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Effect of spectral manipulation and seasonal variations on cut foliage production and quality of *Philodendron* (*Philodendron* 'Xanadu')

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Abstract: Influence of spectral manipulation of light using coloured nets and seasonal variation on cut foliage yield and quality of *Philodendron* 'Xanadu' was evaluated under red, green, white and black coloured shade nets permitting light intensities ranging from 240.50 to 370 μ mol m⁻² s⁻¹ (75% shade net), for two consecutive years from 2014-16, at ICAR- IIHR, Bengaluru. The plants grown under white shade net (75% shade) resulted in higher foliage production plant⁻¹ month⁻¹ (14.53) and were on par with those grown under green shade net. The quality of the cut foliage in plants grown under white shade net with respect to stalk length (24.91 cm) and width of lamina (5.19 cm) was on par with those under green and black shade nets. Coloured shade nets did not influence vase life of the cut foliage. Developmental stages of the foliage under the different coloured nets have indicated that leaves attained the harvestable maturity stage at 29.92 days post emergence under white shade. Cultivation of *Philodendron* 'Xanadu' under white shade resulted in maximum cut foliage yield and quality.

Keywords: Coloured shade nets, Cut foliage, *Philodendron* 'Xanadu' and Photomorphogenesis.

INTRODUCTION

Philodendron 'Xanadu' is a perennial evergreen tropical shrub, which belongs to the family Araceae and is cultivated under partial shade for its glossy green foliage. The cut foliage is used in floral bouquets as fillers and in floral arrangements. Coloured shade nets are used to regulate the crop growth and quality by screening various spectral bands of the solar radiation. According to Shahak (2008), the spectral manipulation by use of coloured nets influences the microclimate to which the plant is exposed, and promotes light-regulated desirable physiological responses, besides the nets providing physical protection against excessive radiation, insect pests and environmental changes. Stuefer and Huber (1998) opined that changes in light composition influence the development and morphogenesis. Photomorphogenesis is influenced by phytochromes (Quail *et al.*, 1995), cryptochromes (Ahmad and Cashmore, 1996; Batschauer, 1998), and specialized UV-A and UV-B (Christie and Jenkins, 1996) receptors, about which little is known. Mohr (1994) reported that in many of the photomorphogenetic reactions, more than

one photoreceptor is involved. Coloured shade nets induce desirable physiological responses and this is related to the production and quality of the crop. According to Ganelevin (2008), this is an economical and environmentally friendly alternative to labour and chemical intensive crop production and is being assessed in an increasingly growing number of crops, leading to gradual expansion of the commercial use. Many of the cut greens are commercially grown in India under green or black shade nets. A study was conducted to evaluate the coloured shade net most suitable for commercial production of *Philodendron* 'Xanadu' cut foliage, with the objective of exploring the possibility of improving the yield and quality.

MATERIALS AND METHODS

An experiment was conducted at the Division of Flower and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Bengaluru during 2014 to 2016 on *Philodendron* 'Xanadu' grown under four coloured polypropylene shade nets (75%) viz., red, black, green and white in randomised block design with six replications. Healthy, uniform suckers of *Philodendron* 'Xanadu' were planted on raised beds at 45 x 45cm spacing. Well decomposed FYM was added to the beds @ 2 kg m⁻² and was thoroughly mixed. Fertilizers were applied to the plants @ 100:30:60 kg NPK ha⁻¹ per year. Entire dose of phosphorous was supplied as basal dose and nitrogen and potash were applied in six equal split doses at bimonthly intervals. Observations on the number of cut foliage plant⁻¹ month⁻¹, length of lamina, length of stalk, frond width and diameter of stalk were recorded. Based on the importance with regard to marketable standards, some of these parameters were assigned a factor with which it was multiplied and the weighted averages were calculated.

