EVALUATION OF DIFFERENTIAL EFFECTS OF COLOURED SHADE NETS ON SELECTED ORNAMENTALS

by
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(2014-12-126)

THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Evaluation of differential effects of coloured shade nets on selected ornamentals"** is a bonafide record of research done by me during the course of study and the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"Evaluation of differential effects of coloured shade nets on selected ornamentals"** is a record of research work done independently by Andrew L. Myrthong (2014-12-126) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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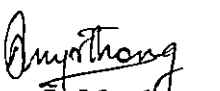

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ABBREVIATIONS

Chl.	- Chlorophyll
Carot.	- Carotenoid
DAA	- Days after anthesis
PAR	- Photosynthetically active radiation
°C	- Degree Celsius
%	- Per cent
nm	- Nano meter
cm	- Centimetre
cm^2	- Square centimetres
OD	- Optical density
V	- Volume
W	- Weight
rpm	- Rotations per minute
ml	- millilitre
mg	- milligram
mg/g	- milligram per gram
$\mu molm^{-2}S^{-1}$	- micro mol per meter square per second
R/FR	- Red by Far-red
B:R	- Blue by Red
RH	- Relative humidity
sp.	- Species
Fig.	- Figure
et al.	- and others
cv.	- Cultivar
i.e.,	- that is
viz.,	- namely
FYM	- Farm Yard Manure

Introduction

INTRODUCTION

Foliage plants include all plants which are grown for their attractive foliage and/or flowers that can be cultivated in pots in shaded greenhouses (Chen *et al.,* 2002). They can be used for indoor decoration or as landscape plants, when grown under shade. Most of these plants are of tropical origin and thrives well under shade. Plants show phototropism, which can be judiciously harnessed in order to improve the quality of ornamental plants. Every plant has a specific requirement of light and shade to which it responds and hence prospers at its best.

The use of coloured shade nets in the protected cultivation of foliage ornamental plants is an emerging approach. They function to safeguard the plants from pests and other unforeseen hazards while also spectrally altering and scattering the incoming solar radiation. The spectral alteration allows for differential promotion of desired physiological responses while scattering enables the penetration of the altered light deeper into the canopy of the plants (Shahak *et al.,* 2009). These responses include increased plant vigor, dwarfing, better development of root system and canopy, bushiness, leaf size and variegation. This is an economical and environmentally friendly alternative to current labour consuming methods like pruning and thinning and intensive use of growth regulators (Ganelevin, 2008). The red and yellow nets were found to specifically stimulate vegetative growth rate and vigor and blue net, dwarfing, whereas grey net was found to stimulate branching and bushiness, reduced leaf size and variegation in leaves (Ovadia, *et al.,* 2009). However, the effect may vary as genes play a vital role in mediating the plants response to changes in light quality.

Kerala, otherwise known as God's own country is blessed with a rich diversity of ornamental foliage plants. The prevalence of humid tropical climate in the state presents itself a charming environment for the year round cultivation of flowers and/or foliage plants of commercial importance and therefore, leads the country in fulfilling both the domestic as well as international demands. Although coloured shade nets are being widely implemented in the protected cultivation of

high value horticultural crops, the scientific principle behind the effect generated by each net is still lacking. Recently many enquiries have been received from farmers on the use of coloured nets in commercial floriculture for which an authentic reply is not available.

With this background, the present study "Evaluation of differential effects of coloured shade nets on selected ornamentals" was attempted with the objective to assess the performance of selected ornamentals *viz., Nephrolepis exaltata*, *Asparagus* sp. (green leaf type), *Spathiphyllum wallisii*, *Chrysothemis pulchella* (flowering type), *Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* (coloured leaf type) under shade nets of five different colours *viz.,* red, yellow, green, blue and black.

Review of literature

2. REVIEW OF LITERATURE

In agriculture nets are employed in order to provide protection from pests such as birds, bats, insects as well as environmental hazards such as hail, storm, heavy winds *etc.* They are also effective in shading the crops from the harmful ultra violet rays. Coloured shade nets are a new technology which aims at modifying/manipulating the light rays while also improving the climate at the micro scale. This will in turn positively affect the growth and development of the plants inside a net house in addition to providing physical protection. These coloured nets are not harmful to the environment and can substitute the manual labour required for thinning and pruning as well reduce the use of growth regulators (Ganelevin, 2008). Depending on the pigmentation and the knitting design, the nets provide varying mixtures of natural, unmodified light and spectrally modified scattered light aimed at optimising desirable physiological responses (Elad *et al.,* 2007).

2.1. Role of nets in controlling the microclimate

Environmental conditions play a pivotal role in the growth and development of plants. For a better production of the plants, manipulation of microclimate under the greenhouse is important. Employment of shading screens or nets is a common approach for such modifications. Due to its many advantages and benefits plastic screens have been put to use as covering materials during the last decade (Castellano *et al.,* 2006; Briassoulis *et al.,* 2007; Castellano *et al.,* 2008).

2.1.1. Light and photo-selectivity

Light plays a very important role in plants. The most important being its role in photosynthesis. Plants have the ability to sense the quality, quantity and direction of perceived light which acts as a signal to optimise their growth and development in a given environment.

Use of shade net decreases the radiation reaching the plants underneath which will ultimately affect both the temperature as well as the relative humidity (Stamps, 1994). According to Wong (1994) shade nets of any level can influence and scatter the ultra violet radiation as they are usually made up of plastic material that is resistant to ultraviolet rays.

It has been revealed that diffused light can improve the radiation use efficiency, yield and also affect flowering in plants (Sinclair *et al.,* 1992; Healey *et al.,* 1998; Gu *et al.,* 2002; Ortiz *et al.,* 2006; Guenter *et al.,* 2008).

At different times of the day, the light intensity as well as the spectral properties of sunlight is not constant and it varies according to the day, season and year. Furthermore, dust and air pollution also affect the diffusion as well as reflection of light. Thus penetration of light into the dense canopies of the plant depends on these parameters which will ultimately influence the response of plant to light. Phototropic, photoperiodic and photomorphogenetic response are possible only in the presence or absence of light. In addition, it also manages the use of photosynthetic products within the developing plant (Oren-Shamir *et al.,* 2001).

Development of plants with respect to light is a complicated process which involves the integrated activity of several photoreceptor systems such as the phytochromes, which detects the far-red (FR) and red light (R) as well as sensing the blue and UV light (Quail *et al.,* 1995); the cryptochromes, that absorbs the blue-UV-A light (Ahmad and Cashmore, 1996; Batschauer, 1998), and specialised UV-A and UV-B receptors (Christie and Jenkins, 1996). These photoreceptors are effectively utilised by the plants in order to sense and precisely respond to changing light conditions (Mohr, 1994). For instance, phytochromes can detect the R/FR ratio which acts as a signal of competition from other plants, and as an instigator of changes that supports the plant survival (Kasperbauer, 1994; Smith, 1995). As per Mohr (1994), more than one photoreceptor may be involved in the photomorphogenetic reactions.

During cloudy situations, covering of the house with bright coloured nets having high porosity is recommended (Al-Helal and Abdel-Ghany, 2010) as the high porosity nets have higher diffused PAR transmittance value than the nets having low porosity. Also, the brightly coloured nets have a higher transmittance compared to dark coloured nets. Bright colour nets will reflect most of the incident PAR while dark ones absorb the incident PAR. The black colour shade nets had the lowest solar radiation transmissivity, photosynthetically active radiation (PAR) and net radiation (Rn) (Holcman and Sentelhas, 2012). The Photosynthetically Active Radiation (PAR) and ultraviolet-A and ultraviolet-B were highest under red net (Arthurs *et al.*, 2013).

It was observed by Lobos *et al.* (2012) that both the intensity of shade as well as the colour of the nets can modify the spectral photon irradiance. He uncovered that in contrast with full sun, the distinctions in spectral irradiance were biggest under red nets. At shading levels of 50 and 75per cent, the red hued net apparently caused a marked reduction in the visible range (400-700nm) and expands the infrared radiation. The white hued net caused only a slight reduction in the visible spectrum, decreases the ultra violet rays and increases the infrared rays while the black coloured net was neutral in effect.

It was found by Meena *et al.* (2014) that both light intensity and PAR was lower inside the coloured shade nets than outside. The maximum light intensity and PAR was recorded in white, followed by red, green and black in both summer and rainy season. Both the parameters recorded values lower during rainy season and higher during summer season. The light intensity recorded was reduced by 47.8-67.1% under white, 55.4-72.5% under red, 63.7-74.3% under green and 62-82.7% under black colour shade net. The PAR was reduced by 33.4-42.7% under white, 26.7-36.1% under red, 19.4-32.5% under green and 17.2-20.1% under black coloured shade net.

2.1.2. Movement of air

The topography of the location as well as the porosity of the nets together influences the air movement within a net house. In addition, it may also depend on time of the day, season and other environmental factors. Stamps (1994) observed that nettings can help in reducing the wind speed and wind run. This will affect the temperature, relative humidity and the concentration of gas due to reduction in air mixing (Rosenberg *et al.,* 1983). The alteration of these parameters will indirectly affect the processes of transpiration, respiration and photosynthesis.

2.1.3. Temperature and Relative humidity

In places experiencing tropical climates, shade nets play a crucial role by minimising the light intensity and the effective heat during the day time. The nets have often been used as a tool for reducing heat stress (Elad *et al.,* 2007; Retamales *et al.,* 2008; Shahak *et al.,* 2004). On the contrary, the temperature inside the net house is higher than outside during the day time (Pèrez *et al.,* 2006; Stamps, 1994) and lower during the night (Stamps, 1994).

Depending on the transmission of solar radiation, ventilation and size of the greenhouse, the air temperature inside the greenhouse changes (Burio *et al.,* 2000). However, it was observed by Zoratti *et al.* (2015) that under white, red, blue and black coloured net, although there was an increase in temperature during the night hours however, a progressive decrease in temperature was recorded during the warmest period of the day.

Relative humidity is higher within a net house even when the temperature is higher inside compared to outside (Stamps, 1994). In an experiment by Holcman and Sentelhas (2012), they found that the temperature and relative humidity were highest in blue coloured shade nets.

As per Elad *et al.* (2007) the relative humidity under shade net is always higher than outside. This is due to transpiration of water vapour by the plants

inside the net house as well as reduction in mixing with the drier air outside the netted area.

The study of micro environment under different coloured shade nets was carried out in IARI, New Delhi and it was recorded that the temperature under the different nets viz., white (10.6-5°C), red (1.3-3.6°C), green (1.2-3.4°C) and black (0.4-1.9°C) was lower than control. A higher relative humidity was also recorded under coloured shade nets viz., white (3.8-10.4%), red (2.5-9.5%), green (0.5-7.2%) and black (0.2-3.1%) higher than control. The temperature as well as relative humidity difference in rainy season was lower than summer season (Meena *et al.,* 2014).

2.2 Effect of nets on the vegetative characteristics

Effect of different levels of shade on *Lilium sp.* cultivars 'Dreamland' and 'Alhambra' was evaluated and found that stem diameter as well as the number of florets per stem did not show any significant differences under all treatments viz., 35, 50, 65 and 80 per cent shading. However, a higher bulb weight was recorded in both the cultivars of liliums grown under control and under 35 per cent shade treatments. In case of bulb perimeter, cv. Dreamland performed better under control and under 35 per cent shade, whereas, Alhambra showed no difference for all the treatments. It was also observed that plants of both the cultivars were taller when grown under nets of 65 and 80 per cent shade levels. It was concluded that getting cut flowers and bulbs of good quality is necessary in case of dual purpose crops, thus use of 50 per cent shade is proposed (Schiappacasse *et al.,* 2006).

A similar experiment to study the effect of different levels of shade on the flower stem as well as the quality of corm of liatris (*Liatris spicata*) was conducted by Schiappacasse *et al.* (2007). It was observed that shade treatments had a negative impact on both the flower quality as well as weight of the corm which was very evident at the time of harvesting. They found that plants that grew under open condition were more superior in terms of spike length and stem diameter.

This was supported by Dolatkhahi *et al.* (2013) who showed that shading may be the reason for the inferior quality of cut roses and that the prevailing light intensity can be regarded as a limiting factor while cultivating rose in greenhouse. They concluded that shading delays the sprouting of bud in roses and reduced the fresh and dry weight of the flowering stems.

Gardenia (*Gardenia jasminoides* 'Ellis') placed under shade nets with 30 and 60 per cent shading were shorter in height by 10 and 13 per cent respectively compared to those placed under greenhouse conditions. The leaf area and fresh weight were 23 and 45 per cent lower than those grown under greenhouse conditions. However, shading resulted in more pronounced green colour in the leaves as well as uniform plant production in gardenia (Lykas and Katsoulas, 2012).

It was found by Dussi *et al.* (2005) that shade nets considerably reduced the specific leaf weight, flesh firmness and soluble solid content as well as the colour (redness) of apple cultivar Fuji.

In a study to evaluate the influence of different levels of shade on the yield and quality parameters of tomato revealed that shade level of 35 per cent is most preferred for the better growth and development of tomato plants. The maximum number of fruits produced per plant and the highest yield were recorded at this intensity. A significant improvement in the fruit mass, diameter, size and a reduction in the incidence of sunscald and puffiness was also observed (El-Gizawy and Mohamed, 1992).

Cultivating pepper under coloured nets resulted in higher yield compared to the traditional black net (Shahak *et al.*, 2009). In a study by Milenković *et al.* (2012), they found that a shading level of 40% results in increased marketable yield of pepper.

2.3. Effect of different coloured shade nets on the growth and development of different crop plants

2.3.1. Black colour shade net

Stamps (2008) found that in comparison to blue, gray or red nets, cast iron plant (*Aspidistra elatior* 'Variegata') growing under black colour nets had a higher fresh weight and more number of total harvestable leaves. The black shade net quantitatively reduced the transmission of light to the plants without altering its quality maintaining the spectral composition (Shahak, 2008a)

The performance of anthurium in terms of growth and yield when it is cultivated under different shading screens was studied by Nomura *et al.* (2009) who concluded that *Anthurium andreanum* cv. Apalai subjected to shading by black coloured net outperformed those that grew under red, blue and thermo-reflective screens. The plants under black net had the greatest length of stem, petiole, sheath and spadix, maximum width of the spathe, maximum leaf area and recorded highest production of average number of flower stalk per plant per year. However, these plants had the lowest average period of flowering.

A study to evaluate the effect of coloured shade nets on the yield and profitability of blueberries revealed that vegetative growth of plants were greatly influenced under black net which reduced PAR resulting in increased internodal length, leaf length and width as well as shoot length compared to no-net control (Retamales *et al.*, 2008).

Zoratti *et al.* (2015) tried to study the effect of photo-selective nets on the anthocyanin profile in berries of *Vaccinium sp.* and found that due to lower light intensity and temperature under black shade nets, the highest content of anthocyanins was accumulated in bilberries while the lowest accumulation was in blueberries. They also found that ripening in blueberries was delayed by 20 days under black net.

2.3.2. Blue colour shade net

Regulation of growth is an important feature when it comes to cultivation of ornamentals. For this purpose, a wide array of chemical regulators is available in the market. Oyaert *et al.* (1999) tried to study the possibility of substituting the chemical growth regulators by using coloured plastic films in chrysanthemum and inferred that blue coloured plastic films inhibit the elongation of stem leading to maximum reduction of growth upto 22 per cent as compared to those under control treatment. This film also suppressed the production of axillary branches, reduced leaf area and resulted in the overall reduction in dry weight of the plant.

The performance evaluation of *Pittosporum variegatum* in terms of yield and quality of green decorative branches under different coloured shade nets revealed that blue coloured net had a suppressive effect on several plant parameters. It was observed that blue netting decreases the branch length as well as shortens the internode of variegated pittosporum. The production of commercial branches was reduced thus reducing the overall yield. However, compared to black netting, blue net enhanced the leaf variegation which is a desirable feature (Oren-Shamir *et al.,* 2001).

The leaves and roots of *Phalaenopsis* grown under blue nets had the highest surface area and biomass (Leite *et al.,* 2008). Effect of coloured shade nets in the production of *Lisianthus* sp. was studied by Torres-Hernandez *et al.* (2012) and found that blue colour nets decreased the height of the plant as well as the number of buds per stem.

A study to evaluate the effects of coloured nets of blue, red, white, grey and no net control on Hayward kiwi in southern Italy revealed that in comparison with treatments of no net and red net, the plants under blue net which were pruned in the winter had a lower fresh weight (Basile *et al.,* 2008). Blue netting also resulted in advanced maturation of grape variety 'Superior' but delayed that of 'Perlette' (Shahak *et al.,* 2008b)

It was observed that blue coloured nets resulted in apple fruit with maximum growth rate and the fruit weight was also greater than control (Bastias *et al.,* 2012). Also the photosynthesis by the leaves as well as the total leaf area was the highest under blue colour shade net.

An experiment conducted to evaluate the effect of light intensity using coloured shade nets on the yield and quality of pepper revealed that pepper from vines grown under blue coloured nets had the highest vitamin C content (Milenković *et al.,* 2013).

Arthurs *et al.* (2013) reported that depending on the season, light intensity between 400-500 nm was increased by 34 to 44 per cent under blue nets. The red to near infrared ratio (R:NR) was also found to be highest under blue nets (Gilbert *et al.,* 2013).

2.3.3. Red colour shade net

Oren-Shamir *et al.* (2001) evaluated *Pittosporum variegatum* under different coloured shade nets and reported that red net increases branch length of variegated pittosporum. The plants under red coloured net also had the longest internode, larger leaf area and the branch yield and production was also the highest under red nets.

The response of potted dracaenas to the photoselective shade net showed that when cultivated under red shade netting, *Dracaena deremensis* 'Janet Craig' and *Dracaena marginata* 'Colorama' produced the largest number of leaves. It was also observed that plants were taller in stature and had a fully developed appearance. D. marginata 'Colorama' also recorded a maximum growth of cane under red net. However, the plants had a lesser leaf area and also scored the least in terms of visual scoring by the grower (Kawabata *et al.,* 2007).

In a study by Leite *et al.* (2008), they found that *Phalaenopsis growing* under red nets took lesser time to reach anthesis and the number of flowers was more.

Stamps (2008) conducted a two year experiment to study the effect of different coloured nets with 70 per cent shade and observed that there was no effect on the leaf mass of Xanadu philodendron. However, the highest and lowest number of leaves was recorded in plants under red and blue netting respectively.

Red coloured net increased the plant height of *Lisianthus* sp. whereas its influence on the stem diameter, leaf area, number of internodes and number of flower buds per stem is intermediate. The number of days taken for flowering was also inferior to those under no net control (Torres-Hernandez *et al.*, 2012).

In hydrangea variety 'Tricolor' the maximum leaf variegation was induced by the red nets while variety 'Zorro' was the shortest in height under the red net (Nesi *et al.*, 2013), which is contrary to the findings by other authors.

Fruit set of Hermosa peaches was greatly influenced by red nets with 30 per cent shade (Shahak et al., 2004). Similarly, Giaccone *et al.* (2012) observed that peach trees covered by red nets had the capacity to intercept a higher light thus increasing the tree vigour. The firmness of the fruits was considerably higher but the soluble solids content as well as the percentage of dry matter was lower in fruits under red colour nets.

Shahak et al. (2008b) reported that fruit russeting was greatly reduced in pear fruits under red netting. It was observed by Anushma *et al.* (2014) that grafted jamun under red colour nets recorded the highest success percentage. It was recorded that these grafts had the maximum number of leaves at 90 days after germination.

In an experiment using coloured photo-selective nets to evaluate the effect of light on the sensory quality of apple, it was observed that apples under the red hail nets secured the highest score for yellow flesh, sweet taste and firmness in addition to having the highest mean fresh weight (Corollaro *et al.*, 2015).

An evaluation of coloured shade nets on leaf parameters and fruit quality in tomato revealed that plants under red colour nets had the largest leaf area index

(LAI) and the fruits under this net had the highest concentration of lycopene (Ilić *et al.,* 2015).

2.3.4. Green colour shade net

Oren-Shamir *et al.* (2001) reported that green coloured nets produced the largest leaves of pittosporum.

Gilbert *et al.* (2013) in a study in *Eucalyptus grandis* x *Euclayptus nitens* found that the plants under blue and green coloured nets had the shortest internode while those under red coloured nets had the longest.

Cordyline grown under green coloured nets with 75 per cent shade were taller compared to those grown under 50 and 90 per cent shade (Gaurav *et al.,* 2015) He also observed that in addition to protecting the plant from high light intensities, shade nets also enhanced the vegetative growth, yield, shelf life and quality of cordyline.

In Papaya (*Carica papaya*) the highest percentage of seed emergence was obtained in seeds sown under green coloured plastic shade. Furthermore, seedlings under green shade were tallest and also recorded maximum plant girth as well as seedling vigour. The fresh weight of root, stem, leaf and the total dry matter was higher in the seedlings under green colour shade (Baiyeri, 2006).

Cultivating tomato under green colour shade nets with 35 per cent shade resulted in higher plant yield, TSS, acidity and ascorbic acid content while under 75 per cent shade the yield was low (Nangare *et al.,* 2015). In comparison with open field, shade nets improved the glossiness as well as the colour of the tomato.

Effect of different coloured shade nets on the behaviour of Spinach (*Spinacia oleracea*) was evaluated and it revealed that under green coloured shade net, spinach had the maximum growth followed by red, black and white coloured shade nets. It was observed that the plant height, leaf length, leaf area, root length under green net was found to be double that of the control and yield was maximum. Number of leaves was also higher inside the net which implies that

during off season viz., summer season, the cultivation of spinach under shade net is profitable. However, during rainy season the plants under control condition recorded more number of leaves (Meena *et al.*, 2014).

2.3.5. Yellow, grey and pearl colour shade net

Grey coloured nets resulted in the decreased leaf variegation of pittosporum while the branch yield, production and vase life for stems of the same plant was intermediate. Grey coloured net also improves branching and encourages bushy appearance of the plant (Oren-Shamir *et al.*, 2001).

Enhanced branching of *Myrtus communis* pot plants and increased number of flowers per branch in *Crowea* 'Poorinda Extasy' under pearl nets were reported by Nissim-Levi *et al.* (2008). For 'Samantha' variety of pelargonium, both pearl and yellow colour nets enhanced the rooting rate of the cuttings while the highest yield was obtained under yellow colour net (Nissim-Levi *et al.*, 2014).

Under pearl, yellow, red and blue coloured nets with 30 per cent shade, there was an increase in the flowering of Hermosa peaches. However, grey coloured net with the same amount of shade had no effect on the flowering of this plant (Shahak *et al.*, 2004).

An experiment on grapes by Shahak *et al.* (2008b) reported that the yellow net increased the berry and cluster weight of cultivar 'Superior' while only the berry size was found to increase in cultivar 'Red Globe'. They also found that pearl coloured nets with 30 per cent shade increased the fruit yield in pear.

Shahak *et al.* (2008b) opined that there was an increase in the production of three bell pepper cultivars under pearl net compared to black netting. Yellow coloured net had an exceptional influence on the productivity of bell pepper. It was reported that the total fruit yield and the export quality fruit yield improved by 43 and 71 per cent respectively (Shahak *et al.*, 2009).

Shahak *et al.* (2008c) also reported that pearl and yellow nets significantly reduced the incidence of aphid borne cucumber mosaic virus by 10 and 3 folds

respectively. In comparison with black nets, the entry of whiteflies was lowered by 2 fold under yellow nets.

In an experiment by Ayala-Tafoya *et al.* (2011) to study the response of tomato in terms of growth and yield to the sunlight radiations that are transmitted by the shade nets revealed that pearl coloured shade nets with 30 per cent shade produces tomato with reduced stem length and leaf area. These plants had the highest chlorophyll content and a higher yield of good quality fruits was realised thus, causing a marked increase in the in total as well as exportable yield of tomato. This was further supported by Tinyane *et al.* (2013) who inferred that the cultivar AlfaV of tomato grown under pearl coloured net had a higher fruit weight with more firm flesh and elevated concentration of bioactive compounds viz., lycopene, β-carotene, total phenols and by Selahle *et al.* (2014) who opined that under this net tomatoes had a higher shelf life.

2.4. Effect of shade nets on the chlorophyll content and other pigments

For any landscape plant, the ability to resist high solar radiation is an important aspect which indicates its ability to tolerate stress. The diverse taxa of *Illicium L.* was evaluated for its chlorophyll content when grown in open as well as shaded condition and it was found that *I. parviflorum* 'Forest Green' maintained a higher chlorophyll content and higher photosynthetic capacity when it was grown under open sunlight while all the other taxa showed a reduction. It was concluded that *I. parviflorum* 'Forest Green' was highly tolerant to high light while *I. floridanum* 'Ellis' was tolerant to low light conditions (Griffin *et al.*, 2004).

Zhou *et al.* (2010) studied the performance of *Lycoris radiata* to shade treatments *viz.*, High irradiance (HI), Medium irradiance (MI) and Low irradiance (LI) which were about 100, 65 and 15 per cent of full ambient irradiance respectively and reported that as the shading intensity increases the content of Chlorophyll *a/b* decreases. However, plants under LI recorded a higher content of Chlorophyll *a*, Chlorophyll *b* and Chlorophyll *a+b*.

Similar results were obtained with *Anoectochilus roxburghii* under natural irradiance of 50, 30, 20 and 5 per cent. It was observed that as the intensity of irradiance reduced, the concentration of chlorophyll a and b increased and that of chlorophyll a/b decreased (Shao *et al.,* 2014).

In Paeonia (*Paeonia lactiflora* Pall), as the temperature increases, the content of Chlorophyll *a*, Chlorophyll *b* and Chlorophyll *a+b* starts declining. However, compared to the sun exposed plants the Chlorophyll *a*, Chlorophyll *b* and Chlorophyll *a+b* content were always higher in plants that grew in shade with the exception of Chlorophyll *a/b* which showed a reverse trend by continuing to decline in plants grown under compared to those under full sun throughout the period of investigation (Zhao *et al.,* 2015).

The results obtained on studying the impact of shade on the concentration of chlorophyll in cut rose (*Rosa hybrid* cv. Avalanche) were contrasting the results in many reports. It was found by Dolatkhahi *et al.* (2013) that the total chlorophyll profile as well as the chlorophyll a and b shows a diminishing trend as the shade increases while increasing the chlorophyll a/b ratio. This led to the conclusion that shading decreases the total chlorophyll concentration due to reduced acquisition of light.

Casierra-Posada and Avila-Leon (2015) also noted comparable observations when they examined pot marigold's chlorophyll and carotenoid content under shade. The results obtained revealed that a higher proportion of chlorophyll a/b (8.41%) and a lower proportion of carotenoids to chlorophyll (5.45%) were recorded in plants under shade contrasted with those under full sun. The plant's proportion of chlorophyll a/b provides insights into its shade tolerance capacity. Generally plants which are adapted to shade conditions have a lower value of chlorophyll a/b compared to their counterparts in exposed condition (Dai *et al.,* 2009). This is because of increased in the chlorophyll b value under shaded condition. Henceforth, it was construed that pot marigold (*Calendula officinalis* L.) may be lacking the ability to endure shade.

