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Effect of Light Environment on Runner Plant Propagation of Strawberry

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Abstract

In strawberry (*Fragaria* × *ananassa* Duch.) production, the availability of high quality plants is one of the most important factors in obtaining good yields. Starting production with healthy and plentiful plants gives the grower a greater chance of high productivity. Recently, the high efficient, low cost and long life artificial light applied in horticultural crop production was a widespread technology, especially in controlled environment agriculture. The runner plant propagation of strawberry in Taiwan usually was limited at certain district and season. Using facility cultivation for strawberry propagation and production may be a feasible strategy. In order to evaluate the suitable light environment to propagation strawberry runner plants, 'Toyonoka' strawberry plants were planted in a controlled environment growth chamber using T5 light or LED as light source for 6-8 weeks. The result showed cool white light (6500K and 5000K) combined with high light intensity (6 lamps) not only enhanced plant growth, but also promoted runner formation and ramet growth. The treatment of 70% red light＋30% blue light (R＋B) had the highest SPAD value, dry weight, crown diameter, carbohydrate and starch content and produced the most runners. But the treatment of 70% red light＋20% blue light＋10% green light (R＋B＋G) generated the most ramets in a runner chain. Using LED as light source for runner production was better than those of using T5 light.

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) is an important horticultural crop and high value crop. In strawberry production, the availability of high quality plants is one of the most important factors in obtaining good yields. Starting production with healthy, uniform and plentiful plants gives the grower a greater chance of high productivity. Light is one of the most important and variable components of the plant environment. Light is also a major factor in determining the photosynthesis and photomorphogenesis of the plant. Although the effect of light in strawberry has been studied, its effects have not been well quantified. Moreover, it is not well known that different cultivars and growth stage have different light requirements. Recently, the high efficient, low cost and long life artificial light applied in horticultural crop production was a widespread technology, especially in controlled environment agriculture. The runner plant propagation of strawberry in Taiwan usually was limited at certain district and season. Moreover, the seedlings usually are not uniform by commonly used cultivation. Using facility cultivation for strawberry propagation and production may be a feasible strategy. In order to evaluate the suitable light environment to propagation strawberry runner plant, the

main commercially variety used in Taiwan 'Toyonoka' strawberry plants were planted in a controlled environment growth chamber using T5 light or LED light as radiation source.

MATERIALS AND METHODS

Single crowned plants with 4 developed leaves of strawberry (*Fragaria* × *ananassa* Duch. cv. Toyonoka) were obtained from a commercial nursery in Miaoli, Taiwan. The plants were potted in 7 inches plastic pots filled with medium (2peat: 2sand: 2perlite: 1vermiculite v/v) and arranged as a completely randomized design placed in growth chamber where day/night temperature 25/20℃ for 6-8 weeks. The plants were fertilized once a week with a complete fertilizer solution (Hyponex #2, 20-20-20) in 1000 dilution. The plants were maintained in 16 day-length using different artificial supplementary lights. Experiment 1: Four kinds of colour temperature (3000K, 4000K, 5000K, 6500K) of T5 light combined with 3 or 6 lamps (50-55, 110-122 μmol m^{-2} s^{-1}) were treated as 1. 6500 K × 6 ; 2. 6500 K × 3; 3. 5000 K × 6; 4. 5000 K × 3; 5. 4000 K × 6; 6. 4000 K × 3; 7. 3000 K × 6. Experiment 2: Three kinds of LED (83-100 μmol m^{-2} s^{-1}), 1. 100% red light (R). 2. 70% red light＋30% blue light (R＋B). 3. 70% red light＋20% blue light＋10% green light (R＋B＋G). Leaf number, width, length and chlorophyll content (SPAD value), crown size, runner number of the strawberry plants were determined every 2 weeks. At the end of experiments, dry weights, soluble carbohydrate and starch level were analyzed.

