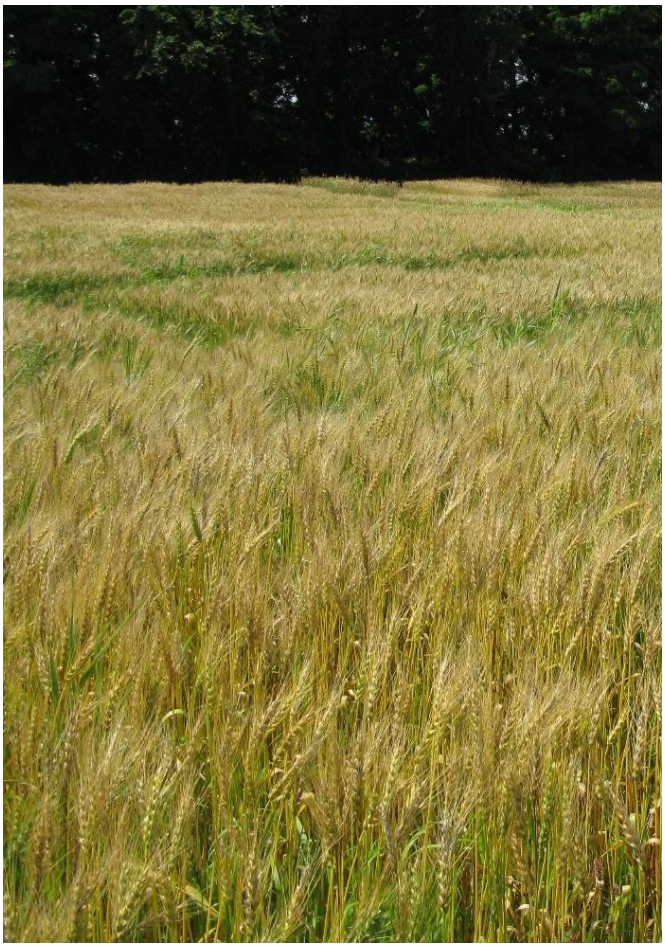
NORTHWEST CROPS & SOILS PROGRAM

2023 Steam Treatment to Reduce *Ustilago spp.* Infection in Spring Barley



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2023 STEAM TREATMENT TO REDUCE *USTILAGO SPP.* INFECTION IN SPRING BARLEY

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Locally grown barley is in high demand in the Northeast by local breweries and distilleries. One major challenge that grain growers encounter is infection by fungal diseases, such as loose smut. 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. Loose smut reduces grain yield and quality, and uncontrolled outbreaks have the potential to wipe out an entire grain crop. Because the disease is seed-borne and spread by wind throughout the crop while the grain is heading, it can increase exponentially in the seed supply. In the US, seed-borne pathogens are often managed with conventional fungicides. This 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 are 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 three different aerated steam treatments (varying in time and temperature) to assess the efficacy of steam treatment in reducing the incidence of loose smut in spring barley.

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 spring barley seed lot (Robust 6-row barley) had been identified by an organic seed distributor as being high in loose smut. Seed was treated in an AltoShaam Combi steam oven. The three steam treatments were 75 C for 90 seconds, 70 C for 180 seconds, and 65 C for 300 seconds. Germination response of the seed at different temperatures was determined for each time interval, with a target germination rate of 90% (a reduction in germination of about 8% from the untreated seed). The germination rates after treatment were 98% (no change from untreated seed) for the 90 second treatment and 95% for the other two treatments. The seed lot had been identified by an organic seed distributor as being high in loose smut. Seeds were treated on 20-Mar. Approximately three pounds of seed per treatment were treated in 1" deep trays. After treatment, the seeds were dried to 14% moisture in the oven over a period of 1 hour and 10 minutes at 30 C. Steam-treated and untreated spring barley from the same seed lot were planted on 14-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, 2023.

	Borderview Research Farm, Alburgh, VT
Soil type	Benson rocky silt loam 8-15% slope
Previous crop	Industrial hemp
Tillage operations	Disk and spike tooth harrow
Harvest area (ft.)	5 x 20
Seeding rate (live seeds m^{-2})	350
Replicates	4
Planting date	14-Apr
Barley harvest date	8-Aug

On 9-May, at the tillering growth stage, populations were recorded by taking plant counts in 1-foot lengths 3 times per plot. On 21-Jun, the plots were assessed for the incidence of loose smut. The number of plants and the number of smutted heads were counted in two one-meter segments in each plot.

The barley was harvested on 8-Aug. Grains were harvested with an Almaco SPC50 plot combine. Grain moisture, test weight, and yield were determined with a DICKEY-John M20P meter and pound scale.

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. 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 this 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 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 cooler and much wetter than normal. Between April and August, over 28 inches of rain fell at the farm, 9.65 inches more than the 30 year average. 4441 Growing Degree Days (GDDs) accumulated, 304 days less than normal.

Table 2. Temperature and precipitation summary for Alburgh, VT, 2023.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	48.3	57.1	65.7	72.2	67.0
Departure from normal	2.70	-1.28	-1.76	-0.24	-3.73
Precipitation (inches)	4.94	1.98	4.40	10.75	6.27
Departure from normal	1.87	-1.78	0.14	6.69	2.73
Growing Degree Days (base 32°F)	280	766	1023	1274	1098
Departure from normal	-132	-53	-40	22	-101

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.