The shade net influence on the chlorophyll content in leaves of blackberry (*Rubus ulmifolius* Schott.) cultivars Black Satin and Smoothstem revealed that because of their adaptation to environments having a comparatively lower intensity of light, leaves under shade possessed greater amount of chlorophyll. An increase in the chlorophyll a+b content from 668 to 7.75 µg/mg d.m and 8.02 to 9.26 µg/mg d.m respectively was observed as compared to those under full sunlight in Black Satin and Smoothstem cultivars respectively (Rotundo *et al.*, 1998).

Chang *et al.* (2016) investigated the responses of 'Shih Huo Chuan' pitaya (*Hylocereus polyrhizus* (Weber) Britt. & Rose) to different degrees of shading nets and they found that the chlorophyll a and b, and total chlorophyll content increased considerably in plants grown under shade of various intensities. Plants under 75% black shading had the highest amounts of chlorophyll a and b, and total chlorophyll while the control plants had the lowest. It was also observed that the flesh colour of pitaya was affected by shading treatment. On the 24th day after anthesis (DAA), the fruit of plants under 25% white net and 50% black net was slightly pinkish in colour while it was milky-white in plants under 75% black net and control. The fruits turned red as the DAA progressed from 25 to 32. The total betacyanin content was higher in fruits under shade compared to control and the highest was found in fruits under 50% black net.

When the chlorophyll profile of *Spinacia oleracea* grown under different coloured *viz.*, white, red, green and black shade nets was studied, it was found that the plants under red recorded 54 to 67 per cent, green 52 to 62 per cent, white 19 to 35 per cent and black 12 to 31 per cent more content than the control. Similar results were obtained during the rainy season (Meena *et al.*, 2014).

An experiment to evaluate the effect of the light intensity as well as quality on the chlorophyll and carotenoid content of *Ocimum gratissimum* was conducted by Martins *et al.* (2010) and found that the lowest concentration of both chlorophyll a and b was in plants that were grown under open condition while the

highest was recorded in plants under black coloured net. In case of carotenoid, the highest carotenoid content was recorded in plants under full sunlight. The plants under black net had the lowest density of chloroplast while chloroplasts with larger surface areas and starch grains with bigger perimeters were recorded in plants under open and under blue coloured net.

Materials and methods

3. MATERIALS AND METHODS

The investigation entitled "Evaluation of differential effects of coloured shade nets on selected ornamentals" was conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur during 2014-15. The materials used and the methodology adopted for the investigation is presented in this chapter.

3.1. Location

Geographically the area lies 22-25m above the mean sea level. The area is situated at latitude of $10^0 31`$ N and longitude of $76^0 13`$ E.

3.2. Climate

The area experiences a humid tropical weather. During the course of investigation the weather parameters have been recorded and presented in Appendix 1 to 4.

3.3. Evaluation of the selected ornamentals under different coloured shade nets

3.3.1. Materials

Six species of ornamental plants were selected for the investigation. The selected belongs to three categories *viz.*, green leaf type, flowering type and coloured leaf type. The selected species are given in Table 1 and Plate 3.

3.3.2. Growing system

The selected ornamentals were evaluated under different coloured shade nets *viz.*, red, yellow, green, blue and black in rain shelter. The shade level was maintained at 50 per cent.

3.3.3. Planting management

The plants were planted in pots of 30 cm diameter. The medium used for planting consisted of sand, well rotten FYM and red earth at the ratio of 1:1:1. A homogenous plant management practice was carried out for all experiment plants. Irrigation was provided daily and plant protection chemicals were applied as and when needed.

Table 1. List of plants selected for study

Sl. No.	Scientific name	Common name	Family	Type
1	*Nephrolepis exaltata,*	Sword fern	Lomariopsidaceae	Green leaf type
2	*Asparagus* sp.	Foxtail fern, plume asparagus	Asparagaceae	Green leaf type
3	*Chrysothemis pulchella,*	Sunset Bells, Black Flemingo	Gesneriaceae	Flowering type
4	*Spathiphyllum wallisii*	Peace lily	Araceae	Flowering type
5	*Cordyline terminalis*	Good luck tree	Agavaceae	Coloured leaf type
6	*Tradescantia spathacea* 'Sitara'	Moses in a cradle or Oyster plant	Commelinaceae	Coloured leaf type

Nephrolepis exaltata

Asparagus sp.

Spathiphyllum wallisii

Chrysothemis pulchella

Tradescantia spathacea **'Sitara'**

Cordyline terminalis

Plate 1: Selected ornamentals

3.3.4. Design of the experiment

The design for the experiment was CRD (Completely randomised design) with four replications.

3.3.5. Observations

3.3.5.1. Quantitative characters

3.3.5.1.1. Plant height

The height of the plant was measured from collar region to the tip of the youngest mature leaf at monthly intervals and expressed in centimetres.

3.3.5.1.2. Plant spread

The spread of the plant was measured in the East-West and North-South directions and recorded in square centimetre.

3.3.5.1.3. Number of leaves

The total number of leaves present on the plant was counted and recorded at the time of each observation.

3.3.5.1.4. Length of leaves

The length of the leaf was measured from the basal lobe to the tip and expressed in centimetres.

3.3.5.1.5. Breadth of leaves

The breadth of the leaves was measured at the centre portion of the leaf where the leaf width is maximum and expressed in centimetres.

3.3.5.1.6. Leaf area

The leaf area was calculated using the dot method (Bleasdale, 1977) and expressed in square centimetres.

3.3.5.1.7. Petiole length

The length of the petiole was measured from the point of its emergence to the base of the leaf lamina and expressed in centimetres.

3.3.5.1.8. Petiole girth

The petiole girth was recorded by measuring the circumference of the middle portion of the petiole and expressed in centimetres.

3.3.5.1.9. Internodal length

The length between two successive nodes was measured and expressed in centimetres.

3.3.5.1.10. Total number of flowers per plant

The total number of flowers present at the time of data collection was counted and recorded.

3.3.5.1.11. Size of the flower

The maximum length and breadth of the flower was recorded and expressed in square centimetres.

3.3.5.1.12. Length of the stalk

The length of the stalk was measured from the point of its emergence to the base of the calyx.

3.3.5.1.13. Longevity of flower on the plant

The number of days taken from the opening of the flower till the flower shows symptoms of wilting on the plant was recorded.

3.3.5.1.14. Interval of flower production

The number of days taken for the emergence of successive flower/inflorescence was recorded.

3.3.5.1.15. Pest and disease incidence

The plants were observed regularly for any incidence of pests and diseases, if any.

3.3.5.2. Qualitative characters

Leaf characters which contribute towards their use as cut foliage were observed.

3.3.5.2.1. Texture of leaves- Smooth, leathery or cereous

3.3.5.2.2. Shape of leaves- Linear, lanceolate, ovate or cordate

3.3.5.2.3. Margin of leaves- Entire, wavy, lobed, spinous or serrate

3.3.5.2.4. Tip of leaves- Acute, obtuse or acuminate

3.3.5.2.5. Bending/ drooping of leaves- Whether they are bent or drooped

3.3.5.2.6. Leaf pigmentation- Colour changes during maturity

3.3.5.2.7. Plant quality rating

The different plant species grown under different coloured shade nets were rated according to its fullness, growth, tolerance capacity (suitability under each shade net) and visual appearance viz., colour and pigmentation, texture, shape and

pattern and size of the foliage during the growth period. The grades ranged from 1 to 10 for each character and the total values for each species/ varieties are given.

3.3.5.3. Vase life

Fresh and healthy matured leaves were collected from ornamentals suitable for use as cut foliage *viz., Nephrolepis exaltata, Asparagus* sp., *Spathiphyllum wallisii* and *Cordyline terminalis*. These were placed in normal water until they show symptoms of wilting and yellowing.

3.3.5.4. Weather parameters

Readings of temperature (^{o}C) and relative humidity (%) were taken daily three times *viz.,* at 09.00, 12.00 and 15.00 hours.

Light intensity was recorded once in a day by using a light meter (Model: LX-1102, Lutron Electronic Enterprise Co., Ltd., Taiwan) and expressed in lux.

Photosynthetically Active Radiation (PAR) was recorded once in a week using a quantum light meter (Model- 3415 F, Field scout, spectrum technology, Inc. USA) and expressed in $\mu molm^{-2}S^{-1}$.

3.3.5.5. Estimation of total chlorophyll and carotenoid content.

Fresh leaf samples were collected in the morning and brought to the laboratory for analysis. 100 mg of fresh leaf sample was weighed and transferred to a pestle and mortar, where it was macerated along with 10ml of 80% acetone. The contents were then centrifuged at 3000 rpm for 10 minutes. Thereafter, the supernatant was filtered using Whatman filter paper 1 and the volume was made up to 25 ml by using 80% acetone. The optical density was then measured at 480, 510, 645 and 663 nm by a spectrophotometer.

Calculation:

$$\text{Total chlorophyll} = (8.02 \times \text{OD at } 663) + (20.2 \times \text{OD at } 645) \times \frac{V \times 1000}{1000 \times W}$$

$$\text{Carotenoid} = (7.6 \times \text{OD at } 480) - (1.49 \times \text{OD at } 510) \times \frac{V \times 1000}{1000 \times W}$$

3.3.5.6. Statistical analysis

The statistical analysis was done by using the Web Based Agricultural Statistics Software Package (WASP 2.0) developed by ICAR Research Complex for Goa, Ela, Old Goa. Correlation (Pearson Spearman Rank and Kendall's Tau) analysis was done by using OPSTAT software developed by the Chaudhary Charan Singh Haryana Agricultural University, Hisar.

Results

4. RESULTS

4.1. PLANT CHARACTERS

Selected ornamental plants viz., *Nephrolepis exaltata, Asparagus sp.* (green leaf types), *Spathiphyllum wallisii, Chrysothemis pulchella* (flowering types), *Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* (coloured leaf types) were grown under red, yellow, green, blue and black coloured shade nets of 50 per cent shade level. The growth and performance of these plants under different coloured shade nets were evaluated. The data on quantitative and qualitative plant characters were recorded at monthly interval for one year. The data collected were statistically analysed and the results are presented here.

4.1.1 Quantitative characters

4.1.1.1. Plant height (cm)

The height of all the six different plants growing under different coloured shade nets showed considerable variations.

In *Nephrolepis exaltata,* the plant height was observed to be significantly different between treatments throughout the year. The plants grown under red (T_1) coloured shade net were the tallest and the height recorded during the 12^{th} month was 67.15 cm. The height was on par with the plants grown under black (T_5) coloured net during 5^{th}, 7^{th}, 9^{th}, 10^{th}, 11^{th} and 12^{th} months. The plants grown under green (T_3) and blue (T_4) coloured shade nets recorded lower values (52.87 and 52.86 cm respectively during the 12^{th} month) throughout the period of study. Yellow (T_2) coloured shade nets had an intermediate effect on the height of the plant (Table 2).

In *Asparagus* sp. significant difference in plant height was observed during the 2^{nd}, 3^{rd}, 4^{th}, 11^{th} and 12^{th} months. In 12^{th} month, the maximum height (39.39 cm) was recorded in plants grown under red coloured shade net followed by plants under black coloured net (38.25 cm) which was on par with plants under

red net during 2nd, 3rd and 4th months after planting. The plants under yellow and green coloured shade nets were intermediate in height while plants under blue coloured shade nets were the shortest in height (33.75 cm recorded during the 12th month) throughout the year (Table 3).

The plant height of *Spathiphyllum wallisii* was significantly influenced by all the treatments throughout the year except during 2nd and 3rd months (Table 4). The plants grown under black and red coloured shade nets were the tallest recording 60.58 and 63.34 cm respectively, during the 12th month and they are on par with each other during the 1st, 4th, 10th, 11th and 12th months. However, plants under black coloured shade nets outperformed the plants under red coloured shade nets considerably. Yellow coloured shade net showed an intermediary effect while plants under green and blue coloured nets were the shortest growing only up to 52.59 and 48.67 cm respectively, during the 12th month after planting.

Chrysothemis pulchella showed considerable difference in plant height throughout the year except at one month after planting as presented in Table 5. The plants grown under red coloured shade net were the tallest (41.36 cm during the 12th month) in height throughout the year. The plants under black net recorded values on par with those under red net during the 5th, 6th, 7th, 8th, 9th, 10th 11th and 12th months (39.25, 44.52, 47.70, 47.94, 50.06, 47.77, 43.95 and 41.36 cm respectively). The plants under yellow, green and blue nets were intermediate in height for most part of the year and did not differ much from each other.

Tradescantia spathacea 'Sitara' showed variation in plant height under different coloured nets except during 2nd, 4th and 12th months. The maximum height throughout the year was recorded in plants grown under red nets. This was followed by plants under black net while those under yellow, green and blue were intermediate in height. However, the plants under T_2, T_3, T_4 and T_5 recorded values on par with one another during the 9th, 10th and 11th months after planting (Table 6).

Table 2: Effect of different coloured shade nets on the plant height of *Nephrolepis exaltata*

Treatments (Shade net colours)	Plant height (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	36.08^{a}	43.15^{a}	47.79^{a}	51.26^{a}	53.84^{a}	64.41^{a}	62.31^{a}	62.87^{a}	65.19^{a}	67.52^{a}	66.49^{a}	67.15^{a}
T_2 (Yellow)	32.43^{bc}	37.95^{b}	46.42^{ab}	48.50^{ab}	53.32^{a}	57.79^{b}	59.53^{a}	59.34^{b}	60.90^{b}	59.04^{b}	58.55^{b}	57.58^{b}
T_3 (Green)	30.57^{c}	38.80^{b}	43.98^{abc}	45.57^{bc}	50.58^{ab}	51.73^{c}	52.65^{b}	52.56^{c}	53.23^{c}	52.69^{c}	53.37^{c}	52.87^{c}
T_4 (Blue)	30.69^{c}	40.04^{ab}	41.89^{c}	43.80^{c}	46.37^{b}	52.04^{c}	54.62^{b}	53.84^{c}	55.95^{c}	56.25^{bc}	55.08^{bc}	52.86^{c}
T_5 (Black)	34.30^{ab}	38.57^{b}	42.20^{bc}	47.14^{bc}	53.72^{a}	58.08^{b}	62.04^{a}	61.03^{ab}	65.90^{a}	66.00^{a}	66.25^{a}	65.12^{a}

Table 3: Effect of different coloured shade nets on the plant height of *Asparagus* sp.

Treatments (Shade net colours)	Plant height (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	19.06	24.37^{a}	27.78^{a}	29.51^{a}	28.79	31.41	33.23	34.67	36.91	38.32	39.10^{a}	39.39^{a}
T_2 (Yellow)	19.51	24.07^{a}	24.24^{b}	25.36^{b}	28.31	31.12	33.50	33.56	35.00	36.13	37.65^{ab}	37.77^{ab}
T_3 (Green)	18.90	24.30^{a}	23.26^{bc}	25.08^{bc}	31.39	31.07	32.65	34.24	35.41	36.00	36.15^{bc}	35.41^{bc}
T_4 (Blue)	19.02	20.89^{b}	21.85^{c}	23.67^{c}	27.00	29.70	31.81	32.59	34.70	35.79	34.65^{c}	33.75^{c}
T_5 (Black)	17.14	23.93^{a}	27.16^{a}	30.28^{a}	27.50	30.41	33.95	35.70	36.00	37.62	38.34^{ab}	38.25^{ab}

Table 4: Effect of different coloured shade nets on the plant height of *Spathiphyllum wallisii*

Treatments (Shade net colours)	Plant height (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	30.75^{a}	33.58	32.38	33.67^{a}	37.50^{ab}	41.6^{bc}	42.87^{bc}	47.38^{ab}	47.83^{b}	54.67^{a}	59.72^{a}	63.34^{a}
T_2 (Yellow)	24.45^{b}	32.66	30.40	33.45^{a}	37.00^{abc}	43.00^{b}	44.67^{b}	45.76^{abc}	47.08^{b}	52.45^{ab}	57.35^{a}	59.49^{a}
T_3 (Green)	29.96^{a}	32.17	29.35	30.20^{b}	34.16^{bc}	39.25^{c}	42.95^{bc}	44.87^{bc}	45.1^{bc}	50.55^{b}	51.65^{b}	52.59^{b}
T_4 (Blue)	25.04^{b}	30.31	28.89	29.20^{b}	33.58^{c}	39.89^{bc}	41.08^{c}	42.72^{c}	43.29^{c}	44.79^{c}	47.90^{c}	48.67^{b}
T_5 (Black)	30.32^{a}	29.76	30.61	34.24^{a}	38.34^{a}	47.34^{a}	48.54^{a}	49.29^{a}	52.9^{a}	55.35^{a}	57.65^{a}	60.58^{a}

Table 5: Effect of different coloured shade nets on the plant height of *Chrysothemis pulchella*

Treatments (Shade net colours)	Plant height (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	13.51	22.92^{a}	29.44^{a}	35.01^{a}	39.58^{a}	45.50^{a}	49.85^{a}	51.69^{a}	51.00^{a}	52.40^{a}	47.82^{a}	41.36^{a}
T_2 (Yellow)	13.42	22.20^{ab}	28.80^{a}	30.68^{b}	31.83^{b}	30.83^{b}	34.04^{b}	36.02^{b}	36.41^{b}	37.31^{b}	38.50^{b}	25.66^{b}
T_3 (Green)	14.87	25.38^{a}	28.05^{a}	31.99^{ab}	33.58^{b}	36.85^{b}	33.25^{b}	32.60^{b}	36.91^{b}	38.50^{b}	37.35^{b}	36.95^{a}
T_4 (Blue)	15.40	23.32^{a}	27.03^{ab}	29.17^{b}	31.45^{b}	30.87^{b}	36.25^{b}	35.95^{b}	38.20^{b}	40.68^{b}	38.73^{b}	35.65^{a}
T_5 (Black)	14.34	18.67^{b}	23.77^{b}	29.02^{b}	39.25^{a}	44.52^{a}	47.70^{a}	47.94^{a}	50.06^{a}	47.77^{a}	43.95^{a}	41.19^{a}

The height of *Cordyline terminalis* was influenced significantly by the treatments except during the 1st month after planting. The plants grown under red net were the tallest throughout the year and recorded the maximum height of 122.49 cm during the 12th month after planting. This was followed by plants under blue and yellow nets which were on par with one another from the 4th month onwards. The plants under green net were intermediate in height while plants under black net were the shortest (93.71 cm) (Table 7).

4.1.1.2. Plant spread (cm^2)

Plant spread was recorded in two ways viz., north-south and east-west and presented by multiplying both the values in such a way to show the total area covered by a plant.

The spread of *Nephrolepis exaltata* was significantly different throughout the year. The plants grown under red net recorded the maximum spread (4297.96 cm^2) and it was on par with plants grown under black net almost throughout the year, except during the 2nd, 3rd and 4th months after planting. The plants under green and blue nets had a comparatively lower plant spread, throughout the year. Medium spread was observed in plants under yellow net recording values on par with the highest (T_1 and T_5) during the 5th, 7th, 8th and 9th months while during the 2nd, 3rd, 4th and 12th months after planting it was on par with green and blue (T_3 and T_4) (Table 8).

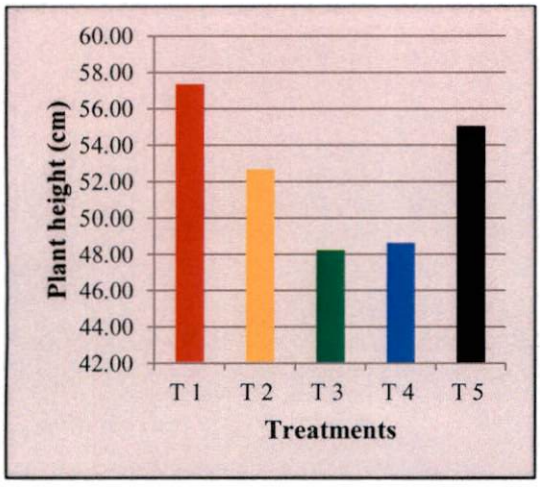
In *Asparagus* sp., plant spread did not differ much with different treatments. Significance was found only in the 1st, 4th, 9th and 10th months. During these months the highest spread was recorded in plants grown under black net (469.21, 778.60, 1212.04 and 1311.62 cm^2 respectively) and it was on par with plants under red net (316.34, 783.75, 1193.91 and 1334.33 cm^2 respectively). The spread of plants under yellow, green and blue coloured shade nets did not differ much. The lowest spread value (887.25 cm^2) was recorded during the 9th month in plants under the blue net (Table 9).

Table 6: Effect of different coloured shade nets on the plant height of *Tradescantia spathacea* 'Sitara'

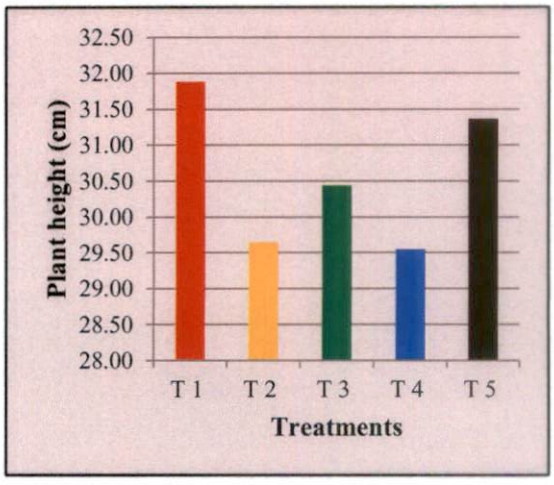
Treatments (Shade net colours)	Plant height (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	21.71^{a}	23.40	26.52^{a}	26.88	30.91^{a}	30.85^{ab}	36.12^{a}	38.54^{a}	37.51^{a}	38.30^{a}	34.64^{a}	33.00
T_2 (Yellow)	18.50^{b}	21.78	26.20^{ab}	27.60	28.08^{abc}	29.58^{abc}	30.84^{b}	31.30^{bc}	31.79^{b}	32.26^{b}	32.41^{b}	30.34
T_3 (Green)	17.13^{bc}	20.25	24.15^{bc}	26.22	26.16^{bc}	27.95^{bc}	29.45^{b}	29.54^{c}	31.75^{b}	31.57^{b}	31.48^{b}	29.50
T_4 (Blue)	15.37^{c}	22.97	23.04^{c}	26.14	25.41^{c}	26.34^{c}	29.95^{b}	29.59^{c}	30.94^{b}	31.21^{b}	31.20^{b}	30.85
T_5 (Black)	19.64^{ab}	23.80	25.01^{abc}	26.44	28.82^{ab}	31.80^{a}	32.74^{ab}	32.54^{b}	33.77^{b}	33.26^{b}	32.72^{b}	32.32

Table 7: Effect of different coloured shade nets on the plant height of *Cordyline terminalis*

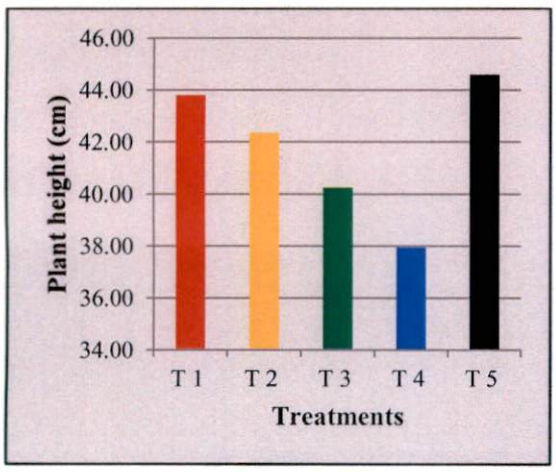
Treatments (Shade net colours)	Plant height (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	51.52	72.89^{a}	81.41^{a}	90.00^{a}	99.03^{a}	105.51^{a}	112.87^{a}	114.75^{a}	116.91^{a}	119.12^{a}	119.90^{a}	122.49^{a}
T_2 (Yellow)	41.9	62.58^{b}	72.00^{ab}	82.12^{a}	87.00^{ab}	96.02^{ab}	99.95^{ab}	101.82^{ab}	105.25^{ab}	108.50^{ab}	109.78^{ab}	111.55^{ab}
T_3 (Green)	47.12	58.22^{bc}	66.19^{b}	69.34^{b}	78.62^{b}	86.34^{bc}	93.37^{bc}	96.01^{bc}	98.16^{b}	98.40^{bc}	102.62^{bc}	104.57^{bc}
T_4 (Blue)	47.96	64.74^{ab}	76.14^{a}	84.80^{a}	90.72^{ab}	98.00^{ab}	102.40^{ab}	104.80^{ab}	106.34^{ab}	110.74^{ab}	115.30^{ab}	117.44^{ab}
T_5 (Black)	45.81	49.45^{c}	53.41^{c}	58.14^{b}	64.08^{c}	74.28^{c}	79.45^{c}	84.35^{c}	89.70^{b}	90.20^{c}	90.75^{c}	93.71^{c}



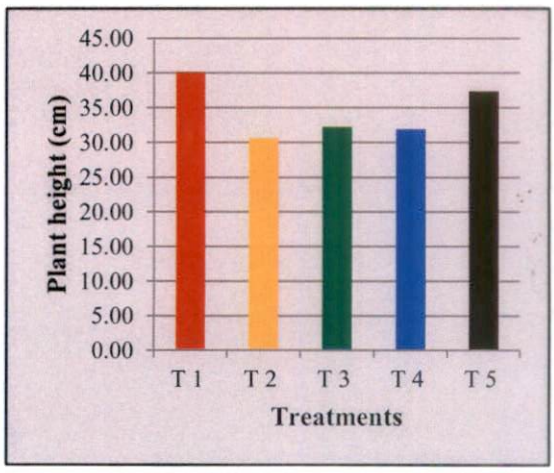
Nephrolepis exaltata



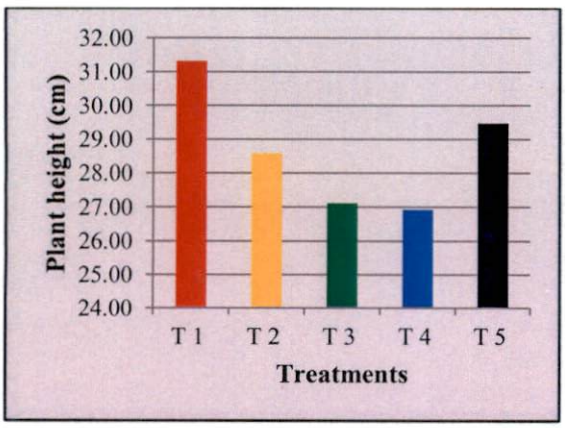
Asparagus sp.