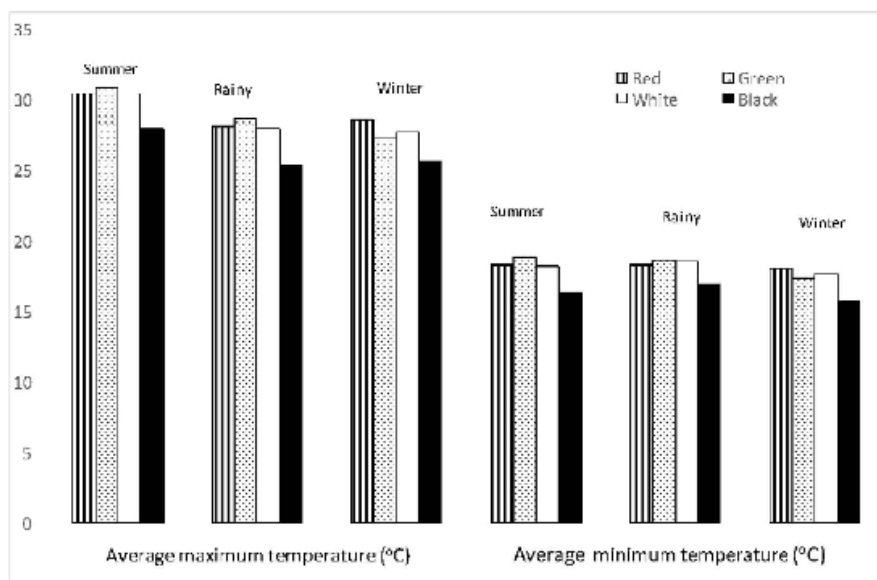


Fig. 1a

Maximum and minimum temperatures (°C) inside coloured shade nets during different seasons

Fig. 1a: Maximum and minimum temperatures (°C) inside coloured shade nets during different seasons

RESULTS AND DISCUSSION

Data pertaining to the influence of coloured shade nets on production and quality of the cut foliage of *Philodendron* 'Xanadu' have been presented in Table 1. Plants grown under white shade nets produced the maximum number of cut foliage plant⁻¹month⁻¹ (14.53) which was on par with those grown under green shade net (13.71) followed by plants under red net (13.31). Minimum yield of cut foliage plant⁻¹month⁻¹ was obtained under black shade net (10.36). However, Stamps (2008) recorded the maximum foliage production under red shade net in *Philodendron* 'Xanadu'. In this study, the foliage production was highest under white shade net which might be due to the higher PAR availability. The foliage quality was significantly influenced by the colour of the shade nets. Plants grown under black shade net recorded Developmental stages of the foliage, epicuticular wax content of the foliage and post harvest qualities under the different coloured shade nets were recorded. The gas exchange parameters, net photosynthesis (PN), transpiration rate (E) and stomatal conductance (gs) were recorded between 09:30 h and 11:00 h on fully expanded fourth leaf from shoot apex using portable photosynthetic system (LC pro+, ADC Bioscientific limited, UK). Seasonal influence on the production and quality attributes of the foliage was also analysed. The pooled data were statistically analysed (Gomez and Gomez, 1984) and the results have been presented. The average maximum and minimum temperatures and relative humidity recorded under the different coloured

shade nets during the experimental period have also been presented in Figs.1 a and 1b.

