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2013 Organic Spring Wheat Planting Date Trial

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The local food movement has revived otherwise historical crops in Vermont including small-scale grains. As the demand for local organic wheat has risen over the last few years, University of Vermont Extension has been developing best agronomic practices for wheat production. In an organic system, weed management can be one of the biggest challenges. One strategy to manage weeds is to modify planting dates. Early planting dates can establish a crop prior to weed flushes, while a late-planted crop can avoid some weed species. Planting date can also have an overall impact on both grain yield and quality. Certain wheat varieties may respond better to earlier or later planting dates. At this time, there is minimal data to document optimum spring wheat planting dates for the Northeast. The objective of this project was to determine the effect of planting date on the yield and quality of multiple spring wheat varieties.

MATERIALS AND METHODS

A trial was conducted in 2013 at Borderview Research Farm in Alburgh, VT. The experimental design was a randomized complete block with split plots and four replications (Table 1). The soil was a Benson rocky silt loam and the area was previously planted with corn. The seedbed was prepared with a fall plow, followed by spring disk and spike tooth harrow. Plots were seeded at 125 lbs per acre in 6" rows with a Kincaid Cone Seeder. All plots were managed with practices similar to those used by producers in the surrounding area.

Table 1. Agronomic information for the 2013 Spring Wheat Planting Date Trial at Borderview Research Farm.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Corn
Tillage operations	Fall plow, spring disk, spike tooth harrow
Row spacing (in)	6
Replications	4
Seeding rate (lbs ac^{-1})	125
Harvest area (ft)	5 x 20

Four hard red spring wheat varieties were selected to represent varieties of varying heights (Table 2).

Table 2. Seed varieties and seed sources for planting date trial at Borderview Research Farm in Alburgh, VT.

Variety	Type	Seed source
Ladoga	Hard red spring wheat	Saved seed from 2012 trial, VT
McKenzie	Hard red spring wheat	Saved seed from 2012 trial, VT
RB07	Hard red spring wheat	Minnesota Foundation Seed, MN
AC Superb	Hard red spring wheat	Seedway, VT

Treatments in the main plots were planting date and subplots consisted of varieties. Planting dates started on 23-Apr and continued approximately every week for 5 weeks (Table 3). Planting date, plant emergence, and harvest dates are listed in Table 3.

Table 3. Spring wheat planting, plant emergence, and harvest dates at Borderview Farm in Alburgh, VT.

Planting date	Plant emergence	Harvest date
23-Apr	3-May	6-Aug
29-Apr	6-May	6-Aug
6-May	13-May	6-Aug
13-May	17-May	16-Aug
28-May	3-Jun	16-Aug

Heights and lodging were measured before harvest on 5-Aug. Plant heights were measured excluding the awns. The first three planting dates were harvested on 6-Aug and the last two planting dates were harvested on 16-Aug (Table 3). Plots were harvested with an Almaco SPC50 small plot combine and yields were measured. After harvest, grain moisture and test weight were determined using a DICKEY-john® M2OP moisture meter and a Berckes test weight scale.

Harvested seed was cleaned with a small Clipper fanning mill (A.T. Ferrell, Bluffton, IN). An approximate one pound subsample was collected to determine quality. Quality measurements included standard testing parameters used by commercial mills. Test weight was measured by weighing a known volume of grain. Typically, a higher test weight results in a higher-quality baking flour. The acceptable test weight for bread wheat is 56-60 lbs per bushel. Once test weight was determined, the samples were then ground into flour using the Perten LM3100 Laboratory Mill. Grains were analyzed for protein content using the Perten Inframatic 8600 Flour Analyzer. Protein levels in grains affect gluten strength and loaf volume. Most commercial mills target 12-15% protein. Protein was calculated on a 12% moisture and 14% moisture basis. Falling number was measured on the Perten FN 1500 Falling Number Machine (AACC Method 56-81B, AACC Intl., 2000). Falling number is related to the level of sprout damage that has occurred in the grain. It is determined by measuring the number of seconds required for a stirrer to fall through a slurry of flour and water to the bottom of a 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) analysis 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.

Most data 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. Mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$). In the case of test weight and moisture, where data were not available for every treatment and replication, a Tukey-Kramer adjustment was used for pairwise comparisons. P-values are given at the bottom of tables to display levels of significance. In all tables, the top-performing variety can be found in bold.

