THE RELATIONSHIP BETWEEN DAY AND NIGHT TEMPERATURE INFLUENCES PHOTOSYNTHESIS BUT NOT LIGHT COMPENSATION POINT OR FLOWER LONGEVITY OF EASTER LILY, *LILIUM LONGIFLORUM* THUNB.

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Abstract

The difference between day and night temperature (DIF) influenced photosynthesis in Easter Lily 'Nellie White'. Photosynthetic rate was greatest with a positive DIF, intermediate with a zero DIF, and lowest with a negative DIF. Light compensation point was not significantly influenced by DIF. Application of silver thiosulfate had no effect on stem elongation, leaf orientation or leaf color indicating ethylene action was not responsible for thermomorphogenic growth responses. Chlorosis and reduced photosynthesis of plants grown with a negative DIF did not influence flower longevity.

1. Introduction

Growth of the Easter Lily is thermomorphogenic (Erwin et al 1989). Easter lily stem elongation is highly correlated with the relationship between day and night temperature (Erwin et al, 1989). As the difference between the day temperature (DT) and the night temperature (NT) (DIF = DT-NT) decreases plant height decreases. Lily plants grown with warmer day temperature than night temperature are taller than plants grown with common day and night temperature, which in turn are taller than plants grown with cooler day than night temperature. Stem elongation responses to DIF have been reported for other plant species including, chrysanthemum (Karlsson et al 1989), fuschia (Erwin and Heins 1988), poinsettia (Berghage and Heins, 1988), and campanula (Moe, 1989). Other responses to DIF include, flower number and flower initiation (Moe, 1989), leaf orientation (Erwin et al, 1989) and leaf color (Heins et al 1988).

The thermomorphogenic stem elongation responses observed in the lily are not likely due to carbohydrate supply or translocation (Erwin et al 1989). However reduced dry matter accumulation in fuschia and chrysanthemum plants grown with a negative DIF (Erwin personal communication) suggest that net carbon assimilation (A) is influenced by the relationship between day and night temperature. Since both photosynthesis and dark respiration increase as temperature increases up to some optimum, it is not unexpected that net carbohydrate accumulation should be reduced in plants grown with low day temperatures (reduced photosynthetic carbon assimilation) and high night temperatures (increased maintenance respiration). It is not known however, if the relationship between day and night temperatures and the consequent thermomorphogenic growth responses in plants affect photosynthetic potential.

Thermomorphogenic plant growth responses are currently employed for commercial control of Easter Lily growth and development (Heins et al 1988). Although the influence of DIF on stem elongation has been well

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characterized, little is known about the effects of DIF on photosynthesis and post-production flower longevity. This study was undertaken to determine if thermoperiodic preconditioning influences photosynthesis of the Easter lily and subsequent post-production flower longevity.

2. Materials and Methods

2.1 Photosynthetic rate determinations

Lilium longiflorum Thunb. bulbs 17.7-20.3 cm in circumference were planted in a 1:1:1 sphagnum peat: vermiculite: perlite growth medium in 15.2 cm (1.2l) plastic pots on 14 October, 1986. Potted bulbs were placed in a controlled environment greenhouse for 14 days at 17°C ± 1°C to encourage rooting. Plants were then transferred to a temperature of 5°C ± .5°C for 6 weeks for vernalization. Bulbs were returned to a 20°C constant temperature greenhouse under natural photoperiods until shoot emergence was observed. Upon emergence plants were exposed to 10 μmol $s^{-1}m^{-2}$ PPF from incandescent lamps from 2200 to 0200 hr for 7 days. Plants were then returned to natural photoperiodic conditions (42°N lat.) until treatments were begun on February 10.

Flower initiation was verified by terminal shoot dissections of randomly selected plants. Floral initiation was considered complete at the first visible sign of differentiation of the vegetative meristem into floral primordia (DeHertogh, 1976). All plants had completed floral initiation by late January.

