2009

Vermont Food Grade Soybean Performance Trial Results

Heather Darby
University of Vermont, heather.darby@uvm.edu

Erica Cummings
University of Vermont

Amanda Gervais
University of Vermont

CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES

2009
Vermont Food Grade Soybean Performance Trial Results

Dr. Heather Darby
UVM Extension Agronomic Specialist
Rosalie Madden, Erica Cummings, and Amanda Gervais
802-524-6501

2009 VERMONT FOOD GRADE SOYBEAN VARIETY PERFORMANCE TRIALS
Heather Darby, University of Vermont Extension

heather.darby@uvm.edu

In 2009, the University of Vermont Extension continued their evaluation of organic food grade soybean varieties at two locations. The purpose of the program was to provide yield comparisons, growth characteristic observations, and bean quality evaluations of food grade soybeans in Vermont's climate. Performance trials were established as replicated research trials in northern Vermont.

Food Grade Soybeans:

Over the past few years, UVM Extension has documented that high quality food grade soybeans can be produced in Vermont. There are many requirements that growers need to be aware of for food grade soybeans to be acceptable to processors. The most important is the cleanliness of the beans. Processors are interested in beans that will produce a uniform, pure colored soy product. This means that the beans must be harvested properly, with the combine set far enough off of the ground so that no dirt or rocks are picked up that might stain the beans. It is also important to note that weed sap can cause beans to be off-colored, so fields should be relatively weed free. However, attention must be paid during cultivation so that dirt is not kicked up over the beans, yet again causing staining. If weeds are problematic, some farmers choose to harvest after a killing frost, as the frost will kill the weeds and allow them to dry down prior to harvest. This will prevent them from staining the beans. It goes without saying that food grade soybeans must meet other regulations as well, and be free of *E. coli*, rodent feces, pathogens, and GMO free (if raised for organic production). When choosing soybean varieties it is important to select cultivars that have a clear or yellow hilum, to prevent discoloration of the final soy product. Beans should also generally be above 30% protein. Cultivars that produce uniformly sized and colored beans should be favored. Mostly importantly, a variety that fits the climate of the production area is of absolute importance. If beans do not mature, then a crop is not marketable at all! Soybean varieties are broken down into Maturity Groups ranging from 000 up to 13. In Vermont soybean maturity groups from 000 up to early group 2 are grown. The Champlain Valley offers a longer growing season and generally farmers grow group 1 to early group 2. In shorter season climate farmers will plant 000 to early group 1. To the best of our knowledge food grade soybeans are not available for very early maturity groups 000 – 0.

Replicated Research Trials:

Replicated soybean variety trials were conducted in Alburgh and Hardwick, Vermont. The experimental design at both locations was a randomized complete block with four replications, with soybean varieties as the treatments. Varieties planted in Alburgh were maturity group 0.6 to 1.4, and varieties planted in Hardwick were group 0.4-1.4 (Table 1).

Table 1. Varieties and maturity groupings trialed in Hardwick and Alburgh, VT.

Variety	Producer	Maturity group	Alburgh	Hardwick
06F8	Blue River Organics	0.6	x	x
1F44	Blue River Organics	1.4	x	x
Auriga	Elite - La Coop Fédérée	0.4		x
CFS062	Elite - La Coop Fédérée	0.5		x
Dares	Elite - La Coop Fédérée	0.8		x
Phoenix	Elite - La Coop Fédérée	0.1		x
Acora	Prograin	1.1	x	x
Korus	Prograin	0.9	x	x
Lotus	Prograin	0.8	x	x
Naya	Prograin	0.4		x
Nova	Prograin	0.4	x	x
Ohgata	Prograin	0.5	x	x
Oria	Prograin	0.9	x	x
Venus	Prograin	0.5	x	x

The season's precipitation and temperature were recorded at weather stations in close proximity to the test sites, and are shown in Table 2 and 3 for the Alburgh and Hardwick sites respectively. Both locations had cooler temperatures and higher than normal rainfall patterns than the 30 year average, affecting yields.

Table 2. Temperature, precipitation, and calculated Growing Degree Days (GDD) for Alburgh, VT.

	June	July	August	September	October
Average Temperature	62.8	65.9	67.7	57.7	44.1
Departure from Normal	-3.0	-5.2	-1.3	-2.7	-4.7
Precipitation	5.19	8.07	3.59	4.01	5.18
Departure from Normal	+1.98	+4.66	-0.26	+0.55	+0.79
Growing Degree Days	398.0	494.5	557	286	40.5
Departure from Normal	-76.0	-158.1	-32.0	-26.0	-61.8

Based on National Weather Service data from South Hero, VT. Historical averages are for 30 years of data (1971-2000).

Table 3. Temperature, precipitation, and calculated GDD for Hardwick, VT.

