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Growth of Rose Moss (Portulaca Grandiflora Hook) In Relation To Led Light Intensities

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Abstract

Change in climatic condtions Hook at transplantation created stress and photo inhibition presence of absence of light greatly effects negetative and flowering behavior of ornamental plants. Therefore the study was carried out during the summer 2017 on growth of portulaca (Portulaca grandiflora HOOK) in relation to LED light intensities in a three replicated Completely Randomized Design (CRD)-Factorial conducted at Student House of Horticulture Garden, Sindh Agriculture University Tandojam. The results revealed that growth of rose moss were significantly ($P<0.05$) affected by LED bulbs of 5 w sqm^{-1}. The rose moss plant treated with 04 LED bulbs sqm^{-1} produced maximum 50.10 cm plant spread, 22.50 branches plant^{-1}, 521.75 number of leaves plant^{-1}, 35.57 days to flower emergence, 14.91 flowers plant^{-1}, 4.19 cm flower diameter, 0.47 g flower weight and 11.10 days to flower persistence. The rose moss grown with 03 bulbs sqm^{-1} produced 36.79 cm plant spread, 16.16 branches plant^{-1}, 299.33 number of leaves plant^{-1}, 39.19 days to flower emergence, 2.00 flowers plant^{-1}, 1.99 cm flower diameter, 0.24 g flower weight and 6.45 days to flower persistence. The plants with 02 LED bulbs sqm^{-1} produced 30.39 cm plant spread, 12.26 branches plant^{-1}, 163.75 number of leaves plant^{-1}, 49.58 days to flower emergence, 9.00 flowers plant^{-1}, 2.39 cm flower diameter, 0.08 g flower weight and 3.85 days to flower persistence.

However, the minimum lowest rose moss flower performance was observed in 01 bulb sqm^{-1}, having 12.11 cm plant spread, 7.58 branches plant^{-1}, 45.17 number of leaves plant^{-1}, 56.99 days to flower emergence, 4.00 flowers plant^{-1}, 1.52 cm flower diameter, 0.12 g flower weight and 2.42 days to flower persistence. It might be concluded that the vegetative and flower characteristics of rose moss plant increased simultaneously with increasing LED bulbs. 04 LED bulbs sqm^{-1} resulted in maximum growth of rose moss. In case of varieties, “Portulaca peppermint” resulted in significantly maximum vegetative and flowering traits as compared to variety “Portulaca orange”.

Keywords: Rose moss, LED lights, vegetative, flowers.

Introduction

The Rose moss (Portulaca grandiflora L.) is a member of the Portulacacae family, has 25 genera of succulent herbs and shrubs [1]. Flowering is an important step in a plant cycle which shows the adaptability of plants to seasonal changes and decides the subsequent reproductive success [2]. Photoperiod, light intensity and light quality influence plant growth and development from seed germination to flowering. Light intensity is one of the detrimental parameters affecting plant growth and flowering behavior. The influence of the light intensities duration on flowering and rooting of ornamental plants has received a lot of attention [3]. Celosia and Portulaca are qualitative short day plants in which short-days, 12 hours or less of light, promote faster flowering. Long days, increase the amount of fascination, deformity at the base of the flower stem [4]. High temperatures decrease the number of days from visible bud to flower [5]. Temperature can influence the flowering response of many photoperiod sensitive plants [6].

In general, increase in duration of light intensities reduced time to first visible bud in Portulaca. Temperature and light intensity are related in the sense that as the natural day length becomes longer or shorter, the temperature warms or cools, respectively. In plants, every chemical, physiological, and biological process is influenced by temperature and light intensities [2]. During the summer months when temperatures exceed 38 ^{o}C several biological processes in the plant may be adversely affected, therefore affecting the plant optimum performance. At extremely high intensities, proteins in the plant are denatured (2-Kim *et al.*, 2009), critically affecting biological processes. From seed to post-harvest, light is probably the one factor that causes the highest loss in flower quality [7].

Keeping in view the importance of light intensities, the present research was carried out with the objectives of to determine morphological traits of varieties under LED intensities and to evaluate flowering behavior in relation to LED intensities.

