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Influence of different protected structures on growth, yield and severity of powdery mildew of capsicum (*Capsicum annuum* L.) in semi-arid region

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Abstract
Protected cultivation of high value vegetables has tremendous potential and it has been gaining momentum from the last decade. With the progress of economy and the advent of improved technologies in agriculture, protected cultivation is being given lot of impetus. An experiment was conducted to investigate the influence of different protected structures on growth and yield of capsicum cv. Indira, in semi-arid region during 2017-18 and 2018-19 in the fields of AICRP on Plasticulture Engineering Technology, Raichur, University of Agricultural Sciences, Raichur. There were four treatments with five replications in the experiment consisting of different protective structures *i.e.*, polyhouse, shade net and sides opened shade net with open field condition as a control. Protective structures had remarkable and significant influence on plant growth and yield parameters of capsicum. The capsicum grown under polyhouse exhibited higher plant height (71.67 cm), number of branches (13.90), number of leaves (75.56), rind thickness (0.55 cm) and chlorophyll content (92.16%), with maximum yield (2.70 kg/plant & 85.39 t/ha). On contrary, the mean per cent severity of powdery mildew was more under open field condition (52.60) followed by poly house condition (48.40), whereas the severity of powdery mildew is less in closed shade net (16.00) and sides opened shade net (16.40). Added to this, the water and fertilizer use efficiency was more in polyhouse compared to other structures and open condition. The results indicated that there is a bright scope for cultivation of capsicum under polyhouse.

Keywords: polyhouse, shade net, sides opened shade net, open field, powdery mildew

Introduction
Protected cultivation being the most efficient means to overcome climatic diversity, has the potential of fulfilling the requirements of small growers as it can increase the yield of produce by many folds and at the same time improve the quality of the produce significantly as per the demand of the market. In India, the area under protected cultivation is presently around 25000 ha while the greenhouse vegetable cultivation area is about 2000 ha (Navid and Singh, 2013) [18]. Faced with constraints of land holdings, rapid urbanization, declining crop production, declining biodiversity and ever increasing population, demand for food, especially vegetables has increased by manifolds and protected cultivation has offered a new dimension to produce more in a limited area. Protected cultivation also known as controlled environment agriculture (CEA) is highly productive, as it conserves water, soil and protects the environment (Jensen, 2002). The quality of greenhouse vegetable crop improves in all respects such as fruit size, TSS content, ascorbic acid content and pH (Mahajan and Singh, 2006) [16]. The economic returns are 10 to 15 times higher under protected structures as compared with open-field cultivation (Panda *et al*., 2008) [20]. Protected structures such as polyhouse, extends the crop span as they safeguard the crop from vagaries of weather. Further, the vegetables grown under these structures possess better quality, decreased pesticide residue and higher yields than the ones grown under open-field conditions (Hunter *et al*., 2012) [8]. The concept of growing vegetables under protected structures has been gaining popularity among Indian growers, especially those with small land holdings (Kumar and Verma, 2009) [12]. Green house, polyhouse, shade net house and low tunnels are the different types of protected cultivation structures commonly adopted by the Indian farmers.

