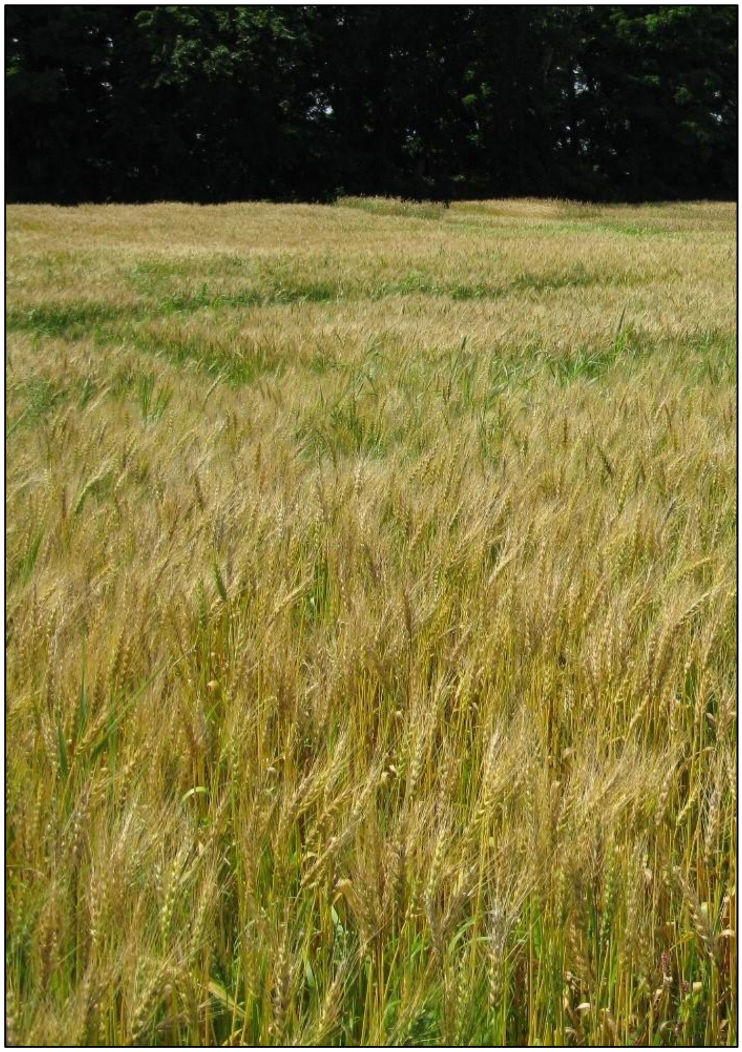
2020 Steam Treated Grains Trial



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THE UNIVERSITY OF VERMONT
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2012 STEAM TREATED GRAINS TRIAL

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Locally grown grains, such as wheat and barley, are in high demand in the Northeast for both livestock feed and human consumption. One major challenge that grain growers encounter is infection by fungal diseases, such as loose smut and the infection of *Fusarium* head blight (FHB). Loose smut appears on grains as “smutted grain heads”, which are filled with spores that appear black or brown. The spore masses replace the grain heads, so that fewer or no viable kernels are left for harvest. Smutted heads are caused by the fungal pathogen genus *Ustilago*. *Ustilago nuda* commonly infects barley, while *Ustilago tritici* infects wheat. Uncontrolled blights of loose smut not only reduce yield and grain quality but have the potential to wipe out an entire grain crop. In the U.S., seed-borne pathogens are often managed with fungicides, which presents a challenge to organic systems, as organic farmers cannot use conventional fungicides in their practices, but still need successful methods of preventing pathogens that commonly infect grains. Alternatives to fungicides include organic seed amendments and aerated steam treatments. Aerated steam treatments have been used to disinfect contaminated grain to mitigate cereal seed-borne diseases and fungi. The University of Vermont Extension Northwest Crop and Soils (NWCS) Program conducted a trial consisting of steam treated and untreated Prosper spring wheat and Robust 6-row barley to evaluate the effect of steam treatment on grain health, yield, and quality.

MATERIALS AND METHODS

The trial was conducted at Borderview Research Farm in Alburgh, VT. The experimental design was a randomized complete block with four replicates. The treatments were steam treated or non-steam treated certified organic wheat *(var* Prosper) and barley (*var* Robust) seed. The seed lots had been previously identified as being high in loose smut. Prosper is a variety of wheat considered moderately resistant to Fusarium head blight (FHB). Robust is an FHB susceptible barley cultivar. Seeds were treated with steam at High Mowing Organic Seeds (Wolcott, VT). Approximately two pounds of each grain were steam treated at 65℃ for 90 seconds in 1” deep trays. After treatment, the seeds were dried to their original moisture (<14% moisture) over a period of 1 hour in a dehydrator at 30℃ . Steam-treated and untreated barley and wheat were planted on 15-Apr at a seeding rate of 350 live seeds m^{-2} into plots that were 5’ x 20’ (Table 1).