Materials And Methods

The experiment was conducted during summer, 2017 at Horticulture Garden, Sindh Agriculture University Tandojam. Completely Randomized Design (CRD) was laid-out with three replications and each treatment contained ten pots. Seeds of two portulaca varieties (V_1 = Portulaca orange and V_2 = Portulaca peppermint) were sown in pots. After 15 days of germination each seedling was transplanted in separate pots and subjected to each treatment (LED Bulbs (LB) = 04; LB_1 = 01 bulb sqm^{-1}, LB_2= 02 bulbs sqm^{-1}, LB_3= 03 bulbs sqm^{-1}, LB_4= 04 bulbs sqm^{-1}). Afterwards each observation was recorded on each plant of both varieties.

Setting out of Experiment

- 50 seeds of each variety were sown in separate pots under tree shade
- After 15 days of germination, healthy seedlings were transferred to individual pots filled with FYM + river silt in 1:1 ratio.
- In the greenhouse a thick black cloth was imposed on three sides of 1 Square meter area per treatment.
- LED bulbs of 5W as per treatments were hanged 2 feet above the seedling pots

Observations recorded:

Plant spread (cm), branches plant^{-1}, number of leaves plant^{-1}, days to flower emergence, flowers plant^{-1}, flower diameter (cm), flower weight (g), days to flower persistence

Procedure for recording observations

Plant spread (cm): Six plants of each variety was selected at random from treatments and their spread was measured horizontally from one end to the other end with the help of a measuring tape and the average of the plants was worked out in cm at the time of flowering.

Branches plant^{-1}: Average number of branches per plant was counted from six randomly selected plants of each variety from different LED treatments.

Number of leaves plant^{-1}: Average number of leaves per plant was counted on visually from six randomly selected plants of each variety under different LED treatments.

Days to flower emergence: The days to flowers emergence in each variety of the randomly selected plants were noted as they 1st appeared after germination and average was worked out.

Flowers plant^{-1}: The number of flowers from each plant of both varieties under each treatment were counted and the average was worked out for about one month.

Flower diameter (cm): The diameter of all the flowers from randomly selected plants were measured in centimeters with vernier caliper and the diameter was worked out with the following formula.

Area = 3.14 x r^2

Flower Weight (g): Flowers of varieties were collected and tagged at random and weighed as an individual on weighing balance machine to record the weight in g.

Days to flower persistence: This observation was recorded from the day to flower emergence till the flower withered or dropped then days were counted and average was worked out.

Statistical analysis The data was statistically analyzed using Statistix-8.1 computer software (Statistix, 2006). The LSD test was applied to compare treatments superiority in case results are significant at $P \leq 0.05$ probability level.

Results

Plant spread (cm) and Branches plant^{-1}

Plant spread (cm) and branches plant^{-1} are generally a major growth characters associated with the growth habit of a particular variety being used and use of inputs. The results regarding the average plant spread and branches plant^{-1} of two rose moss varieties as affected by LED bulb applications are presented in Table-1 indicated that the plant spread and branches plant^{-1} of both varieties were significantly ($P<0.01$) influenced by LED intensities. The results further showed that the plant spread of rose moss variety “Portulaca peppermint” was greatest than variety “Portulaca orange”. The effect of LED bulb level of 04 LED bulbs sqm^{-1} on variety “Portulaca peppermint” resulted in maximum plant spread (53.85 cm) followed by “Portulaca orange”; and the lowest plant spread (8.45 cm) was found in the interaction of 01 bulb sqm^{-1} × variety “Portulaca orange”.

The results further showed that the branches plant^{-1} of rose moss variety “Portulaca peppermint” was greatest than variety “Portulaca orange” (14.04). The interactive effect of LED bulb level of 04 LED bulbs sqm^{-1}× variety “Portulaca peppermint” resulted in maximum branches plant^{-1} (23.50) and the lowest branches plant^{-1} (6.33) were found in the interaction of 01 bulb sqm^{-1} × variety “Portulaca orange”.

Table-1. Plant spread (cm) and Branches plant^{-1} of rose moss varieties under LED light intensities

Treatments	Plant spread (cm)		Branches plant^{-1}	
	Portulaca orange	Portulaca peppermint	Portulaca orange	Portulaca peppermint
LB_1 = 01 bulb sqm^{-1}	8.45 g	15.78 f	6.33 f	8.83 ef
LB_2= 02 bulbs sqm^{-1}	24.95 e	35.83 d	12.83 cd	11.70 de
LB_3= 03 bulbs sqm^{-1}	33.20 d	40.38 c	15.50 bc	16.83 b
LB_4= 04 LED bulbs sqm^{-1}	46.35 b	53.85 a	21.50 a	23.50 a
SE±	1.2002		0.9165	
LSD 0.05	3.8655		2.9518	
Prob.	0.1064		0.0395	

Number of leaves plant^{-1} and Days to flower emergence

The results in regards to number of leaves plant^{-1} of two rose moss varieties as affected by different LED bulbs are given in Table-2 The analysis of variance showed that there was significant ($P<0.05$) effect of LED bulb intensities on the number of leaves plant^{-1} of both the varieties.

