Potato Germplasm Winter grow-out 2015/2016

An evaluation of potato growth during the winter

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Introduction

The Potato Germplasm at the Plant Materials Center (PMC) conducted a winter grow out in cooperation with the PMC Horticulture Program. The USDA State National Harmonization Program (SNHP) requires that, after harvest, a sample of certified seed be grown to the vegetative state in the winter, and be sampled and screened for virus prior to export across state lines for participating states. Participation in the program is voluntary, but the requirements of any destination state or country must be met. The purpose of the SNHP is to unify the certification requirements among states to control the spread of disease. Large scale production and export businesses often send their certified seed to Hawaii or Florida to meet this requirement. The cost of this service when added to the high cost of export from Alaska has been detrimental to the potato export industry in the state. The purpose of this project was to determine the feasibility of a local winter grow out. The potato plants were grown through tuber development in order to test the formulation and performance of a new fertilizer mix specifically adapted to hydroponic potato production as well as to evaluate the potential for additional G-0 tuber production.

Materials and Methods

A sunroom style greenhouse attached to the PMC main building was selected as the site for the study. The greenhouse has constant access to water and electricity throughout the winter as well as residual heat from the main building. Additional heat was supplied with a Marley® unit heater. Readily available materials that were used for the project include: 2-gallon pots, plantlets/tubers, hoses, wands, a Marley® unit heater, 35-gallon water tank, grow lights, benches, Greenshield®, PVC pipe, hand shears, grading screens, bags, labels, cold storage units, 1 liter Erlenmeyer Flasks, pH/Conductivity meter, light meter, controllers for lights and heat. Purchased for this project were 2 5-gallon buckets with lids, a Little-GIANT® pump, 2 bales of Pro-Mix, 4 bags of perlite, two T5 High Output (HO) fluorescent lights, and fertilizer.

Varieties to plant were chosen from a spectrum of maturity rates with an emphasis on mid-term maturity, typically 80-100 days under normal field conditions. Varieties were planted from either plantlets or G-0 tubers. The greenhouse was sterilized with Greenshield® on Jan. 7, 2016 and all pots were planted on Jan. 11, 2016.

Variety	Source	# of Pots	Maturity
Granola	Plantlet	10	Late
German Butterball	G-0 tubers	7	Late
Denali	G-0 tubers	10	Late
All Blue	Plantlet	5	Mid
All Red	Plantlet	12	Mid
Kennebec	G-0 tubers	2	Mid
Krantz	G-0 tubers	4	Mid
Candy Cane	Plantlet	7	Mid
Magic Molly	G-0 tubers	13	Mid
Bushes Peanut	Plantlet	20	Early
French Fingerling	Plantlet	10	Early

The greenhouse was equipped with two T5 High Output (HO) fluorescent lights, one 324-watt and one 216-watt; as well as one High Intensity Discharge (HID) 600-watt Metal Halide lamp on a moving track system. After planting, the output of the grow lights was measured with an Apogee light meter. At pot level, the light output ranged from 164µmol/m^2/s to 226µmol/m^2/s. The lights were programmed to be on for 18 hours/day at initiation. The duration of the light cycle was systematically diminished after the flowering stage.

Fertilizer components were purchased individually and were measured appropriately for 5 gallons of 100x concentrate. The components were separated into two discrete solutions that were only combined at dilution in order to reduce precipitation.

<u>Solution A</u>

734.5 g	Potassium Nitrate
1,695.3 g	Calcium Nitrate
24.4 g	Iron EDTA

The components were combined and filled to 5 gallons with potable water in a 5-gallon bucket with a lid.

<u>Solution B</u>

215.0 g	Magnesium Sulfate
128.7 g	Potassium Monobasic Phosphate
8.6 g	Boric Acid
7.4 g	Manganese Sulfate
0.154 g	Sodium Molybdate
1.785 g	Copper Sulfate
3.43 g	Zinc Sulfate
186.5 g	Ammonium Monobasic Phosphate
292.7 g	Potassium Sulfate

The components were combined and filled to 5 gallons with potable water in a 5-gallon bucket with a lid.

