data from test sites that are as similar to your region as possible. Wheat is generally considered a specialty crop in the Northeast and it is recommended growers consider quality standards, consider post-harvest handling requirements, and communicate with potential buyers during variety selection and prior to planting large acreage of grain.

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