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Impact of various micro climates on the physiological parameters and yield of capsicum (*Capsicum annuum* L.)

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ABSTRACT

The study was carried out to determine effect of different micro climate on physiological parameter and yield of capsicum (*Capsicum annuum* L.) at Plasticulture Farm, CTAE, Udaipur, Rajasthan. There were four small structures (1, 2, 3, and 4) of 64 m^2 (16 m x 4 m) area each with varying cladding materials *i.e.* 75% shade net, 40 mesh insect net, 200 micron LDPE UV stabilized sheet air vent on side and top provided with 75% shade net, and 200 micron LDPE UV stabilized sheet and air vent on side and top provided with insect net, respectively. It was observed that maximum plant height (174.7 cm), leaves per plant (64) and first harvesting (57.3 DAT) was found in Structure-1. Early flower initiation (29 DAT) was found in Structure-2. Maximum number of flower per plant (23.7), cumulative number of flower per plant (18.20), highest individual fruit weight (94.4 g), highest fruit yield (1720 g $plant^{-1}$) were found in Structure-4. The water use efficiency (WUE) was found 14.62, 13.52, 15.17, and 18.91 kg m^{-3} under Structure-1, Structure-2, Structure-3 and Structure-4, respectively. Based on the results, Structure-4 was found best in respect of yield, physiological yield, physio-logical parameters, maximum net income (₹ 13813/- per structure *i.e.* ₹ 215.83 m^{-2} area) and B:C ratio (1.87).

1. INTRODUCTION

The increasing global demand for food and other agricultural products calls for urgent measures to increase unit crop production in terms of land and water. Concerning this problem, protected cultivation is a scientific intervention through which production can be multiplied many times per unit land and per unit water. Capsicum botanically known as *Capsicum annuum* L. is placed in Solanceae family and classified as fruit vegetable crop. It is 6-10 months crop is under protected conditions. One can take its production advisably through greenhouse farming. With the development of protected cultivation facility, acreage of capsicum is increasing under greenhouse to pursue maximum economic profits. However, its cultivation is confined to warm and semi-arid countries where water is often a limiting factor for production (Dorjia *et al.*, 2005). The crop grown under open conditions will not fulfill the export standards, so search for new avenues has led to development of Hi-Tech precision horticultural systems. Greenhouse, the latest word in Indian agriculture, is one such means where plants are grown under controlled or partially controlled environment resulting in higher yields than that possible under open conditions (Navale *et al*., 2003) in capsicum. Protected structure is created locally by using different types of material. These structures are designed as per climatic requirements of the area for different sets of environmental conditions. Growing of capsicums under cover has been reported to give good quality produce with higher productivity. Recently, few entrepreneurs have started its cultivation under protected conditions like greenhouse, shade house *etc.* to get higher productivity and quality by adopting hybrids supplied by private companies. Now a day, apart from green color, other varieties like red, yellow, light green are also available. However, there is a need to assess the performance of capsicum hybrids under different structures to advise small and marginal farmers of regions to get higher per unit returns.

The main purpose of protected cultivation is to create a favorable environment for sustained growth of crop so as to realize its maximum potential even in adverse climatic conditions. It has very high entrepreneurial value and profit maximization leading to local employment, social empowerment and respectability of growers. The greenhouse covering materials play a important role in defining the microclimate based on their transmissivity (Finch *et al*., 2004), also impacting different energy balance components such as sensible, latent heat flows, transpirations and photosynthetic processes (Stanghellini *et al.,* 2011 and Ferrari and Leal, 2015). The choice of the greenhouses cover material is essential for optimizing crop production. The scientific information regarding interaction between environment and capsicum fruit yield and quality is still lacking. Therefore, this study aimed to evaluate and compare effects of different types of cladding material on physiological parameters of capsicum crop.

