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Cultivation of sweet pepper cultivars (*Capsicum annuum* var. grossum L.) under shade net in tropical plains of Tamil Nadu

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ABSTRACT

Shade net can be commercially exploited for successful year round cultivation of high value thermo sensitive vegetable sweet pepper. To explore the possibility of using shade net houses for year round production of sweet pepper by modifying the inside environment ,an experiment was taken up at Horticulture unit, Department of Soil and Crops, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam using two sweet pepper cultivars *viz*., Indra and Kohinoor during two seasons *viz*., September, 2004-March,2005 (Season I) and June-December, 2005 (Season II) under three levels of shade (open field condition, 35 per cent and 50 per cent).The experiments were laid out in factorial randomized block design. Observations were recorded on yield characters, physiological characters and biochemical constituents. From the experiment it was concluded that 35 per cent shade is most suitable for cultivating sweet pepper under tropical conditions and sweet pepper cultivar Indra is a suitable cultivar for cultivation under shade net for year round cultivation .

Key words : Sweet pepper, Shade net**,** Chlorophyll, Proline, Leaf temperature.

Sweet pepper occupies a place of pride among vegetables in Indian cuisine because of its delicacy and flavor occupied with rich content of ascorbic acid and other vitamins and minerals. There is always a large and sustained demand of sweet pepper round the year in big cities. Since sweet pepper is sensitive to growing environments, growing sweet pepper in open condition is not possible in tropical condition. Shade net can be commercially exploited for successful year round cultivation of high value thermo sensitive vegetable sweet pepper. To explore the possibility of using shade net houses for year round production of sweet pepper by modifying the inside environment ,an experiment was taken up at Horticulture unit, Department of Soil and Crops, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam during two seasons *viz*., September,2004-March,2005 (Season I) and June-December,2005 (Season II)

MATERIALS AND METHODS

Studies were conducted to know the effect of shade levels *viz*., open field condition, 35 and 50 per cent during during two seasons *viz*.,September 2004 to March, 2005 and June – December 2005 on yield, physiology and bio chemical characters of sweet pepper cultivars *viz*., Indra and Kohinoor .The experiments were laid out in factorial randomized block design and a plot size of 4.5 x 2.2 m was used for each treatment. Raised beds of 80 cm width were formed with a furrow of 40 cm between two beds. Forty five Days old seedlings were transplanted in paired rows on both sides of the the drip laterals adopting a spacing of 60 cm between rows and 45 cm between plants. The recommended dose of N, P and K at 150 : 150 : 150 kg/hectare was applied through fertigation. Observations were recorded on yield characters *viz*., fruits/plant, fruit length, fruit girth, mean fruit weight, seeds/fruit, yield/ha, physiological characters *viz*. cell membrane integrity, relative water content, stomatal diffusive resistance, transpiration rate, leaf temperature, chlorophyll content and light transmission ratio)and biochemical constituents *viz*., soluble protein, peroidase activity, nitrate reductase activity and proline content).Five plants selected at random in each treatment and each replication were used for recording plant growth and yield characters.

RESULTS AND DISCUSSION

Effect of shade on yield and yield parameters:

The yield characters recorded in sweet pepper cultivars under different shade levels in two seasons are tabulated in Table 1 and 2.The yield is decided by the parameters like number of fruits per plant, fruit length, fruit girth, fruit weight and seeds per fruit. Prevailing weather parameters significantly influenced the yield parameters and more number of fruits per plant were observed under 35 per cent shade (22.35,18.15) than open (5.70,3.20) and 50 per cent shade (16.05,12.98) in sweet pepper cultivar Indra. This is in line with the findings of El Aidy (1986b) who reported that tomato plants grown

Table 1: Effect of shade levels on yield and yield contributing characters in sweet pepper cultivars– Season I

Characters	Indra			Kohinoor		
	Open	35 %	50 %	Open	35 %	50 %
No. of fruits per plant	5.70	22.35	16.05	6.60	19.98	14.10
Fruit length (cm)	6.10	10.33	12.68	5.28	9.53	11.28
Fruit girth(cm)	16.00	20.53	25.55	18.58	21.85	25.83
Fruit weight (g)	90.85	145.90	203.13	83.55	130.08	181.85
No. seeds per fruit	133.43	173.00	345.70	122.85	163.65	313.25
Yield per hectare(t)	19.40	113.88	111.70	23.18	113.18	109.63

