NORTHWEST CROPS & SOILS PROGRAM

2015 Heirloom Dry Bean Variety Trial

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2015 HEIRLOOM DRY BEAN VARIETY TRIAL

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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 continues to diversify and expand, consumers are asking stores to carry more and more locally-produced foods, and dry beans are no exception. Currently, the demand for heirloom dry beans has far exceeded the supply. In an effort to support and expend the local bean market throughout the northeast, the University of Vermont Extension Northwest Crops and Soils (NWCS) Program, as part of a USDA NE-SARE Partnership Grant (PG15-045), established trials in 2015 to evaluated heirloom dry bean varieties under organic management to see which ones thrive in our northern climate. The trials were established at the Borderview Research Farm in Alburgh, VT and at our partner farm, Morningstar Meadows farm in Glover, VT.

MATERIALS AND METHODS

The experimental plot design at both locations was a randomized complete block with four replications in Alburgh and three replications in Glover. The heirloom dry bean varieties, seed sources, and seeding rates for both sites are listed in Table 1, starred varieties (*) were trialed in Glover.

Table 1. Names, seed sources, and seeding rates of the eighteen heirloom dry bean varieties planted in Alburgh, VT and Glover, VT 2015.

Variety	Seed Source	Seeding rate
		seeds ac^{-1}
Black Calypso*	Purcell Mountain Farms Moyie Springs, ID	77,000
European Soldier	Purcell Mountain Farms Moyie Springs, ID	72,000
Eye of Goat	Purcell Mountain Farms Moyie Springs, ID	83,000
Jacob's Cattle	Purcell Mountain Farms Moyie Springs, ID	76,000
King of the Early	Morningstar Meadows Farm, Glover, VT	78,000
Light Red Kidney	Purcell Mountain Farms Moyie Springs, ID	83,000
Orca *	Purcell Mountain Farms Moyie Springs, ID	112,000
Pinto	Morningstar Meadows Farm, Glover, VT	99,000
Raquel *	Purcell Mountain Farms Moyie Springs, ID	76,000
Rattlesnake *	Purcell Mountain Farms Moyie Springs, ID	86,000
Red Calypso *	Purcell Mountain Farms Moyie Springs, ID	72,000
Snow Cap *	Purcell Mountain Farms Moyie Springs, ID	83,000
Spanish Talosna *	Purcell Mountain Farms Moyie Springs, ID	79,000
Tiger Eyes	Purcell Mountain Farms Moyie Springs, ID	93,000
Tongues of Fire *	Purcell Mountain Farms Moyie Springs, ID	76,000
Vermont Appaloosa *	Purcell Mountain Farms Moyie Springs, ID	99,000
Vermont Cranberry *	Rogers Farmstead, Berlin, VT	86,000

Yellow Eye	Morningstar Meadows Farm, Glover, VT	76,000

The seedbeds at both the Alburgh and Glover locations were 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 crop planted at the Alburgh site was sweet corn and in Glover it was a mixture of grains and wheat. The field in Alburgh was spring plowed, disked and spike tooth harrowed to prepare for planting. At the Glover site the seedbed was prepared by spring moldboard plowed and followed by disk harrow. In Alburgh, the plots were planted on 5-Jun with a John Deere 1750 planter fitted with soybean cups. Seeding rates were determined by calibrating the planter for each bean type's recommended seeding rate. The trial at Glover was seeded on 10-Jun with a White 140 plate planter. Prior to planting, bean seed at both trial locations were treated with dry bean inoculant. Additionally in Glover, an organic approved fertilizer called MicroSTART 60 (3-2-3) was applied as a starter fertilizer at 350 lbs ac^{-1}. Plot size at both locations were 5' x 20', with 30-inch row spacing.

Table 2. General trial management information of the 2015 heirloom dry bean trials in Alburgh, VT and Glover, VT.

