Light-emitting diode lights can make rooting cuttings easier and safer©

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INTRODUCTION

Bailey Nurseries in St. Paul roots over 9 million cuttings every year. This includes a portion grown from tissue culture. These micro-cuttings started in January are the *Syringa vulgaris* hybrids (frequently called the French hybrids lilacs). These micro-cuttings lilacs are shipped to Minnesota from a tissue culture laboratory in Oregon.

Minnesota in winter is not the ideal place to root micro-cuttings in a greenhouse. Cold temperatures, low humidity, and low light conditions make rooting cuttings a real challenge. The current method, which uses small tents to better control the environment, yields variable results, and the cuttings require a lot of labor to maintain.

When we began reading about how European growers were using light-emitting diode (LED) lights to root cuttings, it piqued our interest and several questions came to mind. Here are some of the key questions:

- Where can we install some LED lights?
- Will they produce a good crop?
- Which crops will benefit from this system?
- Will they simplify grower care and improve rooting?
- Will they last in the environment in which we'll eventually put them?

METHODS AND MATERIALS

In 2011, we worked with Philips and Hort Americas [our supplier and technical support – the contact info is Chris Higgins (chiggins@hortamericas.com)] to design a propagation chamber using LED lights in one of the buildings.

We started the initial trial in February 2011. We partitioned a section of the germination chamber. This chamber provides a constant 75°F temperature in the winter, has light provided by 8 ft-long fluorescent tubes, has misting capacity (fog nozzles suspended from the ceiling), and readily available electricity. The tent we created was partitioned from the rest of the chamber with black and white plastic to avoid light contamination from the fluorescent lights (used for germination). We used three Cannon carts tied together side-by-side to form one large shelf that could hold up to 15 trays. The light source under this tent was provided by five Philips GreenPower LED production modules made of 70% deep red and 30% blue lights. The distance from the shelf to the module was 15 in. These modules are 5 ft long, which matches the size of the Cannon carts. We had room for 15 flats.

A range of cuttings were taken from plants in the greenhouses, including *Spiraea*, *Celastrus*, *Physocarpus*, and *Hydrangea*, to name a few. The cuttings originating from the greenhouses were stuck in 38-cell plastic trays (standard size of 11×21 in.) and treated with IBA. We also added 900 micro-cutting lilacs to the LED area. These micro-cutting lilacs were grown in three 288-trays. The medium used was Preforma and without the use of IBA.

In 2012 we purchased more GreenPower LED production modules. We created and partitioned six stalls from the main germination chamber. We are now able to move the Cannon carts in and out of the chamber with total ease. Each cart has five shelves, or layers, with 15-in. spacing between shelves. The modules are mounted on the frame of the stalls and are tilted 90° towards the center of each shelf. Each shelf is lit by two modules. The light

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cycle is 16 h on and 8 h off. During the off time, the mist cycle is also turned off. During the day time, the mist cycle is controlled by a timer. The cuttings receive more mist during the first 2 days. As they acclimate and develop roots, the mist is reduced each day. A grower is responsible to check the lilacs 5 or 6 times a day. This check only takes a few minutes each time, as every element (moisture, temperature, and light) stays constant. The mist water is treated with a reverse osmosis system. This system prevents the build-up of calcium carbonate on surfaces, especially the diodes. The first roots are seen after a few days. At 10 days, most cuttings will show some roots. At 2 weeks, some roots will be at the bottom of the cell and coming out of the drain holes. This is when they will get fertilized. A liquid solution of 50 ppm nitrogen is applied over the top of the cuttings. As early as 3 weeks, but preferably at 4, the lilacs can be moved to a greenhouse. Once in the greenhouse, they are fertilized again. It is important to acclimate them to ambient light, under some shade. Full sun will burn the foliage. After a few days of acclimation, they can be planted in the sand.

This setup can accommodate a total of 150 flats. Because of the multi-layer production design, we now think in number of plants per cubic foot instead of square foot. During the winter of 2012, we rooted 16,000 micro-cutting lilacs, or 25% of the schedule. And during the winter of 2013, we rooted 66,000 micro-cutting lilacs, or 100% of the schedule. This practice was repeated in 2014 and 2015.

Our normal greenhouse growing practices require the presence of a grower every 30 min during work hours, or more often when the light level (sun/cloud) keeps changing. In this system, these tissue culture lilacs are rooted inside several small tents (24 flats each) in one of our greenhouses. This greenhouse is heated by steam pipes buried in the sand and by forced air. The tents are used to create a micro climate that is easier to control than trying to control the entire greenhouse. Depending on the level of sun intensity, on how much moisture is in the air and on how often the heaters are running, the grower in charge has to adjust: the mist cycle, which is done by hand; the amount of shade, which is a combination of different layers of plastic covering the tent; and the level of venting, which is done by opening or closing these same layers of plastic to match the outside growing conditions. This takes place all day long.

In the LED chamber, there is none of this constant monitoring. We have experienced a significant reduction of crop monitoring. The fogging system fills the entire room with fog, and for this reason, no hand misting is necessary. The fog keeps the cuttings turgid, the fluorescent tubes in the germination chamber maintain a constant air temperature of 75°F and the LED lights provide the proper light quality, intensity, and duration to promote plant growth.

