Effect of LEDs Irradiation Muskmelon Seedling on 'Yin Hui' Grafted Plant Growth

Aditya Ferryanto [1)] Yu Sung [2)]

Key words: Light-emitting diodes (LEDs), Grafting, Muskmelon

Summary

The effects of application of light-emitting diodes (LEDs) prior to grafting was studied 'Yin Hui' seedling under 9B (100% blue) and 7R1G1B (red 85%, green 7%, blue 8%) LED treatment was obtained 100% grafting survival rate. Seedlings under 7R1G1B had significantly better growth than control in terms of height and true leaves, and its flowering day was sooner but resulted in a lower vigor. Meanwhile the growth of WW slightly lower than 7R1G1B but it had the highest specific leaf area than other light treatments. The dry weight and vigor index of 7R1G1B was significantly lower than natural light, but it was higher compared with WW.

Introduction

Light is very important for plants as it is a key factor in the process of photosynthesis, plant survival, plant development, and crop yield (Massa *et al*., 2008). Light quality, intensity and duration are three factors that affect plant growth. In nature for plant growth, it is difficult to achieve the desired optimal light environment. This problem can be overcome by use of the growth chambers (Vu *et al.*, 2013).

LEDs are generally used because they have advantages over other methods of horticultural lighting. They are small in size and can be adjusted to the needs of various plants; they are durable and have a long lifetime; they do not get hot like other lights; and they are able to be set to specific wavelengths, unlike other light sources (Massa *et al.*, 2008). Additional light

1) Graduate student in Master Program, Department of Horticulture, National Chung Hsing University.

2) Professor, Department of Horticulture, National Chung Hsing University. Corresponding author.

sources such as LEDs can increase the intensity of photosynthesis and transpiration, thereby enhancing plant vigor (Klamkowski *et al*., 2014; Li *et al*., 2016).

Most research has examined the effects of LEDs on plant growth and grafted survival rate, but the effects of a short period of irradiance prior to grafting process have rarely been investigated. The objective of this study was to examine the effects of short periods of LEDs irradiance prior to grafting on the muskmelon grafted plant growth.

Material and methods

1. Site and materials

The experiment was performed twice in an olericulture greenhouse and a growth chamber at the Horticulture Department, National Chung Hsing University, Taichung.

The scion tested was the 'Yin Hui' ('銀輝') (*Cucumis melo* L.) the muskmelon, and the rootstocks were the 'Yin Hua' ('銀華') oriental pickling melon (*Cucumis melo* Linn. var. *conomon Makino*). Seeds were purchased from the Know You Seed Company.

2. Seedling production

Rootstock seeds were soaked at 50℃ for 10 minutes and 26℃ for 16 hours on September 26, 2018, while scion seeds underwent the same procedure on October 2, 2018. '銀華' rootstock and '銀輝' scion seeds for control were sown in 72-cell plug trays and put inside greenhouse, while scion seeds for LEDs light treatment were sown in culture bottles (9 × 10 cm) under four different LED light sources (Nano Bio Light Technology Co., Ltd., Taiwan: https://www.nanobiolight.com). Experiment used a mix of substrate (Bio-Mix Potting substratum 011 B, Tref, Netherlands), vermiculite and perlite (振詠興業有限公司, Zhen Yong Company) at a ratio of 8:1:1 (v/v/v).

After the scion seeds had germinated, they were kept inside culture bottles at 24℃ under 70-75% relative humidity. The light intensity range of the LEDs from top culture bottle used for treatment was around 20-25 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PPFD (Photosynthetic Photon Flux Density) depending on the type of LED, while the control scion was placed in the greenhouse. The scion seedlings were placed in a greenhouse from 10.00–16.00 (6 hours), then placed back under the LED light sources from 16.00-02.00 (10 hours) for 3 days to avoid excessive stem growth.

The following light-source treatments were used in the experiment:

- 9R – Red 100%
- 9B – Blue 100%
- 7R1G1B – Red 85%, Green 7%, Blue 8%

- WW – Warm white (2700 K)
- Control – Natural light in greenhouse as the control

3. Grafting method

The grafting method was as described by Lee *et al.* (2010). The splice grafting technique was employed - the first true leaf of the rootstock including the growing point were carefully and thoroughly removed, and the center stem sliced vertically; meanwhile, the scion was cut in an upward direction at an angle on two sides, usually 30-40° to the perpendicular axis, and used a clip to hold.

