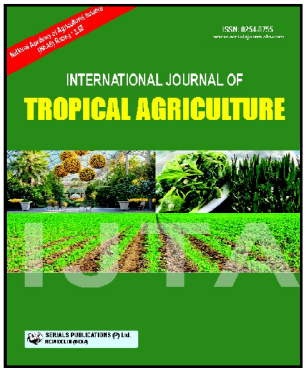

INTERNATIONAL JOURNAL OF TROPICAL AGRICULTURE

ISSN : 0254-8755

available at http: www.serialsjournal.com

Volume 35 • Number 4 • 2017

Effect of Different Shading Intensities on Physio-biochemical Behavior of Cherry Tomato

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Abstract: Cherry tomato is becoming popular among the Indian market. The field experiment was conducted to study effect of different (35, 50 and 75 per cent) shading intensities on growth and yield of cherry tomato. Significantly maximum yield was recorded in 35 per cent shading intensity and genotype KSP-113. Among the different shading intensities and genotypes maximum polar and equatorial diameter were observed in 35 per cent shading intensity and genotype KSP -113. The maximum pericarp thickness was observed in 35 per cent shading intensity and in genotype EC 128021. The maximum juice content was noticed in 50 % shading intensity and genotype KSP-113. The minimum PLW, titrable acidity and maximum shelf life as well as lycopene was recorded in 75 % shading intensity and KSP-113. The maximum TSS, ascorbic acid and total sugars were recorded in open condition and in KSP-113 genotype. The cultivation of KSP-113 genotype under 35 per cent shading intensity was found to be most sustainable for better physio-biochemical behavior and yield of cherry tomato during *summer* season.

Key Words: Cherry tomato, Shading intensities, physiological and Biochemical parameters

INTRODUCTION

Cherry tomato (*Solanum lycopersicon var cerasiforme*) are characterized by their small size fruits, with a bright red colour resembling to cherry and having an excellent taste. Cherry tomatoes are becoming popular in the retail chains and marketed at a premium price compared to regular tomatoes. They are joining the growing market of vegetables and are one of the most promising in the line of differentiated products. It is considered as an exotic vegetable, bringing new taste and appearance to dishes.

The protected cultivation of vegetables is getting popularity in India. The area under greenhouse cultivation is increasing day by day. The cherry tomato is one of the highly remunerative vegetable cultivated in protected condition. The cherry tomato is beneficial to human health because of its high content of antioxidant and phytochemical compounds, including lycopene, β-carotene, flavonoids, **vitamin C** and many essential nutrients **including alpha-lipoic acid, choline, folic acid, beta-carotene and lutein** (Rosales *et al.*, 2011). Lycopene is the strong antioxidant which imparts red colour to tomatoes. Choline is an important nutrient found in tomatoes that helps with sleep, muscle movement, learning and memory which helps to maintain the structure of cellular membranes, aids in the transmission of nerve impulses, assists in the absorption of fat and reduces chronic inflammation.

Open field cultivation of vegetables is often damaged by unfavorable weather conditions especially during sensitive stages of growth and development. Cherry tomato is a very sensitive vegetable and even a slight variation in any of the weather parameters would lead to significant changes in growth physiology of the crop resulting with considerable yield loss. In order to produce high quality fruits with enhanced productivity, cherry tomato could be grown under shade net houses. The shade net house protects the crop from adverse climatic conditions. There are several varieties / hybrids available in cherry tomato. However, there are very few studies on evaluation of varieties of cherry tomato under different shading intensities have been made. Hence, the aim of present study is to identify suitable variety and shading intensity for shade net house cultivation of cherry tomato.

The influence of micro environment on growth of cherry tomato would be much helpful in tapping the potential yield under protected cultivation. Identification of high yielding small fruited F_1 hybrids, suitable for growing in greenhouse and open field conditions will help for successful commercial cultivation of cherry tomato. Genotypes show wide fluctuations in their yielding ability when grown in different environments. Study of stability parameters is useful to identify the stable cultivars. Therefore, the study on effect of different shading intensities on physio-biochemical behavior of cherry tomato was carried out.

