NORTHWEST CROPS & SOILS PROGRAM

The Effects of Seed Steam Treatment on Dry Bean Yield and Quality

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UNIVERSITY OF VERMONT EXTENSION
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THE EFFECTS OF SEED STEAM TREATMENT ON DRY BEAN YIELD AND QUALITY

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Dry beans (Phaseolus vulgaris), a high-protein pulse crop, have been grown in the Northeast since the 1800's. As the local food movement expands, consumers have requested stores stock more and more locally produced foods, and heirloom dry beans are no exception. Currently, the demand for heirloom dry beans has exceeded the supply. Farmers are interested in starting or scaling up dry bean production but require assistance in overcoming production barriers. Local farmers have struggled to obtain consistent high yields and quality. Growers' lack of success with dry beans can be attributed to limitations in acquiring quality seed, poor stand establishment, diseases, and difficulty growing the crop to maturity by harvest. In an effort to improve seed quality, the University of Vermont Extension Northwest Crops and Soils Program collaborated with High Mowing Organic Seeds (Wolcott, Vermont), to evaluate the use aerated steam treatment on bean seed to reduce seedborne disease. A study to evaluate the impact of steam treated beans versus a non-treated control trial was initiated in June at Borderview Research farm, Alburgh, VT.

MATERIALS AND METHODS

The trial evaluated 3 bean types (Black Turtle, Kenearly Yellow Eye, King of the Early) and was conducted in 2017 at Borderview Research Farm in Alburgh, VT. For each bean type, the experimental design was a randomized complete block with three replications. Treatments were seeds receiving aerated steam treatment or non-treated control. Subsamples of each bean variety were taken to High Mowing Organic Seeds, Wolcott, VT, and placed in their aerated steam seed treatment system for 90 seconds at 68 degrees centigrade. The dry bean varieties, seed sources, relative maturity, and seed size are listed in Table 1.

Table 1. Varieties, seed sources, relative maturity, and seed size used in the steam treatment trial, Alburgh, VT, 2017.

Variety	Seed Source	Relative Maturity	Seed Size
Black Turtle	Saved seed, Borderview Research Farm, VT	Late	Small
King of the Early	Saved seed, Borderview Research Farm, VT	Medium	Large
Kenearly Yellow Eye	University of Minnesota, MN	Early	Medium

The soil type at the project site was a Benson rocky silt loam. The seedbed was prepared by conventional tillage methods. All plots were managed with practices similar to those used by producers in the surrounding areas (Table 2). The previous crops planted were winter wheat and barley. The plot area was spring plowed, disked and spike tooth harrowed to prepare for planting. The plots were planted on 4-Jun with a Monosem 2-row planter, at a rate of seven seeds per foot. Prior to planting, bean seed at was treated with dry bean inoculant (*Rhizobium leguminosarum biovar phaseoli*). Additionally, starter fertilizer was applied at 150 lbs ac^{-1} to the acre of 10-20-20. The plot size was 5' x 20', with 30-inch row spacing.

Table 2. Dry bean steam treatment trial specifics, Alburgh, VT, 2017.

Location	Borderview Research Farm, Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Winter wheat and barley
Tillage operations	Spring plow, disk, & spike tooth harrow
Plot size (ft)	5 x 20
Row spacing (inches)	30
Replicates	3
Starter Fertilizer (lbs ac^{-1})	150 (10-20-20)
Planting date	4-Jun
Seeding rate	7 seed ft^2 (~122,000 seeds ac^{-1})
Planter	Monosem 2-row planter
Tineweed	None
Cultivation	4-Row Brillion: 5-Jul
Pesticide	Pygantic (16 fl. oz. ac^{-1})
Harvest date	21-Sep and 4-Oct

The plots were mechanically cultivated with a 4-row Brillion cultivator on 5-Ju1.