Trial Information	**Heirloom dry bean variety trials**	
	Borderview Research Farm, Alburgh, VT	Morningstar Meadows Farm, Glover, VT
Soil type	Benson rocky silt loam	Sandy loam
Previous crop	Sweet corn	Mixed grain & wheat
Tillage operations	Spring plow, disk, & spike tooth harrow	Moldboard plow & disk harrow
Plot size (feet)	5 x 20	5 x 20
Row spacing (inches)	30	30
Replicates	4	3
Starter Fertilizer (lbs ac^{-1})	None	350 – MicroSTART 60 (3-2-3)
Planting date	5-Jun	10-Jun
Tineweed	None	2x
Cultivation	4-Row Brillion: 17-Jun and 7-Jul	John Deere 4-row C-shank w/ crop shields: weekly for 5weeks starting 12-Jun
Harvest date	22-Sep	18-Sep

At both trial locations, plant populations were taken on 30-Jun by counting the number of plants in 10 feet of the two center rows of each plot.

In Alburgh, the plots were mechanically cultivated with a four row Brillion cultivator on 17-Jun and 7-Jul. In addition, the plots were weeded by hand once in June and again in July. At the Glover location, plots were tine weeded twice and a John Deere 4-row C-shank with crop shields was used to cultivate five times weekly starting 12-Jun.

On 14-Jul and 10-Aug, plots were scouted at the Alburgh site and on 15-Jul and 12-Aug in Glover. Trials were scouted by using two, 0.5 meter quadrats for disease symptoms and insect damage in each plot. Quadrats were placed randomly within bean rows. In each quadrat, the number of plants were 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.

At the time of harvest, at both trial locations, the number of pods were counted on three plants, three pod lengths were measured in centimeters, the number of beans in three pods were counted, and 10 pods were examined for the presence of disease. All plots were harvested in Alburgh on 22-Sep by hand. The harvested bean plants were then bundled and hung to dry overnight. Beans were then threshed with an Almaco Large Vogel plot thresher. Beans were then weighed to calculate yields and a DICKEY-John M3G moisture tester was used to determine bean moisture content. In Glover, all plots were harvested on 18-Sep by hand and threshed using an Almaco Large Vogel plot thresher. Beans were then weighed to calculate yield and a DICKEY-John MINI GAC Plus was used to determine bean moisture content and test weight.

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 ($p<0.10$). In Alburgh, diseased pods, moisture, and test weight were analyzed using the PROC MIXED procedure in SAS using the Tukey-Kramer adjustment, which means that each variety was analyzed with a pairwise comparison. There were significant differences among the two locations for most parameters, and therefore data from each location is reported independently.

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. Wheat varieties that were not significantly lower in performance than the highest variety in a particular column are indicated with an asterisk. In the example below, 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 trial site is shown in Table 3. The 2015 growing season brought a warmer and drier than average May followed by cooler and wetter June. Below average rainfall was recorded in July, August, and September totaled almost ten inches below the 30 year average. In Alburgh, there was an accumulation of 2578 Growing Degree Days (GDDs), which is 367 GDDs above the 30 year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2015.

Alburgh, VT	May	Jun	Jul	Aug	Sept
Average temperature (°F)	61.9	63.1	70.0	69.7	65.2
Departure from normal	5.5	-2.7	-0.6	0.9	4.6
Precipitation (inches)	1.94	6.42	1.45	0.00	0.34
Departure from normal	-1.51	2.73	-2.70	-3.91	-3.30
Growing Degree Days (base 50°F)	416	416	630	624	492
Departure from normal	218	-58	-10	43	174

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.
October 2013 precipitation data based on National Weather Service data from cooperative stations in Burlington, VT (http://www.nrcc.cornell.edu/page_nowdata.html).

The 2015 growing season at the Glover location brought a warmer than average May followed by cooler temperatures in June, July, August, and September (Table 4). Above average rainfall was recorded in the months of May, June, July, and September that totaled almost eight inches higher the 30 year average. In Glover, there was an accumulation of 1448 Growing Degree Days (GDDs), which is 687 GDDs below the 30 year average.

Table 4. Temperatures and precipitation summary for Glover, VT, 2015.

