THE EFFECTS OF BLUE LIGHT AT 440 NM ON POTATO TUBERIZATION FOR *SOLANUM TUBEROSUM* L. CV. DESIRÉE AND L. CV. NORLAND

by Erin Austad 2004

Abstract

In my project I determined the effect of blue light at 440 nm on potato callus and tuberization. A potato tuber is the part of the plant that becomes the actual potato. Callus is an isolated thickening of potato plant tissue.

My first goal was to grow a somatic mutation of a Norland plant (*Solanum tuberosum* L. cv. Norland), which is a mutation that responds uniquely to blue light. I was able to grow one possible Norland somatic mutation with a white/green tuber and another possible Red Norland somatic mutation with a pink/purple tuber instead of just producing callus. I found that cloned plants produce the same color callus as plants that are not cloned. My second goal was to determine how long Norland and Desirée plants (*Solanum tuberosum* L. cv. Desirée) had to be exposed to blue light in order for differential responses to occur. I grew six different sets of Norland plants, each set exposed to blue light for different periods of time, from 2-10 weeks. Almost all plants grew red callus near the base of the plant and white callus near the top. The plants did not produce tubers. I repeated the same procedure with Desirée plants. Blue light had an effect on Desirée plants, since all sets of Desirée plants exposed to blue light produced tubers that were white, green, or pink. Desirée plants that were exposed to blue light from 4-6 weeks grew the most tubers, showing that a 4-6 week exposure period was optimal.

Introduction

The overall purpose of my project was to determine the effect of blue light at 440 nm on potato callus and tuberization. It is known that light, along with nitrogen levels and temperature, has one of the greatest effects on potato tuberization (1). A potato tuber is the part of the potato plant that becomes the actual potato. Callus is an isolated thickening of tissue on the potato plant.

A number of factors contribute to the growth of potato tubers, but light is most important (2). Plants primarily absorb blue and red light; the wavelength of light determines the color of potato tubers (3, 4). Effects of white light, red light, and far-red light have been studied, but not much is known about the effect of blue light on potato tuberization (5). Jenkins *et al.* (2001) found that blue light regulates stem extension, phototropism, leaf and chloroplast development, chloroplast movement, stomatal opening, and flowering time in plants; however the effects of blue light on potato tubers were not studied (5).

In a previous study by Tong *et al*., Desirée potato plants (*Solanum tuberosum* L. cv. Desirée) formed pink tubers under blue light but formed white tubers when no light was present. In the same study, Norland potato plants (*Solanum tuberosum* L. cv. Norland) did not form any tubers in blue light but formed red tubers without light (4).

It is not known why some wavelengths of light do not produce potato tubers, but mutant potato plants, called somatic mutations, can spontaneously occur, which react to wavelengths of light differently than most other plants. Although only one or more mutant potato plants are usually found in a population of 100,000, they are more commonly found in potato plants that form genotypically identical clones via stolons, tubers, and bulbs (6).

I had three goals for this project. My first goal was to grow a somatic mutation of Norland potato plant that responded uniquely to blue light at 440 nm by producing tubers. Second, I wanted to determine how long Norland and Desirée potato plants had to be exposed to blue light at 440 nm in order for differential responses to take place. My third goal was to graft the bottoms of Norland plants to the tops of Desirée plants and visa versa to determine the best procedure to graft potato plants together. The data from this study can be used to understand the effect of blue light on the growth of potatoes, which will ultimately help farmers produce superior crops by exposing the plants to specific conditions for optimal growth (7).

Materials and Methods

Somatic Mutation Under Blue Light

I placed 25 tissue-cultured Norland, Red Norland, and Dark Red Norland potato plants into 25 individual test tubes that contained 10 mL of tissue-culture media (30 g sucrose, 4.3 g of basal salts, 1 mL of heated Nitch and Nitch vitamins, made to 1000 mL with deionized water). I kept the pH of the solid media between pH 5.6 and 5.7 using 2 *M* HCl or 1 *M* KOH. Then I added 1.2 g of phytagel and heated the liquid until clear. I autoclaved the solid media.