Plots were scouted on 12-Jul by assessing beans in two 0.50m quadrats per plot for disease symptoms and insect damage. Quadrats were placed randomly within bean rows. In each quadrat, the number of plants was recorded. The number of plants with disease symptoms and insect damage were recorded. In addition, one plant per quadrat was pulled to examine roots for pest damage. Plants with unknown discoloration or damage were pulled, placed in a labeled plastic bag, refrigerated, and identified at the UVM Plant Diagnostic Laboratory. After scouting was completed, plots were sprayed 12-Jul with the OMRI approved pesticide Pyganic (MGK-9643) at a rate of 16 fluid ounces per acre, to help control a severe potato leafhopper outbreak.

At the time of harvest, plant height, lodging, pod distance to ground were determined and 10 pods from each plot were examined for the presence of disease. Plots were hand harvested and then threshed with a portable thresher with a rasp bar rotor (Kincaid, KS). Beans were then weighed to calculate yields and a DICKEY-John MINI GAC Plus meter or an OHAUS MB23 moisture balance was used to determine bean moisture content and test weight. Harvest occurred on 21-Sep and on 4-Oct.

Data was analyzed using mixed model analysis using the mixed 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 when the F-test was considered significant ($p<0.10$).

Variations in yield and quality can occur because of variations in genetics, soil, weather and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties 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 at the 10% level of probability are shown. Where the difference between two varieties 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 varieties. In the following example, variety A is significantly different from variety C, but not from variety B. The difference between A and B is equal to 725, which is less than the LSD value of 889. This means that these varieties did not differ in yield. The difference between A and C is equal to 1454, which is greater than the LSD value of 889. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that variety B was not significantly lower than the top yielding variety.

Variety	Yield
A	3161
B	3886*
C	**4615***
LSD	889

RESULTS

Seasonal precipitation and temperature recorded at a weather station in close proximity to the Alburgh trial site is shown in Table 3. The weather during much of the 2017 growing season was cooler and wetter than average, followed by a warmer and drier September and October. Above average rainfall was recorded in June, July, and August that totaled 4.31 inches above the 30-year average. There was an accumulation of 2335 Growing Degree Days (GDDs), which is 209 GDDs above the 30-year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2017.

Alburgh, VT	June	July	August	Sept	Oct
Average temperature (°F)	65.4	68.7	67.7	64.4	57.4
Departure from normal	-0.39	-1.90	-1.07	3.76	9.20
Precipitation (inches)	5.6	4.90	5.50	1.80	3.30
Departure from normal	1.95	0.73	1.63	-1.80	-0.31
Growing Degree Days (50-86°F)	468	580	553	447	287
Departure from normal	-7.00	-60.0	-28.0	129	175

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of data provided by the NOAA (1981-2010) for Burlington, VT.

There were significant differences in Common bacterial bean blight infection and Potato leafhopper (PLH) damage between the steam and the non-treated control in Black Turtle beans (Table 4). The incidence of Common bacterial bean blight in the steam treated Black Turtle beans was 4.33% compared to the non-treated control, 18.3%. Potato leafhopper damage was also significantly less in the steam treated Black Turtle bean plots, 13.3%, compared to 46.7% damage in the control plots. There were no significant differences in the steam treated and the non-treated control in Bacterial brown spot infection.

For King of the Early beans there were no significant differences between the steam and non-treated control for Bacterial brown spot infection, Common bacterial bean blight, and PLH damage (Table 4).

There were significant differences in Common bacterial bean blight infection and Potato leafhopper (PLH) damage between the steam and the non-treated control in Yellow Eye beans (Table 4). The incidence of Common bacterial bean blight in the steam treated Yellow Eye beans was 4.00% compared to the non-treated control, 20.0%. Potato leafhopper damage was also significantly less in the steam treated Yellow Eye bean plots, 10.0%, compared to 48.3% damage in the control plots.

Table 4. The impact of steam treatment on dry bean foliar and insect pests, Alburgh, VT.

