Benefits of supplemental lighting in citrus nurseries

By Gur Reet Brar and Timothy M. Spann

Nurserymen have long observed the slowdown in tree growth, particularly with trifoliate-type rootstocks, that occurs during the winter months in Florida citrus nurseries. This slowdown can be so dramatic that some nurseries stop propagating on certain rootstocks through the winter. We've recently conducted some research to determine the physiological cause of this slowdown and what can be done to reduce or eliminate it.

Slower growth of plants during winter is a normal response to cooler temperatures and reduced photoperiod (day length). There are two primary ways that day length can affect plant growth. The first is photosynthesis; under shorter days, there are simply fewer hours of sunlight for plants to photosynthesize and produce the carbohydrates they need to function. The second is truly a response to photoperiod — that is, the plant can actually determine the ratio of the number of hours of light and dark. In order to overcome the short-day response, it is important to know which of these — photosynthesis or photoperiod — the plant of interest is responding to.

HOW DO PLANTS SENSE DAY LENGTH?

Plants produce a molecule called phytochrome that is classified as a photoreceptor because it absorbs light. There are two different forms of phytochrome in plants that are interconvertible: phytochrome red (P_r), which absorbs red light (660 nm), and phytochrome far-red (P_{fr}), which absorbs far-red light (730 nm). When one of these molecules absorbs its respective wavelength of light, it is changed within milliseconds to the other form. Under normal daylight conditions, these two different forms of phytochrome reach equilibrium (40 percent P_r, 60 percent P_{fr}) since sunlight contains both red and far-red light. During darkness, P_{fr} changes to P_r through a process called dark reversion (P_r does not undergo such a change). Thus, over time in the dark, the majority of phytochrome will be in the P_r form. It is through the ratio of P_r:P_{fr} that plants can determine how long the day is by actually sensing the length of the dark period. Under short days (long nights) the ratio shifts more to the P_r form than under long days (short nights).

So why is phytochrome important? Because we can very easily change the length of day a plant perceives by simply providing some light (specifically red light) during the dark period to refresh the pool of P_{fr}. Essentially, interrupting the night with a short period of light resets the plant's clock. Additionally, this light does not need to be very bright compared with that needed to activate photosynthesis.

IS CITRUS PHOTOPERIODIC?

We've recently conducted a series of experiments to determine if the reduced growth of nursery trees on trifoliate rootstocks in winter is a photoperiod or photosynthetic response. We grew liners of Swingle and Carrizo rootstocks, as well as Hamlin trees budded on both rootstocks, under 10-hour and 14-hour day lengths for 14 weeks. These day lengths were chosen because they are approximately the shortest and longest day lengths experienced naturally in Florida. To determine if the reduced growth under short days was a phytochrome response or photosynthetic

response, we interrupted the 14-hour dark period of the 10-hour treatment with 1 hour of light (light break, night interrupt) during the middle of the 14 hours of dark.

The results of this experiment can be seen in the series of pictures in Figures 1 and 2 (page 20). Figure 1 shows Carrizo and Swingle liners grown under 10-hour (short day – SD), 14-hour (long day – LD) and 10-hour + 1-hour night interrupt (short day night interrupt – SDNI) photoperiods. The trees grown under LD and SDNI photoperiods grew similarly and were significantly larger than the SD trees. Figure 2 shows that Hamlin trees budded on Carrizo and Swingle rootstocks responded similarly to the liners. These results show that the reduced growth of Carrizo and Swingle trees in winter, whether budded or not, is a phytochrome photoperiod response and not a photosynthetic response.

IMPLEMENTING THIS INFORMATION IN THE NURSERY

Since a phytochrome photoperiod response is a low-light response, virtually any type of light (incandescent, fluorescent, high-pressure sodium, etc.) will work to increase the perceived day length. The goal should be to provide a sufficient number of lights to supply light equivalent to 2 µolm $^{-2}s^{-1}$ of sunlight or greater at plant height. This is roughly equivalent to about 14 foot-candles (1.1 W·m^{-2}) from cool-white fluorescent lamps or 10 foot-candles (5.2 W·m^{-2}) from incandescent lamps. This is in stark contrast to the amount of light that would need to be provided to stimulate photosynthesis, which would be several hundred times greater.

Since the goal is to maintain high levels of P_{fr} relative to P_r, the supplemental lighting can be provided in one of two ways by extending the day length or during the middle of the dark period. For example, if sunrise is at 7 a.m. and sunset at 6 p.m. (11-hour photoperiod), the lights could be on from 6 p.m. to 9 p.m. to provide a 14-hour photoperiod or from midnight to 1 a.m. to provide a light break. The effect will be the same. It is easy to see that the 1-hour night interrupt will consume less electricity than the day length extension scheme. However, if electrical capacity is limiting, the two schemes can be combined so that not all of the lights in a nursery need to run simultaneously.

