Indian Journal of Agricultural Sciences **85** (7): 931–5, July 2015/Article
https://doi.org/10.56093/ijas.v85i7.50125

Effect of shade levels on production and quality of cordyline (*Cordyline terminalis*)

ABHAY KUMAR GAURAV[1], D V S RAJU[2], T JANAKIRAM[3], BHUPINDER SINGH[4], RITU JAIN[5] and S GOPALA KRISHNAN[6]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received: 6 November 2014; Accepted: 27 January 2015

ABSTRACT

An investigation was carried out during 2013-14 to study the effect of different shade levels on the production and quality of cordyline (*Cordyline terminalis* Kunth.) under the subtropical condition of New Delhi, India. The effect of spectral control of light on physiology and vegetative development was evaluated at different crop growth stages. Shade nets did not only protect plants from high light intensities but also improved the vegetative growth, yield, vase life and quality of cordyline cut greens irrespective of shade level. Different shade levels modified microclimates, PAR, transmittance and canopy temperature. The shading improved plant characters like height, number of leaves, chlorophyll content, leaf area, fresh weight, harvest index and vase life. The plants grown under different shade levels showed improved photosynthetic activity and reduced transpiration rate. Plants grown under 50% shade level were taller, along with more number of leaves having longer petiole, chlorophyll content which can be attributed to higher photosynthetic rate, whereas harvest index and vase life was optimum. Overall, shade net with 50% shading was found best for commercial production of cordyline cut greens.

Key words: Cordyline PAR, Photosynthetic activity, Shade net, Specific leaf area (SLA), Leaf area, Transmittance

Cut greens are an important component of the floricultural industry, largely used in decoration as a-filler in floral compositions. They provide freshness, colour and variety to arrangements and bouquets. Cordyline (*Cordyline terminalis* Kunth.) is an important cut green in the world trade and used worldwide for its beautiful foliage.

Each plant has its individual requirement for sunlight and shade under which it flourishes at its best. To create optimum climatic conditions, selection of the correct percentage of shade level is a crucial factor to enhance plant's productivity to its highest. Shade net has been found to improve vegetative growth, yield, vase life and quality (Stamps 1997) of cut foliage. Shade nets are often deployed over crops to reduce heat stress (Elad *et al*. 2007). Diffuse light has been shown to increase radiation use efficiency, yields (both at the plant and ecosystem level), and even be a factor affecting plant flowering timing and amounts. Shade nets can scatter radiation, especially ultraviolet because nets are usually made using ultraviolet-resistant plastic (Wong 1994). Shade nets that increases light scattering but do not affect the light spectrum. Keeping these facts in view the present experiment was undertaken.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm of the Division of Floriculture and Landscaping, IARI, New Delhi during 2013-14 with *Cordyline terminalis*. The planting was done during September 2013 under green coloured shade net with four different shade levels (35%, 50%, 75% and 90%). The micro-environment and production under these shade levels were compared with the open field micro-environment and production (without shade nets).

Weather parameters like temperature, and relative humidity were measured under different shade levels along with control (without shade nets) by pocket weather tracker. Light measurements was carried out periodically during the growth stages under the nets, to monitor the actual light conditions to which the plants were exposed. All measurements were done on clear days at noon. The light intensity was measured by the digital light meter (Extech

It is part of research work carried out for M Sc Thesis submitted in 2014 to IARI, New Delhi.

[1] Ph D Scholar (e mail: gabhaykumar@gmail.com), [2] Senior Scientist, (e mail: rajivalex@ gmail.com), Division of Floriculture and Landscaping; [3] ADG, Horti (e mail: tolety07@gmail.com), KAB-II, New Delhi 110 012; [4] Principal Scientist, (e mail: bsingh@iari.res.in), NRL, [5] Scientist (e mail: ritu.uhf@gmail.com), Division of Floriculture and Landscaping, [6] Senior Scientist (e mail: gopal_icar@yahoo.co.in), Division of Genetics

Instruments, 401025). Transmitted photosynthetically active radiation (PAR) as well as intercepted radiation by plant under each treatment was measured by the Line Quantum Sensor (LICOR 3000), whereas transmittance inside the net was calculated as the ratio of the PAR radiation spectra under a net and outdoor. Canopy temperature was measured using infrared thermometer.