Ten uniform plants were selected from the population and placed in each of three controlled environment greenhouses. Greenhouses were maintained at 15, 20 and 25°C constant temperature. Both +10°C and -10°C temperature differentials (DIF) were obtained by moving plants between the 15° and 25°C greenhouses at 0800 and 1800 hr each day. The 0°C DIF was obtained using plants grown at a constant 20°C. Plants in the 20°C greenhouse were moved from 1 location to another within the greenhouse at 0800 and 1800 hr. An opaque curtain was pulled at 1800 hr and retracted at 0800 Hr each day. Plants were grown using standard cultural practices (Wilkins, 1980).

Light compensation point and CO_2 assimilation rate (A) were determined using an ADC (Analytical Development Company) portable open gas exchange photosynthesis measurement system similar to the method reported by Davies and Flore (1986) on 2, April when all plants had one to two flowers open. Photosynthesis (A) was calculated using the method of Moon and Flore (1986). All plants were moved to a 20°C environment and allowed to equilibrate for 1 hour prior to measurement. Light utilization curves were then determined for each plant at 20°C.

2.2 Flower longevity

Plants were then moved to a post-production environment with 20°C constant temperature and 15 μmol $s^{-1}m^{-2}$ PPF for 12 hours per day. Flower longevity (defined as the number of days from flower opening to the collapse of 50% or more of the perianth) was determined for each of the 5 to 6 flowers which developed on each plant.

2.3 Silver thiosulfate (STS) Applications

A second group of 20 uniform plants was selected prior to visible bud for an experiment to determine if ethylene might be involved in the thermomorphogenic responses observed in the Easter Lily. These plants were placed in a growth chamber maintained with a 15°C DT, 25°C NT and 200 μmol $s^{-1}m^{-2}$ PPF for 10 hours per day on 20 Feb. Ten plants were sprayed with a 0.25mM solution of STS (Cameron et al, 1985). The remaining plants were sprayed with demineralized water. Stem elongation was measured and leaf orientation and leaf color were observed.

3. Results and Discussion.

3.1 Thermomorphogenic growth responses

3.1.1 Observed responses

The effects of DT and NT on Easter lily growth in these experiments were the same as those observed by Erwin et al (1989). Plants grown with a positive DIF were tall, had upward pointing leaves and dark green leaf color. Plants grown with a negative DIF were shorter, had downward pointing leaves and were chlorotic. Plants grown with a 0 DIF were intermediate in these characteristics.

3.2.2 STS applications

There were no differences in stem elongation, leaf orientation or leaf color between plants treated with STS and those treated with water. Since silver blocks ethylene receptors and hence ethylene action (Veen, 1986), the lack of a response to STS implies that ethylene is not involved in thermomorphogenic growth responses.

3.2 Photosynthesis

Thermoperiodic preconditioning treatments influenced the photosynthetic carbon assimilation rate of the Easter lily. Light utilization curves (Fig. 1) indicate that A at 20°C approached a maximum rate at a PPF of about 300 μmol $s^{-1}m^{-2}$. At saturating light intensities (above 300 μmol $s^{-1}m^{-2}$), plants grown with a positive DIF had a higher rate of CO_2 assimilation than plants grown with a negative DIF. Average maximum assimilation rates were 3.2, 4.0, and 4.5 μmol CO_2 $m^{-2}s^{-1}$ for negative, 0, and positive DIF plants respectively (Table 1).

The differences in observed CO_2 assimilation rate could be positively correlated with DIF or day temperature, or negatively correlated with night temperature or average growing temperature. Mean growth temperature has been correlated with photosynthetic capacity (Bunce, 1986). In general plants grown at low temperature have higher photosynthetic capacity. Bunce (1986) suggests that this is the result of increased density of the photosynthetic machinery

Table 1 - Average maximum CO_2 assimilation rates (A) with PPF > 300 μmol $m^{-2}s^{-1}$ of Easter lily grown with -10, 0, and +10°C DIF (DIF = DT - NT).