RESULTS

Seasonal precipitation and temperatures were recorded using a Davis Instruments Vantage Pro2 weather station at Borderview Research Farm in Alburgh, VT (Table 4). Although April, June and August were slightly cooler than normal (based on 1981-2010 data), May and July were slightly warmer than the historical average. May and June had more precipitation than expected, followed by a drier than average July and August. Overall, there were an accumulated 4510 Growing Degree Days (GDDs) at a base temperature of 32°F. This was only 18 days greater than the historical 30-year average for April through August.

Table 4. Summarized weather data for 2013 – Alburgh, VT.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	43.6	59.1	64.0	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	-0.70	1.34	5.54	-2.26	-1.50
Growing Degree Days (base 32°F)	348	848	967	1235	1112
Departure from normal	-36	91	-47	37	-27

Based on weather data from 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.

Impact of Planting Date x Variety

Planting date by variety interactions were significant in observations of heights, lodging, falling number, and DON. This indicates that varieties responded differently to altered planting dates. The variety 'Ladoga' was the tallest for every planting date, and all plant heights decreased for all varieties as planting dates shifted later into the season (Figure 1). The variety Ladoga was much taller than the other three varieties when it was planted earlier in the season (23-Apr, 29-Apr, and 6-May). In May, however, the difference between the heights of Ladoga and the other three varieties becomes much less notable.

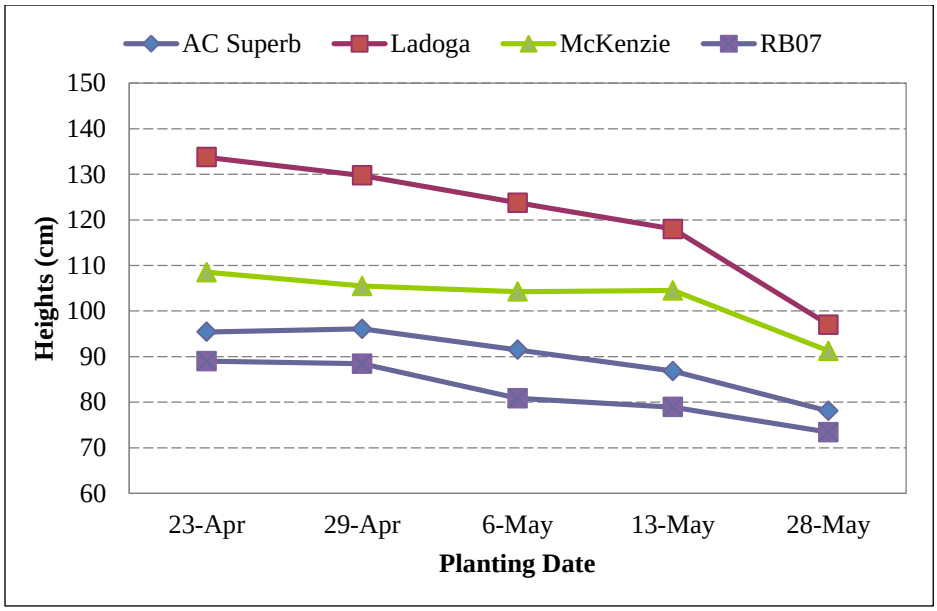

Figure 1. Effect of spring wheat planting date and variety on heights, Alburgh, VT.

The interaction between planting date and variety in regards to falling number was also significant (Figure 2). The falling number for both Ladoga and 'RB07' increased relatively steadily with later planting dates, with the exception of a drop in falling number for Ladoga on the third planting date (6-May). This irregular decrease in falling number can also be seen on the same planting date for the variety 'AC Superb'. Other than this decrease, AC Superb's falling number is relatively stable across planting dates, ranging between 398 and 405 seconds. The observed falling number in the variety 'McKenzie' was also relatively stable across planting dates, ranging between 387 and 410 seconds. Thus, while the falling numbers for RB07 and Ladoga increased with later planting dates, the falling numbers for McKenzie and AC Superb were relatively constant.