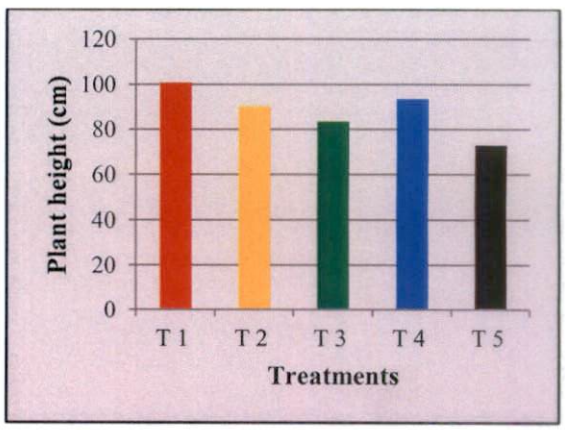
Spathiphyllum wallisii



Chrysothemis pulchella



Tradescantia spathacea **'Sitara'**



Cordyline terminalis

Fig. 1: Plant height of selected ornamentals under different coloured shade nets

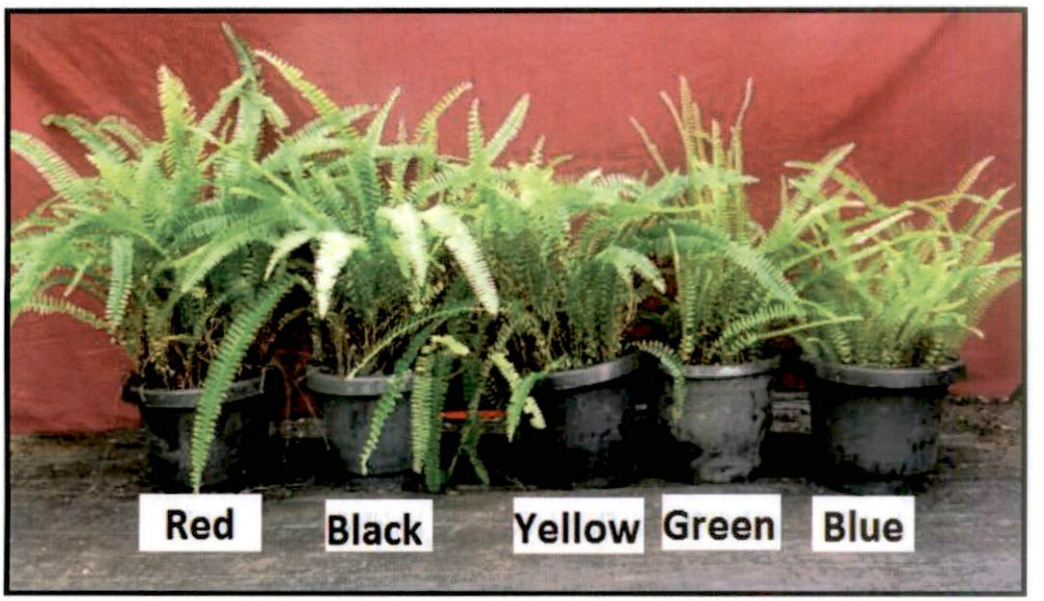


Plate 2a: Plant height of *Nephrolepis exaltata* under different coloured shade nets

Plate 2b: Plant height of *Asparagus* sp. under different coloured shade nets

Plate 2c: Plant height of *Spathiphyllum wallisi* under different coloured shade nets

Plate 2d: Plant height of *Chrysothemis pulchella* under different coloured shade nets

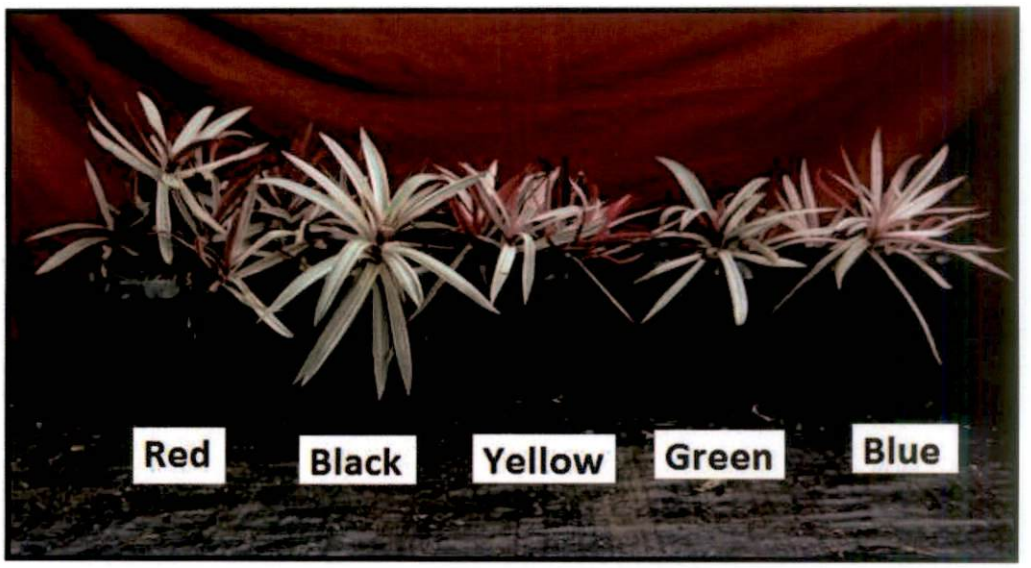


Plate 2e: Plant height of *Tradescantia spathacea* 'Sitara' under different coloured shade nets

Plate 2f: Plant height of *Cordyline terminalis* under different coloured shade nets

Table 8: Effect of different coloured shade nets on the plant spread (EW x NS) of *Nephrolepis exaltata*

Treatments (shade net colours)	Plant spread (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	818.21^{a}	1344.99^{a}	1492.03^{a}	1849.87^{a}	2956.58^{a}	3876.33^{ab}	4187.45^{a}	4173.85^{a}	3518.91^{a}	3873.50^{a}	4277.91^{a}	4297.96^{a}
T_2 (Yellow)	651.17^{ab}	1059.74^{b}	1181.16^{b}	1419.25^{b}	2765.58^{a}	3407.50^{bc}	4205.41^{a}	4053.83^{a}	3637.95^{a}	3106.04^{b}	3140.16^{b}	3068.51^{b}
T_3 (Green)	595.76^{b}	970.15^{b}	1227.13^{b}	1542.97^{b}	3038.75^{a}	2670.58^{c}	2832.58^{b}	2960.83^{b}	2057.71^{c}	2345.92^{c}	2571.16^{c}	2626.52^{b}
T_4 (Blue)	520.56^{b}	904.59^{b}	1046.16^{b}	1420.29^{b}	1899.08^{b}	2951.50^{c}	2976.16^{b}	3258.83^{b}	2556.08^{b}	2306.29^{c}	2648.25^{bc}	3021.48^{b}
T_5 (Black)	804.04^{a}	1006.93^{b}	1129.50^{b}	1364.05^{b}	3393.91^{a}	4428.08^{a}	4416.33^{a}	4389.36^{a}	3519.25^{a}	4136.43^{a}	4406.64^{a}	4499.10^{a}

Table 9: Effect of different coloured shade nets on the plant spread (EW x NS) of *Asparagus* sp.

Treatments (shade net colours)	Plant spread (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	316.34^{b}	607.61	560.53	783.75^{a}	1169.33	1179.66	1278.41	1361.66	1193.91^{ab}	1334.33^{a}	1517.83	1573.10
T_2 (Yellow)	324.83^{b}	586.97	602.75	671.00^{b}	1030.41	1051.58	1141.25	1151.08	1080.45^{ab}	1141.25^{ab}	1267.41	1453.73
T_3 (Green)	318.39^{b}	538.43	640.70	620.87^{b}	955.16	1032.58	1098.91	1118.25	1013.50^{bc}	1108.25^{b}	1319.50	1531.02
T_4 (Blue)	304.47^{b}	499.17	544.81	618.36^{b}	885.75	872.91	1047.83	1121.61	887.25^{c}	1075.66^{b}	1231.83	1414.62
T_5 (Black)	469.21^{a}	590.67	657.08	778.60^{a}	1169.33	1050.25	1236.00	1226.90	1212.04^{a}	1311.62^{a}	1372.42	1534.25

Spread of *Spathiphyllum wallisii,* significantly differed during the 2nd, 3rd, 4th, 5th, 8th and 9th months after planting. The maximum spread throughout the year was observed in plants grown under black net followed by red (T_1), yellow (T_2) and green (T_3) nets. Plants grown under red, yellow and green nets during the 9th month after planting recorded values (1795.64, 1632.41 and 1624.62 cm) which were on par with the plants under black net. The plants grown under blue coloured net had the lowest spread (Table 10).

Chrysothemis pulchella showed significant difference in spread throughout the year except during the 2nd, 7th and 8th months after planting. Plants under red net had a higher spread throughout the year. The value (1320.40 cm^2) recorded during the 12th month after planting was on par with plants under green, blue and black nets (1418.74, 1299.80 and 1252.93 cm^2 respectively). This was followed by spread of plants under black net while plants under green net showed a medium spread. The plants grown under yellow and blue nets had the lowest spread (Table 11).

Tradescantia spathacea 'Sitara' showed significant difference in spread among the treatments during 1st, 2nd, 3rd, 4th, 9th, 10th and 11th months. The maximum spread throughout the year was observed in plants grown under red followed by black nets. The maximum spread (1543.99 cm^2) was observed during the 12th month. The plants under yellow, green and blue had medium spread and the values recorded are on par with one another (Table 12).

When plant spread in *Cordyline terminalis* among different treatments was compared, significant difference was observed during the 1st, 2nd, 3rd, 4th, 9th, 11th and 12th months. The highest spread throughout the year was recorded in plants grown under red net. The plants under yellow and blue nets recorded medium spread with values on par with the highest during 12th month after planting while plants under green and black nets recorded the lowest spread consistently throughout the year (Table 13).

Table 10: Effect of different coloured shade nets on the plant spread (EW x NS) of *Spathiphyllum wallisii*

Treatments (shade net colours)	Plant spread (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	416.74	701.51^{a}	772.15^{ab}	1002.08^{a}	1167.58^{ab}	1517.08	1564.25	1686.08^{b}	1795.64^{a}	1985.54	2141.38	2315.66
T_2 (Yellow)	442.14	512.31^{b}	658.70^{b}	852.91^{ab}	1020.16^{bc}	1427.33	1516.41	1638.20^{b}	1632.41^{a}	1823.66	1992.58	2297.7
T_3 (Green)	452.08	645.49^{ab}	738.17^{ab}	863.83^{a}	1234.66^{ab}	1332.32	1452.58	1622.83^{b}	1624.62^{a}	1734.08	1910.21	2189.58
T_4 (Blue)	381.13	501.26^{b}	499.78^{c}	696.76^{b}	906.25^{c}	1276.41	1421.58	1569.00^{b}	1408.50^{b}	1681.25	1903.58	2124.44
T_5 (Black)	559.09	753.83^{a}	857.10^{a}	996.58^{a}	1357.50^{a}	1536.16	1779.25	1999.79^{a}	1775.58^{a}	1901.33	2091.66	2325.71

Table 11: Effect of different coloured shade nets on the plant spread (EW x NS) of *Chrysothemis pulchella*

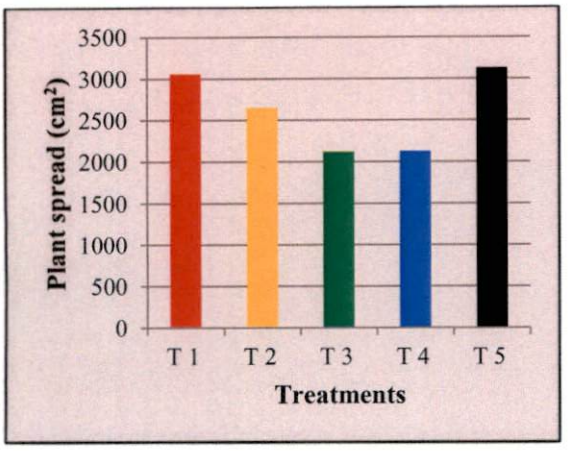
Treatments (shade net colours)	Plant spread (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	561.76^{a}	729.68	1193.31^{a}	1448.83^{ab}	2391.08^{a}	2689.00^{a}	2070.83	2247.75	2229.27^{a}	2404.50^{a}	1402.07^{ab}	1418.74^{a}
T_2 (Yellow)	330.71^{b}	767.66	793.16^{b}	1172.56^{c}	2371.00^{a}	1757.16^{bc}	1708.75	2006.37	1238.52^{d}	1301.29^{c}	929.77^{c}	710.39^{b}
T_3 (Green)	347.34^{b}	812.36	1146.20^{a}	1387.91^{ab}	2321.00^{a}	1966.34^{b}	1986.58	2088.19	1871.00^{bc}	1645.79^{b}	1114.05^{bc}	1299.80^{a}
T_4 (Blue)	356.25^{b}	621.37	985.60^{ab}	1251.29^{bc}	1312.34^{b}	1353.58^{c}	1408.16	1944.41	1652.67^{c}	1788.25^{b}	982.66^{c}	1252.93^{a}
T_5 (Black)	288.69^{b}	871.36	1157.41^{a}	1460.41^{a}	1886.16^{a}	1652.50^{bc}	1911.75	2124.33	1973.16^{ab}	2201.50^{a}	1507.83^{a}	1320.40^{a}

Table 12: Effect of different coloured shade nets on the plant spread (EW x NS) of *Tradescantia spathacea* 'Sitara'

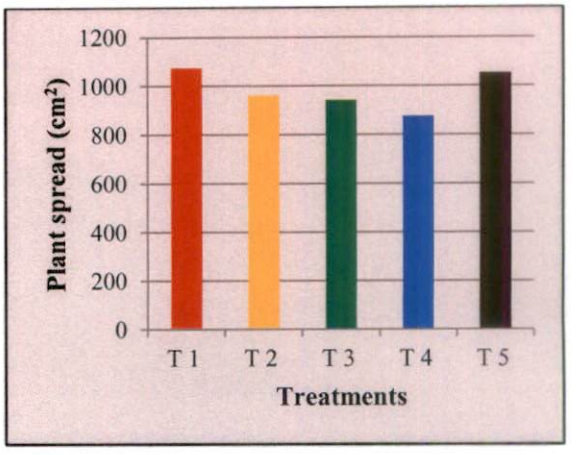
Treatments (shade net colours)	Plant spread (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	569.05^{ab}	920.73^{a}	997.14^{a}	1128.51^{a}	1405.33	1281.83	1355.25	1422.41	1466.37^{a}	1423.91^{a}	1478.70^{a}	1543.99
T_2 (Yellow)	402.02^{c}	779.92^{ab}	823.00^{b}	813.75^{c}	1093.50	1289.00	1303.50	1308.58	1166.16^{b}	1139.67^{bc}	1198.16^{b}	1334.45
T_3 (Green)	413.42^{bc}	760.25^{ab}	795.79^{b}	819.12^{bc}	1229.00	1120.66	1038.75	1137.81	963.45^{c}	1212.83^{bc}	1234.00^{b}	1450.99
T_4 (Blue)	368.12^{c}	640.87^{b}	710.50^{b}	769.15^{c}	1176.25	1131.25	1339.33	1362.66	912.41^{c}	1072.33^{c}	1175.83^{b}	1292.13
T_5 (Black)	693.98^{a}	881.98^{a}	826.22^{b}	949.39^{b}	1229.00	1192.58	1341.25	1413.70	1201.75^{b}	1307.12^{ab}	1283.74^{b}	1485.06

Table13: Effect of different coloured shade nets on the plant spread (EW x NS) of *Cordyline terminalis*

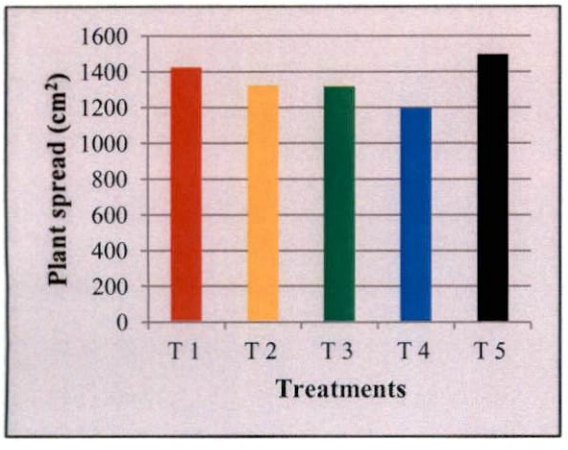
Treatments (shade net colours)	Plant spread (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	1880.04^{a}	3181.07^{a}	3330.08^{a}	3484.83^{a}	3237.50	3384.83	3757.33	3913.41	3956.08^{a}	3730.16	3474.33^{a}	3798.72^{a}
T_2 (Yellow)	1455.78^{b}	2251.79^{b}	2476.84^{b}	2737.25^{bc}	2799.83	3050.08	3334.83	3564.25	3361.66^{b}	3262.41	3063.91^{ab}	3587.05^{a}
T_3 (Green)	1383.35^{bc}	1957.00^{bc}	2164.39^{bc}	2507.91^{c}	2873.58	2971.58	2880.66	3187.08	2590.02^{d}	2942.18	2446.83^{c}	2674.02^{b}
T_4 (Blue)	886.84^{d}	2278.25^{b}	2601.50^{b}	3105.33^{b}	2976.66	2979.16	3469.91	3688.16	3076.24^{bc}	3272.66	3407.12^{a}	3703.95^{a}
T_5 (Black)	1088.06^{cd}	1511.97^{c}	1700.16^{c}	1937.55^{d}	2669.16	3181.16	3130.25	3438.04	2719.64^{cd}	2996.12	2599.33^{bc}	2799.40^{b}



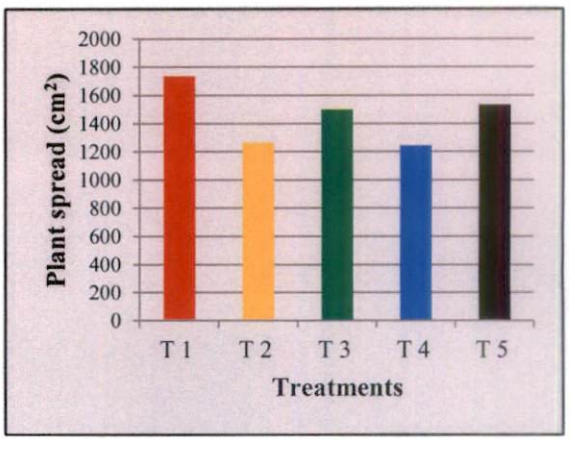
Nephrolepis exaltata



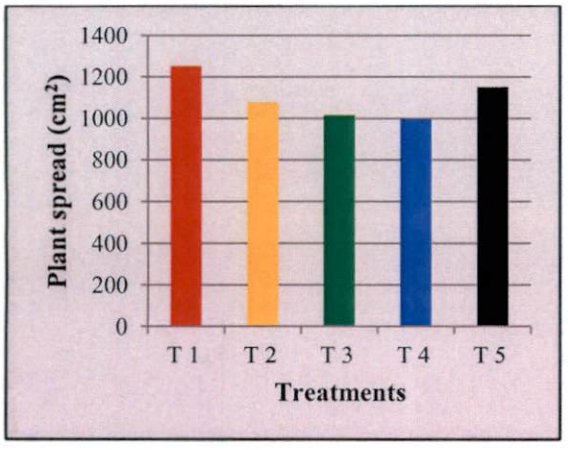
Asparagus **sp.**



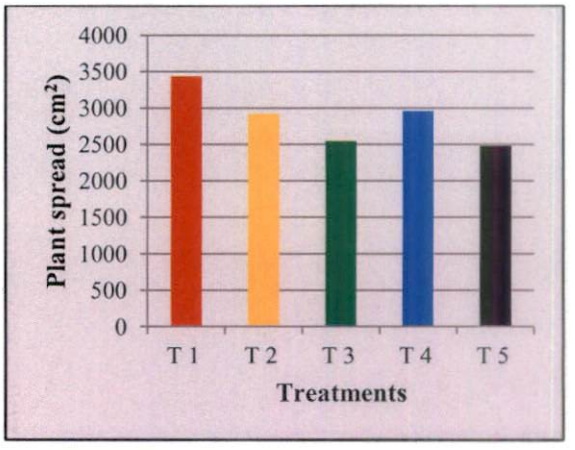
Spathiphyllum wallisii



Chrysothemis pulchella



Tradescantia spathacea **'Sitara'**



Cordyline terminalis

Fig. 2: Plant spread of selected ornamentals under different coloured shade nets

4.1.1.3. Leaf area (cm^2)

The adaptability of a plant to a particular location is determined by its leaf area. Using dot method, the leaf area was measured at monthly intervals and the results are presented in Tables 14 to 19.

In *Nephrolepis exaltata*, significant difference in leaf area was observed except during the 2nd and 3rd months. It was found that plants grown under black net had the highest leaf area throughout the year. The highest value (251.0 cm^2) was recorded during 12 months after planting which was followed by plants under red and yellow nets (212.00 and 209.50 cm^2, respectively). The lowest leaf area was exhibited by plants grown under green and blue nets (151.0 cm^2 and 157.25 cm^2 respectively) throughout the year (Table 14).

In *Asparagus* sp., leaf area was not significant under the different coloured shade nets during the later stage. However, significant difference was observed during certain months. When they were compared, the highest leaf area (213.87 cm^2) was found in plants grown under red net during the 10th month and it was significantly superior to the other net colour. Rest of the nets affected almost equal with each other (Table 15).

Spathiphyllum wallisii showed a significant variation among treatments during the later stages of growth (Table 16). It was observed that plants grown under black net had the largest leaves throughout the year. The maximum area of 258.12 cm^2 was recorded during the 12th month and it was on par with plants under red and blue nets. The plants under green net had comparatively smaller leaf area (198.0 cm^2) which was closely followed by plants under yellow coloured net (217.12 cm^2).

The leaf area of *Chrysothemis pulchella*, was found to be influenced significantly throughout the year except during the 2nd and 3rd months after planting (Table 17). It was observed that a higher leaf area was maintained consistently by plants grown under the black net. The maximum area of 127.37 cm^2 was recorded during the 7th month. During the 12th month, the plants grown

Table 14: Effect of different coloured shade nets on the leaf area of *Nephrolepis exaltata*

Treatments (Shade net colours)	Leaf area (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	137.47^{b}	157.62	173.5	222.25^{a}	206.87^{ab}	210.00^{ab}	222.25^{a}	236.00^{a}	219.57^{ab}	212.50^{b}	213.12^{b}	212.00^{b}
T_2 (Yellow)	121.72^{b}	135.87	137.5	181.75^{ab}	198.37^{abc}	208.50^{b}	209.87^{ab}	220.12^{ab}	204.00^{bc}	209.37^{bc}	211.75^{b}	209.50^{b}
T_3 (Green)	123.00^{b}	145.25	158	164.00^{b}	158.00^{c}	151.12^{c}	163.62^{b}	181.42^{b}	184.37^{c}	166.50^{d}	169.50^{c}	151.00^{c}
T_4 (Blue)	123.42^{b}	132.12	141.87	150.50^{b}	161.85^{bc}	155.37^{c}	165.10^{b}	175.62^{b}	176.25^{c}	175.07^{c}	174.87^{c}	157.25^{c}
T_5 (Black)	179.42^{a}	177.5	173.75	227.50^{a}	243.85^{a}	247.25^{a}	238.75^{a}	250.75^{a}	252.12^{a}	253.00^{a}	253.50^{a}	251.00^{a}

Table 15: Effect of different coloured shade nets on the leaf area of *Asparagus* sp.

Treatments (Shade net colours)	Leaf area (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	98.50	132.12^{a}	145.20^{a}	137.25	162.00^{a}	164.00	141.37	191.25^{a}	189.00^{a}	213.87^{a}	177.25	193.25
T_2 (Yellow)	86.87	96.62^{b}	109.35^{b}	129.75	116.37^{b}	137.25	150.10	138.72^{b}	145.50^{b}	141.75^{b}	137.50	142.25
T_3 (Green)	90.87	110.45^{ab}	122.25^{ab}	126.50	120.97^{b}	127.50	134.70	138.75^{b}	134.95^{b}	140.75^{b}	134.05	140.25
T_4 (Blue)	89.27	104.37^{b}	112.25^{b}	116.50	119.62^{b}	134.37	133.22	147.10^{b}	150.62^{b}	160.70^{b}	161.50	187.75
T_5 (Black)	91.75	114.92^{a}	133.87^{ab}	142.25	135.75^{b}	145.37	139.62	151.50^{b}	161.12^{ab}	163.75^{b}	172.75	189.00

Table 16: Effect of different coloured shade nets on the leaf area of *Spathiphyllum wallisii*

Treatments (Shade net colours)	Leaf area (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	98.97^{b}	106.50	99.75	104.75	120.62	164.87^{ab}	186.50^{ab}	209.62^{ab}	213.12^{ab}	223.62^{abc}	241.37^{ab}	234.75^{ab}
T_2 (Yellow)	94.57^{b}	90.37	92.00	104.00	126.00	146.37^{b}	143.12^{c}	165.12^{c}	193.37^{b}	208.87^{bc}	221.25^{bc}	217.12^{bc}
T_3 (Green)	95.75^{b}	98.72	95.75	116.75	130.75	142.87^{b}	174.00^{bc}	186.00^{bc}	187.00^{b}	201.85^{c}	204.12^{c}	198.00^{c}
T_4 (Blue)	103.37^{ab}	102.00	98.25	112.75	135.12	161.12^{b}	169.37^{bc}	192.12^{abc}	209.87^{b}	226.62^{ab}	229.00^{abc}	233.00^{ab}
T_5 (Black)	115.10^{a}	109.50	96.72	122.25	133.10	198.50^{a}	215.50^{a}	231.47^{a}	242.10^{a}	244.87^{a}	250.00^{a}	258.12^{a}

Table 17: Effect of different coloured shade nets on the leaf area of *Chrysothemis pulchella*

Treatments (Shade net colours)	Leaf area (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	82.50^{ab}	84.87	88.25	103.25^{ab}	108.57^{ab}	112.10^{ab}	104.62^{b}	96.00^{b}	99.87^{b}	100.85^{ab}	94.50^{ab}	93.50^{a}
T_2 (Yellow)	78.50^{bc}	81.50	85.25	85.75^{b}	85.12^{c}	88.62^{c}	88.00^{b}	92.07^{b}	92.30^{b}	89.85^{b}	83.87^{c}	65.75^{b}
T_3 (Green)	67.40^{c}	78.00	81.50	86.25^{b}	93.45^{bc}	98.97^{bc}	91.62^{b}	89.32^{b}	88.50^{b}	87.07^{b}	89.25^{bc}	70.50^{b}
T_4 (Blue)	85.67^{ab}	97.12	89.50	92.00^{b}	102.75^{bc}	105.50^{abc}	99.82^{b}	99.70^{b}	93.50^{b}	94.60^{b}	89.00^{bc}	80.25^{ab}
T_5 (Black)	93.25^{a}	89.35	106.00	121.25^{a}	122.37^{a}	125.12^{a}	127.37^{a}	120.17^{a}	122.87^{a}	114.87^{a}	103.72^{a}	93.00^{a}

under red net recorded an area of 93.50 cm^2 which was on par with black coloured net (93.00 cm^2). The plants under blue, green and yellow coloured nets were almost equal in their leaf area.

A significant difference in leaf area of *Tradescantia spathacea* 'Sitara', was observed during 6^{th}, 7^{th}, 9^{th}, 11^{th} and 12^{th} months after planting. The plants grown under black net had the largest leaves that were on par with red and yellow coloured nets during the 11^{th} and 12^{th} months after planting. The plants under green net had a medium leaf area while those under blue net had the minimum (49.50 cm^2) leaf area (Table 18).