At formulation 1 liter of solution A and 1 liter of solution B were added to a partially filled 35-gallon tank and filled to a premeasured 100-liter mark with potable water. After dilution, the pH was measured and found to be within the acceptable range at 6.91. The conductivity was also measured and found to be high at 2220µS/cm. Future dilutions incorporated 3-5 liters of distilled water to reduce the conductivity. The 100-liter final formulation tank was equipped with a Little GIANT® pump with a bypass valve made from PVC pipe for mixing, attached to a hose and a wand. All the potato pots were hand watered as necessary.

On March 4th, the PMC pathology department (part of the PMC Horticulture Program) sampled the grow-out. One percent (1%) of each variety was sampled with a minimum of 10 leaves collected per variety. All varieties were tested by ELISA and found to be negative for PLRV, PVX and PVY. Also, any pots without growing plants were eliminated. Removed from the project were: 3 pots of Denali, 1 pot of Kennebec, 1 pot of Krantz and 1 pot of German Butterball. These six pots were all initiated from tubers.

Vine kill was performed manually with hand shears by cutting and removing the vines on April 27th. Watering was discontinued and the heat in the greenhouse was turned off in order for the tubers to suberize in the pots prior to harvest. This occurred 107 days after planting.

Potatoes were harvested on May 4th, 114 days after planting. Adequate suberization had occurred in the pots and the skins were in good shape. The tubers were collected on grading screens, bagged and labeled and removed to a cold storage unit maintained between 38-40°F.

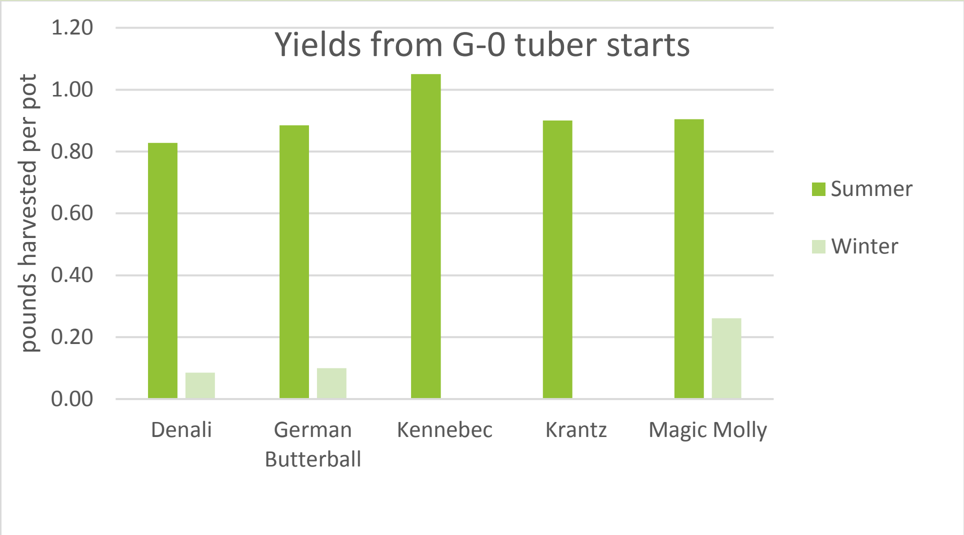
Results

In terms of creating vegetative growth for winter pathogen screening, the winter grow out was a success. All the varieties produced very good top growth.

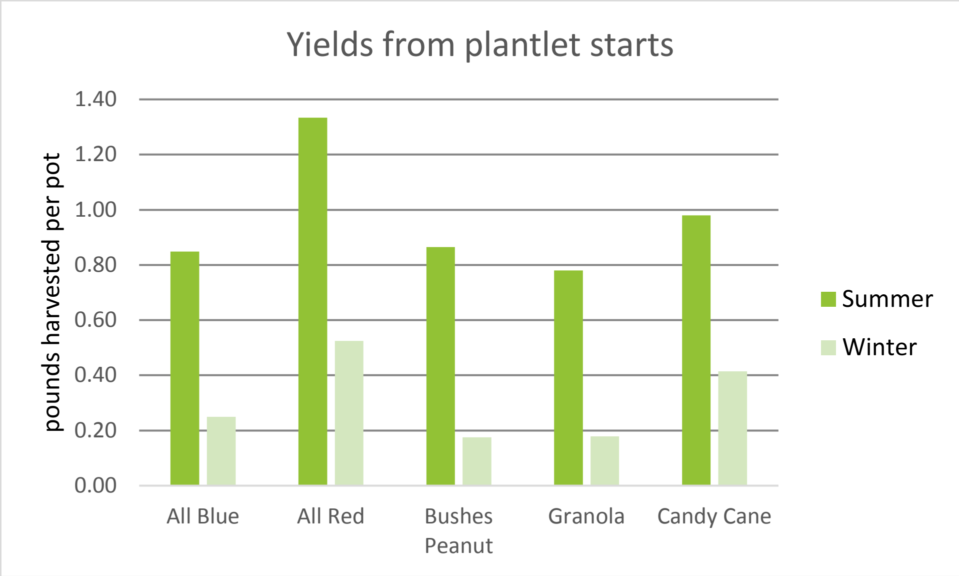
The harvest yields of tubers were very low compared to the yields of summer production. French Fingerling was not grown in the summer greenhouse and so data for this variety was not included in the comparisons. Only plantlets were used for the summer greenhouse production.