2. MATERIALS AND METHODS

The experiment was carried out at Plasticulture Farm CTAE, Udaipur. Experiment has been laid out inside four small size structures of 16 m x 4 m size each. The plants were transplanted at a spacing of 50 cm x 30 cm. Each structure consisted 400 plants (100 plant per raised bed). Irrigation was given through gravity fed drip irrigation system of 4 laterals in each structure. The crop was taken during January 2013 to July 2013. Capsicum was cultivated under four small sized, naturally ventilated protected structures that were shade net house, insect net house, poly house with shade net vents, and poly house with insect net vents, during February to July, 2013. Four types of raised arch shaped structures were used for study- Structure-1: Structure fully covered with shade net; Structure-2: Structure fully covered with insect proof net; Structure-3: Structure covered with 200 µ LDPE polythene and natural ventilation through shade net (top of the structure covered by polythene sheet, side opening and top vents covered by shade net with provision of 1.0 m wide apron from the ground); Structure-4: Structure covered with 200 µ LDPE polythene and natural ventilation through shade net (top of the structure covered by polythene sheet, side opening and top vents covered by insect net with provision of 1.0 m wide apron from the ground). Standard package of practices were followed during entire crop period and standard management practices were followed as per guide line of plant protection measures. Various plant physiological and inside climatic parameters such as plant height (cm), number of leaves per plant, time required for first harvest number of flowers per plant, number of fruits per plant, per cent fruit set, fruit weight (g), fruit yield per plant (kg), fruit yield (t ha^{-1}), temperature (^{0}C), and relative humidity (%) were recorded under each structure. Standard statistical methods were used to analyse the observed data.

3. RESULTS AND DISCUSSION

Maximum fruit set (77.66%) was recorded under Structure-1, which was significantly superior over all other growing structures (Table 1). The minimum fruit set (71.86%) was recorded under Structure-4. The highest individual fruit weight (94.4g) was recorded under Structure-4, which was significantly superior over all other growing structures, while the lowest yield (82.3g) was recorded under Structure-2. This was as a consequence of production of more flowers per plant and less interference of adverse climatic conditions like rainfall and wind velocity during crop growth and development.

Maximum (174.7 cm) plant height (Table 2) was noted in Structure-1 at 150 DAT, which was significantly superior over the other three growing structures. The least plant height (147.6 cm) was recorded under Structure-2 at 150 DAT. During the successive stages of crop growth *viz.,* 30, 60, 90 and 120 days after transplanting (DAT), the plant height of capsicum was found to be increasing and it was 174.7 cm at 150 DAT under Structure-1, followed by Structure-4 (162.0 cm). This may be attributed to the enhanced plant metabolic activities like photosynthesis and respiration due to favorable micro-climatic conditions that prevailed in Structure-1 as compared to Structure-4. The results of higher growth rate under structures were also reported by Maurer (1981) in bell pepper, More *et al.* (1990) in cucumber and Kumar *et al.* (2016) in casicum.

Maximum (64.1) number of leaves (Table 3) per plant

Table: 1
Effect of different types of growing structures on percent fruit set of capsicum cv. *'Indira'*

Growing structure	Per cent fruit set (%)*
Structure-1	77.66 (74.48)
Structure-2	76.86 (74.20)
Structure-3	76.83 (73.56)
Structure-4	71.86 (72.77)
SE m±	**0.39**
CD (P = 0.05)	**1.25**
CV (%)	**1.04**

**Data are arcsine transformed values; actual value is given within parenthesis*

Table: 2
Effect of different types of growing structures on plant height of capsicum cv. *'Indira'*

Growing Structure	Plant height (cm)				
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT
Structure-1	91.7	122.2	137.5	150.2	174.7
Structure-2	68.9	101.2	110.4	132.6	147.6
Structure-3	77.6	112.0	122.6	141.5	159.9
Structure-4	78.6	113.2	124.7	142.5	162.0
SE m±	1.758	2.198	3.079	3.734	3.079
CD at 5%	5.625	7.031	9.850	11.948	9.850
CV (%)	4.44	3.92	4.97	5.27	3.82

was obtained in Structure-1, which was significantly superior over other three growing structures. The least number of leaves per plant (46.6) was recorded under Structure-2 at 150 DAT. This might be due to the taller plants, increased number of branches and the congenial microclimate that prevailed inside Structure-1, favoring increased growth rate of plants. Similar results were obtained by Ohigbu *et al*. (1989) in cucumber.