In *Cordyline terminalis*, during the later stage a considerable influence of the treatments on the leaf area of the plants was observed. The plants grown under red net were found to be having the largest leaves. The maximum area of 299.00 cm^2 was reached during the 10^{th} month after planting. This was followed by plants under blue net. The leaf area of plants under green and black nets was medium while the area under yellow net was the minimum. However, T_3, T_5 and T_2 recorded values on par during the 10^{th} and 11^{th} months after planting (Table 19).

4.1.1.4. Number of leaves

The vigour of a plant is decided by the number of leaves it produces. The total number of leaves in a plant also determines the physiological functions like photosynthesis and transpiration. The number of leaves per plant was recorded at monthly interval in this study.

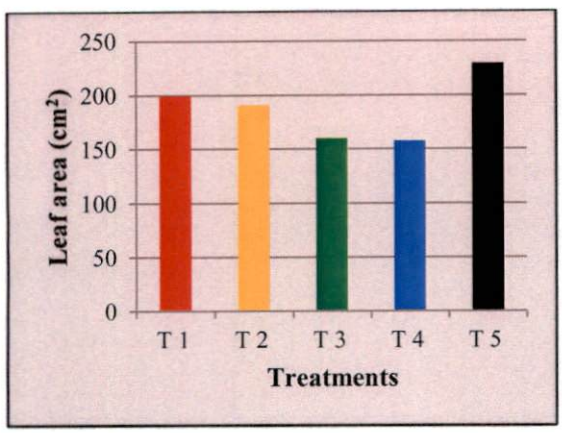
The colour of nets influenced the production of leaves in *Nephrolepis exaltata* throughout the year (Table 20). The maximum number of leaves was recorded in plants grown under red net with consistently higher values throughout the year except in the 11^{th} month (48.83) when it was higher in plants under black net (53.83). The values recorded were on par with the plants under black net from the 5^{th} month onwards. The plants under blue net had medium number of leaves. The plants under green and yellow nets produced the lowest number of leaves per plant (47.50 and 47.25, respectively).

Table 18: Effect of different coloured shade nets on the leaf area of *Tradescantia spathacea* 'Sitara'

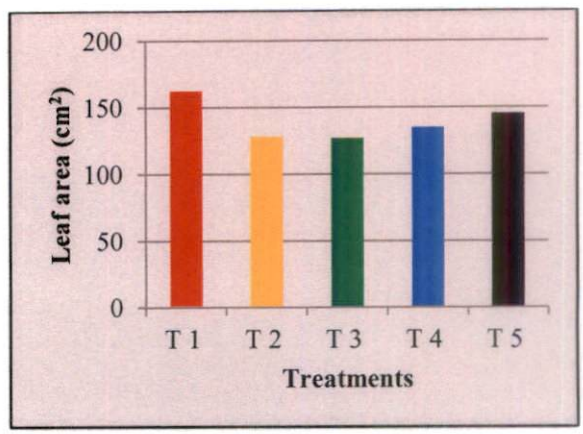
Treatments (Shade net colours)	Leaf area (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	46.25	48.25	52.00	50.75	50.62	52.50^{ab}	53.00^{b}	53.62	56.00^{ab}	58.22	60.25^{a}	61.75^{a}
T_2 (Yellow)	44.07	46.25	47.00	43.50	48.62	51.37^{b}	52.75^{b}	55.75	55.87^{ab}	57.12	58.25^{a}	59.75^{a}
T_3 (Green)	39.45	42.75	46.00	49.50	48.12	49.00^{b}	52.25^{b}	51.62	51.75^{b}	54.62	55.75^{ab}	56.50^{ab}
T_4 (Blue)	43.07	44.50	44.00	45.75	49.50	50.37^{b}	51.87^{b}	52.37	52.37^{b}	51.00	49.37^{b}	49.50^{b}
T_5 (Black)	46.62	49.37	53.00	51.25	54.37	58.00^{a}	59.75^{a}	57.25	60.37^{a}	59.12	62.50^{a}	62.50^{a}

Table 19: Effect of different coloured shade nets on the leaf area of *Cordyline terminalis*

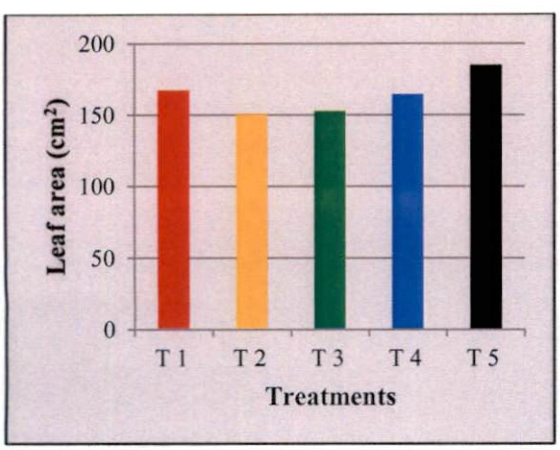
Treatments (Shade net colours)	Leaf area (cm^2)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	167.25	172.62	216.00	236.00	236.37	258.12^{a}	279.87^{a}	279.50^{a}	280.12^{a}	299.00^{a}	282.10^{a}	211.00
T_2 (Yellow)	148.25	180.25	194.50	193.25	193.20	200.50^{b}	225.32^{b}	225.37^{c}	224.25^{c}	244.12^{b}	237.37^{b}	236.75
T_3 (Green)	180.87	208.35	197.25	203.75	206.62	236.12^{a}	246.37^{b}	261.45^{ab}	266.75^{ab}	247.62^{b}	246.62^{b}	204.75
T_4 (Blue)	203.00	204.50	201.62	211.25	220.37	247.37^{a}	239.97^{b}	261.25^{ab}	262.37^{ab}	264.37^{b}	264.37^{ab}	252.75
T_5 (Black)	147.50	166.00	172.50	225.00	239.17	243.62^{a}	240.35^{b}	243.40^{bc}	254.45^{b}	247.25^{b}	235.37^{b}	214.25



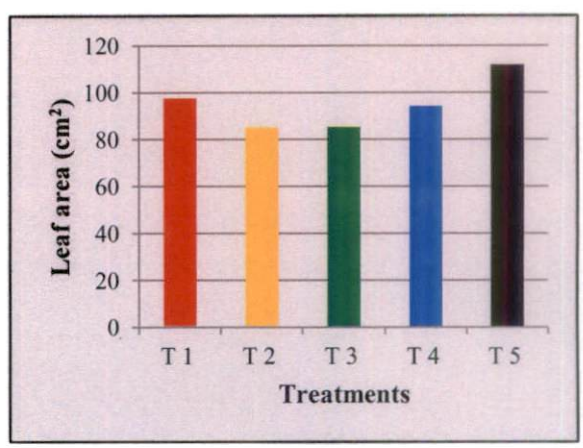
Nephrolepis exaltata



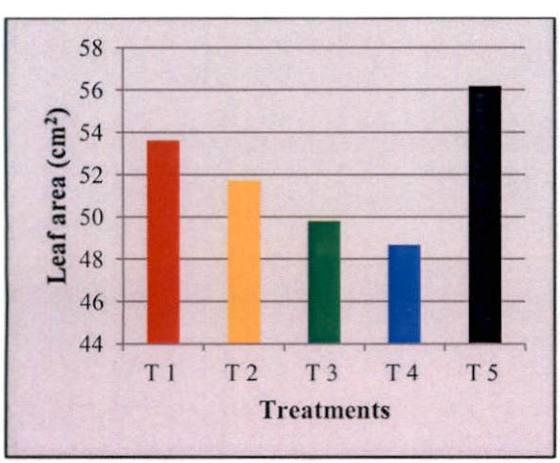
Asparagus sp.



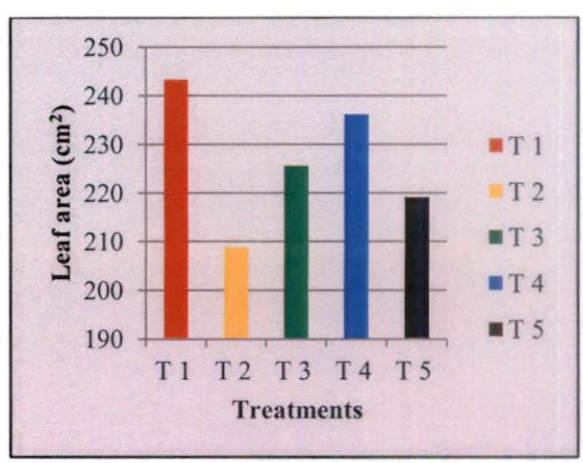
Spathiphyllum wallisii



Chrysothemis pulchella



Tradescantia spathacea **'Sitara'**



Cordyline terminalis

Fig. 3: Leaf area of selected ornamentals under different coloured shade nets

The number of leaves produced was found to vary significantly with treatments in *Asparagus* sp. The highest number of leaves throughout the year was recorded in plants under red and blue coloured nets. Plants under yellow and green nets had medium number of leaves produced while plants under black net had the lowest (32.50) leaf number which was on par with that of the green coloured net during the 3rd, 4th, 5th and 12th months (Table 21).

In *Spathiphyllum wallisii*, significant difference in number of leaves under different coloured nets was observed during the 1st, 7th, 8th, 9th, 10th, 11th and 12th months after planting. The plants grown under blue coloured net produced the highest number of leaves, the maximum being (38.16) produced at 11 months after planting. The rest of the treatments did not differ much and were almost equivalent in the production of leaves (Table 22).

Significant difference between all treatments was observed during the later stage of growth in *Chrysothemis pulchella*. The highest number of leaves was observed in plants grown under red net. The maximum number of leaves (58.58) was produced during the 10th month after planting. This was followed by plants under yellow, green and blue nets (33.41, 33, 30.83 respectively, recorded during the 12th month). The plants grown under black net had the lowest number of leaves (20.58) per plant throughout the year (Table 23).

In *Tradescantia spathacea* 'Sitara', significant difference in leaf production was observed during the 1st, 7th, 8th, 9th, 10th, 11th and 12th months after planting. The plants grown under black coloured net had a comparatively lower number of leaves throughout the year. The other four treatments *viz.*, red, yellow, green and blue did not differ from each other in leaf production in this plant. The results obtained are presented in Table 24.

In *Cordyline terminalis*, significant difference in leaf production was observed during certain months (3rd, 4th, 8th, 9th, 10th and 11th months after planting). During these periods, the plants under red net recorded maximum number of leaves, followed by plants under blue and black coloured nets. The

Table 20: Effect of different coloured shade nets on the number of leaves of *Nephrolepis exaltata*

Treatments (Shade net colours)	Number of leaves											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	31.16^{a}	42.66^{a}	43.16^{a}	47.25^{a}	43.83^{a}	44.75^{ab}	50.58^{a}	50.91^{a}	55.00^{a}	50.66^{abc}	48.83^{b}	46.58
T_2 (Yellow)	21.50^{bc}	33.83^{b}	35.58^{bc}	37.08^{c}	32.75^{b}	36.08^{c}	43.91^{ab}	44.41^{b}	48.25^{b}	47.50^{c}	47.25^{b}	46.00
T_3 (Green)	20.33^{bc}	32.00^{b}	40.25^{ab}	42.66^{b}	41.25^{a}	41.08^{abc}	39.75^{b}	43.83^{b}	47.66^{b}	49.33^{bc}	47.50^{b}	44.16
T_4 (Blue)	19.08^{c}	32.08^{b}	35.33^{c}	39.75^{bc}	41.25^{a}	40.50^{bc}	49.91^{a}	52.91^{a}	54.08^{ab}	54.75^{a}	51.41^{ab}	47.83
T_5 (Black)	24.50^{b}	31.16^{b}	43.41^{a}	42.33^{b}	45.16^{a}	48.00^{a}	51.25^{a}	50.66^{a}	58.00^{a}	53.83^{ab}	53.83^{a}	48.33

Table 21: Effect of different coloured shade nets on the number of leaves of *Asparagus* sp.

Treatments (Shade net colours)	Number of leaves											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	17.75	28.41^{a}	27.75^{ab}	32.75^{a}	40.91^{a}	42.41^{a}	45.75^{a}	46.25^{a}	47.75^{a}	44.33^{ab}	44.25^{ab}	45.33^{a}
T_2 (Yellow)	17.75	23.25^{b}	22.16^{c}	28.66^{ab}	32.91^{b}	31.83^{b}	38.75^{a}	39.91^{b}	43.66^{a}	44.16^{ab}	42.75^{ab}	38.41^{ab}
T_3 (Green)	15.33	25.16^{ab}	23.83^{bc}	24.50^{b}	25.66^{c}	39.83^{ab}	37.91^{a}	39.66^{b}	42.58^{a}	41.75^{b}	38.25^{b}	32.50^{b}
T_4 (Blue)	17.00	25.25^{ab}	29.83^{a}	30.50^{a}	38.25^{ab}	39.41^{ab}	46.16^{a}	46.66^{a}	48.25^{a}	49.58^{a}	48.75^{a}	42.25^{a}
T_5 (Black)	17.16	22.08^{b}	23.66^{bc}	25.33^{b}	25.66^{c}	22.33^{c}	21.58^{b}	24.08^{c}	25.25^{b}	27.83^{c}	30.25^{c}	32.50^{b}

Table 22: Effect of different coloured shade nets on the number of leaves of *Spathiphyllum wallisii*

Treatments (Shade net colours)	Number of leaves											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	5.33^{b}	8.58	10.08	11.84	13.00	15.83	18.00^{b}	23.75^{b}	26.58^{bc}	27.83^{bc}	28.50^{bc}	28.00^{b}
T_2 (Yellow)	5.41^{b}	7.16	8.58	10.41	12.08	14.08	14.34^{b}	17.91^{b}	18.25^{c}	21.50^{c}	24.00^{c}	22.67^{b}
T_3 (Green)	6.16^{b}	8.08	9.83	11.50	11.75	17.91	19.83^{b}	24.41^{b}	28.16^{ab}	30.75^{ab}	30.83^{b}	28.75^{b}
T_4 (Blue)	9.08^{a}	9.34	10.41	14.00	16.50	24.16	30.75^{a}	33.08^{a}	37.08^{a}	35.66^{a}	38.16^{a}	36.34^{a}
T_5 (Black)	5.75^{b}	7.16	10.16	11.34	11.58	14.41	19.34^{b}	23.34^{b}	25.66^{bc}	25.75^{bc}	24.83^{bc}	23.08^{b}

Table 23: Effect of different coloured shade nets on the number of leaves of *Chrysothemis pulchella*

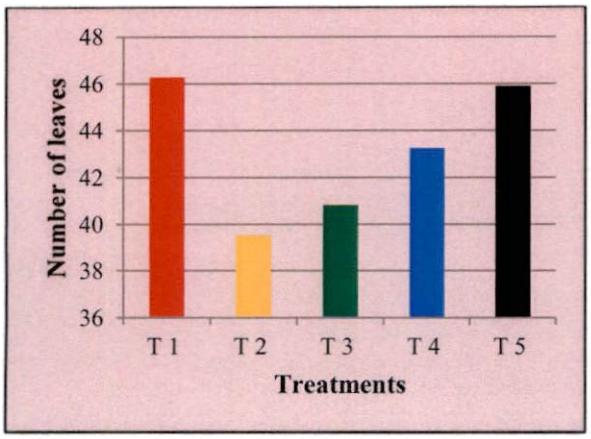
Treatments (Shade net colours)	Number of leaves											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	14.08	28.58	42.16	43.08	51.00	50.58^{ab}	53.41^{a}	57.50^{a}	57.00^{a}	58.58^{a}	36.50^{a}	39.34^{a}
T_2 (Yellow)	15.25	25.50	41.00	41.58	60.16	45.25^{abc}	36.00^{b}	45.50^{b}	45.25^{b}	50.84^{b}	26.16^{b}	33.41^{ab}
T_3 (Green)	16.75	29.91	39.84	44.41	45.83	42.84^{bc}	57.25^{a}	54.66^{a}	54.50^{ab}	51.00^{b}	37.50^{a}	33.00^{ab}
T_4 (Blue)	17.66	28.34	35.00	40.58	57.66	57.16^{a}	51.91^{a}	53.16^{ab}	53.16^{ab}	55.91^{ab}	32.66^{ab}	30.83^{b}
T_5 (Black)	17.91	27.67	35.34	46.16	46.50	34.41^{c}	29.41^{b}	34.25^{c}	32.84^{c}	33.08^{c}	26.58^{b}	20.58^{c}

Table 24: Effect of different coloured shade nets on the number of leaves of *Tradescantia spathacea* 'Sitara'

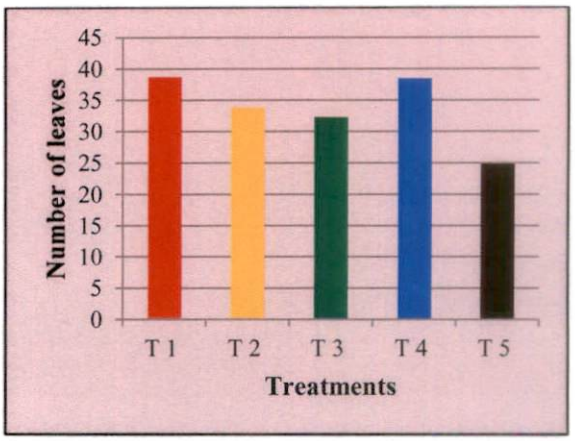
Treatments (Shade net colours)	Number of leaves											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	33.75^{a}	55.75	51.83	52.16	49.67	52.16	52.25^{ab}	55.75^{bc}	61.84^{a}	67.75^{a}	73.34^{a}	73.16^{a}
T_2 (Yellow)	24.34^{bc}	44.58	50.25	49.58	42.16	49.50	58.58^{a}	60.50^{ab}	67.58^{a}	66.08^{a}	62.16^{ab}	67.08^{a}
T_3 (Green)	27.34^{abc}	51.25	56.41	56.50	49.58	43.58	56.66^{a}	62.50^{ab}	63.84^{a}	64.66^{a}	61.58^{ab}	62.16^{ab}
T_4 (Blue)	19.34^{c}	37.50	43.25	48.58	47.41	50.84	68.91^{a}	70.58^{a}	73.84^{a}	68.91^{a}	67.84^{a}	69.25^{a}
T_5 (Black)	30.84^{ab}	20.25	56.41	53.58	47.25	36.91	35.91^{b}	43.41^{c}	44.16^{b}	49.34^{b}	52.50^{b}	52.25^{b}

Table 25: Effect of different coloured shade nets on the number of leaves of *Cordyline terminalis*

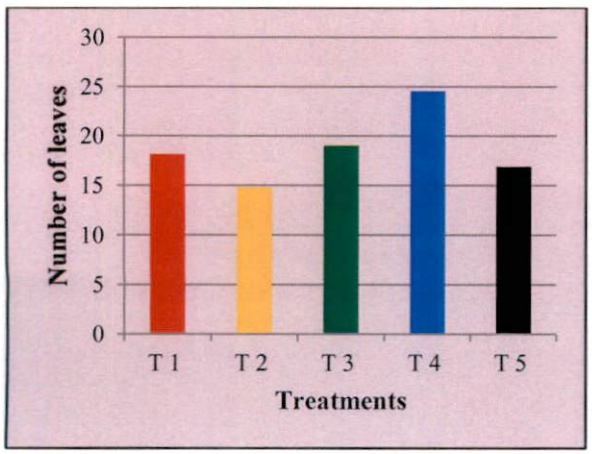
Treatments (Shade net colours)	Number of leaves											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	17.16	20.58	23.25^{a}	22.58^{ab}	21.34	22.50	24.66	26.16^{a}	28.00^{a}	28.08^{a}	25.34^{a}	22.41
T_2 (Yellow)	14.83	18.00	19.75^{b}	19.16^{c}	21.08	18.41	19.66	19.91^{c}	21.58^{b}	21.00^{c}	20.75^{c}	19.75
T_3 (Green)	17.58	19.08	18.34^{b}	19.83^{c}	21.08	22.41	22.91	21.34^{c}	22.60^{b}	21.67^{c}	21.25^{c}	21.34
T_4 (Blue)	17.16	21.16	22.08^{a}	21.91^{b}	21.58	20.16	23.25	25.34^{ab}	25.50^{ab}	27.50^{ab}	24.16^{ab}	25.75
T_5 (Black)	17.41	21.83	23.83^{a}	24.41^{a}	22.91	21.75	22.08	22.58^{bc}	24.41^{ab}	24.08^{bc}	24.66^{a}	24.00



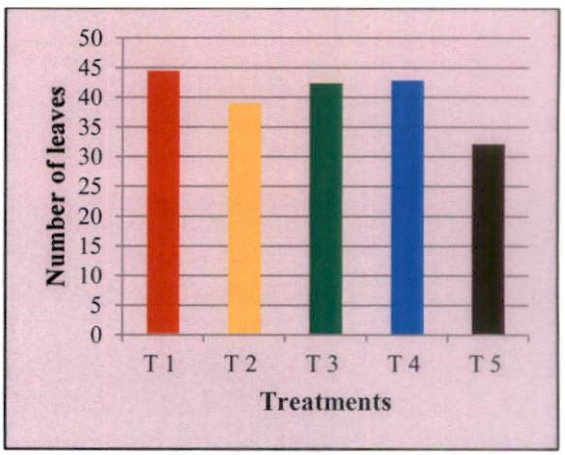
Nephrolepis exaltata



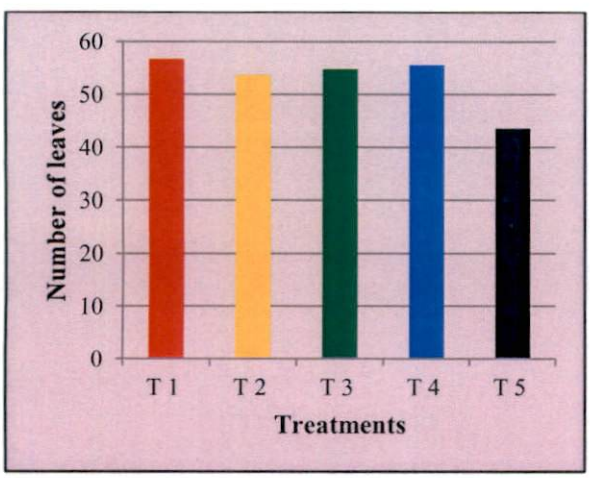
Asparagus **sp.**



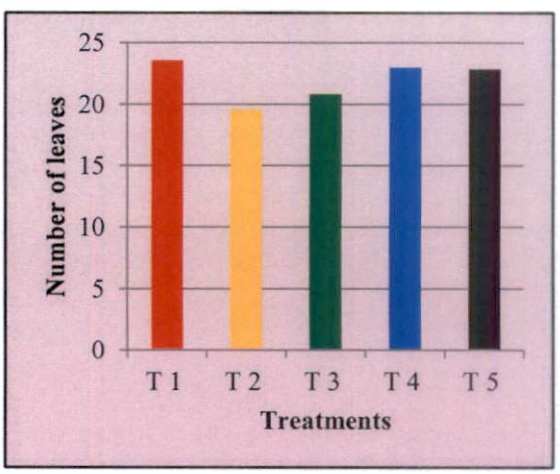
Spathiphyllum wallisii



Chrysothemis pulchella



Tradescantia spathacea **'Sitara'**



Cordyline terminalis

Fig. 4: Number of leaves of selected ornamentals under different coloured shade nets

plants under yellow and green coloured nets recorded the lowest number of leaves throughout the year (Table 25).

4.1.1.5. Length and breadth of leaves (cm)

Leaves are the most important feature of any foliage ornamental plant so it is necessary to study the leaf characters. In this study, the length and breadth of leaves were measured and recorded at monthly interval for a period of one year.

4.1.1.5.1. Leaf length (cm)

Leaf length of *Nephrolepis exaltata* compared under the five different treatments revealed that plants under black coloured net had the longest leaf (53.12 cm) throughout the year, followed by those under red net (52.6 cm). Plants under yellow net produced leaves with medium length while under green and blue nets, the leaves were the shortest (43.44 cm and 40.95 cm respectively) throughout the year (Table 26).

In *Asparagus* sp., significant difference in leaf length was observed during 4^{th}, 10^{th}, 11^{th} and 12^{th} months (Table 27). It was observed that the plants under red, blue and black nets had the longest leaves (33.25, 30.75 and 32.10 cm, respectively, recorded during the 12^{th} month after planting). The plants under yellow net had medium length while those under green net were the shortest (26.34 cm).

Leaf length in *Spathiphyllum wallisii* was found to be significantly different under different nets during the 3^{rd}, 4^{th}, 6^{th}, 7^{th}, 10^{th}, 11^{th} and 12^{th} months after planting. The longest leaves were observed throughout the year in plants under black net. The maximum length of 30.5 cm was recorded during the 10^{th} month after planting. This was followed by plants grown under red and blue coloured nets. The plants under yellow and green nets did not differ much in the length of leaves produced. The treatments T_1, T_2, T_3 and T_4 were on par with each other during the 10^{th} and 12^{th} month after planting (Table 28).

Table 26: Effect of different coloured shade nets on the leaf length of *Nephrolepis exaltata*

Treatments (Shade net colours)	Leaf length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	30.95^{ab}	33.65	36.27	37.72^{bc}	40.89^{bc}	49.20^{a}	53.34^{a}	52.80^{a}	55.22^{a}	52.06^{a}	50.87^{b}	52.60^{a}
T_2 (Yellow)	28.83^{abc}	33.04	35.1	36.87^{c}	43.41^{ab}	47.91^{a}	49.83^{b}	47.40^{b}	49.04^{b}	46.08^{b}	46.34^{c}	44.58^{b}
T_3 (Green)	27.99^{bc}	33.50	34.06	41.06^{a}	40.66^{bc}	41.98^{b}	44.66^{c}	44.70^{b}	45.10^{c}	45.04^{b}	44.68^{c}	43.44^{bc}
T_4 (Blue)	26.85^{c}	33.93	38.45	40.03^{ab}	38.12^{c}	43.45^{b}	46.91^{bc}	45.10^{b}	48.06^{bc}	47.42^{b}	44.66^{c}	40.95^{c}
T_5 (Black)	31.23^{a}	33.77	38.59	42.95^{a}	46.34^{a}	48.06^{a}	53.49^{a}	53.66^{a}	54.15^{a}	54.12^{a}	53.71^{a}	53.12^{a}

Table 27: Effect of different coloured shade nets on the leaf length of *Asparagus* sp.