MATERIALS AND METHODS

The field experiment was conducted to study effect of different shading intensities on yield and physio-biochemical behavior of cherry tomato at Horticulture Section, College of Agriculture, Kolhapur (Maharashtra) during *summer* 2015. The four genotypes of cherry tomatoes viz., EC-128021, EC-539, KSP-113 and EC-123021 were cultivated in three shade net houses having 35, 50 and 75 per cent shading intensities and in open field conditions. The experiment was laid out in Factorial Completely Randomized Design. The cherry tomato was planted on the raised bed. The two lateral drip lines were arranged on each bed along the crop row and drippers were placed to each plant at the spacing of 60 cm. The shade net was provided with the foggers to protect the crop from excessive heat and to control the humidity. The healthy seedlings were transplanted in March 2015 at the spacing of 60 x 60 cm on the raised beds under shade net. Plants were irrigated on every alternate day through drip irrigation system laid on bed. Water soluble fertilizers were applied through fertilizer tank initially 1½ month N: P: K (1:2:0.5) and onwards N: P : K (2:1:3) on alternate days. The micronutrients were applied through foliar spray.

Physiological parameters

Polar and equatorial diameter of ten randomly selected fruits was measured using Vernier caliper and pericarp thickness measured with the help of Screw guage and average is worked out. The fruits were cut and blended in a pestle and mortar and filtered through a muslin cloth to get the juice. The juice yield was measured and expressed as per cent on the basis of total weight of the fruits.

Biochemical parameters

The biochemical attributes includes determination of total soluble solids in tomato juice were recorded by using digital refractometer and expressed in degree Brix, Total titratable acidity (%) and Ascorbic acid (mg/100gm) was determined by method suggested in A.O.A.C., 1990. The lycopene content of tomato fruit is measured as method suggested by Sadashivam and Manickum (1996) while total sugars by (Ranganna, 1994).

RESULTS AND DISCUSSION

Yield and Physiological parameters

The cherry tomato responds better to different shading intensities especially under the summer condition. The yield per hectare was significantly influenced by different shading intensities. (Table 1) The significantly maximum yield per ha was observed in 35 per cent shading intensity (579.44 q) followed by 50% shading and minimum yield per ha was observed in open conditions. The yield per hectare was significantly influenced by different genotypes. The significantly maximum yield per hectare was observed in KSP-113 followed by genotype EC- 539 and minimum yield per hectare was observed in EC-128021. The interaction effect between shade net intensities and genotypes on yield per hectare of cherry tomato was found to be significant. Among the different shading intensities maximum yield per hectare was observed by genotype KSP-113 in 35% shading intensity whereas minimum yield per hectare was observed in open conditions by genotype EC-128021. These results are in accordance with findings of Priya *et al.* (2002). Tomato, eggplant, capsicum, radish, amaranthus and coriander had higher yield under shade net house due to light compensation for higher photosynthesis. Significantly the lowest yield was observed in open conditions. The similar results were obtained in cauliflower by Swagatika *et al.* (2006) and Vethamoni and Natarajan (2008) in sweet pepper.

Polar and equatorial diameter

The polar and equatorial diameter was influenced by different shading intensities (Table 1). The maximum polar and equatorial diameter was observed in 35 per cent shading intensity (1.83 and 1.93 cm, respectively) which was at par with 75% shading and minimum polar diameter was observed in 50% shading intensity and equatorial diameter in open condition. The polar and equatorial diameter was significantly influenced by different genotypes. The significantly maximum polar diameter was observed in KSP-113 (1.96 and 2.03 cm, respectively) followed by genotype EC- 123021 and minimum polar diameter was recorded in EC-128021 and equatorial diameter in EC 539 which was at par with EC-128021. The interaction effect between shade net intensities and genotypes on polar and equatorial diameter of cherry tomato was found to be non significant. These results are in accordance with the results reported by Anonymous (2001) and Wagh (2002).

Pericarp thickness (mm)

The pericarp thickness was influenced by different shading intensities (Table 1). The maximum pericarp thickness was observed in 35 per cent shading intensity (2.20 mm) which was at par with 75% and 50% shading intensity while minimum pericarp thickness was observed in open condition. The pericarp thickness was influenced by different genotypes. The maximum pericarp thickness was observed in EC-128021 which was at par with genotypes in EC- 123021 and KSP-113 and

Table 1
Yield and physiological parameters as influenced by different shading intensities and genotypes

Genotypes	*Polar diameter (cm)*					*Equatorial diameter (cm)*					*Pericarp thickness (mm)*					*Yield per hectare (q)*				
Shading intensities	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*
S_1	1.33	1.73	1.93	1.80	1.70	1.47	1.20	1.93	1.80	1.60	1.93	1.60	1.87	1.80	1.80	255.55	299.99	322.22	259.25	284.25
S_2	1.47	1.83	2.07	1.93	1.83	1.80	1.70	2.07	1.93	1.88	2.53	1.67	2.13	2.47	2.20	513.33	611.11	648.88	544.44	579.44
S_3	1.33	1.63	1.93	1.70	1.65	1.57	1.50	2.03	1.70	1.70	1.97	1.97	2.17	2.20	2.08	488.88	551.85	577.77	514.81	533.33
S_4	1.53	1.70	1.90	1.93	1.77	1.50	1.53	2.10	1.90	1.76	2.33	1.93	2.00	2.17	2.11	399.99	444.44	466.66	422.22	433.33
Mean	1.42	1.73	1.96	1.84	1.74	1.58	1.48	2.03	1.83	1.74	2.19	1.79	2.04	2.16	2.05	414.43	476.84	503.88	435.18	457.58

