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Effects of Shading on Growth, Flowering and Cut Flower Quality in Carnation (*Dianthus caryohyllus*)

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ABSTRACT

Carnation is widely cultivated on commercial scale in different parts of the world. It is mainly used as a bedding plant and for cut flower production due to high international market value. The aim of this investigation was to determine the influence of shading on growth, yield and quality of carnation cut flowers. There were five treatments i.e., 0 (no shading/control), 20, 40, 60 and 70% shading. The highest plants were obtained from carnations provided with 70% shading, while the lowest from control plants. The highest number of leaves per plant, leaf area and number of lateral shoots per plant were observed in plants provided with 20% shading. Control plants had the highest number of cut flowers (28.0) and the lowest (13.0) in carnations provided with 70% shading. Increased shading significantly reduced the number of cut flowers per plant, while it increased the stem length. The highest flower diameter (4.5 cm) and cut flower stem fresh mass (3.8 g) were obtained from carnations provided with 20% shading. In most of the parameters determined, the provision of 20% shading gave the best results. Thus to obtain better carnation vegetative growth, flowering and flower quality, 20% shading using black nets may be used.

Key Words: Carnation; Cut flower growth attributes; Shading

INTRODUCTION

Carnation (*Dianthus caryophyllus* L.) belongs to the Caryophyllaceae Family. Some carnation varieties are annual, biennial or perennial. They are used as bedding plants and for cut flower production (Biondo & Noland, 2000; Dole & Wilkins, 2005). Due to their long lasting cut flowers (vase-life of 2-3 weeks), wide range of forms and ability to withstand long distance transportation, carnations are very popularly used in boutonnieres, corsages, bouquets and wide range of floral arrangements (Biondo & Noland, 2000; Dole & Wilkins, 2005; El-Naggar, 2009). They are very popularly favoured on special occasions, especially Mother's Day and weddings. Carnation cut flowers are used to express love, admiration, good luck, fascination and distinction (Anonymous, 1989). The modern carnation cultivars offer diversity of colors, shapes and sizes not available in other flowering plants. They are cultivated on large scale in the Mediterranean region. However, it can be produced all over the world in greenhouses (El-Naggar, 2009).

Flower initiation in carnation occurs when the plant have 18 pair of leaves (Larson, 1992). It flowers usually in summer under long days. Flower bud development is enhanced by high light intensity. There is an interaction between amount of ambient light and number of long-days for flower initiation (Bunt & Powell, 1983). Twenty to 30 long-days are required under low light and seven to 14 days under high light intensities. A good supply of light is required for high quality flower formation. Extremely high light intensity, which exceeds photosynthetic capability of the plants results in photo-inhibition, pale foliage and flowers, whilst it is also possible that plants will become burnt (Anthura, 2010a; Stancato *et al*., 2010). This can be overcome by shading. For cultivation of cut anthurium cut flowers in the tropical countries, a screening net offering about 75% shading is required. The use of plastic screens is recommended, when plants are grown in regions with a great deal of rain, since this will result in a drier crop and a reduced incidence of diseases (Anthura, 2010a & b). Temperature is directly associated with light. The optimum temperature for good growth of carnations is 10^{o}C for night temperature and 13-15^{o}C day temperature (Sparnaaiji & Demmink, 1983).

The more sunlight a plant receives the better capacity it has to produce food through photosynthesis (Birk, 2010; Van de Hoeven, 1987). As sunlight quantity decreases, the photosynthetic process decreases. Light intensity can be decreased in a garden or greenhouse by using shade cloth or shading paint over the plants. It can be increased by surrounding the plants with white or reflective materials e.g., mulch or supplemental lights (Van de Hoeven, 1987).

Light intensity determines the rate of floral induction in carnations (Biondo & Noland, 2000; Dole & Wilkins, 2005). When light levels are low, floral induction is slow and more leaves are produced and vice versa. However the rate of floral development is not influenced by irradiance (Bunt *et al*., 1981). Low irradiance is responsible for weak stems and consequently, poor quality or low grade cut flowers, regardless of flower diameter (Mastalerz, 1983; Birk, 2010). High light intensity increases flower size, number of petals and stem diameter. High plant densities or low light intensity reduce the number of flowering shoots, flower quality, fresh and dry mass (Mastalerz, 1983). Supplemental lighting during low light periods can increase growth and development and enhance flowering (Anthura, 2010b).

