Final Report: Further Innovations and Expansions for Nova Scotia's Burgeoning Sweet Potato Industry

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1. Project Description

In Canada, sweet potato consumption has nearly doubled between 2007 and 2012, from 0.72 kg/person/year to 1.43 kg/person/year (Timlick 2014). This is in part due to the public perception that sweet potatoes are a healthier option than traditional types of potato. Additionally, the rising popularity of sweet potato fries has introduced this food as a delicious option outside the usual consumption patterns of only-at-Thanksgiving-and-Christmas. Canada imported approximately $42 million (CAD) of sweet potatoes in 2013, mostly originating in the southern US (Industry Canada 2014). Traditionally, sweet potatoes require a long, hot growing season, and are sensitive to cold air and soil, presenting a short available growing season in Nova Scotia.

Despite the challenging climate, sweet potatoes grow well in Nova Scotia as found in previous work conducted by Perennia and Charles Keddy Farms Ltd in conjunction with Horticulture Nova Scotia (Farm Innovation Project Number FI2013-0016: "Capturing New Opportunity: Development of sweet potato cultivars and production techniques to suit Maritime growing conditions," 2014 – 2016). There are currently approximately 20 growers of sweet potatoes in Nova Scotia, the majority of whom are small-scale producers. Charles Keddy Farms Ltd planted 40 acres in 2017, making them the largest producer in the province.

Sweet potatoes are a high value crop with gross revenue of $25,000/acre. However, it would take 200-300 acres of sweet potatoes to meet even 50% of Atlantic Canadian sweet potato consumption, thus the industry could grow to be worth $5,000,000 – 7,500,000.

Through this previous work by Perennia, Charles Keddy Farms Ltd, and Horticulture Nova Scotia, a new variety (V12.B445) has been identified that has been shown to be more frost-tolerant with high yields, making it overall well-suited for commercial production in Nova Scotia. This project proposed to continue evaluating promising varieties from the southern US as well as new genetics being evaluated at Vineland in order to capitalize on new opportunities (**Objective 1**). Through the development of multiple varieties that are well-suited to the Canadian climate, growers are better able to mitigate risks associated with relying solely on a single variety. Additionally, the development of new varieties specifically designed to do well in more northern climates opens the door to further opportunities, i.e. Nova Scotia slip production to supply local demand as well as for the export market to Canada and the Northeastern US (**Objective 2**).

There is little to no sweet potato slip propagation currently taking place in Canada. In order for these new genetics to become widely available to farmers, further research must be undertaken to determine best practices for slip production and to evaluate whether Nova Scotia slips meet, or even surpass, current quality standards (**Objective 2).** Not having slip production in Canada is a setback to this burgeoning industry as obtaining slips from the US is administratively and logistically burdensome. Currently, producers are paying $0.11-0.12/slip when all costs are considered, and slips are planted ~20,000/acre. This adds a production cost of up to $2,400/acre in slips alone, and producers are buying them in the 100's of thousands. Should it be successfully proven that Nova Scotia can produce high quality slips, this would not only represent a savings to local growers in slip expenses, but it would also add further value to the industry through the export market to other Canadian producers and the Northeastern US (**Objective 2**). Nova Scotian slips have the potential to become a provincial export, thereby ensuring that not only Nova Scotian but also presenting an opportunity to supply other Canadian growers and growers in the Northeastern US with high quality propagative material.

The work outlined herein also proposes to determine best management practices for V12.B445 in order to ensure that yield potential is maximized while minimizing costs of production (**Objective 3, Objective 4**). It has been determined that this new variety grows well using production methods that worked with var. Covington, one of the most popular varieties in the Southern US. However, it remains to be seen whether there might not be better production practices (row spacing, without black plastic, using row covers, etc.) that are more economical.

Ideal crop spacing is determined by logistical factors such as machinery size for planting, weeding, and harvesting, as well as by biological factors such as how effectively a plant can use allotted space and nutrients to achieve maximum growth. With sweet potatoes, as plant density increases, the number and size of potatoes decreases. As sweet potatoes are graded predominantly by size in the Canadian market, plant spacing can have a significant effect on crop quality and market price. Very large or very small potatoes sell at a lower price point. Plant spacing recommendations for sweet potatoes varies by region: in Ontario they recommend 30-40 cm within row by 102-112 cm between rows (OMAFRA 2010), 25-30 cm by 81-107 cm in North Carolina (NCSPC 2015), and 25-36 cm by 91-122 cm in Kentucky (Coolong et al. 2012). Recent work in Quebec suggests that sweet potato variety has an influence on optimal plant spacing (Wees et al. 2016). Varietal differences were recorded in response to changes in plant density: one variety responded with greater changes in root weight, while another variety responded with greater changes in root numbers. Further work was needed to determine optimal plant spacing for varieties new to Nova Scotia (**Objective 3**).

Currently, sweet potatoes in Nova Scotia are planted at the end of May through early June on black plastic. Black plastic is an expensive input, and producers are interested in alternative season extension practices such as row covers. Sweet potatoes are responsive to day length, and an earlier planting date would maximize growth during longer photoperiods (**Objective 4**), which has been linked to increased root number and increased sweet potato yield (Wees et al. 2016).

1.1 Project Objectives

1. Continue to identify varieties that are uniquely suited to growing conditions in Nova Scotia.
2. Comparison of yield and quality of slips from various points of origin (Nova Scotia, Ontario, US).
3. Determine best management practices (i.e. plant spacing) for the newly released variety V12.B445. In 2017, this objective was amended to include other new varieties to Nova Scotia from the US (Bellevue and Bayou Belle).
4. Explore season extension options for sweet potatoes.

A YouTube video was created showcasing this work, and can be found on the Perennia YouTube page.

1.2 2016 Field Season

Several trials were conducted in 2016 to meet these objectives, and were reported in full in the mid-term report:

1.) Testing the suitability of second generation (G2) sweet potato slips under development at Vineland Research Institute, Vineland, Ontario on raised beds using black plastic. **(Objective 1)**

2.) Continued evaluation of promising varieties and third generation (G3) varieties being evaluated at Vineland Research Institute, Vineland, Ontario. **(Objective 1, 2, 4)**
    a. Evaluating a September and an October harvest date
    b. On raised beds with and without the use of black plastic
    c. Evaluating the effects of slip origin
3.) Evaluating the effect of season extension techniques on two varieties of sweet potatoes in Nova Scotia **(Objective 4)**
4.) Evaluating the effect of slip plant spacing on sweet potato yield characteristics. **(Objective 3)**

1.3 2017 Field Season

Several trials were conducted in 2017:

1.) Testing the suitability of second generation (G2) sweet potato slips under development at Vineland Research Institute, Vineland, Ontario on raised beds using black plastic (**Objective 1)**
2.) Continued evaluation of promising varieties and third generation (G3) varieties being evaluated at Vineland Research Institute, Vineland, Ontario (**Objective 1, 2, 4)**
    a. Evaluating a September and October harvest date
    b. On raised beds with and without the use of black plastic
    c. Evaluating the effects of slip origin (US in comparison with Ontario or Nova Scotia)
3.) Field scale data collection on the effect of cover removal timing on the variety Bayou Belle (**Objective 4**)
4.) Field scale data collection comparing a number of agronomic management factors (**Objective 3 and 4**):
    a. Plant spacing (8", 10", 12", 16")
    b. Variety (Bellevue, Bayou Belle, slips of V12.B445 grown by Keddy's)
    c. Row cover vs no row cover
    d. Plastic vs bare ground
5.) Field scale data collection to compare the effect of using row cover on the Covington variety (**Objective 4)**
6.) Field scale data collection of three late planted varieties (NC-198, K445, Covington) (**Objective 2 and 4**)

2. Materials and Methods

2.1 Testing the suitability of second generation (G2) sweet potato slips under development at Vineland Research Institute, Vineland, Ontario on raised beds using black plastic

All slips were planted in double staggered rows on raised beds measuring 30cm high and 76cm wide. Spacing between plants was 30cm (12"), and spacing between the double staggered rows was also 30cm. Distance from hill centre to hill centre was 1.34m. All beds were covered with 0.9mm black plastic mulch prior to planting. Slips were planted on 31-May-2017. Population survival data was collected on 18-July-2017. During the course of the growing season, plots were irrigated as needed through drip irrigation. Minimal hand weeding was performed, as needed.

Each plot consisted of 20 plants for a plot length of 3m. Eleven varieties were tested (Table 1), with Covington and Orleans as industry standards for a total of thirteen treatments, with four replicates of each.

