The Effects of Seed Steam Treatment on Dry Bean Yield and Presence of Pests & Disease

Dr. Heather Darby, UVM Extension Agronomist
Rory Malone, Erica Cummings, and Hillary Emick
UVM Extension Crops and Soils Technicians
(802) 524-6501

Visit us on the web at: http://www.uvm.edu/nwcrops

THE UNIVERSITY OF VERMONT EXTENSION

2018 THE EFFECTS OF SEED STEAM TREATMENT ON DRY BEAN YIELD AND PRESENCE OF PESTS & DISEASE

Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

Dry beans (*Phaseolus vulgaris*) are a high-protein pulse crop that have been grown in the Northeast since the 1800's. As local foods such as heirloom dry beans are increasingly in demand, there is also an increasing need for agronomic information specific to the production of dry beans in New England. Crops such as dry beans, especially in organic systems, are susceptible to seedborne pathogens that thrive in moist conditions. Foliar diseases like anthracnose have the potential to wipe out an entire crop, and can ruin future crops after the seed is infected. After plant residue or seed is infected, the disease becomes difficult to control. Seedborne diseases are often prevented via conventional fungicides. However, in organic systems, conventional seed treatment is prohibited. Alternative seed treatments that may reduce seedborne disease and are also available for use in organic systems, is a priority. The goal of this project was to evaluate the efficacy of aerated steam treatment to improve dry bean seed quality.

MATERIALS AND METHODS

The dry bean steam treatment trial was conducted at Borderview Research Farm in Alburgh, VT during the 2018 field season. The experimental design was a randomized complete block with four replicates. Plots were prepared with conventional tillage methods. The previous crop was hemp and the soil type was Covington silty clay loam with 0-3% slopes. The dry bean varieties 'Yellow Eye', 'Black Turtle', and 'King of the Early' (saved seed from Borderview Research Farm, Alburgh, VT) were planted on 22-May with a 4-row John Deere 1750 Conservation Planter fitted with Almaco seed distribution units (Nevada, IA). The beans were planted at a rate of 7 seeds ft^{-1} into 5' x 20' plots with 2 rows and 30" spacing (Table 1). For each variety, there were two treatments which consisted of steam treated seeds and untreated seeds. The steam treatment was performed by High Mowing Organic Seeds (Wolcott, VT). Bean seed was placed in their aerated steam seed treatment system for 90 seconds at 68 degrees centigrade.

Table 1. Agronomic information for the steam treated dry beans trial, Alburgh VT, 2018.

	Borderview Research Farm Alburgh, VT
Soil type	Covington silty clay loam, 0-3% slopes
Previous crop	Hemp
Tillage operations	Disc and spike tooth harrow
Planting date	22-May
Plot size (feet)	10 x 20
Row spacing (inches)	30
Replicates	4
Dry bean varieties	Yellow Eye, Black Turtle, King of the Early
Seeding rate (seeds ft^{-1})	7
Biomass sampling date	31-Jul
Harvest date	19-Oct

The dry bean varieties, seed sources, relative maturity, and seed size are listed in Table 2.

Table 2. Varieties, seed sources, relative maturity, and seed size used in the steam treatment trial, Alburgh, VT, 2018.

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	Saved seed, Borderview Research Farm, VT	Early	Medium

On 8-Jun, populations and vigor were assessed. Populations were taken by counting each of the two rows per plot to determine population per plot. Vigor was ranked on a 0-5 scale, where 0 was poor vigor and 5 was high vigor. Plots were scouted for severity of root rots, ascochyta, anthracnose, bacterial brown spot, common bacterial bean blight, and halo blight on 2-Jul, 12-Jul, 19-Jul, and 31-Jul. Plots insect pests included potato leaf hoppers, thrips, and aphids. Scouting data were recorded on a 0-5 severity scale, where 0 was none and 5 was severely damaged. The presence of other insects during scouting and plant growth stages were noted. Biomass samples were collected on 31-Jul in order to calculate dry matter yield per acre. Biomass samples were taken by pulling up 5 plants per plot and measuring biomass yield.