Capsicum cultivation in the protected structure has ample scope and is one of the most remunerative enterprises that would bring huge socio-economic benefits to the farmers. Capsicum popularly known as Shimla mirch or bell pepper is one of the important high value vegetable crop cultivated in open fields and in protected conditions (Nikki *et al*., 2017) [19]. Capsicum is rich in vitamin-A, C and minerals. Capsicum is grouped under non-traditional category of vegetables (Kallo and Pandey, 2009) [10] and it is primarily cultivated during *Kharif* and *rabi* seasons in Karnataka, Maharashtra, Tamil Nadu, Himachal Pradesh and hilly areas of Uttar Pradesh and West Bengal (Manna and Ray, 2015) [17]. India contributes one fourth of world production of capsicum with an average annual production of 0.90 m. t. from an area of 0.88 m. ha. with a productivity of 1266 kg/ha (Kumar *et al*., 2018) [13]. Despite its economic importance, growers are not in a position to produce good quality capsicum with high productivity due to various biotic (pest and diseases), abiotic (rainfall, temperature, relative humidity and light intensity) and crop factors (flower and fruit drop). Hence, to obtain a good quality produce and production during off season, there is a need to cultivate capsicum under protected conditions such as green house or polyhouse or shade net houses (Kallo and Pandey, 2009) [10]. Capsicum is a high value crop and it needs intensive factors of production. Hence capsicum cultivation under protected structures has been gaining momentum in the recent past. To date, the work on protected cultivation of capsicum is scanty. There is a need to assess the cultivation of capsicum in different protected structures to meet the growing demand of this vegetable in the market**.** Hence this investigation was taken up.

Material and Methods

The study was conducted at experimental field of All India Coordinated Research Project on Plasticulture Engineering Technology in the Department of Soil and Water Conservation Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur during 2017-18 and 2018-19. This site is located at 16˚15' N latitude and 77˚20ʹ E longitude and is at an elevation of 407 m above mean sea level (MSL). The region falls under North-Eastern dry zone *i.e.*, Zone-II in region-1 of Karnataka. The climate of the region is semi-arid and average annual rainfall is 596 mm.

The experiment consisted of four treatments comprising of closed shade net, polyhouse, sides opened shade net and open field condition. The experiment was laid out in Factorial Randomized Block Design with five replications. Raised beds of 1 m width and 18m length were prepared with a gap of 50 cm between two beds in all the structures and in open field. Capsicum seeds of cv. Indira were treated with *Trichoderma viridae* and they were sown in portrays using cocopeat as a propagating media. One month old healthy seedlings were selected and they were transplanted in the raised beds at a spacing of 60 cm between rows and 45 cm between plants within a row.

Fertilizers were provided to the plants through fertigation in a phased manner. Up to 10 days of transplanting of capsicum seedlings, nitrogen (3.4g sq/mt), phosphorus (1.7 g/m^2) and potassium (2.5 g/m^2) were provided to the beds at an interval of three days. For the next 30 days, nitrogen, phosphorus and potassium (10.9 g, 2.5 g and 7 g/m^2, respectively) were provided to beds at an interval of three days. For rest of the period of the crop, nitrogen, phosphorus and potassium (8.4 g, 1.7 g and 4.5 g/m^2, respectively) were provided to beds at an interval of three days. Vegetable special- a mixture of micronutrients procured from Krishi Vigyan Kendra, Gangavathi, was sprayed on the crop (5 g/l of water) twice *i.e.*, during vegetative growth phase and during flower initiation.

Meteorological observations such as light intensity, humidity and air temperature were recorded daily inside the shade net, polyhouse and open shade net at 9 am, 2 pm and 5 pm during the cropping period using Lux meter, Hygrometer and Digital Thermometer. Every fortnight, soil moisture at surface and 10 cm depth was recorded using soil moisture meter. Plant growth parameters *i.e.*, plant height (cm), number of branches per plant, number of leaves per plant, rind thickness (cm) and chlorophyll content (per cent) were recorded from five randomly selected plants from each replication. Yield parameters *i.e.*, yield (kg/plant) were recorded during harvest. The data was subjected to statistical analysis as per the standard procedures. The data of two years (2017 and 2018) and the pooled data were subjected to Fisher’s method of analysis of variance (ANOVA) as applicable to randomized block design.