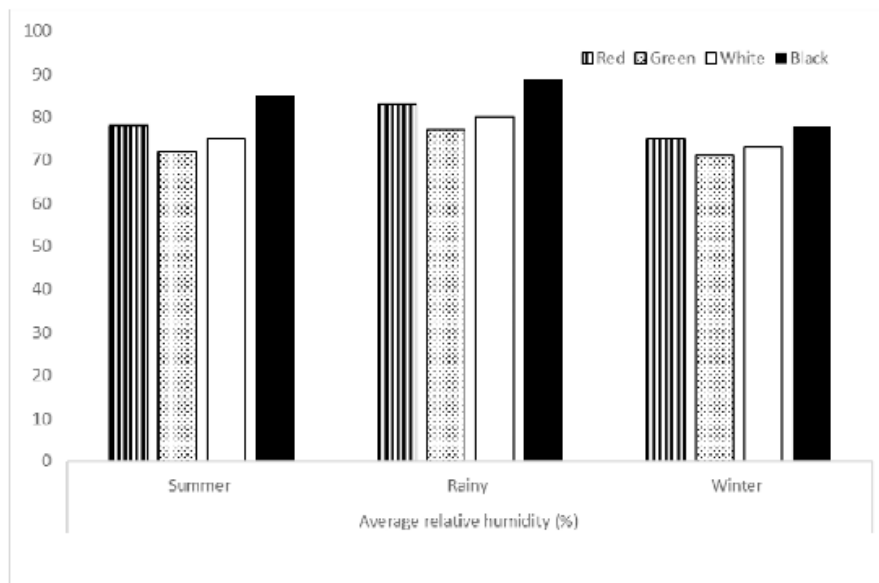


Fig. 1b

Seasonal effect on the relative humidity (%) inside coloured shade nets

maximum length of stalk (26.27 cm), which was on par with green (25.86 cm), white net (24.91) and was minimum in red (22.95 cm). Cultivation of plants under green shade net resulted in the maximum average width of lamina (5.36cm) which was on par with black (5.23 cm), white (5.19) and it was minimum in red (4.97 cm). Cultivation of plants under green shade net resulted in maximum stalk diameter (5.11 mm) and was minimum in black nets (4.49 mm).

The seasonal influence on cut foliage production and quality of *Philodendron* 'Xanadu' during three seasons *viz*, summer (March to June), rainy (July to October) and winter (November to February) was analysed and graphically presented in Figs. 2(a-e).

During rainy season, the cut foliage production plant-1 was higher in the plants grown under all the coloured nets as compared to summer and winter seasons. The cut foliage production plant-1 month-1 (Fig. 2) was maximum in plants grown under white shade net during rainy season (19.54) and minimum in plants grown under black shade net during summer (9.01). Production of foliage was at par during the summer and winter seasons. Foliage quality was influenced to a certain extent by seasonal variations for characters like length of lamina, length of stalk, average width of lamina and diameter of stalk across the colour of the nets. The quality of cut foliage harvested from plants grown under green shade nets was superior for length of lamina (15.68 cm, 15.77 cm and 15.65 cm during summer, rainy and winter seasons, respectively), length of stalk (28.26cm during rainy season), lamina width (5.52 cm during summer season) and diameter of stalk (7.30 mm during winter season). The quality attributes of the foliage grown under white shade nets in respect of

length of lamina (14.97 cm) and length of stalk (25.60 cm) during winter months and width of lamina during summer months (5.18 cm) were at par with that of the green nets. In general, the quality parameters of the foliage were lower under red and black nets depending on the season.

Table 1

Influence of shade net colour on the production and quality of cut foliage in *Philodendron*

Treatment (Shade net colour)	Number of foliage/plant/month	Length of lamina (cm)	Length of stalk (cm)	Average lamina width (cm)	Diameter of stalk (mm)
Red	13.31	15.23	22.95	4.97	4.67
Green	13.71	15.70	25.86	5.36	5.11
White	14.53	15.24	24.91	5.19	4.74
Black	10.36	14.70	26.27	5.23	4.49
SEm ±	0.40	0.30	0.38	0.87	0.10
CD (P=0.05)	1.17	NS	1.12	0.25	0.3

The per cent available Photosynthetically Active Radiation (PAR) inside the green coloured nets was highest (35.45 % during summer, 41.54% during rainy season and 38.16% during winter season), followed by the PAR inside white coloured nets (29.09 % during summer, 31.75% during rainy season and 35.04% during winter season). PAR designates the spectral range of solar radiation from 400 to 700 nanometres that plants are able to use in the process of photosynthesis. Higher PAR might have contributed to increase in photosynthesis by the plants, production of more photosynthates, thereby resulting in increased production of foliage. The quality of foliage like longer lamina, stalk and width of lamina could be correlated with the increase in sink capacity due to production of more photosynthates.