Different plant characteristics like plant height (cm) was taken up to the center of growing young leaves for cordyline, petiole length (cm) of 4th mature was taken, and length of 3rd inter-node was measured using standard scale during different growth stages. Number of matured leaves was also counted during stages. Leaf readings to determine chlorophyll content were taken with a Minolta chlorophyll meter (model SPAD 502) by averaging the 10-15 reading per plant. The photosynthesis/CO_2 uptake rate (µmol CO_2/m^2/s), transpiration (µmol H_2O/m^2/s), stomatal conductance (µmol/m^2/s), PS2 efficiency and total light intensity (µmol/m^2s/) were taken by Licor-6400 Leaf Gas Exchange instrument, i.e. Infra-red gas analyzer (IRGA) during different growth stages (Long *et al.* 1996). The leaf area was measured using Leaf area meter (Licor-3100) while fresh weight was also taken using same leaves. The SLA was computed using the fresh weight and leaf area. HI was calculated as percentage yield of economic yield to the biological yield whereas vase life was estimated by placing the petiole of mature leaves in a test tube containing distilled water. The trial was laid out in Randomized Block Design (RBD) and the data were analyzed accordingly.

RESULTS AND DISCUSSION

Most of the cut greens are tropical plants with a requirement for shade when grown under areas differing in climatic conditions from their place of origin. Shade nets are often used in the summer to protect plants from high light intensities (Nelson 2003). High light intensity can damage the chloroplasts, and cause leaf and petal burn. The light intensity under different shade levels was lower than control. The reduction in light intensity was 51.24%, 40.90%, 22.06% and 12.17% as compared to control for shade nets with shading intensity of 35%, 50%, 75% and 90% respectively.

Temperature varied under nets with different shade levels, and it played a significant role in modifying microclimate under nets. Temperature was found to be higher under control as compared to different shade levels in net. Temperature reduction was directly proportional to shade level with highest in 90%. In the present study under shade net, there was a reduction in temperature in summer months to the tune of 3-6ºC and in winter months it was higher compare to control (Fig 1). Relative humidity was higher under net house even though temperature was low. RH was highest under 90% shade (17%), followed by 75% shade (12%), 50% shade (10%) and 35% shade (9%) compared to control (Fig 2). The relative humidity (RH) increased with increase in shade levels whereas; the light intensity decreased with increase in shade levels. Lugassil-

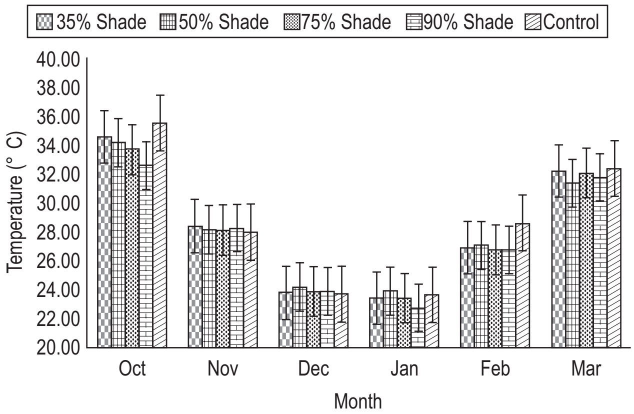

Fig 1 Air temperature under different shade levels during different months after planting