Root rot can be caused by pathogens like *Fusarium*, *Rhizoctonia,* or water molds in saturated conditions.

Anthracnose (*Colletotrichum lindemuthianum*), is a foliar fungal disease. Symptoms include dark or black lesion lines along leaf veins, and circular lesions on pods that are surrounded by reddish brown to black borders with a grayish black interior. White fungal growth can also be visible. These pod lesions begin as small brown spots, then grow to become sunken and necrotic. Anthracnose thrives in cool, humid weather.

Ascochyta fungi (*Ascochyta spp*.) include pathogens of several species of *Ascochyta*. Ascochyta thrives in cool, moist conditions, and can be identified by small circular brown spots on leaves in early growth stages, and larger, dark grey lesions in later growth stages. Leaf tissue around the lesions may turn black.

Bacterial brown spot is caused by the *Pseudomonas syringae* bacterium. Symptoms on plants include small circular, brown, necrotic lesions that are sometimes surrounded by yellow. Lesions may join to form linear streaks between veins on the leaf, and the centers of old lesions fall out, leaving strips or holes in the plant's leaves. Bacterial brown spot thrives in warm, humid conditions.

Common bacterial blight *(Xanthomonas campestris pv. Phaseoli)* begins with water-soaked spots on the underside of leaves, which then grow into larger necrotic areas with a bright yellow border. Eventually the damaged parts of the leaves appear burnt, but remain attached to the plant. Common bacterial blight favors wet, moist conditions.

Halo blight (*Pseudomonas syringae pv. Phaseolicola*) also favors cool and moist conditions. Symptoms include yellow-green halos around necrotic spots on the leaves, and can develop into systemic chlorosis, which is a condition where leaves do not produce enough chlorophyll.

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 this example, 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. This means that 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

Weather data were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 3). The summer 2018 field season was hotter and drier than normal, with above average temperatures from July to September, and record setting temperatures in July. From May to October precipitation was 4.36 inches less than the average. Between May to October 2018, there were 2731 Growing Degree Days (GDDs), 520 days above the 30-year normal.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2018.

Alburgh, VT	May	June	July	August	September	October
Average temperature (°F)	59.5	64.4	74.1	72.8	63.4	45.8
Departure from normal	3.10	-1.38	3.51	3.96	2.76	-2.36
Precipitation (inches)	1.90	3.70	2.40	3.00	3.50	3.50
Departure from normal	-1.51	0.05	-1.72	-0.95	-0.16	-0.07
Growing Degree Days (50°F-	352	447	728	696	427	81
Departure from normal	154	-27	88	115	109	81

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.

Plant Diseases and Pests Identified

In 2018, root rots and halo blight were not identified. Anthracnose and common bacterial blight were identified on three out of four scouting dates, ascochyta once, and bacterial brown spot was recorded on all dates (Table 4). The number of plots infected with anthracnose, bacterial brown spot, and common bacterial bean blight increased from the first to the last date. Overall plot severities for pathogens were low.

Table 4. Dry bean plant diseases identified by scouting date, Alburgh, VT, 2018.

Date	Anthracnose	Ascochyta	Bacterial brown spot	Common bacterial blight
2-Jul	X		X	X
12-Jul			X	
19-Jul	X	X	X	X
31-Jul	X		X	X

Thrips or aphid damage were not observed during scouting. Potato leaf hopper damage was recorded on all scouting dates (Table 5). Flea beetles and Japanese beetles were noted during the last two scouting dates. Severities of potato leaf hoppers were relatively moderate, with rankings predominantly 2 or 3 on the 0-5 severity scale. Potato leaf hoppers damage plants via feeding on the vascular tissue with piercing-sucking mouthparts. This restricts phloem and xylem flow to the rest of the leaf, resulting in yellowing and curling of the leaf edge.

Table 5. Dry bean pests identified, Alburgh, VT, 2018.

