Using Ultraviolet-C Light as a Plant Growth Regulator©

Mark Bridgen
Cornell University, 3059 Sound Ave., Riverhead, New York 11901, USA
Email: mpb27@cornell.edu

INTRODUCTION

Plants use sunlight for photosynthesis and are exposed to the ultraviolet (UV) radiation that is present in sunlight. Ultraviolet radiation is divided into three classes: UV-C, UV-B, and UV-A. The ultraviolet-C (UV-C) region of the UV spectrum includes wavelengths from 200-280 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.

At 254 nm wavelength, UV-C irradiation is germicidal. As a result, 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 (Gonzalez-Aguilar et al., 2007; Vicente et al., 2005; Wilson et al., 1997). 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 (Darras et al., 2012, 2013). Other potential uses of UV-C irradiation have also been identified in the plant sciences, especially with plant tissue culture (Aros and Bridgen, 2013).

A new research project has begun this year using UV-C irradiation thanks to a grant from the American Floral Endowment. The objective of this project is to determine the effects of ultraviolet-C irradiation (UV-C) on commercially-valuable greenhouse ornamental plants with specific interest in disease suppression, growth regulation (height/branching/fresh weight), and postharvest longevity. The use of UV-C irradiation is a low-cost technique that is easy to apply to plants. It has already been shown to be a defense-inducible biological elicitor in horticultural products that can extend the postharvest vase life of cut flowers, suppress attack from natural diseases such as *Botrytis cinerea*, *Penicillium expansum*, and other plant pathogens, and act as a natural growth regulator (Darras, 2013; Darras et al., 2010).

MATERIALS AND METHODS

Germicidal low-pressure vapor UV lamps were assembled on a moveable frame in the Cornell University greenhouses for treatment applications. A plywood box measuring 4×4×8 ft. was constructed on the greenhouse bench and surrounded the lights to exclude outside light. Each lamp has a nominal power output of 30 W and peak wavelength emission of 254 nm. The dosage rate was measured at room temperature (~25°C) using a Zenith Ultraviolet Meter. Ultraviolet-C doses of 0, 0.5, 1.0, 2.5, 5.0 or 10.0 $kJ \cdot m^{-2}$ were applied to the test plants depending on the experimental design and exposure times in seconds.

Seedlings of *Pelargonium* × *hortorum* (geranium), *Impatiens wallerana* (impatiens), *Salvia splendens* (scarlet sage), *Catharanthus roseus* (vinca), *Portulaca grandiflora* (moss-rose), *Viola* × *wittrockiana* (pansy) and others were treated for different times (weekly treatments) and UV-C intensities. The light intensities were accomplished by varying the closeness of the lamps to the plants and the duration of treatments. The duration of treatments varied on the day of application (for example: 15, 30, 90 min) and the number of treatments (weekly for multiple weeks). After treatment, the seedlings were transplanted into larger pots and grown until anthesis. The plants received normal watering and fertilizer regimes and were arranged in the greenhouses in a randomized complete block design. Three to six replications per species were used per crop cycle with replicate trials; non-irradiated plants were used as controls.

Growth and flowering responses were evaluated from phenotypic observations during the cultivation period. The number of days to first inflorescence, number of inflorescences, and plant height (cm) were recorded every week or at the termination of the treatment and experiment. The number of lateral stems were recorded when the plant reached anthesis. Fresh and dry weights of the upper parts of the plants (i.e., stems, leaves and inflorescences) were recorded with a digital balance.

RESULTS

This research recently began this year and the results that have been seen so far are very exciting. The first thing that was determined was the range of dosages of UV-C light that were damaging to the plants. The dosage of light that a plant receives is a combination of the distance from the plant that the light is and the amount of time that a plant is exposed to the light. If the dosage is too high, plants show damage within 24 h of treatment. Extreme damage symptoms include crispy and off-color leaves.

When young plants receive certain levels of UV-C irradiation, they will have shorter growth habits when they reach flowering than plants that received no UV-C irradiation. Plants that showed this response included African marigold (*Tagetes erecta*), French marigold (*T. patula*), pansy (*V. tricolor*), scarlet sage (*S. coccinea*), vinca (*C. roseus*), and zinnia (*Zinnia elegans*). Some plants showed increased branching when they received UV-C irradiation as seedlings. These included pansy (*V. tricolor*), scarlet sage (*S. coccinea*), and to some degree, geraniums (*P.* × *hortorum*). There is evidence that UV-C light treatments affect the time to flower of some plants. With pansy plants that received UV-C light, it was noticed that flowering began 1 to 3 days earlier than control plants. With other plants, such as scarlet sage (*S. coccinea*) and geranium (*P.* × *hortorum*), flowering was slightly delayed due to the UV-C light treatments. These results were dosage-dependent.

SUMMARY

There are several positive and significant impacts of applying UV-C irradiation to greenhouse seedlings. This research has shown that UV-C light treatments can be used as a plant growth regulator; proper application of UV-C light to seedlings of annual plants can reduce plant height, increase branching, and delay or promote flowering depending on species.

This technique has worked successfully on a number of annual plant species including African marigold (*T. erecta*), French marigold (*T. patula*), pansy (*V. tricolor*), scarlet sage (*S. coccinea*), vinca (*C. roseus*), zinnia (*Z. elegans*), and geraniums (*P.* × *hortorum*). This research has just begun and will continue to fine-tune the dosage rates and amount of time that seedlings need to be treated.

The use of UV-C irradiation has several advantages as a plant growth regulator. This novel technology 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 be administered. It has the potential to save time and money for greenhouse growers by decreasing, or possibly eliminating, the need for plant growth regulators (PGR). If implemented as a PGR, it can have tremendous benefits for the environment by reducing pesticide applications to plants.

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