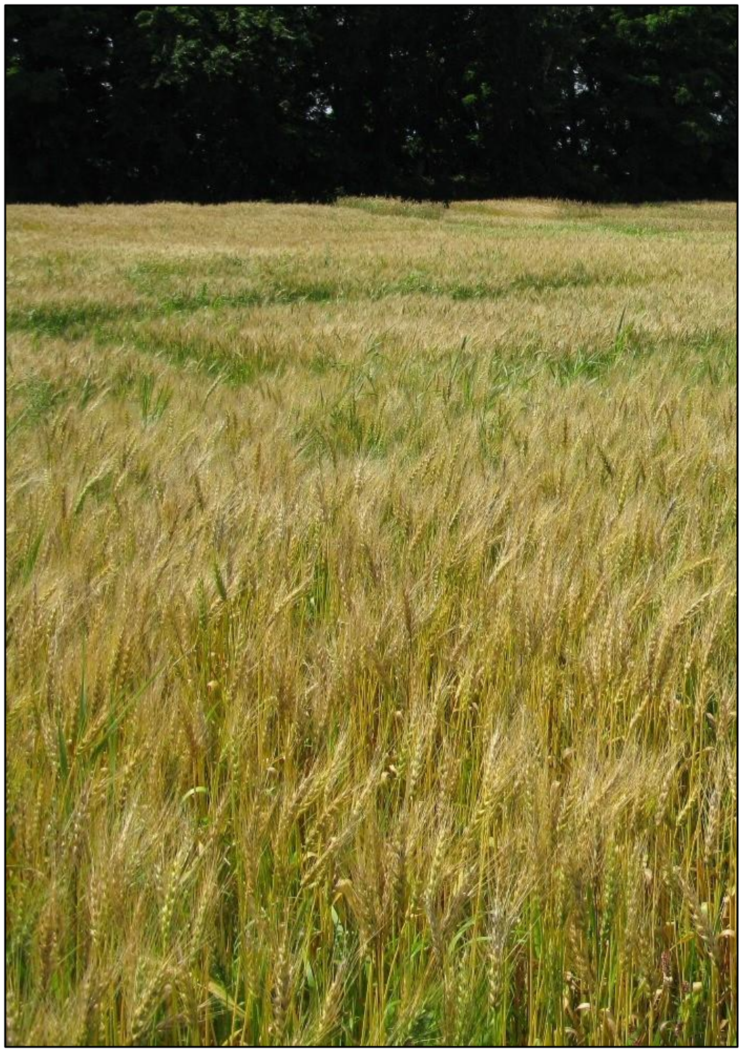
2019 Steam Treated Grains Trial



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2019 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 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). 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 6-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, 2019.

	Borderview Research Farm, Alburgh, VT
Soil type	Benson rocky silt loam 8-15% slope
Previous crop	Spring Grains
Tillage operations	Disk and spike tooth harrow
Harvest area (ft.)	5 x 20
Seeding rate (live seeds m^{-2})	350
Replicates	4
Planting date	6-May
Barley harvest date	2-Aug
Wheat harvest date	2-Aug

Prosper is a variety of wheat considered moderately resistant to Fusarium head blight (FHB). Robust is an FHB susceptible barley cultivar. On 21-May, at the 1-3 leaves growth stage, populations were recorded by taking plant counts in three 1-foot lengths per plot. On 9-Jul, the plots were scouted for powdery mildew, loose smut, *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. Smutted heads in the entire plot were also counted.

Both the Robust barley and the Prosper spring wheat were harvested on 2-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 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. Don was only tested on one replication to gauge the level of toxin present. If all samples tested below the industry standard of 1ppm no future replications were tested.

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. Precipitation was 1.45 inches above average in May, then fell below in June and July. A cool spring led to Growing Degree Days (GDDs) lagging behind the 30-year average in May and June, followed by a hotter than normal July. A total of 2916 GDDs were accumulated May through July, 52 less than the 30-year normal. During this time there were also 0.99 inches less of precipitation than average.

Table 2. Temperature and precipitation summary for Alburgh, VT, 2019.