Date	Potato leaf hoppers	Flea beetles	Japanese beetles
2-Jul	X		
12-Jul	X		
19-Jul	X	X	X
31-Jul	X	X	X

Steam Treatment Trial Results

Bean Variety x Steam Treatment Interactions

There were no significant interactions between the varieties and the treatments, with the exception of potato leaf hopper severity on 12-Jul. On 12-Jul, severity ratings for potato leaf hopper damage were higher on the steam treated plots, with the exception of the 'Yellow Eye' variety. However, all severities for potato leaf hoppers on this date were 1 or less on the 0-5 scale. While this interaction was statistically significant, it likely holds no biological significance. Overall, the varieties seemed to respond similarly to the treatments.

Impact of Variety

'King of the Early' had the highest plant populations and vigor, followed by 'Black Turtle' and 'Yellow Eye' (Table 6). All populations and vigor assessments by variety were significantly different from each other. However, 'Black Turtle' had the highest biomass yield, followed by 'Yellow Eye', which were both significantly higher than the yield of 'King of the Early'. Scouting results by variety are shown in Table 7.

Table 6. Dry bean populations, vigor, and biomass moisture and yield by variety, Alburgh, VT, 2018.

Variety	Populations	Vigor	Dry matter yield
	plants ac^{-1}	0-5*	lbs ac^{-1}
Black Turtle	65122[b]	3.31[b]	**2391[a]**
King of the Early	**91367[a]**	**4.50[a]**	1794[b]
Yellow Eye	43397[c]	1.94[c]	2152[a]
LSD (0.10)	8222	0.48	350
Trial Mean	66629	3.25	2112

Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**
*Vigor was ranked on a 0-5 scale where 0 was poor vigor and 5 was vigorous.
LSD – Least significant difference.

Table 7. Dry bean scouting results by variety, Alburgh, VT, 2018.

Date	Variety	Ascochyta	Anthracnose	Bacterial brown spot	Common bacterial blight	Potato leaf hopper
		0-5*	0-5*	0-5*	0-5*	0-5*
2-Jul	Black Turtle	0.00	**0.00**	0.63[a]	**0.38**	0.50
	King of the Early	0.00	**0.00**	1.00[a]	0.50	**0.38**
	Yellow Eye	0.00	0.13	**0.13[b]**	0.50	0.75
	LSD (0.10)	NS	NS	0.49	NS	NS
	Date Mean	0.00	0.04	0.58	0.46	0.54
12-Jul	Black Turtle	0.00	0.00	0.13	0.00	0.38
	King of the Early	0.00	0.00	**0.00**	0.00	**0.13**
	Yellow Eye	0.00	0.00	**0.00**	0.00	**0.13**
	LSD (0.10)	NS	NS	NS	NS	NS
	Date Mean	0.00	0.00	0.04	0.00	0.21
19-Jul	Black Turtle	0.38	0.13	**0.88[b]**	**1.13[b]**	1.00
	King of the Early	**0.00**	**0.00**	1.50[a]	1.88[a]	1.38
	Yellow Eye	0.25	0.13	1.00[ab]	**1.13[b]**	**0.88**
	LSD (0.10)	NS	NS	0.57	0.52	NS
	Date Mean	0.21	0.08	1.13	1.38	1.09
31-Jul	Black Turtle	0.00	**0.13[b]**	**0.88**	**0.25[c]**	0.50
	King of the Early	0.00	0.75[a]	1.13	2.75[a]	0.50
	Yellow Eye	0.00	**0.13[b]**	1.50	1.25[b]	0.50
	LSD (0.10)	NS	0.43	NS	0.89	NS
	Date Mean	0.00	0.33	1.17	1.41	0.50

Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**
*Scouting data were ranked on a 0-5 scale where 0 was none and 5 was severely damaged.
LSD – Least significant difference.
NS- Not significant.

Ascochyta was only recorded on 19-Jul. On 31-Jul, 'Black Turtle' and 'Yellow Eye' had significantly lower anthracnose severity than 'King of the Early'. 'Yellow Eye' had significantly lower bacterial brown spot on 2-Jul, compared to the other bean types. 'Black Turtle' had the least bacterial brown spot on 31-

Jul. Only the last two scouting dates for common bacterial blight were statistically significant and Black Beans had lowest severity. All three varieties had the same average severity ranking for potato leaf hopper damage on 31-Jul.