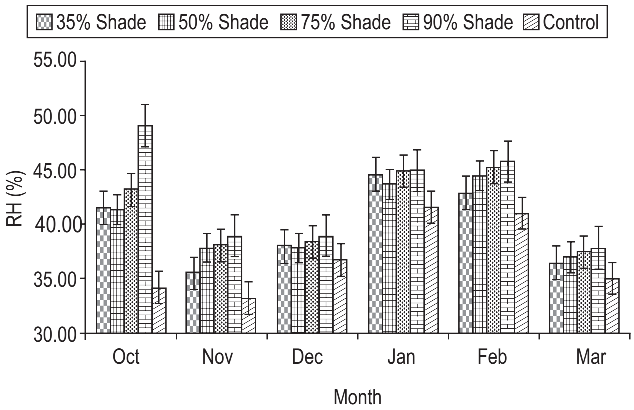

Fig 2 Relative humidity under different shade levels during different months after planting

Ben-Hamo *et al*. (2010), reported similar reduction of 5.7±2.5 ºC with 67-85% shading. Smith *et al.* (1984) observed that under shade nets the air temperature was lower than that of the ambient air. The reduced air temp was mainly due to reduced solar radiation and lower light intensity under shade nets. There was direct relation between air temperature and light intensity. Relative humidity (RH) is often higher under shade nets than outside as water vapor being transpired by the crop and reduced mixing with drier air outside the netted area (Elad *et al*. 2007). Netting also reduces wind speed and wind run (Stamps 1994) which can affect temp, RH and gas concentration resulting from reduction in air mixing.

Shade cloth has the potential to change light intensity, the proportion of diffuse radiation and light quality compared to full sun, depending on the density/shade factor (Yates 1989). The photosynthetically active radiation (PAR) and transmittance under shade net was found to be lower and it decreased with increasing shade levels. The range was from 573.00-698.00, 482.60-572.90, 175.26-246.20, and 103.57-152.74 micro mol/m^2/s for 35%, 50%, 75% and 90% shade nets respectively, while in control it was 1233.90-1452.30 micro mol/m^2/s (Fig 3), while the maximum transmittance was observed under 35% shade (46.44-48.17%) while it was lowest under 90% shade (8.39-10.8%)

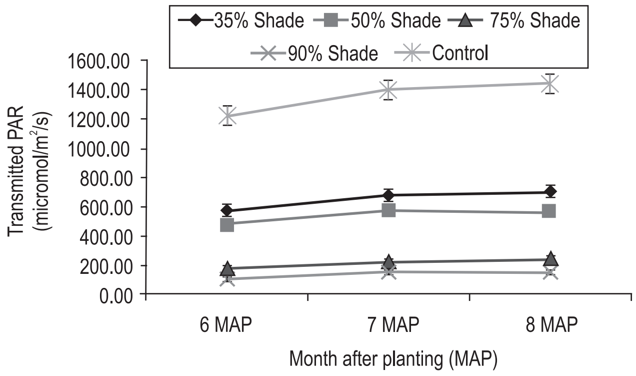

Fig 3 Transmitted PAR under different shade levels during different months after planting

compared to control (Fig 4). Radiation intercepted by canopy under shade net with different shading levels was found to be lower as compared to the control. PAR levels were reduced under shade nets of different shade levels (Middleton and Mc Waters 2002). Plastic nets alter the spectrum of the filtered light and enrich the content of scattered light (Oren-Shamir *et al*. 2001). The lower transmittance level was because of light being filtered and scattered.

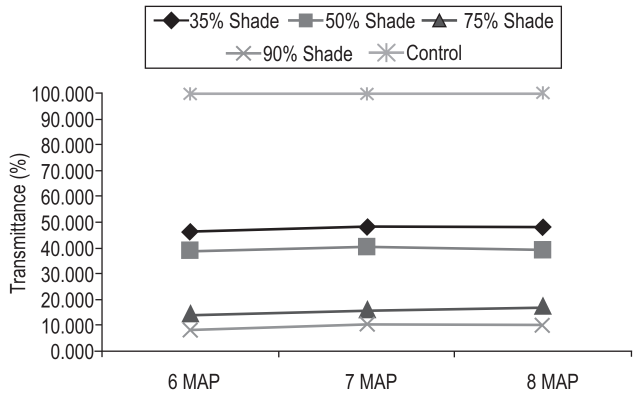

Fig 4 Transmittance under different shade levels during different months after planting

