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Evaluation of Growth and Yield Performances of *Nephrolepis biserrata* under Light Modification by Colored Shade Nets

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ABSTRACT

An experiment was conducted at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India under different photo-selective shade nets to evaluate the growth and quality performances of *Nephrolepis biserrat*a. All four treatments and four replications were analyzed under Complete Randomized Design (CRD). All the treatments were maintained under similar cultural practices. The vegetative parameters like plant height, plant spread, leaf length and breadth were performed significantly better under the green shade net whereas petiole girth was highest under the red colored shade net. In most of the vegetative characters, the lowest result was found in the plants grown without any shade net (control), except leaf breadth which was noticed at minimum under the red colour shade net. Among the leaf production characters i.e. the number of leaves per plant and leaf longevity was maximum under red coloured shade net. The plants were grown under red colored shade net produced leaf less frequently, therefore recorded with least leaf production interval. The leaf quality was also superior under the red shade net regarding leaf chlorophyll content, color intensity and vase life whereas control showed comparatively low-quality characteristics.

Keywords Nephrolepis, Shade net, Leaf production, Fern, Growth.

INTRODUCTION

Cut foliage like ferns plays the fundamental role as ornamental filler by providing a lustrous touch to any floral arrangement and is also known for its increasing popularity in the local as well as the international market because of naturally symmetrical lush green foliage, diverse nursery production and comparatively lower cost of production than cut flowers (Safeena *et al.* 2019, El-Ghait *et al*. 2012). Since India is known as the land of festivals and treasure house of ornamental plants, the demand for cut foliage in India is forging ahead due to its year-round availability (Chowdhuri *et al.* 2021). *Nephrolepis biserrata*, commonly known as 'Fishtail Sword Fern', is a tufted herbaceous perennial ornamental plant with feather-shaped fronds and

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belongs to the Nephrolepidaceae family (Anonymous 2016). In India, this fern is widely cultivated as cut green as filler and called by the name 'Ghoda palm' in flower markets (Muthukumar and Prabha 2012).

Colored shade netting technology is a predominant eco-friendly concept that triggers the ability of plants to sense the changes in light quality and apply it to maximize their growth and development (Nissim-Levi *et al.* 2008, Ovadia *et al*. 2009). These colored shade nets were first invented in Israel (Zare *et al.* 2019) and their application is now gaining momentum around the world (Khyber *et al.* 2019, Gaurav *et al.* 2016a, Gaurav *et al*. 2016b). In both the floral industry and academic sector, this shade netting concept has acquired a notable rise (Stamps 2009, Shahak 2014). Photo-selective shade nets are wispy polyethylene fabrics that facilitates proper ventilation, filtrate solar radiation by absorbing different spectral bands and transform it into a relative proportion of scattered light (Shahak 2016, Selahle *et al.* 2014) which can infiltrate efficiently into the inner canopy of the plant and encourage photosynthesis and productivity (Ilic *et al.* 2015, Kong *et al.* 2013). Therefore it improves the growth and quality of cut foliage and other ornamentals (Mupambi *et al.* 2018, Ilic *et al.* 2017a). Besides this, it also reduces canopy temperature, transpiration rate (Ilic *et al*. 2017b) and offers desirable physical protection against wind speed, wind run (Oliveira *et al.* 2016, Gaurav *et al.* 2015), insect pests and environmental changes (Costa *et al.* 2010, Stamps 2009). Keeping these facts in consideration, the present research work was undertaken in search of better shade conditions for improving the leaf quality of *Nephrolepis biserrata* and attracting farmers for its commercial cultivation.

MATERIALS AND METHODS

The current study was carried out at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India under AICRP on Floriculture during 2016–17 and 2017–18. The research field is situated 9.75 m above the mean sea level (23^{0}05" N and 89° E) where the average temperature, annual rainfall and relative humidity was 21°C-30°C, 950 mm-1200 mm and 81% respectively. The experiment was conducted under three different colored shade nets which are White (50%), Green (50%), Red (50%) and open condition (control). The four treatments and four replications were laid out with Complete Randomized Design (CRD), where healthy and vigorous plants were planted in pots of 20× 20 cm^2 size in the month of March. In each treatment there were 40 pots, therefore 10 pots were there for every replication. Randomly three plants were selected from each replication for recording the findings. The growing media for the pots was prepared with cow dung manure and sandy loam soil in 1:3 proportion. For the better nutrition of the plants, 19:19:19 was applied with a dose of 1 g per liter of water at monthly intervals during the whole growing period. The necessary management practices were the same for all the plants. All the growth parameters i.e., plant height, plant spread, leaf breadth, leaf length, leaf numbers per plant and girth of petiole were taken at a 3-month gap, while quality parameters were collected at the time of harvesting. The RHS color chart was used for collecting the leaf colour intensity. The acetone method was used for leaf chlorophyll analysis and was estimated with the help of a spectrophotometer (Sadasivam and Manicham 1992). Vase life data was taken till the leaves started to turn yellow. The pooled data of two years were statistically analyzed by the proper standard method in OPSTAT with 5% significance level (Panse and Sukhamte 1989).