RESULTS AND DISCUSSION

Experiment 1: Effect of T5 Light on the Growth and Runner Formation of Strawberry

There was no significant difference on the leaf number, leaf width, leaf length, SPAD value, crown diameter of plants under different colour temperature treatments (Table 1). But all using six lamps treatment could enhance plant growth. The results showed the highest growth parameters were observed under 6500×6 and 5000×6 treatment. Light intensity obviously influenced strawberry plant growth, so all growth parameters of plants under six lamps treatment were better than those under three lamps.

Figure 1 showed a significant effect on the runner formation. The first runner formed after 14 days under 6500×6 treatment. Runners were significantly increased after 28 days treatment. The 6500×6 treatment obtained the highest runner number, next was 5000×6 treatment. Colour temperature had effect on the runner formation of strawberry.

Strawberry plants under 6500K and 5000K colour temperature generated significantly more runners than those under 3000K and 4000K treatment (Fig. 1). The number of runner under six lamps was more than those under three lamps. Plants under 6500×6 treatment were more dry weights, soluble carbohydrate and starch level than other treatments (Table 2). Strawberry plants require a large amount of carbohydrate not only for the vegetative growth but also for the reproductive growth. Crown is a very important carbohydrate storage organ of strawberry (Macias-Rodriguez et al., 2002). The biggest crown of plant was also found by treated with 6500×6 treatment. Such treatment provided a good foundation for plant growth and development.

Experiment 2: Effect of LED on the Growth and Runner Formation of Strawberry

The results showed red light (R) significantly increased leaf length and leaf area (Table 3). However, 70% red light＋30% blue light (R＋B) treatment had the highest

SPAD value, dry weight, crown diameter, carbohydrate and starch content (Table 3, 4) . Plants under this treatment also produced the most runners (Fig. 2). But the treatment of 70% red light＋20% blue light＋10% green light (R＋B＋G) generated the most ramets in a runner (Table 5). Red light along can find its application in the growth of *Zantedeschia* plantlets in vitro and tuber formation (Jao et al., 2005). The combination of red and blue LED light was an effective light source for several crops (Jao and Fang, 2003; Xu et al., 2006). Folta (2004) showed green light irradiation leads to a rapid increase in the growth rate of etiolated Arabidopsis seedlings. Seedlings grown under green, red, and blue light together are longer than those grown under red and blue alone. We have the similar results.

The capacity to produce new clonal plants through runners is exploited by nurseries as the main protocol of strawberry vegetative propagation. *Fragaria* × *ananassa* can produce up to 10-15 runner chains per plant per year (Hancock, 1999), depending on the variety and cultural conditions, with three to five ramets per runner chain, giving the opportunity to generate 40-50 colonal ramets per each initial plant in a sigle season (Savini et al., 2008). In this study, it could produce 6.2 ramets per runner under R＋B＋G treatment for six weeks. It should be a potential application for runner plant production. The grower also has a better opportunity to control planting schedules.

CONCLUSIONS

Cool white light (6500K and 5000K) combined with high light intensity (6 lamps) not only enhanced plant growth, but also promoted runner formation and ramets growth. It could promote more and stronger runner plant for propagation.

Light quality was found critical not only to grow, but also to produce runner of strawberry. Our result showed using LED as light source for runner production was better than those of using T5 light. Moreover, leaf morphogenesis is also influenced by the light quality.

Our study with strawberry plants suggested that using LED as light source in facility cultivation for strawberry propagation and production seems to be a feasible strategy. Therefore, it will be possible to implement this technique easily on a commercial scale.

Literature Cited

Folta, K. M. 2004. Green light stimulates early stem elongation, antagonizing light-mediated growth inhibition. Plant Physiol. 135: 1407-1416.

Hancock, J. 1999. Strawberries. CABI publishing, Wallingford, UK, pp. 1-25/95-115.

