Effect of Shading on Stock Plant Growth and Cuttings Production

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Keywords: Stock plant, Cutting, Shading, Rooting, Carbohydrate.

Summary

Stock plants of Poinsettia ‘Fisnovired' were grown under three shading level including 0 %, 55%, and 80%. Stock plant with small leaf, short stem and stunted growth was appeared under 80% of shading. Number of harvested cuttings increased as shading level increased from 0% to 55%. However, it declined when shading rate reached 80%. Additionally, subsequent cuttings harvested from 55% shaded plants showed longer roots (12cm) and more roots (13.7) compared to control plants and 80% shaded plants. Plants under 55% shading had higher concentration of sucrose and glucose in leaf. But higher value of total soluble sugar and starch was occurred in the leaf of plant grown under either 0% or 80% of shading.

Introduction

Poinsettia was one of the most economically valuable potted flowers in the world(Clifford *et al*., 2004). According to the Floriculture Crops 2008 Summary presented that the total wholesale value of poinsettia for 15 states of USA was around 154 million dollars (equivalent to 36 million pots per year) (USDA., 2009).

Many floriculture crops had been propagated vegetatively (Faust and Grimes, 2004). Because vegetatively propagated cuttings from stock plants produced flowering plants true to cultivar (Ecke *et al*., 1990). The stock plant of poinsettia should be produced as many cuttings as possible with in the short time span (StrØmme, 1994). Stock plant culture might be the most important procedure of the entire poinsettia production program.

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There were many factors that influenced asexual propagation, such as cultural practices, plant growth regulators, genotype, temperature, light (photoperiod, irradiance, and quality) and mineral nutrition(Read *et al*., 1986). Light is an essential prerequisite factor for the plant growth and development (Saifuddin *et al*., 2010). The range of light intensity to which a plant can acclimate was determined by an individual species genetic adaptation to the light environment of its native habitat (Boardman, 1977). Numerous changes in leaf morphology, physiology, and biochemistry were required for acclimation of photosynthesis to various light intensities (Bjökman, 1981; Boardman, 1977).

Therefore, the objective of this research is to determine the effect of shading on poinsettia stock plant growth and cuttings production.

Materials and Methods

Materials

The Poinsettia, *Euphorbia pulcherrima* 'Fisnovired', was used as material for stock plant managing experiment. It was bred by Katharina Zerr, Höhr-Grenzhausen and was introduced by Syngenta Crop Protection AG.

Methods

The poinsettia 'Fisnovired' young plantlets were received on the 10th June 2009 from Fort Port Nursery. Plantlets were then grown in green house of National Chung Hsing University. During the first two weeks, the plants were fertilized every day by the 1000 ppm solution of Jack’s fertilizer 20-20-20 (Scotts-Sierva Horticultural product co., Marysville, USA). After that, all the plant were shifted to 1.6 L pots (15 cm diameter) filled with a mixture of equal volume of peat moss (Hochmootrorf für jeden Garten Zersetzt H2-H5, karl wolpe, Germany) and perlite (4-6mm, Hopes Int'l Floriculture & Horticulture Co., Taoyuan, Taiwan). On the 6th July, 2009, all plants were pinched back to the two lowest basal leaves and each plant ensured had equal 6 branches. They were then managed as stock plants for shading experiments.

On the 7th July 2009, 27 above-mentioned stock plants were placed randomly on the bench (CK) and in two shelters which were established at different shading levels. Two shelters (1 x 1 x 1.45 m) were built by steel frame and covered with single or double layer, respectively, of woven polypropylene black cloth (Hsin Long Netting Co., Ltd, Taichung, Taiwan). The actual light transmission through chambers and direct sunlight was measured by using a Light Meter LI-250 and LI-190SA Quantum Sensor (LI-COR Company, Nebraska, USA). Afterwards, the shading levels of two chambers in this experiment were approximately 55% or 80% of natural condition, respectively. Stock plants were spaced at the density of 25 plants.m^{-2}. From the beginning to the end, all of stock plants were fertilized weekly by modified Hoagland's solution (Hoagland and Arnon, 1950).