Treatments (Shade net colours)	Leaf length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	17.82	21.20	22.12	23.29^{a}	24.58	24.66	27.75	28.45	30.16	32.39^{a}	32.66^{a}	33.25^{a}
T_2 (Yellow)	17.00	20.98	21.27	20.00^{b}	22.50	24.66	26.91	27.40	31.08	30.79^{a}	30.04^{bc}	29.32^{ab}
T_3 (Green)	17.13	19.91	22.55	20.93^{b}	24.50	22.90	26.08	28.29	29.41	27.40^{b}	28.09^{c}	26.34^{b}
T_4 (Blue)	17.71	20.52	21.35	23.35^{a}	24.33	25.95	30.08	29.34	32.16	30.69^{a}	31.41^{ab}	30.75^{a}
T_5 (Black)	16.85	21.42	23.85	25.06^{a}	24.00	25.16	30.41	31.70	32.36	32.05^{a}	32.27^{a}	32.10^{a}

In *Chrysothemis pulchella*, significant difference was observed during the 5th, 6th, 8th, 9th, 10th, 11th and 12th months (Table 29). On comparison, it was observed that the longest leaves were produced under black coloured net, and the maximum length being 18.50 cm at 10 months after planting. This was followed by plants under red net (13.97 cm) which was also on par with black during the 11th month after planting. Plants under blue net produce leaves of medium length. The shortest leaves throughout the year were observed in plants under yellow and green coloured nets.

Significant difference in leaf length was observed throughout the year except during the 1st and 7th months in *Tradescantia sapthacea* 'Sitara'. The longest leaves throughout the year were observed in plants under black net and it was on par with plants under red and green nets during the 12th month after planting. The maximum length (19.26 cm) was recorded during the 3rd month. The plants under yellow and green were medium while plants under blue net had the smallest leaves (15.39 cm recorded during 12th month after planting) throughout the year (Table 30).

In *Cordyline terminalis*, significant difference in leaf length was observed during 1st, 3rd, 8th, 9th, 10th and 11th months after planting. It was found that throughout the year, plants under red net had the longest leaves, the maximum length (32.59 cm) being at the 8th month after planting. Plants under blue net followed closely behind and it was on par with those under red during the 3rd, 9th and 11th months after planting. Plants under yellow and green coloured nets recorded medium length while those under black net had the smallest leaves throughout the year (Table 31).

4.1.1.5.2. Leaf breadth (cm)

In *Nephrolepis exaltata*, plants grown under black followed by red coloured nets had the broadest leaves throughout the year. The maximum breadth (5.65 cm) under black net was recorded during the 9th month after planting. The

Table 28: Effect of different coloured shade nets on the leaf length of *Spathiphyllum wallisii*

Treatments (Shade net colours)	Leaf length (cm)											
	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	18.08	18.81	20.45^{b}	23.12^{a}	23.25	25.66^{ab}	26.66^{ab}	27.48	28.34	28.58^{b}	28.90^{ab}	27.78^{b}
T_2 (Yellow)	19.16	18.41	18.57^{c}	20.32^{b}	21.29	23.91^{b}	25.95^{bc}	26.79	27.34	27.37^{b}	27.78^{bc}	27.41^{b}
T_3 (Green)	16.63	17.99	17.49^{c}	19.86^{b}	21.81	24.04^{b}	25.00^{c}	26.06	27.58	27.83^{b}	27.26^{c}	26.67^{b}
T_4 (Blue)	17.30	19.35	21.75^{ab}	23.08^{a}	23.25	25.00^{b}	26.40^{abc}	27.34	28.62	28.34^{b}	28.37^{abc}	26.35^{b}
T_5 (Black)	18.20	19.56	22.80^{a}	23.93^{a}	23.00	26.95^{a}	28.00^{a}	27.48	29.34	30.50^{a}	29.20^{a}	29.99^{a}

Table 29: Effect of different coloured shade nets on the leaf length of *Chrysothemis pulchella*

Treatments (Shade net colours)	Leaf length (cm)											
	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	9.55	13.00	15.35	14.50	13.34^{b}	13.95^{b}	11.91	15.91^{ab}	15.16^{b}	15.77^{b}	13.97^{a}	13.81
T_2 (Yellow)	10.83	11.46	13.70	14.04	12.41^{b}	10.83^{c}	12.00	11.93^{c}	12.33^{d}	13.05^{c}	12.45^{b}	12.72
T_3 (Green)	10.30	12.32	13.95	14.43	12.70^{b}	11.45^{c}	13.75	14.23^{b}	13.07^{cd}	14.99^{b}	12.50^{b}	13.16
T_4 (Blue)	12.07	13.12	14.23	15.63	11.79^{b}	10.80^{c}	14.53	14.93^{b}	14.16^{bc}	15.24^{b}	13.80^{ab}	14.45
T_5 (Black)	9.74	12.22	14.15	15.10	16.25^{a}	17.75^{a}	12.83	17.50^{c}	18.04^{a}	18.50^{a}	15.00^{a}	11.13

Table 30: Effect of different coloured shade nets on the leaf length of *Tradescantia spathacea* 'Sitara'

Treatments (Shade net colours)	Leaf length (cm)											
	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	15.52	16.50^{ab}	17.08^{b}	17.60^{b}	16.25^{ab}	16.20^{b}	16.16	18.11^{ab}	19.00^{a}	18.10^{a}	17.54^{ab}	16.85^{a}
T_2 (Yellow)	14.22	16.11^{b}	17.35^{b}	17.00^{bc}	15.41^{bc}	15.54^{b}	16.95	17.17^{bc}	17.50^{b}	16.86^{b}	16.77^{cd}	16.34^{ab}
T_3 (Green)	14.25	15.77^{b}	16.75^{b}	17.31^{bc}	15.91^{bc}	15.54^{b}	16.04	16.54^{c}	17.34^{b}	17.01^{b}	17.09^{bc}	16.70^{a}
T_4 (Blue)	14.26	15.85^{b}	17.16^{b}	16.90^{c}	14.91^{c}	16.41^{b}	17.35	16.54^{c}	15.87^{c}	15.98^{c}	16.16^{d}	15.39^{b}
T_5 (Black)	16.34	17.45^{a}	19.26^{a}	19.20^{a}	17.16^{a}	17.41^{a}	16.50	18.95^{a}	19.01^{a}	18.82^{a}	18.19^{a}	16.93^{a}

Table 31: Effect of different coloured shade nets on the leaf length of *Cordyline terminalis*

Treatments (Shade net colours)	Leaf length (cm)											
	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	25.12^{a}	26.42	27.65^{a}	28.77	28.95	30.41	30.62	32.59^{a}	32.15^{a}	32.38^{a}	30.10^{a}	28.55
T_2 (Yellow)	22.20^{bc}	25.15	26.16^{ab}	26.83	28.00	29.75	28.83	28.87^{bc}	29.75^{ab}	28.79^{cd}	28.18^{bc}	28.68
T_3 (Green)	22.52^{bc}	25.20	26.48^{ab}	28.12	28.41	29.08	28.83	29.37^{bc}	30.34^{a}	30.31^{bc}	29.70^{ab}	29.98
T_4 (Blue)	23.75^{ab}	25.26	26.79^{a}	28.56	30.39	30.50	29.99	30.56^{ab}	30.50^{a}	31.61^{ab}	31.35^{a}	29.72
T_5 (Black)	21.14^{c}	23.94	24.83^{b}	27.45	27.75	28.75	28.41	28.04^{c}	27.25^{b}	27.98^{d}	27.66^{c}	28.49

plants under yellow, green and blue coloured nets did not differ significantly (Table 32).

The leaf breadth of *Asparagus* sp. showed no significant difference between the treatments except during the 1st, 3rd and 4th months after planting. During these months, the plants under black net recorded the highest values for leaf breadth values which were followed by plants grown under red, blue, yellow and green coloured nets (Table 33).

The treatments did not differ with each other with respect to leaf breadth of *Spathiphyllum wallisii*. Significant results could be observed during the 3rd, 4th and 12th months after planting. During this period, the plants grown under black net had the highest leaf breadth (12.9 cm recorded during the 12th month), followed by those under red coloured net (12.05 cm). Plants with a medium breadth were observed under yellow and green nets. The plants grown under blue net were the narrowest, and the values were on par with T_2 and T_3 during the 12th month after planting (Table 34).

In *Chrysothemis pulchella*, a significant variation was observed during the later stages of growth. The plants grown under black coloured net had a consistently higher leaf breadth throughout the year. This was followed by plants under red net. The leaves with the smallest breadth were observed in plants grown under blue net. The plants under yellow and green coloured nets produced leaves with medium breadth (Table 35).

When *Tradescantia spathacea* 'Sitara' was compared for leaf breadth among different treatments, it was observed that plants under black net recorded the highest leaf breadth throughout the year. The maximum breadth (2.79 cm) was recorded during 9th month after planting. This was followed by plants under red which recorded values on par with black net during the 7th, 8th and 9th months after planting. The plants under yellow and green nets had medium leaf breadth, while plants under blue net produced the narrowest leaves throughout the year (Table 36).

Table 32: Effect of different coloured shade nets on the leaf breadth of *Nephrolepis exaltata*

Treatments (Shade net colours)	Leaf breadth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	3.49^{b}	3.83	4.25^{b}	4.55^{a}	4.91^{a}	4.73^{a}	4.51^{b}	4.77^{b}	4.50^{b}	4.62^{b}	4.81^{b}	4.54^{b}
T_2 (Yellow)	3.51^{b}	3.87	3.85^{c}	4.00^{b}	4.55^{ab}	4.37^{ab}	4.25^{bc}	4.29^{c}	4.46^{bc}	4.15^{c}	4.25^{cd}	4.52^{b}
T_3 (Green)	3.38^{b}	4.04	3.95^{c}	3.98^{b}	3.98^{bc}	3.90^{b}	3.90^{c}	4.18^{c}	4.18^{cd}	4.10^{c}	4.47^{c}	4.38^{b}
T_4 (Blue)	3.39^{b}	4.04	4.15^{b}	4.00^{b}	3.35^{c}	3.75^{b}	3.94^{c}	4.08^{c}	4.08^{d}	4.22^{c}	4.11^{d}	3.79^{c}
T_5 (Black)	3.96^{a}	3.75	4.70^{a}	4.50^{a}	4.55^{ab}	5.04^{a}	5.60^{a}	5.20^{a}	5.65^{a}	5.60^{a}	5.47^{a}	5.00^{a}

Table 33: Effect of different coloured shade nets on the leaf breadth of *Asparagus* sp.

Treatments (Shade net colours)	Leaf breadth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	5.15^{a}	5.70	6.72^{ab}	7.05^{ab}	6.31	6.83	6.87	7.64	7.62	7.32	7.68	7.32
T_2 (Yellow)	4.91^{ab}	5.70	5.95^{bc}	6.19^{bc}	6.25	6.95	6.66	7.65	7.16	7.43	7.50	6.56
T_3 (Green)	4.68^{ab}	5.51	5.44^{c}	5.87^{c}	5.89	6.17	7.08	7.39	7.66	7.79	7.53	7.36
T_4 (Blue)	4.40^{b}	5.69	5.86^{bc}	6.80^{ab}	6.04	6.41	7.41	7.75	6.91	8.11	8.01	7.82
T_5 (Black)	5.01^{a}	6.04	7.22^{a}	7.53^{a}	6.12	6.60	6.45	7.56	7.91	7.39	7.60	7.20

Table 34: Effect of different coloured shade nets on the leaf breadth of *Spathiphyllum wallisii*

Treatments (Shade net colours)	Leaf breadth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	5.92	6.32	6.75^{b}	7.16^{b}	6.29	9.86	11.51	11.11	12.91	12.30	11.75	12.05^{ab}
T_2 (Yellow)	5.75	6.30	5.66^{cd}	6.44^{cd}	6.57	10.03	10.87	11.52	11.16	11.30	11.23	11.39^{b}
T_3 (Green)	5.85	6.35	6.14^{bc}	6.63^{bc}	6.74	9.66	10.83	11.58	10.54	10.75	11.47	11.46^{b}
T_4 (Blue)	5.71	6.35	5.35^{d}	5.91^{d}	7.14	10.06	10.54	10.34	10.87	11.53	11.20	10.83^{b}
T_5 (Black)	5.71	6.59	8.24^{a}	8.39^{a}	7.58	10.06	10.71	10.75	11.00	11.70	11.34	12.90^{a}

Table 35: Effect of different coloured shade nets on the leaf breadth of *Chrysothemis pulchella*

Treatments (Shade net colours)	Leaf breadth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	4.90	5.04	5.80	6.65^{a}	7.29^{a}	6.10^{b}	6.04^{b}	6.78^{b}	6.41^{b}	6.49^{b}	5.90^{ab}	5.84
T_2 (Yellow)	4.93	5.07	5.87	6.62^{a}	5.62^{b}	5.50^{bc}	5.77^{b}	6.73^{b}	6.18^{b}	6.26^{b}	5.39^{bc}	5.51
T_3 (Green)	4.70	5.35	5.27	5.34^{b}	5.34^{bc}	5.08^{cd}	5.00^{c}	6.41^{b}	5.37^{b}	6.21^{b}	4.97^{c}	6.34
T_4 (Blue)	5.35	5.55	6.47	6.4^{ab}	4.54^{c}	4.31^{d}	4.45^{c}	4.93^{c}	5.45^{b}	5.85^{b}	4.77^{c}	6.21
T_5 (Black)	4.79	5.84	6.07	7.45^{a}	7.90^{a}	7.95^{a}	7.62^{a}	7.68^{a}	7.54^{a}	7.67^{a}	6.37^{a}	6.04

In *Cordyline terminalis*, significant difference was observed during the 3rd, 4th, 10th and 11th months. The broadest leaves were found under black followed by red coloured nets. The maximum breadth (9.13 cm) was obtained during the 11th month after planting. The plants under yellow and green coloured nets had leaves with medium breadth. The narrowest leaves (7.75 cm) were observed in plants grown under blue coloured net (Table 37).

4.1.1.6. Internodal length (cm)

The compactness of a plant is determined by the length of the internode it possesses. It is an important character that needs to be considered as it influences the overall appearance of the plant. In this study, *Spathiphyllum wallisii* and green leaf types' viz., *Nephrolepis exaltata* and *Asparagus* sp. did not have any measurable internodal length. However, the internodal length of the other three plants viz., *Chrysothemis pulchella*, *Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* was recorded at monthly intervals and presented below in Tables 38 to 40.

In *Chrysothemis pulchella*, significant difference in internodal length was observed throughout the year except during the 2nd and 5th months after planting. The plants grown under red net had the longest internodes followed by plants under black net. The value (5.56cm) for internodal length recorded under this during the 12th MAP was on par with plants under yellow, green and black coloured nets (5.49, 5.46 and 5.02 cm, respectively). The plants under yellow and green coloured nets did not differ much while the plants under blue net had the shortest (3.93 cm) internodes (Table 38).

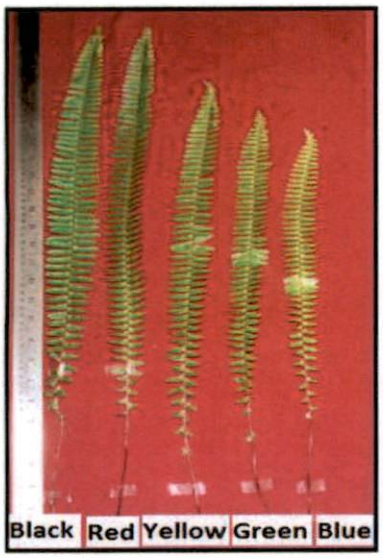
The internodal length of *Tradescantia spathacea* 'Sitara' was found to be significantly influenced by the treatments throughout the year except during the 1st and 3rd months after planting. It was observed that plants grown under red net had the longest internodal length throughout the year and it was on par with black net during the 11th and 12th months after planting. Plants under yellow and green

Table 36: Effect of different coloured shade nets on the leaf breadth of *Tradescantia spathacea* 'Sitara'

Treatments (Shade net colours)	Leaf breadth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	2.28	2.14^{b}	2.40^{ab}	2.20	2.12	2.42	2.75^{a}	2.75^{a}	2.58^{a}	2.62^{ab}	2.50^{ab}	2.53
T_2 (Yellow)	2.12	2.10^{b}	2.31^{abc}	2.37	2.20	2.29	2.45^{bc}	2.52^{b}	2.24^{b}	2.41^{b}	2.34^{bc}	2.38
T_3 (Green)	2.00	2.03^{b}	2.25^{bc}	2.40	2.03	2.12	2.21^{cd}	2.50^{b}	2.25^{b}	2.41^{b}	2.39^{bc}	2.37
T_4 (Blue)	2.00	2.11^{b}	2.18^{c}	2.35	2.04	2.15	2.15^{d}	2.39^{b}	2.29^{b}	2.12^{c}	2.25^{c}	2.34
T_5 (Black)	4.20	2.40^{a}	2.43^{a}	2.45	2.03	2.31	2.59^{ab}	2.77^{a}	2.79^{a}	2.70^{a}	2.66^{a}	2.55

Table 37: Effect of different coloured shade nets on the leaf breadth of *Cordyline terminalis*

Treatments (Shade net colours)	Leaf breadth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	7.26	7.68	8.14^{ab}	8.57^{ab}	8.54	8.29	8.06	8.68	8.08	8.75^{a}	8.81^{ab}	8.67
T_2 (Yellow)	6.80	7.24	8.12^{ab}	8.04^{bc}	7.62	8.29	8.00	8.99	8.29	8.75^{a}	8.00^{bc}	8.15
T_3 (Green)	7.00	7.51	7.87^{b}	7.65^{cd}	7.67	8.29	8.25	8.46	8.70	8.5^{ab}	7.89^{bc}	7.91
T_4 (Blue)	6.50	7.05	7.37^{b}	7.19^{d}	7.50	7.55	6.83	7.85	7.66	7.34^{b}	7.75^{c}	7.83
T_5 (Black)	6.44	8.05	8.85^{a}	8.86^{a}	8.57	8.58	8.58	8.86	8.69	9.01^{a}	9.13^{a}	9.00



Nephrolepis exaltata

Asparagus **sp.**

Spathiphyllum wallisii

Chrysothemis puchella

Tradescantia spathacea **'Sitara'**

Cordyline terminalis

Plate 3: Leaf characteristics of selected ornamentals under different coloured shade nets

Table 38: Effect of different coloured shade nets on the internodal length of *Chrysothemis pulchella*

Treatments (Shade net colours)	Internodal length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	2.10^{a}	3.17	5.50^{a}	5.60^{a}	5.76	5.53^{ab}	6.20^{ab}	6.90^{a}	7.00^{a}	6.64^{a}	5.35^{a}	5.56^{a}
T_2 (Yellow)	1.62^{bc}	2.78	4.59^{bc}	4.87^{bc}	5.54	5.25^{b}	5.75^{abc}	5.23^{bc}	5.52^{b}	5.50^{bc}	4.31^{bc}	5.49^{a}
T_3 (Green)	1.40^{c}	2.66	4.07^{c}	4.25^{cd}	5.09	5.08^{b}	5.44^{bc}	5.62^{c}	5.75^{b}	5.40^{bc}	4.43^{b}	5.46^{a}
T_4 (Blue)	1.35^{c}	2.93	3.21^{d}	4.12^{d}	5.26	5.00^{b}	4.97^{c}	4.97^{c}	5.40^{b}	4.84^{c}	3.53^{c}	3.93^{b}
T_5 (Black)	1.87^{ab}	3.30	4.99^{ab}	5.48^{ab}	5.94	6.34^{a}	6.37^{a}	6.60^{a}	6.90^{a}	5.80^{b}	4.85^{ab}	5.02^{a}

Table 39: Effect of different coloured shade nets on the internodal length of *Tradescantia spathacea* 'Sitara'

Treatments (Shade net colours)	Internodal length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	0.15	0.20^{a}	0.19	0.25^{a}	0.29^{a}	0.39^{a}	0.41^{a}	0.55^{a}	0.61^{a}	1.20^{a}	1.58^{a}	2.22^{a}
T_2 (Yellow)	0.13	0.18^{a}	0.21	0.21^{ab}	0.21^{b}	0.28^{bc}	0.30^{c}	0.27^{cd}	0.34^{c}	0.45^{cd}	0.60^{bc}	1.10^{b}
T_3 (Green)	0.13	0.20^{a}	0.20	0.20^{b}	0.24^{b}	0.258^{bc}	0.28^{c}	0.37^{bc}	0.40^{bc}	0.65^{c}	0.83^{b}	1.22^{b}
T_4 (Blue)	0.11	0.14^{b}	0.19	0.19^{b}	0.22^{b}	0.254^{c}	0.28^{c}	0.22^{d}	0.28^{c}	0.34^{d}	0.39^{c}	0.47^{c}
T_5 (Black)	0.16	0.20^{a}	0.20	0.22^{ab}	0.22^{b}	0.32^{ab}	0.35^{b}	0.44^{b}	0.53^{ab}	0.92^{b}	1.44^{a}	1.81^{a}

nets had internode of medium length while the shortest internodes were recorded in plants under blue coloured net (Table 39).

In *Cordyline terminalis*, the longest internodes were found in plants grown under red net. The maximum value (3.16 cm) was recorded during the 12th month after planting and was significantly superior to other net colour. The plants under yellow and blue nets had medium (2.65 and 2.78 cm, respectively) while those under green and black coloured nets had the shortest (2.55 and 2.31 cm, respectively) internodes (Table 40).

4.1.1.7. Length and girth of petiole (cm)

Petiole is responsible for providing support to the leaves, hence studying their length and girth is equally important just like any other plant character. In this study *Tradescantia spathacea* 'Sitara' is the only plant in which the petiole is very minute and not measurable. The petiole length and girth of all the other plants were measured at monthly interval and recorded.

4.1.1.7.1. Petiole length (cm)

In *Nephrolepis exaltata*, a significant difference was observed in the length of petiole among the different treatments. The plants under black, followed by red coloured nets had comparatively longer petioles (14.86 and 14.02 cm, respectively). The plants under other coloured nets had shorter petioles throughout the period of the study (Table 41).

The *Asparagus* sp. showed significant effect of the treatments on the petiole length from the 4th month up to the 10th month after planting. The petiole length was highest in plants grown under black coloured net, followed by plants under red net while those under yellow, green and blue coloured nets did not differ significantly (Table 42).

In *Spathiphyllum wallisii*, the petiole length was found to be significantly influenced by the treatments during the later stage of growth. The longest petiole (23.00 cm) was observed in plants under black net which was followed by plants

Table 40: Effect of different coloured shade nets on the internodal length of *Cordyline terminalis*

Treatments (Shade net colours)	Internodal length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	1.24	1.60	2.03^{a}	1.90^{a}	1.62	2.09	2.30	2.37	3.02^{a}	3.05^{a}	3.02^{a}	3.16^{a}
T_2 (Yellow)	0.92	1.62	1.69^{ab}	1.93^{a}	2.04	2.23	2.25	2.58	2.45^{b}	2.69^{ab}	2.66^{ab}	2.65^{ab}
T_3 (Green)	1.05	1.39	1.57^{b}	1.74^{ab}	1.85	2.10	2.15	2.22	2.29^{b}	2.37^{bc}	2.55^{b}	2.55^{b}
T_4 (Blue)	1.34	1.45	1.45^{b}	1.56^{b}	1.95	2.52	2.70	2.64	2.50^{b}	2.69^{ab}	2.68^{ab}	2.78^{ab}
T_5 (Black)	1.22	1.43	1.60^{b}	1.78^{ab}	1.65	1.91	1.94	2.18	2.27^{b}	2.25^{c}	2.31^{b}	2.31^{b}

Table 41: Effect of different coloured shade nets on the petiole length of *Nephrolepis exaltata*

Treatments (Shade net colours)	Petiole length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	5.25^{a}	6.65^{a}	6.72^{bc}	8.94^{a}	9.33	10.91^{a}	12.16^{a}	11.21^{a}	12.83^{a}	12.79^{ab}	13.29^{ab}	14.02^{ab}
T_2 (Yellow)	4.46^{ab}	6.16^{ab}	7.58^{ab}	8.25^{ab}	10.25	10.83^{a}	11.42^{a}	11.91^{a}	11.75^{a}	11.32^{bc}	12.25^{bc}	12.57^{b}
T_3 (Green)	2.30^{d}	4.41^{c}	6.30^{c}	7.40^{b}	10.25	9.08^{b}	8.66^{b}	8.94^{b}	9.58^{b}	10.12^{c}	11.11^{c}	12.45^{b}
T_4 (Blue)	3.19^{cd}	5.46^{b}	6.67^{bc}	7.42^{b}	7.82	8.16^{b}	9.29^{b}	7.77^{b}	9.29^{b}	11.55^{bc}	11.75^{c}	12.99^{b}
T_5 (Black)	3.60^{bc}	5.97^{ab}	8.00^{a}	9.62^{a}	10.83	11.50^{a}	12.20^{a}	12.25^{a}	13.34^{a}	13.45^{a}	14.75^{a}	14.86^{a}

Table 42: Effect of different coloured shade nets on the petiole length of *Asparagus* sp.

Treatments (Shade net colours)	Petiole length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	1.38	3.76	1.38	6.14^{a}	7.50^{a}	6.50^{a}	6.18^{b}	6.08^{b}	6.40^{a}	7.16^{ab}	7.11	7.59
T_2 (Yellow)	2.19	3.39	2.19	4.14^{b}	4.66^{b}	4.08^{b}	5.05^{b}	4.82^{c}	4.41^{b}	5.61^{c}	7.41	8.35
T_3 (Green)	2.34	3.75	2.34	3.96^{b}	4.54^{b}	5.08^{b}	6.01^{b}	5.46^{bc}	4.25^{b}	6.54^{bc}	8.76	9.20
T_4 (Blue)	2.00	3.34	2.00	4.35^{b}	3.91^{b}	4.08^{b}	5.09^{b}	5.59^{bc}	5.08^{b}	6.15^{bc}	7.22	8.50
T_5 (Black)	2.45	3.30	2.45	6.34^{a}	6.84^{a}	6.34^{a}	8.00^{a}	7.21^{a}	6.50^{a}	8.01^{a}	8.26	9.84

under red and yellow coloured nets (21.66 and 20.34 cm, respectively) during the 12th month after planting. The plants grown under green net were having medium length petiole while the shortest was observed in plants grown under blue coloured net (Table 43).

In *Chrysothemis pulchella*, longer length of petioles throughout the year was observed in plants grown under black coloured net. Maximum petiole length of (1.60 cm) was recorded during the 12th month and it was significantly superior over the other coloured nets. The plants under the rest of the net colours were on par with respect to petiole length (Table 44).

In *Cordyline terminalis*, the plants under red net had the longest petiole throughout the year which was on par with plants grown under blue coloured net during the 7th, 8th, 9th, 10th and 11th months after planting while the shortest was in plants grown under black net (9.75 cm recorded during the 11th month). The plants grown under yellow and green coloured nets had medium length (Table 45).

4.1.1.7.2. Petiole girth (cm)

In *Nephrolepis exaltata*, the petiole girth was found to be more in plants grown under black net, followed by plants under red net. The maximum girth (0.49 cm) recorded during the 12th month was on par with plants under red net. The plants under yellow, green and blue coloured nets did not differ much in petiole length throughout the study period (Table 46).

In *Asparagus* sp., significant difference was produced during the initial and later stages of growth. The plants under blue net recorded the minimum petiole girth throughout the year while those under red, yellow, green and black nets were on par (Table 47).