I began performing subcultures with one Norland, one Red Norland, and one Dark Red Norland potato plant and subcultured each of the plants until I had 25 plants of each variety. I performed all tissue culturing in a laminar flow hood, using sterilized forceps and razor blades. Once I had 25 two-week old plants from each variety, I transferred them to individual test tubes containing 20 mL of tuber-inducing media (60 g sucrose, 4.3 g of basal salts, 1 mL Nitch and Nitch Vitamins, 25 mL 0.1 *M* kinetin, made to 1000 mL with deionized water). I kept the liquid media between pH 5.6 and 5.7, using 2 *M* HCl or 1 *M* KOH. I grew 25 plants from each variety under blue light at a wavelength of 440 nm.

Over time, I looked for callus versus number of tubers, how the color develops, and the number of days until tuberization. I also looked for somatic mutants that exhibited different responses than the other plants that shared the same differential response.

Response to Blue Light For Differential Responses

The second part of my project was to grow Norland and Desirée plants under different periods of blue light at 440 nm and in darkness, as seen in Table 1 for Norland plants and Table 2 for Desirée plants. The plants I used were two weeks old and grown in 20 mL tuber-inducing media. First, I grew the plants under blue light and then in darkness. When I took the plants out of blue light, I wrapped aluminum foil around each test tube so that light could not reach the plant.

Table 1: Norland Plants Grown Under Different Periods of Blue Light

Potato Plant Set	Number of Norland Plants	Weeks Under Blue Light	Weeks In Darkness
Set A	5	0	10
Set B	5	2	8
Set C	5	4	6
Set D	5	6	4
Set E	5	8	2
Set F	5	10	0

Table 2: Desirée Plants Grown Under Different Periods of Blue Light

Potato Plant Set	Number of Desirée Plants	Weeks Under Blue Light	Weeks in Darkness
Set G	5	0	10
Set H	5	2	8
Set I	5	4	6
Set J	5	6	4
Set K	5	8	2
Set L	5	10	0

Grafting

In the third part of my project, I grafted tops and bottoms of Norland and Desirée potato plants together, using two different methods. The first method I used was direct splice grafting. That method can be seen at http://www.ces.ncsu.edu/depts/hort/hil/grafting.html.

For the second method, I prepared agar blocks from 2 mL of 0.2 *M* sodium phosphate, 3 g phytagel, and made to 200 mL with deionized water. I boiled and autoclaved the liquid. I poured the agar into plates and let the agar dry in the hood until it solidified. I grafted tops of Norland plants to bottoms of Desirée plants, tops of Desirée plants to bottoms of Norland plants. I grafted Norland tops to Norland bottoms and Desirée tops to Desirée bottoms as my two controls. The plants I used were two weeks old and grafted together in test tubes to make sure they were sterile. Once the plants were grafted together, I grew them under blue light at 440 nm.

Results

Table 3 shows data from six different sets of plants, each set exposed to blue light for the stated period of time. Each set of plants produced callus, ranging from 40-100%, but callus production followed no specific trend during any of the time intervals. In sets A, C, D, and F, 75% of the plants grew callus. In set B, 100% of the plants grew callus, and in set E, 40% of the plants grew callus. Sets B, C, D, E, and F all had callus that was white near the top and red near the base. None of the Norland plants in any set formed tubers.

Table 3: Blue Light vs. Darkness For Norland Plants

Potato Plant Set	Weeks Under Blue Light	Weeks In Darkness	% With Callus	Callus Color	% With Tubers	Tuber Color
Set A	0	10	75	White/Pink	0	-
Set B	2	8	100	White – on top Red – near base	0	-
Set C	4	6	75	White – on top Red – near base	0	-
Set D	6	4	75	White – on top Red – near base	0	-
Set E	8	2	40	White – on top Red – near base	0	-
Set F	10	0	75	White – on top Red – near base	0	-

Table 4 shows data from six different sets of plants, each set exposed to blue light for the stated period of time. Each set of plants produced callus, ranging from 20-100%, but callus growth followed no specific trend during any of the growth times. The callus color was white, except for the plants in set K, which had white and pink callus. Of the plants in sets I and J, 75% produced tubers. Sets H, I, and L produced white/green tubers. Sets J and K produced white/green/pink tubers. Set G produced white tubers.

