Funding Generations of Progress
Through Research and Scholarships

Special Research Report # 534: Utilization of Ultraviolet-C (UV-C) Irradiation on Ornamental Plants for Growth Regulation

Mark P. Bridgen, Cornell University
School of Integrative Plant Science – Horticulture Section, Riverhead, NY

BACKGROUND

Ultraviolet (UV) light is an electromagnetic radiation with a wavelength from 400 nm to 100 nm. These wavelengths are shorter than that of visible light but longer than X-rays and usually invisible. Plants use sunlight for photosynthesis and are exposed to the ultraviolet (UV) radiation that is present in sunlight. UV radiation is divided into 3 classes: UV-C (100–280 nm), UV-B (280–315 nm), and UV-A (315–400 nm). Because the UV-C region of the spectrum includes wavelengths below 280 nm, these highly energetic wavelengths are absorbed by ozone and are not present in the sunlight at the earth's surface. Under normal growing conditions, effects of UV-C light are not seen on plants.

UV-C irradiation has been successfully used in the food industry as an environmentally friendly and safe defense-inducible biological elicitor for meats and horticultural products such as juices, fruits, and vegetables. Very recent research from Europe has demonstrated very promising uses of UV-C to suppress diseases in ornamental plants, to extend postharvest life of cut flowers, and as a pre-harvest treatment, to make plants flower quicker and grow with increased fresh mass and lateral branching.

MATERIALS AND METHODS

Germicidal, low-pressure vapor UV lamps (Osram HNS OFR) were assembled on a frame within an enclosed, opaque chamber for secure treatments under controlled conditions in the Cornell University greenhouses. Each lamp (2.5 cm diameter tube and 88 cm long) has a nominal power output of 30 W and peak wavelength emission of 253 nm. The dosage rate was measured at room temperature (~25 °C) using a StellarNet miniature fiber optic spectrometer (BLACK-Comet) fitted with a F600 UV VIS-SR fiber optic cable with CR2 cosine receptor. Various UV-C doses from 0 to 10.0 kJ m^2 were applied to the test plants depending on the experimental design and exposure times in seconds.

Common annual bedding plants, such as Viola tricolor (pansy), Salvia splendens (scarlet sage), Tagetes erecta (African marigold) and other plant species, not listed in this report, were evaluated by placing the plants at various distances below the lamps and applying the UV-C treatments for different times ranging from 15 to 60 minutes. UV-C irradiation was applied weekly at different dosages for up to 8 weeks. Non-irradiated plants were used as controls.

Growth and flowering responses were evaluated by recording the number of days to first inflorescence, number of inflorescences, and plant height (cm) every week. The number of lateral stems of the plants were recorded, as well as fresh weights and dry weights (oven dried at 75°C for 72 hours) when the plants reached anthesis or when the experiment was terminated.
During the experiments, the plants were arranged on expanded metal, aluminum benches in greenhouses in a randomized complete block design. Six to eight replications per treatment were used per crop cycle with replicate trials. Means were separated using Fisher's LSD multiple range test at P = 0.05.

RESULTS

Several species of plants received low dosages of UV-C irradiation for different time periods (15 minutes, 30 minutes, 45 minutes, and 60 minutes), at different frequencies (daily and weekly), and at different dosages. The dosage of UV-C irradiation was measured in kJ/m^2. The time of application and the distance from the lamp are two considerations when applying UV-C irradiation. Similar dosage rates can be accomplished by placing the plant closer to the UV-C light for shorter periods of time or farther from the UV-C light for longer periods of time. Because dosage rate controls the effect on the plant growth, determining the best dosage rate by the most appropriate procedure (time vs. distance) is one of the challenges of this research.

1. Dosage rates are critical

Too high a dosage of UV-C irradiation will burn plants and too low will have no effect. In the photos of African marigolds (Figure 1) and pansies (Figure 2), the control plants are in the row on the far left. In each photo there are 4 replications per treatment going from front to back. The plants in the right rows received the highest dosage rates by placing the UV-C light closest to the plants. The plants on the left side of the photos, after the control row, received the lowest dosages. It is clear that too high a dosage will damage or kill plants (right rows).

Figure 1. Tagetes erecta (African marigold) plants that were treated with UV-C irradiation. The control plants that did not receive UV-C light are in the row on the far left. There are 4 replications per treatment going from front to

back. The plants in the right rows received the highest dosage rates. The plants on the left side of the photos, after the control row, received the lowest dosages.