Table 1. Agronomic and trial information for the steam treated grains trial, 2020.

Location:	**Borderview Research Farm, Alburgh, VT**
Soil type	Benson rocky silt loam 3-8% slope
Previous crop	Corn silage
Tillage operations	Disk and spike tooth harrow
Harvest area (ft.)	5 x 20
Seeding rate (live seeds m^{-2})	350
Planting date	15-Apr
Barley harvest date	21-Jul
Wheat harvest date	21-Jul

On 25-Jun, a smut assessment was done by taking three 1-foot sections and counting the total number and number of smutted heads per section. On 8-Jul, the plots were scouted for powdery mildew, *Fusarium* head blight, and other signs of disease or insect damage in three 1-foot sections. These observations were recorded by percent severity (0-100%) by a visual assessment.

Both the Robust barley and the Prosper spring wheat were harvested on 21-Jul. Grains were harvested with an Almaco SPC50 plot combine. Following the harvest, seeds were cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN). Grain moisture, test weight, and yield were determined with a DICKEY-John M20P meter and pound scale. A subsample of approximately one pound was collected to determine quality, which was ground into flour with a Perten LM3100 Laboratory Mill, and analyzed for protein content, falling number, and deoxynivalenol (DON) levels. Crude protein (CP) content was analyzed using a Perten Inframatic 8600 Flour Analyzer, and falling numbers were determined (AACC Method 56-81B, AACC Intl., 2000) using a Perten FN 1500 Falling Number Machine. The falling number is related to the amount of sprout damage in the grain and 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 a test tube. A falling number greater than 350 indicates low enzymatic activity and good quality. Falling numbers less than 200 indicate high enzymatic activity and poor quality. Grain samples were analyzed for deoxynivalenol (DON) using the Veratox DON 5/5 Quantitative test (NEOGEN Corp.), which 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 genetics, soil, weather, and other growing conditions can result in variations in yield and quality. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or field. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 90% of the time. Treatments within a column that have the same letter are statistically similar. In the example to the right, treatment C was significantly different from treatment A, but not from treatment B. The difference between C and B is 1.5, which is less than the LSD value of 2.0 and so these treatments were not significantly different in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0 indicating the yields of these treatments were significantly different from one another. The letter ‘a’ indicates that treatment B was not significantly lower than the top yielding treatment, indicated in bold.

Treatment	Yield
A	6.0[b]
B	7.5[ab]
C	**9.0[a]**
LSD	2.0

RESULTS

Seasonal precipitation and temperature were recorded at Borderview Research Farm in Alburgh, VT and are displayed in Table 2. Weather data were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger. Precipitation was below average from April through July; overall there was nearly 1 in. less rain during that four-month period. A cool April led to Growing Degree Days (GDDs) lagging behind the 30-year average, followed by a hotter than normal June and July. It was over 4 degrees warmer than normal in July. Plants may have exhibited drought stress as a result of the lack of rain and warm temperatures. A total of 3434 GDDs were accumulated April through July, 56 more than the 30-year normal.

Table 2. Temperature and precipitation summary for Alburgh, VT, 2020.

Alburgh, VT	April	May	June	July
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) from Burlington, VT.

Prosper Spring Wheat

Populations were measured and plants were scouted for signs of disease and insects prior to harvest. No powdery mildew was observed. Overall, disease and pest pressure were low this season. For spring wheat observed disease severity, there was a statistically significant difference in leaf rust. The steam treated wheat had 0% leaf rust severity compared to 0.750% for the non-steam treated wheat (Table 3). Arthropod damage was significantly lower in the non-steam treated wheat (1.65%) than the steam treated wheat (3.70%). There was no significant difference in the number of smutted heads between the two treatments of spring wheat.

Table 3. Disease severity and arthropod damage for Prosper spring wheat, Alburgh, VT, 2020.

	Leaf spots	Leaf rust	Physiological spotting	Arthropod damage	Smutted heads
Treatment	% severity				%
None	2.40	0.750	7.35	**1.65**	0.0264
Steam	2.98	**0.00**†	10.1	3.70	0.0366
LSD (0.10) ‡	NS¥	0.588	NS	1.39	NS
Trial mean	2.69	0.375	8.71	2.68	0.0315

†Top performers are in **bold.**
‡LSD – Least significant difference between treatments at p=0.10.
¥NS – No significant difference between treatments.

Grain moisture, yield, and test weight were measured at harvest (Table 4). Grain moisture at harvest is preferred to be below 14% moisture for optimal grain storage. The non-steam treated wheat had a significantly lower harvest moisture (17.4%) than the steam treated wheat (20.3%). There was no significant difference in yield between the treatments. The average test weight for non-steam treated seeds was significantly higher (57.8 lbs. bu^{-1}). Test weight is determined by weighing a known volume of grain, and measures grain density. The higher the test weight, the greater the quality of the grain. The spring wheat treatments did not differ statistically for other quality parameters (Table 5). The DON concentration was not significantly different between treatments.