	May	June	July	August	September	October
Average Temperature	50.3	58.6	62.1	62.9	52.6	39.3
Departure from Normal	0.9	-1.8	-2.8	+0.1	-1.2	-2.8
Precipitation	5.74	4.69	5.82	4.66	2.62	4.17
Departure from Normal	+1.97	+0.38	+1.39	-0.13	-1.35	+0.57
Growing Degree Days	177.0	305.0	405	461	264.5	24.5
Departure from Normal	-69.5	-64.0	-56.9	+45.6	+5.0	-37.5

Based on National Weather Service data from Sutton, VT. Historical averages are for 30 years of data (1971-2000).

The seedbed at each location was prepared by conventional tillage methods. All plots were managed with practices similar to those used by producers in the surrounding areas (Table 4). In Alburgh, plots were originally seeded at 175,000 seeds per acre, but due to poor germination, and unsuccessful tineweeding, were reseeded again 3 weeks later at 180,000 seeds/acre with a John Deere 1750 four row corn planter. The plot size was 5' x 25'. Plots were seeded at 175,000 seeds per acre in Hardwick with a Planet Junior and an Earthway Seeder. Plots were 5' x 10'. Both sites were harvested with an Almaco SP50 plot combine. Yields were measured by weighing each plot separately on a platform scale. At harvest, moisture was measured for each plot. In Hardwick, data was also recorded on a five plant subsample of height, pod distance to the soil, and number of pods per plant. In Alburgh, many plots were so weedy, and germination was so poor, that some plots were given up for lost and only yield data was collected on those that remained, resulting in missing data. Weight per seed was recorded for all plots by weighing 10 seeds on a Scout Pro SP402 balance (Ohaus Corporation), and subsamples were analyzed for protein and fat content. All data was analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate treatment means when the F-test was significant ($P< 0.10$). Since there was missing data at the Alburgh site, a Tukey-Kramer test was used to separate treatment means at the $P< 0.10$.

Table 4. Soybean Variety Trials, general plot management in Alburgh and Hardwick, VT.

	Borderview Farm, Alburgh, VT	**High Mowing Seeds, Hardwick, VT**
Soil type	Silt loam	Sandy loam
Seeding rate	180,000 seeds/acre	175,000 seeds/acre
Previous crop	Wheat	Cover crop
Tillage operations	Spring plow, disk	Spring plow, disk
Planting date	6-15-2009	6-5-2009
Row width	30 inches	30 inches
Fertilizer	2 ton/acre poultry compost	2 ton/acre poultry compost
Cultivation	Tineweed, inter-row cultivation, 3x	Handweeded
Harvest date	11-2-2009	10-23-2009

Figure 1. Hardwick variety trials drying down, 10-13-2009, just prior to harvest.

Alburgh Trial Results:

The trial in Alburgh, VT was first planted on May 21, 2009 in what turned out to be a particularly weedy area. Germination was poor, and tineweeding was attempted as a means of cultivation, but resulted in uprooting many seedlings. Trials were replanted on June 15, 2009, just prior to one month of rain (Table 2). Due to moist conditions, cultivation was not possible, and the weeds got out of hand, completely eclipsing certain treatments, which were subsequently mowed down.

As a result, out of 40 plots planted, 19 were harvested. The varieties Naya, 1F44 and Nova were completely eliminated from the trial due to weed competition. In Table 5, results of the Alburgh trial are presented.

Table 5. Results for Alburgh Food Grade Soybean Trial.

Variety	Harvest moisture	Yield at 13% moisture	Weight of 10 seeds	Protein	Fat
	%	lbs/acre	grams	% DM	% DM
06F8	15.5	**2640**	1.67 b*	35.6 abc	18.2 bcdef
Acora	15.3	1870	2.19 ab	34.3 c	18.5 cdef
Korus	**15.9**	1520	2.07 b	38.2 ab	17.8 bcde
Lotus	**15.9**	1130	2.25 ab	37.1 abc	**15.0 a**
Ohgata	15.5	2010	2.07 ab	33.7 c	20.2 f
Oria	**15.9**	1730	**3.00 a**	36.1 abc	16.4 ab
Venus	15.6	2000	1.67 b	**38.4 a**	17.5 bc
Trial means	15.6	1840	2.1	36.3	17.7

*Values with the same letter within a column are not statistically different.

Overall there was no significant difference among variety yields. While small beans do not have an effect on tofu yields or quality, generally larger beans are preferred, as long as they are uniform in shape (Chang and Hou 2003). Oria produced the largest seeds, and upon visual inspection were white, round, and uniformly shaped, as is favored by soy product processors. Venus, on the other hand, whether due to the weedy conditions, or genetics, were small, darker and discolored, despite having very good protein content.

