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Effect of Shade Net Colours, Its Intensity and Fertilizer Levels on Growth and Yield of Beetroot (*Beta vulgaris* L.)

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The effect of shade net colours, its intensity and fertilizer levels on some growth parameters viz. plant spread, leaf area, biomass yield and beetroot yield indicated that red shade net colour significantly increased beetroot yield (28.02 t ha^{-1}) as compared to green (25.23 t ha^{-1}) and black (21.87 t ha^{-1}) however, leaf area plant^{-1} at 30, 45, 60 DAS and at harvest were 9.87, 18.63, 29.36 and 38.56 dm^2, respectively. shade net colours, suggesting suitability of the red shade net colour for beetroot cultivation. The 35 per cent shading intensity significantly increased beetroot yield (29.32 t ha^{-1}) as compared to 50 (26.22 t ha^{-1}) and 75 per cent (19.57 t ha^{-1}) and plant spread at 30, 45, 60 DAS and at harvest were 28.40, 40.13, 51.99 and 57.46 cm, respectively. The significantly higher beetroot yield was recorded in 125 per cent RDF (26.00 t ha^{-1}) than 100 per cent RDF (24.08 t ha^{-1}).

Keywords: Shade Net, Beetroot, Yield, Growth, Fertilizer.

Attaining food security has been a major challenge for the nation since independence. The demand for food and processed commodities is increasing due to growing population and rising per capita income. There are projections that demand for food grains would increase from 192 mt in 2000 to 345 mt in 2030 (Anonymous, 2011).

Beetroot (*Beta vulgaris* L) is a member of the *Chenopodiaceae* family which includes silver beet, sugar beet and fodder beet. Beetroot is also known as 'garden beet' or 'table beet'. They are believed to have originated from Germany. They are biennials although they usually grow as annuals. Beetroot is essentially a modern vegetable and has become an important home-garden and market garden crop, cultivated for its fleshy roots. Beetroot produces green tops and swollen root during its first growing season. It is highly productive as it grows quickly and usually free from pests and diseases.

Light intensity, soil water content and nitrogen supply are important factors affecting the biomass of the crops, and also have a direct impact on photosynthesis and growth. Diversified light could have different effects on the development of leaf area, growth and yield (Feijuan and Cheng, 2012). At the same time, insufficient shade can affect productivity by causing more light to be incident on the plant, bringing about photo inhibitory effects that harm the metabolic process of the system. Therefore, it is necessary to investigate the optimal light conditions to maximize productivity of the crops. Light quality and quantity can be manipulated through different coloured shade nets.

The ColorNets represent a new agro-technological concept, which aims at combining the physical protection, together with differential filtration of the solar radiation, for specifically

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promoting desired physiological responses that are light regulated. The spectral manipulation is aimed at specifically promoting photomorpho-genetic-physiological responses, while light scattering improves light penetration into the inner canopy. Radiation use efficiency increases when the diffuse component of the incident radiation is enhanced under shade. The target responses are those determining the commercial value of each crop, including yield, product quality, and rate of maturation (Shahak and Gussakovsky, 2004).

MATERIALS AND METHODS

The experiment was conducted in a specially designed shade net house situated at Post Graduate Instructional Farm (19° 48'-19° 57' N, 74°19'-74° 52' E) allotted to Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar during *rabi* 2010-2011. The topography of the experimental site was fairly uniform and leveled.

Shade net house is a framed structure covered with UV stabilized shading net as a cladding material, large enough to grow crops under controlled environmental conditions and also large enough to allow a person to walk within it and carryout cultural operations to get optimum growth and productivity. Shade net house protects crops from excessive sunlight, temperatures, winds, dust and also helps in increasing humidity to a certain extent. Shade nets used for cladding are of different types depending upon the shading percentage and different colours, imparting different light wavelengths on the crops grown underneath. Three different colours of shade net were selected for the present study, on the basis of predominantly used by the farmers *viz.* green, red and black. Three different shading percentages were selected for the study *viz.* 35, 50 and 75 per cent. The orientation of shade net house used in present investigation was in East-West direction, so that the colour effect on particular treatment will be homogenous for most of the time of the day. The rows selected for the observation were also in the centre of the treatment plot so that the border effect will be eliminated. The shade net house was of Flat Top type having the height of 3.25 m and an area of 1400 m^2.

Raised beds were prepared having 30 cm height, 18 m length and 1 m width along with 50 cm path between two raised beds inside the shade net house 30 days before sowing of the crop. The basal dose of 65 kg P_2O_5 ha^{-1} and 65 kg K_2O ha^{-1} along with half dose of nitrogen @ 55 kg ha^{-1} was applied through single superphosphate, muriate of potash and urea, respectively, one day before sowing. The remaining dose of nitrogen @ 55 kg ha^{-1} was applied 40 days after sowing. The farm yard manure @ 10 t ha^{-1} was applied at the time of raised bed preparation. The sowing of beetroot (Action F_1 Hybrid) in completely randomized design (Factorial) was done in three different colours of shade net (green, red and black), three different shading percentages (35, 50 and 75 per cent) and two fertilizer levels (100 % RDF 125 % RDF) on 08/12/10 by dibbling two seeds $hill^{-1}$ with spacing of 30 cm x 15 cm. The biometric observations on various growth characters *viz.* plant spread, leaf area, biomass yield and beetroot yield were determined at different stages of crop growth as influenced by shade net colours, shading intensities and fertilizer levels during the experiment.