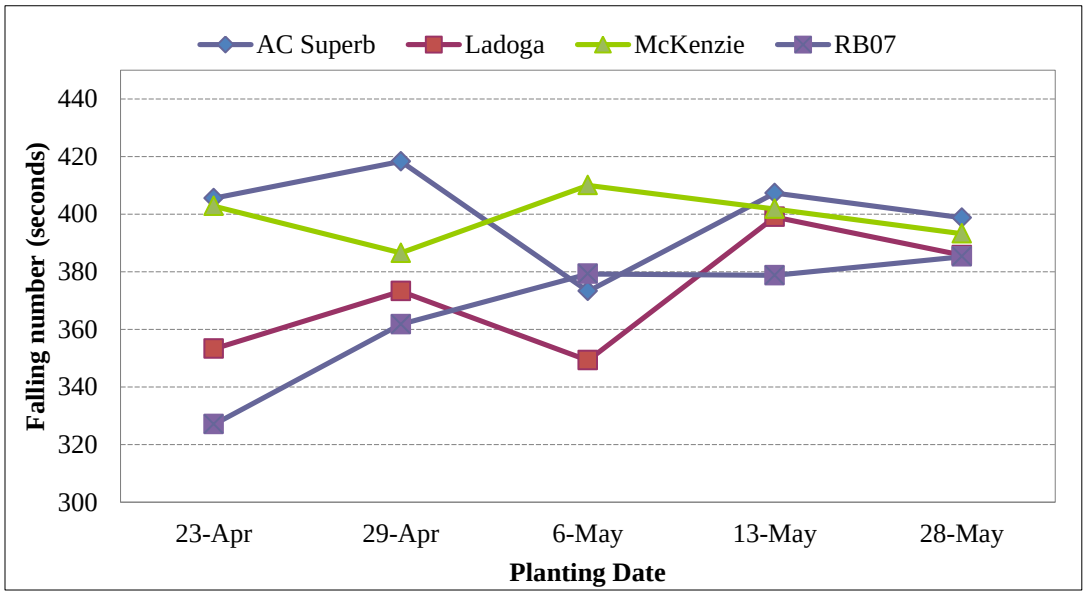

Figure 2. Effect of spring wheat planting date and variety on falling number, Alburgh, VT.

Impact of Planting Date

The two earliest planting dates, 23-Apr and 29-Apr, resulted in significantly taller crops across all varieties (Table 5). Later planting dates led to decreased plant height. The latest planting date (28-May) resulted in the least amount of lodging (3.1%). This was statistically similar to the planting date 6-May, but statistically different from the other three planting dates. The planting date that resulted in the greatest yield was the earliest planting date, 23-Apr (1761 lbs per acre) (Figure 3). This was significantly greater than all other planting dates and 715 lbs per acre greater than the trial mean.

Due to the low yields from 28-May planting date, grain moisture and test weight were not recorded for this treatment. Therefore, excluding the last planting date, 6-May had the highest moisture (18.0%). This was a significantly higher moisture level than the three other recorded planting dates. Excluding the last planting date, the two planting date treatments with the greatest test weights were 23-Apr and 13-May (53.9 and 52.8 pounds per bushel, respectively). These measurements were significantly greater than the two remaining planting dates.

The greatest level of crude protein was observed in the third planting date (6-May) (16.1%) and was significantly greater than all other planting dates (Figure 3). The planting date 13-May had the highest falling number (397 seconds). This was significantly greater than 23-Apr and 6-May, but statistically similar to planting date treatments of 29-Apr and 28-May. DON was lowest in the two latest planting dates 28-May and 13-May (3.7 ppm and 4.2 ppm respectively). These were significantly lower than the other three planting dates.

Table 5. Yield and quality characteristics by planting date across all spring wheat varieties, Alburgh, VT.

Planting date	Height	Lodging	Moisture	Yield at 13.5% moisture	Test weight	Crude protein at 12% moisture	Falling number	DON
	cm	%	%	lbs ac^{-1}	lbs/bu	%	seconds	ppm
23-Apr	**106.7***	19.7	12.7	**1761***	**53.9***	14.9	372	5.64
29-Apr	104.9*	35.0	13.0	1267	52.6	15.5	385*	5.22
6-May	100.1	10.6*	**18.0***	1495	50.3	**16.1***	378	6.03
13-May	97.1	15.6	11.4	452	52.8*	14.5	**397***	4.23*
28-May	84.9	**3.1***	-	256	-	14.2	391*	**3.73***
LSD (0.10)	2.8	10.8	-	230	-	0.5	15	0.74
p-value (<0.10)	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0706	<0.0001
Trial mean	98.7	16.8	13.8	1046	52.4	15.0	384	4.97

Treatments indicated in **bold** had the top observed performance.