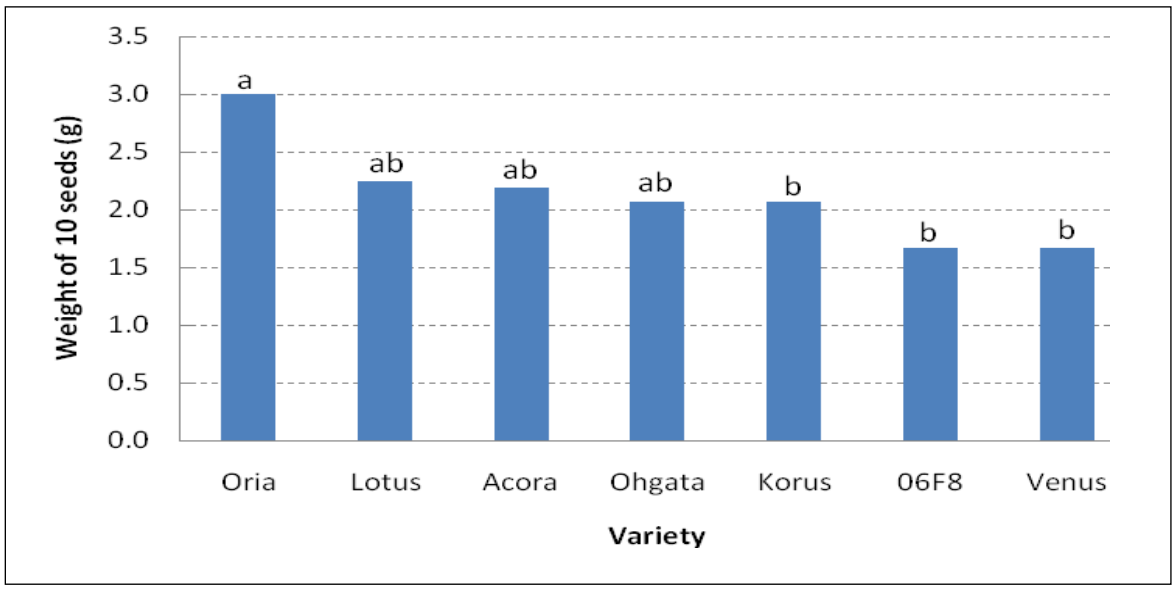

Figure 2. Varietal influence on the weight of 10 seeds in food grade soybeans.

While protein is the most important consideration for soy products like soymilk and tofu, fat is also important. It has been found that seed oil content is negatively correlated with soymilk and tofu yields, as well as tofu quality parameters (Poysa and Woodrow 2002).

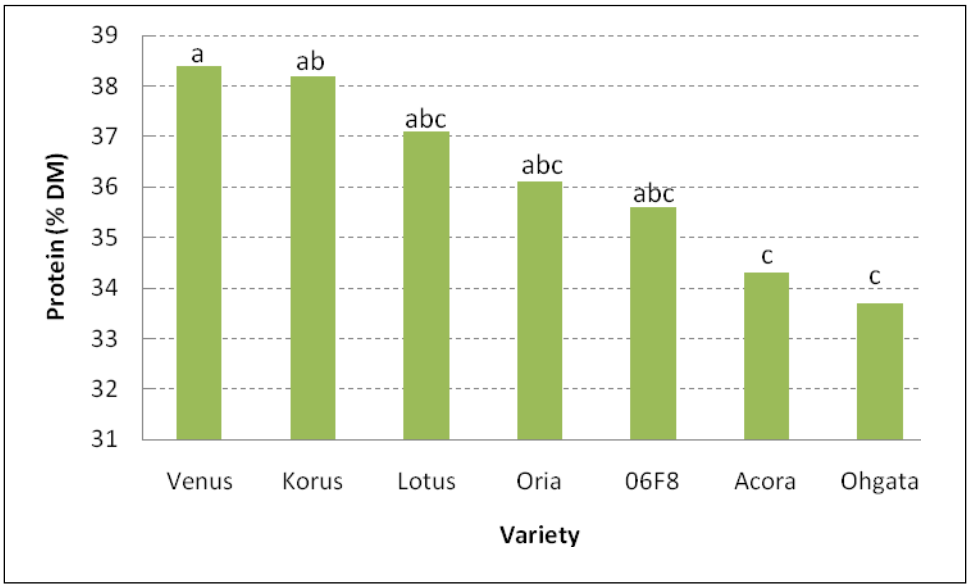

Figure 3. Varietal influences on protein concentrations in food grade soybeans.