The results further showed that the interactive effect of LED bulb level of 04 LED bulbs sqm^{-1}× variety “Portulaca peppermint” resulted in maximum number of leaves plant^{-1} (571.67) followed by “Portulaca orange” (471.83) and the lowest number of leaves plant^{-1} (35.33) was found in the interaction of 01 bulb sqm^{-1} × variety “Portulaca orange”. The LSD test suggested that the differences in number of leaves plant^{-1} of rose moss between LED bulb levels was significant ($P<0.05$) and also significant ($P<0.05$) between rest of the LED bulb treatments and varieties.

The results in regards to days to flower emergence of two rose moss varieties as affected by LED bulbs are given in Table-2. Rose moss plants grown under 01 LED bulb sqm^{-1} produced flower at late, while, the minimum days to flower emergence was noted under 04 LED bulbs sqm^{-1}. The results further showed that the days to flower emergence of rose moss variety “Portulaca orange” was greatest than variety “Portulaca peppermint”. The effect of LED bulb level 01 bulb sqm^{-1} for variety “Portulaca orange” resulted in maximum days to flower emergence (58.35); and the minimum days to flower emergence (32.48) was found under 04 LED bulbs sqm^{-1} for variety “Portulaca peppermint”. The LSD test suggested that the differences in days to flower emergence of rose moss between LED bulb levels was significant ($P<0.05$) and also significant ($P<0.05$) between rest of the LED bulb levels and varieties.

Table-2. Number of leaves plant^{-1} and Days to flower emergence of rose moss varieties under LED light intensities

Treatments	leaves plant^{-1}		Days to flower emergence	
	Portulaca orange	Portulaca peppermint	Portulaca orange	Portulaca peppermint
LB_1 = 01 bulb sqm^{-1}	35.33 f	55.00 f	58.35 a	55.63 a

LB_2= 02 bulbs sqm^{-1}	170.17 e	157.33 e	49.50 b	49.66 b
LB_3= 03 bulbs sqm^{-1}	236.67 d	362.00 c	40.38 c	38.00 c
LB_4= 04 LED bulbs sqm^{-1}	471.83 b	571.67 a	38.66 c	32.48 d
SE±	12.259		1.1002	
LSD 0.05	39.484		3.5435	
Prob.	0.0000		0.0030	

Flowers plant^{-1}

The results in regards to flowers plant^{-1} of two rose moss varieties as affected by number of LED bulbs are given in Table-3. The flowers plant^{-1} of rose moss was highest in plants under 04 LED bulbs sqm^{-1}, followed by 03 bulbs sqm^{-1}, respectively. The rose moss treated with 01 bulb sqm^{-1} produced less flowers plant^{-1}. The results further showed that the flowers plant^{-1} of rose moss variety "Portulaca peppermint" was greatest than variety "Portulaca orange". The effect of LED bulb level of 04 LED bulbs sqm^{-1} for variety "Portulaca peppermint" resulted in maximum flowers plant^{-1} (16.50) followed by "Portulaca orange" (13.33) and the lowest flower plant^{-1} (3.16) was found in the interaction of 01 bulb sqm^{-1} × variety "Portulaca orange". The LSD test suggested that the differences in flowers plant^{-1} of rose moss between LED bulb levels was significant ($P<0.05$) for varieties.

The results regarding the average flower diameter of rose moss varieties as affected by LED bulb applications are presented in Table-3. The flower diameter of rose moss was highest in plants grown under 04 LED bulbs sqm^{-1}, followed by 03 bulbs sqm^{-1}, respectively. While the minimum flower diameter was noted in plants under 01 bulb sqm^{-1}. The results further showed that the flower diameter of rose moss flower variety "Portulaca peppermint" was greater than variety "Portulaca orange". The effect of LED bulb level of 04 LED bulbs sqm^{-1} on variety "Portulaca peppermint" resulted in maximum flower diameter (4.85 cm) followed by "Portulaca orange" (3.53); and the lowest flower diameter (1.45 cm) was found in the interaction of 01 bulb sqm^{-1} with variety "Portulaca peppermint". The LSD test suggested that the differences in flower diameter of rose moss between LED bulb levels and varieties was significant ($P<0.05$).