Tissue analysis

a) Chlorophyll analysis

One hundred milligram of leaf disk per leaf was punched out. Chlorophyll was extracted using 80% acetone following the method of Bruuinsma (1963). The leaf disk sample was then put in dark for 24h. Then, the solution was measured with a spectrophotometer (Hitachi U-2001, Japan) at 663nm wavelengths.

b) Carbohydrate analysis:

Leaf samples of poinsettia stock plant were dried and ground. Samples were then weighed accurately (0.1 g) into plastic centrifuge tubes and 15ml of ethanol (80%) was added to each tube. Slurries were mixed well and boiled at 70^{0}C for 20 minutes. After that, samples were centrifuged at 10000 x g for 15 min; the supernatant was decanted (insoluble substance at the bottom of each tube after centrifugation was taken to analyze starch). The extracted solution was next reduced to around 1ml by using a rotary vacuum evaporator (VAPOUR-X, KC-12) at 40^{0}C. Consequently, the sample extracts were filtered through 0.45 µMillipore filter and made to 1.5 ml with deion water. Finally, the samples were taken for carbohydrate analysis by using Shimadzu RID-6A detector (Shimadzu Corp., Japan).

Experiment design, data collection and analysis

Poinsettia stock plants were arranged in a randomized complete design with 3 treatments, 9 replications per treatment. Leaf nitrogen content, carbohydrate content, stock plant growth, number of cuttings…were determined. Root number and root length of cuttings were also measured. Data were subjected to a one factor analysis of variance (ANOVA) using CoStart version 6.101 (CoHort software, Monterey, CA, USA), according to LSD's test, at $P \leq 0.05$.

Results

Shaded plant had dark green leaf, especially stock plant with 80% shading. Plant grown under 50% shading level was more and longer branches. Conversely, Plant was shaded with 80% shading had small leaf and stunted growth (Fig. 1). The height of stock plant grown under 80% shading were lower. At the first harvest, stock plants treated with shading of 55% were shorter than control plant. However, from the second harvest to the final harvest, this considerable variation of plant height between them did not exist anymore (Table 1). The plants shaded by 55% shading achieved the larger plant canopy, followed by control plants and plants shaded of 80% at the third harvest date.

In the three harvest dates, harvested cuttings increased as shading level increased from 0% to 55%. However, number of cuttings harvested from stock plant declined when shading rate reached 80%. Subsequently, total cuttings of stock plant received 55% shade treatment was slightly higher than control plant's, but significantly greater than total cutting harvested from the ones shaded by 80% shading (Table 2).

Fig. 1. Effect of shading on the growth of Poinsettia 'Fisnovired' stock plants (Photos were taken on 20/9/2009)

Table 1. Effect of shading on the growth of *Euphorbia pulcherrima* 'Fisnovired' stock plant.

Shading (%)	Plant height (cm)			Canopy diameter (cm)		
	H[z] 1	H 2	H3	H1	H 2	H 3
0	20.3 a[y]	18.1a	18.4 a	21.7 a	24.9 a	28.7 b
55	17.6 b	18.6 a	19.0 a	21.8 a	26.0 a	32.0 a
80	13.2 c	13.7 b	13.1 b	17.1 b	16.5 b	15.5 c

[z] Data were collected on 18/8, 22/9 or 25/10/2009, respectively.

[y] Mean within each column followed by a different letter are significantly different at $P \leq 0.05$ by LSD's test.

Table 2. Effect of shading level on the quantities and quality of harvested cuttings of *Euphorbia pulcherrima* 'Fisnovired' stock plant

Shading level (%)	Number of cutting				Cutting stem diameter (mm)			Chlorophyll content (mg/g)[z]		
	H[y]1	H2	H3	Total	H1	H2	H3	Chl a	Chl b	Total
0	7.7 a[x]	8.9 a	10.7 b	27.3 a	3.6 a	3.3 a	3.2 a	2.20 a	0.43 a	3.38 a
55	8.4 a	9.6 a	12.6 a	30.6 a	3.7 a	3.5 a	3.4 a	1.82 ab	0.32 b	2.68 ab
80	4.7 b	3.7 b	2.6 c	11.0 b	3.0 b	2.4 b	2.1 b	1.51 b	0.31 b	2.18 b

[z] Leaf chlorophyll content was measured on 22/9/2009.

[y] Data were collected on 18/8, 22/9 or 25/10/2009, respectively.

[x] Mean within each column followed by a different letter are significantly different at $P<=0.05$ by LSD's test.