In order to grow cut flowers over wide range of seasons round the year, it becomes readily apparent that crop management and growth techniques must be periodically modified if maximum yields are to be obtained despite the differing climatic factors like light and temperature (Cermeno *et al*., 2001). During summer when levels of solar radiation are high, the use of shading meshes reduces the incidental radiation on the crop. This reduction helps cool the greenhouse and protect the plants from excessive temperature and light (Mascarini *et al*., 2001). In Mediterranean conditions, excess radiation and heat are the main problems to the production of *Cyclamen* among other ornamental plants in summer. It is therefore, cultivated under shading nets (Villegas *et al*., 2006). Jeong *et al*. (2007) reported that, during summer, the quality of some begonia species and inter-specific hybrids tend to deteriorate due to high light intensity in the greenhouses.

To compete in the international markets, cut flower growers must produce high quality produce. Carnations are grown in those parts of the world also, where light intensity and heat are higher than the optimal required for quality cut flower production especially in summer. The objective of this investigation, therefore was to determine the optimal shading level for the production of highest yields and quality of carnations under Swaziland environmental conditions.

MATERIALS AND METHODS

Experimental site: The investigations were carried out in lath houses constructed using wooden posts and planks in the Horticulture Department, Faculty of Agriculture, Luyengo Campus, at the University of Swaziland. The site is located at Luyengo, Manzini Region in the Middleveld agro-ecological zone. Luyengo is 26^{o} 34’ S and 31^{o} 12’ E. Swaziland is in the sub-tropics. The average altitude of this area is 750 m above sea level. The mean annual precipitation is 980 mm with most rainfall between October and April. The average summer temperature is about 27^{o}C and winter temperature is about 15^{o}C (FAO, 2006a &b).

Experimental design: The experiments were laid out in a randomised complete block design (RCBD). The five treatments used included 0 (no shading/control), 20, 40, 60 and 70% shading provided by black nets. The treatments were replicated four times and each replication consisted of 20 carnations planted in six-litre-plastic bags. Five-week-old carnation seedlings were used. The bags were filled with growing medium, which consisted of a mixture of garden soil, compost and sand at the ratio of 1:1:1 (v/v). They were placed in different lath houses, constructed using wooden posts and planks. Each lath house was 3 m long, 3 m wide and 1.5 m high. Each lath house, except for the control, was covered with different density black shading net according to the objectives of the experiment. The pots were irrigated, when necessary, until water started dripping from the bottom holes.

Data collection and analysis: Data were collected at 2, 4, 6 and 8 weeks after transplanting (WAT). Five randomly selected carnation plants were used in each replication and treatment for data collection. Data collected included: plant height, number of leaves, leaf area, number of nodes, number of lateral shoots, number of cut flowers per plant, cut flower stem length, flower diameter and cut flower fresh mass. Collected data were subjected to analysis of variance (ANOVA) using M Stat-C statistical package and Duncan’s New Multiple Range Test (DNMRT) was used to separate means that were significant.

RESULTS AND DISCUSSION

Plant height: Plant height was significantly ($P < 0.05$) higher in carnation plants grown at 70% shading when compared to those grown at 0, 20, 40 and 60% shading at 4, 6 and 8 WAT (Table I). At 8 WAT, plants grown under no shading (control) had the lowest plant height (27.8 cm) among all the treatment, while the highest plant height (37.6 cm) was recorded among carnations provided with 70% shading (Table I). From 4 to 8 WAT, an increase in shading level resulted in a corresponding increase in plant height. However there was no significant ($P < 0.05$) difference in plant height in plants provided with 0, 20, 40 and 60% shading. Shading reduced plant height in *Cyclamen* (Villegas *et al*., 2006). Cermeno *et al*. (2001) reported that, a moderate reduction of radiation increased stem length in chrysanthemums. Increase in growth characteristics of sweet pepper grown under black net screen house was attributed to better microclimate in terms of reduction in temperature, relative humidity, wind speed and light intensity (Medany *et al*., 2009). A high plant height observed in carnation plants under shading in this investigation could also be attributed to improved microclimate. Germana *et al*. (2001) attributed increased vegetative growth in citrus under shading to increased amount of far red as compared to red lights.

Number of leaves per plant: There was no significant ($P < 0.05$) difference in the number of leaves per plant between carnation plants grown under the different shading levels.