Harvest data was collected on 10-October-17. Four consecutive plants (two from each staggered row) were dug in each plot (harvested area = 0.804m²) and each individual tuber was weighed and length measured. Tubers were classified into size based on diameter into three classes: Size 2 (2.5”-3” diameter or “baggers”), Size 3 (3”-3.5” diameter, US #1), and Size 4 (>3.5” diameter, Jumbo). Anything that was smaller than 2.5” in diameter was recorded as a total weight of “smalls” for each plot.

Data on Brix content was collected on three potatoes from each plot after a period of curing at room temperature of approximately four weeks.

Table 1. Varieties in G2 Trial.

G2 Varieties*	Industry Standard (Comparison)
V15.C292	Covington
V15.K078	Orleans
V15.L007	
V15.B514	
V15.L026	
V15.E274	
V15.M001	
V15.L045	
V15.C314	
V15.K061	
V15.D227	

**All G2 varieties originated from the sweet potato variety development program at Vineland, Ontario.*

2.2 Continued evaluation of promising varieties and third generation (G3) varieties being evaluated at Vineland Research Institute, Vineland Ontario on raised beds with and without the use of black plastic.

Cultivars originating from the Vineland Research Institute sweet potato program were trialed on Charles Keddy Farms in Woodville, NS. One of the varieties (V12.B445) has been performing strongly for the last four years and three more promising varieties were added (V14.D195, V14.D179 and V14.E246) based on results from 2016 G2 trials conducted across the country (including in Nova Scotia). None of the varieties trialed in the G3 trials in 2016 were repeated in this year’s G3 trials, other than B445.

Additionally, Vineland has been trialing slip production at their facility and were interested in comparing Ontario-originating slip quality with more conventional slip production from the United States. In addition to their own breeding stock, Vineland produced slips of popular commercial varieties (Orleans and Covington) and they were compared with Orleans and Covington slips produced in the US. Additionally, Charles Keddy Farms was interested in trialing slip production in Nova Scotia for the promising variety V12.B445, termed K445 for the rest of the report to differentiate from Ontario-produced slips (B445). Charles Keddy Farms was also interested in comparing two new varieties out of the US (Bellevue and Bayou Belle) with the Canadian breeding stock (Table 2).

Two trials were established as an incomplete factorial design, variety as one treatment (n = 7 treatments) and slip origin (n=2), classified as “Ontario” or “other” (NS or the US), as a second treatment. There were four replicates on black plastic. Each plot consisted of 30 plants and was 4.5m long.

This trial was duplicated on bare ground (black plastic was removed from formed hills in the middle of Keddy's fields, just prior to planting). Each plot on bare ground consisted of 20 plants and was 3m long.

All slips were planted on 31-May-2017, with the exception of Orleans sourced from the US, and Bellevue, both of which were planted on 5-June-2017 due to slip availability.

Tubers were harvested from the trial on black plastic on 12-September-2017 as outlined in section 2.1.

Table 2. Varieties and slip origins in G3 trial.

Variety	Slips originating from Vineland	Slips originating from the US	Slips originating from NS
V12.B445	X		X
V14.D195	X		
V14.D179	X		
V14.E246	X		
Orleans	X	X	
Covington	X	X	
Bellevue		X	
Bayou Belle		X	

Tubers were harvested from both the trial on black plastic and the trial on bare ground on 10-October-2017 following the same procedure as in section 2.1.

2.3 Effect of cover removal timing on Bayou Belle sweet potatoes on raised beds with black plastic

Bayou Belle sweet potatoes were planted in double staggered rows on raised beds measuring 30cm high and 76cm wide. Spacing between plants was 30cm (12"), and spacing between the double staggered rows was also 30cm. Distance from hill centre to hill centre was 1.34m. All beds were covered with 0.9mm black plastic mulch prior to planting. Planting was done on 27-May-2017. This trial was conducted on a field scale level, and therefore no defined plots were established.

Sampling area was established over nine beds, and spanned the length of the field (approximately 180m). The entire area was covered with row cover on 20-June-2017.

On 4-July-2017, row cover was removed from a 45m section, starting at one end of the field. Subsequent removal of row cover took place on 18-July-2017, and 9-August-2017. Row cover was removed from the entire section for a week prior to 18-July-2017, to accommodate spraying and watering, and was then replaced on the section of the field that had not been uncovered yet. Sections were marked with flags and labelled with stakes to delineate the three removal date sections.

Three samples each of four consecutive plants were harvested on 5-October-2017 in each section as well as from three adjoining beds which had no cover on them for the duration of the season. Tuber measurements were taken as outlined above in section 2.1.

2.4 Evaluating the effect of different management factors on yield potential at two different harvest dates

The main goal of this evaluation was to determine if there were agronomic management factors that could secure high yields for a September harvest in order to target the Canadian Thanksgiving market. Season extension techniques that would increase heat units were evaluated (i.e. row cover over black plastic) on different varieties at different spacings. Wider spacings typically yield larger tubers, and the intent was to determine if wider spacings harvested in September would yield profitably. Narrower spacings were evaluated to see if they would boost yields under season extension techniques for an October harvest. Additionally, the long-term objective of Charles Keddy Farms is to find a method of producing high quality sweet potatoes without the use of black plastic, as it significantly adds to the costs of production.

A field scale trial was established to determine the effects of a number of agronomic management factors. Table 3 outlines the various combinations tested.

Varieties K445, Bellevue, and Bayou Belle sweet potatoes were planted in double staggered rows on raised beds measuring 30cm high and 76cm wide. Spacing between plants varied (8", 10", 12", and 16", Table 3), and spacing between the double staggered rows was 30cm. Distance from hill centre to hill centre was 1.34m. Beds with a plastic mulch treatment were covered with 0.9mm black plastic prior to planting. Plastic was then removed from the bare ground section of each bed immediately after forming. Planting was done on 2-June-2017. Treatments receiving row cover were covered with row cover. Row cover was removed periodically for routine pest management (inter-row herbicide). This trial was conducted on a field scale level, and therefore no defined plots were established.

2.4.1 September harvest

Three samples of four plants each were harvested from beds with plastic mulch spaced at 12" and 16" on 11-September-2017 (Table 3). Effort was made to find and harvest four plants within a group of eight consecutive, evenly spaced plants, however due to poor survivability of some of the varieties, this was not always possible. Plants at the narrower spacings were not harvested at this time because it has been previously determined that potatoes at the narrower spacings do not reach marketable size by mid-September. Similarly, beds without plastic mulch were not harvested at this time, as it has been previously determined that potatoes grown on bare ground (regardless of whether there is row cover or not) will not have reached marketable size by mid-September.

Table 3. Treatments harvested in the field-scale management trial in September 2017.

Variety	Ground cover	Spacing	Row cover
K445	Plastic	12"	Yes
			No
		16"	Yes
			No
Bayou Belle	Plastic	12"	Yes
			No
		16"	Yes
			No
Bellevue	Plastic	12"	Yes
			No
		16"	Yes
			No

2.4.2 October harvest

All treatments were harvested on 5-October-2017, with the exception of K445 at the 16" spacing, which had been entirely harvested for market the previous week and was therefore not available to sample (Table 4). It has been previously determined that K445 at 16" spacing harvested in mid-October results in too many large potatoes outside of the ideal grade of "US #1". Effort was made to find and harvest 4 plants within a group of eight consecutive, evenly spaced plants, however due to poor survivability of some of the varieties, this was not always possible.

Table 4. Treatments harvested in the field-scale management trial in October 2017.

Variety	Ground cover	Spacing	Row cover
Bayou Belle	Plastic	8"	Yes
			No
		10"	Yes
			No
		12"	Yes
			No
		16"	Yes
			No
	Bare ground	8"	Yes
		10"	Yes
		12"	Yes
		16"	Yes
Bellevue	Plastic	8"	Yes
			No
		10"	Yes
			No
		12"	Yes
			No
		16"	Yes
			No
	Bare ground	8"	Yes
		10"	Yes
		12"	Yes
		16"	Yes
K445	Plastic	8"	Yes
			No
		10"	Yes
			No
		12"	Yes
			No
	Bare ground	8"	Yes
		10"	Yes
		12"	Yes

2.5 Effect of using row cover on the sweet potato variety 'Covington' on raised beds with black plastic

Covington sweet potatoes were planted in double staggered rows on raised beds measuring 30cm high and 76cm wide. Spacing between plants was 30cm (12"), and spacing between the double staggered rows was also 30cm. Distance from hill centre to hill centre was 1.34m. All beds were covered with 0.9mm black plastic mulch prior to planting. Planting was done on 31-May-2017. This trial was conducted on a field scale level, and therefore no defined plots were established. Sampling area was established over six beds (three with cover and three without cover). Row cover was applied to three beds on 20-June-2017, and removed on 10-August-2017.

