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Effect of different photoselective shade nets on growth and yield of fern

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Abstract
An experiment on "Effect of different photoselective shade nets on growth and yield of fern" was carried out at KRC college of Horticulture, Arabhavi, Gokak, Karnataka during 2018-19. The result revealed that, three fern species grown under grey shade nets performed better with respect to plant height, plant spread, number of fronds per plant, leaf area, stipe length and girth. Higher yield and quality in terms of number of cut leaves per plant (146.25), per square meter (1083.69), fresh weight of cut leaves per plant (358.39 g), per square meter (2655.66 g) and vase life (11.78 days) was recorded in grey shade net. Among different species, higher cumulative number of cut fronds per plant (144.45) and per m^2 (1083.69), fresh weight of cut cladophyll per plant (281.00g) and per m^2 (2084.00 g) was recorded in *Nephrolepis exaltata* cv. Aurea followed by *Nephrolepis exaltata* cv. Bostoniensis. Higher vase life was recorded in *Nephrolepis exaltata* cv. Bostoniensis (11.00 days) followed by *Nephrolepis exaltata* cv. Aurea (9.07).

Keywords: Photoselective shade net, cut foliage, cut greens, ferns, stipe, frond

Introduction
The term ''cut greens'' includes all cultivated or non-cultivated decorative foliage cut from growing plants used as fresh cut decorative foliage (except Christmas trees) and produced under cover or in open field (Anon., 1993) [1]. Cut greens also known as ornamental filler crops, occupy an important position in the local and international market and constitute an important section of floral industry as cut foliages. Cut foliage is used in large quantities for decoration either on its own or in combination with flowers in bouquets. The commercial interest in cut foliage is a recent one. Its increasing popularity is due to diversification of flower and nursery production and lower production costs as compared to the traditional production of cut flowers (Bhattacharjee, 2006) [2]. Many species of ferns are being commercially used as cut greens. Ferns are shade loving and require high humidity. Manipulation of light quality by use of photoselective shade nets is recent technology and becoming popular worldwide. These nets are designed to screen various spectral bands of the solar radiation, and/or transform direct light into scattered light. The spectral manipulation intends to specifically promote desired physiological responses, which are light-regulated, while the scattering improves the penetration of the modified light into the inner plant canopy (Shahak, 2008) [8]. Literature available on effect of photoselective shade nets is very less. Hence an experiment was planned to study the "Effect of different photoselective shade nets on growth and yield of fern".

Material and Methods
The experiment was laid out in a factorial completely randomized block design (FCRD) with two factors at Department of Floriculture and Landscape Architecture, KRC College of Horticulture, Arabhavi (University of Horticultural Sciences, Bagalkot) during the year 2018-2020. Five different photoselective shade nets (Red, blue, grey, pearl and green) were used as factor I and three different species of fern (*Rumohra adiantiformis*, *Nephrolepis exaltata* cv. Aurea and *Nephrolepis exaltata* cv. Bostoniensis) as factor II with three replications. Shade houses were constructed at 5 m apart to avoid overlapping of shade. Shade houses of size 15 m X 10 m were covered with five different photoselective shade nets of 50 percent light factor. Raised beds were prepared with size of 90 cm width and 45 cm height. Each bed was divided into plots of 1.8 m length and twelve plants were planted per plot with spacing of 45 cm between rows and 30 cm between each plant. Data on growth and yield parameters were recorded at 18 months after planting.

Result and Discussion
Among different photoselective shade nets, fern plant grown under grey shade net exhibited maximum plant height and spread (41.79 cm and 915.27 cm^2 respectively) followed by red shade net while, minimum was recorded in green shade net (30.97 cm and 746.64 cm^2 respectively). Similar variations due to photoselective shade net in cut foliages was also observed by Rasheed *et al.* (2018) [11] in *Schefflera arboricola* 'Hicolour'. Among the species significant difference was noticed for plant height and spread. Maximum plant height and spread was recorded in *Nephrolepis exaltata* cv. Bostoniensis (47.21 cm and 1166.47 cm^2 respectively) while, minimum in *Rumohra*

adiantiformis (15.66 cm and 234.25 cm^2 respectively). These variations among varieties/ species might be due to genetic makeup of plant along with congenial growing conditions. Similar variations in plant height were observed previously in ferns by Suryapriya *et al.* (2015) [10].

Though *Rumohra adiantiformis* is a highly valued among ferns for cut foliage, it did not perform well under Arabhavi condition which might be due to higher soil pH. Initial establishment was better because planting was done during rainy season as there was leaching of salts from the soil due to rainwater. During summer months, increase of salt levels in irrigation water from open-well resulted in accumulation of salts in the soil. This might have led to seizure of growth. Hence, after 9 months of planting, leaves started drying and overall growth also reduced. It did not perform well under any of photoselective shade nets.