Figure 2. Viola tricolor tricolor (pansy) plants that were treated with UV-C irradiation. The control plants that did not receive UV-C light are in the row on the far left. There are 4 replications per treatment going from front to back. The plants in the right rows received the highest dosage rates. The plants on the left side of the photos, after the control row, received the lowest dosages.

2. UV-C light can decrease plant height

At appropriate dosage rates, UV-C light can decrease plant height on some species. On the African marigolds (Fig. 3), pansies (Fig. 4), and red salvia (Fig. 5) below, the control plants are on the far left (treatment #10). In each case, the UV-C irradiation has affected the height of the plants. The higher dosage rates are on the right side of the photos.

Figure 3. Height effects of UV-C irradiation on Tagetes erecta (African marigold). The control plants that did not receive UV-C light are in the row on the far left. There are 4 replications per treatment going from front to back. The plants in the right rows received the highest dosage rates. The plants on the left side of the photos, after the control row, received the lowest dosages.

Figure 4. Height effects of UV-C irradiation on Viola tricolor tricolor (pansy). The control plant that did not receive UV-C light is on the far left. The plant in the right row received the highest dosage rate.

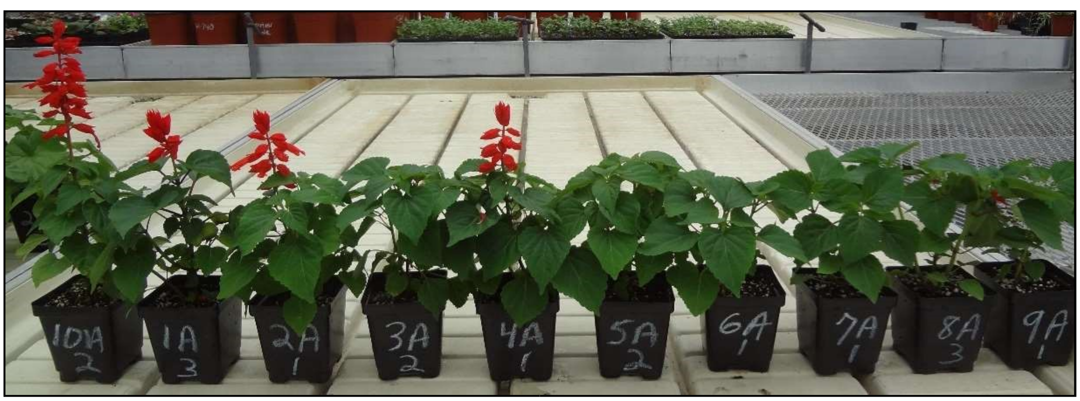

Figure 5. Height effects of UV-C irradiation on Salvia splendens (Scarlet sage). The plants are arranged from lowest to highest (left to right) with the highest dosage rate on the far right and the control plant that did not receive UV-C light on the far left.

3. UV-C light can increase branching

At appropriate dosage rates, UV-C light can increase branching on some plant species. This effect avoids the need to pinch plants and to apply plant growth regulators. In the photos below, the control plants are on the far left. Fig. 6 is red salvia; increased branching is obvious on UV-C treated plants. Delayed flowering is also obvious on UV-C treated plants. The pansy plants in Figure 7 that were treated with UV-C irradiation branched early in their growth and had greater numbers of flowers.

Figure 6. Height effects of UV-C irradiation on Salvia splendens (Scarlet sage). The control plant that did not receive UV-C light is in the row on the far left. The plant on the right received the highest dosage rates. The two plants in the center of the photo received dosages in between the two extremes.

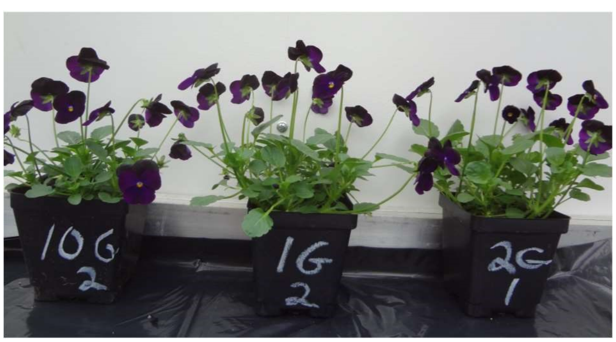

Figure 7. Height effects of UV-C irradiation on Viola tricolor tricolor (Pansy). The control plant that did not receive UV-C light is in the row on the far left. The plant on the right, that received the highest dosage rate, has increased branching.