Table 2 : Effect of shade levels on yield and yield contributing characters in sweet pepper cultivars– Season II

Characters	Indra			Kohinoor		
	Open	35 %	50 %	Open	35 %	50 %
No. of fruits per plant	3.20	18.15	12.98	4.70	16.23	11.83
Fruit length (cm)	5.25	9.15	11.58	4.33	8.60	10.33
Fruit girth(cm)	14.33	16.65	23.65	16.65	18.15	24.48
Fruit weight (g)	60.14	121.55	152.28	53.28	112.44	139.92
No. seeds per fruit	114.33	133.70	273.55	104.35	124.55	246.63
Yield per hectare(t)	7.48	80.03	72.15	11.15	74.18	70.40

under shade tended to produce higher fruit yield than those in open field, but such tendency was reduced with the increase in the amount of shade. The reduction in number of fruits per plant under open field condition might be due to poor fruitset under high temperature and low humidity

Fruits in 50 per cent shaded plots were significantly longer (12.68, 11.58 cm) than open field condition (6.10,5.25 cm) in sweet pepper The conditions, which would have influenced the availability of auxin to the developing ovary (Priya *et al.*, 2002a). Reduction in fruit size under open condition could be ascribed to the reduced supply of assimilates to developing sink and excess respiration. (Cockshull *et al.*, 1992).

Fruit girth was more in shaded plants as compared to open field condition in sweet pepper cultivar Indra with the highest value at fifty per cent shade(22.55, 23.65cm) This might be due to favourable temperature inside the shade which would have increased both linear and circumferential growth of fruit (Priya *et al.*, 2002b). Reduced fruit girth under open condition could be attributed to high temperature and low relative humidity at the time of flowering leading to increased transpiration and exhaustion of water.

The fruits of sweet pepper cultivar Indra at 50 per cent shade were the heaviest. (203.13, 152.28 g). Priya *et al.* (2002b) reported similar results in paprika. The lowest fruit weight under open condition (90.85, 60.14 g) might be due to reduced fruit size and high transpiration leading to water deficit in the plant system. The weight of fruit was more during September –October than June - July season possibly due to favourable environment, which would influenced the availability of auxin to developing ovary and thereby increased the fruit weight (Priya *et al.*, 2002b).

The number of seeds per fruit was influenced by shade and the highest value was observed at fifty per cent shade (345.70, 273.55) in sweet pepper cultivar Indra. The reduced solar radiation would have resulted in bigger fruits with more seeds. These results are in conformity with those of Rylski (1986) in sweet pepper, who obtained bigger fruits with more seeds at fifty per cent shade.

The yield per hectare was significantly superior at 35 per cent shade (113.38, 80.03 t) in sweet pepper cultivar than open (19.40,7.48 t) and 50 per cent shade (111.70,72.15 t). Similar results were observed by El-Aidy (1986a, 1986b) who stated that vegetables under shade tended to produce higher fruit yield than those in open, but such tendency was reduced with increase in the amount of shade. Increased yield under shade might be due to increased number of branches per plant and the highest number of fruits per plant. Similar results were reported by Diez *et al.* (1986) who observed increase in tomato production under plastic house condition due to greater number of fruits per plant and number of fruits per cluster than in the open. The poor yield under open field condition in sweet pepper might be due to high temperature. The plants were able to grow faster under high temperature, which promotes the earliness but decreases the total yield. Rylski (1986) reported that pepper plants in the open field set fruit at lower nodes and restricted further vegetative growth and flowering,

giving the plant a determinate appearance with poor yield.

Sweet pepper cultivars had significant variation in yield parameters during both the seasons. Similar variation were also observed by El-Aidy (1986a) and Mishra *et al.* (2004).

Effect of shade on physiological parameters:

The physiological parameters indicate the efficiency of the plant in terms of yield. The observations recorded on physiological characters of sweet pepper under shades in season I and II are given in Table 3 and 4. The damage on cell membrane integrity was measured in terms of percentage of electrolyte leakage from the cell. In the present investigation, percentage of electrolyte leakage was the highest (less membrane integrity) under open field condition in Kohinoor (73.23,82.53 per cent) and lowest under 35 per cent shade in sweet pepper cultivar Indra(26.12,37.12 per cent). This was due to the extremes of temperature in open field, which increased the percentage of leakage, followed with reduction in photosynthetic efficiency and respiration rate, and accelerated senescence. This is in accordance with the findings of Leopold *et al.* (1981). The highest yield under shade might be due to reduced leakage percentage. Similar result was observed by Kavitha (2005) in tomato.