Early flower initiation (29.0 DAT) was recorded under Structure-2, which was significantly superior over other structures (Table 4). Late flower initiation (34.3 DAT) was noticed in Structure-1. The early first harvesting of plant *i.e.* 57.30 DAT was observed under Structure-1, while the late first harvesting of plant *i.e.* 66.7 DAT was noted under Structure-3. This may be due to accumulation of maximum photosynthates favouring fast growth, which triggered early initiation of flowers under Structure-2. Similar results were obtained by Rui *et al.* (1989) in capsicum. Effect of different growing structures on plant height and number of leaves per plant is graphically represented in Fig.1.

The maximum number of flowers (Table 5) per plant *i.e.* 23.7, was recorded under Structure-4, while the minimum number of flowers per plant *i.e.* 19, were noted under Structure-1 at 150 DAT. At last harvesting (150 DAT), among the different structures, cumulative number of fruits per plant was observed maximum (18.2) under Structure-4, which was significantly superior over all other structures, while the least number of fruits per plant (14.9) was recorded under Structure-1. Plants grown under Structure-4 recorded more (25.0) numbers of flowers per plant followed by Structure-2, (23.5) at 150 DAT. This could be attributed to the increased number of secondary branches per plant.

Table: 3
Effect of different types of growing structures on number of leaves per plant of capsicum cv. *'Indira'*

Growing structure	No. of leaves/plant				
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT
Structure-1	13.8	24.0	39.6	47.9	64.1
Structure-2	6.9	15.2	30.8	31.4	46.6
Structure-3	9.0	19.3	34.9	39.1	55.3
Structure-4	9.6	19.8	35.4	39.7	55.9
SE m±	0.428	0.702	0.598	1.330	1.274
CD (P = 0.05)	1.370	2.248	1.914	4.257	4.078
CV (%)	8.72	7.19	3.41	6.73	4.60

Table: 4
Effect of different types of growing structures on time taken for flower initiation and to first harvest of capsicum cv. *'Indira'*

Growing structure	No. of days to flowering	No. of days to first harvest
Structure-1	34.3	66.7
Structure-2	29.0	57.3
Structure-3	31.7	63.3
Structure-4	30.7	60.7
SE m±	0.756	1.401
CD (P = 0.05)	2.420	4.482
CV (%)	4.82	4.52

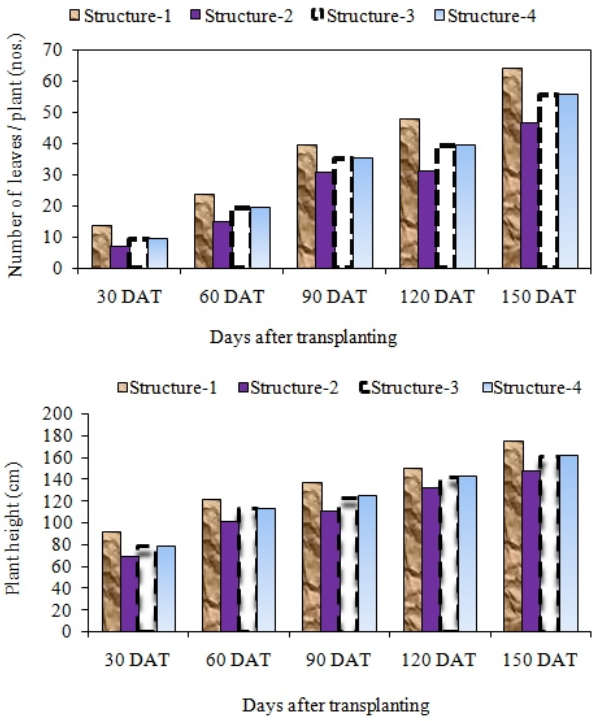

Fig. 1. Effect of different growing structures on plant height and number of leaves per plant

Table: 5
Effect of different types of growing structures on number of flowers and fruits per plant of capsicum cv. *'Indira'*

Growing structure	No. of flowers/plant				No. of fruits per plant
	60 DAT	90 DAT	120 DAT	150 DAT	
Structure-1	11.5	13.6	16.9	19.4	14.9
Structure-2	14.8	16.9	20.3	22.7	17.5
Structure-3	13.9	16.0	19.4	21.8	16.8
Structure-4	15.8	17.9	21.3	23.7	18.2
SE m±	0.473	0.473	4.473	0.473	0.364
CD (P = 0.05)	1.515	1.515	1.515	1.515	1.165
CV (%)	6.77	5.88	4.86	4.32	4.32

The number of fruits (Table 5) per plant was higher (18) at 150 DAT under Structure-4, followed by Structure-2 (17.5). This might be due to the more number of flowers and maximum per cent fruit set under Structure-4. Similar observations were recorded by Backer (1989) for sweet pepper.