RESULTS AND DISCUSSION

Vegetative parameters

The conferred data (Table 1) and photographs (Figs. 1a -1d, Fig. 2) are depicting that the colour of shade

Table 1. Vegetative growth parameters of *Nephrolepis biserrata* (pooled data) under colored shade nets.

Treatments	Plant height (cm)	Plant spread (cm)	Leaf length (cm)	Leaf breadth (cm)	Petiole girth (cm)
T_1	81.27	74.00	81.43	9.60	0.75
T_2	86.17	92.67	87.17	10.44	0.95
T_3	76.14	62.67	76.57	7.47	1.02
T_4	46.54	39.17	47.37	8.50	0.65
SEm±	1.27	1.35	0.98	0.31	0.04
CD (p=0.05)	4.49	4.75	3.44	1.09	0.13

T_1: White colored shade nets (50%), T_2 : Green coloured shade net (50%), T_3: Red colored shade net (50%) and T_4: Control (without shade net).

Fig. 1a. Vegetative growth under white shade net (50%). **Fig. 1b.** Vegetative growth under green shade net (50%). **Fig. 1c.** Vegetative growth under red shade net (50%). **Fig. 1d**. Vegetative growth under red shade net (50%).

nets affected the vegetative growth significantly.

The plants of *Nephrolepis biserrata* raised under different shade nets showed better performance regarding plant height than the plants kept without any shade net. Among all the three photo-selective nets, the green shade net was responsible for the highest plant height (86.17 cm) followed by the white shade net (81.27 cm) whereas the lowest plant height (46.54 cm) was found in the plants treated without any shade net (control). The comparatively low light intensity under the green colored shade net than the white and red shade net may be encouraged the flow of auxin as well as apical dominance which lead to better cell elongation and plant height (Zervoudakis *et al*. 2012, Wang *et al.* 2009). In an experiment on Hydrangea cultivar Dienemann and Tricolor, a similar response was observed with the black colored shade net (Nesi *et al.* 2013). Stamps and Chandler (2008) also found better plant height in the Aspidistra plant when kept under low light intensity with black colored shade net.

The plants which were kept under the green shade net gave the maximum (92.67) plant spread and other shade nets also performed well compared to the control. The plants without any shade net (control) had the minimum plant spread (39.17 cm). The congenial microclimate for better plant growth regarding temperature, humidity and light intensity under the green shade net may be influenced the

Fig. 2. Vegetative growth comparison of *Nephrolepis biserrata* under different colored shade nets.

plant spread in comparison with other colored shade nets (Medany *et al.* 2009). The plants of *Nephrolepis cordifolia* raised under the green shade net gave better plant spread than the white and red colored shade net (Khyber *et al.* 2019).

In case of leaf length, the longest leaf (87.17 cm) was observed in the plants grown under the green color shade net followed by the white colour shade net (81.43 cm). The shortest leaf length (47.37 cm) was recorded from the control. The white and red colored shade nets produce higher reflection and shorter photosynthetically active radiation compared to the green colored shade net which eventually reduces the net photosynthetic activity and can be the cause of shorter leaf length (Middleton and Mc Waters 2002). Khyber *et al.* (2019) found that *Nephrolepis cordifolia* performed better under green colored shade net compared to the white and red shade net regarding leaf length.

Regarding leaf breadth, the widest leaf (10.44 cm) was attained in the treatment where plants were maintained under the green shade net. The least wide leaf (7.47 cm) was found in the plants kept under the red shade net which was closely followed by the control (8.50 cm). A similar type of response was observed in *Asparagus plumosus* under the green shade net (Chowdhuri *et al*. 2021).

The petiole girth was maximum (1.02 cm) under the red color shade net which was at per with the plants raised under the green color shade net (0.95 cm), whereas the plants kept without any shade net (control) were recorded with the minimum petiole girth (0.65 cm). The wavelength and color of the light have a great impact on the plant morphology (Li *et al.* 2013). Though no such conclusive evidence regarding leaf petiole girth under red shade net has been found, Gaurav *et al*. (2016a) recorded better petiole length under red colored shade net than white and green shade net, which indicates that petiole growth was better under red colored shade net.