Three samples of four plants each were harvested on 5-October-2017 in each section. In addition, three samples of four plants each were harvested from three adjoining beds which had no cover on them for the duration of the season. Tuber measurements were taken as outlined above in Section 2.1.

2.6 Yield comparison of three later planted varieties.

Covington, K445, and NC-198 were planted in double staggered rows on raised beds measuring 30cm high and 76cm wide. Spacing between plants was 30cm (12"), and spacing between the double staggered rows was also 30cm. Distance from hill centre to hill centre was 1.34m. All beds were covered with 0.9mm black plastic mulch prior to planting. Planting was done on 23-June-2017. This trial was conducted on a field scale level, and therefore no defined plots were established. Six beds running the length of the field were planted with K445, three with NC-198, with the remainder of the field planted with Covington. Slips are typically cut, however, in this case, the K445 slips were pre-rooted. Three samples of four consecutive plants were taken at random points within each variety section on 12-October-2017. Tuber measurements were taken as outlined above in Section 2.1.

3. Results

3.1 G2 variety trial

Yield in pounds/acre was calculated assuming even emergence across the field. The data for corrected yield in pounds/acre was calculated using the percent survival of each individual plot to better reflect the anticipated yield rather than the potential yield with 100% survivability. A visual comparison can be found in Figure 1 between yields that are not corrected for slip survivability and for yields where losses due to poor slip vigor, etc. were accounted for.

Statistically significant differences were found in yield of US #1's between varieties for both corrected yield ($p=0.0735$) and for not corrected yield ($p=0.0486$). All G2 varieties from Vineland yielded statistically similarly amounts of US #1's when compared to the industry standard, Covington.

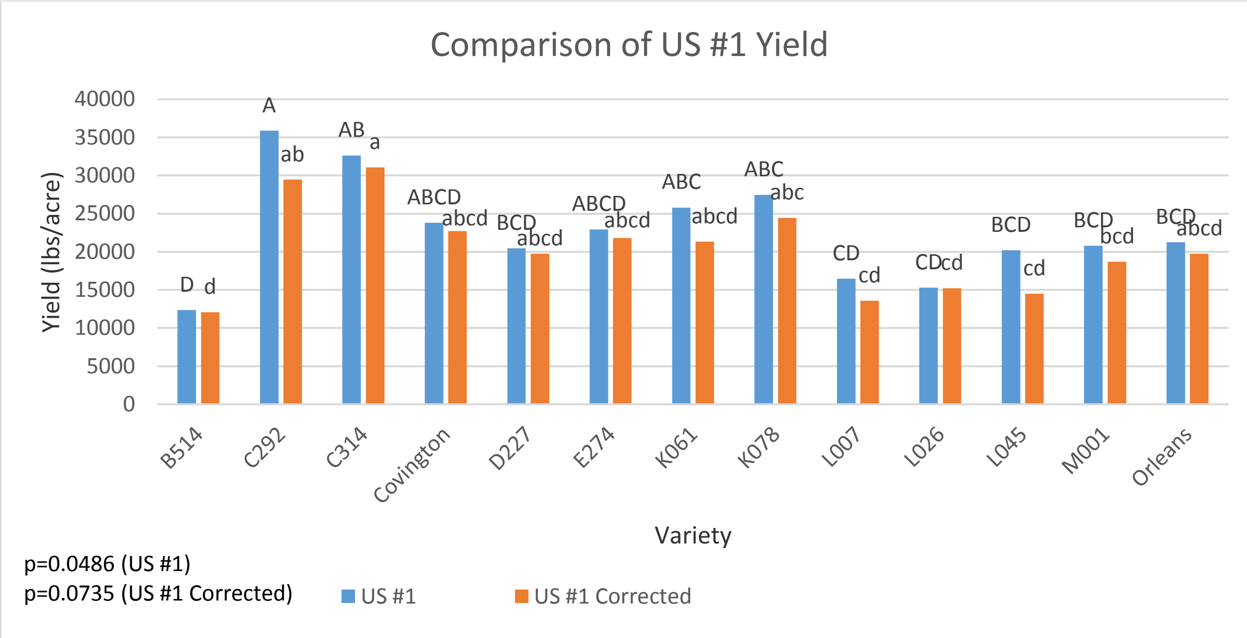

Figure 1. Comparison of sweet potato variety trial (G2) yields in Nova Scotia, columns followed by the same letter (lower case denote significance for US #1 Corrected yields) do not have statistically different yields of US #1s.

Statistically significant differences in total yield were found between varieties (p=0.0970). All G2 varieties from Vineland had a statistically similar total yield in comparison to the industry standard, Covington.

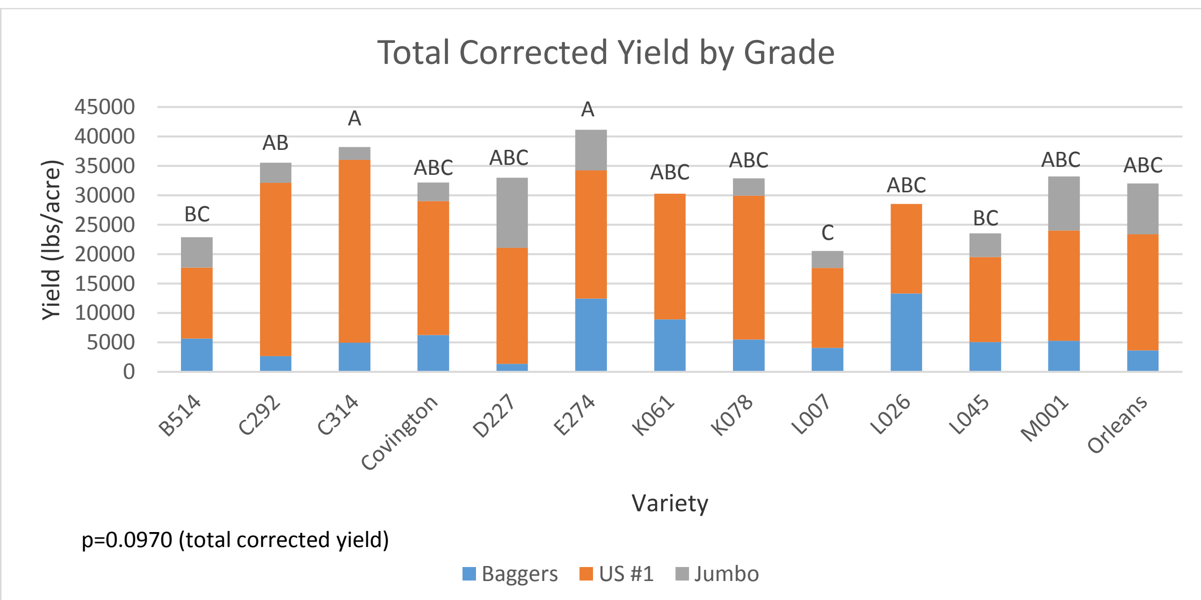

Figure 2. Sweet potato variety trial (G2) yields in Nova Scotia, columns followed by the same letter have statistically similar total yields.

Significant differences were found between varieties (p=0.0001) in survival. Greater than 5-7% loss of slips shows poor slip survivability, making it unlikely that those varieties would do well in commercial production. L045 and C292 had 20% or greater slip loss (Table 5). Significant differences were found between varieties (p=<0.0001) for Brix, where E274 had a significantly higher Brix measurement than all other varieties.

Table 5. Percent survival (p=0.0001) and Brix (p=<0.0001) for the G2 variety trial grown on black plastic in Nova Scotia, October 10, 2017.

Variety	**Survival %**		**Brix (°Bx)**	
B514	98	A	8.5	DEF
C292	80	CD	8.9	CDEF
C314	95	A	8.2	F
Covington	95	A	9.5	CD
D227	95	A	10.8	B
E274	95	A	12.4	A
K061	83	BC	8.2	EF
K078	89	ABC	9.6	BCD
L007	84	BC	6.7	G
L026	99	A	9.8	BC
L045	71	D	9.3	CDE
M001	91	AB	9.7	BC
Orleans	93	AB	8.3	EF

Figure 3. G2 variety C292, displaying an interesting flesh colouration. C292 had only 80% survivability, but maintained very strong yields.

Photos were taken of each variety at the time of Brix measurements to show the variations in skin colour and tuber shape (Figure 4). Grade is dependent on size and shape, and marketability can be dependent on skin colour. Figure 3 shows the flesh of variety C292, which has a purplish skin, orange flesh, and a core of purple flesh, making it visually interesting when cut open. C292 had very poor survivability in this trial (80%), but strong yields despite that.