Variety	Winter Source	Summer lbs/pot	Winter lbs/pot	% Reduction
All Blue	Plantlet	0.85	0.25	71%
All Red	Plantlet	1.33	0.53	61%
Bushes Peanut	Plantlet	0.86	0.18	80%
Candy Cane	Plantlet	0.98	0.41	58%
Denali	Tuber	0.83	0.09	90%
German Butterball	Tuber	0.88	0.10	89%
Granola	Plantlet	0.78	0.18	77%
Kennebec	Tuber	1.05	0.00	100%
Krantz	Tuber	0.90	0.00	100%
Magic Molly	Tuber	0.91	0.26	71%
French Fingerling	Plantlet	na	0.19	na

There was a high loss of yield in terms of pounds harvested per pot when summer yields and winter yields are compared. The contrast was most marked in the varieties started from tubers. Kennebec and Krantz were the smallest lots with only 3 pots of Krantz and only 1 pot of Kennebec harvested. Neither variety produced any suitable tubers. If Kennebec and Krantz are removed from consideration, the varieties started from G-0 tubers exhibited an average 83% reduction in yield between the summer grow out and the winter grow out.



The varieties initiated from plantlets performed slightly better than those started from tubers with an average reduction in yield between summer harvest and winter harvest of 69.4%.



Discussion

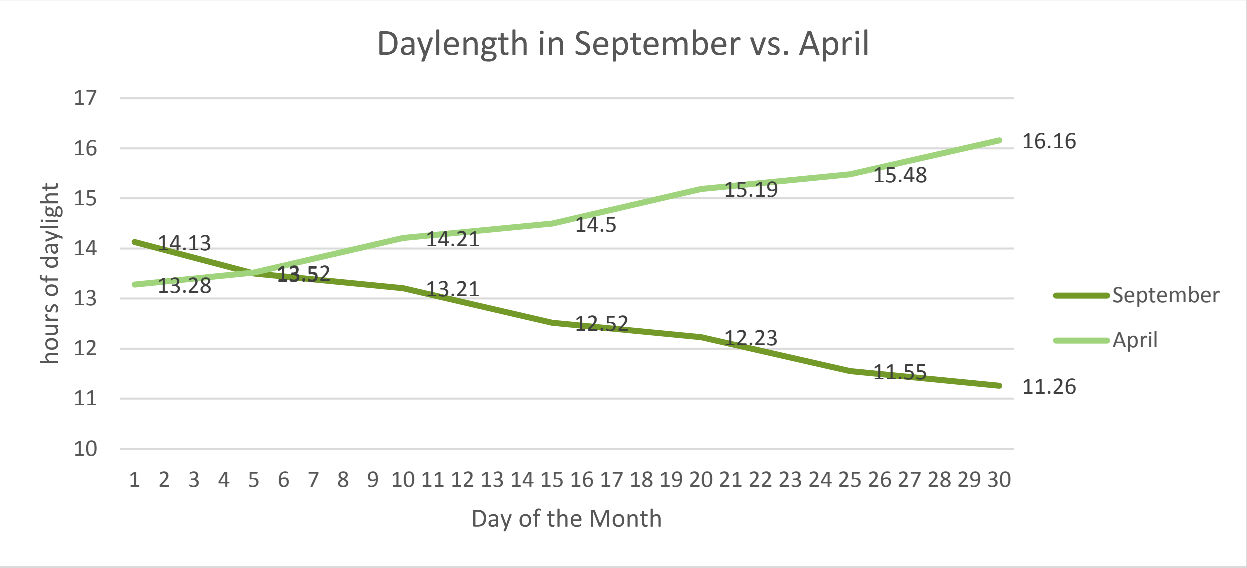
The difference in production efficiency is startling and suggests that tuber production outside of the normal growing season is not going to be cost effective. However, there are times when winter tuber production would be very useful: we occasionally get tuber requests under unique circumstances which we would like to fulfill, there are times that varieties in the gene bank are without tuber back-ups, or additional tubers are needed on a short turnaround time for a project. In preparation for a second year of our experiment, there are some adjustments to make to try to increase our efficiency.