Canopy temperature measured under different shade levels was lower compared to control. It decreased with increase in shade intensity. Plant grown under higher shade had lower canopy temperature. It was lower by 4.73-6.50°C under 35% shade, 5.43-6.08°C under 50% shade, 7.15-9.60°C under 75% and by 6.00-6.40°C under 90% shade when compared to control. Over-all minimum canopy temp was found in 75% shade. Cordyline had lower canopy temperature because of higher transpiration rates. Smith *et al*. (1984) also observed that, under shade nets, canopy temperatures were lower than those of control, depending on the intensity of shading.

The light intensity has its effect on photosynthesis. The photosynthetic activity of the cordyline leaves was significantly higher by 68.17% under 50% shade over control. The stomatal conductance was found to be higher under open condition. The efficiency of Photosystem 2 is directly related with CO_2 absorbance. It was observed that the efficiency of PS2 decreases with increase in shade levels and it was observed maximum under open condition for both species followed by 35% shade, 50% shade, 75% shade and 90% shade. The leaves of cordyline showed significant differences in transpiration rate. The rate of transpiration was found to be inversely proportional to shade level with maximum in control and minimum in 90% shade (Table 2). Transpiration rate is directly dependent on temp, light, RH and transmittance. Accordingly the rates were lower under shade nets compared to open conditions.

Plants grown under different shade levels had different growth. The plant height of cordyline was found to be significantly higher under 75% shade (36.26 cm) and it was on par with 50% and 90% shade. The lowest plant height was observed in control (29.17 cm) (Fig 5). The number of leaves was found to be highest in plants grown in 50% shade (Fig 6). The leaf petiole length was found to be maximum under 90% shade followed by 50% shade while the inter-node length was found to be longer by 43.80 % under 50% shade compared to control. 50% shade levels recorded higher plant height, number of leaves and petiole length. The superior performance at this level was because of higher leaf chlorophyll content and photosynthetic rate. Similar observations were made by Stamps (1997) in

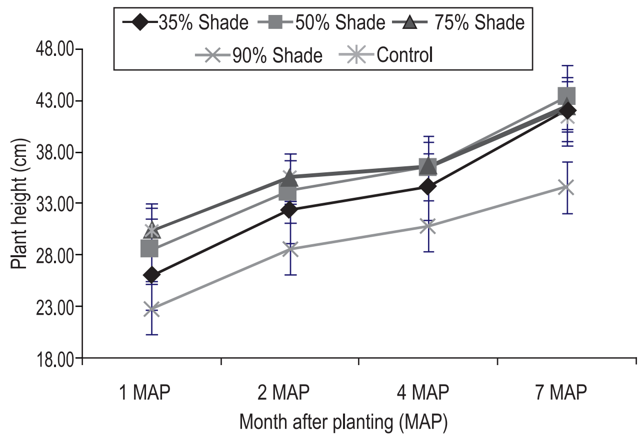

Fig 5 Influence of shade levels on plant height during different months after planting

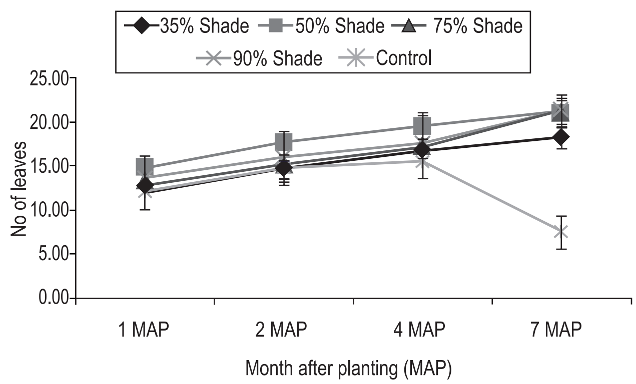

Fig 6 Influence of shade levels on number of leaves during different months after planting

Table 1 The influence of shade levels on the harvest index of cordyline

Treatment	Harvest index (%)
35% Shade	47.42
50% Shade	46.23
75 % Shade	45.55
90% Shade	45.87
Control	41.12

Aspidistra, Ophiopogon and *Ruscus.* For all the three crops, the stem length and leaf weight peaked in 50-80% range and declined at higher shade levels. Hlatshwayo and Wahome (2010) made similar observation that plants grown under open condition (control) had the lowest plant. This was also supported by the study of Bibi *et al*, (2012) who observed taller tomato plants when grown under partial shade.