* Treatments indicated with an asterisk did not perform significantly worse than the top-performing treatment in a particular column.

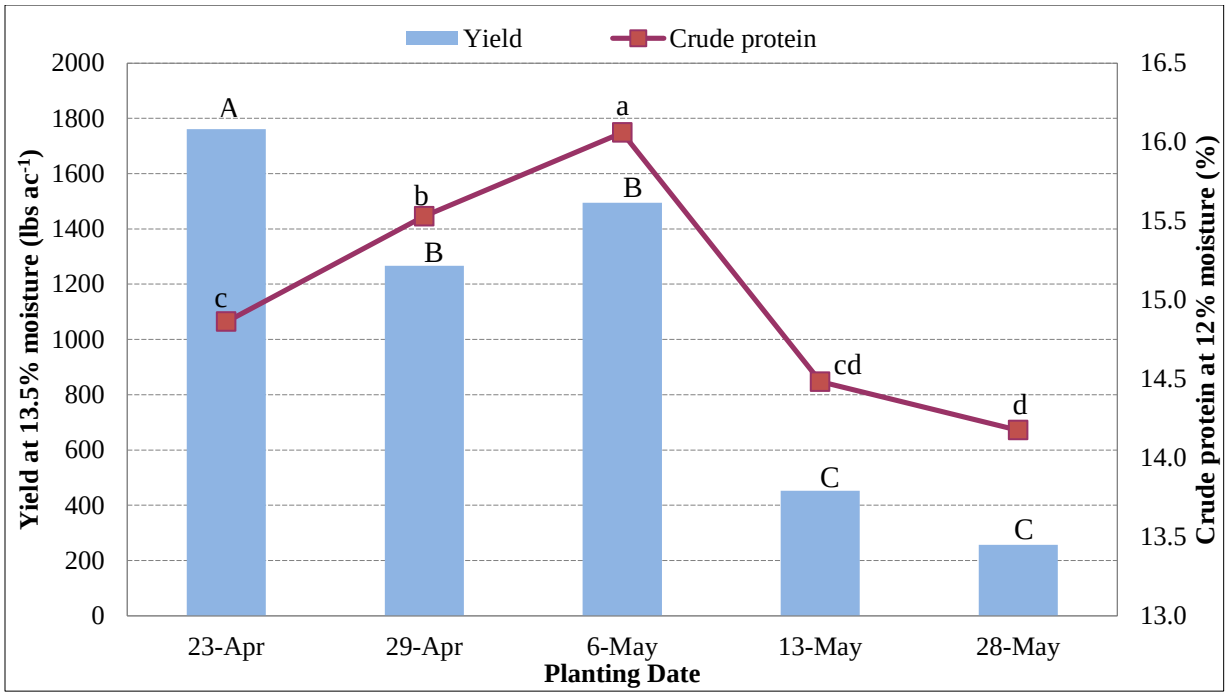

Figure 3. Effect of planting date across all spring wheat varieties on yield and crude protein, Alburgh, VT. Treatments with the same letter did not differ significantly from one another (p=0.10). Compare capital letters for yield and lower-case letters for crude protein.

Impact of Variety

The variety Ladoga was the tallest at the time of harvest (120.5 cm), and was significantly taller than all other varieties (Table 6). The variety with the least lodging was AC Superb (2.0%). This was statistically similar to the variety RB07, and significantly lower than varieties Ladoga and McKenzie. The trial mean for yield at 13.5% moisture was 1046 lbs per acre. Although none of the varieties varied significantly from one another, the highest yield was 1145 lbs per acre (RB07) (Figure 4). Excluding RB07 (missing data), the greatest moisture level was observed in AC Superb (15.3%). However, this was not significantly different from the other varieties. The variety with the greatest test weight was RB07 (53.5 pounds per bushel). This was statistically similar to varieties Ladoga and AC Superb (53.2 and 51.9 bushels per acre respectively), and statistically different from the variety McKenzie.

AC Superb had significantly greater crude protein (15.6%) than any of the other varieties (Figure 4). AC Superb also had the greatest observed falling number (401 seconds), which was statistically similar to the falling number of McKenzie (399 seconds) and significantly greater than the other two varieties. Ladoga and RB07 had the lowest levels of DON (4.2 and 4.6 ppm respectively). These levels were significantly lower than the varieties AC Superb and McKenzie.