The higher fruit yield per plant (1720 g plant^{-1}) was recorded under Structure-4, which was significantly superior over all other growing structures, while the lowest yield (1285 g plant^{-1}) was recorded under Structure-1 (Table 6). The marketable fruit yield of capsicum was higher (1720 gm plant^{-1} and 68.8 t ha^{-1}) under Structure-4 as compared to Structure-1 (1285 g plant^{-1} and 51.4 t ha^{-1}). This may be attributed to the favorable climatic conditions that prevailed under Structure-4, leading to higher vegetative growth, contributing to more number of flowers, more number of fruits, higher per cent of fruit set, maximum fruit weight and fruit volume. Similar results were obtained by Nagendra Prasad (2001) in capsicum crop and Dalai *et al.* (2018) in pointed gourd.

The maximum temperature was observed under Structure-3, *i.e.* 50.7 ^{0}C, and the minimum temperature was recorded under Structure-2, *i.e.* 9.4^{0}C. The maximum relative humidity was observed under Structure-1, *i.e.* 89.9%, and the minimum relative humidity was recorded under Structure-3, *i.e.* 81.7%. Variation in average inside temperature and relative humidity under different growing structures during February to July, 2013 is graphically represented in Fig. 2.

The maximum light intensity was observed under Structure-2, *i.e.* 228.5 watt m^{-2}, and the minimum light intensity was recorded under Structure-1, *i.e.* 136.0 watt m^{-2}. Variation inside light intensity (K lux) and solar radiation (watt m^{-2}) under different growing structures during Feb to July, 2013 is graphically represented in Fig. 3.

Table: 6

Effect of different types of growing structures on quantitative parameters of Capsicum cv. *'Indira'*

Growing structure	Fruit weight (g)	Fruit yield/plant (g)	Fruit yield/sqm area (g)	Fruit yield (t ha^{-1})
Structure-1	86.2	1285	5140	51.4
Structure-2	82.3	1440	5760	57.6
Structure-3	91.4	1535	6140	61.4
Structure-4	94.5	1720	6880	68.8
SE m±	2.45	51.06	225.15	2.25
CD (P = 0.05)	7.82	163.36	720.31	7.20
CV (%)	5.52	6.83	7.53	7.53

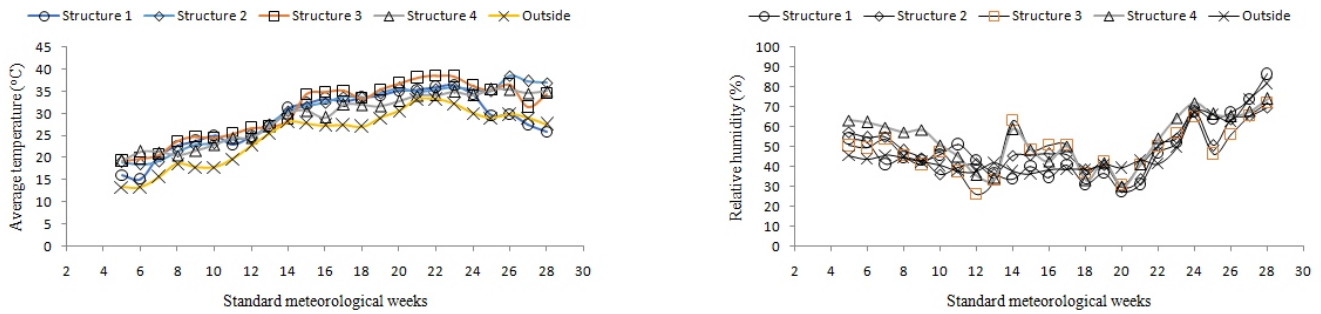

Fig. 2. Variation in average inside temperature and relative humidity under different growing structures during February to July, 2013