RESULTS

Right away in 2011 we were able to answer several of our questions. The first year indicated that growing under LED lights is possible. We were able to root cuttings with minimum maintenance. These cuttings (*Hydrangea paniculata* and *Spiraea*) were transplanted into larger containers (quart size) and again grown under LED lights in a different tent, outside the germination chamber. We were able to root and grow and take cuttings from these plants. This second generation of cuttings was also rooted under LED light. This meant that this last generation of cuttings were plants that had never seen sunlight.

In regards to crop quality, not all crops responded equally to these new growing conditions. It was ideal for the micro-cuttings, but plants like *Rhus typhina* 'Bailtiger', Tiger Eyes® staghorn sumac for example had issues because of the high level of humidity. We experience cuttings growing roots above the soil line (because of the light, temperature, and humidity). Spireas and hydrangeas were more prone to this reaction than other crops like roses. The aesthetic value of the plugs was reduced by the presence of these roots.

The next observation on plant quality was that plants needed to be moved out as soon as they were rooted. Keeping them under these growing conditions (high humidity) was not helping. The growing conditions were promoting the growth of botrytis rapidly. Weekly sprays were required to keep this fungus under control.

Seed germination was also successful in these conditions (under LED lights) when compared to the normal conditions (fluorescent light) in the germination chamber. What was observed using impatiens seeds was that these seedlings were shorter under the LED light source than under the fluorescent light source. This can be an advantage for a bedding plant grower. Shorter plugs make for a better finished product. Germinating under LED light can also provide some safety if the seedlings are not moved fast enough to a greenhouse, as they are elongating at a slower pace under LED than under fluorescent light.

This system is not without a significant capital investment, even for a small scale (150 flats), as described in this paper. It is important to determine the benefits from this system. Here the principal goal was to increase the yield and reduce or simplify labor associated with rooting micro-cutting lilacs. The second goal was to determine if other crops would benefit from this system. The focus was put on crops that are difficult to root. The problem crops are *R. typhina* 'Bailtiger', Tiger Eyes® staghorn sumac; *Amelanchier*; *Cotinus;* or *Daphne*, for example. Several trials have been performed with mixed results. Regarding these trials, the main source of problems (causing failure) is the management of the level of moisture. The mist of this chamber is not adequate for all crops. As a result, we are seeing good and poor rooting success on the same crop. Proper management of the moisture level in the chamber is critical for success. It works for the micro-cuttings (Table 1).

Linked to high humidity level, one more observation is necessary. The Philips GreenPower LED production modules are rated to 95% humidity. Our chamber exceeds this level. Everything is wet, and droplets form on the diodes and other surfaces. From our experience, we believe water finds its way into the modules in two ways. The first is via the splicing that connects the power cords. Even though our process has improved, we still see water getting into the power cord. This is not a defect of the production modules. It is directly linked to our setup and the level of moisture in the air, which is more like 100%. The second way for the water to enter the module is around the diodes. Because water enters the module, over time it will damage some of the electronic components inside the module. These two observations result from the "extreme" environmental growing conditions, conditions that exceed the manufacturer recommendations.

Table 1. Rooting percentages — germination chamber versus tents in the greenhouse.

Cultivars	2012	2013[1]	2014	2015[2]	Tents (7-year average)
Albert F. Holden		72	92	42	61
Krasavitsa Moskvy (syn. Beauty of Moscow)		87	93		74
Charles Joly			85	93	
Common white lilac		93	94	95	87
Ludwig Spaeth		90	95		67
Madame Lemoine		96	86		71
Président Grévy			96	87	
President Lincoln		100	94	100	72
Sensation		96	85	94	80
Wedgwood Blue			88	97	
Yankee Doodle	95	51	81	45	63
Wonder Blue		95	96		83
Declaration			85	44	
Miss Ellen Willmott		89	89		75
Pocahontas				98	

[1]In 2013 the 'Yankee Doodle' arrived with cold damage (frozen). This explains the low rooting percentage.

[2]In 2015 'Albert F. Holden', 'Yankee Doodle', and 'Declaration' experienced spray damages from a contaminated backpack with herbicide residue.

When a yield percentage is missing, that cultivar was not grown that year.

SUMMARY

Growers can benefit greatly from using the right source of LED lights, for the right crop, and in the right circumstances. Here is a summary of these benefits:

Advantages:

- Increased yield
- Increased plant quality
- Reduced crop timing
- Reduced and simplified grower care
- Reduced greenhouse cost, heat and maintenance
- Freed up greenhouse space
- Accelerated propagation, and
- Propagation made possible at any time of the year, as long as a cutting source is available

Disadvantages:

- Investment cost
- Durability and reliability
- Directional light

CONCLUSION

Under the controlled environmental conditions of the germination chamber (uniform temperature, light and humidity), the Preforma plugs remain moist, the micro-cutting lilacs keep turgid, the temperature and light source is constant and the cuttings never get stressed. There is little to no grower care required in these growing conditions. Because the cuttings are not stressed as much as in the greenhouse under the tents, the yield (percent of rooted plants) is increased, and grower time is reduced.