Newport, VT	May	Jun	Jul	Aug	Sep
Average temperature (°F)	54.9	54.6	62.4	62.9	59.0
Departure from normal	-1.43	-11.0	-7.56	-4.88	-0.99
Precipitation (inches)	3.58	8.59	6.44	2.40	4.05
Departure from normal	0.22	4.58	2.32	-1.82	0.66
Growing Degree Days (base 50°F)	217	163	384	401	283
Departure from normal	20.0	-305	-234	-151	-16.8

Based on National Weather Service data from cooperative observation stations in Walden, VT. Historical averages are for 30 years of NOAA data (1981-2010) from St. Johnsbury, VT.
Data taken from Sutton, VT when Newport data was not available

Heirloom Dry Bean Scouting

Several plant pests were identified through scouting this season (Table 5, Table 6). At both trial locations the fungal disease Anthracnose appeared to be an important systemic disease in bean fields (Image 1). Discoloration was observed that began as red spots on leaves that developed into lesions. As lesions developed, leaf veins turned reddish-dark brown. Signs of bean pod infection are black, circular lesions on the pod. Anthracnose survives in crop residue and seeds.

Table 5. 2015 Heirloom dry bean pests identified in Alburgh, VT.

Variety	Alternaria	Anthracnose	Fusarium	Bacterial brown spot	Common bacterial bean blight	Potato leaf-hopper
Black Calypso	X	X	X	X	X	X
European Soldier		X	X		X	
Eye of Goat		X			X	
Jacob's Cattle		X	X	X	X	
King of the Early	X				X	
Light Red Kidney					X	
Orca					X	
Pinto	X				X	X
Raquel						
Rattlesnake		X			X	
Red Calypso		X			X	
Snow Cap		X			X	
Spanish Talosna	X	X			X	
Tiger Eyes		X	X		X	
Tongues of Fire			X		X	X
Vermont Appaloosa	X	X			X	X
Vermont Cranberry		X			X	X
Yellow Eye				X	X	

Image 1. Reddish, dark brown anthracnose in leaf veins and lesions on pods appear in pictures on left and right. Note the leaf curling from potato leafhopper in the middle picture.

At the Alburgh location Anthracnose was identified on Black Calypso, European Soldier, Eye of Goat, Jacob's Cattle, Rattlesnake, Red Calypso, Snow Cap, Spanish Talosna, Tiger Eye, Vermont Appaloosa, and Vermont Cranberry. The most prevalent disease was Common bacterial bean blight. Additional pests identified in Alburgh include; Alternaria, Fusarium, Bacterial Brown Spot, and Potato Leafhoppers. Interestingly, Potato Leafhopper was the only insect pest, at both locations, identified. This insect causes leaf damage often referred to as "Hopper burn" (Image 1).

Table 6. 2015 Heirloom dry bean pests identified in Glover, VT.

Variety	Anthracnose	Rust	Bacterial brown spot	Common bacterial bean blight	Potato leaf-hopper
Black Calypso	X		X	X	X
Ocra			X		X
Raquel	X			X	X
Rattlesnake	X		X	X	X
Red Calypso		X	X	X	X
Snow Cap	X		X	X	
Spanish Talosna			X		X
Tongue of Fire	X		X		X
Vermont Appaloosa	X		X	X	X
Vermont Cranberry	X	X	X	X	X

In Glover, Anthracnose was identified on Black Calypso, Raquel, Rattlesnake, Snow Cap, Tongue of Fire, Vermont Appaloosa, and Vermont Cranberry. Bacterial brown spot and Common bacterial bean blight were also prevalent. Leaf Rust was identified on Red Calypso and Vermont Cranberry. Potato Leafhoppers were more of an issue in Glover, all varieties, except for Snow Cap, showed signs of "hopper burn".

Heirloom Dry Bean Harvest

In Alburgh, Spanish Talosna had the highest plant population (58,370 plants) (Table 7). All plant populations were below target seeding rates. The highest number of pods per plant was Orca with 23 pods and the lowest was Red Calypso with 7 pods. The longest pod was Vermont Appaloosa, (15.8 cm), Rattlesnake also had long pods (15.4 cm) and therefore, was not significantly different from Vermont Appaloosa. In addition, Rattlesnake had the highest number of beans per pod (7 beans). The highest yielding variety was Pinto (1476 lbs ac^{-1}) and the lowest yielding was European Soldier (169 lbs ac^{-1}) (Figure 1).

Table 7. 2015 Heirloom dry bean plant populations and harvest measurements, Alburgh, VT.