Results and Discussion

Weather is one of the most limiting factors in production of capsicum. Protected structures provide congenial conditions of temperature, relative humidity and sunshine and promote the production of good quality produce. The maximum temperature range during the crop growth period in polyhouse was 35.22 to 40.31 ℃ and the minimum temperature ranged from 27.33 to 31.25 ℃. On contrary, the maximum and minimum temperature range in open field (control) was 33.46 to 38.04 ℃ and 21.48 to 27.14 ℃, respectively (Fig. 1). The maximum relative humidity recorded in polyhouse was in the range of 44.42 to 70.60 per cent and minimum relative humidity recorded in polyhouse was in the range of 21.35 to 42.94 per cent. In control, the maximum relative humidity was in the range of 55.68 to 80.67 per cent and minimum relative humidity was in the range of 38.61 to 49.33 per cent (Fig. 2). Maximum light intensity and minimum light intensity recorded in polyhouse was in the range of 13534.52 to 30400.00 lux and 3199.77 to 7709.00 lux, respectively. Maximum light intensity and minimum light intensity recorded in open field was in the range of 31656.13 to 48650.00 lux and 8697.42 to 18967.00 lux, respectively and presented in Fig. 3. Daily variation of maximum and minimum temperature was recorded during the crop growth period for consecutive two years in different protected cultivation structures *i.e.*, poly house, shade net house, open shade net and open field. Temperature of these structures showed that the use of different covering materials for structure exerted an influence on temperature. Air temperature, relative humidity and light intensity tended to be higher in polyhouse than other structures, due to the gain in temperature caused by the use of polythene cover. Added to this, the Interception of air movement tended to be higher and movement of air from outside to inside and vice versa was lower within the polyhouse structure. Poly film increases the temperature by accumulation of solar radiation inside the polyhouse and shade net reduces the temperature inside the structure by reducing the amount of solar energy entering the structure. Due to these reasons, the daily maximum and minimum temperature, relative humidity and light intensity was high in polyhouse and low in shade net house.

There was a significant difference among the treatments in the growth parameters during 2017-18 and 2018-19. The pooled data also exhibited significant difference among the treatments for the growth parameters (Table 1 to 2).

During 2017-18 the plant height, number of leaves, number of branches, rind thickness and chlorophyll content in polyhouse increased by 114.93per cent, 83.24 per cent, 355 per cent, 160 per cent and 68.48 per cent, respectively over control. During 2018 -19 the plant height, number of leaves, number of branches, rind thickness and chlorophyll content in polyhouse increased by 44.63 per cent, 76.78 per cent, 333 per cent, 137.50 per cent and 64.81 per cent, respectively over control. The pooled data also exhibited similar trend (69.83, 79.86, 344, 150 and 66.87 per cent increase in plant height, number of leaves and branches, rind thickness and chlorophyll content, respectively over control). Temperature affects the vital functions of plants such as germination, transpiration, respiration, photosynthesis, growth and flowering (Goto and Tivelli, 1998). When temperature falls below optimum or exceeds the optimum temperature, growth is usually retarded and yield decreases. High air humidity improves the fruit set. These could be the reasons for higher growth parameters recorded in the present study. Similar results were documented by Cemek *et al*. (2005) [6] who reported higher plant height in brinjal plants grown in polyhouse, which had a higher temperature than shade net and open field conditions.

During 2017-18, the yield per plant (kg) and yield per square meter (kg/m^2) increased by 153.33 per cent and 107.93 per cent, respectively, in polyhouse when compared to open field condition (control). During 2018-19, the yield per plant (kg) and yield per square meter (kg/m^2) in polyhouse increased by 155.74 per cent and 87.82 per cent respectively, over control. The pooled data also exhibited similar trend (154.72 per cent and 96.77 per cent increase in yield per plant (kg) and yield per square meter (kg/m^2), respectively over the control) and presented in Table 3. The root zone temperature in polyhouse affects the growth and fruit yield by altering the weather parameters. Studies on plant microclimate modification ssuggested that CO_2 released by plants during night was trapped inside the polyhouse, raising its level to around 0.1per cent compared with 0.03 per cent outside the polyhouse (Burke *et al.*, 2001) [5]. This increased the rate of photosynthesis during day time, improving plant growth and crop productivity. In controlled experiments with elevated levels of CO_2, Burke *et al*. (2001) [5] harvested 32 per cent higher tuber yield in potato, mainly because of the increased tuber size. Thus, in the current study, elevated levels of CO_2 could also have contributed toward enhancing fruit yield of bell pepper under polyhouse conditions. Kanwar *et al.* (2014) [11] found higher number of fruits per plant in bell pepper under greenhouse conditions. Kurubetta and Patil (2009) [14] recorded significantly higher number of flower and fruits (13.41 and 12.11, respectively) in the Indra hybrid of capsicum. The higher yield in capsicum might also be due to the favourable climatic conditions, protective ability against major abiotic stresses (Singh *et al*., 2010) [25] and sufficient accumulation of photosynthates in the plants grown in polyhouse.