In the present investigation, shaded plants of sweet pepper showed higher relative water content during both the seasons than under open field condition. The highest relative water content was observed at 35 per cent shade (86.50, 85.00 per cent) in sweet pepper cultivar Indra and the lowest content was observed in Kohinoor at open field. (80.27, 77.8 per cent). The reduction in leaf relative water content under open field condition could be attributed to increased light intensity, transpiration rate and reduced stomatal diffusive resistance. This is in accordance with the findings of Dhindsa *et al.* (1981). Reduction in leaf water content might be the reason for poor yield under open field condition. This is in conformity with the findings of Slatyer (1955), who observed that reduction of relative water content in plants by five per cent may lead to a reduction in photosynthetic efficiency by 40 - 60 per cent.

The results of the present study revealed that stomatal resistance was higher under 50 per cent shade in sweet pepper cultivar Indra during both the seasons (9.97, 8.97 s cm^{-1}) which might be due to low light intensity resulting in reduced transpiration rate.

In the present study, sweet pepper cultivar Kohinoor grown under open field condition showed the highest rate of transpiration (2.64,4.33μg H_2O $cm^{-1}s^{-1}$), which could be attributed to reduced stomatal diffusive resistance. This result is in conformity with the findings of Woosung *et al.* (1999).

Shade conditions were able to reduce the leaf temperature with more pronounced effect at 50 per cent shade (30.47,33.06 °C), followed by 35 per cent shade(31.73,33.51°C) in both the seasons in Indra and the plants of sweet pepper cultivar Kohinoor under open field condition (32.32,34.11°C) showed the highest leaf temperature. Similar results were obtained by Franscescangeli *et al.* (1994) and Priya *et al.* (2002a), who reported that shading treatments reduced air, leaf and soil temperatures compared to control.

Chlorophyll content was higher under shade than in open field condition in sweet pepper and the highest content was observed at 35 per cent shade in sweet pepper cultivar Indra (0.96,0.93mg g^{-1}). This could be ascribed to decreased light intensity under shade and this is in accordance with the findings of Sui Xiolei *et al.* (1999).

The results of the present study also showed significant reduction in light transmission ratio under shade than open condition and the lowest ratio was observed at

Table 3: Effect of shade levels on physiological and bio chemical characters in sweet pepper cultivars– Season I

Characters	Indra			Kohinoor		
	Open	35 %	50 %	Open	35 %	50 %
Cell membrane integrity (per cent)	71.03	26.12	31.52	73.23	27.53	33.13
Relative water content (per cent)	81.98	86.50	83.30	80.27	84.88	82.00
Stomatal diffusive resistance (s cm^{-1})	8.87	9.36	9.97	8.77	9.32	9.82
Transpiration rate (μg H_2O cm^{-1} s^{-1})	2.52	2.18	2.09	2.64	2.22	2.14
Leaf temperature (°C)	32.11	31.73	30.47	32.32	31.84	31.25
Chlorophyll content (mg g^{-1})	0.83	0.96	0.86	0.80	0.91	0.85
Light transmission ratio (per cent)	4.24	4.01	4.13	4.28	4.12	4.19
Soluble protein content (mg g^{-1})	20.30	23.98	21.98	18.70	20.90	19.70
Peroxidase content (min^{-1} g^{-1})	0.025	0.022	0.016	0.021	0.116	0.114
Nitrate reductase activity (μg of NO_2 g^{-1} h^{-1})	2.37	2.52	2.43	2.02	2.44	2.14
Proline content (μg g^{-1})	63.73	55.00	58.68	61.83	53.80	56.05

Table 4: Effect of shade levels on physiological and bio chemical characters in sweet pepper cultivars– Season II

Characters	Indra			Kohinoor		
	Open	35 %	50 %	Open	35 %	50 %
Cell membrane integrity (per cent)	81.03	37.12	42.02	82.53	38.51	43.51
Relative water content (per cent)	80.98	85.00	81.55	77.08	83.13	80.08
Stomatal diffusive resistance (s cm^{-1})	7.82	8.36	8.97	7.72	8.28	8.76
Transpiration rate (μg H_2 O cm^{-1} s^{-1})	4.24	2.91	2.58	4.33	2.96	2.66
Leaf temperature (°C)	33.42	33.51	33.06	34.11	33.63	33.24
Chlorophyll content (mg g^{-1})	0.81	0.93	0.83	0.79	0.89	0.82
Light transmission ratio (per cent)	5.19	4.81	4.88	5.26	4.85	5.02
Soluble protein content (mg g^{-1})	17.15	20.25	17.85	15.73	18.90	17.30
Peroxidase content (min^{-1} g^{-1})	0.036	0.030	0.027	0.031	0.029	0.023
Nitrate reductase activity (μg of NO_2 g^{-1} h^{-1})	1.72	2.32	1.94	1.56	2.14	2.03
Proline content (μg g^{-1})	75.10	65.20	68.38	70.08	62.70	66.48