Variety	Plant population	Pods per plant	Pod length	Beans per pod	Yield
	# per ac^{-1}	#	cm	#	lbs ac^{-1}
Black Calypso	23,740	14	10.4	5	402
Jacob's Cattle	33,323	15	13.3	4	806
King of the Early	39,857	8	13.6	4	946
Ocra	14,593	**23***	10.4	5	451
Pinto	36,590	14	12.7	5	**1,476***
Raquel	34,412	8	11.1	4	389
Rattlesnake	45,085*	12	15.4*	**7***	993
Red Calypso	21,344	7	9.4	6	183
Light Red Kidney	28,967	12	14.3	5	1,027
Snow Cap	27,443	8	14.1	5	590
European Soldier	11,979	13	11.3	5	169
Spanish Talosna	**58,370***	11	11.8	4	917
Tigers Eye	43,342*	9	12.3	4	857
Tongues of Fire	34,848	10	11.5	5	761
Vermont Appaloosa	49,005*	10	**15.8***	5	1,043
Vermont Cranberry	33,977	14	10.3	5	818
Yellow Eye	30,492	11	11.4	5	1,076
LSD (0.10)	15,936	6	1.33	1	386
Trial Mean	23,740	12	12.3	5	759

Values shown in **bold** are of the highest value or top performing.
* Dry beans that did not perform significantly lower than the top performing variety in a particular column is indicated with an asterisk.

In Alburgh there were no significant differences in the number of diseased pods and harvest moisture (Table 8). The variety with the highest test weight was Spanish Talosna (58.8 lbs bu^{-1}). However, all varieties were below industry standards of 60 lbs bu^{-1}.

Table 8. 2015 Severity of pod disease, harvest moisture, and test weight, Alburgh, VT.

Variety	Diseased pods	Harvest moisture	Test weight
	# out of 10	%	lbs bu^{-1}
Black Calypso	10a	**13.0a**	56.8a
Jacob's Cattle	10a	14.6a	57.9a
King of the Early	10a	14.0a	55.7ab
Ocra	9a	14.1a	57.5a
Pinto	10a	16.4a	52.3bc
Raquel	10a	16.1a	55.8ab
Rattlesnake	**8a**	13.9a	52.8bc

Red Calypso	10a	13.6a	-
Light Red Kidney	10a	16.7a	54.5ab
Snow Cap	9a	15.3a	47.0c
European Soldier	10a	-	-
Spanish Talosna	9a	14.8a	**58.8a**
Tigers Eye	10a	17.9a	52.8bc
Tongues of Fire	10a	13.2a	52.5
Vermont Appaloosa	10a	18.1a	58.5a
Vermont Cranberry	10a	16.1a	55.9ab
Yellow Eye	10a	14.0a	58.0a
p-value	NS	NS	<0.0001

Within a column values followed by the same letter are not significantly different.
'-' indicates there wasn't enough sample to measure.
NS – no significant difference.