Leaves are very important part of any plant. 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 investigation, among the photoselective shade nets higher number of fronds per plant was recorded in grey shade net (54.70) while, minimum was recorded in green shade net (37.33). This might be attributed to more frequent production of frond *i.e.* lower frond production interval in grey shade net (6.53 days) whereas, less frequent production of fronds was recorded in green shade net (12.51). Similar variations with respect to number of leaves per plant due to colour shade net was also reported in *Nephrolepis exaltata* (Myrthong, 2016) [3]. Further higher frequency may be attributed to improved branching/ suckering in grey shade net as reported by Oren-Shamir *et al.* (2001) [4]. With respect to species, higher number of fronds per plant was recorded in *Nephrolepis exaltata* cv. Aurea (64.68) while lower number was recorded in *Rumohra adiantiformis* (6.60). Lower frond production interval was reported in *Nephrolepis exaltata* cv. Aurea (2.08 days) which might have manifested into higher number of fronds per plant. Higher value of frond production interval was found in *Rumohra adiantiformis* (20.91 days) which led to lower number of fronds per plant. Varietal variations among species may also be due to genetic makeup of plant as well as microclimatic conditions around plants. Similar variations due to species/ varieties for number of fronds per plant was also reported in ferns Suryapriya *et al.* (2015) [10]; Safeena *et al.* (2019) [7].

Stipe length and girth of fern are very important quality parameters. Longer stipe length is a desirable character in ferns. Length of the stipe plays a vital role in making the cut fern frond presentable and stalk girth gives sufficient strength to hold frond in position. Significant differences were observed with respect to stalk length and girth due to photoselective shade nets and varieties (Table 1). Among the photoselective shade nets, significantly maximum stipe length and girth were recorded under grey shade net (6.83 cm and 1.86 mm respectively). While, minimum stipe length was recorded in red shade net (5.46 cm) and minimum stipe girth was recorded in pearl shade net (1.53 mm). Increase in stipe length and girth in grey shade net may be attributed to the congenial micro-climatic conditions around plant. Similar variations in stipe length and girth due to colour shade net are also reported by Myrthong (2016) [3] in *Nephrolepis exaltata.* With respect to species, maximum stipe length was recorded in *Nephrolepis exaltata* cv. Bostoniensis (7.23 cm and 1.97 mm respectively) while, minimum in *Rumohra adiantiformis* (4.54 cm and 1.41 mm respectively). Variations among varieties may be attributed to genetic makeup of plant and favourble micro-climate around it. Similar variations among species were also reported by Safeena *et al.* (2019) [7] in ferns.

Among the photoselective shade nets maximum leaf area per plant and leaf area index was observed in grey shade net (2183.44 cm^2 and 1.617 respectively) while, minimum (1202.9 cm^2 and 0.891 respectively) was recorded in green shade net (Table 1). Higher leaf area in grey shade net might be attributed to creation of congenial climatic condition which might have led to production of more number of leaves, higher leaf length and width and more number of suckers per plant which manifested into a higher leaf area. Similar variations among colour shade net was also reported in chrysanthemum (Oyaert *et al.,* 1999) [5]. Among species, *Nephrolepis exaltata* cv. Aurea recorded maximum leaf area per plant and leaf area index (2291.34 cm2 and 1.697 respectively) while, *Rumohra adiantiformis* recorded minimum leaf area per plant and leaf area index (116.14 cm^2 and 0.086 respectively). This variation among species may be due to varietal character, soil and microclimatic conditions around plant. Similar variations due to varieties/ species is also reported in fern (Suryapriya *et al.*, 2015 and Safeena *et al.*, 2019) [10, 7].

Yield parameters

Among the photoselective shade nets days to first harvest did not vary significantly. However, plants under grey took lesser number of days to harvest (159.23 days) compared to other photoselective shade nets (Table 2). Among the species *Nephrolepis exaltata* cv. Aurea took minimum days to first harvest (160.67 days) followed by *Nephrolepis exaltata* cv. Bostoniensis (165.47 days) and maximum days in *Rumohra adiantiformis* (172.44 days). Similar variations with respect to days taken for first harvest among varieties was also reported by Patil (2001) [6] and Shiragur (2002) [9] in carnation.