Significant difference for petiole girth was observed in *Spathiphyllum wallisii* throughout the year. The plants with the thickest petioles were found in black net throughout the year. The maximum girth (1.50 cm) was recorded during

Table 43: Effect of different coloured shade nets on the petiole length of *Spathiphyllum wallisii*

Treatments (Shade net colours)	Petiole length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	11.33	14.34^{a}	14.53	14.31	12.00	16.08^{ab}	16.75^{bc}	20.04^{b}	21.66^{b}	21.75^{b}	22.48^{b}	21.66^{ab}
T_2 (Yellow)	11.69	15.08^{a}	15.66	16.00	12.41	14.16^{b}	17.91^{b}	19.16^{b}	20.00^{b}	20.50^{bc}	21.00^{bc}	20.34^{b}
T_3 (Green)	10.69	12.83^{a}	15.35	16.16	11.54	14.50^{b}	15.16^{c}	16.25^{c}	16.70^{c}	18.75^{cd}	19.62^{cd}	19.40^{bc}
T_4 (Blue)	8.92	10.37^{b}	13.62	14.20	11.66	11.66^{c}	15.34^{c}	16.62^{c}	16.75^{c}	17.79^{d}	18.50^{d}	17.39^{c}
T_5 (Black)	10.53	14.15^{a}	14.60	14.95	12.20	17.41^{a}	21.58^{a}	23.16^{a}	24.91^{a}	26.00^{a}	25.62^{a}	23.00^{a}

Table 44: Effect of different coloured shade nets on the petiole length of *Chrysothemis pulchella*

Treatments (Shade net colours)	Petiole length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	0.77^{a}	1.04	1.21^{ab}	1.10^{b}	1.09	1.09^{b}	1.46^{a}	1.37^{ab}	1.60^{ab}	1.00^{b}	0.94	1.18^{b}
T_2 (Yellow)	0.63^{ab}	1.46	1.04^{bc}	0.94^{b}	0.94	0.63^{d}	1.38^{ab}	1.16^{bc}	1.30^{bc}	1.12^{b}	1.12	0.97^{b}
T_3 (Green)	0.31^{c}	1.10	0.90^{c}	0.95^{b}	1.24	0.81^{cd}	0.98^{c}	1.01^{c}	1.12^{c}	1.10^{b}	0.95	1.09^{b}
T_4 (Blue)	0.45^{bc}	1.01	0.91^{bc}	0.87^{b}	0.91	1.08^{bc}	1.06^{bc}	1.01^{c}	1.14^{c}	1.17^{b}	0.85	1.11^{b}
T_5 (Black)	0.77^{a}	1.21	1.50^{a}	1.45^{a}	1.34	1.42^{a}	1.56^{a}	1.58^{a}	1.68^{a}	1.54^{a}	1.16	1.60^{a}

Table 45: Effect of different coloured shade nets on the petiole length of *Cordyline terminalis*

Treatments (Shade net colours)	Petiole length (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	7.40	9.82^{a}	8.79	9.46^{a}	11.08	11.50^{a}	12.08^{a}	11.00^{b}	11.50^{ab}	11.73^{a}	12.08^{a}	12.09
T_2 (Yellow)	7.14	8.45^{abc}	8.34	8.50^{b}	9.87	9.91^{c}	9.83^{b}	10.04^{b}	10.37^{bc}	10.00^{bc}	10.45^{bc}	11.24
T_3 (Green)	7.30	8.26^{bc}	8.61	8.63^{b}	9.95	10.16^{bc}	11.04^{ab}	10.66^{b}	11.00^{abc}	10.66^{b}	10.78^{b}	11.95
T_4 (Blue)	7.08	9.58^{ab}	9.66	9.05^{ab}	10.87	11.25^{ab}	12.27^{a}	12.29^{a}	12.20^{a}	12.29^{a}	12.25^{a}	12.48
T_5 (Black)	7.64	8.09^{c}	8.58	8.41^{b}	9.95	10.50^{abc}	10.50^{b}	10.15^{b}	9.91^{c}	9.54^{c}	9.75^{c}	10.79

Table 46: Effect of different coloured shade nets on the petiole girth of *Nephrolepis exaltata*

Treatments (Shade net colours)	Petiole girth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	0.22^{b}	0.22^{b}	0.30^{b}	0.34^{b}	0.41	0.35^{b}	0.46^{ab}	0.45^{a}	0.45	0.39	0.45	0.46^{a}
T_2 (Yellow)	0.22^{b}	0.22^{b}	0.25^{bc}	0.32^{b}	0.40	0.31^{b}	0.41^{bc}	0.44^{a}	0.40	0.41	0.41	0.46^{a}
T_3 (Green)	0.18^{c}	0.18^{c}	0.23^{c}	0.31^{b}	0.43	0.38^{b}	0.37^{c}	0.30^{b}	0.36	0.39	0.44	0.36^{b}
T_4 (Blue)	0.21^{bc}	0.20^{bc}	0.24^{c}	0.31^{b}	0.40	0.31^{b}	0.35^{c}	0.38^{a}	0.42	0.44	0.45	0.46^{a}
T_5 (Black)	0.26^{a}	0.34^{a}	0.35^{a}	0.43^{a}	0.46	0.49^{a}	0.49^{a}	0.45^{a}	0.45	0.48	0.48	0.49^{a}

Table 47: Effect of different coloured shade nets on the petiole girth of *Asparagus* sp.

Treatments (Shade net colours)	Petiole girth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	0.35^{a}	0.37^{a}	0.41^{a}	0.39	0.41	0.47	0.55	0.56^{a}	0.46^{b}	0.54^{ab}	0.61^{a}	0.59^{a}
T_2 (Yellow)	0.31^{ab}	0.32^{ab}	0.34^{abc}	0.37	0.45	0.43	0.54	0.48^{a}	0.45^{b}	0.53^{ab}	0.57^{ab}	0.58^{a}
T_3 (Green)	0.34^{a}	0.27^{b}	0.34^{bc}	0.32	0.41	0.39	0.51	0.51^{a}	0.52^{ab}	0.45^{bc}	0.50^{b}	0.55^{a}
T_4 (Blue)	0.25^{b}	0.28^{b}	0.27^{c}	0.34	0.43	0.42	0.44	0.31^{b}	0.34^{c}	0.38^{c}	0.35^{c}	0.42^{b}
T_5 (Black)	0.34^{a}	0.36^{a}	0.41^{a}	0.40	0.40	0.47	0.50	0.56^{a}	0.55^{a}	0.58^{a}	0.61^{a}	0.57^{a}

the 12th month. The plants under yellow net had medium while those under red, green and blue nets were on par with each other (Table 48).

The petiole girth of *Chrysothemis pulchella* was significantly influenced by the colour of the nets. The maximum was observed in plants grown under black net. The maximum value (1.51cm) was recorded during the 9th month after planting, followed by plants grown under red and yellow coloured nets. The plants under blue and green nets had the lowest petiole girth and were comparable (Table 49).

In *Cordyline terminalis*, significant variation was produced throughout the year. The highest petiole girth (1.90 cm) recorded in plants grown under black coloured net during the 12th month was on par with plants under red and blue coloured nets. The plants under green and yellow coloured nets had the least girth of petiole recording only 1.15 and 1.36 cm, respectively during the 12th month after planting (Table 50).

4.2. FLOWER CHARACTERS

4.2.1. Quantitative characters

The flower characters were studied for the flowering ornamentals included in the study, *viz., Spathiphyllum wallisii* and *Chrysothemis pulchella.* The characters observed were, size of flowers, length of flower stalk, number of flowers produced, longevity of flowers on the plant and interval of flower production and the data are presented in Table 51a and 51b.

All the flower character studied *viz.,* flower size, stalk length and longevity of flower on the plant showed detectable difference only in *Spathiphyllum wallisii.*

The flowers of maximum size were in plants grown under black and red nets (17.31 and 16.88 cm^2, respectively) and were significantly superior to others. Minimum flower size (15.16 cm^2) was recorded in plants under blue which was

Table 48: Effect of different coloured shade nets on the petiole girth of *Spathiphyllum wallisii*

Treatments (Shade net colours)	Petiole girth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	0.75^{ab}	0.76^{a}	0.82^{a}	0.91^{a}	0.81^{ab}	0.94^{a}	0.86^{bc}	0.82^{b}	0.98^{bc}	1.09^{b}	1.28^{ab}	1.25^{b}
T_2 (Yellow)	0.80^{a}	0.80^{a}	0.90^{a}	0.86^{a}	0.80^{ab}	0.87^{ab}	0.95^{b}	1.13^{a}	1.05^{b}	1.23^{ab}	1.39^{a}	1.39^{ab}
T_3 (Green)	0.47^{c}	0.50^{b}	0.51^{b}	0.55^{c}	0.70^{bc}	0.75^{bc}	0.92^{bc}	0.93^{b}	0.82^{c}	1.20^{b}	1.38^{a}	1.25^{b}
T_4 (Blue)	0.46^{c}	0.55^{b}	0.51^{b}	0.70^{b}	0.63^{c}	0.68^{c}	0.80^{c}	0.85^{b}	0.82^{c}	1.11^{b}	1.16^{b}	1.22^{b}
T_5 (Black)	0.60^{b}	0.72^{a}	0.80^{a}	0.89^{a}	0.89^{a}	0.91^{a}	1.30^{a}	1.29^{a}	1.27^{a}	1.37^{a}	1.40^{a}	1.50^{a}

Table 49: Effect of different coloured shade nets on the petiole girth of *Chrysothemis pulchella*

Treatments (Shade net colours)	Petiole girth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	0.85^{a}	0.85^{a}	0.80^{a}	0.98^{ab}	1.06	1.06^{b}	1.13^{b}	1.00^{b}	$1.04b^{c}$	1.16^{ab}	0.81^{a}	0.80^{ab}
T_2 (Yellow)	0.43^{bc}	0.60^{b}	0.57^{b}	0.81^{abc}	1.15	0.95^{b}	1.08^{b}	1.04^{b}	1.20^{b}	1.05^{b}	0.70^{ab}	0.68^{bc}
T_3 (Green)	0.38^{c}	0.42^{c}	0.45^{b}	0.80^{bc}	1.06	0.71^{c}	0.73^{c}	0.73^{c}	0.86^{cd}	0.83^{c}	0.42^{c}	0.41^{d}
T_4 (Blue)	0.40^{c}	0.39^{c}	0.44^{b}	0.66^{c}	0.97	0.73^{c}	0.64^{c}	0.75^{c}	0.81^{d}	0.85^{c}	0.63^{b}	0.56^{c}
T_5 (Black)	0.50^{b}	0.55^{b}	0.91^{a}	1.02^{a}	1.05	1.25^{a}	1.35^{a}	1.30^{a}	1.51^{a}	1.35^{a}	0.85^{a}	0.89^{a}

Table 50: Effect of different coloured shade nets on the petiole girth of *Cordyline terminalis*

Treatments (Shade net colours)	Petiole girth (cm)											
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
T_1 (Red)	1.17^{b}	1.13^{b}	1.21^{b}	1.22^{b}	1.61^{b}	1.34^{b}	1.32^{b}	1.34^{bc}	1.42^{ab}	1.70^{b}	1.75^{b}	1.80^{a}
T_2 (Yellow)	0.85^{c}	0.78^{c}	0.85^{c}	0.95^{c}	1.34^{bc}	1.20^{b}	1.11^{c}	1.11^{c}	1.15^{bc}	1.19^{c}	1.32^{c}	1.36^{b}
T_3 (Green)	0.73^{c}	0.71^{c}	0.72^{c}	1.08^{bc}	1.25^{c}	1.18^{b}	1.11^{c}	1.11^{c}	1.05^{c}	1.01^{c}	1.15^{c}	1.15^{b}
T_4 (Blue)	1.06^{b}	1.27^{b}	1.25^{ab}	1.51^{a}	1.59^{b}	1.73^{a}	1.41^{b}	1.55^{ab}	1.70^{a}	1.87^{ab}	1.95^{ab}	1.95^{a}
T_5 (Black)	1.43^{a}	1.50^{a}	1.48^{a}	1.65^{a}	1.95^{a}	1.83^{a}	2.00^{a}	1.81^{a}	1.70^{a}	1.97^{a}	1.96^{a}	1.90^{a}

closely followed by green coloured net (15.57 cm^2). The same trend was noticed in flower stalk length also.

Longevity of the flower on the plant was significantly more (44.25 days) in plants grown under black coloured net and it was superior over the other net colour. This was followed by plants under red, yellow and green nets (38.25, 37.51 and 36.75 days, respectively) while those under blue net had the minimum vase life (33.75 days).

With respect to interval of flower production, both *Spathiphyllum wallisii* and *Chrysothemis pulchella* grown under red net took the least number of days (32.50 and 25.50 days, respectively) to produce successive flowers. Rest of the nets recorded values on par in *Chrysothemis pulchella* while in *Spathiphyllum wallisii*, blue net took the maximum number (42.75) of days for emergence of successive flower and yellow, green and black nets were on par.

4.3. Vase Life

The vase life of foliage's from selected species grown under different coloured shade nets were evaluated and the results are presented in Table 52.

Among the selected plants, significant difference was observed only in *Nephrolepis exaltata* and *Cordyline terminalis.*

In *Nephrolepis exaltata,* leaves collected from plants under black and red coloured nets recorded maximum vase life (43.75 and 41.25 days, respectively). This was followed by leaves from yellow and green nets (33.75 and 24.75 days, respectively) while leaves from blue coloured net had the minimum (15.5 days).

In *Cordyline terminalis*, foliage collected from plants under yellow and black nets had the maximum vase life (38.50 days), followed by green and red nets (33.75 and 31.75 days, respectively) and were on par. Foliage collected from blue net recorded the minimum (20.50 days) vase life.

Table 51a: Effect of different coloured shade nets on the flower characters

Treatments (Shade net colour)	Size of flower (cm^2)		Length of flower stalk (cm)		No. of flowers	
	Spathiphyllum wallisii	*Chrysothemis pulchella*	*Spathiphyllum wallisii*	*Chrysothemis pulchella*	*Spathiphyllum wallisii*	*Chrysothemis pulchella*
T_1 (Red)	16.88^{a}	3.12	47.21^{a}	3.41	1.25	17.58
T_2 (Yellow)	16.02^{b}	2.86	45.94^{ab}	3.08	1.16	11.91
T_3 (Green)	15.57^{bc}	3.08	42.18^{b}	3.33	1.16	15.41
T_4 (Blue)	15.16^{c}	3.15	42.15^{b}	3.16	1.33	14.75
T_5 (Black)	17.31^{a}	3.24	47.54^{a}	6.91	1.08	13.58

Table 51b: Effect of different coloured shade nets on the flower characters

Treatments (Shade net colour)	Longevity of flowers (days)			Interval of flower production (days)	
	Spathiphyllum wallisii	*Chrysothemis pulchella*		*Spathiphyllum wallisii*	*Chrysothemis pulchella*
		Calyx	Corolla		
T_1 (Red)	38.25^{b}	10.50	2.75	32.50^{d}	25.50^{b}
T_2 (Yellow)	37.50^{b}	10.50	3.75	37.00^{bc}	28.00^{a}
T_3 (Green)	36.75^{bc}	9.50	2.50	38.25^{b}	29.00^{a}
T_4 (Blue)	33.75^{c}	9.50	2.50	42.75^{a}	28.50^{a}
T_5 (Black)	44.25^{a}	11.00	2.75	32.50^{b}	27.00^{ab}

Table 52: Effect of different coloured shade nets on the vase life of leaves of selected foliage plants

Treatments (Shade net colour)	Vase life (in days)			
	Nephrolepis exaltata	*Asparagus* sp.	*Spathiphyllum wallisii*	*Cordyline terminalis*
T_1 (Red)	41.25[a]	20.00	13.75	31.75[a]
T_2 (Yellow)	33.75[ab]	16.50	13.25	38.50[a]
T_3 (Green)	24.75[bc]	14.75	11.75	33.75[a]
T_4 (Blue)	15.50[c]	9.75	11.00	20.50[b]
T_5 (Black)	43.75[a]	22. 25	11.50	38.50[a]

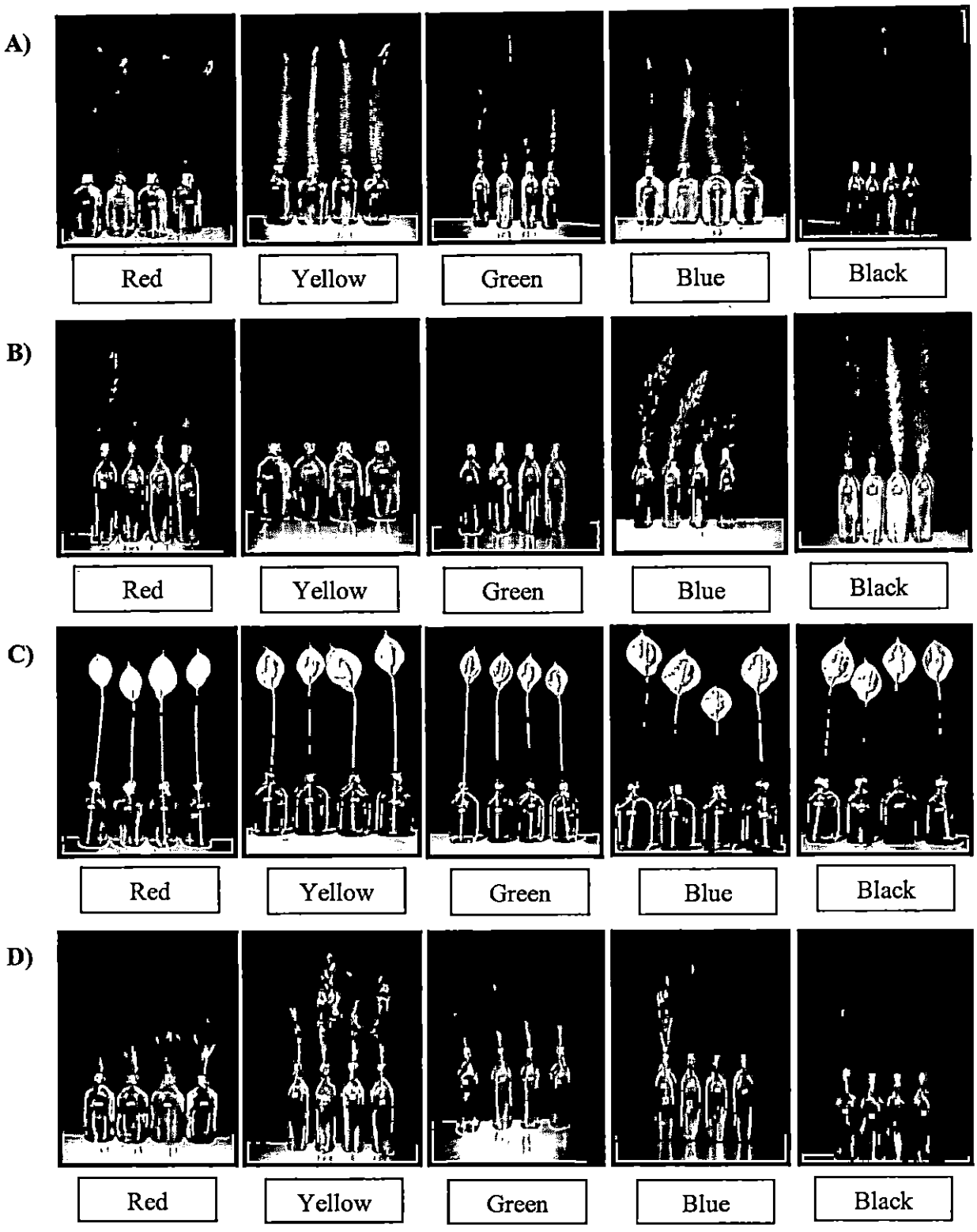


Plate 4: Vase life studies in selected ornamentals grown under different coloured shade nets A) *Nephrolepis exaltata* B) *Asparagus* sp. C) *Spathiphyllum wallisii* D) *Cordyline terminalis*

4.4. Correlation Studies

Correlation studies were done by correlating the microclimatic parameters, *viz.*, maximum and minimum temperature, relative humidity, light intensity and PAR with plant characters like height, spread, leaf area and number of leaves produced. This has been done to assess the influence of weather parameters on the performance of selected ornamentals and the results obtained are presented in Tables 53 to 60.

4.4.1. Correlation between maximum temperature and plant characters

None of the plant characters showed any influence by maximum temperature under all net colours.

4.4.2. Correlation between minimum temperature and plant characters

The minimum temperature was found to influence some of the plant characters. The number of leaves of *Asparagus* sp. grown under black colour net was found to be positively correlated. Rest of the characters like plant height, spread, leaf area and number of leaves in all the plants were negatively correlated but no significant correlation was observed in the plant spread of *Nephrolepis exaltata* and area, plant spread and number of leaves in *Chrysothemis pulchella* under all treatments (Table 53 and 54).

4.4.3. Correlation between relative humidity and plant characters

Relative humidity did not show any significant correlation between the plant characters of all the selected ornamentals except in *Chrysothemis pulchella,* where a positive correlation was observed with certain characters. The leaf area under red, green, blue and black; plant spread under yellow and green; and the number of leaves under yellow, blue and black nets showed positive correlation with this parameter(Table 55 and 56).

Table 53: Correlation between minimum temperature and plant characters (area and plant height)

Correlation between minimum temperature and plant characters										
Plant species	**Leaf area**					**Plant height**				
	T_1(red)	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**	**T_1(red)**	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**
Nephrolepis exaltata	-	-	-	-0.62*	-	-0.66*	-	-0.62*	-0.63*	-0.65*
Asparagus sp.	-0.71**	-	-0.66*	-0.76**	-0.83**	-0.80**	-0.75**	-0.72**	-0.59*	-0.77**
Spathiphyllum wallisii	-0.69*	-0.77**	-0.67*	-0.71**	-0.59*	-0.79**	-0.79**	-0.72**	-0.71**	-0.68*
Chrysothemis pulchella	-	-	-	-	-	-	-0.62**	-0.69*	-0.71**	-
Tradescantia spathacea 'Sitara'	-0.87**	-0.71**	-0.78**	-	-0.71**	-	-0.69*	-0.69*	-0.71**	-0.59*
Cordyline terminalis	-	-0.76**	-	-0.61*	-	-0.68*	-0.71**	-0.69*	-0.73**	-0.68*

Table 54: Correlation between minimum temperature and plant characters (plant spread and no. of leaves)

Correlation between minimum temperature and plant characters										
Plant species	**Plant spread**					**No. of leaves/plant**				
	T_1(red)	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**	**T_1(red)**	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**
Nephrolepis exaltata	-	-	-	-	-	-	-0.74**	-0.77**	-	-0.65*
Asparagus sp.	-0.66*	-0.65*	-0.69*	-0.69*	-0.66*	-	-0.65*	-	-0.64*	0.90*
Spathiphyllum wallisii	-0.75**	-0.70*	-0.72**	-0.69*	-0.67*	-0.78**	-0.82**	-0.75**	-	-0.69*
Chrysothemis pulchella	-	-	-	-	-	-	-	-	-	-
Tradescantia spathacea 'Sitara'	-0.68*	-	-0.68*	-	-	-0.92**	-0.73**	-0.74**	-0.64*	-0.63*
Cordyline terminalis	-	-	-	-0.62*	-	-0.59*	-0.69*	-	-0.71*	-0.79**

*significance at 5% ** significance at 1%

Table 55: Correlation between relative humidity and plant characters (area and plant height)

Correlation between relative humidity and plant characters										
Plant species	**Leaf area**					**Plant height**				
	T_1(red)	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**	**T_1(red)**	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**
Nephrolepis exaltata	-	-	-	-	-	-	-	-	-	-
Asparagus sp.	-	-	-	-	-	-	-	-	-	-
Spathiphyllum wallisii	-	-	-	-	-	-	-	-	-	-
Chrysothemis pulchella	0.61*	-	0.59*	0.69*	0.73**	-	-	-	-	-
Tradescantia spathacea 'Sitara'	-	-	-	-	-	-	-	-	-	-
Cordyline terminalis	-	-	-	-	-	-	-	-	-	-

Table 56: Correlation between relative humidity and plant characters (plant spread and no. of leaves)

Correlation between relative humidity and plant characters										
Plant species	**Plant spread**					**No. of leaves/plant**				
	T_1(red)	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**	**T_1(red)**	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**
Nephrolepis exaltata	-	-	-	-	-	-	-	-	-	-
Asparagus sp.	-	-	-	-	-	-	-	-	-	-
Spathiphyllum wallisii	-	-	-	-	-	-	-	-	-	-
Chrysothemis pulchella	-	0.70*	0.65*	-	-	-	0.62*	-	0.60*	0.76**
Tradescantia spathacea 'Sitara'	-	-	-	-	-	-	-	-	-	-
Cordyline terminalis	-	-	-	-	-	-	-	-	-	-

*significance at 5% ** significance at 1%

4.4.4. Correlation between light intensity and plant characters

A negative correlation was found between light intensity and some of the plant characters. In case of leaf area, significant correlation was found in *Nephrolepis exaltata* grown under red and *Chrysothemis pulchella* grown under red, green and black coloured nets. Plant spread in *Chrysothemis pulchella* under yellow and green and in *Cordyline terminalis* under green and the number of leaves of *Chrysothemis pulchella* alone under yellow, green and black nets showed negative correlation with light intensity (Table 57 and 58).

4.4.5. Correlation between PAR and plant characters

The number of leaves in *Asparagus* sp. under black net showed a positive correlation with PAR values while that of *Chrysothemis pulchella* under the same net colour showed negative correlation. No significant correlation was observed with the rest of the characters in all the other plants under different treatments (Table 59 and 60).

4.5. Qualitative characters

4.5.1. Plant qualitative characters

The selected foliage plants were also observed for their qualitative characters which determine their overall acceptability for use as cut foliage or as indoor plant. The various characters observed include texture, shape, margin (entire, wavy, lobed, spinous etc.), tip (acute, obtuse, acuminate etc.), bending or drooping of the leaves, leaf pigmentation and pests and disease if any.

None of the qualitative characters of the plants studied were influenced by the colour of shade nets. The qualitative characters observed are presented in Table 61.

