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Shading Impact on Qualitative Characteristics and Chlorophyll Content of Cut Rose (*Rosa hybrida* cv. Avalanche)

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Abstract

Light intensity is considered a limiting factor in greenhouse rose production. The main aim of this experiment was to evaluate the effect of shading treatments (0, 25, 50, and 65% shading) on quality and chlorophyll content of cut rose (*Rosa hybrida* cv. Avalanche), under greenhouse conditions. The experiment was planned in randomized completely block design with four replications. All shoots were bent downwards from above the second bud after removing the young flower bud. Shading significantly affected on bud sprouting, flowering stem fresh and dry weight and flowering stem diameter, so that earliest bud sprouting, highest flowering stem, fresh and dry weight and flowering stem diameter were observed in no shading treatment. However, shading had no significant effect on flowering stem length and leaf area, but specific leaf area increased with shading percentage increment at 65% shade. Results of total chlorophyll content as well as chlorophyll a and b showed a decrement with increasing of shading percentage. In general, shading could be a cause of low-quality in cut roses; therefore greenhouse roses growers should consider greenhouse architecture to maximize light deep penetration.

Keywords: Bending, Canopy, Chlorophyll, Greenhouse roses, Marketing quality, Shading.

INTRODUCTION

Roses are, undoubtedly, one of the world's most favorite cut flowers (Dole and Wilkins, 1998). Rose growth, harvesting time, and flower quality are usually affected by light intensity (Zieslin and Mor, 1990). Light affects on the number of buds developing from the base of the plant and the remaining part of a branch after harvesting the rose flowers, also, it influences in flower development (Mass and Bakx, 1995). Although natural solar irradiance rate is ideal in Iran, the production rate of greenhouse roses is low per square meter in comparison to other countries (Hashemabadi and Zarchini, 2010). There are several reasons for the low yield; however the main reason is a lack of attention to canopy architecture related to maximizing light absorption (Matloobi, 2007). It has been shown that leaf distribution pattern within the canopy influences in plant photosynthesis by light penetration rate to the inner layers of the canopy (Baille *et al.,* 2006). Also, at present, 'heightened systems' are increasingly used by modern rose growers. In these systems, natural shade caused by a dense leaf canopy, has a low Red: Far-red ratio and is deficient in photosynthetically active radiation (PAR) due to selective filtering by photosynthetic pigments (Smith, 1982). Research on changes of photosynthesis rate and photosynthetic parameters within a rose plant canopy showed that rose leaves growing at the top of the canopy had higher rates of photosynthesis and photosynthetic traits comparing to those at the bottom of the canopy (Gonzalez-Real and Baille, 2000; Matloobi *et al.*, 2009). Therefore, it is critical for cut rose growers to optimize light interception in a plant canopy to gaining maximize yield, especially in temperate regions, where natural irradiance can be very low (Mortensen *et al.*, 1992). Moreover, there are some reports of decreasing the light intensity by shading causes reduction in flower quality in *Antirrhinum majus* (Munir *et al.*, 2004) and *Eustoma grandiflorum* (Lugassi-Ben-Hamo *et al.*, 2010). Apart from flower quality, plants tend to respond to ambient light by adjusting their chlorophyll content and composition (Walters, 2005). It has been found that leaf chlorophyll content is increased and chlorophyll a/b ratio is decreased under shade conditions (Boardman, 1977).

The arching technique is an advanced method in cut rose cultivation developed in late 1980's in Japan. In this system, bending non-productive shoots down into the canopy or towards the aisle instead of pruning, resulted in a canopy consisting of horizontally bent shoots in addition to upright shoots (Ohkawa and Suematsu, 1999; Kim and Lieth, 2004).

The main objective of the present study was to evaluate the effect of shading on qualitative characteristics and chlorophyll content of cut roses.

MATERIALS AND METHODS

Plant material

The experiment was conducted in a greenhouse at Research Station of Khalatpooshan, Faculty of Agriculture, Tabriz University, Tabriz, Iran (27°38'N, 27°46'E and 1360 m above sea level) from October to November 2011. Rooted cuttings of *Rosa hybrida* cv. 'Avalanche' were grown in 6 liter pots filled with a medium composed of 70% cocopeat and 30% perlite. The currently local growers nutrient solution was used (mM l^{-1}: NO_3^- 11.25; $H_2PO_4^-$ 1.2; SO_4^{2-} 0.5; NH_4^+ 1.25; K^+ 4.25; Ca^{2+} 2.00; Mg^{2+} 1.25). The pH and electrical conductivity (EC) of the nutrient solution was maintained between 5.5 - 6.0 and 1.5 - 2 mS cm^{-1}. When the primary shoot reached the pea size stage, bending was done above the second bud after removing the young flower bud. Shade treatments were implemented using internal shading nets fixed at a height of 1 m above plants providing 25, 50, and 65% reduction in light intensity. Full sun light was considered as control.