In combination with the strong yields (Figure 1, Figure 2) demonstrated by E274 and good survivability, should this variety move forward in the trials, it would be interesting to see consumer preferences panels with this line as a result of the high Brix (12.4). There were a large number of baggers and jumbos for variety E274, so it may be worth experimenting with adjusting spacing. The skin of E274 has a purplish hue (Figure 4) which would require some marketing to get the large retailers to accept.

C314 and C292 both had good yields and a nice, uniform shape. C292 had poor survivability (20% of slips were lost), so some further work refining slip production may be required to make this a commercial variety. The interior of C292 could be a marketing point (Figure 3).

Figure 4. G2 and industry comparison varieties, Nova Scotia, 2017.

3.2 G3 variety and slip origin trial

3.2.1 G3 variety trial: September harvest

Yield in pounds/acre was calculated assuming even emergence across the field. The data for corrected yield in pounds/acre was calculated using the percent survival of each individual plot to better reflect the anticipated yield rather than the potential yield with 100% survivability (Figure 5). With varieties with strong slip survivability, this showed up as only a minor difference, however poor quality slips, such as in the case of Bellevue (Figure 5), has a very apparent effect on marketable yield.

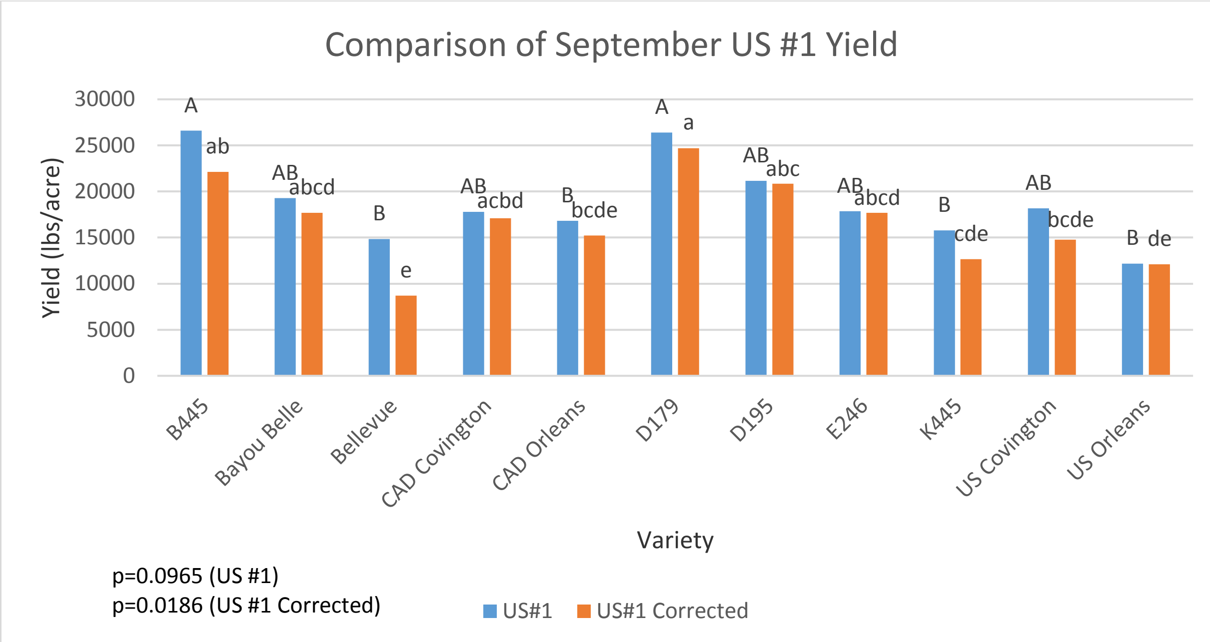

Figure 5. Comparison of sweet potato variety trial (G3) yields in Nova Scotia, columns followed by the same letter (lower case letters relate to other lower case letters for US #1 corrected yield) do not have statistically different yields of US #1s.

There were significant differences in corrected yield of US #1's between varieties for the September harvest, on plastic (p=0.0186).

D179 had the highest corrected yield of US #1's, and was statistically similar to B445, Bayou Belle, Canadian Covington, D195, and E246, all of which yielded better than US Covington (Figure 6).

There were no significant differences in Brix (p=0.5328) between varieties at the September harvest timing (Table 6). There were highly significant differences in survival between varieties. E246 had the highest survival rate, at 99.3%, comparable to the survival rates for Canadian Covington, D179, and D195. Bellevue had a very low survival rate (56%) as did slips of B445 produced in Nova Scotia (K445) (79%).

3.2.2 G3 variety trial: October harvest

There was marginally significant differences in corrected yield between varieties by the October harvest (p = 0.1574). Statistical differences between harvest dates were not evaluated.

With an October harvest, D179 had a statistically higher corrected yield than all varieties and was statistically similar to D195, E246, and US Orleans (Figure 6).

Bellevue had the highest yields of US #1's in the 2016 harvest season at both the September and October harvest dates (52,900 lbs/acre and 54,500 lbs/acre, respectively), but was amongst the lowest for both months in 2017 (8,693 lbs/acre, and 18,959 lbs/acre). This is due to only 56% survival of Bellevue slips (Table 5).

There were significant differences in Brix (p=0.0064) between varieties harvested in October on plastic. E246 had the highest Brix levels, comparable to those of Covington from both the US and Ontario (Table 6).

3.2.3 G3 variety trial: Comparing September and October harvest dates

Table 6. Survival and Brix levels for September and October harvested G3 variety trial grown on black plastic in NS, 2017.

Variety	Brix (^{0}Bx) – September	Brix (^{0}Bx) – October		Survival (%)	
B445	8.6	9.1	BCDE	84.0	DEF
Bayou Belle	9.2	8.8	BCDE	89.0	CDE
Bellevue	8.8	8.8	CDE	56.0	G
Covington (ON)	9.2	9.7	ABC	95.8	ABC
Orleans (ON)	9.3	7.9	DE	91.0	BCD
D179	9.7	8.6	CDE	94.3	ABC
D195	10.3	9.1	BCDE	98.5	AB
E246	10.1	10.5	A	99.3	A
K445	8.5	9.2	BCD	78.8	F
Covington (US)	9.9	10.1	AB	81.3	EF
Orleans (US)	9.2	7.8	E	98.3	AB
	p=0.5328	**p=0.0064**		**p<0.0001**	

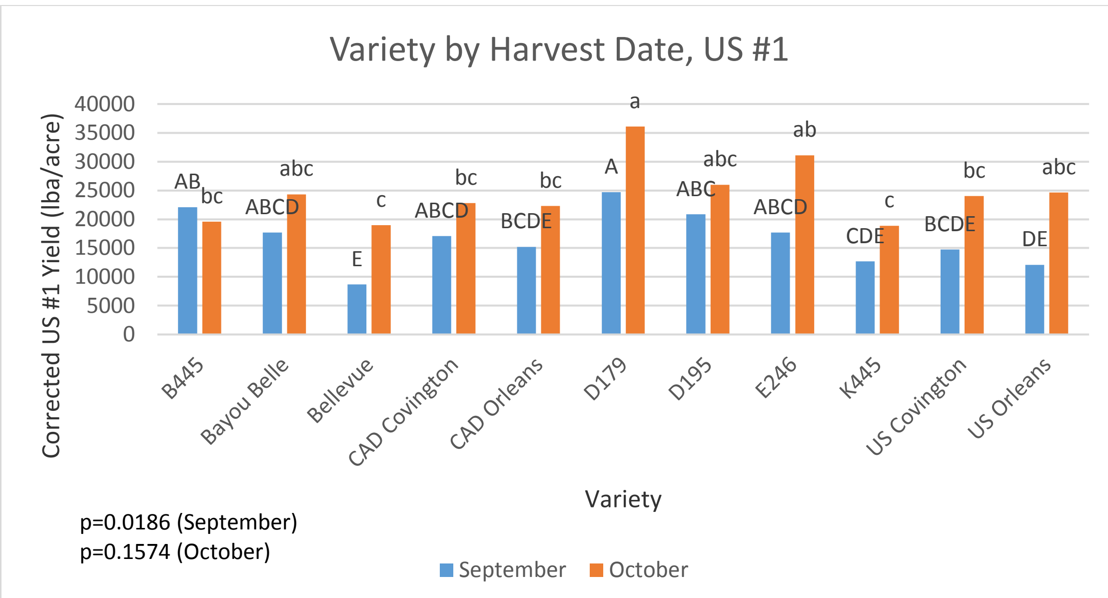

Figure 6. Sweet potato variety trial (G3) corrected yields of US #1's at two different harvest dates in Nova Scotia, 2017. Columns followed by the same capital letter (September harvest) are not significantly different. Columns followed by the same lower case letter (October harvest) are not significantly different. Statistical comparisons between the two harvest dates were not evaluated.