4. UV-C light can either delay flowering or cause earlier flowering

   Depending on the plant species and the dosage rate, UV-C light can either delay flowering or cause earlier flowering. Pansy plants show faster flowering when treated with UVC light. In figure 8, the 4 plants in the container on the right are the control plants. The plants that were treated with UV-C light flowered earlier. However, in some plant species, UV-C light delays flowering. In figures 5 and 6 (Salvia splendens), flowering was delayed by UV-C treatment. If the intensity of UV-C light is too great, flowering will also be delayed.

Figure 8. Viola tricolor tricolor (pansy) plants show faster flowering when treated with UV-C light. The control plants that did not receive UV-C light are on the right.

CONCLUSIONS

A consistent and clear effect of UV-C irradiation on flowering and growth performance was observed during this research. Our findings confirm that brief periods of UV-C exposure to young plants in the greenhouse are effective in regulating plant growth. We have concluded that when applying UV-C light to greenhouse-grown plants, the dosage rates that the plants receive are critical to the response. The proper weekly dosage, for as little as 15 minutes a week, will control a plant’s growth response. In addition, too high a dosage of UV-C irradiation will burn plants and too low will have no effect. In addition, this research has demonstrated that at appropriate dosage rates, UV-C light can decrease overall plant height. Several species responded to UV-C light by being shorter than the control plants that receive normal greenhouse lighting. UV-C light can also increase plant branching. At appropriate dosage rates, UV-C light increases branching on some species and increases the number of flowers that are produced. This avoids the need to pinch plants and to apply plant growth regulators. In some cases however, the increased branching is accompanied by delayed flowering. UV-C light can affect the time of flowering for plants. The application of UV-C irradiation can either delay flowering or cause earlier flowering depending on plant species and dosage rate.

Now, additional research is needed to determine the most effective UV-C dosage rates for multiple greenhouse crops and to develop applicable procedures for greenhouse growers. Treatments with UV-C irradiation have the potential to facilitate production in commercial greenhouses in a cost effective and environmentally friendly way.

INDUSTRY IMPACT

There are several positive and significant impacts that the success of this novel technology can have on the greenhouse industry. UV-C irradiation is a low-cost technique that is easy to apply to plants. By using simple light fixtures with special light bulbs, the UV-C can easily be administered. We have demonstrated that this technology has the ability to be used as an environmentally-safe, natural plant growth regulator affecting plant height, branching, and fresh weight thus decreasing or eliminating the need for chemical growth retardants.

This technology has been shown to control a plant's growth response. At appropriate dosage rates, UV-C light can decrease overall plant height. Several species responded to UV-C light by growing shorter than the control plants that receive normal greenhouse lighting. UV-C light can also increase plant branching. At appropriate dosage rates, UV-C light increases branching on some species and increases the number of flowers that are produced. This avoids the need to pinch plants and to apply plant growth regulators. UV-C light can affect the time of flowering for plants. The application of UV-C irradiation can either delay flowering or cause earlier flowering depending on plant species and dosage rate.

There are several advantages to using UV-C light in greenhouse-grown plants. UV-C light can be used under all weather conditions, at any time, it leaves no residue in the ground or water, there is no problem with drift, there is minimal energy use, it is a more accurate, localized application than chemicals, and it is approved as organic. It will have tremendous benefits for the environment by reducing pesticide applications to plants and help to reaffirm our industry's commitment to a safer and healthier environment.

The impact of applying this technology to whole plants will be a breakthrough for the floriculture industry. It will save time and money by decreasing, or possibly eliminating, the need for plant growth regulators. It will have tremendous benefits for the environment by reducing pesticide applications to plants; this will help to reaffirm our industry's commitment to a safer and healthier environment. This is a novel, sophisticated, and inexpensive technique that can be a sustainable and environmentally-friendly tool for the greenhouse production industry.

For additional information, contact mpb27@cornell.edu

American Floral Endowment
Phone: 703.838.5211
afe@endowment.org
www.endowment.org