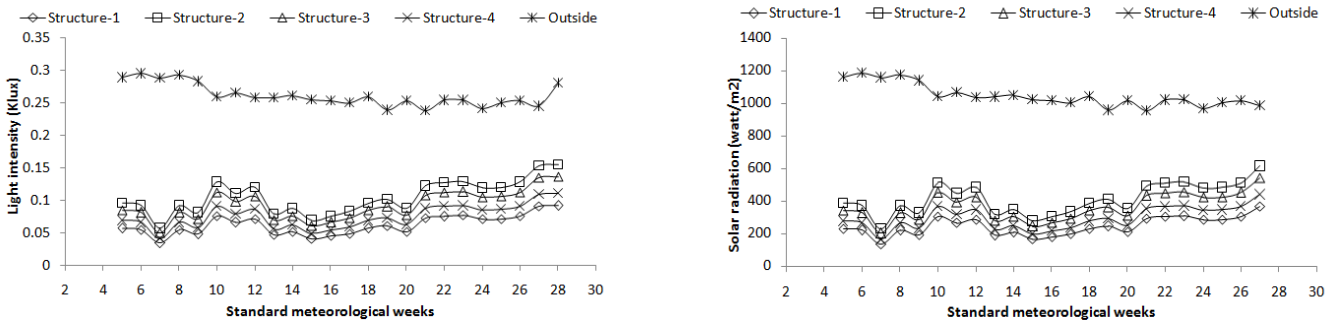

Fig. 3. Variation of inside light intensity (K lux) and solar radiation (watt m^{-2}) under different growing structures during February to July, 2013

Environment is the aggregate of all external conditions which influences the growth and development of crop that play dominant role in crop production. Each crop has its own set of environmental conditions under which it grows best. Generally, crops are not profitable unless they are adapted to the region in which they are produced. Raising a crop successfully means the crop must be productive and economical to grower under prevailing conditions.

Among the environmental factors, the temperature, relative humidity and light intensity are the factors which mainly influence the crop growth and development considerably. Solar radiation consists of different wave lengths of light, in which only the visible portion is useful for crop growth, while ultraviolet and infrared radiations are not beneficial for crop growth, as they bring changes at molecular level that leads to cellular disorganization of the crops grown under open environment. However, excellent growth and higher yield is generally realized in the crops grown under shadenet house, because the covering structure has the property of absorbing UV and infrared radiations.

Temperature is the major regulator of the development process. It influences flower and fruit development. Temperature was higher in the month of April under Structure-1. The effect of temperature on net photosynthesis is of vital concern in crop production. The higher temperatures have more adverse influence on net photosynthesis than lower temperature leading to decreased production of photosynthates above a certain temperature (Bhatt and Rao 1993). Temperature can be controlled and regulated under protected structure, therefore healthy and better growth of plants can be expected under protected structures.

Atmospheric moisture also plays a significant role in crop growth and development. The maximum relative humidity was recorded in the month of July under polyhouse. Relative humidity increases the availability of net energy for crop growth and prolongs the survival of crops under moisture stress conditions, which leads to optimum utilization of nutrients. It also maintains turgidity of cells. The light intensity was maximum in the month of April under Structure-1.

The WUE was found to be 14.6, 13.5, 15.2 and 18.9 kg m^{-3} under Structure-1, Structure-2, Structure-3 and Structure-4, respectively. It has been found maximum under Structure-4 and minimum under Structure-2.

The highest net income of ₹ 13813/- per structure (means ₹ 215.83 per sq m area) and B:C ratio of 1.87, was under Structure-4.

4. CONCLUSIONS

It is concluded that the maximum plant height, leaves per plant and first harvesting was found in Structure-1. Early flower initiation was found in Structure-2. Maximum number of flowers per plant, cumulative number of flowers per plant, highest individual fruit weight, highest fruit yield and WUE were found in Structure-4. After comparing given four structure types, Structure-4 showed best response of yield and physiological parameters. Net income of ₹ 13813/- per structure (*i.e.* ₹ 215.83 per sqm area) and B:C ratio of 1.87 was estimated for Structure-4. Therefore, Structure-4 may be recommended to capsicum growers of the regions.

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