All of the varieties in the G3 trial had fairly nice, uniform shape with the exception of Bayou Belle (Figure 7).

Figure 7. G3 and industry comparison varieties, Nova Scotia, 2017

Figure 8. 2016 photos of Vineland varieties from the 2016 G2 trial. These varieties then matriculated to the 2017 G3 trial.

3.2.4 G3 and slip origin trial: Plastic vs. bare soil

Varieties grown on plastic typically have higher survival rates than when they were grown on bare soil (Figure 9). Covington slips originating from Ontario, Orleans from both the US and Ontario, and E246 did not have significant differences in survival between plastic versus bare ground, indicating hardy slips (Figure 9). It is interesting to note that while Covington from Ontario had statistically similar survival rates on both plastic and bare ground, Covington from the US did not, having significantly lower survival on bare ground. K445 (B445 slips grown in Nova Scotia) had very poor survival when grown on bare soil. As mentioned previously, Bellevue had poor quality slips in 2017 with low survival, which impacted "corrected" yields as presented in Figure 5.

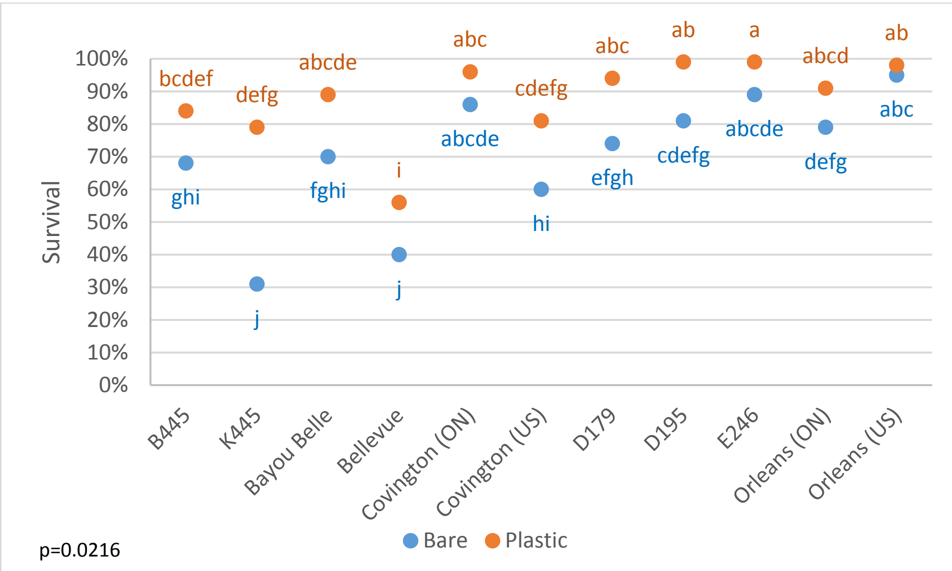

Figure 9. Comparison of slip survival when planted on plastic vs. bare soil, G3 variety trial, Nova Scotia, 2017.

There was no significant interaction between ground cover and variety for corrected yield of US #1 (p=0.9183), although there was significant interaction for total yield (p=<0.0001) (Table 7). There were significant differences for yield of US #1 between varieties (p=<0.0001) and between plastic vs bare ground (p=<0.0001). This indicates that varieties perform similarly in relation to other varieties when grown on either plastic or bare ground.

In terms of total yield, sweet potatoes grown on plastic almost always yielded significantly higher than on bare ground, however, this increase in yield can sometimes be attributed to a large yield of jumbo size potatoes, which are less marketable.

Table 7. Effects of ground cover on G3 sweet potato corrected yield and quality. Nova Scotia, 2017.

Variety	Ground Cover	Baggers	US #1		Jumbo		Total Yield	
		-----------------	-------------------	lbs/acre	-------------------			
	Bare	5105	12209	B	1631	B	18946	B
	Plastic	5500	24375	A	7626	A	37501	A
	p value	**0.5582**	**<0.0001**		**<0.0001**		**<0.0001**	
B445	Plastic	1050	19562		31088	A	51700	A
B445	Bare	3204	15531		4064	BC	22799	I-L
Bayou Belle	Plastic	7835	23788		60	C	31683	D-I
Bayou Belle	Bare	3988	10858		0	C	14845	LM
Bellevue	Plastic	2219	18959		6674	BC	27852	F-J
Bellevue	Bare	1879	2751		0	C	4630	O
Covington (ON)	Plastic	8330	22795		0	C	31124	E-I
Covington (ON)	Bare	9997	10453		3267	BC	23716	H-K
Orleans (ON)	Plastic	2231	22286		3103	BC	27618	G-J
Orleans (ON)	Bare	1809	11416		6925	BC	20149	J-M
D179	Plastic	4891	36086		0	C	40977	BCD
D179	Bare	6515	21638		2131	C	30284	F-I
D195	Plastic	8440	25983		4695	BC	39118	B-E
D195	Bare	3965	13255		1560	C	18779	KLM
E246	Plastic	9416	31105		4436	BC	44957	ABC
E246	Bare	12316	19479		0	C	31795	E-H
K445	Plastic	3642	18854		23692	A	46187	AB
K445	Bare	1181	3911		0	C	5092	NO
Covington (US)	Plastic	2195	24043		10139	B	36376	C-F
Covington (US)	Bare	2813	11001		0	C	13814	MN
Orleans (US)	Plastic	10256	24666		0	C	34921	D-G
Orleans (US)	Bare	8489	14012		0	C	22501	I-M
	p value	**0.2947**	**0.9183**		**<0.0001**		**<0.0001**	

The yield of US #1's for D179 on bare ground was 21,638 lbs/acre, which was the highest of the bare ground varieties. This is fairly comparable to the industry standard of US Covington on black plastic (24,043 lbs/acre). A rough estimate is that the cost of laying black plastic and trickle tape (labour and materials included) is $1,000/acre. Current growing practices (US Covington on black plastic) yielded 2,400 more lbs of US #1's in 2017 when compared to the best variety on bare ground (D179). Assuming that US #1's are sold for an average price of $0.75/lb, the extra yield results in an extra revenue of $1,800, which offsets the costs of black plastic. It is recommended to continue growing on black plastic for the best returns per acre.

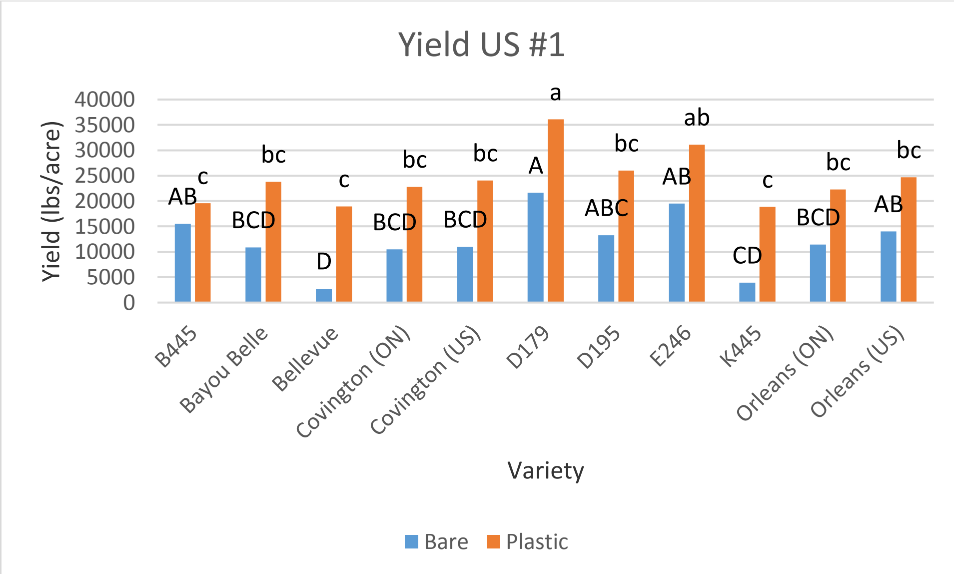

Figure 10. Sweet potato yield of US #1's by variety and ground cover treatments (plastic vs bare ground) in G3 trial.

3.2.5 G3 and slip origin trial: Slip origin (September)

Slips grown in Ontario yielded higher than slips produced in either US or NS for both US #1's and for total yield when harvested in September (Table 8).

Table 8. Effects of slip origin on sweet potato corrected yield, quality, and survivability at September harvest date, Nova Scotia, 2017.