Epicuticular wax content (EWC) of the foliage was estimated and presented in Fig.5. EWC in the foliage of plants grown under green shade net was 871.8 μgdm^{-2} whereas the plants under white nets recorded 800.2 μgdm^{-2} . EW strongly contributes to the maintenance of high photosynthetic rates on leaves, which are able to keep their stomata open for longer periods, with high water use efficiency (Medeiros *et al.*, 2017).

The vase life of cut foliage was evaluated under room condition (temperature 24-28 C and 50-67% RH) in distilled water and it did not vary significantly among the cut foliage grown under different shade net colours (Fig 3) which was in accordance with the findings of Stamps (2008) in *Philodendron* 'Xanadu'. The developmental stages of *Philodendron* (Fig. 4) were studied and the days taken by the foliage to attain each of the three critical stages i.e., Stage 1 (leaf tightly rolled in cataphyll), Stage 2 (just expanded tender leaf) and Stage 3 (fully expanded matured leaf) under the different shade nets were recorded. The days taken for progression from the first to second stage did not show marked difference under the different coloured nets. Green shade net (30.83 days) followed by white shade net (29.92 days) was found to have increased time intervals for the attaining the fully expanded mature stage from

the tender leaf stage as compared to black (28.00 days) and red shade nets (26.08 days). This can be correlated with the quality of the foliage indicating that with the increase in time taken to attain maturity, the foliage would have accumulated more of photosynthates resulting in superior quality.

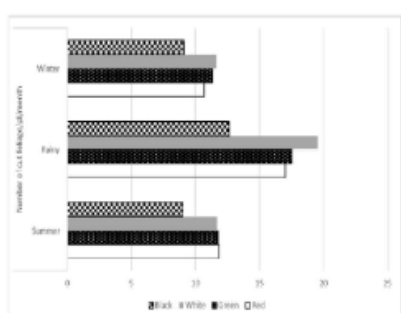


Fig. 2a. Number of foliage plant⁻¹ month⁻¹

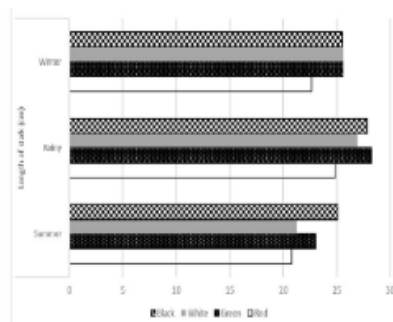


Fig. 2b. Length of stalk (cm)

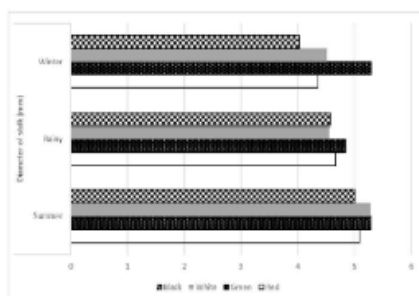


Fig. 2c. Diameter of stalk (mm)

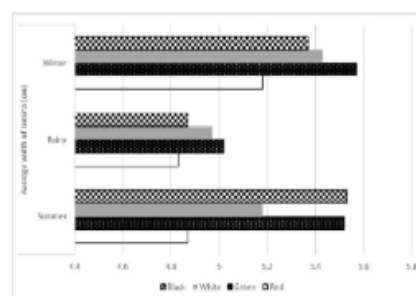


Fig. 2d. Width of lamina (cm)