Table-3 Flowers plant^{-1} and Flower diameter (cm) of rose moss varieties under LED light intensities

Treatments	**Flowers plant^{-1}**		**Flower diameter (cm)**	
	Portulaca orange	**Portulaca peppermint**	**Portulaca orange**	**Portulaca peppermint**
LB_1 = 01 bulb sqm^{-1}	3.16 e	4.83 e	1.60 d	1.45 d
LB_2= 02 bulbs sqm^{-1}	7.00 d	11.00 c	2.41 c	2.36 c
LB_3= 03 bulbs sqm^{-1}	10.50 c	13.50 b	1.51 d	2.46 c
LB_4= 04 LED bulbs sqm^{-1}	13.33 b	16.50 a	3.53 b	4.85 a
SE±	0.5786		0.1728	
LSD 0.05	1.8634		0.5567	
Prob.	0.0550		0.0000	

Flower weight (g)

flower weight of two rose moss varieties as affected by LED bulbs applications (Table-4) have been influenced greatly with light intensities. The flower weight of rose moss was highest (0.47 g) in plants having grown under 04 LED bulbs sqm^{-1}, followed by 03 bulbs sqm^{-1}. The rose moss treated with 01 bulb sqm^{-1} produced average flower weight of 0.12 g, respectively; while the minimum flower weight of 0.08 g was noted with 02 bulbs sqm^{-1}. The results further showed that the flower weight of rose moss flower variety “Portulaca orange” was greater (0.28 g) than variety “Portulaca orange” (0.17 g). The interactive effect of LED bulb level of 04 LED bulbs sqm^{-1} × variety “Portulaca orange” resulted in maximum flower weight (0.58 g); and the lowest flower weight (0.08 g) was found in the interaction of 01 bulb sqm^{-1} × variety “Portulaca peppermint”. The LSD test suggested that the differences in flower weight of rose moss between LED bulb levels was significant ($P<0.05$) and also significant ($P<0.05$) between rest of the LED bulb levels and varieties.

The results regarding the average days to flower persistence of rose moss varieties under LED bulbs applications are presented in Table-4. The results further showed that the days to flower persistence of rose moss variety “Portulaca peppermint” was greatest than variety “Portulaca orange”. The effect of LED bulb level of 04 LED bulbs sqm^{-1} on variety “Portulaca peppermint” resulted in maximum days to flower persistence (12.73) followed by “Portulaca orange” (9.47); and the lowest days to flower persistence (2.31) were recorded in plants grown under 01 bulb sqm^{-1} with variety “Portulaca peppermint”. The LSD test suggested that the differences in days to flower persistence of rose moss between LED bulb levels and varieties were significant (P<0.05.

Table-4 Single flower weight (g) and Days to flower persistence of rose moss varieties under LED light intensities

Treatments	Single flower weight (g)		Days to flower persistence	
	Portulaca orange	Portulaca peppermint	Portulaca orange	Portulaca peppermint
LB_1 = 01 bulb sqm^{-1}	0.08 c	0.08 c	2.53 f	2.31 f
LB_2= 02 bulbs sqm^{-1}	0.08 c	0.17 bc	3.35 ef	4.36 e
LB_3= 03 bulbs sqm^{-1}	0.17 bc	0.30 bc	5.76 d	7.13 c
LB_4= 04 LED bulbs sqm^{-1}	0.35 ab	0.58 a	9.47 b	12.73 a
SE±	0.0768		0.3677	
LSD 0.05	0.2473		1.1843	
Prob.	0.2522		0.0000	