4.5.2. Qualitative characters of flower

The qualitative character of the flowers of *Spathiphyllum wallisii* and *Chrysothemis pulchella* were observed. The characters observed were the period

Table 57: Correlation between light intensity and plant characters (area and plant height)

Correlation between light intensity and plant characters										
Plant species	**Leaf area**					**Plant height**				
	T_1(red)	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**	**T_1(red)**	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**
Nephrolepis exaltata	-0.63*	-	-	-	-	-	-	-	-	-
Asparagus sp.	-	-	-	-	-	-	-	-	-	-
Spathiphyllum wallisii	-	-	-	-	-	-	-	-	-	-
Chrysothemis pulchella	-0.81**	-	-0.64*	-	-0.70*	-	-	-	-	-
Tradescantia spathacea 'Sitara'	-	-	-	-	-	-	-	-	-	-
Cordyline terminalis	-	-	-	-	-	-	-	-	-	-

Table 58: Correlation between light intensity and plant characters (plant spread and no. of leaves)

Correlation between light intensity and plant characters										
Plant species	**Plant spread**					**No. of leaves/plant**				
	T_1(red)	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**	**T_1(red)**	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**
Nephrolepis exaltata	-	-	-	-	-	-	-	-	-	-
Asparagus sp.	-	-	-	-	-	-	-	-	-	-
Spathiphyllum wallisii	-	-	-	-	-	-	-	-	-	-
Chrysothemis pulchella	-	-0.69*	-0.71*	-	-	-	-0.74**	-0.66*	-	-0.86**
Tradescantia spathacea 'Sitara'	-	-	-	-	-	-	-	-	-	-
Cordyline terminalis	-	-	-0.60*	-	-	-	-	-	-	-

*significance at 5% ** significance at 1%

Table 59: Correlation between PAR and plant characters (area and plant height)

Correlation between PAR and plant characters										
Plant species	**Leaf area**					**Plant height**				
	T_1(red)	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**	**T_1(red)**	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**
Nephrolepis exaltata	-	-	-	-	-	-	-	-	-	-
Asparagus sp.	-	-	-	-	-	-	-	-	-	-
Spathiphyllum wallisii	-	-	-	-	-	-	-	-	-	-
Chrysothemis pulchella	-	-	-	-	-	-	-	-	-	-
Tradescantia spathacea 'Sitara'	-	-	-	-	-	-	-	-	-	-
Cordyline terminalis	-	-	-	-	-	-	-	-	-	-

Table 60: Correlation between PAR and plant characters (plant spread and no. of leaves)

Correlation between PAR and plant characters										
Plant species	**Plant spread**					**No. of leaves/plant**				
	T_1(red)	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**	**T_1(red)**	**T_2(yellow)**	**T_3(green)**	**T_4(blue)**	**T_5(black)**
Nephrolepis exaltata	-	-	-	-	-	-	-	-	-	-
Asparagus sp.	-	-	-	-	-	-	-	-	-	0.58*
Spathiphyllum wallisii	-	-	-	-	-	-	-	-	-	-
Chrysothemis pulchella	-	-	-	-	-	-	-	-	-	-0.62*
Tradescantia spathacea 'Sitara'	-	-	-	-	-	-	-	-	-	-
Cordyline terminalis	-	-	-	-	-	-	-	-	-	-

*significance at 5% ** significance at 1%

Table 61a: Salient qualitative characters of ornamentals (green leaf type) grown under different coloured shade nets

Plant	Characters	Colour of shade nets				
		T_1 (Red)	T_2 (Yellow)	T_3 (Green)	T_4 (Blue)	T_5 (Black)
Nephrolepis exaltata	Texture	Fine	Fine	Fine	Fine	Fine
	Shape	Lanceolate; ovate	Lanceolate; ovate	Lanceolate; ovate	Lanceolate; ovate	Lanceolate; ovate
	Margin	Serrate; undulate	Serrate; undulate	Serrate; undulate	Serrate; undulate	Serrate; undulate
	Tip	Acute	Acute	Acute	Acute	Acute
	Pigmentation	Green	Green	Green	Green	Green
	Bending/Drooping	Drooping	Drooping	Drooping	Drooping	Drooping
Asparagus sp.	Texture	Fine	Fine	Fine	Fine	Fine
	Shape	Linear	Linear	Linear	Linear	Linear
	Margin	Entire	Entire	Entire	Entire	Entire
	Tip	Acute	Acute	Acute	Acute	Acute
	Pigmentation	Green	Green	Green	Green	Green
	Bending/Drooping	Drooping	Drooping	Drooping	Drooping	Drooping

Table 61b: Salient qualitative characters of ornamentals (flowering type) grown under different coloured shade nets

Plant	Characters	Colour of shade nets				
		T_1 (Red)	T_2 (Yellow)	T_3 (Green)	T_4 (Blue)	T_5 (Black)
Spathiphyllum wallisii	Texture	Medium	Medium	Medium	Medium	Medium
	Shape	Ovate	Ovate	Ovate	Ovate	Ovate
	Margin	Entire	Entire	Entire	Entire	Entire
	Tip	Acute	Acute	Acute	Acute	Acute
	Pigmentation	Glossy green	Glossy green	Glossy green	Glossy green	Glossy green
	Bending/Drooping	No	No	No	No	No
Chrysothemis pulchella	Texture	Leathery	Leathery	Leathery	Leathery	Leathery
	Shape	Elliptic	Elliptic	Elliptic	Elliptic	Elliptic
	Margin	Crenate	Crenate	Crenate	Crenate	Crenate
	Tip	Acute	Acute	Acute	Acute	Acute
	Pigmentation	Bronze or shiny dark green	Bronze or shiny dark green	Bronze or shiny dark green	Bronze or shiny dark green	Bronze or shiny dark green
	Bending/Drooping	Drooping	Drooping	Drooping	Drooping	Drooping

Table 61c: Salient qualitative characters of ornamentals (coloured leaf type) grown under different coloured shade nets

Plant	Characters	Colour of shade nets				
		T_1 (Red)	T_2 (Yellow)	T_3 (Green)	T_4 (Blue)	T_5 (Black)
Tradescantia spathacea 'Sitara'	Texture	Medium	Medium	Medium	Medium	Medium
	Shape	Linear	Linear	Linear	Linear	Linear
	Margin	Entire	Entire	Entire	Entire	Entire
	Tip	Acute	Acute	Acute	Acute	Acute
	Pigmentation	Dark green or green upper surface with pale yellow stripes; lower surface usually purple	Dark green or green upper surface with pale yellow stripes; lower surface usually purple	Dark green or green upper surface with pale yellow stripes; lower surface usually purple	Dark green or green upper surface with pale yellow stripes; lower surface usually purple	Dark green or green upper surface with pale yellow stripes; lower surface usually purple
	Bending/Drooping	Drooping	Drooping	Drooping	Drooping	Drooping
Cordyline terminalis	Texture	Medium	Medium	Medium	Medium	Medium
	Shape	Linear	Linear	Linear	Linear	Linear
	Margin	Entire	Entire	Entire	Entire	Entire
	Tip	Acute; obtuse	Acute; obtuse	Acute; obtuse	Acute; obtuse	Acute; obtuse
	Pigmentation	Reddish purple; greenish red	Reddish purple; greenish red	Reddish purple; greenish red	Reddish purple; greenish red	Reddish purple; greenish red
	Bending/Drooping	No	No	No	No	No

of flowering, type, colour and appearance of the flower (Table 62). None of the characters showed any differences under the different net colours.

4.5.3. Incidence of pest and disease

The incidence of pests and disease varied with respect to the colour of nets (Table 63). In *Nephrolepis exaltata*, the incidence was little except under black net, under which, rotting was common. In *Asparagus* sp., mealy bug incidence was observed under red and black nets. The incidence of tip burning was observed in *Spathiphyllum wallisii* under all nets except yellow. Leaf spot was common under red, yellow, green, blue and black nets while damage by leaf eating caterpillar was high under red net. Incidence of stem borer and mealy bug was common under all net colours in *Chrysothemis pulchella*, and snails almost destroyed the plants under red and black nets. Rotting of leaf was observed in *Tradescantia spathacea* 'Sitara' under all nets. In *Cordyline terminalis*, leaf spot and thrips were observed under all nets, leaf eating caterpillar under red and sooty mould under red, yellow and black nets.

4.5.4. Plant quality rating

Plant quality rating was done by visual scoring on a scale of one to 10. The scoring was done based on individual plant characters like growth and fullness, colour and pigmentation and general health of the plants. Score one is the lowest while 10 ten is the highest. The individual score for each character was added and the total was obtained out of 30 (Table 64).

Based on the scores obtained, it was observed that among the green leaf types, *Nephrolepis exaltata* scored the highest under black shade net (27), followed by green and red (22.5 and 22.25 respectively) while *Asparagus* sp. scored the highest under red net (24). Both the plants scored the lowest under blue coloured net (19.62 and 21.00, respectively).

In flowering types, both *Spathiphyllum wallisi* and *Chrysothemis pulchella* grown under black coloured net scored the highest (25.25 and 28.5 respectively)

Table 62: Flower characteristics of *Spathiphyllum wallisii* and *Chrysothemis pulchella*

Plants	Flowering duration	Type of flower	Colour	Appearance	Remarks
Spathiphyllum wallisii	Periodically throughout the year	Spadix	White	Spathe ovate; Spadix born in front of the spathe and packed with numerous small flowers	The spathe turns green after 10-15 days and thereafter lasts for approximately a month
Chrysothemis pulchella	February to November	Umbel	Corolla - yellow with orange stripes; Calyx- reddish orange	Corolla with flared lobes which narrows down to a tube at the base and is short lived; the calyx or sepal is cup shaped and gives an ever blooming effect since it lasts longer than corolla	The plant is upright and the bright coloured flower provides a sharp contrast to the dark background of foliage; Tubers are formed at the base of the stem and also in the leaf axils

Table 63: Pest and disease incidence observed in ornamental plants under different coloured shade nets

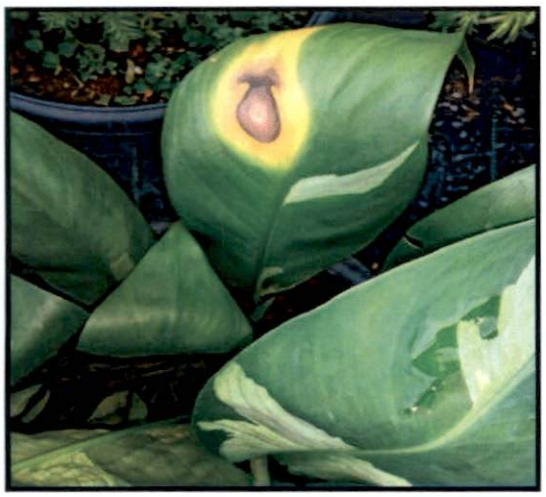
Sl. No.	Plants	Pest and disease incidence under different coloured nets				
		T_1 (Red)	T_2 (Yellow)	T_3 (Green)	T_4 (Blue)	T_5 (Black)
1	*Nephrolepis exaltata*	Nil	Nil	Nil	Nil	Rotting
2	*Asparagus* sp.	Rotting, mealy bug	Nil	Nil	Nil	Mealy bug
3	*Spathiphyllum wallisii*	Tip burning, hairy leaf caterpillar, leaf spot	Leaf spot	Tip burning, leaf spot	Tip burning, leaf spot	Tip burning, Leaf spot
4	*Chrysothemis pulchella*	Snails, leaf rot, stem borer, mealy bug	Leaf rot, stem borer, mealy bug	Leaf rot, stem borer, mealy bug	Leaf rot, mealy bug	Snails, leaf rot, stem borer, mealy bug
5	*Tradescantia spathacea* 'Sitara'	Leaf rot	Leaf rot	Leaf rot	Leaf rot	Leaf rot
6	*Cordyline terminalis*	Leaf spot, thrips, leaf eating caterpillar	Leaf spot, thrips	Leaf spot, thrips	Leaf spot, thrips	Leaf spot, thrips

Rotting in *Nephrolepis exaltata*

Rotting in *Asparagus* sp.

Mealy bug in *Asparagus* sp.

Tip burning in *Spathiphyllum wallisii*



Leaf spot in *Spathiphyllum wallisii*

Hairy leaf caterpillar in *Spathiphyllum wallisii*

Plate 5a: Pests and diseases of selected ornamentals observed under different coloured nets

Snail in *Chrysothemis pulchella*

Rotting in *Chrysothemis pulchella*

Stem borer in *Chrysothemis pulchella*

Mealy bug in *Chrysothemis pulchella*

Wilting in *Chrysothemis pulchella*

Rotting in *Tradescantia spathacea* 'Sitara'

Plate 5b: Pests and diseases of selected ornamentals observed under different coloured nets

Leaf spot on *Cordyline terminalis*

Thrips attack in *Cordyline terminalis*

Leaf eating caterpillar in *Cordyline terminalis*

Sooty mould in *Cordyline terminalis*

Plate 5c: Pests and diseases of selected ornamentals observed under different coloured nets

and plants under green net scored the lowest (21.62 and 18. 75, respectively). This was followed by plants under red net (24.5 and 24, respectively) while those under yellow and blue were medium.

Among the coloured leaf types, *Tradescantia spathacea* 'Sitara' scored the highest under black and red coloured nets (23.5 and 23.25 respectively) followed by blue (22.75), yellow (21.75) and green (20.25). *Cordyline terminalis* grown under black net scored the highest (26) while the lowest score was for plants under blue net (19.75). The plants under red, yellow and green coloured nets scored 23.25, 22.5 and 22.75 respectively.

4.6. Total chlorophyll and carotenoid content

The total chlorophyll and carotenoid content were analysed by acetone method. The result obtained is presented in Table 65.

4.6.1. Total chlorophyll content

Significant difference was observed in chlorophyll content of all the plants under different treatments except in *Chrysothemis pulchella*.

The total chlorophyll content in *Nephrolepis exaltata* under black coloured net is 1.57 mg/g followed by plants under yellow and green coloured nets (1.29 and 1.29 mg/g respectively). The plants under red coloured net recorded the minimum concentration of total chlorophyll (0.92 mg/g).

In *Asparagus* sp., total chlorophyll profile was the highest in plants under black coloured net (1.374mg/g). The plants under yellow and blue coloured shade nets also recorded concentration on par with the highest (1.33 and 1.32 mg/g respectively). The plants under red coloured net had the minimum concentration of total chlorophyll (1.13 mg/g).

Spathiphyllum wallisii grown under blue coloured net recorded the highest concentration of total chlorophyll (2.85 mg/g) followed by plants under black

Table 64a: Plant quality rating

Plant quality rating					
Plants	**Treatments (Shade net colour)**	**Growth & fullness**	**Colour**	**Incidence of pest and diseases**	**Overall acceptability**
Nephrolepis exaltata	T_1 (Red)	6.8	7.0	8.5	22.3
	T_2 (Yellow)	5.5	7.5	8.0	21.0
	T_3 (Green)	7.0	7.5	8.0	22.5
	T_4 (Blue)	5.8	6.3	7.7	19.8
	T_5 (Black)	8.8	9.3	9.0	27.1
Asparagus sp.	T_1 (Red)	7.5	8.0	8.5	24.0
	T_2 (Yellow)	7.3	8.3	7.7	23.3
	T_3 (Green)	6.0	7.3	8.0	21.3
	T_4 (Blue)	6.0	7.0	8.0	21.0
	T_5 (Black)	7.0	7.8	8.0	22.8
Spathiphyllum wallisii	T_1 (Red)	7.8	8.0	8.8	24.6
	T_2 (Yellow)	7.8	8.0	7.5	23.3
	T_3 (Green)	7.5	6.5	7.7	21.7
	T_4 (Blue)	6.3	7.3	8.5	22.1
	T_5 (Black)	8.3	8.3	8.8	25.4

Table 64b: Plant quality rating

Plant quality rating					
Plants	**Treatments (Shade net colour)**	**Growth & fullness**	**Colour**	**Incidence of pest and diseases**	**Overall acceptability**
Chrysothemis pulchella	T_1 (Red)	7.8	7.5	8.8	24.1
	T_2 (Yellow)	5.5	6.5	7.8	19.8
	T_3 (Green)	5.3	6.0	7.5	18.8
	T_4 (Blue)	5.8	6.5	8.3	20.6
	T_5 (Black)	10.0	9.5	9.0	28.5
Tradescantia spathacea 'Sitara'	T_1 (Red)	7.3	7.3	8.8	23.4
	T_2 (Yellow)	6.5	7.0	8.3	21.8
	T_3 (Green)	6.3	5.8	8.3	20.4
	T_4 (Blue)	6.5	7.5	8.3	22.3
	T_5 (Black)	7.0	8.0	8.5	23.5
Cordyline terminalis	T_1 (Red)	7.8	7.3	8.3	23.4
	T_2 (Yellow)	7.3	7.3	8.0	22.6
	T_3 (Green)	7.3	7.3	8.3	22.9
	T_4 (Blue)	5.5	6.8	7.5	19.8
	T_5 (Black)	8.8	8.5	8.8	26.1

(2.21 mg/g), green (2.17 mg/g), yellow (2.06 mg/g) and red (1.90 mg/g) coloured nets.

Tradescantia spathacea 'Sitara' grown under black coloured net recorded the highest (0.58 mg/g) concentration of total chlorophyll. Under yellow coloured net, the values were medium (0.47 mg/g) and the minimum was when grown under green net (0.37 mg/g).

In *Cordyline terminalis* the highest concentration of total chlorophyll was in plants under black and yellow net (1.69 and 1.67 mg/g respectively). Plants under red (1.38 mg/g) had medium value while plants under blue (1.23 mg/g) and green (1.13 mg/g) coloured shade nets had the lowest concentration of total chlorophyll.

4.6.2. Carotenoid content

The concentration of carotenoid was significantly varied with all plants under different nets except in *Chrysothemis pulchella* and *Cordyline terminalis* (Table 65).

Nephrolepis exaltata recorded the maximum content (0.46 mg/g) in plants under black and minimum (0.28 mg/g) under red coloured nets. The plants grown under yellow, green and blue coloured nets recorded medium values for carotenoid concentration.

In *Asparagus* sp., the highest carotenoid content was when grown under black coloured net (0.48 mg/g) followed by plants under green (0.44 mg/g). The plants under yellow (0.40 mg/g) and blue (0.39 mg/g) nets had intermediate concentration of carotenoid while plants under red coloured net had the lowest values (0.31 mg/g).

In *Spathiphyllum wallisii,* the highest concentration of carotenoid was recorded in plants grown under blue coloured net (1.05 mg/g) followed by black coloured net (0.95 mg/g). The plants under yellow and green nets had

intermediate values (0.79 and 0.86 mg/g respectively) while the plants under red had the lowest (0.73 mg/g).

Tradescantia spathacea 'Sitara' recorded the highest content of carotenoid under blue (0.18 mg/g), followed by black (0.17 mg/g) and yellow (0.16 mg/g) coloured nets. The plants under green coloured net recorded medium value (0.14 mg/g) while under red net, plants recorded the lowest (0.12 mg/g) concentration of carotenoids.

Table 65: Effect of different coloured shade nets on the total chlorophyll and carotenoid content of selected ornamentals

Total chlorophyll and carotenoid content (mg/g)												
Treatments (Shade net colour)	***Nephrolepis exaltata***		***Asparagus* sp.**		***Spathiphyllum wallisii***		***Chrysothemis pulchella***		***Tradescantia spathacea* 'Sitara'**		***Cordyline terminalis***	
	Total chl.	**Carot.**	**Total chl.**	**Carot.**	**Total chl.**	**Carot.**	**Total chl.**	**Carot.**	**Total chl.**	**Carot.**	**Total chl.**	**Carot.**
T_1 (Red)	0.92^{c}	0.28^{c}	1.13^{b}	0.31^{c}	1.90^{b}	0.73^{c}	1.16	0.31	0.43^{b}	0.12^{b}	1.37^{ab}	0.46
T_2 (Yellow)	1.29^{b}	0.36^{b}	1.33^{a}	0.40^{b}	2.07^{b}	0.79^{bc}	1.19	0.31	0.48^{ab}	0.16^{a}	1.67^{a}	0.52
T_3 (Green)	1.29^{b}	0.34^{bc}	1.26^{ab}	0.44^{ab}	2.17^{b}	0.86^{abc}	1.11	0.29	0.37^{b}	0.14^{ab}	1.13^{b}	0.37
T_4 (Blue)	1.08^{bc}	0.32^{bc}	1.32^{a}	0.39^{b}	2.86^{a}	1.05^{a}	1.10	0.28	0.47^{b}	0.17^{a}	1.23^{b}	0.46
T_5 (Black)	1.57^{a}	0.46^{a}	1.37^{a}	0.48^{a}	2.21^{b}	0.95^{ab}	1.35	0.34	0.58^{a}	0.17^{a}	1.68^{a}	0.57

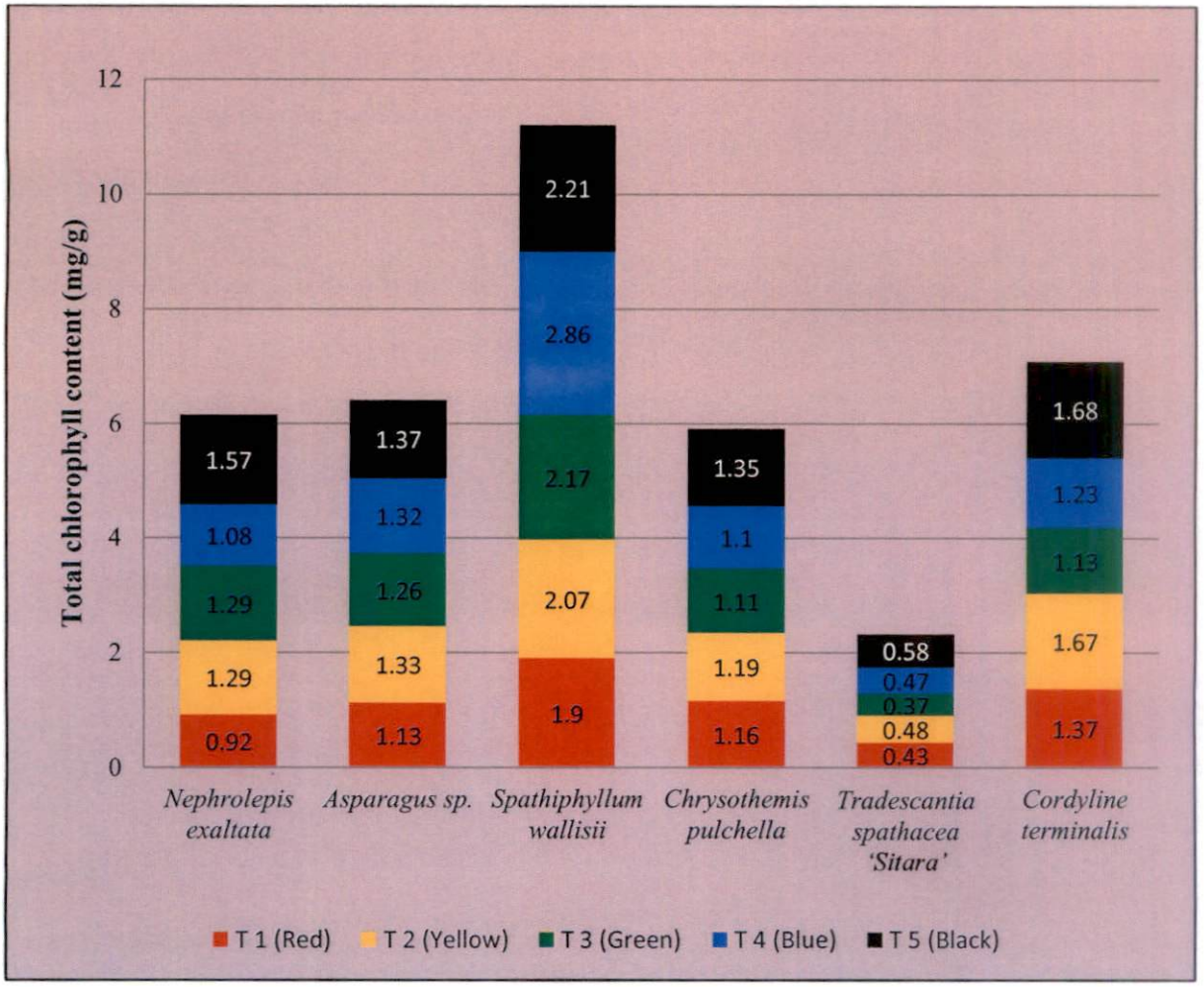


Fig. 5: Total chlorophyll content of selected ornamentals under different coloured shade nets

Discussion

5. Discussion

5.1. Performance of selected ornamentals grown under different coloured shade nets

The impact of different coloured shade nets (red, yellow, green, blue and black) on the performance of selected ornamentals viz., *Nephrolepis exaltata*, *Asparagus* sp. (green leaf types), *Spathiphyllum wallisii*, *Chrysothemis pulchella* (Flowering types), *Tradescantia spathacea* 'Sitara', *Cordyline terminalis* (Coloured leaf types) was studied.

5.1.2. Quantitative characters

The plant characters studied includes plant height, spread, length and breadth of leaves, leaf area, number of leaves produced, internodal length and length and girth of petiole,. The floral characters include size, stalk length, number of flowers produced and longevity of flowers on the plant.

When plant height is concerned, it was found that out of the six species of ornamental plants selected, five of them viz., *Nephrolepis exaltata*, *Asparagus* sp., *Chrysothemis pulchella, Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* were taller when grown under red coloured shade net while *Spathiphyllum wallisii* attained maximum height under black coloured shade net followed by red coloured shade net. All the plants except *Cordyline terminalis* had stunted growth under blue coloured shade net. In *Cordyline terminalis* minimum height was observed under black coloured net. Yellow coloured shade net had intermediate effect on the plant height followed by green net. This is in concurrence with the results obtained by Oren-Shamir *et al.* (2001) in *Pittosporum variegatum* and Kawabata *et al.* (2007) in *Dracaena* sp. where they found plants to be taller in red net. Torres-Hernandez *et al.* (2012) reported that blue colour nets suppressed the elongation of *Lisianthus* sp. As per Kasperbauer (1994) and Dritz and Sager, (1990), increase in stem elongation may be attributed to the reduced ratio of R/FR light or the deficiency of blue light. However, Oren-Shamir *et al.* (2001) opined that the increase in the stem elongation under red nets might be due to the higher

R/FR ratio. The lower plant height in blue colour net could be attributed to the blue light-phytochrome B-cyptochrome effect which could reduce the transport of auxin (Ballarè *et al.,* 1995). It has been reported that the transport of auxin is generally reduced on that part of the plant which absorbs blue light in the phototropic gap-filling response. Since the plants grown under blue colour shade net are likely to receive blue light from all directions, it is possible that the reduction in auxin transport minimizes the elongation of cells surrounding the stem just beneath the zone of cell division of the apical meristem, thereby, leading to reduced elongation of stem just as in the case of chrysanthemum and easter lilies (Oyaert *et al.,* 1999; Rajapakse and Kelly, 1992; Kambalapally and Rajapakse, 1998). The increased height of *Spathiphyllum wallisii* under black colour net indicates that these plants might have undergone stem elongation because of low radiation, a mechanism of adaptation to escape the light deficit condition (Bachin-Mazzini-Guedes and Fernandes-Lopes-Pivetta, 2014).

Plant spread determines the compactness of the plant and its suitability to various growing conditions. In the present study, *Nephrolepis exaltata* and Asparagus sp. showed maximum spread under red and black coloured net and minimum under blue colour net. *Chrysothemis pulchella, Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* were found to be more spreading when grown under red colour net while *Spathiphyllum wallisii* recorded maximum spread under the black net. For all the plants, yellow and green coloured nets were intermediate and blue coloured net resulted in the minimum spread except in *Cordyline terminalis* which recorded the lowest spread under green and black coloured nets, thus, implying that under blue coloured net the plants will be most compact.

