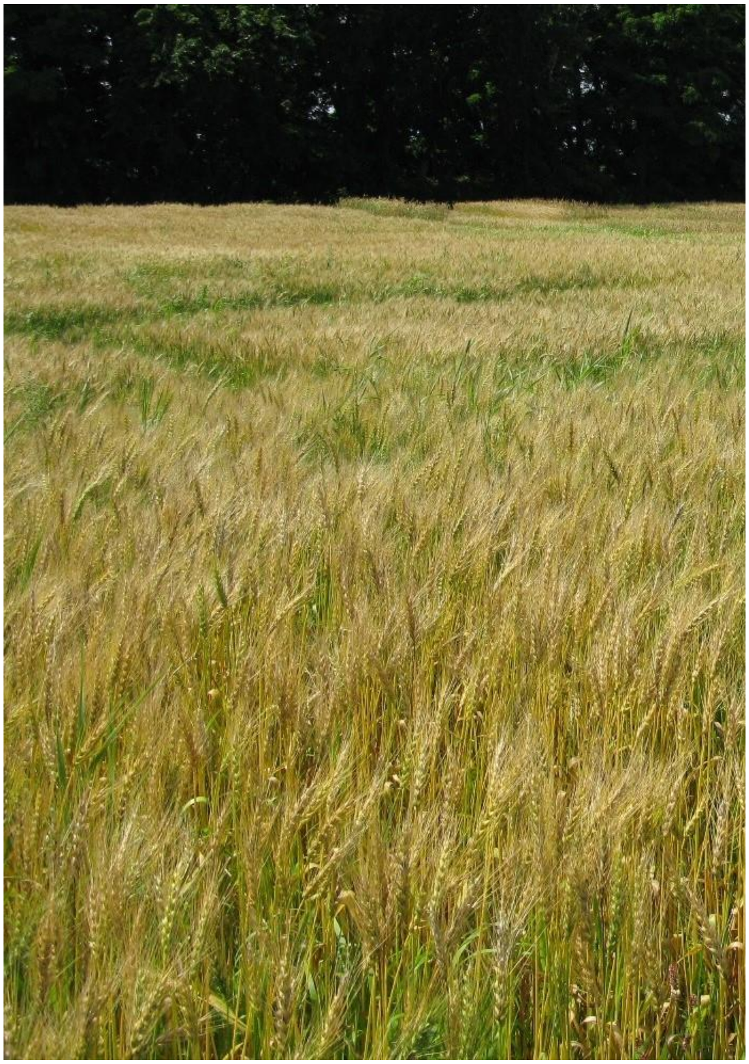
2018 Steam Treated Grains Trial



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2018 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 appear 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 kernals 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 wheat and barley seed. The seed lots had been identified as being high in loose smut. Seeds were treated at High Mowing Organic Seeds (Wolcott, VT) on 20-Mar. Approximately two pounds of seed of each grain were 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 Robust 6-row spring barley and Prosper hard red spring wheat were planted on 8-May 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, 2018.

	Borderview Research Farm, Alburgh, VT
Soil type	Benson rocky silt loam 8-15% slope
Previous crop	Potatoes
Tillage operations	Disk and spike tooth harrow
Harvest area (ft.)	5 x 20
Seeding rate (live seeds m^{-2})	350
Replicates	4
Planting date	8-May
Barley harvest date	30-Jun
Wheat harvest date	8-Aug

Prosper is a moderately Fusarium head blight (FHB) resistant wheat variety. Robust is an FHB susceptible barley cultivar. On 18-May, at the 1-3 leaves growth stage, populations were recorded by taking plant counts in 1-foot lengths 3 times per plot. Vigor was ranked on a 0-5 scale where 0 was dead and 5 was vigorous. Heading dates were recorded when a plot was >50% headed. On 25-Jun, the plots were scouted for powdery mildew, loose smut, *Fusarium* head blight, and other signs of disease or insect damage. These observations were recorded on a 0-5 scale where 0 indicated no incidence of disease or damage, and 5 indicated severe incidence of disease or damage (75 to 100% of heads exhibited disease or damage).