Discussion

Light-emitting diodes emit a wide range of wavelengths, including those within the photo synthetically active waveband. Continues light cause negative effect on plants growth like chlorosis, stunted plant growth. The findings of the present research indicated that the growth of rose moss plant increased simultaneously with increasing LED bulbs. 04 LED bulbs sqm^{-1} resulted in maximum growth of rose moss. In case of varieties, “Portulaca peppermint” resulted in significantly maximum vegetative and flowering traits as compared to variety "Portulaca orange". These results are in agreement with those of [8] evaluated the growth and yield of three genotypes of commercial cultivar Pursulane Dark Green. Found that the genotype A had a prostrate growth habit, whereas the genotypes B and C had an upright growth habit.[9] revealed significant variations ($P< 0.05$) for purslane genotypes morphological traits viz., plant height, number of main branches, number of nodes, internodal distance, stem diameter, number of leaves, leaf area, number of flowers, root length, fresh and dry weight but no significant difference were observed for physiological traits *viz.* [10] grew seedlings under two light intensities (low, 125 µmol m^{-2} S^{-1} and high, 250 µmol m^{-2} S^{-1}) consisting of 10% B and 10% G light and the following percentages of R–HR: 0–80, 40–40, 80–0. Shoot fresh weight was similar in all light treatments, whereas shoot dry weight was often greater under the higher light intensity, especially under the 40–40 treatments. Leaf chlorophyll concentration under 40–40 low , 80–0 , or both was often greater than that in plants under the high light treatments, indicating that plants acclimated to the lower light intensity to better use photons available for photosynthesis. [11] reported that plants grown with 720-nm light had lower photosynthetic rates accumulated less biomass than those only grown with photons between 400 and 700 nm. The well-established paradigm is that increasing light intensity increases photosynthesis, biomass accumulation, and harvestable yield up to a 50% increased when grown under white fluorescent lamps at a PPF of 200µmol m^{-2} S^{-1} compared with 100 µmol m^{-2} S^{-1}. [12] studied meteorological parameters and compared chlorophyll contents of *Portulaca grandiflora* and *Phyla nodiflora* in coastal wild conditions during total solar eclipse on July 22, 2009. Changes in meteorological parameters such as temperature by 0.5˚C, relative humidity by 4% and light intensity around 100 lux were set to be low during eclipse day when compared to that of corresponding week. Minor changes were also observed in the wind speed and direction during solar eclipse day. [13] observed that antirrhiumn cultivars under long days produced early flowering (41.9 days) with a minimum number of leaves below the inflorescence (8.2) as compared to short days, which triggered late flowering (57.3 days) and produced the maximum number of leaves (18.2). [14] reported that both the plant dry mass (leaf, shoot, root and whole plant) and the number of the leaves responded similarly to light intensity. They were the highest at FAL and decreased as much as the plants were shaded. The decrement was 30-50% for the plants which were grown under 25% of FAL. Further, they indicated that high-light grown *S. officinalis* plants yielded greater productivity than low-light grown ones just like was shown for several other plants [15]. On the other hand, the height of *S. officinalis* plants was increased as the light intensity decreased. In particular, the plants which were grown under 25% of FAL became about 70% taller than the plants grown under full sunlight [16]. The synthesis and degradation of the photosynthetic pigments are associated with the plants adaptability to different environments. The chlorophylls are usually synthesized and photo-oxidized in the presence of light. Nonetheless, the excess of light can cause greater degradation and consequently, a reduction in the levels of total chlorophyll [16]. On the other hand, under deficit light conditions, the plants set a series of compensatory mechanisms into motion such as a substantial increment of the photosynthetic pigments. This response fulfils the function of the photosynthetic antennae absorbing the required light energy [17] considering that the highly pigmented leaves show higher light absorption efficiency per unit of leaf biomass, which may allow the plant to achieve a better carbon balance under light limitation. In environments with high solar radiation, the increase of photo-oxidation of chlorophylls depends upon the concentration of carotenoids, which can prevent chlorophylls photo-destruction [17], while in low light environments carotenoids may play a more important role in light absorption and its transfer to chlorophyll [18]. From present results, there appear to be two alternative explanations for the observed effects of light intensity. First, it is possible that leaves developed in weaker light could have lower activity of the carboxylating enzyme, carboxydismutase, than those from stronger light.

Conclusions

After going through the findings of the present research, it can be concluded that the growth of rose moss plant increased simultaneously with increasing LED bulbs. 04 LED bulbs sqm^{-1} resulted in maximum growth of rose moss; produced maximum 50.10 cm plant spread, 22.50 branches plant^{-1}, 521.75 number of leaves plant^{-1}, 35.57 days to flower emergence, 14.91 flowers plant^{-1}, 4.19 cm flower diameter, 0.47 g flower weight and 11.10 days to flower persistence. In case of varieties, “Portulaca peppermint” resulted in significantly maximum vegetative and flowering traits as compared to variety “Portulaca orange”.

References

[1] J.C. Cushman, S. Agarie, R.L. Albion, S.M. Elliot, T. Taybi, and A.M. Borland, ‘Isolation and characterization of mutants of ice plant, *Mesembryanthemum crystallinum*, deficient in crassulacean acid metabolism’, Plant Physiology, 2008, 147:228–238.