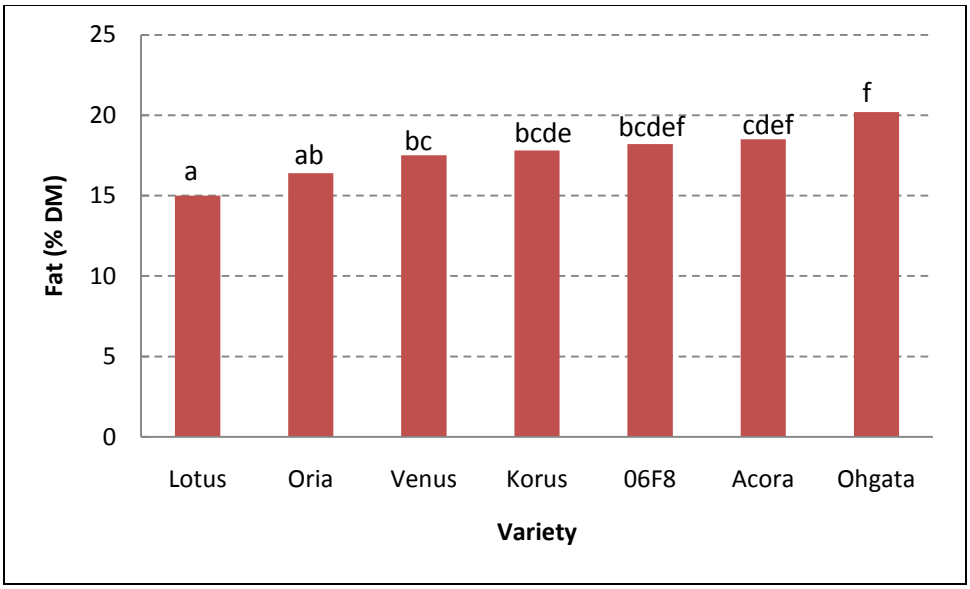

Figure 4. Varietal influences on fat concentration in food grade soybeans.

Hardwick Trial Results:

The plots in Hardwick had less weed pressure than the trials in Alburgh, due to the diligent efforts of the staff at High Mowing Seeds.

Table 6. Results from Hardwick Food Grade Soybean Variety Trial.

Variety	Population	Germination	Harvest moisture	Yield at 13% moisture	Canopy width **	Harvest height	Pod distance to the soil	Pods/ plant
	plants/acre	%	%	lbs/acre	in	in	in	
1F44	26,100	14.9	**20.0**	305	20.5	28.5	3.84	37.8*
Acora	71,400	40.8	16.6	1610	21.8	32.0*	3.43	33.7*
CFS062	83,000	47.4	15.3	2130*	25.5	27.4	4.31	32.3
Dares	**130,000**	**74.6**	15.9	**2190***	**30.8***	**33.1***	3.85	24.2
Korus	79,500	45.5	15.6	1350	22.3	23.5	4.20	30.0
Lotus	34,400	19.7	15.8	1140	21.0	22.5	3.59	**40.2***
Naya	58,400	33.4	16.8	907	23.3	21.1	3.28	34.1*
Nova	89,500	51.2	16.0	1370	25.8	28.6	**5.40***	23.7
06F8	79,900	45.7	15.8	1546	24.3	29.0	4.55*	40.1*
Ohgata	96,000	54.9	15.9	1455	25.8	28.2	3.68	24.3
Oria	75,600	43.2	17.9	762	27.8*	26.1	4.41	23.2
Phoenix	48,400	27.7	15.5	988	22.8	21.3	3.00	35.9*
Venus	52,300	29.9	15.5	1342	21.3	25.1	3.53	39.3*
LSD (0.10)	14,500	8.26	0.829	229	3.02	1.83	0.939	6.89
Means	71,200	40.7	16.3	1310	24.0	26.6	3.93	32.2

* Treatments that did not perform significantly lower than the top performing treatment in a particular column are indicated with an asterisk.

** Measurement of canopy width at R2 and R3 stage.

NS - None of the treatments were significantly different from one another.

In past food grade soybean trials that UVM Extension has undertaken, it has been noted that germination is generally quite poor. In Hardwick, Dares had the greatest survival rate. Out of all beans planted, 74.6% of them germinated, which was significantly greater than all other varieties (Figure 5). When germination was evaluated on June 19th, 2009, two weeks after planting, it was noted that 1F44 had not germinated well, perhaps because it was seed leftover from last season, emphasizing the importance of new seed every year. Lotus also did not germinate well. However, soybeans were seeded in Hardwick under non-ideal conditions: the Planet Junior and Earthway Seeder did not produce a completely reliable seeding rate nor seeding depth. Additionally, the soil in the trial plots was very sandy, this could result in insufficient moisture for timely germination, and as the seeds are organic, no seed treatment was used.