Evaluated traits

After flowering stems appearance, traits including days to bud sprouting after bending, flowering stem length and diameter, fresh and dry weight of flowering stem, leaf area, specific leaf area and leaf chlorophyll content were measured. Length of flowering stems was measured from the shoot base to the flower bud base before harvesting. After harvesting, flowering stems were weighed by a digital balance. To measure the dry weight of flowering shoots, the materials were put in an oven with the temperature of 80°C for 48 hr. Leaf area was measured by leaf area meter (Li-Cor, Li-1300, USA), and the leaves then dried at 80°C in order to determine specific leaf area (SLA). Chlorophyll was extracted with 80% acetone. Extracts were filtrated and chlorophyll a and b (mg/g^{-1} FW) were determined by spectrophotometry at 645 and 663 nm, respectively (Arnon, 1949). Chlorophyll content was calculated using below equation:

Chlorophyll a = (9.93 × A 663 - 0.77 × A 645) × V/W × 1000

Chlorophyll b = (17.6 × A 645 - 2.81 ×A 663) × V/W × 1000

Total chlorophyll = (7.12 × A 663 + 16.8 ×A 645) × V/W × 1000

V= solution volume, W= leaf sample fresh weight (g)

Experimental design and statistical analysis

The experiment was performed in a randomized completely block design with four replications (two plants per replication). Statistical analysis was undertaken using SPSS (version 16) and means comparisons were done by Tukey method ($P \leq 0.05$).

RESULTS

Days to bud sprouting after bending

Shading had a significant effect on days to bud sprouting, so that days to bud sprouting increased with increasing of shading percentage (Table 1). The earliest and the latest bud sprouting were related to control and 65% shade treatment, respectively (Table 2).

Length and diameter of flowering stem

Shading had a significant effect on diameter of flowering stems, but length of flowering stems was not affected significantly (Table 1). The highest (5.52 mm) and the lowest (4.22 mm) flower stem diameter were found in control and 65% shading, respectively (Table 2).

Fresh and dry weight of flowering stem

Effect of shading in this experiment was significant on fresh and dry weight of flowering stems (Table 1). On the basis, the highest and the lowest fresh and dry weight of flowering stem were obtained from control and 65% shade, respectively (Table 2). In general, shading reduced fresh and dry weight of flowering stem. Positive correlation was also observed between dry weights of flowering stem with fresh weight of flowering stem (Table 4).

Leaf area and specific leaf area

There was no significant difference among treatments in respect of leaf area (Table 1). However, the highest leaf area was observed in 25% shade treatment. In addition, shade treatments had higher

Table 1. Analysis of variance for *Rosa hybrida* to evaluate effect of shading treatment on studied traits.

		Mean squares										
Source of variation	df	bud sprouting (day)	flower shoot length (cm)	Flower shoot diameter (mm)	Fresh weight (g)	Dry weight (g)	Leaf area (cm^2)	Specific leaf area ($cm^2 g^{-1}$)	Chl. a	Chl. b	Chl. (a+b)	Chl. (a/b)
Block	3	2.04 *	1.04 ns	0.193 ns	0.044 ns	0.006 ns	4317.52 ns	188.87 **	0.0027 ns	0.0009 ns	0.0066 ns	0.008 ns
Shading	3	3.12 *	1.45 ns	2.28 **	58.67 **	6.37 **	11760.79 ns	40397.92 **	0.260 **	0.061**	0.566 **	0.072 **
Error	9	0.486	3.70	0.110	1.77	0.058	7366.81	19.73	0.011	0.0021	0.023	0.0037

*: Significant at P<0.05. **: Significant at P<0.01. ns: not significant.

Table 2. Effect of shading on bud breaking and qualitative characteristics of cut roses

Dry weight (g)	Fresh weight (g)	Flower shoot diameter (mm)	Flower shoot length (cm)	Bud sprouting (day)	Shading (%)
5.57 a	20.64 a	5.52 a	47 a	6.5 a	0 (control)
5.24 a	19.09 ab	4.91 ab	46.25 a	7.25 ab	25
4.54 ab	17.27 ab	4.77 ab	46.5 a	7.5 ab	50
3.56 b	14.29 b	4.22 b	46 a	8 b	65

Means with in each column of followed by the same letter are not significantly different

Table 2. Effect of shading on leaf area, specific leaf area and chlorophyll content of cut roses (*Rosa hybrida* cv. Avalanche).