Jao, R.C. and Fang, W. 2003. An adjustable light source for photo-phyto related research and young plant production. Applied Engineering in Agriculture 19(5):601-608.

Jao, R. C., Lai, C.C., Fang, W. and Chang, S.F. 2005. Effects of red light on the growth of *Zantedeschia* plantlets in vitro and tuber formation using Light-emitting Diodes. HortScience, 40(2):436-438.

Macias-Rodriguez, L., Quero, E. and Lopez, M. G. 2002. Carbohydrate differences in strawberry crowns and fruit (*Fragaria* × *ananassa*) during plant development. J. Agric. Food Chem. 50(11): 3317-3321.

Savini, G., Giorgi, V., Scarano, E. and Neri, D. 2008. Strawberry plant relationship through the stolon. Physiol. Plant. 134: 421-429.

Serce, S. and J. Hancock. 2005. The temperature and photoperiod regulation of flowering and running in the strawberries, *Fragaria chiloensis*, *F. virginiana*, and *F*. x *ananassa*. Sci. Horti. 103: 167-177.

Xu, K., Y. P. Guo, S. L. Zhang and Dai, Fu. 2006. Effect of light quality on plant growth and fruiting of Toyonoka strawberry (*Fragaria* × *ananassa*) cultivar. J. Fruit Sci. 23: 818-824.

Tables

Table 1. Effect of various radiation source on leaf number, leaf width, leaf length and crown diameter of strawberry plant for eight weeks

Radiation source	Leaf number	Leaf width (cm)	Leaf length (cm)	Crown diameter (mm)
3000 K × 6	9.8 abc	7.56 a	17.00 ab	20.95 a
4000 K × 6	9.0 bc	7.31 a	16.40 abc	20.42 a
5000 K × 6	10.6 a	7.78 a	17.78 a	21.97 a
6500 K × 6	10.2 ab	7.57 a	16.46 abc	22.20 a
4000 K × 3	9.0 bc	6.57 b	16.00 abc	20.42 a
5000 K × 3	9.2 abc	5.81 c	15.10 c	15.36 b
6500 K × 3	8.4 c	5.86 c	15.36 bc	15.77 b

Means followed by the different letters in each column are significantly different at 5% level by Duncan's Multiple Range Test

Table 2. Effect of various radiation source on dry weight, SPAD value, soluble carbohydrate content and starch content of strawberry plant for eight weeks

Radiation source	Dry weight (g)	SPAD value	Soluble carbohydrate content (mg/g)	Starch content (mg/g)
3000 K × 6	9.70 b	55.66 ab	544.18 b	763.99 ab
4000 K × 6	12.02 a	54.94 ab	598.75 a	499.27 b
5000 K × 6	11.42 a	56.74 a	633.66 a	856.95 a
6500 K × 6	11.30 a	56.54 a	638.27 a	841.61 a
4000 K × 3	6.78 c	54.70 ab	597.95 c	771.73 ab
5000 K × 3	5.58 c	54.52 ab	513.08 c	480.52 b
6500 K × 3	6.54 c	52.52 b	527.93 c	841.61 ab

Means followed by the different letters in each column are significantly different at 5% level by Duncan's Multiple Range Test

Table 3. Effect of various light quality on leaf number, leaf width, leaf length and crown diameter of strawberry plant for six weeks

Radiation source	Leaf number	Leaf width (cm)	Leaf length (cm)	Crown diameter (mm)
R	9.75 a	8.74 a	27.73 a	14.81 b
R+B	9.60 a	8.36 a	22.66 b	17.32 a
R+B+G	9.20 a	8.26 a	22.10 b	13.52 b

Means followed by the different letters in each column are significantly different at 5% level by Duncan's Multiple Range Test

Table 4. Effect of various light quality on dry weight, SPAD value, soluble carbohydrate content and starch content of strawberry for six weeks