RESULTS AND DISCUSSION

Plant spread

The red coloured shade net exhibited significantly higher plant spread at 30, 45, 60 DAS and at harvest (28.36, 40.02, 52.50 and 57.81 cm, respectively) compared to the green and black shade net colours. However, it was at par with green coloured shade net at 45 DAS of beetroot. Significantly lowest plant spread was observed in black shade net colour at 45 and 60 DAS, but it was at par with green shade net at 30 DAS and at harvest. These results are in conformity with Shahak *et al*. (2008c).

The plant spread was influenced significantly due to different shading intensities. Significantly higher plant spread was recorded in 35 per cent shading intensity at 30, 45, 60 DAS and at harvest (28.40, 40.13, 51.99 and 57.46 cm, respectively), which was followed by 50 per cent and 75 per cent shading intensities, respectively. However, it was at par with 50 per cent shading intensity at 45 DAS and at harvest. Significantly lowest plant spread was noticed under 75 per cent shading intensity during the crop growth period. The more plant spread in 35 per cent shading

Table 1. Effect of shade net colours, its intensity and fertilizer levels on plant spread, leaf area, biomass yield and beetroot yield

Treatments	Plant spread (cm)					Leaf area plant^{-1} (dm^2)					Biomass	Weight	Biomass	Beetroot
	15 DAS	30 DAS	45 DAS	60 DAS	At harvest	15 DAS	30 DAS	45 DAS	60 DAS	At harvest	Plant^{-1} (g)	of Beet-root (g)	Yield (t ha^{-1})	Yield (t ha^{-1})
Shade net colours														
Green	12.48	27.64	39.79	50.97	56.08	1.27	9.62	18.03	27.85	38.13	190.50	133.50	36.44	25.23
Red	12.69	28.36	40.02	52.50	57.81	1.34	9.87	18.63	29.36	38.56	203.61	145.94	39.23	28.02
Black	12.65	27.47	38.62	48.98	54.71	1.28	9.11	16.65	27.09	34.49	174.22	118.61	32.40	21.87
SEm(±)	0.100	0.25	0.32	0.31	0.62	0.03	0.10	0.22	0.34	0.54	3.64	3.75	0.86	0.78
CD @ 5 %	NS	0.70	0.90	0.87	1.72	NS	0.27	0.61	0.96	1.50	10.19	10.51	2.41	2.19
Shading intensities														
35 %	12.69	28.40	40.13	51.99	57.46	1.33	9.88	18.53	29.32	38.07	204.61	148.16	40.19	29.32
50 %	12.65	27.71	39.96	51.02	56.36	1.24	9.59	18.08	28.69	37.60	191.72	134.72	37.39	26.22
75 %	12.48	27.36	38.34	49.45	54.78	1.32	9.13	16.70	26.29	35.51	172.00	115.16	30.48	19.57
SEm(±)	0.100	0.25	0.32	0.31	0.62	0.03	0.10	0.22	0.34	0.54	3.648	3.75	0.86	0.78
CD @ 5 %	NS	0.70	0.90	0.87	1.72	NS	0.27	0.61	0.96	1.50	10.19	10.51	2.41	2.19
Fertilizer levels														
100 % RDF	12.56	27.50	38.63	50.31	55.40	1.33	9.36	17.45	27.44	36.18	183.92	126.85	34.72	24.08
125 % RDF	12.65	28.14	40.32	51.33	57.00	1.27	9.71	18.08	28.76	37.93	194.96	138.52	37.32	26.00
SEm(±)	0.08	0.205	0.263	0.254	0.503	0.03	0.08	0.18	0.28	0.44	2.97	3.069	0.71	0.64
CD @ 5 %	NS	0.57	0.74	0.71	1.41	NS	0.22	0.50	0.79	1.22	8.32	8.58	1.96	1.79
General mean	12.61	27.82	39.47	50.81	56.19	1.30	9.53	17.77	28.10	37.06	189.44	132.68	36.02	25.03
C.V. (%)	3.36	3.83	3.47	2.59	4.65	11.17	4.29	5.22	5.21	6.14	8.17	12.02	10.02	13.31

intensity may be attributed to the favourable temperature for enhanced leaf expansion consequently increasing the plant spread. Similar results were reported by Swagatika *et al.* (2006), Haque *et al.* (2009) and Shivakumar *et al*. (2011).

Leaf area

The red coloured shade net exhibited significantly higher leaf area plant^{-1} at 30, 45, 60 DAS and at harvest (9.87, 18.63, 29.36 and 38.56 dm^2, respectively) compared to the green and black shade net colours. However, it was at par with green coloured shade net at 30, 45 DAS and at harvest. Significantly lowest leaf area plant^{-1} was observed in black shade net colour, but it was at par with green shade net at 60 DAS. The results are in conformity with Shahak *et al*. (2008c).