Among the photoselective shade nets, significantly maximum cumulative number of cut fronds per plant, per square meter, fresh weight of cut cladophylls per plant and per square meter (Table 2) was recorded under grey shade net (146.25, 1083.69, 358.39 g and 2655.66 g respectively) while minimum was recorded in green shade net (79.18, 586.70, 130.99 g and 970.60 g respectively). Ferns grow well in lower light intensity, cooler temperature and high humidity. Grey shade net created congenial microclimatic conditions for ferns. Hence, fern plants grown under grey shade net produced more number of fronds per plant and higher fresh weight. Similar variations with respect to cut leaf yield due to colour shade net was also reported in *Nephrolepis exaltata* (Myrthong, 2016) [3]. With reference to species significantly maximum number of cut fronds per plant, per square meter and fresh weight of cut cladophylls per plant and per square meter were noticed in *Nephrolepis exaltata* cv. Aurea (144.45, 1070.37, 281.25 g and 2084.09 g respectively) and minimum was recorded in *Rumohra adiantiformis* (44.97, 333.20, 61.91g and 458.77g respectively). Similar variations due to species/ varieties for frond yield was also reported in ferns by Suryapriya *et al.* (2015) [10] and Safeena *et al.* (2019) [7].

Vase life of fern species was carried out by placing cut stems in distilled water. Among the photoselective shade nets significantly maximum vase life of 11.78 days was recorded in cut greens

grown under grey shade net followed by red shade net. While, minimum vase life (7.67 days) was recorded in green shade net. These variations might be attributed to higher accumulation of photosynthetic pigments in grey shade net due to optimum growing conditions which might have led to higher rate of photosynthesis and accumulation of carbohydrates. Similar variations in ferns due to colour nets are also reported by Myrthong (2016) [3]. With reference to species, maximum vase life of 11.00 days was recorded in *Nephrolepis exaltata* cv. Bostoniensis while minimum was recorded in *Rumohra adiantiformis* (8.13 days). Similar variations among species was also reported by Suryapriya *et al.* (2015) [10] in ferns.

Table 1: Growth parameters in fern species as influenced by photoselective shade nets at 18 months after planting

Treatments	Plant height (cm)	Plant spread (cm^2)	Number of fronds per plant	Frond production interval (days)	Stipe length (cm)	Stipe girth (mm)	Leaf area per plant (cm^2)	Leaf area index
Factor A (S- Photoselective shade nets)								
S_1	32.99	859.02	42.77	7.11	5.46	1.60	1519.99	1.126
S_2	32.53	844.37	41.26	9.24	5.84	1.86	1423.74	1.055
S_3	41.79	915.27	54.70	6.68	6.83	1.86	2183.44	1.617
S_4	34.70	838.59	40.71	6.53	5.59	1.53	1417.64	1.050
S_5	30.97	746.64	37.22	12.51	5.57	1.72	1202.19	0.891
SEm±	0.77	20.66	0.85	0.37	0.14	0.04	36.17	0.027
CD @ 1%	2.98	80.35	3.29	1.43	0.55	0.17	140.68	0.104
Factor B (T- *Asparagus* species)								
T_1	15.66	234.25	6.60	20.91	4.54	1.41	116.14	0.086
T_2	40.92	1121.62	64.68	2.08	5.80	1.76	2291.34	1.697
T_3	47.21	1166.47	58.72	2.25	7.23	1.97	2240.71	1.660
SEm±	0.59	16.00	0.66	0.29	0.11	0.03	28.02	0.02
CD @ 1%	2.31	62.24	2.55	1.11	0.43	0.13	108.97	0.08
Factor A X B (S X T)								
S_1T_1	15.49	242.22	5.58	17.22	4.22	1.31	98.49	0.073
S_1T_2	35.78	1166.67	64.03	2.00	4.69	1.61	2197.59	1.628
S_1T_3	47.70	1168.17	58.72	2.11	7.46	1.89	2263.89	1.677
S_2T_1	13.55	233.12	5.78	23.32	4.11	1.84	79.46	0.059
S_2T_2	37.05	1141.80	60.49	2.10	6.32	1.75	2083.92	1.544
S_2T_3	46.99	1158.20	57.51	2.30	7.09	2.00	2107.85	1.561
S_3T_1	23.61	245.00	8.96	16.93	5.91	1.33	261.65	0.194
S_3T_2	47.61	1224.53	85.51	1.48	6.76	1.98	3359.15	2.488
S_3T_3	54.14	1276.27	69.64	1.62	7.83	2.27	2929.52	2.170
S_4T_1	13.65	241.90	6.15	15.14	4.22	1.05	74.31	0.055
S_4T_2	44.01	1048.40	59.07	2.08	5.58	1.80	2043.81	1.514
S_4T_3	46.45	1225.47	56.89	2.35	6.97	1.73	2134.81	1.581
S_5T_1	11.98	209.00	6.51	31.94	4.23	1.53	66.81	0.049
S_5T_2	40.12	1026.70	54.31	2.73	5.67	1.67	1772.24	1.313
S_5T_3	40.79	1004.23	50.84	2.87	6.81	1.97	1767.50	1.309
SEm±	1.33	35.78	1.47	0.64	0.25	0.08	62.65	0.046
CD @ 1%	5.17	NS	5.70	2.48	0.96	0.30	243.66	0.180

S1 – Red Shade net T1: Rumohra adiantiformis
S2 – Blue Shade net T2: Nephrolepis exaltata cv. Aurea
S3 – Grey Shade net T3: Nephrolepis exaltata cv. Bostoniensis
S4-– Pearl Shade net NS- Non-significant
S5 – Green Shade net

Table 2: Days to first harvest, yield and vase life of fern species as influenced by photoselective shade nets.