	SE±	*CD at 5%*	*SE±*	*CD at 5%*	*SE±*	*CD at 5%*	*SE±*	*CD at 5%*
Genotypes (G)	0.041	0.119	0.046	0.132	0.057	0.165	6.844	19.767
Shading intensities (S)	0.041	0.119	0.046	0.132	0.057	0.165	6.844	19.767
Interaction (GxS)	0.082	NS	0.092	NS	0.114	NS	13.688	39.534

minimum pericarp thickness was observed in EC-539. The interaction effect between shade net intensities and genotypes on pericarp thickness of cherry tomato was found to be non significant. The similar results were obtained in tomato crop by Thakur and Kolhi (2005). The pericarp thickness of fruit increased due to more deposition of dry matter into insoluble cell wall components like cellulose (Stevens *et al.,* 1979).

Juice content (%)

The juice content of cherry tomato as influenced by different shading intensities and genotypes (Table 2) throughout the crop growth period, was found to be non significant as reported by Rai *et al.* (1996).

Physiological loss in weight (%) and shelf life (days)

The PLW and shelf life was influenced by different shading intensities (Table 2). The minimum PLW and shelf life was observed in 75 per cent shading intensity (8.50% and 11.75 days, respectively) while maximum PLW and minimum shelf life was observed in open condition. The PLW and shelf life was influenced by different genotypes. The minimum PLW and maximum shelf life was observed by KSP-113. The interaction effect between shade net intensities and genotypes on PLW and shelf life of cherry tomato was found to be significant. High temperature increases difference in the vapour pressure between the fruit and the surrounding, this diffrence is one of the driving factor that induce faster moisture transfer from the tomato fruit to the surrounding air which is responsible for PLW (Seyoum and Woldetsdik, 2004). Also the extending shelf life of green mature tomato may be attributed to the low temperature and high relative humidity which usually have a delaying effect on the onset of respiratory climacterics (Wills and Getinet, 1998).

Biochemical parameters

Total soluble solids (^{0}Brix) and Total sugars (%)

The TSS and total sugars were significantly influenced by different shading intensities (Table 2). The significantly maximum TSS and total sugars were observed in open condition (5.48 °B and 3.26 %, respectively) followed by 35% shading and minimum TSS was observed in 50% shading which was at par with 75% shading and minimum total sugars was observed in 75 % shading intensity which was at par with 50 % shading intensity. The TSS and total sugars were significantly influenced by different genotypes. The significantly maximum TSS and total sugars were observed in KSP-113 (6.13 °B and 3.39 %, respectively) and minimum TSS and total sugars were observed in EC-123021. The interaction effect between different shade net intensities and genotypes on TSS of cherry tomato was found to be significant while in total sugars was found to be non significant. These results were similar to the findings of Loures (2001) who found TSS content in tomato fruits were higher in open condition than the protected cultivation. Total sugar contents of tomato fruits produced in the field is higher than fruit produced in the protected environment. This may be due to the greater light intensity and greater photosynthetic plant activity in this crop environment (Backman *et al.,* 2006).

Titrable acidity (%) and Ascorbic acid (mg 100 g^{-1})

The titrable acidity and ascorbic acid were significantly influenced by different shading intensities (Table 2). The significantly maximum titrable acidity and ascorbic acid were observed in open condition (0.54% and 43.40 mg 100 g^{-1}, respectively) followed by 35% while minimum titrable acidity and ascorbic acid were observed in 75% shading intensity. The titrable acidity and ascorbic acid were influenced by different genotypes. The maximum titrable acidity was observed in EC-

Table 2
Biochemical parameters as influenced by different shading intensities and genotypes