Bear in mind that since the objective is to prevent the levels of P_{fr} from falling too low, there is a point in time during the night when a light break will no longer be effective. Therefore,

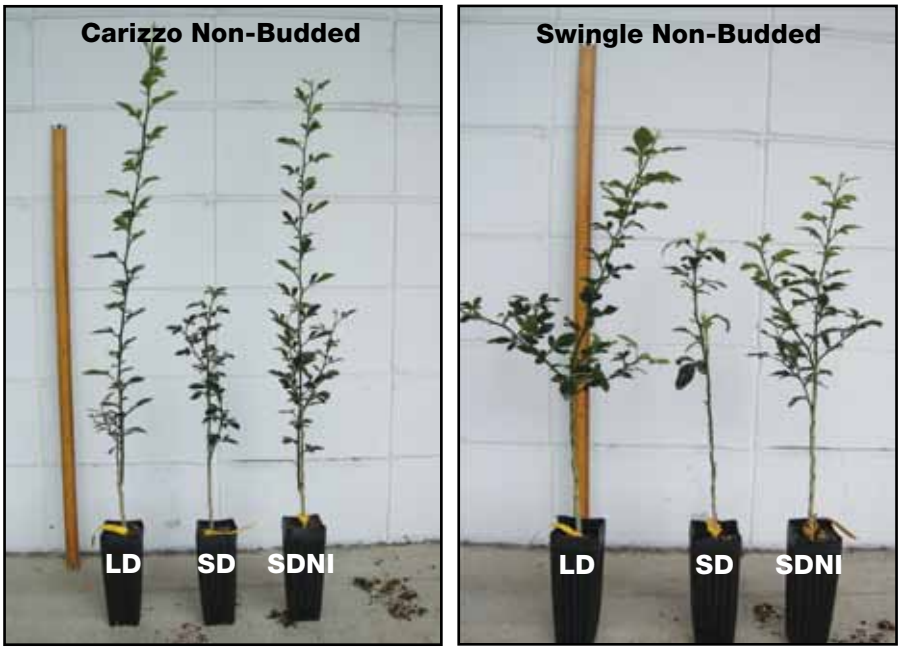

Figure 1. *Carrizo (left) and Swingle (right) liners grown for 14 weeks under 14-hour long days (LD), 10-hour short days (SD) or 10-hour short days + 1 hour night interrupt (SDNI).*

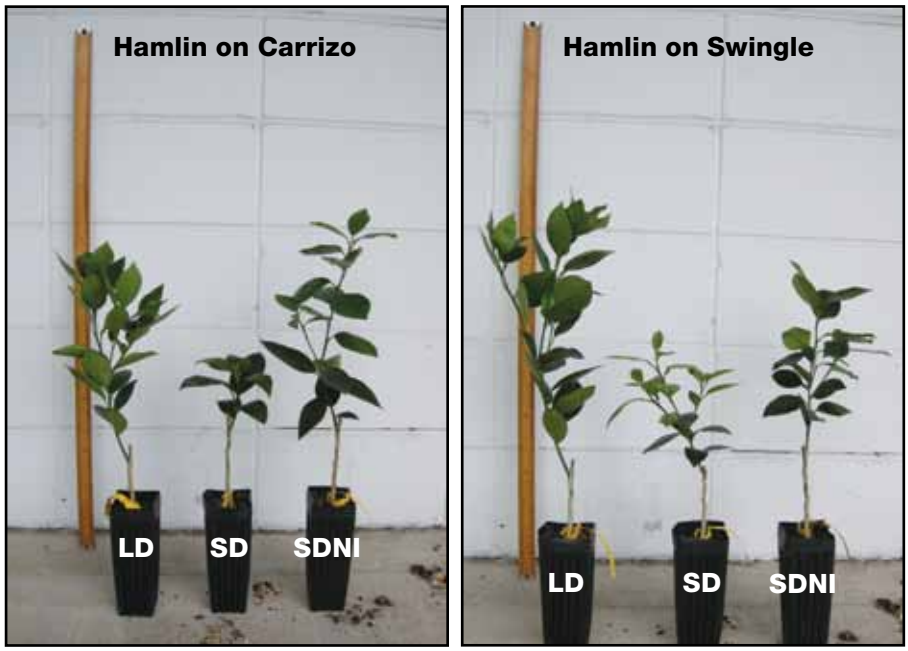

Figure 2. *Hamlin trees on Carrizo (left) and Swingle (right) rootstocks grown for 14 weeks under 14-hour long days (LD), 10-hour short days (SD) or 10-hour short days + 1 hour night interrupt (SDNI).*

day-length extension is only effective at the end of the day and not in the morning, and light breaks should be targeted at the middle of the dark period.

We are continuing our research on this topic to further refine our recommendations for supplemental lighting in citrus nurseries. We are particularly interested in determining whether all citrus rootstocks exhibit a photoperiod response or if this is restricted to trifoliate-type rootstocks. Additionally, we are working to define the relationship between temperature and photoperiod in citrus. As mentioned above, both factors play a role in reducing plant growth in winter, and there is likely to be a critical temperature below which supplemental lighting will not stimulate growth. However, we anticipate that this temperature threshold is below normal temperatures that are maintained in Florida citrus nurseries.

Low-intensity lighting for improving citrus nursery tree growth in winter should be an economical way to improve production efficiency. By maintaining growth through the winter, trees can be grown at a more uniform rate year-round. This will allow for more precise scheduling in the nursery and timely delivery of finished trees to the grower.

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WHAT'S SHAKIN'

Final totals for mechanically harvested acres and boxes for 2009-10 season

The Florida Department of Citrus announced in September that the number of acres and boxes of citrus mechanically harvested in the 2009-2010 season decreased, compared to the previous year. In 2009-10, 29,121 acres were mechanically harvested, a decrease of 18 percent from the 35,600 acres mechanically harvested in 2008-09. Total boxes mechanically harvested in 2009-10 were 7.1 million, compared to 9.5 million boxes mechanically harvested in 2008-09 — a 25 percent reduction.

The decreases in acreage and boxes harvested by mechanical systems were not totally unexpected as the overall crop yield was down. Visit http://citrusmh.ifas.ufl.edu to see a chart of the past 11 years of acres and boxes harvested mechanically.