The SPAD meter was used to determine the relative amount of chlorophyll present by measuring the absorbance of the leaf in two wavelength regions (650 and 940). Increasing SPAD values indicate higher concentrations of Chlorophyll per leaf unit area. The SPAD reading was found to be higher under 50% shade as well as under 90% shade, the value recorded was 47.81 which were higher by 43% to control (Fig 7). In agreement with the present studies, Devkota and Jha (2010) reported longer petiole length and internode length at 50-70% shade level in *Centella asiatica* and increase in leaf chlorophyll upto 70% level. Lykas *et al*. (2012) also reported use of shading nets to favour chlorophyll production in Compact Gardenia (*Gardenia jasminoides* Ellis) Potted Plant.

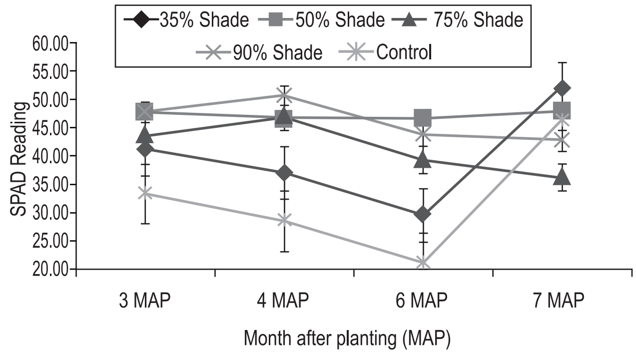

Fig 7 Influence of shade levels on SPAD reading at different months after planting

The leaf area was found to be lowest in control, followed by 35% shade, 50% shade, 90% shade and it was highest under 75% shade. The percentage increase in leaf area was nearly 90% under 75% shade as compared to control. The SLA (Specific leaf area) was found to be increasing with increase in shade levels as it was highest under 90% shade followed by under 75% shade, 50% shade, 35% shade and control. Fresh leaf weight in cordyline was found to be highest under 75% shade followed by 50% shade. The dry leaf weight which denotes the solid matter present in the leaf was also follows the similar trend (Table 2). Similarly Marenco and Reis (1998), reported better leaf area at 50% shade in wrinkled grass. This was because of greater Relative growth rate in shaded plants. But, it was in contrast to study by Zhao *et al*. (2012) who observed the reduction in plant height and number of leaves in

Table 2 The influence of shade level on plant height, number of leaves, petiole length, internode length, chlorophyll content (SPAD), canopy temperature, leaf area, leaf weight, specific leaf area (SLA), gas exchange characteristics and vase life of cordyline

Treatment	Plant height (cm)	Number of leaves (no)	Petiole length (cm)	Internode length (cm)	SPAD reading	Canopy temperature (°C)	Leaf area (cm^2)
35% shade	33.75±1.01	15.50±0.29	8.99±0.16	1.51±0.08	41.39±0.55	28.29±0.07	1 245.83±91.79
50% shade	35.63±1.71	18.27±0.50	9.26±0.10	1.96±0.13	47.81±0.44	27.42±0.07	1 441.83±57.09
75% shade	36.26±1.22	16.69±0.20	9.14±0.39	1.55±0.08	43.75±0.77	25.93±0.07	1 690.90±167.91
90% shade	35.93±0.78	17.12±0.18	9.43±0.06	1.57±0.07	47.81±0.70	27.52±0.78	1 583.53±159.28
Control	29.17±1.45	12.69±0.21	8.18±0.14	1.37±0.04	33.54±0.51	33.05±0.12	879.38±69.82
CD (P=0.05)	3.97	0.98	0.68	0.27	1.66	1.08	185.62