Impact of Steam Treatment

There were no significant differences between the treatments for populations, vigor, or biomass yield (Table 8).

Table 8. Dry bean populations, vigor, and biomass moisture and yield by treatment, Alburgh, VT, 2018.

Treatment	Populations	Vigor	Dry matter yield
	plants ac^{-1}	0-5*	lbs ac^{-1}
Steam	**68825**	**3.29**	2066
None	64433	3.21	**2159**
LSD (0.10)	NS	NS	NS
Trial Mean	66629	3.25	2113

*Vigor was ranked on a 0-5 scale where 0 was poor vigor and 5 was vigorous.
Top performers are in **bold.**
LSD – Least significant difference.
NS- Not significant.

Disease and pest severity were extremely low and mostly insignificant by treatment, as seen in Table 9. Many of the average severities were 0 or close to 0 across all dates. Only one sampling date, 19-Jul, showed significant differences between severities for bacterial brown spot, where the untreated beans had a lower average severity than the steam treated beans. Overall, the disease and pest severity rankings were low and did not vary significantly by treatment.

Table 9. Dry bean scouting results by treatment, Alburgh, VT, 2018.

Date	Treatment	Ascochyta	Anthracnose	Bacterial brown spot	Common bacterial blight	Potato leaf hopper
		0-5*	0-5*	0-5*	0-5*	0-5*
2-Jul	Steam	0.00	0.08	0.58	**0.25**	**0.50**
	None	0.00	**0.00**	0.58	0.67	0.58
	LSD (0.10)	NS	NS	NS	NS	NS
	Date Mean	0.00	0.04	0.58	0.46	0.54
12-Jul	Steam	0.00	0.00	**0.00**	0.00	0.33
	None	0.00	0.00	0.08	0.00	**0.08**
	LSD (0.10)	NS	NS	NS	NS	NS
	Date Mean	0.00	0.00	0.04	0.00	0.21
19-Jul	Steam	**0.12**	0.17	1.5	**1.33**	1.08
	None	0.25	**0.00**	**0.75**	1.42	1.08
	LSD (0.10)	NS	NS	0.46	NS	NS
	Date Mean	0.19	0.08	1.13	1.37	1.08

31-Jul	Steam	0.00	0.42	1.33	1.67	0.67
	None	0.00	**0.25**	**1.00**	**1.17**	0.33
	LSD (0.10)	NS	NS	NS	NS	NS
	Date Mean	0.00	0.33	1.17	1.42	0.50

*Scouting data were ranked on a 0-5 scale where 0 was none and 5 was severely damaged.
Top performers are in **bold.**
LSD – Least significant difference.
NS- Not significant.

DISCUSSION

Bacterial brown spot was the most common foliar disease across all sampling dates. The last two scouting dates indicate that the 'Black Turtle' dry bean variety may be more resistant to common bacterial blight, and may be correlated with higher yield. However, 'King of the Early' also performed well in terms of populations and vigor.

It is important to remember this trial only represents one season of data. In July 2018, when the scouting was conducted, there was 1.72 inches less than average of precipitation. The overall warm and dry growing conditions resulted in low levels of foliar and root diseases. Warmer and drier conditions during seed germination and early plant growth resulted in the absence of root rot.

While the dry beans did not show significant differences by treatment, all disease and pest severities were low, so it is possible a difference by treatment may be detectable in a year with greater disease and pest levels. More research needs to be done to determine the effects of steam treatment on dry bean yields, quality, and pest and seedborne disease severity.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Program would like to thank Roger Rainville and the staff at Borderview Research Farm for their generous help and hosting this trial as well as John Bruce, Catherine Davidson, Haley Jean, Freddy Morin, Lindsey Ruhl, and Sara Ziegler for their assistance with data collection and entry. Any reference to commercial products, trade names, or brand names is for information only, and no endorsement or approval is intended.

UVM Extension helps individuals and communities put research-based knowledge to work.

THE UNIVERSITY OF VERMONT EXTENSION