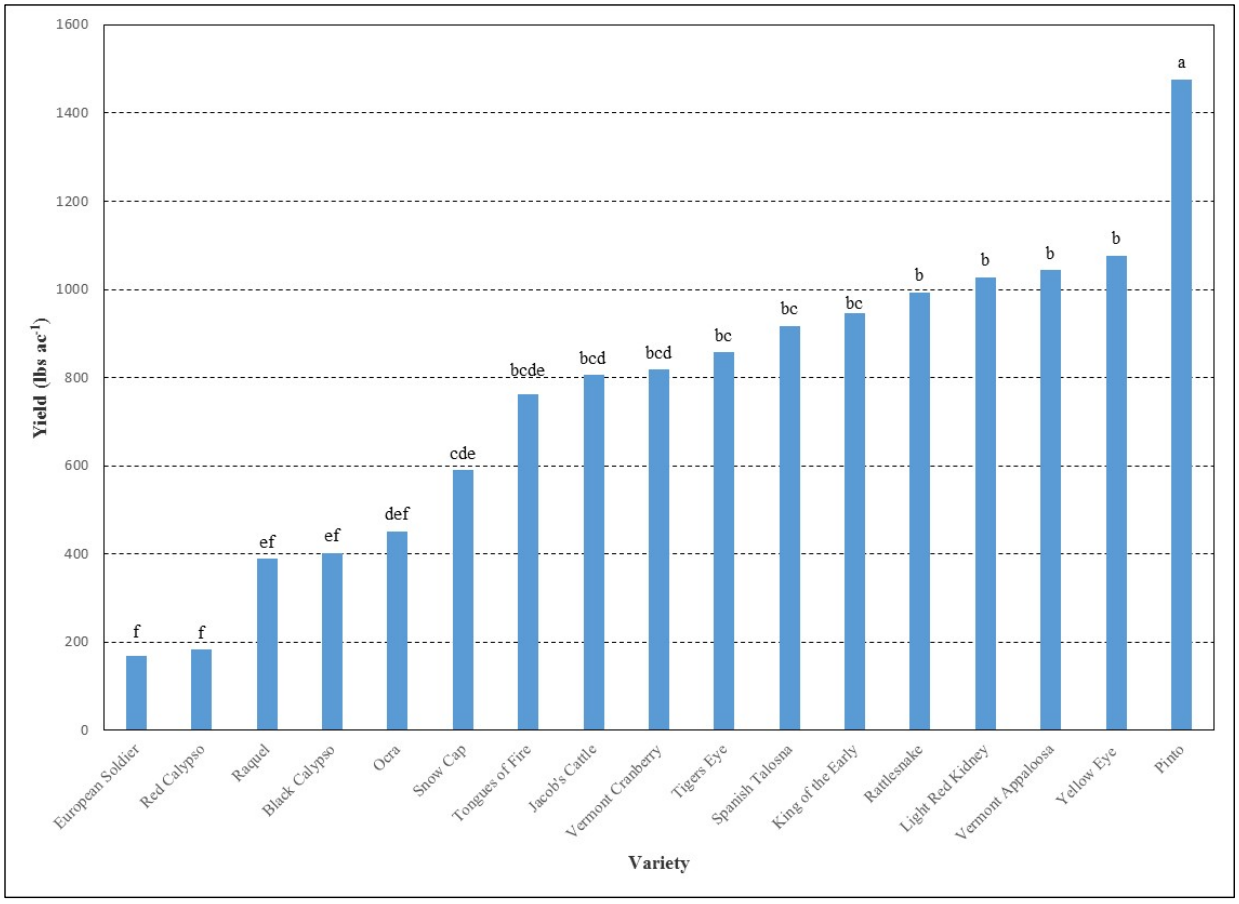

Figure 1. 2015 Heirloom dry bean yields, Alburgh, VT.
Varieties with the same letter did not differ significantly in yield

Plant population, pods per plant, beans per pod, and the number of diseased pods were all significantly different at the Glover trial location (Table 9). Red Calypso had the highest plant population (61,274 plants) and the lowest plant population was Spanish Talosna (11,906 plants). All of the plant populations of the varieties trialed at this site were also below the targeted seeding rates. The highest number of pods

per plant was Orca with 22 pods. Rattlesnake beans had the largest number of beans per pod (7 beans) and also had lowest number of diseased pods (3 pods). Snow cap had the highest pod disease incidence, 10 out of 10 pods.

Table 9. 2015 Heirloom dry bean plant populations and harvest measurements in Glover, VT.

Variety	Plant population	Pods per plant	Beans per pod	Diseased pods
	# per ac^{-1}	#	#	# out of 10
Black Calypso	45,012	14	5	8
Orca	59,242*	**22***	6	7
Raquel	41,818	14	4	7
Rattlesnake	42,398	16	**7***	**3***
Red Calypso	**61,274***	5	5	9
Snow Cap	48,206	10	5	10
Spanish Talosna	11,906	13	4	9
Tongues of Fire	27,588	8	5	8
Vermont Appaloosa	28,750	10	6	9
Vermont Cranberry	20,328	14	5	9
LSD (0.10)	7646	6	1	2
Trial Mean	38652	13	5	8

Values shown in **bold** are of the highest value or top performing.
* Dry beans that did not perform significantly lower than the top performing variety in a particular column is indicated with an asterisk.