The Robust barley was harvested on 30-Jun and the Prosper spring wheat was harvest on 8-Aug. 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 higher 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 that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. 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 asterisk indicates that treatment B was not significantly lower than the top yielding treatment, indicated in bold.

Treatment	**Yield**
A	6.0
B	7.5*
C	**9.0**
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. The season was hotter and dryer than normal, with above average temperatures Jul-Sep. 4395 growing degree days (GDDs) were accumulated May-August, 287 above the 30-year normal. During this time there were 4.13 inches less of precipitation than average.

Table 2. Temperature and precipitation summary for Alburgh, VT, 2018.

Alburgh, VT	May	June	July	August
Average temperature (°F)	59.5	64.4	74.1	72.8
Departure from normal	3.10	-1.38	3.51	3.96
Precipitation (inches)	1.9	3.7	2.4	3.0
Departure from normal	-1.51	0.05	-1.72	-0.95
Growing Degree Days (base 32°F)	853	973	1305	1264
Departure from normal	97	-42	107	125

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

The average heading date for steam treated spring wheat was 2-Jul, while the heading dates for the untreated spring wheat were 23-Jun and 24-Jun. Populations were measured and plants were scouted for signs of disease and insects prior to harvest. No leaf rust, striped rust, glume spots, FHB, or physiological spotting were observed. Scouting data for loose smut, downy mildew, leaf spots symptomatic of unidentified foliar diseases, cereal leaf beetle (CLB), thrips, mites, and vigor are displayed in Table 3.

Table 3. Impact of steam treatment on plant population and pests for Prosper spring wheat, Alburgh, VT, 2018.

	Population	Loose Smut	Mildew	Leaf spots	Cereal Leaf Beetle	Thrips	Mites	Vigor
Treatment	m^{-2}	0-5†	0-5†	0-5†	0-5†	0-5†	0-5†	0-5‡
Steam	288	**0.00**	0.75	**0.25**	0.25	**1.00**	**1.00**	4.75
None	**306**	1.00	0.25	**0.25**	**0.00**	**1.00**	**1.00**	**4.50**
LSD (0.10)	NS	0	NS	NS	NS	NS	NS	NS
Trial mean	297	0.50	0.50	0.25	0.125	1.00	1.00	4.63

†The 0-5 scale indicates the severity of disease or pest damage where 0 is no incidence and 5 is severe with 75 to 100% of plants exhibiting signs of disease or damage.
‡The 0-5 scale indicates vigor where 0 is dead and 5 is vigorous.
LSD – Least significant difference.
NS – No significant difference in severity between treatments.

For the spring wheat populations, vigor, and insect populations displayed in Table 3, there were no significant differences between the steam-treated and untreated seeds, while loose smut was significantly greater in the plots with non-steam treated seeds.

Grain moisture, yield, and test weight were measured at harvest (Table 4). Grain moisture at harvest are preferred to be below 14% moisture for optimal grain storage. Yield is presented at 13.5% moisture. There were no significant differences between the treatments for harvest moisture or yield at 13.5% moisture, but the average test weight for non-steam treated seeds was significantly higher (57.4 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.

For grain quality (Table 5), the only significant differences were for crude protein (CP) at 12% moisture, where the non-steam treated plants had higher percentage of crude protein (17.6%) than the steam treated plots (15.4%). Prosper spring wheat had similar falling numbers for both treatments (342, 339), and values for DON were identical at 0.2 ppm.

Table 4. Harvest measurements for Prosper spring wheat, Alburgh, VT, 2018.

Treatment	Harvest moisture %	Yield at 13.5% moisture lbs ac^{-1}	Test weight lbs bu^{-1}
Steam	**19.2**	**2228**	53.8
None	19.6	1996	**57.4**
LSD (0.10)	NS	NS	2.7
Trial mean	19.4	2112	55.6

Top performer treatments are shown in **bold**.
LSD – Least significant difference.
NS – No significant difference between treatments.

Table 5. Grain quality for Prosper spring wheat, Alburgh, VT, 2018.