[2] D.H. Kim, M.R. Doyle, S. Sung and R.M, ‘Amasino. Vernalization: winter and the timing of flowering in plants’, Annual Review Cell Development, 2009, 25: 277-299.

[3] E.S. Runkle, and R.D. Heins, ‘Manipulating the light environment to control flowering and morphogenesis of herbaceous plants’, Acta Horticulturae, 2006, 7(11): 51–60.

[4] M.G. Blanchard, and E.S. Runkle, ‘The influence of day and night temperature fluctuations on growth and flowering of annual bedding plants and greenhouse heating cost predictions’, Hortsci, 2011, 46 (4): 599–603.

[5] H. Yu, Y. Xu, E.L. Tan and P.P. Kumar, ‘Agamous-Like 24, a dosage-dependent mediator of the flowering signals’, Proceedings Natal Academy Science, USA. 2013, 99: 16336-16341.

[6] S.D. Lokhande, K. Ogawa, A. Tanaka, and T. Hara, ‘Effect of temperature on ascorbate peroxidase activity and flowering of Arabidopsis thaliana ecotypes under different light conditions’, Journal of Plant Physiology, 2010, 160(1): 57-64.

[7] T.M. Ha, ‘A Review of plants flowering physiology: The control of floral induction by juvenility, temperature and photoperiod in annual and ornamental crops’, Asian J. Agri. and Food. Sci., 2014, 2(3):186-195.

[8] S. A. Petropoulos, A. Karkanis, E. M. Khah and C. Lykas, ‘Evaluation of growth and yield of selected common purslane genotypes (*Portulaca grandiflora* L.)’, Journal of Plant Science, 2015, 35 (4): 185-190.

[9] M. A. Alam, A. S. Juraimi, M. Y. Rafii, A. A. Hamid, F. Aslani and G. M. Mohsin, ‘A Comparison of Yield Potential and Cultivar Performance of 20 Collected Purslane (*Portulacaoleracea* L.) Accessions Employing Seeds *vs.* Stem Cuttings’, J. Agr. Sci. Technology, 2014, 16 (4) : 1633-1648.

[10] M. Heidi, E. Wollaeger and E. S. Runkle, ‘Growth responses of ornamental annual seedlings under different wavelengths of red light provided by light-emitting diodes’, Journal of Hort. Science, 2013, 48 (1): 1478-1483.

[11] S.H. Malayeri, S. Hikosaka, Y. Ishigami and E.Goto, 'Growth and photosynthetic rate of Japanese mint (Mentha arvensis) grown under controlled environment', Acta Hort, 2011, 907:73–79.

[12] K. Sambandan, , K. S. Devi, S. S. Kumar, M. Nancharaiah and N. Dhatchanamoorthy, 'Effects of solar eclipse on photosynthesis of Portulacaoleracea and Phyla nodiflora in coastal wild conditions', Journal of Plant Physiology, 2012, 4 (2): 34-40.

[13] S. R. Adams, and F.A. Langton, 'Photoperiod and plant growth: a review', J. Hort. Sci. Biotechnology, 2011, 80 (1): 2–10

[14] G. Zervoudakis, G. Salahas, G. Kaspiris, and E. Konstantopoulou, 'Influence of light intensity on growth and physiological characteristics of common sage (Salvia officinalis L.)', Brazilian Archives of Biology and Technology, 2012, *55*(1): 89-95.

[15] M.S. Mielke and B. Schaffer, 'Photosynthetic and growth responses of *Eugenia uniflora* L. seedlings to soil flooding and light intensity', Environ. Exper. Botany, 2010, 68:113-121.

[16] Y. Wang, Q. Guo, M. Jin, 'Effects of light intensity on growth and photosynthetic characteristics of *Chrysanthemum morifolium*', *Zhongguo Zhongyao Zazhi*, 2009, 34:1633-1635.

[17] G.J.F. De Carvalho, D.C. De Sousa Barreto, U.M. Jr. Dos Santos, A.V. Fernandes, P.D.T. Barbosa Sampaio, M.S. Buckeridge, 'Growth, photosynthesis and stress indicators in young rosewood plants (*Aniba rosaeodora* Ducke) under different light intensities', Braz. J. Plant Physiology, 2005, 17:325-334.

[18] L. Taiz and E. Zeiger, 'Plant Physiology' 3rd ed., Sunderland: Sinauer Associates, Inc; 2002.