In Glover, harvest yield, mositure, and test weight differed significantly by variety (Table 10). The highest yielding variety was Rattlesnake (1774 lbs ac^{-1}). Spanish Talosna was also high yielding (1364 lbs ac^{-1}). The lowest yeilding harvested variety was Snow Cap (259 lbs ac^{-1}) (Figure 2). Red Calypso had so much disease that it could not be harvested. The lowest harvest moisture was Orca (7.33%). Additional varieties with low moistures included; Rattlesnake (7.40%) , and Spanish Talosna (9.97%). All the other moistures were above 13% and therefore, required drying for longterm storage. Vermont Appaloosa had the highest test weight of 62.5 lbs bu^{-1}, exceeding industry standards of 60 lbs bu^{-1}. Spanish Talosna also had a test weight (61.0 lbs bu^{-1}) that surpassed industry satndards.

Table 10. 2015 Heirloom dry bean yield and quality, Glover, VT.

Variety	Yield	Harvest moisture	Test weight
	lbs ac^{-1}	%	lbs bu^{-1}
Black Calypso	651	20.2	57.4
Orca	596	**7.33***	57.0
Raquel	814	22.2	57.8
Rattlesnake	**1,774***	7.40*	56.7
Red Calypso	-	-	-
Snow Cap	259	13.2	50.0

Spanish Talosna	1,364*	9.97*	61.0*
Tongues of Fire	1,052	17.9	55.0
Vermont Appaloosa	785	19.0	**62.5***
Vermont Cranberry	1,011	24.9	57.5
LSD (0.10)	461	4.90	3.14
Trial Mean	923	15.8	57.2

Values shown in **bold** are of the highest value or top performing.
* Dry beans that did not perform significantly lower than the top performing variety in a particular column is indicated with an asterisk.
'-' indicates crop failure.