In general, cuttings taken from 55% shading tended to have the larger stem diameter than cuttings of control stock plant. And the diameters of cuttings got from these two treatments were considerably greater than 80% shaded plants (Table 2). For example, at the 3[rd] harvest, the stem diameter of cuttings from 0%, 55%, 80% shading treatment were 3.2 mm, 3.4 mm, or 2.1 mm, respectively. Control stock plant had higher value of chlorophyll a, chlorophyll b and total chlorophyll compared to the other treatments. There was no significant difference of leaf chlorophyll contents between 55% and 80% shading treatment (Table 2).

After rooting, cuttings taken from 55% shaded stock plant showed longer root length (12.0 cm), followed by cuttings of control plant (10.0 cm), and 80% shaded stock plant's cuttings (5.2 cm) (Fig. 2, Table 3). Similarly, root number of subsequent cuttings harvested from control and shaded at 55% stock plants was higher than that from 80% shaded stock plant. While dry and fresh weight of subsequent cuttings harvested from plant grown at 80% shading was lower than other treatments (Table 3).

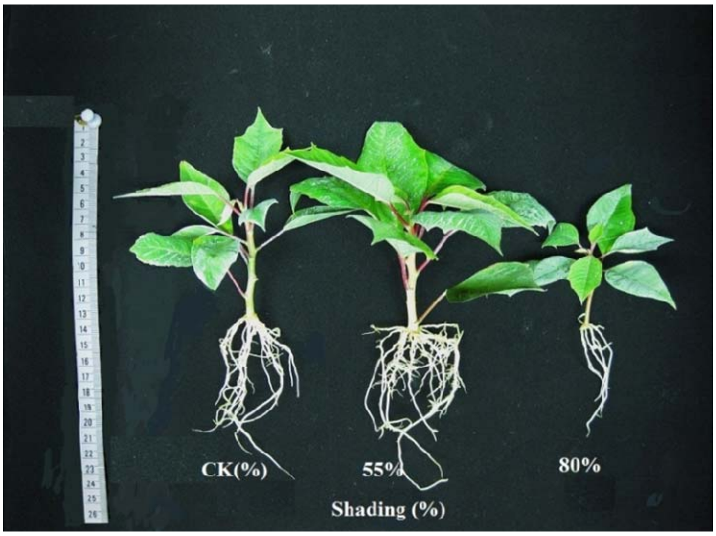

Fig. 2. Effect of shading on rooting of subsequent cuttings of poinsettia 'Fisnovired' stock plants (Photos were taken on 14/10/2009).

Table 3. Effect of shading level on the shoot and root growth of cuttings of *Euphorbia pulcherrima* ‘Fisnovired'

Shading level (%)	Cutting fresh weight (g)		Cutting dry weight		Root number	Root length (cm)
	Shoot (g)	Root (g)	Shoot (g)	Root (mg)		
0	2.91a	0.32 a	0.38 a	37.41 a	12.08 a	10.0 b[z]
55	3.39 a	0.35 a	0.42 a	41.92 a	13.17 a	12.0 a
80	2.23 b	0.21 b	0.27 b	24.82 b	6.73 b	5.2 c

[z] Mean within each column followed by a different letter are significantly different at P<=0.05 by LSD’s test.

Leaf sucrose content in 55% shading stock plant (0.50%) was significant higher compared to those in control plants (0.29%) and 80% shaded plant (0.22%) (Table 4). Shading treatment resulted in reducing sucrose in stem tissue of stock plant about 33%. Plant grown under 80% shading rate had lower glucose in leaf (0.13%) in comparison with other treatments. Shading level treatment had no effect on stem glucose, leaf fructose of stock plant. However, shading treatment resulted in a significant decrease in stem fructose and stem total soluble sugar. Similarly, the total soluble sugar in leaf of stock plant generally declined with increasing shading level. The higher leaf starch of stock plant was attained by treating plant with 80% shading (Table 4).

Table 4. Effect of shading level on sucrose, glucose, and fructose, TSS, starch content in cuttings of *Euphorbia pulcherrima* 'Fisnovired'.