The leaf area plant^{-1} was influenced significantly due to different shading intensities. Significantly higher leaf area plant^{-1} was recorded in 35 per cent shading intensity at 30, 45, 60 DAS and at harvest (1.33, 9.88, 18.53, 29.32 and 38.07 dm^2, respectively), which was followed by 50 per cent and 75 per cent shading intensities, respectively.

The more leaf area plant^{-1} in 35 per cent shading intensity may be attributed to the favourable temperature for enhanced leaf expansion consequently increasing the leaf length and leaf breadth that resulted into increased leaf area plant^{-1}. Similar results were reported by Swagatika *et al.* (2006) and Haque *et al.* (2009).

Biomass plant^{-1} (g) and biomass yield ha^{-1} (t)

The biomass plant^{-1} and biomass yield ha^{-1} was influenced significantly due to different shade net colours. Significantly higher biomass (203.61g) plant^{-1} and biomass yield (39.23 t) ha^{-1} were recorded in red coloured shade net, as compared to green and black coloured shade net. Lowest biomass plant^{-1} and biomass yield ha^{-1} was observed in black coloured shade net. This may be attributed to higher growth attributes achieved under red coloured shade net which might have resulted into better sink source ratio. Significantly highest biomass (204.61 g) plant^{-1} and biomass yield (40.19 t) ha^{-1} were recorded in 35 per cent shading intensity compared to 50 and 75 per cent shading intensities.

Lowest biomass plant^{-1} (172.00 g) and biomass yield (30.48 t ha^{-1}) were recorded in 75 per cent shading intensity. This might be due to increased growth and yield attributes in 35 per cent shading intensity. Similar results were reported by Singh *et al.* (2000), Gimenez *et al*. (2002) and Swagatika *et al.* (2006).

The biomass plant^{-1} and biomass yield ha^{-1} was influenced significantly due to different fertilizer levels. Significantly higher biomass plant^{-1} (194.96 g) and biomass yield (37.32 t ha^{-1}) were recorded under application of 125 % RDF, as compared to application of 100 % RDF. Similar results were reported by Jambukar and Wange (2006), Aquino (2006) and Shalaby *et al*. (2011).

Weight of beetroot

The red coloured shade net recorded significantly higher weight of beetroot (145.94 g), as compared to green and black coloured shade net. Significantly lowest weight of beetroot (118.61 g) was observed in black coloured shade net. Shahak *et al.* (2008c) reported similar results. Significantly higher weight of beetroot (148.16 g) was recorded in 35 per cent shading intensity compared to 50 and 75 per cent shading intensities. Significantly lowest weight of beetroot (115.16 g) was observed in 75 per cent shading intensity. Similar results were reported by Singh *et al.* (2000), and Swagatika *et al.* (2006).

The weight of beetroot was influenced significantly due to different fertilizer levels. Significantly higher weight of beetroot (138.52 g) was recorded under application of 125% RDF as compared to 100% RDF (126.85 g). Similar results were reported by Jambukar and Wange (2006), Aquino (2006) and Shalaby *et al*. (2011)

Beetroot yield

The beetroot yield was influenced significantly due to different shade net colours. Significantly higher beetroot yield (28.02 t ha^{-1}) was recorded under red coloured shade net, as compared to green (25.23 t ha^{-1}) and black (21.87 t ha^{-1}) shade net colours. The beetroot yield was increased to the tune of 28.12 per cent under red coloured shade net compared to black coloured shade net. Significantly lowest beetroot yield was observed in black shade net colour (21.87 t ha^{-1}). This might be due to higher number of leaves, plant spread, length and breadth of leaves, polar and equatorial diameter which leads to increased beetroot yield. The results are in conformity with Shahak *et al*. (2004), Shahak *et al*. (2008c) and Ilic *et al.* (2010).

The beetroot yield was significantly higher in 35 per cent shading intensity (29.32 t ha^{-1}) compared to 50 (26.22 t ha^{-1}) and 75 (19.57 t ha^{-1}) per cent shading intensities. The increase in yield under 35 per cent shading intensity was 49.80 per cent over the yield obtained under 75 per cent shading intensity. The 35 per cent shading intensity recorded the highest number of leaves, plant spread, length and breadth of leaves, polar and equatorial diameter which leads to increased beetroot yield. Significantly lowest beetroot yield was observed in 75 per cent shading intensity. Similar results were reported by Deogirikar (2005), Swagatika *et al.* (2006), Vethamoni and Natarajan (2008), Haque *et al.* (2009), and Ilic *et al*. (2012).

The beetroot yield was influenced significantly due to different fertilizer levels. Significantly higher beetroot yield (26.00 t ha^{-1}) was recorded under application of 125 per cent RDF, as compared to the application of 100 per cent RDF (24.08 t ha^{-1}). This might be due to more available nutrients which increased all the growth and yield attributes of crop that finally lead to increased beetroot yield. Similar results were reported by Trani *et al*. (2005), Jambukar and Wange (2006) and Balakrishnan *et al*. (2007).

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