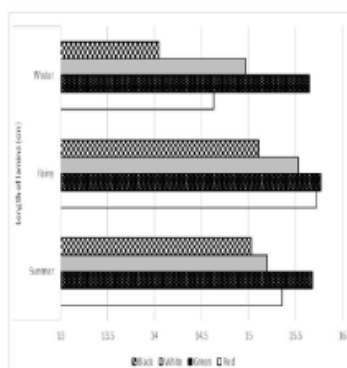


Fig 2 (a-e)

fluence of coloured shade nets and seasons on the cut foliage production and quality of foliage in *Philodendron* 'Xanadu'

Observations on gas exchange characteristics were recorded from the plants grown under different shade net colours. The photosynthesis rate was highest under green shade net during rainy season, which was on par with white shade net (Table 2). During summer and winter seasons, highest photosynthesis rate was observed in the plants under red shade net and was on par with white shade net. Plants under black shade net showed consistently lower photosynthesis rates across the seasons. The per cent PAR availability under different shade nets varied with highest available PAR under the green shade net followed by white shade net and least PAR was available under the black shade net (Table 2). Though

definite trend was not observed among the different shade net treatments, overall, the transpiration rate was higher during summer season compared to rainy and winter seasons. The stomatal conductance was higher during rainy season compared to summer and winter seasons. In this study, it was observed that due to lower PAR availability under black shade net compared to other colour shade net, the photosynthesis rate was also lower. Ayala-Tafoya *et al.* (2018) in their study on the influence of coloured shade nets on photosynthesis and yield of cucumber observed that black shade net provided higher level of shade to the plants. The availability of PAR as well as red and blue lights were lower under black shade net compared to the other colour shade net. Black and white shade nets are known to cause reduction in light quantity and provide shade, while red shade net has effect on changes in red light composition (Ayala-Tafoya *et al.*, 2011; Lobos *et al.*, 2012; Oliveira *et al.*, 2016). Though the green shade net transmitted highest PAR among the shade nets, the photosynthesis rate was highest during rainy season but was lower during summer and winter seasons which might be correlated with the temperature coefficient of real assimilation.

The maximum and minimum temperatures recorded inside the coloured nets also varied with green recording the highest average maximum and minimum temperatures in summer and rainy seasons and red net the highest maximum and minimum temperatures during winter season (Fig. 1a). Black shade net recorded the lowest average maximum and minimum temperatures across the seasons. The highest relative humidity was recorded inside the black shade net across the seasons followed by red shade and lowest inside green net (Fig. 1b).

Table 2

Seasonal influence of shade net colour on transpiration rate ($\text{m mol m}^{-2}\text{s}^{-1}$), stomatal conductance ($\text{mol m}^{-2}\text{s}^{-1}$), photosynthesis rate ($\text{m mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$) and per cent available PAR

Treatment (Shade net colour)	Transpiration rate ($\text{m mol m}^{-2}\text{s}^{-1}$)			Stomatal conductance ($\text{mol m}^{-2}\text{s}^{-1}$)			Photosynthesis rate ($\text{m mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$)			Per cent available PAR		
	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter
Red	6.22	3.36	3.02	0.18	0.30	0.17	9.44	10.44	9.13	26.58	31.69	27.58
Green	4.84	3.58	3.29	0.12	0.31	0.20	7.59	11.64	7.21	35.45	41.54	38.16
White	3.40	2.31	3.33	0.12	0.46	0.25	8.93	11.19	8.49	29.09	31.75	35.04
Black	3.74	3.33	2.43	0.10	0.31	0.17	6.87	5.62	5.13	17.12	31.75	14.80
CV (%)	10.07	13.3	13.63	9.86	12.54	10.4	7.29	11.75	11.39	5.45	10.43	9.77
CD (P=0.05)	1.82	0.83	NS	0.05	0.08	NS	1.19	2.28	1.70	1.88	4.3	3.39