Table 4: Blue Light vs. Darkness For Desirée Plants

Potato Plant Set	Weeks Under Blue Light	Weeks In Darkness	% With Callus	Callus Color	% With Tubers	Tuber Color
Set G	0	10	75	White	25	White
Set H	2	8	100	White	50	White/Green
Set I	4	6	50	White	75	White/Green
Set J	6	4	75	White	75	White/Green/Pink
Set K	8	2	80	White/Pink	40	White/Green/Pink
Set L	10	0	20	White	20	White/Green

Table 5 shows the growth of cloned Norland plants under blue light over an 8-week period. The table shows that Norland plants continued growing callus as they spent more time under blue light. At week 4, the callus was white and pink and did not change color after that. At week 6, one Norland plant formed a white tuber, but the tuber became a white/green color after seven weeks under blue light. This plant was a possible somatic mutation.

Table 5: Cloned Norland Plants

Weeks Under Blue Light	% With Callus	Callus Color	# of Plants With Tubers	Tuber Color
1	12	White	0	-
2	12	White	0	-
3	24	White	0	-

4	29	White/Pink	0	-
5	35	White/Pink	0	-
6	41	White/Pink	1	White
7	41	White/Pink	1	White/Green
8	65	White/Pink	1	White/Green

Table 6 shows the growth of cloned Red Norland plants over an 8-week period. The table shows that callus kept growing on Red Norland plants over the 8-week period. The callus color was white during weeks 1-3, but became white and pink during weeks 4-6; and then white, pink, and red during weeks 7 and 8. At week 7, one Red Norland grew a tuber, which was pink at 7 weeks but became pink/purple at 8 weeks.

Table 6: Cloned Red Norland Plants

Weeks Under Blue Light	% With Callus	Callus Color	# of Plants With Tubers	Tuber Color
1	10	White	0	-
2	10	White	0	-
3	50	White	0	-
4	65	White/Pink	0	-
5	75	White/Pink	0	-
6	75	White/Pink	0	-
7	75	White/Pink/Red	1	Pink
8	90	White/Pink/Red	1	Pink/Purple

Table 7 shows the growth of the cloned Dark Red Norland plants over an 8-week period. The table shows that callus continued growing throughout the 8-week period. Dark Red Norland plants grew less callus than cloned Red Norland and Norland plants. The callus from all Dark Red Norland plants ranged from white to pink. No Dark Red Norland plants grew tubers during the 8-week period.

Table 7: Cloned Dark Red Norland Plants

Weeks Under Blue Light	% With Callus	Callus Color	# of Plants With Tubers	Tuber Color
1	0	-	0	-
2	0	-	0	-
3	15	White	0	-
4	25	White	0	-
5	35	White	0	-
6	40	White/Pink	0	-
7	40	White/Pink	0	-
8	50	White/Pink	0	-

Discussion

Blue Light vs. Darkness for Norland Plants

The overall purpose of my project was to determine the effect of blue light at 440 nm on potato callus and tuberization. Under blue light up to 10 weeks, there was no tuberization

for Norland plants, only callus. The callus on those plants was white near the top and red near the base. This shows that tuberization will not occur under blue light for Norland potatoes. Tubers will not grow after 8-10 weeks (4). Presently, this study is being replicated to see if the same results take place.

Blue Light vs. Darkness for Desirée Plants

Blue light did affect tuberization in Desirée plants. In fact, all sets of plants exposed to blue light produced tubers. Since Desirée plants that were exposed to blue light for 4-6 weeks and darkness for 4-6 weeks produced the most tubers, a 4-6 week exposure period seems optimal. Desirée tubers grown under blue light are white, green, or pink. Desirée plants grown under blue light and in darkness produced callus that was mostly white, some was pink, but none was green. Ideally, potato tubers should be red in color, so the tubers and callus under blue light are not ideal. Presently, this study is being replicated to see if the same results take place.

Norland, Red Norland, and Dark Red Norland Clones

Under blue light, clones of Norland, Red Norland, and Dark Red Norland produced callus as they spent more time growing. Norland and Dark Red Norland clones grew white and pink callus under blue light. Red Norland clones grew white, pink, and red callus under blue light. This shows that the cloned plants seem to produce the same color callus as the plants that were not cloned and behave like clones should.

One Norland clone grew a white/green tuber, and one Red Norland clone grew a pink/purple tuber, so this was probably a somatic mutation. I took tissue samples from the roots, callus, stem, and tubers of these possible somatic mutations for further study to see whether or not they are true somatic mutations. None of the Dark Red Norland plants grew any tubers or produced any possible somatic mutations.

Currently, I am repeating this entire study to see if the same results are achieved. This time I am tracking which part of the original plant the clones come from to see if somatic mutations are more likely to occur if they are from certain areas of the original plant.

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