Variety	Treatment	Bacterial brown spot	Common bacterial bean blight	Potato leafhopper
		%	%	%
Black Turtle	Control	**0.67**	18.3	46.7
Black Turtle	Steam	**0.67**	**4.33***	**13.3***
LSD (0.10)		NS	13.9	20.1
Trial Mean		0.67	11.3	30.0
King of the Early	Control	**4.00**	**15.0**	**15.0**
King of the Early	Steam	5.33	21.7	16.7
LSD (0.10)		NS	NS	NS
Trial Mean		4.67	18.3	15.8
Yellow Eye	Control	6.67	20.0	48.3
Yellow Eye	Steam	**1.67**	**4.00***	**10.0***
LSD (0.10)		NS	11.1	34.5
Trial Mean		4.17	12.0	29.2

*Treatments with an asterisk are not significantly different than the top performer in **bold**.
NS – No significant difference between treatments.

In all bean types, there were no significant differences in plant height, lodging, the pod distance to the ground, or the amount of pod disease in the steam treated compared to the non-treated control (Table 5).

Table 5. The impact of steam treatment on pre-harvest measurements of dry beans, Alburgh, VT.

Variety	Treatment	Plant height	Plant lodging	Pod distance to ground	Pod disease
		cm	%	cm	%
Black Turtle	Control	34.2	**0.00**	2.33	23.3
Black Turtle	Steam	**44.3**	**0.00**	**2.39**	**10.0**
LSD (0.10)		NS	NS	NS	NS
Trial Mean		39.3	0.00	2.36	16.7
King of the Early	Control	**28.2**	**0.00**	1.78	**60.0**
King of the Early	Steam	25.7	**0.00**	**3.06**	63.3
LSD (0.10)		NS	NS	NS	NS
Trial Mean		26.9	0.00	2.42	61.7
Yellow Eye	Control	26.1	**3.33**	**4.00**	43.3
Yellow Eye	Steam	**33.2**	6.67	2.61	**23.3**
LSD (0.10)		NS	NS	NS	NS
Trial Mean		29.7	5.00	3.31	33.3

Top performing treatments are shown in **bold**.
NS – No significant difference between treatments.

In all bean types, there were no significant differences in yield, harvest moisture, and test weight of the steam treated and the non-treated control (Table 6, Figure 1). All of the harvest moistures were above the recommended storage moisture of 13%, and therefore all samples had to be dried down. Additionally, all of the treatments met industry standards of 60 lbs bu^{-1} for test weight.

Table 6. The impact of steam treatment on dry bean yield and quality, Alburgh, VT.

Variety	Treatment	Yield @ 13% moisture	Harvest moisture	Test weight
		lb ac^{-1}	%	lbs bu^{-1}
Black Turtle	Control	1233	**15.1**	**63.2**
Black Turtle	Steam	**1618**	15.4	62.7
LSD (0.10)		NS	NS	NS
Trial Mean		1426	15.3	62.9
King of the Early	Control	762	**19.5**	**63.1**
King of the Early	Steam	**782**	19.9	62.3
LSD (0.10)		NS	NS	NS
Trial Mean		772	19.7	62.7
Yellow Eye	Control	731	**18.4**	**65.7**
Yellow Eye	Steam	**855**	**18.4**	64.2
LSD (0.10)		NS	NS	NS
Trial Mean		793	18.4	64.9

Top performing treatments are shown in **bold**.

NS – No significant difference between treatments.