Table 6. Yield and quality characteristics by spring wheat variety across all planting dates, Alburgh, VT.

Variety	Height	Lodging	Moisture	Yield at 13.5% moisture	Test weight	Crude protein at 12% moisture	Falling number	DON
	cm	%	%	lbs ac^{-1}	lbs/bu	%	seconds	ppm
AC Superb	89.6	**2.0***	**15.3**	1023	51.9*	**15.6***	**401***	6.13
Ladoga	**120.5***	28.8	14.9	1130	53.2*	14.7	372	**4.22***
McKenzie	102.8	31.0	14.3	886	51.0	14.9	399*	4.91
RB07	82.1	5.5*	-	**1145**	**53.5***	14.9	366	4.63*
LSD (0.10)	2.5	9.6	-	NS	-	0.5	14	0.66
p-value (<0.10)	<0.0001	<0.0001	0.2050	0.1421	0.0121	0.0124	<0.0001	<0.0001
Trial mean	98.7	16.8	14.9	1046	52.4	15.0	384	4.97

Treatments indicated in **bold** had the top observed performance.
* Treatments indicated with an asterisk did not perform significantly worse than the top-performing treatment in a particular column.
NS – No significant difference.

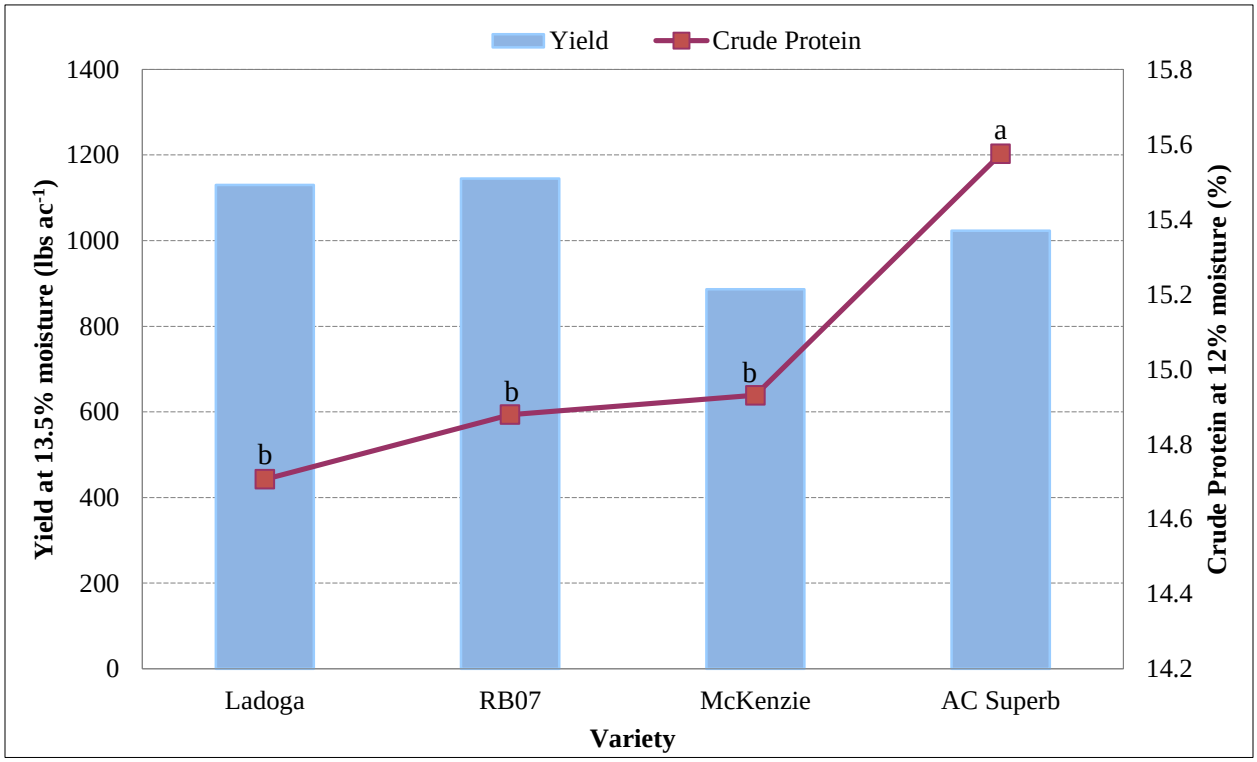

Figure 4. Effect of spring wheat variety across all planting dates on yield and crude protein, Alburgh, VT. Treatments with the same letter did not differ significantly (p=0.10).