Leaf is the most important part of any foliage plant rendering an ornamental value to the plant through its varied features. Leaf characteristics like area, length, breadth and the number of leaves produced were analysed. The quality of light determines the leaf area which may vary from species to species. Under shaded conditions the increase in leaf area coupled with the decrease in the

thickness of the leaf blade are modifications that offer functional advantages to the plants that are grown in environments with low light intensity (Buisson and Lee, 1993). In the present study, the selected ornamentals, *viz., Nephrolepis exaltata*, *Spathiphyllum wallisii*, *Chrysothemis pulchella* and *Tradescantia spathacea* 'Sitara' grown under black coloured net had the maximum leaf area which corroborates with the findings in *Anthurium andreanum* by Nomura *et al.* (2009). Both *Asparagus* sp. and *Cordyline terminalis* recorded a higher leaf area under red coloured net. This supports the findings of the experiment conducted by Ilić *et al.* (2015) who extrapolated that tomato plants under red colour nets produced leaves with maximum area. The rest of the nets were found to be affecting the leaf area almost in a similar manner.

With respect to length of leaves, *Cordyline terminalis* produced the longest and shortest leaves under red and black coloured nets, respectively. However, black coloured net tend to stimulate the longest leaf length in all other plants, viz., *Nephrolepis exaltata*, *Asparagus* sp., *Spathiphyllum wallisii*, *Chrysothemis pulchella* and *Tradescantia spathacea* 'Sitara'. This was followed by red coloured net while green net resulted in smaller leaves in all the plants. Blue coloured net resulted in smaller leaves in *Tradescantia spathacea* 'Sitara' and yellow net, resulted in *Chrysothemis pulchella*. Again, in breadth, the same trend was observed. All the six selected ornamentals had the broadest leaves when grown under black coloured net followed by red. Plants under yellow and green nets produced leaves with medium breadth while leaves of those under blue were the narrowest.

Studying the length and girth of petiole is another important aspect while dealing with foliage plants, as petiole serves as a medium for the transport of the products of photosynthesis manufactured in the leaves to the rest of the plant parts as well as provide physical support to the leaf blades. *Nephrolepis exaltata*, *Asparagus sp., Spathiphyllum wallisii* and *Chrysothemis pulchella* were found to be having longer petioles when grown under black followed by red coloured nets and those under green and blue had shorter petioles. However, *Cordyline*

terminalis had the lengthiest petioles under red and blue and shortest under black coloured nets. As far as girth is concerned, all the plants had petioles with maximum girth when grown under black followed by red coloured nets, intermediate under yellow and thinnest under green and blue coloured nets. In general, petiole length is associated with the plant's ability to withstand conditions of low light. From the observations, it is quite evident that red net can influence the plant height and plant spread whereas, black net, the leaf area, length and breadth of leaf as well as the length and girth of petiole towards the positive direction and gave the best results for all the plants. In *Anthurium andreanum* cv. apalai, the longest leaves and petiole, widest spathe and maximum leaf area was recorded under black shading screens (Nomura *et al.,* 2009), thus endorsing the results attained in this study.

Yet another important factor deciding the quality of foliage plants is the number of leaves. The physiological activities like photosynthesis, respiration etc. of a plant is carried out by the leaves. So more the number of leaves produced, better will be the growth and development of the plant. Leaves also determine the productivity of plants. In the present study, the coloured nets had significant effect on the number of leaves produced. While *Spathiphyllum wallisii* recorded the maximum number of leaves under blue coloured net, *Nephrolepis exaltata, Asparagus* sp., *Chrysothemis pulchella, Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* produced the maximum number of leaves under red coloured net. The capability of the plants to produce more number of new leaves under red net could be associated with the higher PAR levels under red shade net (Kawabata *et al.,* 2007). Yellow and green coloured nets produced the lowest number of leaves in *Nephrolepis exaltata.* Same effect was observed under black coloured net in *Asparagus* sp., *Chrysothemis pulchella* and *Tradescantia spathacea* 'Sitara', which, however, is in contrast to the results obtained by Stamps and Chandler (2008) who found that more number of harvestable leaves was produced in *Aspidistra elatior* plants grown under black colour nets. The lower yield of pelargonium cultivars Samantha and Fernando was in black and aluminet nets

because they were made up of a non-transparent polyethylene which does not reflect sunlight, rather scatters it but the scattering percentage is less than that of the other coloured nets (Nissim-Levi *et al.*, 2014).

With regard to internodal length, only *Chrysothemis pulchella, Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* were observed as the others lack internodes of measurable length. The length of internode indirectly provides an idea about the height of the plant. All the three plants grown under red coloured net recorded maximum internodal length. Both *Chrysothemis pulchella* and *Tradescantia spathacea* 'Sitara' under blue coloured net had the minimum internodal length while *Cordyline terminalis* recorded the same when grown under black coloured net. Green and yellow nets generally had an intermediate effect on the internodal length of the plant. Longer internode under red and shorter under blue nets was reported by Gilbert *et al.* (2013) in Eucalyptus. Shorter internodal length in *Pittosporum variegatum* under blue colour net was also observed by Oren-Shamir *et al.* (2001) who suggested that bushiness or spray look are most often a desirable trait when it concerns with raising of ornamental plants in nursery which might probably supersede the current time and labour consuming pruning activities adopted to achieve similar effects.

The overall reduction in growth rate of plants under blue colour net may be due to the decrease in the CO_2 assimilation rate. (Oyaert *et al,* 1999). Blue light whether alone or in combination with other lights is a critical factor regulating the photomorphogenic response in plants (Rajapakse *et al.,* 1992; Brown *et al.,* 1995). Kim *et al.* (2004) reported that the net photosynthetic rate of plants declines when they are exposed to conditions with high blue and blue-far red light. Rajapakse et al. (1999) also attributed the dwarf inducing effects of films absorbing FR to the higher ratio of R:FR or the removal of Far red light. FR The red net which is characterized by the lower R:FR ratio stimulates the vegetative growth by directly influencing the photomorphogenetic receptors (Nesi *et al.,* 2013).

As far as the flower characters are concerned, *Chrysothemis pulchella* showed no marked difference under the different net colours. However, *Spathiphyllum wallisii* produced the largest spathe and the longest stalk under black and red coloured nets. This is similar to the results obtained by Nomura *et al.* (2009) who found that anthurium with maximum width of spathe and spadix were produced under black colour nets.

The longevity of flowers was also found to be more in the order of black, red, yellow, green and blue. As per Selahle *et al.* (2014), the loss of fruit firmness in tomato cultivar AlfaV during post-harvest storage maybe linked to the PAR level and shading effect of the net which depends on the knitting design. In the present study, the lowest PAR levels were recorded under black colour net. Both in *Spathiphyllum wallisii* and *Chrysothemis pulchella*, interval of flower production was minimum under red net which supports the findings of Ovadia *et al.* (2009) who observed that under red net, *Ornithogallum* flowered eleven days earlier than black and blue nets. The maximum number of days taken by plants under blue net to produce successive flowers coincides with the findings of Shahak *et al.* (2008b) who found that the maturity of grape variety Perlette was delayed under blue coloured net. Far-red absorbing films delayed the flowering in petunia and snapdragon flowers (Cerny *et al.,* 2003).

Vase life is an important parameter based on which flowers and foliage are rendered suitable for use in the ornamental industry. It is the period during which a particular cut flower and/or foliage is able to retain and preserved its appearance and quality. In this study, plants evaluated, *viz., Nephrolepis exaltata*, *Asparagus* sp., *Spathiphyllum wallisii* and *Cordyline terminalis* were found to be having a greater vase life when grown under red and black and the minimum under blue nets. This is in accordance with the findings of Stamps and Chandler (2008), who found that *Pittosporum* grown under red and blue nets had the longest and shortest vase life respectively.

5.1.3. Qualitative characters

The qualitative characters have been studied as they define the aesthetic value of the plant. Texture, type, shape, margin, tip, pigmentation of the leaf and pest and diseases were observed during the study period. It was observed that under all net colours, *Nephrolepis exaltata* and *Asparagus* sp. showed bending, so it is necessary to stake them as well as carry out regular pruning and trimming in order to maintain their form and stature. The other qualitative attributes were similar in all the plants under all the net colours.

The plant quality rating was also done based on visual scoring. The plants were rated according to their quality characters like colour and pigmentation, growth and fullness and intensity of incidence of pest and diseases. *Nephrolepis exaltata*, *Spathiphyllum wallisii*, *Chrysothemis pulchella* and *Cordyline terminalis* under black net and *Asparagus* sp. and *Tradescantia spathacea* 'Sitara' under red net scored high. This kind of visual rating was also done by Kawabata *et al.* (2007) in *Dracaena deremensis* 'Janet Craig'.

The qualitative attributes of the flowers like type, colour and appearance was also studied in *Spathiphyllum wallisii* and *Chrysothemis pulchella* and no significant difference in these characters were observed under different coloured nets.

5.1.4. Pest and disease

The distinction in disease development under the different nets may stem from a direct effect of different light qualities under different coloured nets or from an indirect effect on plant host susceptibility. Some of the common diseases noticed under all net colours were leaf spot and tip burning in *Spathiphyllum wallisii*; leaf rot and mealy bug in *Chrysothemis pulchella*; leaf rot in *tradescantia spathacea* 'Sitara' and leaf spot and thrips in *Cordyline terminalis*. In *Nephrolepis exaltata*, rotting was observed only under black net while in *Asparagus* sp., mealy bug incident was seen in red and black nets. The prevalence of pest and diseases like snails, stem rot, leaf spot, thrips and mealy bugs has already been reported by

Knauss *et al.* (1981) and Hamlen *et al.* (1981) in foliage plants grown under rain shelter. The occurrence of disease in pepper under the shade nets was more pronounced than in open field, the suggested reasons for which is the difference in light intensity, temperature as well as relative humidity (Elad *et al.*, 2007). Regular spray of insecticides can successfully curb the severity of diseases under the different nets.

5.2. Total chlorophyll and carotenoid content

Chlorophyll synthesis in leaves depends both on the genotype as well as the phenotype *viz.*, the variety, and light transmitted by the coloured nets during the growth period (Solomakhin and Blanke, 2008). The chlorophyll profile of the leaf is a well-established reference when quantifying the physiological reactions. It is an important determinant of photosynthetic rate (Mao *et al.*, 2007) and dry matter production (Ghosh *et al.*, 2004). In this context, Bastias *et al.* (2012) found that the net photosynthetic rate of 'Fuji' apple trees was increased by 20-28 per cent in blue colour net than red and white nets. In the present study it was observed that the black coloured net resulted in higher concentration of total chlorophyll in all the plants except in *Spathiphyllum wallisii* which recorded highest chlorophyll content under blue followed by black coloured nets. The plants under red colour net had the lowest concentration of chlorophyll. Similarly, the carotenoid content for all the plants was highest under black and lowest under red coloured nets. The results obtained in this study are in harmony with the findings of Stamps and Chandler (2008), who found the leaf chlorophyll content in *Pittosporum tobira* 'Variegata' was higher under black and blue nets while it was lower under red colour net. The experiment conducted by Li and Syvertsen (2006) also showed that citrus seedlings had the greatest chlorophyll a, b and total chlorophyll under blue and lowest under red coloured nets. The leaf chlorophyll content in *Catharanthus roseus* was also found to be highest in plants under black and blue and lowest under red coloured nets (Melo and deAlvarenga, 2009). This response could be explained by the higher proportion of B:R light under blue colour net compared to red (Bastias *et al.*, 2012). Increase in blue light enhances

the leaf photosynthesis either by stimulating the opening of stomata and/ or improving the efficiency of photosystem II. Large concentration of chlorophyll under these nets may be due to the response of leaves via the phytochrome system to the impaired light regime underneath the coloured shade nets (Solomakhin and Blanke, 2008). Generally the leaves under shaded condition have higher total chlorophyll content compared to that in open condition. Tomato plants under black coloured shade net reported highest chlorophyll to other net colours (Ilić *et al.,* 2015).

5.3. Weather parameters

The recorded weather parameters revealed that light intensity and PAR was lower inside the shade nets and higher outside. Among the coloured nets the highest light intensity was recorded under red colour shade nets followed by blue, green, yellow and the least under black colour net. This is in accordance with the findings of Holcman and Sentelhas (2013) who presented that the red colour screens gave highest transmissivity values.

Geetha *et al.* (2002) stated that foliage plants perform better when grown at 50 per cent shade. But in the present study, no significant correlation with plant characters except for the negative correlation of plant spread of *Chrysothemis pulchella* and *Cordyline terminalis* and number of leaves of *Chrysothemis pulchella* with light intensity was observed. This may be due to the fact that light properties such as direct versus scattered, diffused or reflected depend on cloud formation, dust, air pollution etc., which in turn governs the penetration of light into dense canopies and hence, contribute to the overall response of plant to light (Oren-Shamir *et al.,* 2001).

PAR also exhibited the same trend as light intensity. The PAR value recorded under different coloured nets are in the ascending order of black, yellow, green, blue and red. Al-Helal and Abdel-Ghany (2010) also found similar results and opined that screens with darker colour have the greater capacity to absorb PAR. According to Arthurs *et al.* (2013), the PAR values under black colour nets

were greatly reduced while those under red were reduced the least. Correlation was found to be positive only with the number of leaves produced in *Asparagus* sp. and *Chrysothemis pulchella* under black colour shade net.

The maximum and minimum temperature was found to be higher inside the coloured nets during the morning and evening hours and during the afternoon time it was slightly reduced while relative humidity was always higher inside the shade house. As per Holcman and Sentelhas (2013), temperature and relative humidity inside the net house were always higher than outside temperature. This maybe the result of the partial barrier fostered by the shade nets to the process of convection (Guiselini and Sentelhas, 2004). No correlation was observed between the maximum temperature and the plant characters while minimum temperature showed positive correlation only with the number of leaves produced in *Asparagus* sp. under black nets. The remaining characters were found to be negatively correlated which affirms that higher temperature is not favourable for the growth of foliage plants. High temperature causes excessive transpiration leading to wilting and desiccation of the tissues (Buck and Blessington, 1982). This may be validated with the temperature range already advocated by Manaker (1997) who advised that temperature above 32 to 35°C is injurious to plant cells. He concluded that no plant has a specific temperature at which it performs the best; however, an optimal range will be there for each species which could be maintained. The temperature range of 18 to 24°C has been found to be satisfactory for majority of the tropical foliage plants. Relative humidity was found to be positively correlated with the area, spread and number of leaves of *Chrysothemis pulchella* under different net colours. This implies that a medium range of RH is recommended for foliage plants as higher RH will intensify the undesirable effects and also increase the incidence of pests and diseases (Alex, 2012).

Table 66a: Salient visual changes observed in selected ornamentals grown under different coloured shade nets

Sl. No.	Plants	Colour of shade nets				
		Red	Yellow	Green	Blue	Black
1.	*Nephrolepis exaltata*	The plants are tallest and spreading with large number of longer and broader leaves	Plants intermediate in height with medium spread. Leaves with medium length, breadth and area.	Plants short and compact with less number of small leaves	Plants shorter with less spread. Leaves with minimum length, breadth and area.	Plants tall and spreading; leaves large with long petiole
2.	*Asparagus* sp.	Plants tall and spreading with more number of larger leaves.	Plants are interme - diate in height, spread, area and number of leaves.	Plants are interm- ediate in height, and spread, area and number of leaves is medium.	Plants are stunted and compact with longer leaves of medium breadth and area.	Plants are tall and spreading with longer and wider leaves but lesser in number.
3.	*Spathiphyllum wallisii*	Plants tall with medium sized leaves. Spathe large in size with longer stalk.	Plants medium in stature, spread and area. Size and stalk length of spathe is medium	Plants dwarf and medium in spread. Leaves and flower are smaller.	Plants dwarf and compact, leaves and flowers smaller with less longevity	Plants tall and spreading with large leaves, spathe wide with long stalk.

Table 66b: Salient visual changes observed in selected ornamentals grown under different coloured shade nets

Sl. No.	Plants	Colour of shade nets				
		Red	Yellow	Green	Blue	Black
4.	*Chrysothemis pulchella*	Plants tall with longer internodes, maximum spread and number of leaves with medium length and breadth.	Plants medium, low spreading with smaller leaves.	Plants with medium height and spread, internodes short, leaves small.	Plants medium in height, and spread with medium sized leaves.	Plants tall with medium spread. Leaves less with larger size.
5.	*Tradescantia spathacea 'Sitara'*	Plants tallest with maximum spread, longer internodes, and more number of medium sized leaves.	Plants medium in height, spread with more number of large leaves	Plants short with less spread and more number of medium sized leaves.	Plants shortest with less spread and internodal length. Leaves more in number and small.	Plants medium tall, internodal length shorter, less spread with less number of larger leaves.
6.	*Cordyline terminalis*	Tallest plants with longer internodes, spread maximum, Number and area of leaves high.	Plants medium in height, spread and internodal length leaves small and less in number.	Plants medium in height, area and number of leaves with minimum spread.	Plants medium in height and spread and all leaf characters	Plants stunted and compact in form, medium in size and number of leaves.

Plants under red shade net

Plants under yellow shade net

Plants under green shade net

Plants under blue shade net

Plants under black shade net

Plate 6: Experimental site

Summary

6. Summary

The present investigation on "Evaluation of differential effects of coloured shade nets on selected ornamentals" was undertaken in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period, 2015-2016. The objective of the experiment was to evaluate the growth and performance of the selected ornamentals *viz., Nephrolepis exaltata, Asparagus* sp., *Spathiphyllum wallisii, Chrysothemis pulchella, Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* under different coloured shade nets *viz.,* red, yellow, green, blue and black.

Following is the summary of the salient findings of the study.

1. Plant growth in general was more under red and black nets and stunted under blue nets. Growth was medium under yellow and green nets.
2. Black nets helped enhance the size of leaves whereas the number of leaves was maximum under red net
3. Of the two flowering plants, *Spathiphyllum wallisii* produced bigger flowers with longer stalks under black and red nets. Interval of flower production was least under red and more when grown under blue nets.
4. Vase life of cut foliages like *Nephrolepis exaltata* and *Cordyline terminalis* was enhanced under black and red nets and it was less under blue nets.
5. Plant quality rating also showed superiority of black and red nets.
6. Rotting was observed in *Nephrolepis exaltata* and *Asparagus* sp. under black net; hairy leaf caterpillar in *Spathiphyllum wallisii* and *Cordyline terminalis* under red net; snail was found in *Chrysothemis pulchella* under red and black nets.
7. Total chlorophyll profile was more in plants under black and least under red nets. Light intensity and PAR were reduced inside the nets in the decreasing order of red, blue, green, yellow and black nets.

8. Overall performance of plants under red and black coloured nets overshadowed those under yellow, green and blue net. Red coloured net had a positive influence on certain parameters like height, internodal length and number of leaves while black net improved the leaf characteristics as well
9. Red coloured net can therefore be recommended for getting plants with longer stems that commands a higher price in the cut flower industry. Most of the indoor foliage plants demand a dwarf stature with compact growth for which blue coloured net can be employed successfully.
10. Based on the results obtained, it was observed that different plant species vary in response to the conditions of modified light. Furthermore, the effect may vary with respect to season and climate of different regions. Thus, further investigations would be necessary to find out the effect of these coloured nets on the microclimate, growth and development as well as photosynthetic efficiency of important ornamental crops so that this technology can be harnessed successfully to transform the diverse floricultural industry.

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Appendices

Appendix 1: Light intensity (Lux) recorded under different coloured shade nets during the course of study

Months	T_1 (Red)	T_2 (Yellow)	T_3 (Green)	T_4 (Blue)	T_5 (Black)	Open condition
March	44006.67	34180.00	38093.33	40606.67	19360.00	125080.00
April	46359.09	35077.27	39236.36	44968.18	14327.27	114813.64
May	41920.00	30916.00	32420.00	37664.00	13808.00	116340.00
June	27565.22	17426.09	19200.00	22826.09	11056.52	102626.09
July	32390.91	21100.00	24509.09	30072.73	10438.10	101968.18
August	35127.27	23850.00	26563.64	30477.27	12018.18	105200.00
September	35475.00	24460.00	27390.00	32845.00	12520.00	105415.00
October	38366.67	26414.29	29814.29	36490.48	13890.48	108114.29
November	37409.52	24676.19	27342.86	34409.52	14395.24	107485.71
December	39890.48	27304.76	30952.38	35738.10	16214.29	111047.62
January	42430.43	32995.65	34895.65	38591.30	16252.20	109821.74
February	41408.70	30526.09	33365.22	37617.39	16373.91	112652.17

Appendix II: PAR (µmol/m^2/sec) recorded under different coloured shade nets during the course of study

Months	T_1 (Red)	T_2 (Yellow)	T_3 (Green)	T_4 (Blue)	T_5 (Black)	Open condition
March	848.00	599.40	613.60	806.20	283.40	1400.60
April	976.75	673.25	713.75	957.50	366.25	1630.25
May	554.80	396.40	378.60	500.20	199.60	1040.60
June	1071.50	573.75	712.50	823.50	252.00	1652.75
July	712.60	413.40	469.80	680.60	190.80	1138.20
August	906.00	590.25	648.50	849.75	219.50	1433.75
September	904.20	631.00	703.80	830.40	316.80	1817.00
October	719.75	525.75	504.75	656.75	256.25	1359.75
November	794.20	525.60	629.80	676.20	254.40	1402.00
December	900.25	530.50	627.00	764.50	412.75	1675.25
January	889.00	586.40	659.20	758.60	427.40	1306.80
February	1200.25	791.50	798.50	982.50	477.50	1907.75

Appendix III: Maximum and minimum temperature (°C) recorded inside and outside shade house during the course of study

Months	INSIDE						OUTSIDE					
	MAXIMUM			MINIMUM			MAXIMUM			MINIMUM		
	09.00 hours	12.00 hours	15.00 hours	09.00 hours	12.00 hours	15.00 hours	09.00 hours	12.00 hours	15.00 hours	09.00 hours	12.00 hours	15.00 hours
March	30.60	38.59	34.38	24.70	26.07	25.75	30.50	39.70	34.00	24.50	25.80	25.50
April	30.16	36.83	33.09	24.56	25.31	25.15	30.50	36.50	34.00	22.22	25.00	24.97
May	29.29	33.93	32.18	24.58	24.89	24.84	29.50	35.44	32.10	24.35	25.62	24.80
June	28.74	32.62	31.64	24.68	25.07	24.93	28.70	35.52	31.50	23.59	25.13	24.05
July	31.17	36.19	34.26	24.73	25.10	24.93	28.30	35.50	33.89	23.90	26.42	24.35
August	31.63	37.47	35.21	24.91	25.15	25.02	31.50	37.24	34.12	23.90	25.89	25.00
September	31.73	38.02	35.77	24.89	25.41	25.12	30.56	36.92	33.25	24.12	24.97	24.23
October	30.73	36.30	34.14	24.77	25.01	24.86	29.00	37.68	32.02	23.12	25.65	24.50
November	30.05	35.24	33.58	24.55	24.87	24.67	28.99	37.00	32.00	22.83	25.71	24.32
December	29.45	35.06	33.35	24.15	24.56	24.65	28.00	35.81	32.30	22.96	25.04	24.11
January	30.57	35.27	33.60	23.66	24.07	24.03	30.46	36.55	32.24	24.51	26.83	25.20
February	31.80	37.69	34.97	24.30	24.56	24.40	30.50	37.39	33.40	24.87	25.93	25.32

Appendix IV: Relative humidity (%) recorded inside and outside shade house during the course of study

Months	INSIDE			OUTSIDE		
	09.00 hours	12.00 hours	15.00 hours	09.00 hours	12.00 hours	15.00 hours
March	78.88	87.83	78.38	71.00	83.00	78.00
April	84.12	88.84	82.04	75.62	83.48	79.93
May	91.84	92.24	88.48	84.29	91.50	88.41
June	94.08	95.04	91.12	84.00	92.86	90.24
July	95.31	95.00	91.42	90.55	93.05	90.33
August	92.88	95.33	92.54	87.61	93.72	90.25
September	93.52	92.52	90.40	90.23	90.55	90.21
October	92.35	92.22	89.96	90.08	90.93	87.34
November	86.17	88.54	86.46	82.59	88.12	85.32
December	80.64	84.86	82.18	79.00	83.44	79.50
January	77.63	80.92	77.88	71.00	76.27	76.31
February	83.13	83.67	78.50	76.70	80.95	76.50

EVALUATION OF DIFFERENTIAL EFFECTS OF COLOURED SHADE NETS ON SELECTED ORNAMENTALS

by

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ABSTRACT OF THE THESIS

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ABSTRACT

Evaluation of differential effect of coloured shade nets on selected ornamentals was undertaken in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara. Six plant species *viz.*, *Nephrolepis exaltata*, *Asparagus* sp. (green leaf type); *Spathiphyllum wallisii*, *Chrysothemis pulchella* (flowering type); *Tradescantia spathacea* 'Sitara' and *Cordyline terminalis* (coloured leaf type) were selected for the evaluation. The plants were grown under shade nets of five different colours *viz.*, red, yellow, green, blue and black. Morphological data (both quantitative and qualitative), weather data including temperature, relative humidity, light intensity and PAR (Photosynthetically Active Radiation) were recorded for a period of one year from March 2015 to February 2016. The total chlorophyll and carotenoid contents were evaluated twice, at six and twelve months after planting.

The plant growth in terms of height and spread was found to be greatly influenced by red and black coloured nets as the plants under these two nets were the tallest with more spread. Except for *Cordyline terminalis*, the growth of all plants was the least when grown under blue coloured net. Height and spread of *Cordyline terminalis* was the lowest under black colour net.

Leaf characteristics like area, length and breadth were the highest when grown under black, followed by red coloured nets. The effect of yellow, green and blue coloured nets was not significant. Red net only significantly increased the number of leaves in all plants except *Spathiphyllum wallisii*, in which it was the highest under blue colour net.

The internodal length was the longest in plants under red and shortest under blue coloured nets except in *Cordyline terminalis* which recorded shortest internodes under black net. Length and girth of petiole of all the plants were more when grown under black net except that of *Cordyline terminalis* in which it was the longest under red and blue nets.

The floral characters of *Chrysothemis pulchella* were homogeneous under nets of all colours while *Spathiphyllum wallisii* had bigger flowers with longer stalks under black and red nets. The interval of flower production was the least in red and maximum in plants under blue nets for both the plants.

Vase life was studied for those leaves that could be used as cut foliage. No detectable difference in vase life of *Asparagus* sp. and *Spathiphyllum wallisii* could be observed. But, leaves of *Nephrolepis exaltata* had maximum vase life under black and red; medium under yellow and green and minimum under blue nets. The vase life of *Cordyline terminalis* was minimum under blue net and maximum under all the other net colours which were on par with each other.

A higher concentration of total chlorophyll as well as carotenoid were found under black coloured net in all plants except in *Spathiphyllum wallisii*, in which the maximum concentration was under blue net.

The maximum and minimum temperatures and relative humidity were always higher inside the shade nets compared to the open condition. Both light intensity and PAR were reduced inside the shade nets and the reduction was in the ascending order of black, yellow, green, blue and red nets.

Overall growth of all the plants was higher under red and black nets, while leaf characteristics were better under black net. Quality wise, the plants under black net overshadowed those under red, yellow, green and blue coloured nets. It was observed that all the plant parameters could not be improved by a single net colour. This study will form a base for future works through which we can draw a clear recommendation on the colour of shade net to be used for obtaining the desired plant architecture which will enhance the commercial value of ornamentals.