Treatment	Crude protein at 12% moisture %	Falling number seconds	DON ppm
Steam	15.4	**342**	**0.2**
None	**17.6**	339	**0.2**
LSD (0.10)	1.51	NS	NS
Trial mean	16.5	340	0.2

Top performer treatments are shown in **bold**.
LSD – Least significant difference.
NS – No significant difference between treatments.

Robust Spring Barley

Spring barley heading dates were 23-Jun and 24-Jun for both steam treated and untreated barley. Spring barley populations were measured and plants were scouted for signs of disease and insects prior to harvest. No leaf rust, striped rust, glume spots, FHB, or physiological spotting were observed. Scouting data for loose smut, downy mildew, leaf spots, cereal leaf beetles, thrips, mites, and vigor are displayed in Table 6. The steam treatment had significantly higher vigor rankings (4.88) and populations per square meter (366).

Table 6. Scouting data for Robust spring barley, Alburgh, VT, 2018.

Treatment	Population	Loose Smut	Downy Mildew	Leaf spots	Cereal Leaf Beetle	Thrips	Mites	Vigor
	m^{-2}	0-5†	0-5†	0-5†	0-5†	0-5†	0-5†	0-5‡
Steam	**366**	**1.00**	**1.00**	**0.50**	0.50	**1.00**	**1.00**	**4.88**
None	270	**1.00**	1.25	**0.50**	**0.25**	**1.00**	**1.00**	4.50
LSD (0.10)	91.3	NS	NS	NS	NS	NS	NS	0.271
Trial mean	319	1	1.13	0.5	0.375	1	1	4.69

† The 0-5 scale indicates the severity of disease or pest damage where 0 is no incidence and 5 is severe with 75 to 100% of plants exhibiting signs of disease or damage.
‡The 0-5 scale indicates vigor where 0 is dead and 5 is vigorous.
LSD – Least significant difference.
NS – No significant difference in severity between treatments.

Table 7. Harvest measurements of Robust spring barley, Alburgh, VT, 2018.

Treatment	Harvest moisture	Yield at 13.5 % moisture	Test weight
	%	lbs ac^{-1}	lbs bu^{-1}
Steam	17.3	1679	44.7
None	**16.9**	**1956**	**46**
LSD (0.10)	NS	NS	NS
Trial mean	17.1	1818	45.4

Top performer treatments are shown in **bold**.
LSD – Least significant difference.
NS – No significant difference between treatments.

Table 8. Grain quality for Robust spring barley, Alburgh, VT, 2018.

Treatment	Crude protein at 12% moisture	Falling number	DON
	%	seconds	ppm
Steam	**12.0**	380	0.225
None	11.5	**401**	**0.025**
LSD (0.10)	NS	NS	0.155
Trial mean	11.75	391	0.125

Top performer treatments are shown in **bold**.
LSD – Least significant difference.
NS – No significant difference between treatments.

Insect and disease presence did not greatly differ by treatment, nor did yield, harvest moisture, or test weight. The spring barley treatments did not differ in quality either (Table 8). The DON concentrations were significantly higher for the steam-treated plants, at 0.225 ppm, in comparison to the untreated DON concentration of 0.025 ppm.

DISCUSSION

These results suggest that the steam treatment on Prosper spring wheat may be effective for the prevention of loose smut of *Ustilago tritici.* Steam treatment did not appear to affect other disease indicators, such as spotting or increased DON concentrations. However, these results also suggest that the steam treatment may have decreased grain quality, as indicated by the lower test weight and crude protein in the steam-treated wheat.

The Robust spring barley did not show the same differences in the amount of loose smut or grain quality between treatments that the Prosper spring wheat did. The barley trial found increased vigor, populations, and DON concentrations in the steam treated grains. DON levels for both treatments, however, were under 1 ppm and therefore considered suitable for human consumption.

Interestingly, steam treatment did not significantly impact yields in either spring wheat or barley. While results of this trial suggest that the steam treatment may reduce smut in Prosper spring wheat, it is important to remember that these results only represent one year of data. Weather patterns were unusual for the Northeast region, with recording setting heat in the month of July. The Northwest Crop and Soils Team will be repeating this trial in 2019.

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