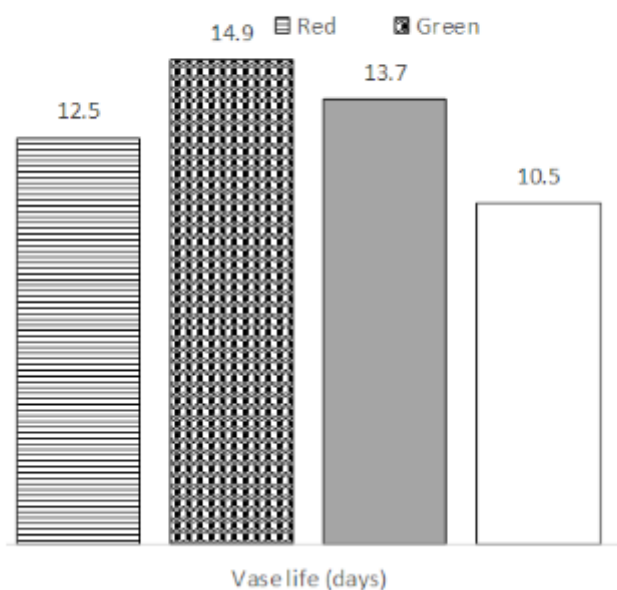


Fig. 3

Vase life of cut foliage of *Philodendron* 'Xanadu' cultivated under coloured shade nets

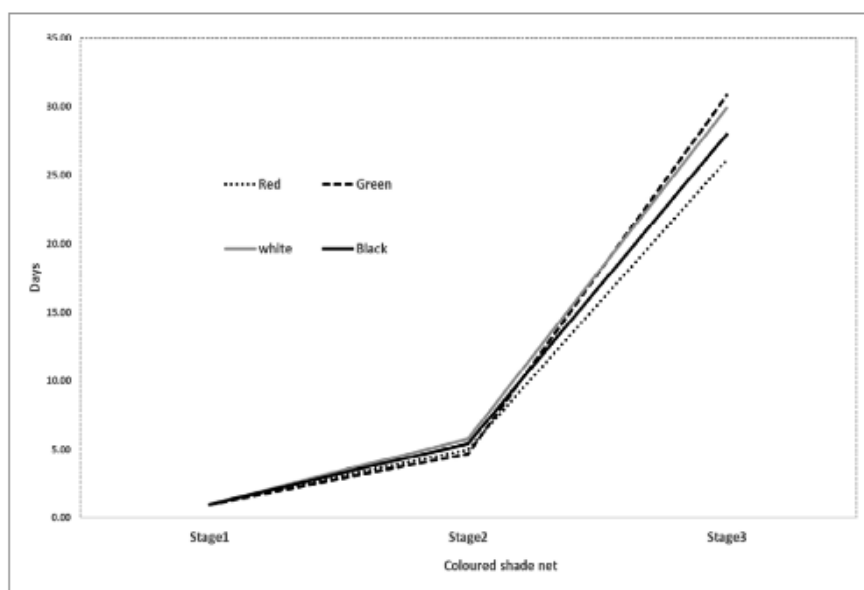


Fig. 4

. Developmental stages of *Philodendron* 'Xanadu' foliage under coloured shade nets Stage 1- Leaf rolled in cataphyll Stage 2- Just expanded tender leaf Stage 3- Fully expanded matured leaf

Weighted averages were assigned for the different characters of commercial importance according to the market standards (Fig. 6). White shade net grown cut foliage had the maximum weighted average (91.37) followed by green net (86.87), red net (84.32) and the least for cut foliage grown under black shade net (68.38).