Variety	Origin	Baggers		US #1's		Jumbos	Total Yield		Survival		Brix
		------------------------lbs/acre------------------------							%		^{0}Bx
445		4658	B	17389		1712	23758		81	B	8.6
Covington		7851	A	15930		0	23781		89	A	9.5
Orleans		8875	A	13651		0	22526		95	A	9.3
p value		**0.0081**		**0.1935**		**0.1051**	**0.7998**		**0.0029**		**0.2306**
	Ontario	7567		18140	A	0	25707	A	90		9.0
	Other	6690		13173	B	1141	21004	B	86		9.2
p value		**0.3832**		**0.0074**		**0.1259**	**0.0164**		**0.1262**		**0.7486**
445	NS	5019	B	12665		3423	21108		79	C	8.5
445	Ontario	4297	B	22112		0	26409		84	BC	8.6
Covington	US	4981	B	14761		0	19742		81	C	9.9
Covington	Ontario	10721	A	17099		0	27820		96	A	9.2
Orleans	US	10068	A	12093		0	22161		98	A	9.2
Orleans	Ontario	7683	AB	15209		0	22891		91	AB	9.3
p value		**0.0096**		**0.1744**		**0.1051**	**0.2521**		**0.0122**		**0.7479**

3.3 Row cover removal timing

No statistically significant differences were found between total yields or yields of US #1's (Figure 11) for Bayou Belle at each row cover removal timing as well as with those which had no row cover at all.

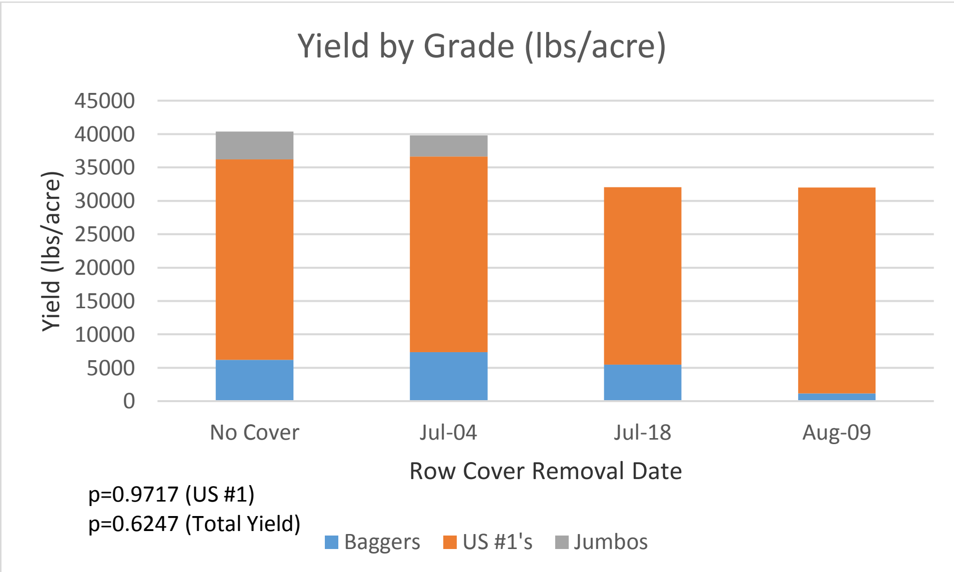

Figure 11. Bayou Belle sweet potato yields by grade for row cover removal timing trial, Nova Scotia, 2017.

3.4 Evaluating the effect of different management factors on yield potential at two different harvest dates

3.4.1 September harvest

Row cover did not have a significant effect on yield of US #1's (Table 9) at a September harvest date.

Table 9. Significance of effects of trialing different management factors as impacted yield of US #1's in September.

Management factor	p-value
Variety	0.0002**
Spacing	0.2032
Variety * Spacing	0.0741**
Row Cover	0.8283
Variety * Row Cover	0.3764
Spacing * Row Cover	0.5228
Variety * Spacing * Row Cover	0.8181

There was a significant interaction between plant spacing and variety for yield of US #1's harvested in September (Figure 12**).** Bayou Belle with plant spacing of 12" yielded significantly more US #1's than any of the other spacing/variety combinations. While not significantly different, Bayou Belle <u>without</u> cover yielded slightly higher (31,643 lbs of US #1's/acre) than Bayou Belle <u>with</u> cover (26,033 lbs US #1's/acre). K445 with plant spacing of 12" yielded significantly lower than Bayou Belle and Bellevue at the same spacing, and was comparable to K445 and Bellevue with plant spacing of 16". Bellevue performance was not very impressive, likely due to poor quality slips.

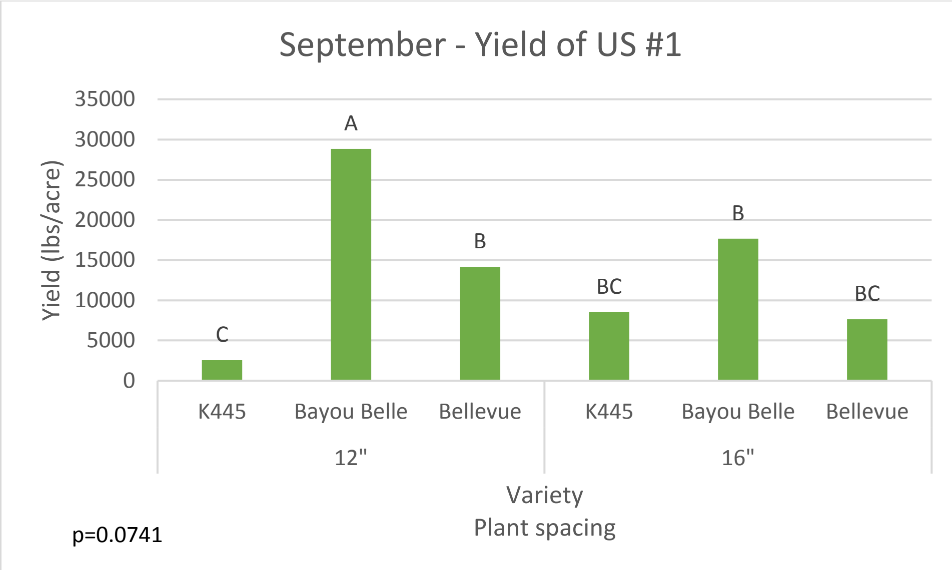

Figure 12. Sweet potato yield of US #1's at September harvest, by plant spacing and variety, columns followed by the same letter are not significantly different.

3.4.2 October harvest

There was a significant interaction between variety, ground cover, and plant spacing for corrected yield of US #1's at the October harvest timing (Table 10, Figure 13). Overall, K445 and Bellevue had the highest yields of US #1's when they were grown on black plastic with no cover, at 8" plant spacing. These yields were comparable to Bayou Belle grown on bare ground with cover, also at 8" plant spacing, and Bayou Belle grown on plastic with no row cover, with 12" plant spacing. Neither Bellevue nor K445 performed well in terms of marketable yield when grown on bare ground with row cover.

Table 10. Significance of effects of trialing different management factors as impacted corrected yield of US #1's in October.

Management factor	**p-value**
Variety	0.1232
Spacing	0.0182**
Variety * Spacing	0.8132
Management[1]	<.0001**
Variety * Management[1]	0.0009**
Spacing * Management[1]	0.4037
Variety * Spacing * Management[1]	0.0002**

[1]Management refers to a comparison between bare ground with row cover and standard practices (black plastic mulch and no row cover)

As there was poor slip survivability in this trial, a population factor was used to calculate corrected yields. Where four plants within eight consecutive plants could not be found, the population factor took into consideration plant spacing (so empty holes) and plant population. This is an approximation of what actual yields would look like. A population factor was used to calculate corrected yield values for all varieties in bare ground/cover, and plastic/cover treatments (*Table 11*). A population factor was not used in calculations for plastic/no cover treatments, so yields for plastic/no cover treatments in Figure 13 may be higher than could be expected.

Table 11. Average population factor by variety and ground cover (across all spacings).