Table I: Effect of different shading levels on plant height of carnation plants

Shading level (%)	WAT/plant height (cm)			
	2	4	6	8
0	5.3a	7.4b	15.7b	27.8b
20	8.0a	9.4b	18.4b	31.4b
40	7.9a	9.6b	18.8b	31.6b
60	6.9a	10.4b	20.3b	32.6b
70	7.7a	13.0a	23.6a	37.6a

Table II: Effect of different shading levels on number of leaves per plant in carnation

Shading level (%)	WAT/number of leaves per plant			
	2	4	6	8
0	8.3a	14.8a	35.0a	133.5a
20	9.0a	16.5a	41.5a	146.5a
40	8.5a	16.0a	39.8a	134.5a
60	8.0a	14.8a	30.5a	127.8a
70	6.5a	13.5a	25.3a	121.3a

Table III: Effect of different shading levels on leaf area of carnation plants

Shading level (%)	WAT/leaf area (cm^2)			
	2	4	6	8
0	3.1a	4.6a	5.3a	5.4a
20	3.5a	4.8a	5.4a	5.7a
40	3.0a	4.5a	4.8a	4.8a
60	2.6a	4.3a	4.6a	4.6a
70	2.5a	4.1a	4.4a	4.5a

Table IV: Effect of different shading levels on the number of lateral shoots per plant in carnation

Shading level (%)	WAT/number of lateral shoots per plant			
	2	4	6	8
0	1.0c	6.2a	8.3a	14.0a
20	2.5a	7.0a	9.5a	15.3a
40	1.8b	5.2b	6.5b	11.8b
60	2.0b	4.0b	7.5b	10.5b
70	2.0b	2.9c	6.0b	8.3b

Means followed by same letter along columns not significantly different, Mean separation by DNMRT at $P \leq 0.05$

Plants grown at 20% shading gave the highest number of leaves per plant, while those grown at 70% shading had the lowest number of leaves (Table II). The highest number of leaves (146.5) was obtained from plants provided with 20% shading at 8 WAT and the lowest number of leaves (121.3) was obtained from plants grown at 70% shading. A similar reduction in number of leaves with increased shading was reported in sweet pepper (Medany *et al*., 2009), weeping fig (*Ficus benjamina* L.) and croton (*Codiaeum variegatum* L.) (Scuderi *et al*., 2008). In addition, no significant reduction in number of leaves in *Cyclamen* (Villegas *et al*., 2006) and chrysanthemums (Cermeno *et al*., 2001) was also observed under different shading levels.

Leaf area: There was no significant ($P < 0.05$) difference in leaf area of carnation plants grown at all the five different shading levels (Table III). In general, plants grown at 20% shading had the highest leaf area, while those shaded at 70% had the lowest leaf area. At 8 WAT, the highest leaf area (5.7 cm^2) was recorded in plants provided with 20% shading, while the lowest (4.5 cm^2) in plants provided with 70% shading. Jeong *et al*. (2007) reported an increase in leaf area of begonia with increased shade levels. Leaf area in sweet pepper (Medany *et al*., 2009), weeping fig (*Ficus benjamina* L.) and croton (*Codiaeum variegatum* L.) (Scuderi *et al*. 2008) was found to decrease with increased shading level. Similarly in this investigation, each increase in shading level above 20% resulted in a corresponding decrease in leaf area of carnation.

Table V: Effect of different shading levels on the number of nodes in carnation

Shading level (%)	WAT/plant height (cm)			
	2	4	6	8
0	2.0b	5.5b	8.0b	11.3b
20	3.5a	6.0b	9.0b	11.8b
40	3.0a	6.0b	9.0b	13.3b
60	3.5a	7.8a	10.0a	14.3a
70	3.6a	7.5a	11.1a	15.3a

Table VI: Effect of different shading levels on number of cut flowers, cut flower stem length, flower diameter, and cut flower fresh mass in carnation

Shading level (%)	Parameter/mean value			
	No. of cut flowers	Cut flower stem length (cm)	Flower diameter (cm)	Cut flower stem mass (g)
0	28.0a	10.3e	4.2b	3.7a
20	23.8b	12.1d	4.5a	3.8a
40	19.8c	12.5c	4.1b	3.4b
60	15.3d	13.7b	4.0b	3.0c
70	13.0d	14.9a	3.7c	2.3d

Means followed by same letter along columns not significantly different mean separation by DNMRT at $P \leq 0.05$