Grafted plants were transferred to a healing bench under humid conditions and covered with two shade clothes in the greenhouse. Healing proceeded in darkness and under continuous light at 65 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PPFD on the third day to the fifth day, and a mist spray machine sprayed every 2 minutes and stopped for 4 minutes from 08.00–16.00. At the end of the 7-day healing period, the seedlings were moved from the healing tables and sprayed with a chemical fertilizer (Hakaphos Blue [葉綠精; 獅馬牌肥料]; N:P_2O_5:K_2O = 15:15:15) every seven days, at a dilution of 1:1000.

4. Planting and management

After all grafted plants had healed, the plants were planted from October 19, 2018 to December 9, 2018 inside a greenhouse at National Chung Hsing University, Taiwan. The average air temperature was 27.00/21.93 ℃ (day/night), and the average relative humidity was 71.72/86.89% (day/night). The five treatments were replicated in triplicate. Each replication was divided into three plastic pots (9 × 9 cm) with a mix of substrate (Bio-Mix Potting Substrate 003 B, Tref, Netherlands), vermiculite and perlite (Zhen Yong Company [振詠興業有限公司]) at a ratio of 8:1:1 (v/v/v).

The plants were cultured by manual irrigation system, and chemical fertilizer Hakaphos Blue (葉綠精) was applied once a week. The experiment included 5 treatments, each performed with 3 grafted plants.

5. Measurements

The following measurements were taken during the experiment:

(1) Survival rate: data were obtained 8 days after grafting.

(2) Height: stem length, data were obtained at 7, 14, 28 and 35 (cm/plant).

(3) Diameter: measured at 1 cm above the graft union, data were obtained at 7, 14, 28 and 35 days (mm/plant).
(4) Number of true leaves: counted as leaves open to 3 cm, data were obtained at 7, 14, 28 and 35 days.
(5) Male and female flowering: first day on which a flower opened.
(6) Total leaf area: data were obtained at the end of experiment using Li-COR 3100A, LICOR Lincoln Neb, the unit being cm^2/plant.
(7) Fresh weight and dry weight: at the end of the experiment; plants were weighed before and after drying at 70℃ for 3 days, and the unit was g/plant.
(8) Plant vigor index: calculated as diameter/height*dry weight at the end experiment.
(9) Specific leaf area (SLA): calculated as leaf area plant/leaf dry weight at the end of experiment, the unit being $cm^2 \cdot g^{-1}$.

6. Data analysis

Standard error was calculated. Each treatment was replicated in triplicate, and each replication consisted of three samples. One-way analysis of variance (ANOVA) was applied, followed by Fisher's LSD test at $P \leq 0.05$ using SAS software (Version 9.4, Institute, Cary, NC).

Results

Following a short period of irradiance from 5 different light sources before grafting, seedling under 9B, 7R1G1B, and control light sources grafted '銀華' rootstock resulted in a 100% survival rate, while second was WW treatment at around 90.9%, and lowest was 9R at around 81.8% (Table 1).

Male flowering was observed under all LED treatments; 9R and 7R1G1B resulted in the earliest male flower opening at around 27 days and there was no significant difference with other LEDs treatments, while for control this required 34.3 days. 7R1G1B treatment resulted in the fastest female flower opening at around 38.8 days, while plants under control treatment needed 46.1 days (Table 1).

After 35 days growth, there were no significant differences in leaf area or SLA of the plants under all treatments. Grafting under 7R1G1B and WW light sources resulted in plants of the highest fresh weight, at more than 51 g, while the lowest fresh weight was observed for plants under 9R treatment, at around 45.4 g. There were no significant difference in fresh weight between plants subjected to 9B, 7R1G1B, WW and control treatment. The highest dry weight was observed following control treatment, at around 7.6 g, but this was not significantly different to the dry

weight observed under 9B and 7R1G1B treatment, while 9R resulted in the lowest dry weight with 6.2 g (Table 1).

Table 1. Effects of 10 hours of LEDs irradiation at 20–25 μmol·m^{-2}·s^{-1} for 3 days before grafting on the 35 days growth of '銀輝' melon grafted on '銀華' rootstock plant.

Treatment	Survival rate (%)	First day of male flowering	First day of female flowering	Plant leaf area (cm^2)	Fresh weight (g)	Dry weight (g)	SLA (cm^2•g^{-1})
9R	81.8 c^z	27.4 b	44.1 a	812.0 a	45.4 b	6.2 b	196.5 a
9B	100.0 a	28.9 b	44.7 a	863.2 a	46.8 ab	6.5 ab	199.4 a
7R1G1B	100.0 a	27.3 b	38.8 b	869.3 a	51.1 a	6.5 ab	198.1 a
WW	90.9 b	28.9 b	41.0 b	898.6 a	51.9 a	6.2 b	225.9 a
Control	100.0 a	34.3 a	46.1 a	943.0 a	48.9 ab	7.6 a	191.5 a

^{z}Means with the same letters in the column were not significantly different according to Fisher's LSD test at the 5% level.