Variety	Ground Cover	Average Population Factor
K445	Bare Ground/Cover	70%
	Plastic/Cover	80%
Bayou Belle	Bare Ground/Cover	88%
	Plastic/Cover	97%
Bellevue	Bare Ground/Cover	53%
	Plastic/Cover	45%

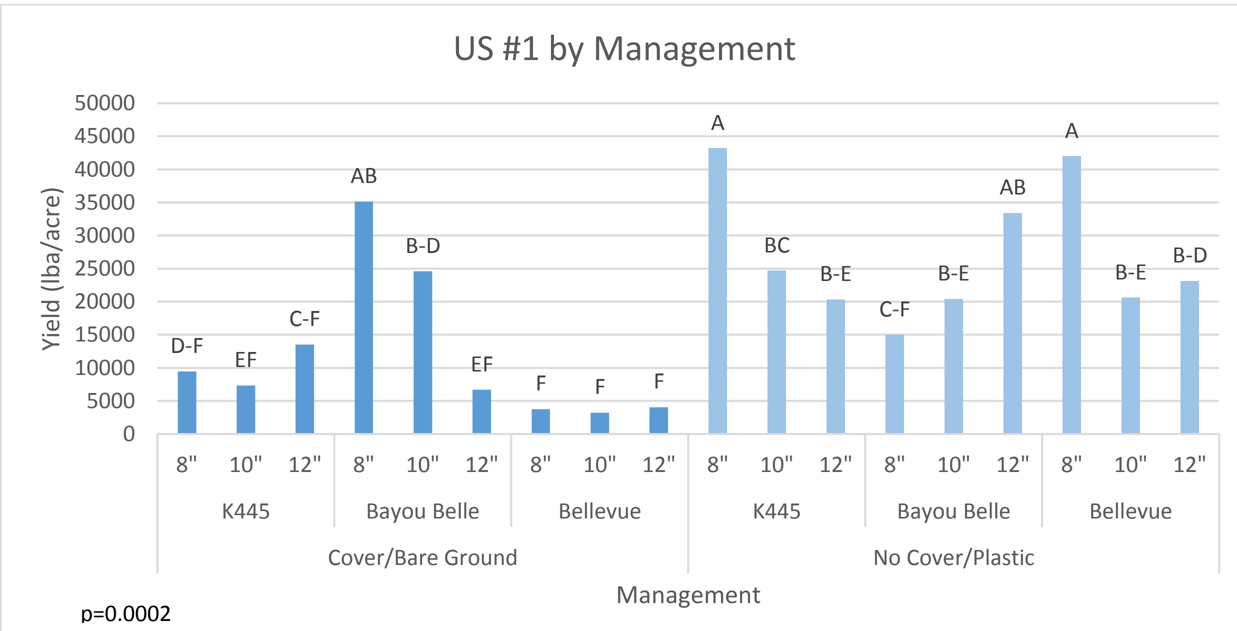

Figure 13. Sweet potato yield of US #1's at October harvest, by ground cover, variety, and plant spacing, columns followed by the same letter are not significantly different. The lighter coloured bars at the right correspond to yields without a population factor, so yields for plastic/no cover treatments may be higher than could be expected.

The next graphs illustrate the effects of ground cover and spacing for each variety individually. Since there was not a complete data set (not all possible combinations for all factors were tested), data cannot be compared between varieties, however, there is useful information to glean within each variety.

For K445, the highest corrected yield of marketable (US #1) sweet potatoes was achieved when plants were grown on black plastic with no cover, at 8" plant spacing (Figure 14). In 2016, K445 was trialed at 25, 30, 35, and 40 cm, and while the closer spacings did yield slightly greater, there were no significant differences found in yield between spacings. However, this year's data indicates that should K445 continue to be grown at Charles Keddy Farms targeting October harvest, it may be worth considering changing the plant spacing to 8" (20cm). There was no yield advantage when using both black plastic and row cover, at any plant spacing. K445 sweet potatoes grown on bare soil with row cover performed poorly in terms of marketable yield, regardless of spacing.

Table 11 indicates that average population factors for K445 were 70-80% across the two corrected ground cover techniques, so yields for plastic/no cover treatments are likely higher than would be expected.

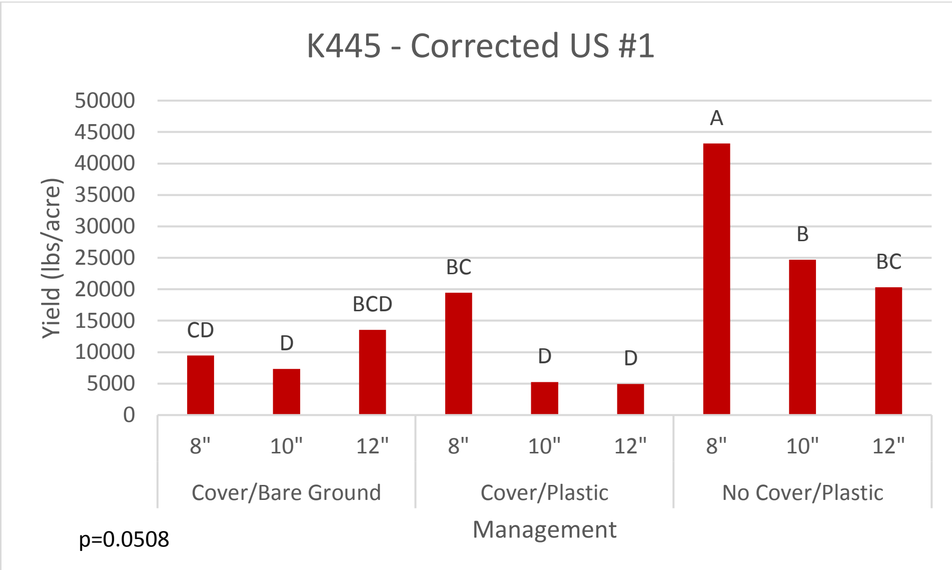

Figure 14. K445 yield of US #1's at October harvest by ground cover and spacing. Columns followed by the same letter are not significantly different.

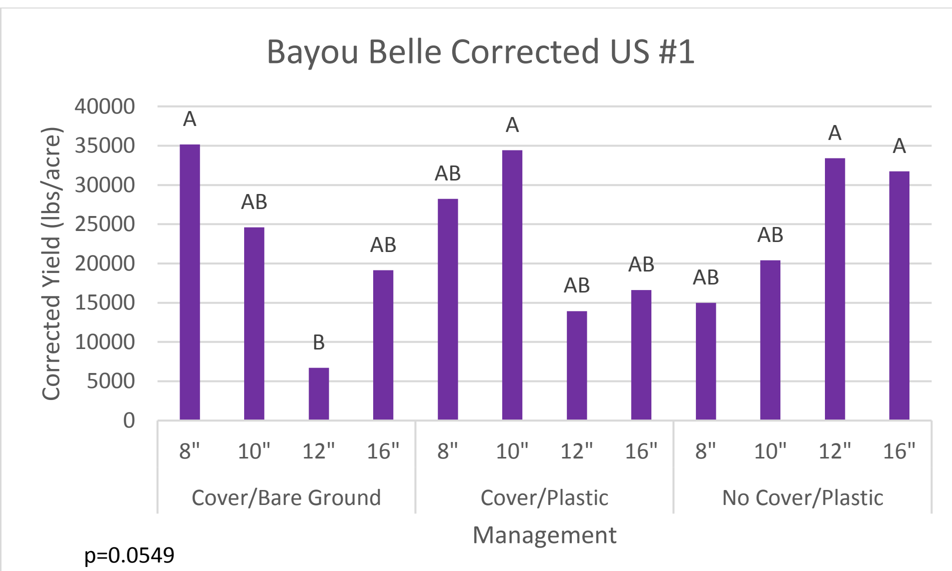

Figure 15. Bayou Belle yield of US #1's at October harvest by ground cover and spacing. Columns followed by the same letter are not significantly different.

Bayou Belle had a fairly comparable yield of US #1 sweet potatoes across the different ground cover and plant spacings tested (Figure 15). Bare ground with row cover at an 8" spacing had one of the highest yields. Bare ground with row cover has lower costs of production in comparison to using black plastic without any apparent yield loss. However other factors should be taken into consideration such as weed management costs without the black plastic, as well as the questionable marketability of Bayou Belle.

Table 11 indicates that average population factors for Bayou Belle were 88-97% across the two corrected ground cover techniques, so yields for plastic/no cover treatments are likely higher than would be expected.