Treatment	*Fresh weight (g)*	*SLA (cm^2/g)*	*Dry leaf weight (g)*	*Gas exchange characteristics* Photo-synthesis rate ($\mu mol\ CO_2/m^2/s$)	Stomatal conductance ($\mu mol\ H_2O/m^2/s$)	*Efficiency of photo system 2*	*Transpiration rate ($\mu mol H_2O/m^2/s$)*	*Vase life (days)*
35% shade	39.39±9.55	33.85±5.32	8.95±1.97	7.15±0.23	0.013±0.001	0.231±0.004	0.66±0.04	32.00±3.63
50% shade	44.37±8.76	34.86±5.41	10.06±1.70	9.47±0.05	0.005±0.001	0.207±0.003	0.27±0.04	30.25±2.59
75% shade	46.72±11.28	37.19±4.73	10.79±2.18	6.86±0.05	0.009±0.001	0.144±0.010	0.49±0.06	24.50±4.01
90% shade	39.06±9.68	41.44±5.22	8.28±2.01	6.58±0.29	0.010±0.000	0.142±0.006	0.55±0.01	26.25±2.84
Control	30.18±7.72	31.77±5.41	6.92±1.75	5.63±0.04	0.014±0.000	0.229±0.012	0.72±0.02	16.00±0.00
CD (P=0.05)	5.44		1.07	0.50	0.002	0.017	0.11	5.23

Data (mean ± SE) at P<0.05

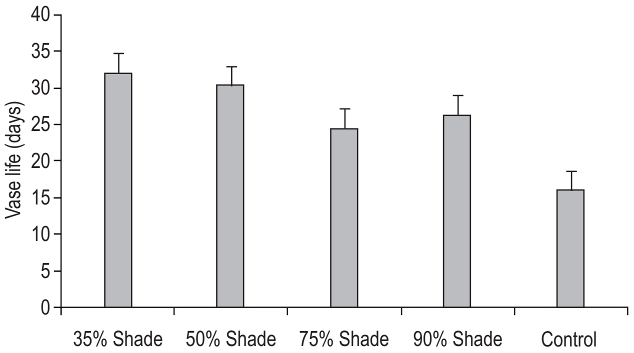

Fig 8 Influence of shade levels on vase life of cordyline cut foliage

shaded plants of *Paeonia lactiflora*. SLA was highest under 90% shade level in cordyline, i.e. the leaf thickness was lowest. Marenco and Reis, 1998 observed that leaf thickness was lower in plants grown in shade. SLA values depend on the quality of light and vary amongst species. Increase in SLA and reductions in the thickness of the leaf blade under shading conditions are common to plants grown in environments with low light intensity (Buisson and Lee 1993).

The harvest index was found to be maximum (15.32% over control) under 35% shade which was closely followed by 50% (12.42). Lowest HI was observed under open condition.

Vase life determines the commercial value of cut greens and higher vase life was always preferred in trade. Higher vase life was obtained at 35% and 50% shade level. This is because of better chlorophyll content, fresh weight, photosynthesis rate and lower transpiration rate. It was higher by almost two (100%) under 35% shade and by 90% under 50% shade over control (Fig 8). Similar improvement in vase life of aspidistra and ruscus with increase in shade level was observed by Stamps (1997) but, it was similar at different shade level. In contradiction to this, Stamps (1995) did not find significant differences in vase life with shade.

The shade levels of 50% were optimal as a result recorded better chlorophyll content and photosynthetic rate at this level. The shade nets provide the optimal environment for growth of cut greens in sub-tropical condition both in winter and summer.