Incidence of pests and diseases was monitored at weekly intervals. The plants remained relatively pest and disease free. Infestation of aphids was observed during the last week of March 2016, with the white shade net recording maximum number (18.35 per leaf) followed by red net (14.38 per leaf). Minimum infestation of 0.38 aphids per leaf was recorded on plants grown under black shade net. Incidence of *Cercospora* Leaf spot was

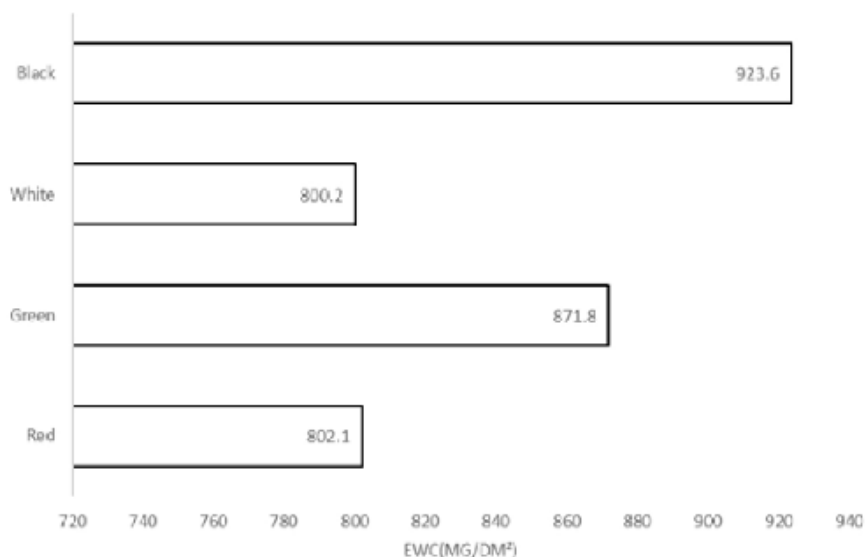


Fig. 5
Epicuticular foliage wax content of *Philodendron* 'Xanadu' cultivated under coloured shade nets

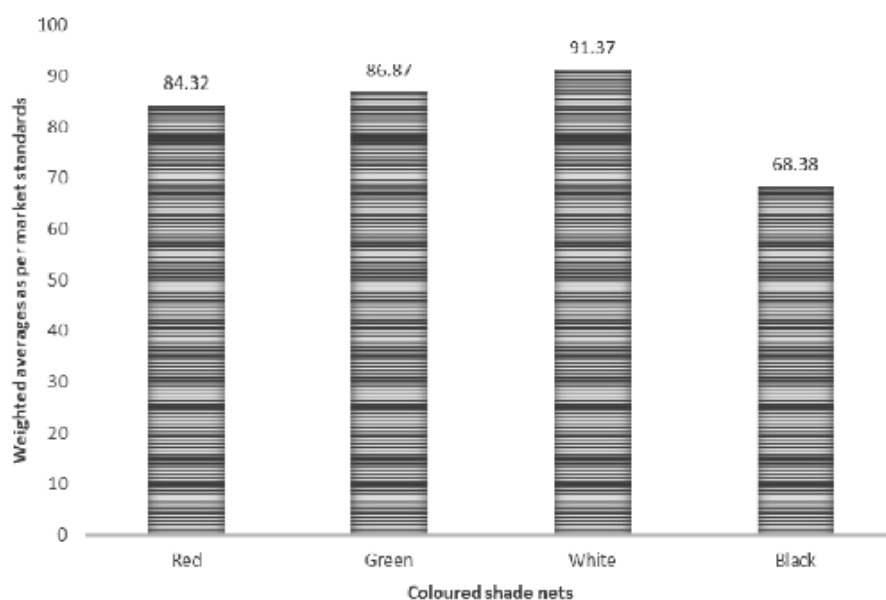


Fig. 6
Weighted averages for cut foliage of *Philodendron* 'Xanadu' cultivated under coloured shade nets

recorded during the months of January- February and PDI was <5 across all the shade net colours.

Among the different coloured shade nets, cultivation of *Philodendron* 'Xanadu' under the white shade net resulted in higher cut foliage

production, whereas, the quality parameters and post-harvest keeping quality were on par with plants cultivated under green shade nets. The yield of cut foliage and quality attributes were higher during the rainy season compared to winter and summer. It can hence be concluded that, cultivation of *Philodendron* 'Xanadu' under white shade net (75%) permitting light intensities ranging from

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