Genotypes	*Juice content (%)*					*PLW (%)*					*Shelf life (days)*					*TSS (°Brix)*				
Shading intensities	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*
S_1	61.67	61.67	60.33	60.00	60.92	17.33	14.00	14.33	15.33	15.25	7.33	7.00	8.67	7.67	7.67	5.34	5.34	6.17	5.07	5.48
S_2	62.33	61.00	62.33	62.00	61.92	12.00	8.67	8.00	12.00	10.17	11.33	12.00	12.00	9.33	11.17	5.13	4.80	6.90	4.03	5.21
S_3	62.00	62.00	66.00	63.00	63.25	8.33	10.33	6.67	11.33	9.08	11.33	10.67	11.00	12.33	11.33	5.33	5.27	5.77	3.43	4.95
S_4	63.33	62.33	63.33	64.00	63.15	8.33	9.67	8.33	7.67	8.50	12.67	10.00	13.33	11.00	11.75	5.27	5.07	5.70	3.94	4.99
Mean	62.33	61.75	63.00	62.25	62.33	11.50	10.67	9.33	11.58	10.75	10.67	9.92	11.25	10.08	10.48	5.26	5.12	6.13	4.11	5.15

	SE±	*CD at 5%*	*SE±*	*CD at 5%*	*SE±*	*CD at 5%*	*SE±*	*CD at 5%*
Genotypes (G)	0.717	NS	0.505	1.460	0.302	0.873	0.083	0.239
Shading intensities (S)	0.717	NS	0.505	1.460	0.302	0.873	0.083	0.239
Interaction (GxS)	1.435	NS	1.011	2.919	0.604	1.746	0.165	0.478

Table 2 Contd.
Biochemical parameters as influenced by different shading intensities and genotypes

Genotypes	*Titrable acidity (%)*					*Ascorbic acid (mg 100 g^{-1})*					*Lycopene content (mg 100 g^{-1})*					*Total sugars (%)*				
Shading intensities	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*	G_1	G_2	G_3	G_4	*Mean*
S_1	0.61	0.59	0.42	0.53	0.54	43.43	41.00	45.30	43.87	43.40	1.10	1.30	1.07	1.20	1.17	3.52	3.17	3.68	2.66	3.26
S_2	0.50	0.42	0.38	0.48	0.44	41.33	38.73	41.53	40.67	40.57	1.50	1.57	1.53	1.57	1.54	3.32	3.03	3.54	2.34	3.06
S_3	0.41	0.40	0.36	0.48	0.42	38.57	37.00	40.33	38.33	38.56	1.57	1.67	1.63	1.37	1.56	3.14	3.03	3.22	2.18	2.89
S_4	0.43	0.39	0.35	0.42	0.41	37.33	36.00	38.67	35.67	36.92	1.23	2.13	2.67	1.70	1.93	3.09	2.87	3.11	2.10	2.79
Mean	0.49	0.45	0.39	0.48	0.45	40.17	38.18	41.46	39.63	39.86	1.35	1.67	1.73	1.46	1.55	3.27	3.03	3.39	2.32	3.00

	SE±	*CD at 5%*	*SE±*	*CD at 5%*	*SE±*	*CD at 5%*	*SE±*	*CD at 5%*
Genotypes (G)	0.008	0.024	0.330	0.953	0.178	0.515	0.063	0.181
Shading intensities (S)	0.008	0.024	0.330	0.953	0.178	0.515	0.063	0.181
Interaction (GxS)	0.017	0.049	0.660	NS	0.357	NS	0.125	NS

128021 while maximum ascorbic acid content was recorded by genotype KSP-113 and minimum titrable acidity was observed in KSP-113 while minimum ascorbic acid by EC-539. The interaction effect between shade net intensities and genotypes on titrable acidity of cherry tomato was found to be significant while ascorbic acid was found to be non significant. Among the different shading intensities minimum titrable acidity was observed by genotype KSP-113 in 75% shading, where as maximum titrable acidity was observed in open condition by genotype EC-128021. Thus, the lower acidity of tomato fruit grown in the protected environment may be a result of the lower photosynthetic activity of the plant (shading protected environment) in this environment and lower carbohydrate accumulation in the fruits during summer season (Bertin *et al.*, 2000) while a lower ascorbic acid content of the fruits produced in a protected environment might be due to the lower light intensity in this environment, which may have reduced the production of sugar, a substrate which is used in the synthesis of ascorbic acid (Davies and Hobson (1981).

Lycopene content (mg 100g^{-1})

The lycopene content was influenced by different shading intensities (Table 2). The maximum lycopene content was observed in 75% shading intensity (1.93 mg 100g^{-1}) which was at par with 50% and 35% shading intensity and minimum lycopene content was observed in open condition. The lycopene content was influenced by different genotypes. The maximum lycopene content was observed KSP-113 while interaction effect was found to be non significant. This may due to tomatoes exposed to direct sunlight in the field often develop a poor colour, mainly exposed to high temperatures has low lycopene content (Helyes *et al.*, 2006).

The cultivation of KSP-113 genotype under 35 per cent shading intensity was found to be most sustainable for better physio-biochemical behavior and yield of cherry tomato during *summer* season.

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