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EFFECT OF LEDs ON FLOWER BUD INDUCTION IN *Chrysanthemum morifolium* cv. ZEMBLA

Mam C. Singh[1]*, Wim van Ieperen and E.P. Heuvelink

Horticultural Production Chains Group, Plant Sciences, Droevendaalsesteeg-1, 6708 PB Wageningen,Wageningen University, The Netherlands

[1]Present address: Centre for Protected Cultivation Technology, I.A.R.I. Pusa Campus, New Delhi-110012, India

**E-mail: mamsingh@gmail.com*

ABSTRACT: The effect of LEDs was studied to induce flower under artificial long days (LD) in *Chrysanthemum morifolium* cv. Zembla plants, using light emitting diodes (LED) @ PAR m^{-2} s^{-1} 80% Red / 20% Blue maintained @ 100 µ mol m^{-2} s^{-1} using royal blue light @ 455 nm and red light @ 640 nm wavelengths and compared with short day (SD) length. Difference in growth and flowering response were also investigated. Stem length is determined as a function of internode length which could be the function of attaining minimum number of leaves required for expressing the diurnal response using LEDs. *Chrysanthemum* plants exhibited a strong diurnal response attained in leaves and transmitted to the apex and took minimum (28 days) and maximum time (61 days) with an exposure to LEDs with (15h) and without (11h) additional blue spectrum, respectively. However, bud induction was possible earliest due to low red/far ratio in the extended exposure of plants with blue LEDs.

Keywords : *Chrysanthemum morifolium, LEDs, bud induction, diurnal reponse.*

Chrysanthemum induces flowering as a short-day plant and requires long, un-interrupted dark period for flowering. It will not flower until the day-length is above critical value (Furuta, 5). Under artificial conditions, flowering can be induced by shortening the day length to 11h. However, the plants grown under long-day conditions has been shown to produce the generative terminal meristem but with aborted flower buds even when the stem growth was attained with certain number of leaves along with formation of side shoots (Cockshull and Kofrank, 3). *Chrysanthemum* has a determinate growth pattern (Pearson *et al.,* 11) with a basipetal progression of flower initiation (Langton, 9). The application of artificial PAR (photo-synthetically active radiation) is restricted because of SD (short day) period. Various experiments have been conducted to see the effect of spectral quality by applying LED lighting in several horticultural plants including the role of red light on accumulation of starch through photosynthesis (Saebo *et al.,* 14) and blue light on individual cell length (Fukuda *et al.,* 4), phytochrome activity (Cathey, 2), chloroplast development, chlorophyll formation and stomata opening (Senger, 15). The plant growth is significantly influenced by light intensity (Khattak *et al.*, 7) and quality (Appelgren, 1) in terms of spectral distribution. Several studies investigating how the light quality influences plant growth and development using different colours including blue and red (Runkle and Heins, 13; Shimizu *et al.,* 16) have been reported. This experiment was attempted to determine, if the plants exposed to long days (LD) with red and blue LEDs alone or in combination, can support the normal growth and flower bud induction without affecting the dark period in chrysanthemum. To induce flower a signal is achieved in leaves and transmitted to let the emerge a bud at apex of the stem. Therefore, the aim of this study was to see the effect of smart LEDs treatments on growth differences for flower bud induction in *Chrysanthemum* under artificial PAR lighting.

MATERIALS AND METHODS

In the experiment conducted on *Chrysanthemum morifolium*, plants of cv. 'Zembla' were grown in 14 cm pots using pot mix and

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fertigated on alternate days in a growth chamber (1.2m x 1m x 1m) in a micro climate, maintained with an optimal temperature (20-22°C) and relative humidity (60-65% RH), ensuring a perfect air circulation inside the growth chamber and outside. 20 plants per treatment were grown under different growth chambers with four different light treatments using light emitting diodes (LED) @ PAR. $m^{-2}.s^{-1}$ 80% *Red*/20% *Blue* viz., short day (SD) for 11h, long days (LD) for 15h, SD+B (Blue) *i.e.* SD for 11h + B additional 4h and B (Blue) for 11h. A light intensity was maintained @ 100 µ mol m^{-2} s^{-1} using royal blue light @ 455 nm and red light @ 640 nm wavelengths for all the treatments. To maintain the plants with similar illumination effects of light intensity inside growth chambers their position was changed from side to centre every fourth day. The light intensities were standardized every week since all the plants reached to higher levels of intercepted light.

Growth differences were measured for the treatments and stem samples were taken after three weeks of growth assuming that the plants may be achieving the signal of bud induction. Terminal shoot apexes were dissected and put under electron microscopic observation to see if there is any bud emerging inside the stem. Observation was repeated every day except for LD treatments. Plant growth measurements were taken at first visible signs of flower induction at 28 days in all the treatments at the time showing visible sign of bud induction in more than 5 plants in each treatment if emerged buds are developed normally under the influence of LEDs. Ten plants per treatment were harvested for further measurements on growth (stem length and leaf number) including microscopic evaluation of end meristems. The same observation was repeated with 5 plants at 41days and 56 days ((plants under long days with LEDs) based visible sign of bud induction was apparent based on the previous experiment. The whole experiment was repeated in time (except for treatment B) for morphogenetic differences for growth and flower bud induction and data was subjected to analysis of variance and T-test (P 0.05).