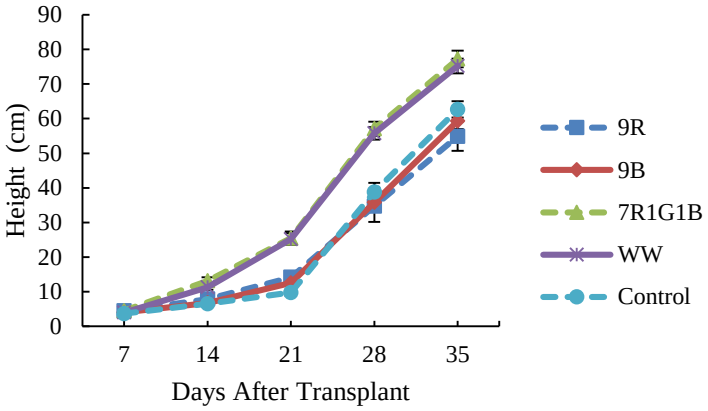

Fig. 1. Effects of 10 hours of light-emitting diodes (LEDs) irradiation at 20-25 μmol·m^{-2}·s^{-1} for 3 days before grafting on the height of '銀輝' melon grafted '銀華' rootstock plant. Values are mean ± SE (n = 3).

LED light sources 7R1G1B and WW resulted in a greater increase in height than the other treatments from 14 days until 35 days after transplant (Fig. 1). Regarding diameter, treatment with 7R1G1B and WW resulted in thicker plants than with 9R, 9B and control at 7 and 14 days. The diameter increase during control treatment was lowest from the first day until 14 days, after which the plants thickened gradually to 5.4 mm at 35 days after transplant (Fig. 2).

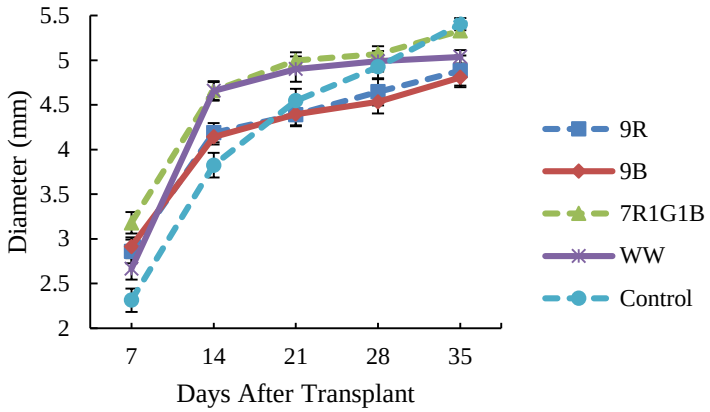

Fig. 2. Effects of 10 hours of LEDs irradiation at 20-25 μmol·m^{-2}·s^{-1} PPFD for 3 days before grafting on the diameter of '銀輝' melon grafted on '銀華' rootstock plant. Values are mean±SE (n=3).

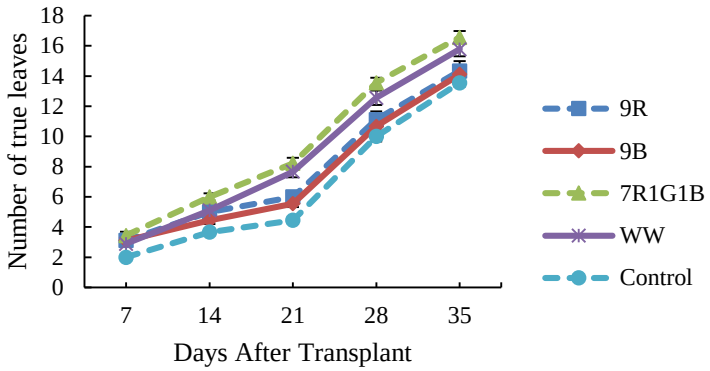

Fig. 3. Effects of 10 hours of LEDs irradiation at 20-25 μmol·m^{-2}·s^{-1} PPFD for 3 days before grafting on the true leaf number of '銀輝' melon grafted on '銀華' rootstock plant. Values are mean ± SE (n = 3).

Regarding true leaf growth, in the first 7 days, all LED treatments resulted in more true leaves than control, and at 21 days, 7R1G1B and WW treatments had more leaf number, while plants under control treatment had the fewest leaves (Fig. 3).

Analysis of the vigor index showed that the control treated plants had the highest vigor at around 0.66, followed by 9R and 9B at around 0.57 and 0.53. The vigor of 7R1G1B and WW was lower than control treatment (Fig. 4).