Shading level (%)	Sucrose (% DM)		Glucose (% DM)		Fructose (% DM)		Total soluble sugar (% DM)		Starch (%DM)	
	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
0	0.29 b[z]	0.24 a	0.22 a	0.27 a	0.59 a	0.68 a	2.09 a	1.37 a	5.03 b	4.65 a
55	0.50 a	0.16 b	0. 27 a	0.24 a	0.67 a	0.44 b	1.93 a	1.00 b	5.74 ab	5.62 a
80	0.22 b	0.16 b	0. 13 b	0.17 a	0.65 a	0.41 b	1.17 b	0.96 b	6.80 a	5.62 a

[z] Mean within each column followed by a different letter are significantly different at P<=0.05 by LSD’s test.

Discussion

Ballare (1999) referred that plants under higher shading produced larger leaves and longer stem, in order to capture more light. Because of a shading avoidance mechanism which resulted in decreasing flower buds and delaying flowering time. Munir *et al*. (2004) found that under low light condition plants tended to vegetative rather than reproductive growth. In addition, these plants had been able to optimize their effectivenees of light absorption by increasing leaf area. On contrast, Andersen *et al*. (1991) concluded that photoinhibition and photooxidation damage was responsible for reduced growth and chlorosis of plants in 100% sunlight. Brand (1997) assumed that a cooler potting medium under shade may benefit root functioning and growth. In our experiment, plant under 55% shading had slightly bigger canopy diameter compared to control plant, especially on the third harvest date. However, there were a significant reduction of plant height and canopy diameter, when plants were grown under 80% shading (Table 1). Sheppart and Pellet (1976) also stated that growth of *Cornus stolonifera* Michx. was optimized with 25% shading, but the growth was reduced with more shading. All these results partly explained that the higher number of cuttings harvested from plant grown at 55% shading but not at 80% shading (Table 2).

In this experiment, the root number and root length of cuttings increased when stock plants were treated with 55% shading, but decreased at 80% shading level for stock plants (Table 3). A decrease in the number of roots with an increase in the irradiance during stock plant stage was in accordance with results obtained in *Pisum sativum* L. cv. Alaska (Hansen, 1976; Hansen and Eriksen, 1974). An opposite effect on root formation by increasing the irradiance was also found in *Chrysanthemum morifolium* Raat (Fischer and Hansen, 1977). Brian and harlevy (1973) reported that reducing natural light intensity by approximately 50% increased rooting percentage of dahlia 'Orpheo' cuttings, but did not affect rooting of the harder cuttings of dahlia 'Lavender Perfection' (Biran and Halevy, 1973). Hansen and Eriksen (1974) suggested that the irradiance effect in *pisum* was mediated through accumulation of carbohydrates and reactions of hormones.

Moreover, differential partitioning of carbohydrate into soluble or storage form affects the role of carbohydrates in rooting of cutting (Haissig, 1984). Nanda *et al*. (2006) found that glucose could stimulate the rooting process. And among carbohydrates, sucrose is the critical mobile carbon source obtained from leaves. Recent studies of pelargonium also suggested the high and steady availability of sucrose in cutting leaves, as a function of initial reserves and current photosynthesis, strongly supports the formation of adventitious roots in leafy stem cuttings (Druege and Kadner, 2008; Rapaka *et al*., 2005). Additionally, there was a significant correlation between sucrose and root length (Henry *et al.*, 1992). Similarly, in our experiment, plants grown under 55% shade had higher concentration of sucrose and glucose in leaf compared to other treatments (Table 4). It could explain the better rootability of cuttings harvested from this treatment.

References

Andersen, P.C., J.G. Norcini, and G.W. Knox. 1991. Influence of irradiance on leaf physiology and plant growth characteristics of Rohdodendron 'Pink Rufles'. J. Am. Soc. Hortic. Sci. 116:881-887.

Ballare, C.L. 1999. Keeping up with the neighbours: phytochrome sensing and other signalling mechanisms. Trends in Plant Sci. 4:97-102.

Biran, I. and A.H. Halevy. 1973. Stock plant shading and rooting of dahlia cuttings. Scientia Hortic. 1:125-131.

Bjökman, O. 1981. Responses to different quantum flux densities. Encyclopedia of Plant Physiology 12:57-107.

Boardman, N.K. 1977. Comparative photosynthesis of sun and shade plants. Annu Rev Plant Physiol. 28:355-377.

Brand, M.H. 1997. Shade influences plant growth, leaf color, and chlorophyll content of *Kalmia latifolia* L. cultivars. HortScience 32:206-208.

Bruuinsma, J. 1963. The quantitative analysis of chlorophylls a and b in plant extracts. Photochem. Photobiol. 2:241-249.