35 per cent shade (4.01,4.81per cent)in sweet pepper cultivar Indra and the highest under open field condition (4.28,5.26 per cent) in sweet pepper during both the seasons. The plants grown at 35 per cent shade were able to trap the available 65 per cent of light and utilized efficiently for photosynthesis. Whereas, under open field condition, the photosynthetic yield was found increasing upto a level (light saturation point) and thereafter reduction was noticed. The higher temperature prevailed under open condition might also have caused dehydration in cells causing permanent injury to the plant and cessation of growth.

The higher cell membrane integrity, relative water content and stomatal diffusive resistance,chlorophyll content with low transpiration rate ,leaf temperature.and low light transmission ratio of sweet pepper cultivar Indra indicated their tolerance to adverse climatic conditions leading to better yield. This is in conformity with the findings of Agarwal and De (1975), Balamohan (1994) and Meera (2003) in chilli for leaf temperature, transpiration rate and relative water content and chlorophyll, respectively.

Effect of shade on biochemical parameters:

The results of the present study on bio chemical characters of sweet pepper cultivars are given in Table 3 and 4.The results revealed that soluble protein content in the leaf of sweet pepper cultivar Indra was more under35 per cent shade (23.98, 20.25mg g^{-1}) and it was low in cultivar Kohinoor.(18.70,15.73mg g^{-1})under open field condition. The highest yield obtained from shaded plants might be due to higher soluble protein contents, which has direct relation to yield. The soluble protein content constitutes more than 70 per cent of the RuBp carboxylase, the enzyme responsible for CO_2 fixation in photosynthesis (Noggle and Fritz, 1983).

The present study revealed that peroxidase activity was much accelerated under open field condition in sweet pepper cultivar Indra.(0.025,0.036 min^{-1} g^{-1}) This could be related to decrease in water potential and stomatal closure resulting in an increased production of active oxygen species (Syherri *et al.*, 1993). These results confirm the earlier findings of Allen (1995) and Willekens *et al.* (1995) that under high and low temperature stress, active oxygen species detoxifying enzymes like peroxidase are activated to correct the adverse effects of stress and regulate the metabolic and physiological processes

In the present study, a comparatively higher rate of nitrate reductase activity was recorded in sweet pepper at 35 per cent shade.(2.52,2.32 μg of NO_2 g^{-1} h^{-1}) Since nitrate reductase is involved in NO_3 assimilation, the higher rate of nitrate reductase might have increased the yield under shade. This result is in accordance with the findings of Kavitha (2005).

Proline content increased with decreasing shade level, which was the highest under open field condition in sweet pepper cultivar Indra (63.73,75.10μg g^{-1}) and low under shade in sweet pepper cultivar Kohinoor (53.80,62.70μg g^{-1}) This might be due to increased evaporation under open field condition which leads to reduction in soil water potential. Proline acts as an osmoticum and helps the plant to maintain the water potential under stress by increasing the osmotic potential of plants which in turn facilitate the plant to extract water from surrounding atmosphere. El-Sayed (1992) also reported increase in proline content in leaves and roots with increased severity of water stress in sweet pepper.

Since sweet pepper 'Indra', recorded the highest rate of soluble protein, nitrate reductase, peroxidase activity and proline content compared to sweet pepper cultivar Kohinoor ,it indicates its capacity for tolerance to adverse climatic conditions, leading to highest yield.

This is in agreement with the findings of Sarkar (1993) who observed proline accumulation as a benefit of surviral and tolerance in crop plants.

From the foregoing discussion, it could be concluded that 35 pre cent shade is most suitable for cultivating sweet pepper under tropical conditions and sweet pepper cultivar Indra is a suitable cultivar for cultivation under shade net since sweet pepper 'Indra' at 35 per cent shade, proved its superiority over other treatments in respect of yield, physiological and biochemical traits.

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