Shade nets are generally used to protect plants from scorching sunlight, heat, cold and winds. Shade net was found to improve vegetative growth, yield, vase life and quality of cut foliage. Good quality of cordyline plant can be cultivated for cut greens under shade net. Shade nets of 50% shading intensity produced plants with better morphological characters and foliage quality. 50% shade net can be recommended for growing cordyline to produce cut greens commercially.

ACKNOWLEDGEMENT

I would like to thank ICAR, New Delhi for providing me the Junior research fellowship during the tenure of study.

REFERENCES

Bibi B, Sajid M, Rab A, Shah S T, Ali N, Jan I, Haq I, Fazal-i-Wahid, Haleema B and Ali I. 2012. Effect of partial shade on growth and yield of tomato cultivars. *Global Journal of Biology, Agriculture and Health Sciences* **1**(1): 22–6.

Buisson D and Lee D W. 1993. The developmental responses of papaya leaves to simulated canopy shade. *American Journal of Botany* **80**: 947–52.

Devkota A and Jha P K. 2010. Effects of different light levels on the growth traits and yield of *Centella asiatica. Middle East Journal of Scientific Research* **5**(4): 226–310.

Elad Y, Messika Y, Brand M, David D R and Sztejnberg A. 2007. Effect of colored shade nets on pepper powdery mildew (*Leveillula taurica*). *Phytoparasitica* **35**: 285–99.

Hlatshwayo M S and Wahome P K. 2010. Effects of shading on growth, flowering and cut flower quality in carnation (*Dianthus caryohyllus*). *Journal of Agriculture Society Science* **6**: 34–8

Long S P, Farage P K and Garcia R L. 1996. Measurement of leaf and canopy photosynthetic CO_2 exchange in the field. *Journal of Experimental Botany* **47**(11): 1 629–42.

Lugassi-Ben-Hamo M, Kitron M, Bustan A and Zaccai M. 2010. Effect of shade regime on flower development, yield and quality in lisianthus. *Scientia Horticulturae* **124**(2): 248–53.

Lykas C H and Katsoulas N. 2012. Use of shading nets to improve quality characteristics of compact gardenia (*Gardenia jasminoides* Ellis) potted plant. *Acta Horticultural* **952**: 281–5

Marenco R A and Reis A C S. 1998. Shading as an environmental factor affecting the growth of *Ischaemum rugosum. Revista Brasileira de Fisiologia Vegetal* **10**(2): 107–12

Middleton S and McWaters A. 2002. Hail netting of apple orchards – Australian Experience. *Compact Fruit Tree* **35**: 51–5.

Nelson P. 2003. Light and temperature. (*In*) *Greenhouse Operation and Management,* 6th edn, pp 401–5. Prentice Hall, New Jersey.

Oren-Shamir M, Gussakovsky E, Shpiegel E, Nissim-Levi A, Ratner K, Ovadia R, Giller Y and Shahak Y. 2001. Coloured shade nets can improve the yield and quality of green decorative branches of *Pittosporum variegatum*. *Journal of Horticultural Science and Biotechnology* **76**: 353–61.

Smith I E, Savage M J and Mills P. 1984. Shading effects on greenhouse tomatoes and cucumbers. *Acta Horticulturae* **148**: 491–500.

Stamps R H. 1994. Evapotranspiration and nitrogen leaching during leather leaf fern production in shadehouses. Special Publication, St. Johns River Water Management District, Palatka, FL.

Stamps R H. 1997. Effects of production shade levels on leaf/stem size and vase life of three herbaceous perennials. *Proceedings of Florida State Horticultural Science* **109**: 309–10.

Wong C F. 1994. Scattered ultraviolet radiation underneath a shade-cloth. *Photodermatology Photoimmunology Photomedicine* **10**: 221–4.

Yates D J. 1989**.** Shade factors of a range of shade cloth materials. *Acta Horticulturae* **257**: 201–17.

Zhao D, Hao Z and Tao J. 2012. Effects of shade on plant growth and flower quality in the herbaceous peony (*Paeonia lactiflora* Pall.). *Plant Physiology and Biochemistry* **61**: 187–96.