DT	NT	DIF	(A) μmol $m^{-2}s^{-1}$
15	25	-10	3.17
20	20	0	4.03
25	15	+10	4.50

Treatment effects significant at the 5% level.
Tukeys HSD(.05) = 1.19

due to a greater impact of low temperatures on leaf expansion than on development of photosynthetic machinery. In this experiment average daily growing temperature varied by only 1.6°C between treatments so it is unlikely that differences in observed photosynthesis rates were due to average temperature.

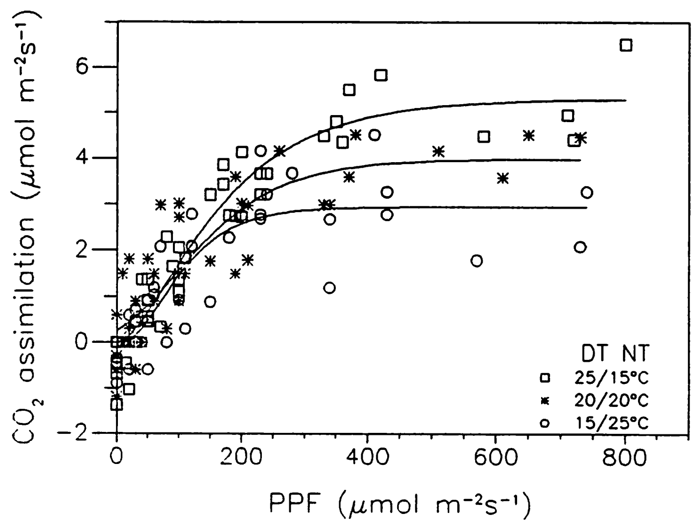

Figure 1 - Light utilization curves obtained at 20°C for Easter lily grown in three preconditioning environments. Negative DIF (15/25°C DT/NT) 0 DIF (20/20), Positive DIF (25/15).

The observed photosynthetic rates could be correlated independently with either day or night temperature preconditioning. However it seems more likely that thermomorphogenic growth responses related to DIF induce changes in photosynthetic potential. Leaves of the negative DIF plants in this experiment were clearly chlorotic. Leaf color changes associated with the temperature differential in fuschia and chrysanthemum (unpublished data) are correlated with reduced chlorophyll content in these leaves. It is not known whether the reduced chlorophyll content in leaves of plants grown with a negative DIF is due to enhanced degradation or reduced synthesis. It is possible that a balance exists between light activated synthesis in the day and metabolic degradation at night. If the rates of both processes are similarly temperature dependent, a positive DIF would result in a plant with higher leaf chlorophyll content than in a plant grown with a negative DIF. It is not surprising then that CO_2 assimilation rates appear to be correlated with DIF as shown here for the Easter lily and also as observed with the chrysanthemum (Erwin, personal communication). The effect of DIF on CO_2 assimilation rates is thus likely linked to DIF induced changes in leaf chlorophyll content.

3.3 Light compensation point

The light compensation point was not significantly influenced by DIF (Fig. 1). Due to the large variability in the data particularly with PPF below 250 μmol $m^{-2}s^{-1}$, the estimated intercepts for the each of the three light utilization curves were all well within the standard error for the other curves.

3.4 Flower longevity

Flower size and longevity were not influenced by the temperature treatments used in this study. Flowers remained open for 5 to 7 days regardless of temperature pretreatment. It is possible that the carbohydrate reserves in the lily bulb served as a source for plants grown in a negative DIF where CO_2 assimilation was reduced. In the poinsettia where there is no bulb, increased cyathia abscission has been observed in plants grown with a large negative (ca.-15°C) DIF (Unpublished data). Premature cyathia abscission has been previously linked with reduced carbohydrate supply (Miller and Heins, 1986). It is therefore likely that the effects of DIF (used for height control) on postproduction longevity of pot plants will depend on the sensitivity of the plant species to carbohydrate supply. In plants where potential carbohydrate supply is high (i.e. Easter lily), reduced photosynthesis associated with a negative DIF will not significantly influence postproduction flower longevity. In plants where postproduction longevity is highly correlated with carbohydrate supply (i.e. poinsettia), the reduced carbohydrate supply caused by growing the plants with a negative DIF may reduce postproduction flower longevity.

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