Shading (%)	Leaf area	Specific leaf area	Chl. a	Chl. b	Chl. (a+b)	Chl. a/b
Shading (%)	(cm^2)	(cm^2 g^{-1})	(mg g^{-1} fresh weight)			
0 (control)	335.23 a	123.53 b	1.29 a	0.55 a	1.84 a	2.35 c
25	418.83 a	125.63 b	1.01 b	0.42 b	1.43 b	2.41 bc
50	413.51 a	156.81 b	0.96 b	0.37 b	1.34 b	2.52 ab
65	391.25 a	220.87 a	0.67 c	0.25 c	0.93 c	2.66 a

Different letters with in a column indicate significant difference according to Tukey's test ($P<0.05$).

leaf area than control plants (Table 3). In case of specific leaf area, significant difference was observed between 65% shade and other treatments. The highest (220.87 cm^2 g^{-1}) and lowest (123.53 cm^2 g^{-1}) specific leaf area were shown in 65% shade plants and control treatment, respectively.

Chlorophyll content

Shading significantly decreased total chlorophyll as well as chlorophyll a and b (Table 1). Plants exposed to full light showed higher total chlorophyll than the shaded plants. Obtained results revealed that severe shading increased chlorophyll a/b ratio. Moreover, total chlorophyll as well as chlorophyll a and b were decreased with increasing of shading percentage (Table 3).

DISCUSSION

Light is a critical factor in bud sprouting and it is reported that high R: FR ratio promoted bud sprouting, but a low R: FR ratio showed a contrary effect (Zieslin and Mor, 1990). It has been found that in shade conditions, the fraction of blue light was increased but red light beam decreased (Li *et al.*, 2010). Therefore, increase in number of days to bud sprouting in shade conditions can be related to decrease in red light (Zieslin and Mor, 1990).

Length and diameter of flowering stem are factors involving in economic value of cut- roses (Kim and Lieth, 2004; Steinmetz *et al.,* 1994). In this research, although shading exhibited no effect on length of flower stems, but flowering stem diameter was affected significantly. In our experiment, positive significant correlation was observed between dry or fresh weight of flowering stem and diameter of flower stem; Thus, it could be concluded that the increase in diameter of flowering stems in control plants resulted from more assimilate production in full ambient light.

Shading significantly affected both fresh and dry weight of flowering stem, so the lowest fresh and dry weight of flowering stem were observed in the highest shade intensity. Similarly, decrease in cut stem weight for plants grown under a lower light integral has been reported in lisianthus (Islam *et al*., 2005). Fresh and dry weight decline of flowering stem seems to be attributed to low carbohydrate generation in shade condition due to reduced photosynthesis.

Lambers *et al.* (2008) believed that plants grown in a shade environment had higher leaf

Table 4. Correlation coefficients of the measured traits within different shading treatments.

Property	Flower stem length	Flower stem diameter	Fresh weight	Dry weight	Leaf area	Specific leaf area
Flower stem length	1					
Flower stem diameter	0.285	1				
Fresh weight	0.214	0.696**	1			
Dry weight	0.196	0.719**	0.979**	1		
Leaf area	0.575*	.000	0.308	0.297	1	
Specific leaf area	0.269	0.771**	0.648**	0.705**	0.028	1

**: In each row or column, indicates significant correlation between variable at the 1% level

area and specific leaf area that is in agreement with our results. Although leaf area in shaded plants was higher than the control, it was not significant. As rose needs high light intensity, it seems that shade causes decrease in photosynthesis; consequently, invested relatively less of the photosynthesis products in leaf area. Moreover, with increasing intensity of shading, specific leaf area increased. In agreement with our experiment, decreasing the light intensity by shading has been reported to cause increase in specific leaf area in *Achillea millefolium* (Bourdot *et al.*, 1984).

Results obtained on chlorophyll a and b contents as well as chlorophyll a/b ratio are inconsistent with more reports, but are in agreement with the finding of Matloobi *et al.* (2009) on *Rosa hybrida* cv. Habari, who indicated that leaves growing at the top of the canopy which received higher light, tended to have more chlorophyll a and b as well as total chlorophyll in comparison with lower parts. Since, shade leaves have lower N concentrations per leaf area unit than those exposed to the high light (Lambers *et al*., 2008), it seems that under N limitations, plants may respond by reducing levels of all chloroplast components (Walters, 2005).

CONCLUSION

Shading could be a cause of low-quality in cut roses. In shade conditions, very low carbohydrate content reserves throughout the plant growth; consequently, natural shade following from a dense leaf canopy should be minimized in rose production.

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