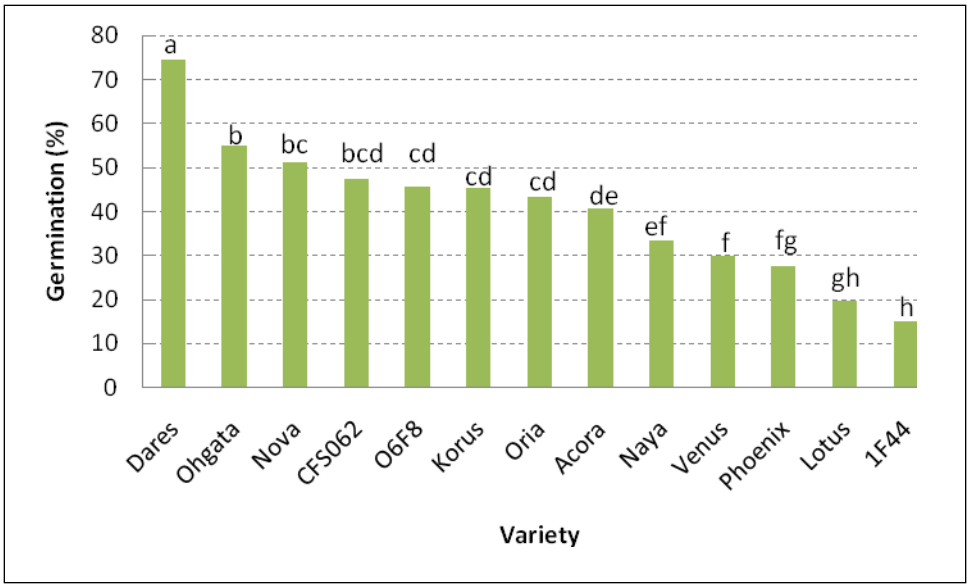

Figure 5. Germination across food grade soybean varieties in Hardwick, VT.

Overall, the Hardwick yields were lower than the Alburgh site. Hardwick has a much shorter growing season and hence often has lower yields. However, poor germination rates may have been another explanation for lower yields. Dares yielded very well in comparison with the other varieties, most likely due to its superior population. CFS062 yielded statistically similar to Dares (Figure 6).

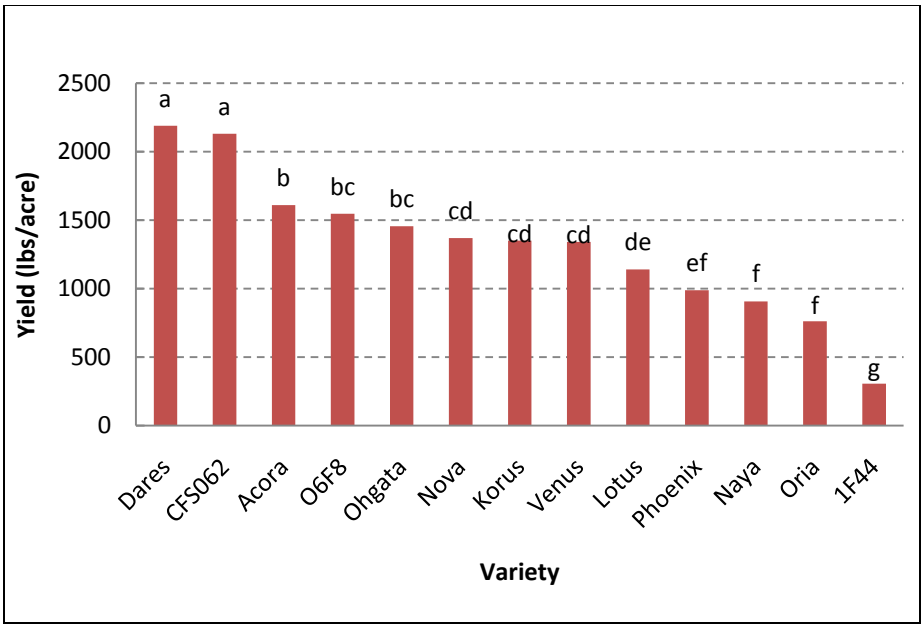

Figure 6. Yield as related to food grade soybean variety.

It is interesting to note that while Lotus did not have a very large population, it still yielded fairly well, with many pods per plant, suggesting that Lotus soybeans are capable of maximizing on the resources that are made available through low population counts. 1F44 did not yield at all well in Hardwick, as not enough GDDs accumulated for 1F44 to reach maturity. When harvested,

plots planted with 1F44 still retained their leaves (Figure 7), and when combined, pods were too wet to shatter properly, resulting in heavy pod contamination in the yield.

Figure 7. Soybean variety trial in Hardwick, VT on October 13, 2009. Variety 1F44 at center, not drying down.

The varieties Dares and Oria had the bushiest plants, effectively forming canopy closure at an earlier stage, shading out weeds, sooner on a 30" spacing, and being more effective in their interception of sunlight (Figure 8). Quick canopy closer is also important for weed control in organic systems. However, if soybeans are planted in 7 inch rows, the less bushy plants might perform better under these conditions.