Alburgh, VT	May	June	July
Average temperature (°F)	53.3	64.3	73.5
Departure from normal	-3.11	-1.46	2.87
Precipitation (inches)	4.9	3.06	2.34
Departure from normal	1.45	-0.63	-1.81
Growing Degree Days (base 32°F)	660	970	1286
Departure from normal	-96	-44	88

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 physiological spotting, cereal leaf beetle, thrips, mites, slug, or aphids were observed. Scouting data for loose smut, leaf rust, leaf spots, and powdery mildew are displayed in Table 3 as percent severity. For spring wheat populations and observed disease severity, there were no statistical differences between steam-treated and untreated seeds.

Table 3. Population and percent disease severity for Prosper spring wheat, Alburgh, VT, 2019.

	Population	Loose Smut	Leaf Rust	Leaf spots	Powdery Mildew	Smutted heads
Treatment	m^{-2}	% severity				% of total plants
Steam	243	1.06	0	0.73	0.07	0.59
None	327	1.77	0	1.00	0	0.53
LSD (0.10)	NS	NS	NS	NS	NS	NS
Trial mean	284	1.41	0	0.87	0.03	0.56

†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. 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 (56.6 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, 2019.

Treatment	Harvest moisture	Yield at 13.5% moisture	Test weight
	%	lbs ac^{-1}	lbs bu^{-1}
Steam	**21.1**	**1779**	53.3
None	19.0	1741	**56.6**
LSD (0.10)†	NS‡	NS	2.01
Trial mean	20.3	1761	55.1

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

Table 5. Grain quality for Prosper spring wheat, Alburgh, VT, 2019.

	Crude protein at 12% moisture	Falling number	DON
Treatment	%	Seconds	
Steam	**11.5**	**403**	0.00
None	11.1	369	0.00
LSD (0.10)	NS	NS	NS
Trial mean	11.3	386	0

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

Robust Spring Barley

Spring barley populations were measured and plants were scouted for signs of disease and insects prior to harvest. No physiological spotting, cereal leaf beetle, thrips, mites, slug, or aphids were observed. Scouting data for loose smut, lead rust, leaf spots, and powdery mildew are displayed in Table 6, and there were no statistical differences between the treatments.

Table 6. Population and percent disease severity for Robust spring barley, Alburgh, VT, 2019.

	Population	Loose smut	Leaf rust	Leaf spots	Powdery mildew	Smutted heads
Treatment	m^{-2}	% severity				% of total plants
Steam	268	1.82	0.07	23.3	23.1	0.24
None	305	1.79	0.07	32.7	37.0	0.43
LSD (0.10)	NS	NS	NS	NS	NS	NS
Trial mean	287	1.81	0.07	28	30.1	0.33

†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. One replicate per treatment was tested for DON, and all DON concentrations were under 1 ppm.

Table 7. Harvest measurements of Robust spring barley, Alburgh, VT, 2019.

Treatment	Harvest moisture %	Yield at 13.5 % moisture lbs ac^{-1}	Test weight lbs bu^{-1}
Steam	**12.8**	**737**	**42.6**
None	12.1	666	42.3
LSD (0.10)	NS	NS	NS
Trial mean	12.5	702	42.4

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

Table 8. Grain quality for Robust spring barley, Alburgh, VT, 2019.

Treatment	Crude protein at 12% moisture %	Falling number Seconds
Steam	**12.0**	**375**
None	11.3	371
LSD (0.10)	NS	NS
Trial mean	11.7	391

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

DISCUSSION

These results suggest that there was no significant effect of the steam treatment on either the barley or the wheat in terms of the severity of pests and disease, and the percentage of spiked smutted heads in the total grain population. Fortunately, the quality of the grains was not affected, but disease severity did not appear to be impacted by the seed treatment. 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. DON levels were under 1 ppm and therefore considered suitable for human consumption.

Previous year's results suggested 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, previous 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. This trial only represents one season of field data and further research is needed. The Northwest Crop and Soils Team will be repeating this trial in 2020.

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