Clifford, S.C., E.S. Runkle, F.A. Langton, A. Mead, S.A. Foster, S. Pearson, and R.D. Heins. 2004. Height control of poinsettia using photoselective filters. HortScience 39:383-387.

Druege, U. and R. Kadner. 2008. Response of post-storage carbohydrate levels in pelargonium cuttings to reduced air temperature during rooting and the relationship with leaf senescence and adventitious root formation. Postharvest Biol. Technol. 47:126-135.

Ecke, P., A. Matkin, and D.E. Hartley. 1990. *The Poinsettia Manual*. Paul Ecke Poinsettias, Encinitas Calif. 267 pp.

Faust, J.E. and L.W. Grimes. 2004. Cutting production is affected by pinch number during scaffold development of stock plants. HortScience 39:1691-1694.

Fischer, P. and J. Hansen. 1977. Rooting of chrysanthemum cuttings, influence of irradiance during stock plant growth and of decapitation and disbudding of cuttings. Scientia Hortic. 7:171-178.

Haissig, B.E. 1984. Carbohydrate accumulation and partitioning in *Pinus banksiana* seedlings and seedling cuttings. Physiol. Plant. 61:13-19.

Hansen, J. 1976. Adventitious root formation induced by gibberellic acid and regulated by the irradiance to the stock plants. Physiol. Plant. 36:77-81.

Hansen, J. and E.N. Eriksen. 1974. Root formation of pea cuttings in relation to the irradiance of the stock plants. Physiol. Plant. 32:170-173.

Henry, P.H., F.A. Blazich, and L.E. Hinesley. 1992. Nitrogen nutrition of containerized eastern redcedar. II. Influence of stock plant fertility on adventitious rooting of stem cuttings. J. Amer. Soc. Hort. Sci. 117:568-570.

Hoagland, D.R. and D.I. Arnon. 1950. The water culture method for growing plants without soil. California Agricultural Experiment Station Circular 347:1-32.

Munir, M., M. Jamil, J. Baloch, and K.R. Khattak. 2004. Impact of light intensity on flowering time and plant quality of *Antirrhinum majus* L. cultivar Chimes White. J Zhejiang Univ. Sci. A 5:400-405.

Nanda, K.K., M.K. Jain, and S. MALHOTRA. 2006. Effect of glucose and auxins in rooting etiolated stem segments of *Populus nigra*. Physiol Plant. 24:387-391.

Rapaka, V.K., B. Bessler, M. Schreiner, and U. Druege. 2005. Interplay between initial carbohydrate availability, current photosynthesis, and adventitious root formation in Pelargonium cuttings. Plant Sci. 168:1547-1560.

Read, P.E., C.D. Fellman, A.S. Economou, and Q.G. Yang. 1986. Programming stock plants for propagation success. Proc. Int. Plant. Propagators Soc. 35:84-91.

Saifuddin, M., A. Hossain, and O. Normaniza. 2010. Impacts of Shading on Flower Formation and Longevity, Leaf Chlorophyll and Growth of *Bougainville glabra*. Asian J. Plant Sci. 9:20-27.

Sheppart, I., R. and a.H. Pellett. 1976. Light intensity effects on red osier dogwood. HortScience 11:200-202.

StrØmme, E.e. 1994. *The Scientific Basis of Poinsettia Production*. The Agricultural University of Norway. 120 pp.

USDA. 2009. Floriculture Crops 2008 Summary. United States Department of Agriculture, and National Agricultural Statistics Service Sp Cr 6-1 (09). 71 pp.

遮光對聖誕紅採穗母株與插穗生產的影響

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關鍵字：插穗母株、插穗、遮光、發根、碳水化合物.

摘要: 聖誕紅‘Fisnovired'的採穗母株栽培於 0%、55%、80%三種遮光程度。於80%遮光程度下採穗母株出現小葉、短莖與發育不良的情形。插穗的產量則會隨遮光程度由 0%增加到 55%而增加，但是在遮光達 80%會減少。此外，55%遮光植株的插穗其後續生長相較於對照組與 80%遮光處理的植株，有較長的根長(12cm)與較多的根數(13.7)。於 55%遮光程度下的植株葉片有較高的蔗糖與葡萄糖濃度，但是於 0%或 80%遮光程度栽培的植株葉片則有較高的總可溶性糖與澱粉含量。

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