Leaf production parameters

The results of Table 2 show significant impacts regarding leaf production parameters under different colored photo-selective nets.

Concerning the number of leaves per plant, the highest number of leaves per plant (79.00) was found in the plants grown under the red colored shade net followed by green colored shade net (71.67), while the lowest number of leaves per plant was observed in control (17.17). A similar type of result has been found by Zare et al. (2019) in *Calendula officinalis* cv

Table 2. Leaf production parameters of *Nephrolepis biserrata* (pooled data) under colored shade nets.

Treatments	No. of leaves plant^{-1} (nos.)	Leaf longevity (days)	Leaf production interval (days)
T_1	55.67	23.00	81.00
T_2	71.67	26.50	72.34
T_3	79.00	33.50	64.00
T_4	17.17	16.17	82.34
SEm±	1.45	1.13	1.29
CD (p=0.05)	5.11	3.97	4.55

T_1: White colored shade nets (50%), T_2 : Green colored shade net (50%), T_3: Red colored shade net (50%) and T_4: Control shade net) .

Table 3. Quality parameters of *Nephrolepis biserrata* (pooled data) under colored shade nets.

Treatments	Chlorophyll Content (mg g^{-1})	Color intensity (RHS color chart)	Vase life (day)
T_1	1.18	Green (RHS-137C)	11.34
T_2	1.22	Green (RHS-137C)	13.50
T_3	1.46	Dark Green(RHS-137A)	16.50
T_4	1.14	Green(RHS-137C)	9.00
SEm±	0.03	-	0.47
CD (p= 0.05)	0.09	-	1.66

T_1: White colored shade nets (50%), T_2 : Green colored shade net (50%), T_3: Red colored shade net (50%) and T_4: Control (without shade net).

"Indian Prince" and *Viola tricolor* cv "Yellow-Black" under red colored shade net. Ilic *et al.* (2017a) reported the highest number of leaf production under pearl and red colored shade net in lettuce plants.

The maximum leaf longevity (33.50 days) was recorded under the red colored shade net, whereas the minimum leaf longevity (16.17 days) data were collected in the plants raised without any shade net (control). The leaf width of the plants under the red shade net was comparatively lower than other colored shade nets, which may reduce transpiration loss from the leaves and give better leaf longevity.

In respect of leaf production interval, the most frequent leaf production (64 days) was captured in the plants maintained under red colored shade net followed by the plants of green colored shade net (72.34 days), while the leaf production interval was the lengthiest in the control (82.34 days). So, the leaf production was highest under the red colored shade net because the leaf production interval was least in the plants raised under the red shade net compared to the other colored shade nets.

Quality parameters

All the quality parameters presented in Table 3 showed significant differences under the various colored shade nets.

Starting from the chlorophyll content in the leaf, the highest chlorophyll content (1.46 mg/g) was observed in the plants of red colored shade net but results in other colored shade nets were at per with each other. The chlorophyll content was lowest (1.14 mg/g) in the plants kept without any shade net (control). The plants grown under shade produce comparatively larger and denser chloroplast and among the different colored shade nets, the red shade net produced more chloroplastic starch grain which may be the reason for better leaf chlorophyll content (Costa *et al.* 2010). The leaf chlorophyll content was also recorded highest in *Nephrolepis cordifolia* under the red coloured shade net by Khyber *et al.* (2019).

RHS (Royal Horticultural Society) color chart was used to assess the color intensity of the leaves raised under different colored shade nets. So, the leaf color intensity was recorded darker (Dark Green: RHS-137A) in the plants grown under red colored shade net, whereas no significant difference was found between the other treatments regarding the leaf color intensity and was marked under Green (RHS-137C) group. The higher chlorophyll content in the leaves of the plants maintained under the red shade net could be the reason for darker leaf color intensity under the red shade net than in the other treatments.

Regarding the vase life of the leaf, plants grown under the red shade net had the longest vase life (16.50 days) followed by the green colored shade net (13.50 days). The shortest vase life (9.00 days) was observed in case of plants grown without any shade net (control). In case of the red shade net, leaf width was the lowest which may lead to less transpiration and longer vase life compared to other colored shade nets. Stamps and Chandler (2008) noticed the highest vase life of *Pittosporum tobira* cv 'Variegata' under red coloured shade net.

CONCLUSION

The plants of *Nephrolepis cordifolia* raised under the green colored shade net recorded significantly higher plant height, plant spread, leaf length and leaf breath whereas the number of leaves per plant, longevity of the leaf, petiole girth, chlorophyll content and vase life were better under red shade net. So, based on the result and discussion of this experiment we may conclude that the red colored shade net performed qualitatively better and could be recommended for more favorable market preference while the green shade net is superior for higher production.

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