Treatments	Days to first harvest	Cumulative yield 18 months after planting				Vase life (days)
		Number of cut fronds		Fresh weight of cut fronds (g)		
		Per plant	Per sq. m.	per plant	per sq. m.	
Factor A (S-Photoselective shade nets)						
S_1	165.81	104.51	774.44	195.16	1446.15	9.78
S_2	171.64	90.84	673.10	139.68	1035.00	8.11
S_3	159.23	146.25	1083.69	358.39	2655.66	11.78
S_4	164.27	101.68	753.42	187.74	1391.13	9.67
S_5	170.02	79.18	586.70	130.99	970.60	7.67
SEm±	2.63	1.36	10.07	3.00	22.19	0.41
CD @ 1%	NS	5.29	39.18	11.65	86.30	1.61

Factor B (T- *Asparagus* species)						
T_1	172.44	44.97	333.20	61.91	458.77	8.13
T_2	160.67	144.45	1070.37	281.25	2084.09	9.07
T_3	165.47	124.05	919.24	264.00	1956.27	11.00
SEm±	2.04	1.05	7.80	2.32	17.19	0.32
CD @ 1%	7.92	4.10	30.35	9.02	66.85	1.24
Factor A X B (S X T)						
S_1T_1	172.05	44.97	333.20	54.26	54.26	8.33
S_1T_2	158.57	145.56	1078.60	280.87	280.87	9.00
S_1T_3	166.79	123.01	911.50	250.36	250.36	12.00
S_2T_1	174.90	41.35	306.40	49.20	49.20	7.00
S_2T_2	168.23	122.99	911.33	190.93	190.93	7.33
S_2T_3	171.80	108.17	801.57	178.90	178.90	10.00
S_3T_1	168.69	57.96	429.46	106.71	106.71	10.67
S_3T_2	153.49	204.90	1518.28	490.32	490.32	11.67
S_3T_3	155.50	175.89	1303.32	478.14	478.14	13.00
S_4T_1	173.25	45.05	333.80	56.52	56.52	8.67
S_4T_2	158.11	143.13	1060.62	273.29	273.29	9.67
S_4T_3	161.45	116.85	865.86	233.41	233.41	10.67
S_5T_1	173.31	35.51	263.13	42.88	42.88	6.00
S_5T_2	164.96	105.67	783.01	170.85	170.85	7.67
S_5T_3	171.78	96.35	713.97	179.22	179.22	9.33
SEm±	4.55	2.35	17.45	5.19	5.19	0.72
CD @ 1%	NS	9.16	67.86	20.17	20.17	NS

S1 – Red Shade net
S2 – Blue Shade net
S3 – Grey Shade net
S4-– Pearl Shade net
S5 – Green Shade net

T1: Rumohra adiantiformis
T2: Nephrolepis exaltata cv. Aurea
T3: Nephrolepis exaltata cv. Bostoniensis
NS- Non-significant

Conclusion

From above results it can be concluded that among different photoselective shade nets, vegetative growth in terms of plant height, plant spread, number of fronds per plant, leaf area, stipe length and girth were better under grey shade net. Early harvesting, higher yield in terms of number of cut leaves per plant (146.25), per square meter (1083.69), fresh weight of cut leaves per plant (358.39 g) and per square meter (2655.66 g) was recorded in grey shade net. Fern plants grown under grey shade net recorded better vase life (11.78 days) followed by red shade net (9.78 days). Among different species, better vegetative growth was recorded in *Nephrolepis exaltata* cv. Aurea followed by *Nephrolepis exaltata* cv. Bostoniensis. Higher cumulative number of cut fronds per plant (144.45) and per m^2 (1083.69) and fresh weight of cut cladophyll per plant (281.00g) and per m^2 (2084.00 g) was recorded in *Nephrolepis exaltata* cv. Aurea followed by *Nephrolepis exaltata* cv. Bostoniensis. Higher vase life was recorded in *Nephrolepis exaltata* cv. Bostoniensis (11.00 days) followed by *Nephrolepis exaltata* cv. Aurea (9.07).

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