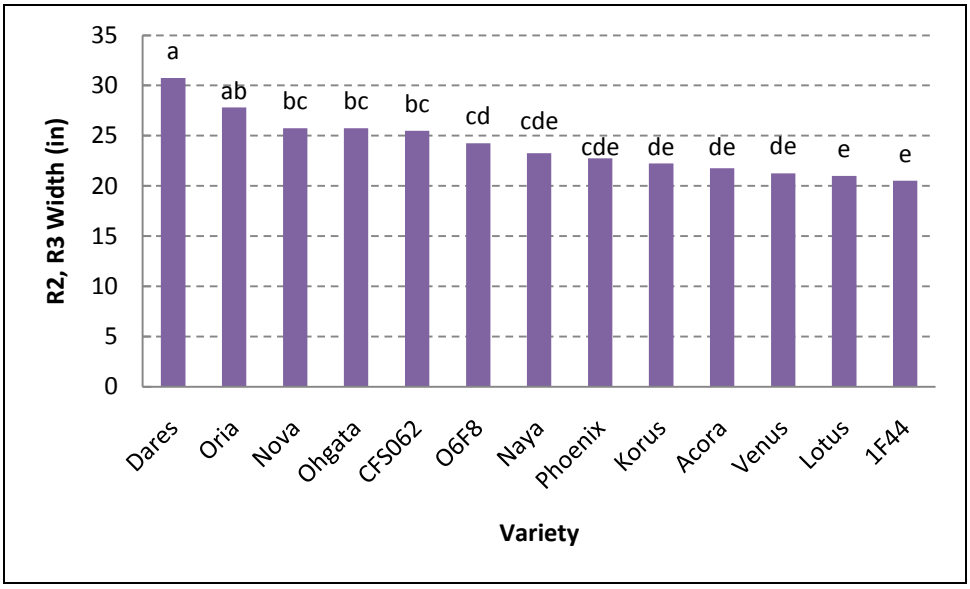

Figure 8. Width of soybean canopy at the R2/R3 growth stage.

As mentioned previously, the distance from the lowest pod to the soil is very important in food grade soybean systems, since if the pods are too low, and the combine is set low to maximize harvest yields, the combine can pick up dirt, thereby staining the seeds. Nova and 06F8 were the varieties that had the highest pods (Figure 9), but since Nova produced shorter plants, and fewer pods per plant (Figure 10), it had lower yields. 06F8 combined high pods with a good number of pods per plant, resulting in yields that would have been acceptable, if germination had been higher, suggesting the need for a higher planting density to reach maximum yield potential.

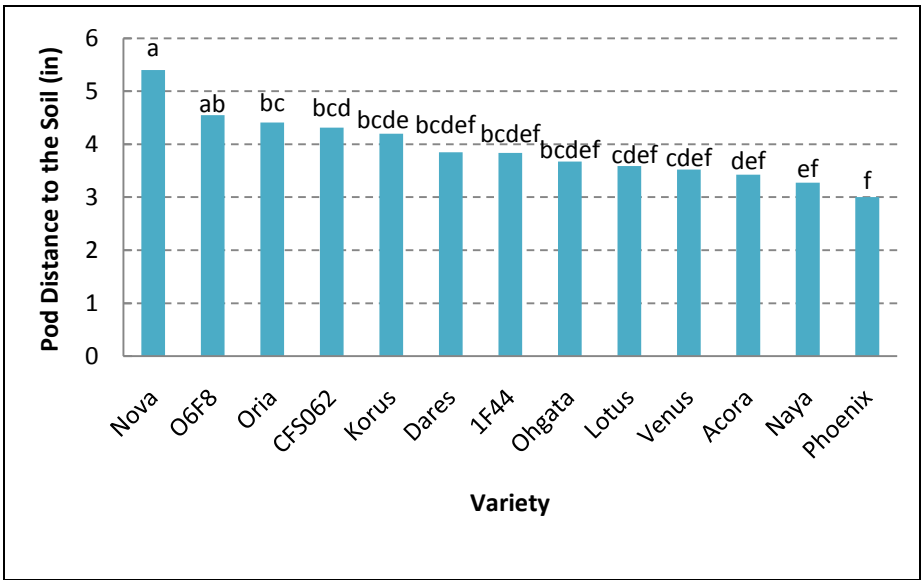

Figure 9. Varietal influence on the distance from the lowest pod to the soil.

Lotus had the greatest number of pods per plant, but was not significantly different than 06F8, Venus, 1F44, Phoenix, Naya, or Acora.