DISCUSSION

Overall, 2013 spring wheat yields and quality were not extraordinary. Heavy rainfall likely caused lodging, which was detrimental to the yields of this trial. The mean yield was 1046 lbs per acre, which is lower than average. Heavy precipitation also led to a high moisture level at harvest. The average test weight for this trial was 52.4 pounds per bushel. This is lower than the acceptable test weight for bread wheat (56-60 pounds per bushel). Most commercial mills target 12-15% protein. This trial had a respectable mean protein level of 15.0%. The average falling number for this trial was 384 seconds, which indicates low enzymatic activity and sound quality wheat. However, the average level of DON was 4.97 ppm, which indicates that the wheat was unsuitable for human consumption.

The interaction between planting date and variety resulted in several significant differences, including plant heights, percent lodging, falling number, and DON. This means that the impact of altered planting date was different by variety. Likewise, the effect of variety played a role in the impact of planting date treatments. Although wheat height declined for all varieties as planting dates were delayed, some varieties saw more drastic reductions in heights over time. Wheat that is short may not compete with weeds as well as taller plants. Hence, later planting dates may have increased weed pressure just due to less competitive ability from the wheat crop. This was the case for the 28-May planting date where weed pressure caused severe yield depression as compared to the other dates. Interestingly, falling number took a sharp decline at the 6-May planting date. This decline was likely due to the grain being at high moisture content at the time of harvest (18% moisture). Harvest dates were split to try and accommodate the various planting dates. It is likely that the falling number would have increased slightly as the grain became more mature.

Plant heights differed significantly by planting date. The first two planting dates, 23-Apr and 29-Apr resulted in significantly taller crops than the remaining three planting dates. The planting dates 6-May and 28-May had significantly lower percentages of lodging than the other planting dates. This is likely due to the shorter plant heights, as taller plants are more likely to lodge in wind or rain. The planting date treatment that resulted in the greatest yield was 23-Apr and was significantly greater than all other planting dates. The planting date that showed the highest moisture level at harvest was 6-May (18.0%); this was significantly higher than all other planting dates (not including 28-May which did not have enough yield to test moisture). Wheat planted on 23-Apr and 13-May had significantly higher test weights than wheat planted on 29-Apr and 6-May. Wheat planted on 28-May did not produce enough yields to measure test weight. Wheat planted on 6-May showed the greatest level of crude protein (16.1%) and was significantly greater than all other planting dates. Falling number was significantly greatest in the planting date treatments 29-Apr, 13-May, and 28-May. The later planting dates, 13-May and 28-May, showed significantly lower levels of DON than other planting dates, but were still higher than 1 ppm and therefore were not safe for human consumption.

Variety had a significant impact on plant height. Ladoga produced significantly taller wheat than the other varieties. AC Superb and RB07 showed significantly less lodging than the other two varieties. Yield did not differ significantly between varieties although RB07 had the highest yield at 13.5% moisture. There was no significant difference in regards to percent moisture between varieties, excluding RB07. AC Superb, Ladoga, and RB07 had the greatest test weights and were significantly greater than the variety McKenzie. AC Superb demonstrated the greatest crude protein level which was significantly

greater than other varieties. AC Superb and McKenzie had statistically significant greater falling numbers than the other two varieties. DON was found to be significantly lower in the varieties Ladoga and RB07, but all varieties showed DONs of higher than 1ppm and therefore were not fit for human consumption.

Based on these results it is critical to plant spring wheat as early as possible in the spring. Quicker canopy closure, taller plants and subsequent reduced weed pressure resulting from earlier planting dates will lead to higher yields. Although it appears that quality levels can be maintained in later planting dates, the increased weed pressure could likely cause staining and off-flavors of the grain. Lastly, severe yield depression would likely not produce an economically viable crop.

It is important to note that these results represent only one year of data at only one location. Consult additional research before making varietal selections or other agronomic decisions.

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