Table 4. Harvest measurements for Prosper spring wheat, Alburgh, VT, 2020.

Treatment	Harvest moisture	Yield at 13.5% moisture	Test weight
	%	lbs. ac^{-1}	lbs. bu^{-1}
None	**17.4**†	2842	**57.8**
Steam	20.3	2353	54.1
LSD (0.10) †	1.88	NS‡	2.73
Trial mean	18.8	2598	56.0

†Top performers are in **bold.**
†LSD – Least significant difference between treatments at p=0.10.
‡NS – No significant difference between treatments.

Table 5. Grain quality for Prosper spring wheat, Alburgh, VT, 2020.

Treatment	Crude protein at 12% moisture	Falling number	DON
	%	Seconds	ppm
None	14.5	329	0
Steam	14.7	323	0
LSD (0.10) †	NS‡	NS	NS
Trial mean	14.6	326	0

†LSD – Least significant difference between treatments at p=0.10.
‡NS – No significant difference between treatments.

Robust Spring Barley

Spring barley plants were scouted for signs of disease and insects prior to harvest. Scouting data for powdery mildew, leaf spots, leaf rust, and physiological spotting are displayed in Table 6, and there were no statistical differences between the treatments. Arthropod damage and percentage of smutted heads were also recorded, but there were no significant differences between treatments for either parameter.

Table 6. Population and percent disease severity for Robust spring barley, Alburgh, VT, 2020.

Treatment	Powdery mildew	Leaf spots	Leaf rust	Physiological spotting	Arthropod damage	Smutted heads
	% severity					%
None	7.24	8.28	0.250	7.08	4.65	0.0239
Steam	8.41	8.25	0	8.88	20.2	0.0147
LSD (0.10) †	NS‡	NS	NS	NS	NS	NS
Trial mean	7.83	8.27	0.125	7.98	12.4	0.0193

†LSD – Least significant difference between treatments at p=0.10.
‡NS – No significant difference between treatments.

Harvest measurements and grain quality for Robust spring barley are shown in Tables 7 and 8 respectively. Yield, harvest moisture, test weight, and quality did not differ by treatment. All DON concentrations were under 1 ppm.

Table 7. Harvest measurements of Robust spring barley, Alburgh, VT, 2020.

Treatment	Harvest moisture	Yield at 13.5 % moisture	Test weight
	%	lbs. ac^{-1}	lbs. bu^{-1}
None	**13.5**†	3937	45.0
Steam	14.1	4121	**47.2**
LSD (0.10) ‡	0.254	NS¥	1.96
Trial mean	13.8	4029	46.1

†Top performers are in **bold.**
‡LSD – Least significant difference between treatments at p=0.10.
¥NS – No significant difference between treatments.

Table 8. Grain quality for Robust spring barley, Alburgh, VT, 2020.

Treatment	Crude protein at 12% moisture	Falling number	DON
	%	Seconds	
None	13.0	368	0
Steam	13.0	361	0
LSD (0.10) †	NS‡	NS	NS
Trial mean	13.0	365	0

†LSD – Least significant difference between treatments at p=0.10.
‡NS – No significant difference between treatments.

DISCUSSION

Overall, there were few differences between the steam treated and non-steam treated spring grains. Although not considered a seedborne disease, the steam treated Prosper spring wheat had significantly lower leaf rust, perhaps a result of elimination of rust as a seed contaminant. The non-steam treated wheat had significantly less arthropod damage; all other diseases observed were not impacted by the steam treatment, nor was there a significant impact on the amount of smutted heads. There were no significant effects on the Robust spring barley in terms of the severity of pests and disease, or the percentage of spiked smutted heads in the total grain population. It is important to note that this trial did not measure the incidence of pests and disease. Smutted heads accounted for less than 1% of grain heads in all treatments. The steam treated Prosper spring wheat had significantly lower harvest moisture and higher test weight than the non-steam treated wheat. The harvest moisture was lower for the non-steam treated spring barley. This indicates that the quality of the grains was not affected by the steam treatment. DON levels were under 1 ppm and therefore considered suitable for human consumption. Overall, this season, there were low levels of pest and disease pressure, potentially due to the hot, dry season.

This is the third year that this experiment has been conducted at Borderview Research Farm in Alburgh, VT, and the results vary by year. In the 2018 season, it was warmer and drier than normal. Overall, loose smut of *Ustilago tritici* and *Fusarium* pressure was low, but results suggested steam treatment of wheat may be effective in reducing loose smut. Steam treatment did not appear to affect other disease indicators, such as spotting or increased FHB. However, the results also suggested that the steam treatment may have decreased grain quality, as indicated by the lower test weight and crude protein in the steam-treated wheat. Those differences were not observed in the spring barley. In 2019, the spring was cool and wet, followed by hot, dry weather in July. DON levels were low and smutted heads accounted for <1% of the total grain population; this trend was seen again in 2020. There was no significant impact of the steam treatment on either spring barley or wheat, nor did the steam treatment affect yield or quality.

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