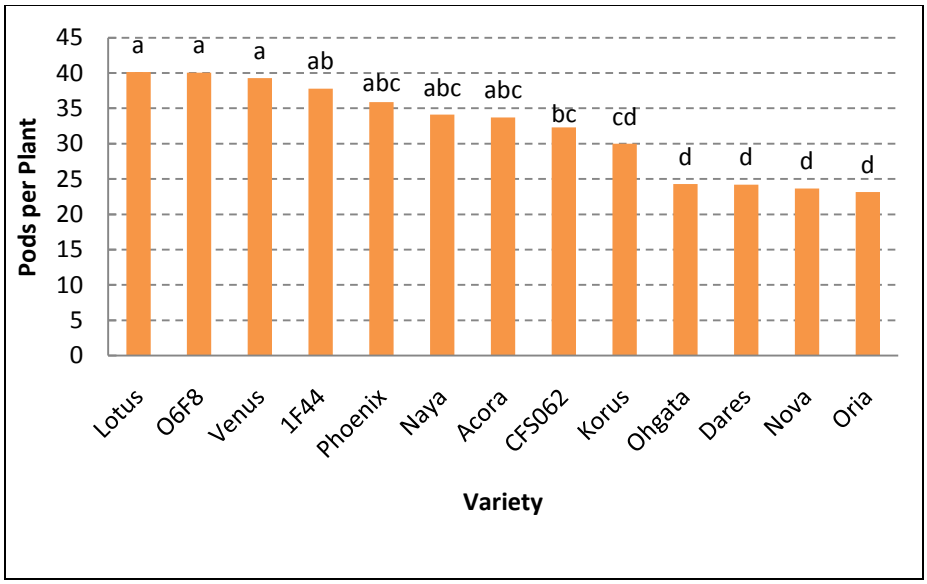

Figure 10. Average number of pods per plant by variety.

Aside from cleanliness of the seed, most soy processors are also concerned with seed size and uniformity, along with protein and fat content (Table 7). While the size of the soybean itself does not influence soy product yield, in general, most processors prefer a larger bean. Oria produced the largest beans (Figure 11) which were very white and round.

Table 7. Quality characteristics of foodgrade soybean varieties.

Variety	Weight of 10 seeds	Protein	Fat
	g	% DM	% DM
1F44	2.23	46.3*	15.6
Acora	2.31	42.4	17.1
CFS062	2.06	41.9	15.6
Dares	2.52	42.0	16.8
Korus	2.02	44.9*	16.2
Lotus	2.16	**46.5***	**14.3**
Naya	2.38	44.2*	16.8
Nova	2.94	44.3*	16.3
O6F8	1.92	36.9	17.7
Ohgata	2.76	46.1*	16.4
Oria	**3.37**	45.4*	15.6
Phoenix	2.26	42.2	17.1
Venus	2.47	44.9*	16.2
LSD (0.10)	0.182	3.58	0.455
Means	2.42	43.7	16.3

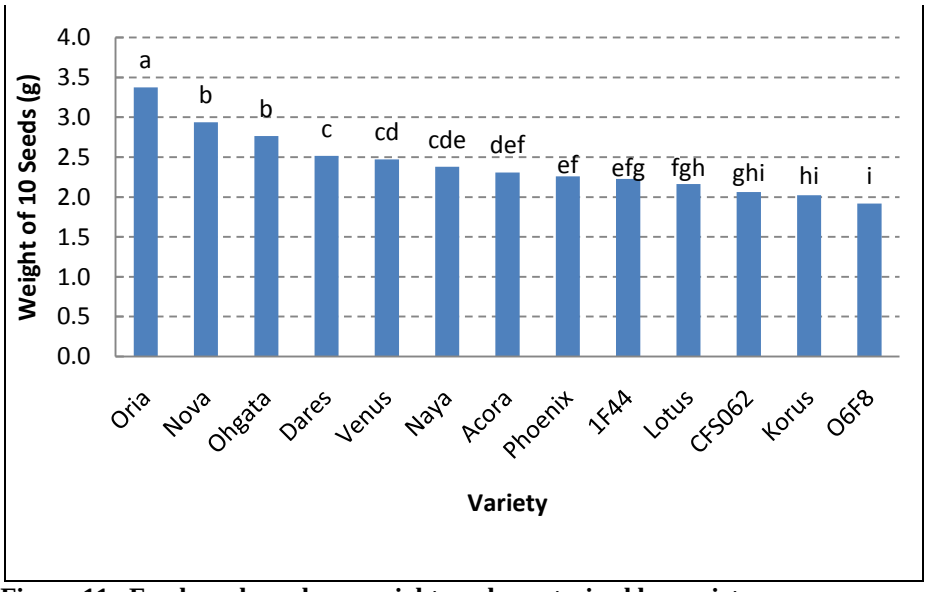

Figure 11. Food grade soybean weight as characterized by variety.