Number of lateral shoots: At 4, 6 and 8 WAT, carnations provided with 0 and 20% shading had significantly ($P < 0.05$) higher number of lateral stems when compared to those shaded at 40, 60 and 70% level (Table IV). There was no significant ($P < 0.05$) difference in the number of lateral shoots per plant in carnations grown at 0 and 20 shading at 4, 6 and 8 WAT. Carnations at 70% shading had the lowest number of lateral shoots, while those grown at 20% shading showed the highest number of lateral shoots per plant at 4, 6 and 8 WAT. At 8 WAT, the number of lateral shoots in plant provided with 20% shading was almost double that of plants provided with 70% shading. The high number of lateral shoots per plant in carnations provided with 20% shading could probably be attributed to improved light, temperature and relative humidity conditions, which increased photosynthesis and consequently sugars, which stimulated more lateral bud sprouting. Increasing shading to 70% probably reduced light to below optimal level for photosynthesis, hence the reduction in lateral shoot formation.

Number of nodes: High number of nodes was obtained in plants provided with 70% shading as compared to all the other shading levels (Table V). However there was no significant ($P < 0.05$) difference in the number of nodes of carnation plants grown at 60 and 70% shading. Similarly there was no significant ($P < 0.05$) difference in the number of nodes in plants grown at 0, 20 and 40% shading at 4, 6 and 8 WAT. Plants that were not shaded had the lowest number of nodes. Germana *et al*. (2001) reported that shading increased the amount of far red as compared to red lights. The reduction in the number of nodes in carnation plants in this investigation could probably be due to inhibition of node formation by the high amount of far red lights.

Number of cut flowers: The highest yield in terms of cut flower stems (28.0), was obtained from carnations grown without shading, while the lowest (13.0) was obtained from plants shaded at 70% (Table VI). Increasing the shading intensity resulted in a significant ($P < 0.05$) decrease in yield of cut flowers. The yield of cut flowers at 0% shading was more than double that of plants provided with 70% shading. A reduction in number of inflorescence produced in begonia (Jeong *et al*., 2007) and chrysanthemum (Cermeno *et al*., 2001) as a result of increased shading intensities has been observed. However Villegas *et al*. (2006) reported no significant difference in the number of flowers in *Cyclamen* under shading.

Cut flower stem length: Each increase in shading intensity resulted in a significant ($P < 0.05$) increase in cut flower stem length of the carnation plants (Table VI). The highest cut flower stem length (14.9 cm) was obtained from plants provided with 70% shading, while the lowest (10.3 cm) was obtained from the control plants. Shading carnation plants at 70% level resulted in almost 50% increase in the length of cut flowers when compared to the control plants. The increased length of carnation cut flowers at higher shading levels could probably be attributed to etiolation.

Flower diameter: Shading the carnation plants at 20% resulted in significantly ($P < 0.05$) higher flower diameter when compared to all the other shading levels (Table VI). The highest flower diameter (4.5 cm) was obtained from plants provided with 20% shading, while the lowest (3.7 cm) was obtained from those provided with 70% shading. The high flower diameter observed at 20% shading could probably be due to improved light and temperature environment of the carnation plants.

Cut flower fresh mass: There was no significant ($P < 0.05$) difference in carnation cut flower fresh mass provided with 0 and 20% shading (Table VI). Increasing shading from 20 to 70% resulted in significant ($P < 0.05$) decrease in cut flower fresh mass. The highest cut flower fresh mass (3.8 g) was obtained in plants provided with 20% shading, while the lowest (2.3 g) from those provided with 70% shading. Provision of more than 20% shading appeared to significantly reduce cut flower stem fresh mass in this investigation. Similar observations were reported in weeping fig (*Ficus benjamina* L.) and croton (*Codiaeum variegatum* L.) (Scuderi *et al*. 2008).

CONCLUSION

Increase in shading level resulted in increased plant height in carnations. Relatively light shading of 20% gave the best vegetative growth of carnations in terms of number of leaves per plant, leaf area and lateral shoot formation. Similarly, the highest quality of cut flowers in terms of flower diameter and cut flower stem mass were obtained from carnations provided with 20% shading. Increased shading reduced number of cut flowers per plant, whilst increasing stem length. Increased shading level above 20% significantly reduced cut flower quality in terms of diameter and fresh mass. Production of carnations should, therefore be undertaken at 20% shading to obtain the best growth and quality of the cut flowers.

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