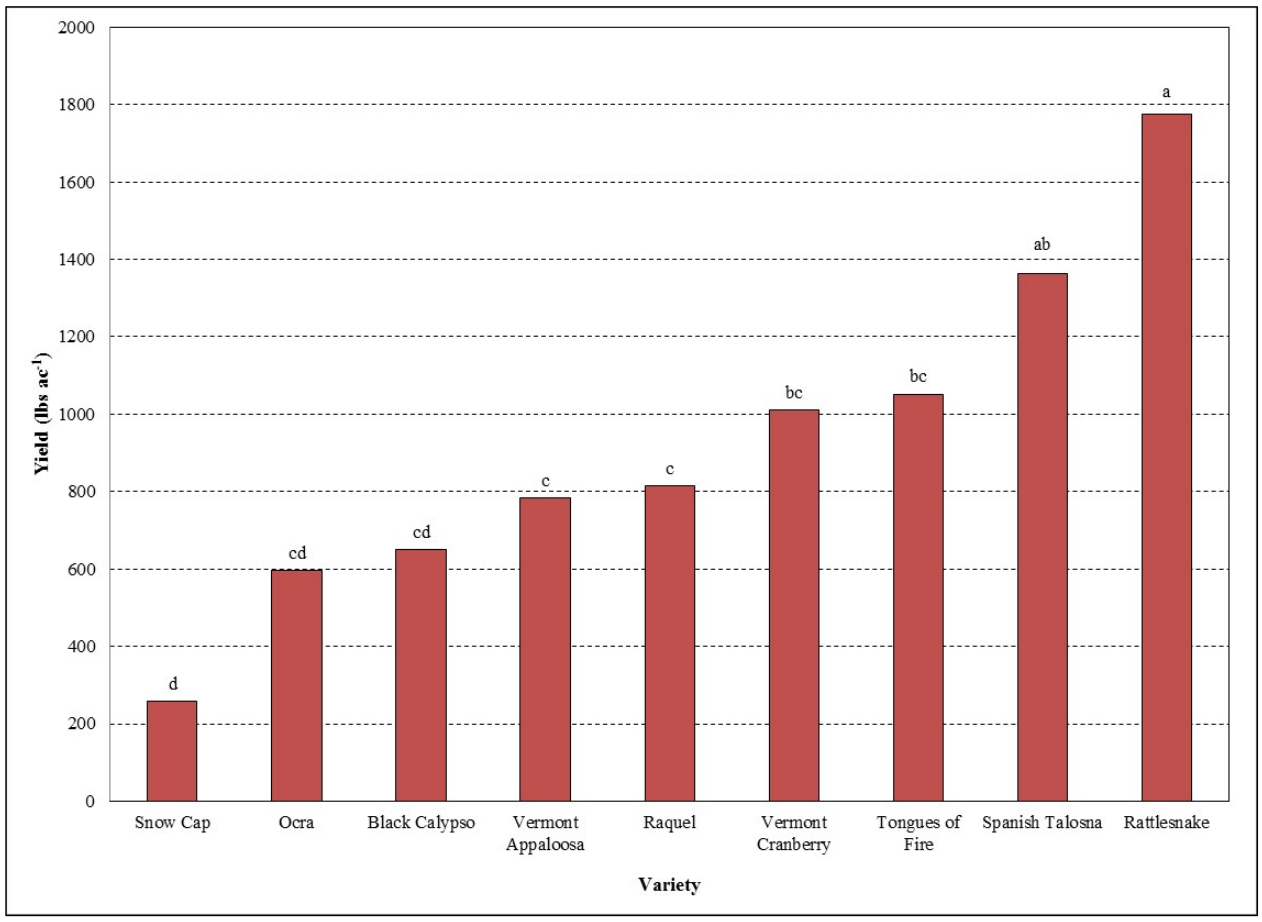

Figure 2. 2015 Heirloom dry bean yeilds, Glover, VT.
Varieties with the same letter did not differ significantly in yield.

DISCUSSION

It is important to remember that the results only represent one year of data. The 2015 growing season brought many challenges during the growing season. Poor seed quality resulted in low plant populations and poor stand establishment in both Glover and Alburgh, which resulted in higher weed pressure and lower than expected yields. Due to poor stands in several plots, seed germination tests were performed by placing 20 seeds in moist paper towels in a plastic bag in the dark at room temperature for 4 days. Each

day germinated seeds were removed and at the end on the fourth day the number on ungerminated seed were counted and the percent germination calculated (Table 11). All of the seed was purchased so it was surprising how variable the germination rates were (0-100%).

Dry bean variety	Seed germination
	%
Black Calypso	60
European Soldier	0
Eye of Goat	25
Jacob's Cattle	55
King of the Early	95
Light Red Kidney	40
Orca	80
Pinto	36
Raquel	70
Rattlesnake	100
Red Calypso	5
Snow Cap	45
Spanish Talosna	95
Tiger Eyes	90
Tongues of Fire	95
Vermont Appaloosa	90
Vermont Cranberry	100
Yellow Eye	29

In Alburgh, the weather in June of below average temperatures and higher than average rainfall resulted in delayed, or prevented mechanical cultivation, and in turn created ideal conditions for weed growth and potentially increased root rot diseases like Fusarium. The low plant populations permitted even more weed growth. Even hand cultivation wasn't enough to knock back the weeds. These factors likely lead to lower than expected yields and quality in Alburgh. The weather at Morningstar Meadows Farm can be summed up as cool, 687 GDDs below the 30 year average, and wet, eight inches above normal. Weeds were also an issue at this site, however, the sandy soil allowed for better drainage and therefore, more mechanical cultivation was used to help reduce weed pressure.

Several plant pests were identified this season: Anthracnose, Common bacterial bean blight, and Bacterial brown spot were the most prevalent diseases. All three of these plant pathogens can be seed-borne and their spores can overwinter on crop debris. Interestingly, Raquel was the only variety to not have Common bacterial bean blight at the Alburgh site. The plant pathogens Fusarium and Alternaria, were identified in Alburgh as well, but with low incidence. The Fusarium fungal spores can live in the soil or on bean crop debris for several years, while Alternaria is an opportunistic fungus that infects plant tissue through wounds or following bacterial infections. There were fewer plant pests identified at the Glover location, but more varieties affected by one or more of the above described pathogens. The Red Calypso beans were completed covered in disease to the extent that they couldn't be harvested. Interestingly, the Glover site had a higher incidence of Potato leafhopper damage.

Overall, there were three heirloom dry bean varieties that performed relatively well this season across trial sites for both yield and quality: Vermont Appaloosa, Spanish Talosna, and Rattlesnake.

More research needs to be done to determine which varieties thrive in our climate and therefore, the Northwest Crops and Soils team plans on repeating this trial in 2016 at both trial locations.

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