An automatic watering system would greatly reduce a source of variability in our trial. As the plants became large, it was difficult to find all the pots and it was impossible to reach all the pots, especially at soil level. An automatic watering system with a stake inserted in the soil on a timer would deliver the same amount of water to each pot much more consistently than hand watering.

Another proposed alteration to the procedure is that more space is needed between pots. We packed the greenhouse as full as we could get it, but ran into spacing issues as the plants grew. Growing fewer pots would allow better aeration between pots and plants as well as improve accessibility to the furthest pots. This would allow a more thorough evaluation of moisture levels as well as tuber production throughout the growing season.

An earlier plant date would give us more control over the amount of light received by the plants and the ambient temperature which are both factors affecting tuber development. The PMC is located near the base of Pioneer Peak and from the months of November to February, the sun does not rise over the top of the mountain. At a minimum, during winter solstice in late December, we receive approximately 5.5 hours of daylight, but it is not direct sunlight at our location because the mountain blocks the sun. When the sun rises high enough in the sky to clear Pioneer Peak in early February, we are in a phase of rapidly increasing daylight, and as natural sunlight hits our south facing greenhouse, it naturally increases the ambient temperature in the greenhouse. Both of these factors were working against us in March and April while we were trying to stimulate tuber development.

September is a common potato harvest month in Alaska. In the figure below, note the decreasing day length in September. We can simulate this decline in hours of daylight with grow lights, but only if natural sunlight is not more abundant than our model. This can be achieved by planting in October or November and continuing through the time when the daylight required by the plants is less than is naturally available. In the winter grow out, vine kill occurred on April 27 marking the end of the growing phase for the potato plants. April 27th had approximately 15.5 hours of daylight and the 27th day in September receives approximately 11.5 hours of daylight.



Harvesting in early May did not leave much time for the tubers to become dormant prior to reconditioning and field planting. The minimum recommended storage duration is 21 days and we did keep potatoes in cold storage for a minimum of 28 days. However, dormancy is variety specific and any potatoes that did not receive adequate time in cold storage may experience reduced viability.

An additional point of interest is the cost of performing this non-seasonal grow out. We did not track our costs during the 2015/2016 winter grow out except for the cost of supplies. For the 2016/2017 grow out it would be interesting to monitor the number of batches of fertilizer prepared as well as monitor the electricity usage with a kilowatt meter. Not only would this data be useful from a budgeting perspective, but it could also be useful as we calculate a reasonable charge for a winter grow out service.

The final alteration to the procedure that is under consideration is to try LED lighting rather than HO fluorescent lights or HID. The minimum amount of light measured at potato pot level was 164µmol/m^2/s. This may be an inadequate intensity for production. LED lights may offer higher output and should reduce the amount of electricity required to operate.

Conclusion

The PMC Potato Germplasm gained some valuable insights into winter potato production in the first of the two years of this project. We were able to confirm that the PMC is able to grow vegetative material for winter testing. As the national potato market moves more toward processing (chips/fries/frozen goods), it could be valuable for Alaska to be able to compete in this market. To do so, Alaskan growers would need to meet the import requirements of any purchasing agent. As is often the case, the scale of production, testing and export necessary to make such a venture economically viable is challenging. At this time, there are no state requirements for winter grow out and testing, nor are there protocols currently in place; but at the PMC we hope to be able to provide this service to the statewide certified potato seed growers should we be called upon to do so.