The severity of powdery mildew under four different protected cultivation was observed during 2017-18 and 2018-19. The pooled data on severity of powdery mildew results shows that, the maximum mean per cent severity of powdery mildew was noticed in open field condition with 52.60 which was on-par with poly house protected condition with 48.40. The least severity of powdery mildew was noticed in closed shade net (16.40%) and side opened shade net (16.40%).

The variation of disease severity in various protected cultivation is mainly attributed to the existing weather factors like temperature, relative humidity, distribution and amount of rainfall followed by cultural practices, sanitation and other suitable management practices. The cool nights and dry weather situation are more favourable for the powdery mildew disease to attain severity (Aust and Jurgen, 1986) [3].

When the age of the crop coincides with favourable weather parameters and water management aggravates the disease and causes a severe incidence. When there was less rain, cooler nights and high day temperatures, which were enough for dew formation and wide variation (13 – 15 °C) in the maximum and minimum temperature and day and night RH (39.9 - 51.7%) increased powdery mildew intensity in black gram (Singh and Sirohi, 2003) [22].

The microclimate builds up due to close spacing and heavy crop canopy also helps in pathogen multiplication (Akhileshwari *et al*., 2012) [1]. Less disease severity depends on factors such as location, cultural practices, followed by susceptibility of the cultivars grown, microclimate congenial for disease progress and meteorological factors such as temperature, relative humidity and rain. The more severity of powdery mildew was attributed to the temperature and relative humidity prevailing during the crop period, which was favourable for the disease development and spread (Ashtaputre *et al*., 2007 and Patil *et al*., 2012) [2, 21].

Capsicum production in open field conditions require high irrigation water compared to other protected structures. During 2017-18 and 2018-19 the water use efficiency (1222.36 kg/ha cm and and 1135.82 kg/ha cm, respectively) was high in polyhouse when compared to open field where the water use efficiency was 685.49 kg/ha cm and 691.82 kg/ha cm (during 2017-18 and 2018-19, respectively) and presented in Table 4 and Fig. 4. Under Protected cultivation, soil water content was higher when compared to open field. Polythene covering material in polyhouse, reduces the crop evapotranspiration, causing reduction in transpiration, resulting in decreased soil water uptake in Capsicum (Díaz-Pérez, 2013) [7]. Similar results were observed in brinjal crop. Lorenzo *et al.* (2006) [15] found that poly house increased yield, reduced crop transpiration and thus water uptake, and improved water use efficiency by 62 per cent for the cucumber crop. On the other hand, crops grown in open fields were subjected to direct sun-light, high temperatures and wind resulting in high crop evapo-transpiration, therefore, demanding large amounts of water.

