**Growth and Photosynthesis of Young *Cymbidium* as Influenced by Supplemental Lighting Timing**

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**Abstract** The effects of supplemental lighting (SL) timing on vegetative growth and photosynthetic assimilation rate of young *Cymbidium* hybrids were examined. Nine-month-old *Cymbidium* ‘Yang Guifei’ and ‘Wine Shower’ were treated with four different SL timings: 22:00 to 02:00 (middle of the night, MN); 17:00 to 21:00 (end of day extension, DE); 07:00 to 09:00 plus 17:00 to 19:00 (both beginning and end of the night as split day extension, SDE), and non-SL (8/16 hours, short day, SD) for 4 months. All SL was provided by two types of 100% red LEDs (640 and 660 nm), with 150 µmol∙m-2∙s-1 and 800 µmol∙mol-1 of CO2 supplied during the night (16 hours and 25°C).

***Additional Key words:*** day extension, juvenile stage, night interruption, orchid, pseudobulb

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**Introduction**

Orchid production has been increasing worldwide in China, Germany, Japan, the Netherlands, Taiwan, Thailand, and the United States (Griesbach 2000; Kim et al. 2011; Lopez and Runkle 2005). Despite this large-scale production, few genera, including *Cymbidium*, *Phalaenopsis*, *Dendrobium,* and *Oncidium*, are popular.

**Materials and Methods**

**Plant and growth conditions**

28 plants of Nine-month-old *Cymbidium* hybrids ‘Yang Guifei’ and ‘Wine Shower’ (Mukoyama Orchids Co., Ltd., Yamanashiken, Japan) were transplanted into 12 cm pots filled with 100% pine bark. The plants were previously purchased from Haepyeung Orchid Farm (Gongju, Korea) at 2 months old and grown for 7 months (from Dec. to Jul.) at the Seoul National University Farm (Suwon, Korea). ~

**Data collection and analysis**

Pseudobulb diameter, the number of leaves, leaf length, and leaf width were measured monthly during the experimental period. Pseudobulb diameter was measured at the widest point of the pseudobulb using a digital vernier caliper (ABS Digimatic Caliper; Mitutoyo Co., Ltd., Tsukuba, Japan). ~ Completely randomized design was used in this study with 7 plants for each treatment. Data were analyzed using the SAS system for Windows version 9.3 (SAS Inst. Inc., Cary, NC, USA). Differences among treatment means were assessed by Duncan’s multiple range test at *p* < 0.05. Regression and graph module analyses were performed using Sigma Plot software version 8.0 (Systat Software, Inc., Chicago, IL, USA).

**Results**

**Photosynthetic assimilation rate**

Net photosynthetic assimilation rate (*An*) in response to SL timings was measured for 24 h after 14 weeks of SL treatment in both cultivars (Tables 1 and 2). The SL for 4 hours prolonged the photosynthetic period, irrespective of application timing. The mean *An* increased during the nighttime, with a rate of approximately 1.55 and 1.24 µmol CO2∙m-2∙s-1 compared to 0.54 and 0.44 µmol CO2∙m-2∙s-1 under the SD condition, in *Cymbidium* ‘Yang Guifei’ and ‘Wine Shower’, respectively. Daily *An* was obtained after calculating *An*, which significantly (*p <* 0.001) increased in SL treatments compared with SD (Table 1 and Fig. 2).

**Discussion**

Prolonging the photoperiod with SL (increasing DLI) improves growth and yield for many horticultural crops. Although *Cymbidium* is a non-photoperiodic plant, it requires long days for rapid growth and pseudobulb maturity (Lopez and Runkle 2005). Dorais (2003) reported that extending photoperiod by SL increased photosynthetic efficiency and carbon partitioning. In this study, *An* of both *Cymbidium* hybrids was increased under 4 hours of extension in photoperiod regardless of timing. These results were similar to the previous study that NI with high light intensity increased plant growth in *Cymbidium* ‘Red fire’ and ‘Yokihi’ because it increased *An* compared with those of short-day conditions without NI (Kim et al. 2015). ~

These results could be useful in selecting artificial lighting in commercial greenhouses to effectively promote the vegetative growth of Cymbidium.

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**Tables and Figures**

**Table 1.** Effects of supplemental lighting timing on the number of new bulbs, pseudobulb diameter, the number of leaves, leaf length, leaf width, and relative chlorophyll content in *Cymbidium* ‘Yang Guifei’ and ‘Wine Shower’ after 16 weeks of treatment.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Treatmentz | Number of  new pseudobulbs | Pseudobulb  diameter (mm) | | Number of  leaves | Leaf  length (cm) | Leaf  width (cm) | Chlorophyll  content (SPAD) |
| *Cymbidium* ‘Yang Guifei’ | | | | | | | |
| SD | 1.1 | 23.11 | by | 17.5 | 51.0 | 1.8 | 45.6 |
| MN | 0.7 | 26.68 | a | 19.3 | 47.4 | 1.8 | 44.7 |
| DE | 1.1 | 25.32 | a | 17.4 | 47.2 | 1.8 | 45.5 |
| SDE | 1.0 | 25.42 | a | 18.8 | 47.6 | 1.8 | 45.6 |
| *Significance* | NS | \* | | NS | NS | NS | NS |
| *Cymbidium* ‘Wine Shower’ | | | | | | | |
| SD | 1.2 | 27.31 | b | 14.2 | 45.3 | 1.8 | 61.8 |
| MN | 1.5 | 29.88 | a | 14.2 | 44.4 | 1.8 | 57.6 |
| DE | 1.7 | 29.05 | a | 14.8 | 46.2 | 1.9 | 60.1 |
| SDE | 1.3 | 29.53 | a | 14.1 | 45.8 | 1.8 | 55.3 |
| *Significance* | NS | \*\* | | NS | NS | NS | NS |

zPlants were grown under short day with non-supplemental lighting (SD), supplemental lighting in the middle of the night (MN), end of day extension (DE), and both beginning and end of night (SDE).

yMean separation within columns by Duncan’s multiple range test at *p* < 0.05.

NS, \*, \*\*Non-significant or significant at *p* <0.05 or 0.01, respectively.



**Fig. 1.** Net photosyntheticassimilation rate (*An*) of *Cymbidium* ‘Yang Guifei’ and ‘Wine Shower’ as affected by supplemental lighting timing. Treatments include short day with non-supplemental lighting (SD; A), supplemental lighting in the middle of the night (MN; B), end of day extension (DE; C), and both beginning and end of night (SDE; D). Measurements were performed after 14 weeks of treatment. Vertical bars represent mean and ± SE (n = 3).