RESULTS AND DISCUSSION

Stem length (*cm*)

There was a significant effect on stem elongation and internode length in the plants exposed to the different light treatments (Fig. 1) recorded 28 days after start of the experiment. The maximum plant height (57.37 cm) and internode length (2.96 cm) was attained in the plants exposed with blue (B) followed by plants in SD+B (53.4 cm and 2.38 cm, respectively) and LD (46.18cm and 1.98 cm, respectively). However, the plants exposed with SD period had the least elongated stem (41.06 cm) and shortest internodes (1.89 cm) to reach the stage of bud induction except in case, the plants exposed under long days. It was noted that the periods of 100% B during the 24h cycle increased stem length at 11h day length (SD) and at 15h day length (LD) as compared to the other treatments. The differences in the stem length and

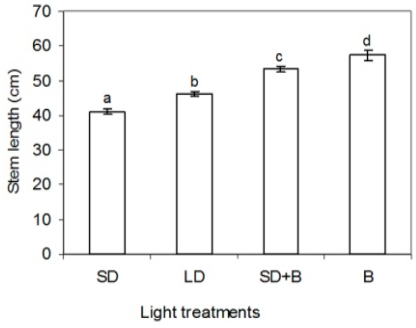

Fig. 2. Stem length due to different light treatments

elongated intenodes were due to low red/far red ratio in an extended exposure with blue LEDs in the plants exposed to SD+B and B compared to those exposed with LD and SD having an effect to induce more lateral branching (Rosario *et al.,* 12) reflecting the shade avoidance phenomenon at SD+B and B treatments as consistent (Shimizu *et al.,* 16).

Leaf number

The significant differences were observed for the leaf number and leaf area attained in the plants

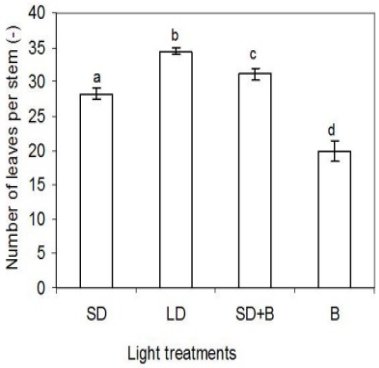

Fig. 2. Number of leaves per stem.

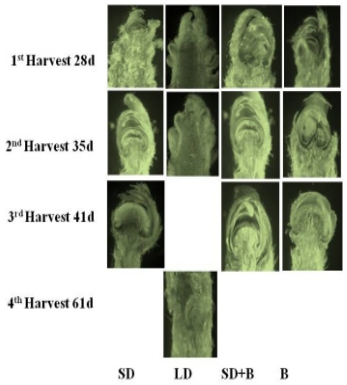

Plate 1. Bud induction under different light treatments.

exposed under different treatments (Fig. 2). Until the period of first visual bud induction (28 days) it was noticed that the leaf number recorded were highest (34.4) in LD plants (without bud induction stage achieved) followed by the plants exposed with SD+B (31.1) and SD (28.2) exposed. Whereas the lowest leaf number was recorded in the plants exposed with only B (19.9). The comparative increase in leaf number and corresponding leaf area expansion was probably higher due to the higher net photosynthetic rate under extended exposure of blue light component (Kim *et al.,* 8) in the entire duration of the treatments.

Time taken for bud induction (days)

Based on visual sign observed for bud induction in at least 5 plants per treatments, a microscopic evaluation of the end meristem was done (Fig 3 & Plate1) and it was apparent from the results that the bud induced was prominent in plants exposed to the SD+B and took 30.8 days as long day treatment with LEDs as compared to the plants exposed to short day treatments i.e. SD (80 % red + 20% blue) and Blue (100%) taking 28 and 30.5 days, respectively to induce the flower bud. However, it was interesting note that the plants exposed under LD (11h SD with additional 100 % blue LEDs for 4 h) exposure, could induce flower at 61 days only after attaining the final leaf number 43.The results obtained in the experiment proved the hypothesis that the dark period was not disturbed by long day treatment using LEDs (and induction of flowering under short day plants can still be possible after attaining the certain number of leaves (Mc Daniel, 10; Irish and Jegla, 6).

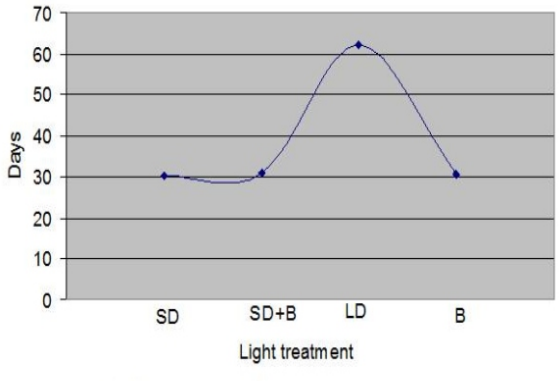

Fig. 3. Time taken for bud induction (days)

SUMMARY AND CONCLUSION

The exposure of the plants with combined LEDs (red and blue) kept at @ 100 µ mol m^{-2} s^{-1} for long days (SD+B) did not disturbed the flower induction (dark period) and proven the principle of reaching at certain stage (minimum number of attained leaves) a short day plant can induce flower bud. Therefore, it was imperative that the induction of flowering in the SD-plant *Chrysanthemum* is possible under LD conditions with smart LED treatments. Similarity with shade avoidance phenomenon was observed as in case of exposure of the plants with B and SD+B remained consistent to grow with elongated stems. It if further concluded that there is a possibility that flower induction may diagnosed to know the reaction time

to bud induction process with help of electron microscopic observations.

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