Although all seed treatments had over 90% germination and the seeding rate adjusted prior to planting, none of the treatments achieved the target population of 350 live plants m^{-2} (Table 3). All barley harvested was above 14% moisture at harvest and required further drying for storage. The seed which had been treated at 70 C for 3 minutes had slightly higher test weight than all other treatments. Seed which had been treated at 65 C for 5 minutes had the highest yield of 2839 lbs ac^{-1} at 13.5% moisture content. This was statistically similar to the yields of both the untreated seed and the seed which had been treated at 70 C for 3 minutes.

Table 3. Agronomic characteristics of steam treated barley, Alburgh, VT 2023.

Treatment	Population	Smut incidence	Harvest moisture	Test weight	Yield at 13.5% moisture
	live plants m^2	%	%	lbs bu^{-1}	lbs ac^{-1}
Control	**191**[a†]	8.30	**15.4**	42.7[b]	2782[a]
90 seconds, 75C	158[b]	**6.60**‡	15.9	42.6[b]	2455[b]
3 minutes, 70C	139[b]	6.78	16.1	42.6[b]	2586[ab]
5 minutes, 65C	149[b]	7.00	15.6	**43.5[a]**	**2839[a]**
LSD (0.10)	30.9	NS§	NS	0.54	307
Trial Mean	159	7.17	15.7	42.8	2665

†Within a column, treatments followed by the same letter are not statistically different at p=0.10.
‡ Values in **bold** indicate the top performer for the production metric and varieties.
§NS –No significant difference between treatments.
¥ LSD –Least significant difference at p=0.10.

Steam treated seed had lower smut incidence than the untreated seed, although none of those differences were statistically significant. The lowest smut incidence occurred in the seed, which had been treated for 90 seconds at 75 C, a 20% reduction in the incidence of smut. However, this treatment also had the lowest yield by a statistically significant margin (Table 3, Figure 1).

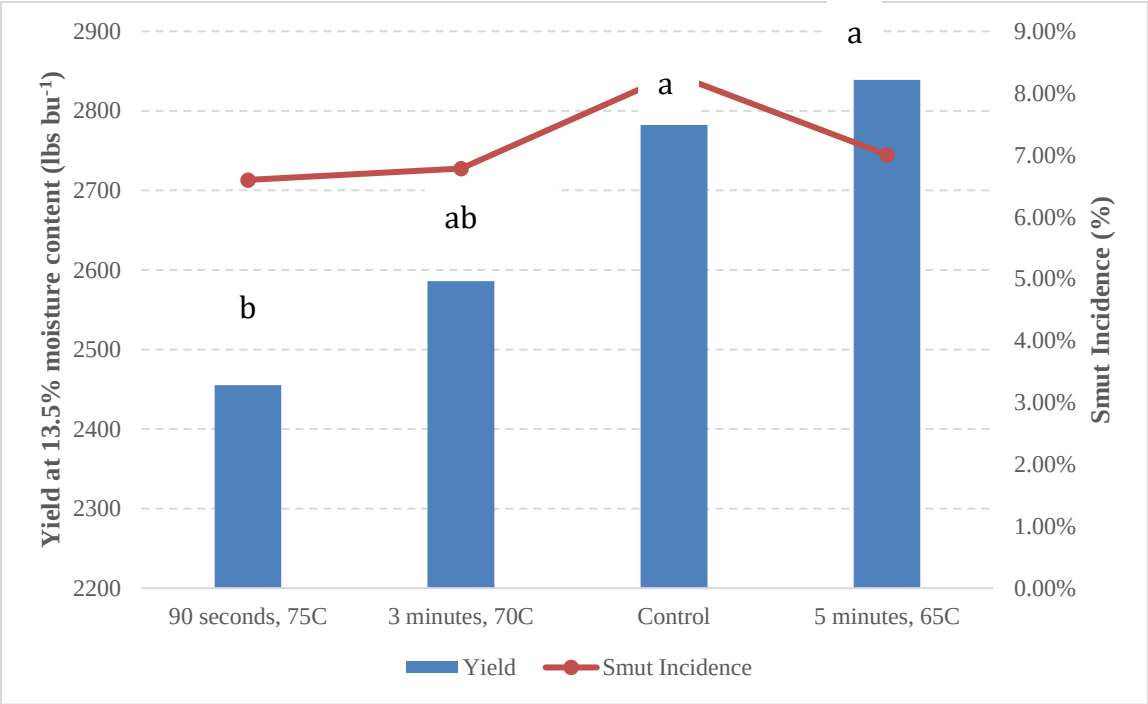

Figure 1. Yield and smut incidence in steam treated spring barley, Alburgh VT 2023. Treatments with the same letter did not differ significantly at p=0.10.

DISCUSSION

Although all steam treatments showed reductions in loose smut compared to the control, none of the differences were statistically significant. The germination rates measured in the lab prior to planting were above the targeted germination rate of 90%, indicating that this barley can withstand steam treatment at higher temperatures at the given time intervals, which could more effectively reduce the smut incidence. The germination responses of this seed lot to steam treatments will be more closely evaluated over the winter of 2023-2024 and steam treatments will be repeated in spring 2024 at higher temperatures for each time and temperature interval.

ACKNOWLEDGEMENTS

This research was funded by the OREI Grains project Award No. 2020-51300-32379. The NWCS team would like to thank Roger Rainville and his staff at the Borderview Research Farm in Alburgh, VT, for hosting this trial. We would also like to acknowledge Anna Brown, John Bruce, Kellie Damann, Catherine Davidson, Ivy Krezinski, Andrea Rainville, Lindsey Ruhl, Laura Sullivan, Sophia Wilcox Warren, and Sara Ziegler for their assistance with data collection and entry. The information is presented with the understanding that no product discrimination is intended and no endorsement of any product mentioned or criticism of unnamed products is implied.

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