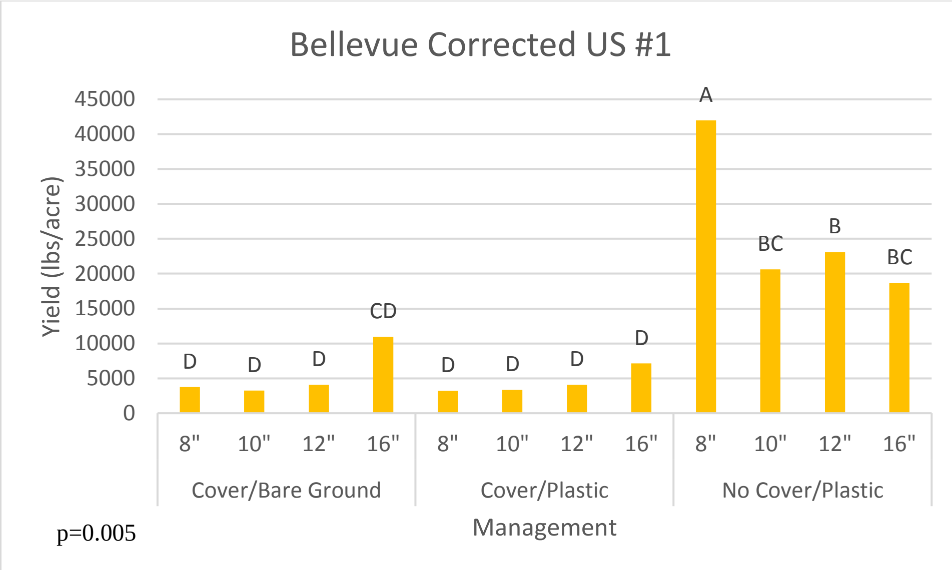

Figure 16. Bellevue yields of US #1's at October harvest by ground cover and spacing. Columns followed by the same letter are not significantly different.

Bellevue sweet potatoes planted on black plastic with no row cover, at a plant spacing of 8" had a significantly higher yield of US #1's (p=0.005, Figure 16) than all other management combinations tested. Bellevue did not produce a sufficient marketable yield at any plant spacing when planted under row cover. There were variations in survivability of Bellevue slips across the field which could make this data somewhat inaccurate. Should Bellevue be brought into regular production for an October harvest, it may be economical to consider a closer spacing on black plastic.

Table 11 indicates that average population factors for Bellevue were 45-53% across the two corrected ground cover techniques, so yields for plastic/no cover treatments are likely higher than would be expected.

At the time of packing, it was observed that sweet potatoes from the October harvest that had been grown at 8" and 10" plant spacings seemed to have shorter, more bulbous potatoes while sweet potatoes grown at 12" were typically somewhat longer.

Figure 17. Golden tortoise beetle damage in Nova Scotia on July 11 (top) and August 11 (bottom), 2017.

It is also noteworthy that pest pressure from Golden Tortoise Beetle (Charidotella bicolor) was higher under the covers for all varieties (likely due to a combination of factors such as protection from Nova Scotia's cool nights and protection from predation). While Golden Tortoise Beetles are not typically considered to be a yield-limiting pest in the major sweet potato production areas of the world, this has not been evaluated in Canada nor under a row cover where beetle populations were so much higher than in the open field.

3.5 Row cover on Covington

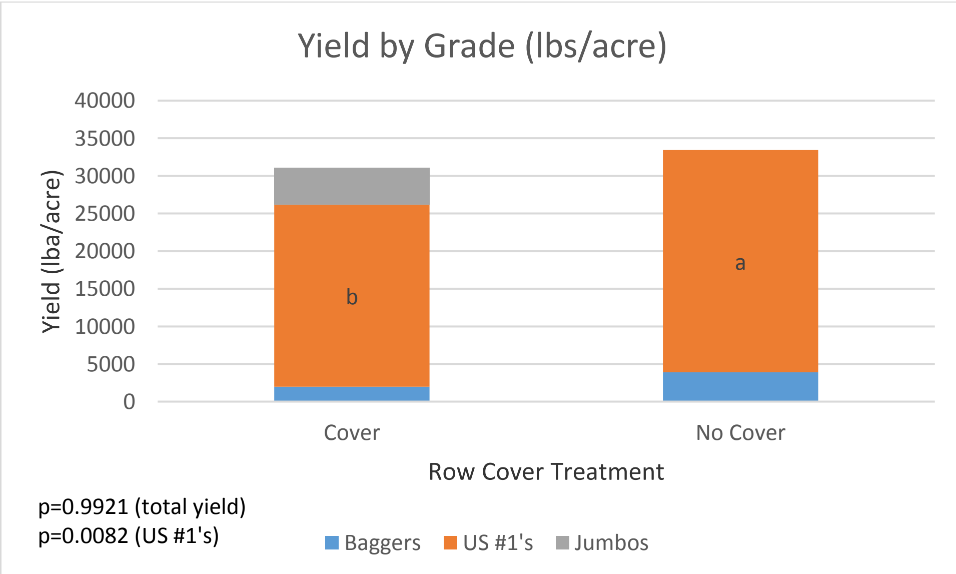

Figure 18. Sweet potato yield of Covington with and without the use of row cover.

Row cover was applied three weeks after planting (20-June-2017) and removed one a half months later (10-August-2017). Covington yielded significantly more US #1's without row cover compared to using row cover (Figure 18). This suggests that increasing air temperature via row cover does not necessarily result in a yield boost, and perhaps soil temperature is of greater import to bulking. Row cover did result in more Jumbos than no row cover, but not significantly so. It is possible that if the row cover had been applied closer to planting, some benefit from the row cover may have been possible. No significant differences were found for total yield between row cover treatments.

3.6 Late planted varieties

The most economical approach to local slip production would be to have two cuts, and it takes 30 days to get a second slip cut. Therefore it was important to consider the viability of a later planting to determine if late-cut slips had any yield potential. Significant differences were found for total yield (p=0.1017) between varieties. No significant differences were found for yield of US #1's (p=0.2451). There were no Jumbos harvested from this late planting (Figure 19).

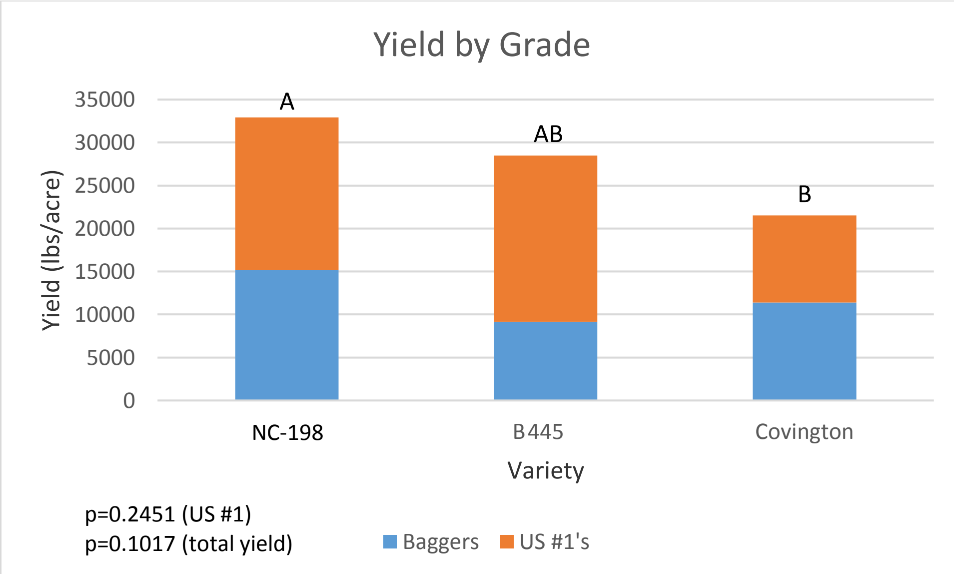

Figure 19. Sweet potato yield by grade of late planted varieties. Letter groupings denote significant differences in total yield

B445 planted on 23-June-2017 yielded just over 19,000 lbs/acre of US #1's, compared to B445 planted in the G3 trial (on plastic), which yielded 23,053 lbs/acre of US #1's. This is likely due to the late-planted B445 slips being pre-rooted, as opposed to the B445 in the G3 trial, which were cut. The pre-rooting likely helped the B445 slips establish more quickly. Similarly, Covington planted on 23-June-2017 yielded just over 10,000 lbs/acre of US #1's, compared to the G3 trial (on plastic), which yielded 23,872 lbs/acre (ON slips).

4. Conclusion

Sweet potatoes can be a very profitable crop in Nova Scotia. Whenever a new crop comes to a region, it is important to determine best management practices to ensure profitable production. There are several new varieties, both from the Vineland breeding program and from the southern US that look to be a good fit in the Maritime climate. It is worth continuing to evaluate these new genetics into the future as the yield and profitability gains can be significant. Ideal row spacing for maximum returns is dependent on variety. Despite the expense of black plastic, it is more profitable to continue to use black plastic than to grow sweet potatoes on bare ground. Season extension efforts such as row cover do not result in higher yields, and, contrary to expectations, can actually negatively affect marketable yield. We can successfully produce slips in Canada that are comparable to the US. However, some modifications to slip production to ensure a high quality slips with good survivability are needed, and future work could focus on this area. Additionally, sweet potatoes have high costs of production due to large labour inputs. Future work could also focus on improving efficiencies to minimize labour inputs.