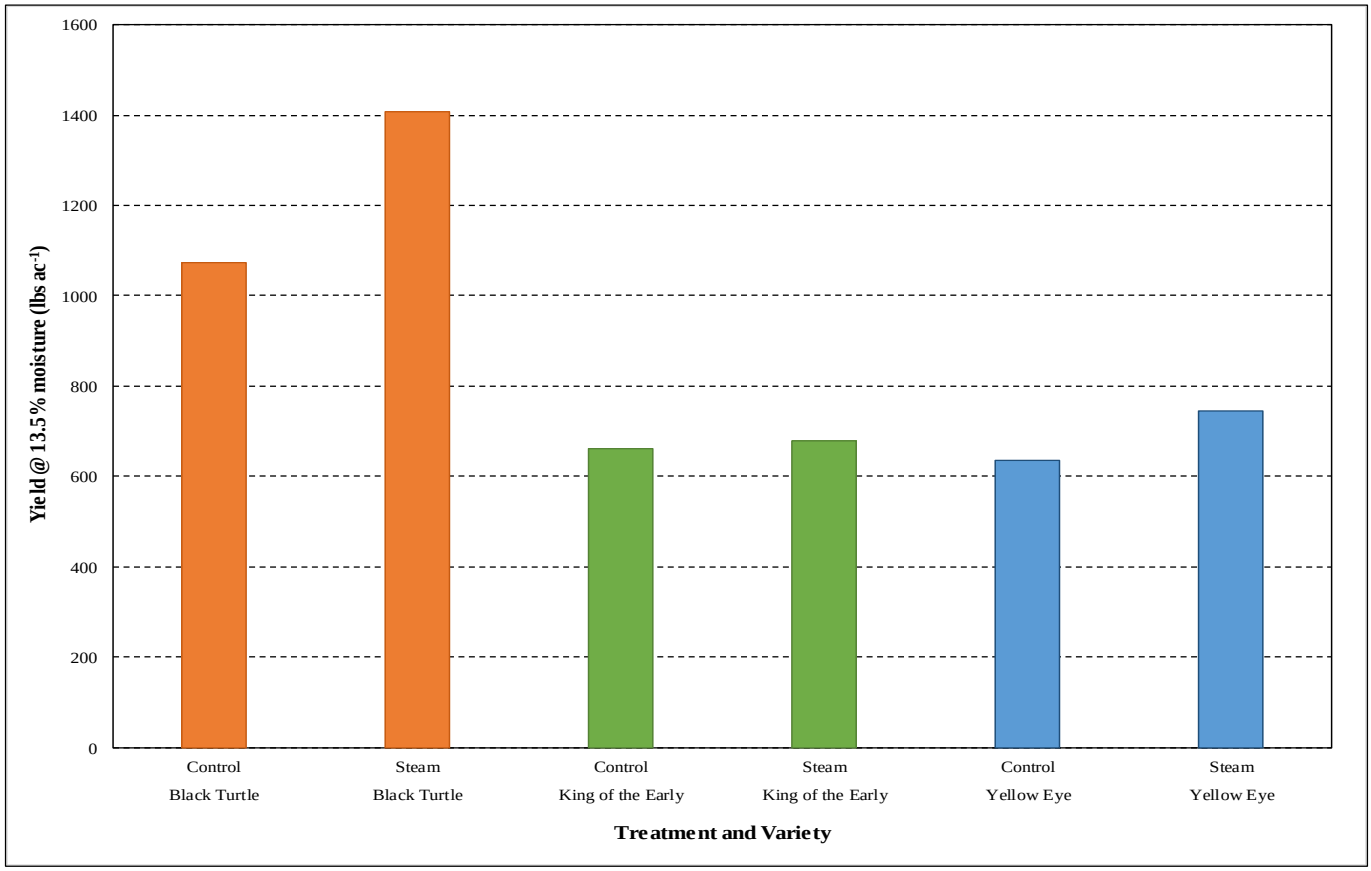

Figure 1. 2017 mean yields, of steam treated compared to the control by dry bean variety, Alburgh, VT.

DISCUSSION

It is important to remember that the results only represent one year of data. Overall, the 2017 growing season was challenging for growing dry beans. The cooler than average temperatures along with higher than normal rainfall throughout much of the growing season likely had impact on dry bean yields and created the ideal conditions for fungal pathogens. Interestingly, even with the challenging weather, we did see a reduced incidence of Common bacterial bean blight and Potato leafhopper damage in the steam treated Black Turtle and Yellow Eye beans. Although not significantly different, the steam treated seed of all three bean varieties yielded the highest.

More research needs to be done to determine the effects of steam treatment on seed quality and the impact it has on dry bean yields and quality. The Northwest Crops and Soils team plans to repeat this trial in 2018.

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