Radiation source	Dry weight (g)	SPAD value	Soluble carbohydrate content (mg/g)	Starch content (mg/g)
R	6.31 ab	40.85 b	248.77 ab	1330.50 a
R+B	7.09 a	44.74 a	294.42 a	1365.29 a
R+B+G	5.07 b	43.12 a	237.07 b	1137.76 b

Means followed by the different letters in each column are significantly different at 5% level by Duncan's Multiple Range Test

Table 5. Effect of various light quality on ramet number, dry weight, crown diameter , chlorophyll content, soluble carbohydrate content and starch content of strawberry ramet

Radiation source	Ramet number	Dry weight (g)	Crown diameter (mm)	Chlorophyll contents (mg/g)	Carbohydrate contents (mg/g)	Starch contents (mg/g)
R	4.75 b	0.50 a	5.29 ab	0.69 a	197.22 a	1024.60 a
R+B	5.00 b	0.57 a	5.37 a	0.78 a	192.69 a	878.47 a
R+B+G	6.20 a	0.45 a	5.17 b	0.88 a	156.61 b	1005.66 a

Means followed by the different letters in each column are significantly different at 5% level by Duncan's Multiple Range Test

Figures

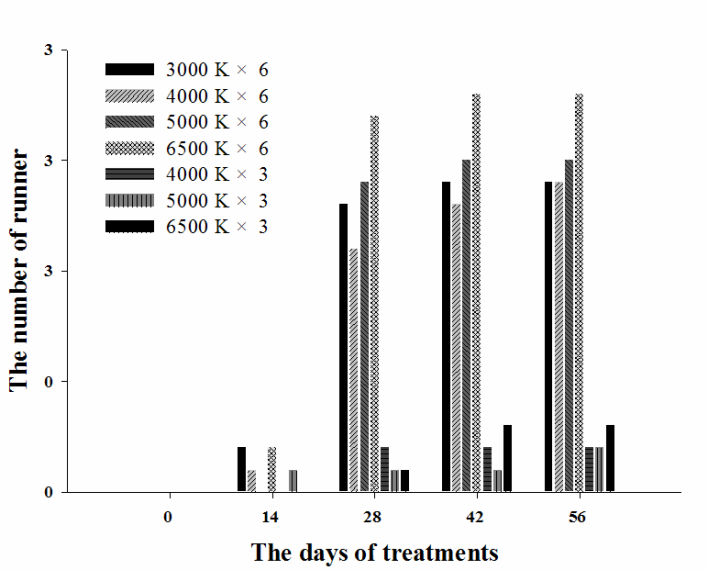

Fig.1 Effect of various radiation source on the runner number of strawberry plant

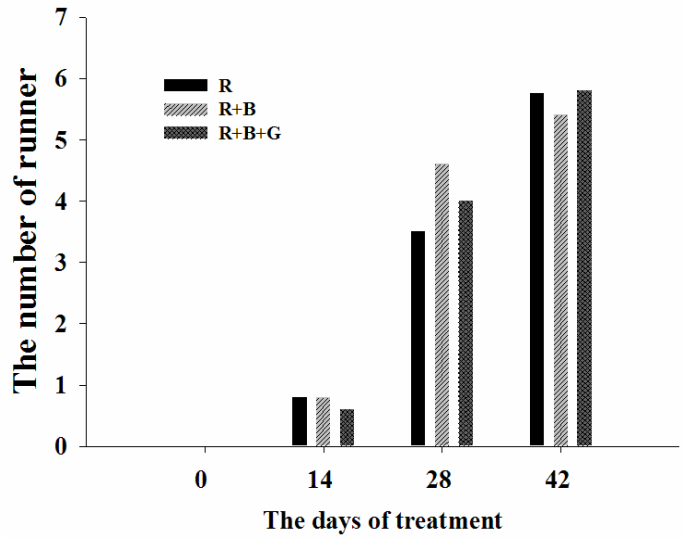

Fig.2 Effect of various light quality on the runner number of strawberry plant