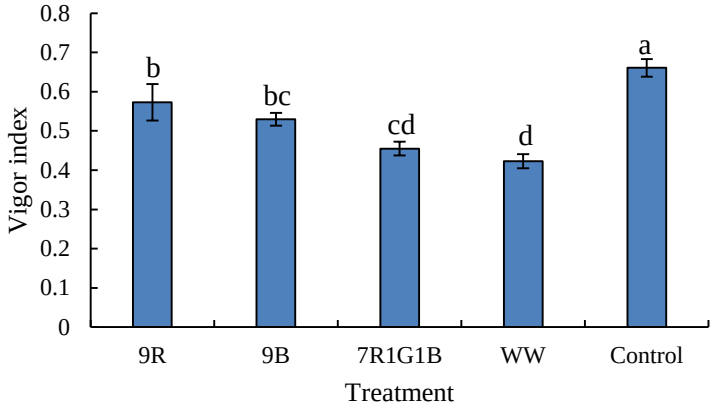

Fig. 4. Effects of 10 hours of LEDs irradiation at 20-25 μmol·m^{-2}·s^{-1} PPFD for 3 days before grafting on plant vigor index at grafted plants growth for 35 days of '銀輝' melon grafted on '銀華' rootstock plant. Values are mean ± SE (n = 3). Means with the same letters within treatment were not significantly different according to Fisher's LSD test at the 5% level. Vigor index = (diameter/height) * plant dry weight.

Discussion

1. Survival rate

A short period of irradiance was applied to the scion seedlings using LEDs for 3 days before grafting. Analysis showed that 9B and 7R1G1B treatments resulted in a 100% survival rate, similar to the result with natural light, which was also 100%. This implied that these two light sources would not decrease the survival rate, unlike 9R and WW treatments. This result was probably due to the fact that the scion had already received sufficient light saturation under sunlight (6 hours) and artificial light under 20-25 μmol·m^{-2}·s^{-1} PPFD LEDs (10 hours) as light blue light. Red light increases the survival rate of the grafted plants and decreases the infection rate of plants as compared with blue light (Vu et al., 2014). Blue light helps to make the opening

of the stomata larger and assists in the photosynthesis process; it also makes the root length longer, accelerating plant growth (Li *et al.*, 2015).

2. Effects of LEDs treatment on grafted plant growth

7R1G1B resulted in a better growth rate in terms of height, diameter, number of true leaves, and first openings of male and female flowers, but this light combination resulted in a lower vigor index as compared with 9R, 9B and natural light. This was due to the fact that diameter growth and the dry weight were not balanced with the height growth rate.

Sole red light resulted in the poorest fresh and dry weights, and a greater vigor index was achieved under natural light, while sole blue light increased plant growth by increasing the stomatal density, which supports better photosynthesis activity (Muneer e*t al.*, 2014). These results were similar to those of Li *et al*. (2015), who demonstrated that a higher blue light ratio could drive photosynthesis activity, which increased the dry weight and vigor index.

The effects of sole green light were studied, and this treatment was found to reduce photosynthesis and oppose stomatal opening; this treatment also decreased stomatal conductance and affected the leaf area. However, when green light irradiance was followed by blue light, and when the green light ratio was smaller than that of the blue light, the growth in stomatal conductance increased (Frechilla *et al.*, 2000). Stomatal conductance under a combination of red and blue light exhibited a similar increase to that under cool white fluorescent light, while a combination of red, green and blue light resulted in a higher increase than a combination of red and blue light, sole green light, and even cool white fluorescent light at 21 days after planting. The combination of red, blue and green light increased the leaf area, shoot fresh mass, and shoot dry mass as compared with red and blue light, green light and cool white fluorescent light (Kim *et al*., 2004).

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甜瓜'銀輝'苗處理 LED 對嫁接越瓜'銀華'後生長之影響

馮 錦 來[1] 宋 妤[2]

關鍵字:發光二極體、嫁接、甜瓜

摘要：甜瓜接穗苗嫁接前以 LED 燈做為光源處理，接穗在 9B (藍光)與 7R1G1B 光源 (85%紅光、7%綠光和 8%藍光)每日照射十小時處理 7 天後，砧木使用越瓜'銀華'嫁接存活率為 100%，以 7R1G1B 光源處理下顯著增加嫁接植株之株高、葉數且提早開花。WW 處理下植株生長略低於 7R1G1B，但其比葉面積和其他光處理相比最高。 7R1G1B 的乾重和活力指數顯著低於自然光，但較 WW 處理高。

1) 國立中興大學園藝學系碩士班研究生。
2) 國立中興大學園藝學系教授，通訊作者。