Nova, Ohgata, Venus, Dares, and Acora beans were also round and regular in shape. In Hardwick, 1F44 produced irregularly shaped beans that had a greenish tinge, most likely due to the fact that they did not have time to reach maturity before harvest. Phoenix produced uniformly round beans, but had a tendency towards a darker hilum. Naya beans were darker and irregularly shaped. CFS062 produced slightly golden beans. All varieties had acceptable protein levels for the food grade soybean market. Fat content has been shown to have a negative correlation with soy product yield (i.e. tofu, soy milk, etc.), and so varieties with lower fat content are preferable. Lotus had the lowest fat content, and 06F8 had the highest.

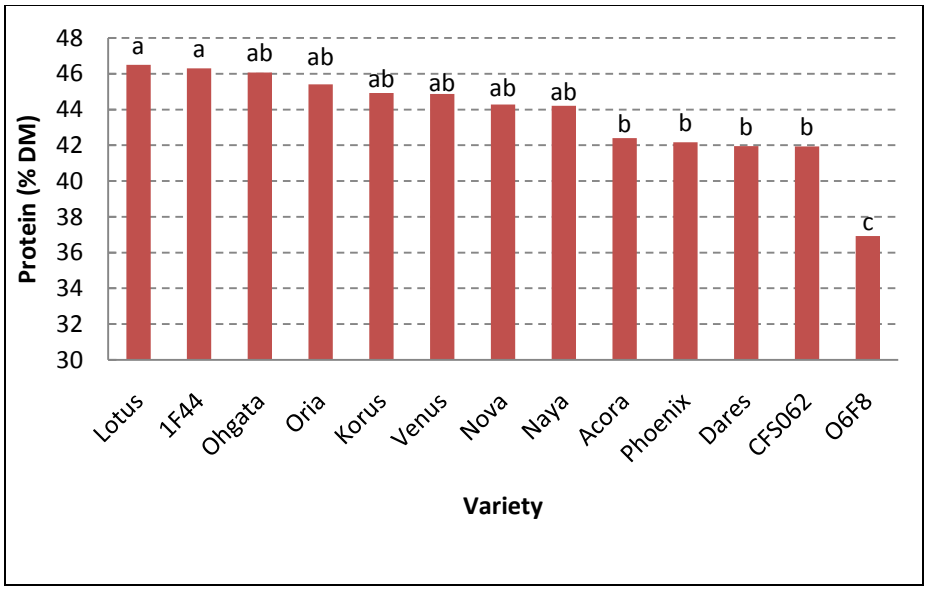

Figure 12. Protein content of food grade soybean varieties.

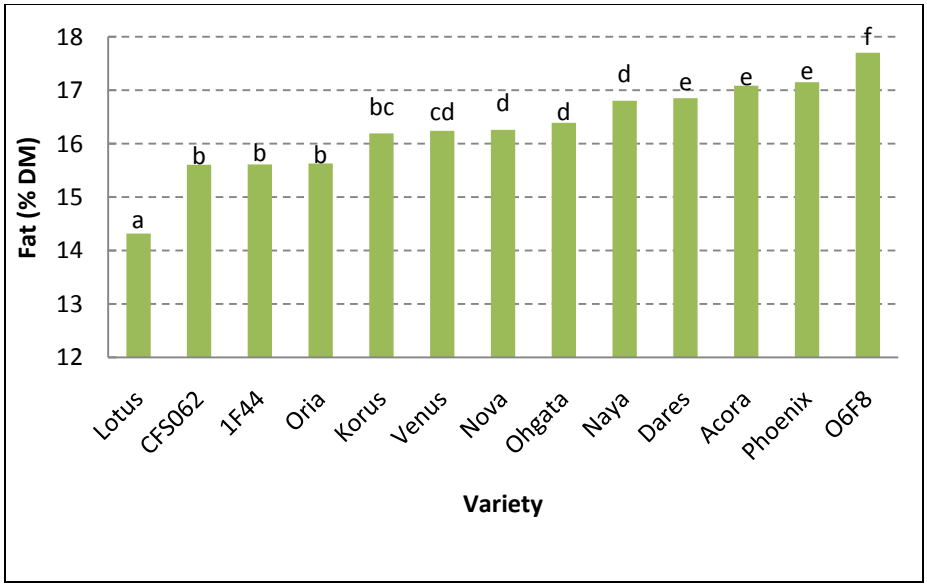

Figure 13. Fat content of food grade soybean varieties.

UVM Extension would like to thank the Rainville family and the folks at High Mowing seeds for their generous help with the trials.

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.

Works Cited:

Chang, K.C.; Hou, H.J. 2003. Science and technology of tofu making. In *Handbook of vegetable preservation and processing*; Hui, Y.H., Ghazala, S. Graham, D.M., Murrell, K.D., Nip, W., Eds.; Dekker: New York, 2003; pp 443-478.

Poysa, V.; Woodrow, L. 2002. Stability of soybean seed composition and its effect on soymilk and tofu yield and quality. *Food Research International*, 35, 337-345.

The UNIVERSITY of VERMONT EXTENSION