Fertilizer use efficiency of capsicum was maximum in polyhouse when compared to open field conditions (Table 5 and Fig. 5, 6 and 7). Nitrogen (0.88 kg per kg of nitrogen applied), phosphorous (0.34 kg per kg of phosphorous applied) and potassium (0.24 kg per kg of potassium applied) use efficiency was higher in polyhouse during 2017-18 when compared to open field (0.42, 0.16 and 0.12 kg per kg of nitrogen, phosphorous and potassium applied, respectively). In 2018-19, similar trend of higher fertilizer use efficiency was observed in polyhouse (0.97, 0.37 and 0.27 kg per kg of nitrogen, phosphorous and potassium applied, respectively) when compared to open field (0.52, 0.20 and 0.14 kg per kg of nitrogen, phosphorous and potassium applied, respectively). Modification of crop microclimate through structural and agronomic interventions improve the plant growth and yield through optimization of soil and air temperature which is critical for promoting the cultivation of bell pepper. The polyhouse, improves the root zone temperature, which might have improved the root growth.

This could have resulted in enhanced t uptake of nutrients and water in the current investigation.

Table 1: Growth parameters of capsicum as influenced by protected structures

Treatment	Plant height (cm)			Number of leaves			Number of branches		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Closed shade net	50.47	70.45	60.46	61.78	68.06	64.92	8.55	9.64	9.09
Playhouse	65.06	78.29	71.67	74.03	77.11	75.56	12.97	14.83	13.90
Sides opened shade net	32.59	62.45	47.52	50.48	54.83	52.65	4.96	5.81	5.38
Open field	30.27	54.13	42.20	40.40	43.62	42.01	2.85	3.42	3.13
SE m±	1.05	0.99	1.31	1.30	0.87	0.73	0.24	0.07	0.12
CD at 5 per cent	3.22	3.06	3.81	4.00	2.67	2.14	0.74	0.23	0.37

Table 2: Rind thickness and chlorophyll content of capsicum as influenced by protected structures

Treatment	Rind thickness (cm)			Chlorophyll content (per cent)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Closed shade net	0.37	0.40	0.38	67.30	72.39	69.84
Playhouse	0.52	0.57	0.55	89.31	95.03	92.16
Sides opened shade net	0.28	0.31	0.29	59.41	65.20	62.30
Open field	0.20	0.24	0.22	53.01	57.66	55.23
SE m±	0.01	0.01	0.008	1.54	1.65	1.05
CD at 5 per cent	0.04	0.03	0.022	4.75	5.08	3.07

Table 3: Effect of different protected structures on the yield of capsicum and its influence on the severity of powdery mildew

Treatment	Yield per plant (kg)			Yield (tons/ha)			Severity of Powdery Mildew (%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Closed shade net	1.46	2.11	1.78	56.32	74.00	65.16	15.20 (22.68)	16.80(24.11)	16.00(23.52)
Polyhouse	2.28	3.12	2.70	81.35	89.42	85.39	49.60(44.77)	47.20(43.38)	48.40(44.07)
Sides opened shade net	1.21	1.65	1.44	48.83	61.57	55.20	16.80(24.00)	16.00(23.41)	16.40(23.73)
Open field	0.9	1.22	1.06	39.18	47.61	43.40	53.60(47.09)	51.60(45.92)	52.60(46.50)
S. Em±	0.07	0.11	0.09	1.73	1.55	1.64	3.66	3.18	3.22
CD at 5%	0.21	0.34	0.28	5.28	4.59	5.02	11.29	9.81	9.93

Table 4: Water use efficiency of capsicum as influenced by different structures

Treatment	Water use efficiency (kg ha^{-1}-cm)	
	2017-18	2018-19
Closed shade net	966.00	889.64
Playhouse	1222.36	1135.82
Sides opened shade net	822.96	816.63
Open field	685.49	691.82

Table 5: Fertilizer use efficiency of capsicum as Influenced by different structures

Treatment	Fertilizer use efficiency (kg yield/ kg nutrient applied)					
	N		P		K	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Closed shade net	0.61	0.80	0.23	0.31	0.17	0.22
Polyhouse	0.88	0.97	0.34	0.37	0.24	0.27
Sides opened shade net	0.53	0.67	0.20	0.26	0.15	0.18
Open field	0.42	0.52	0.16	0.20	0.12	0.14

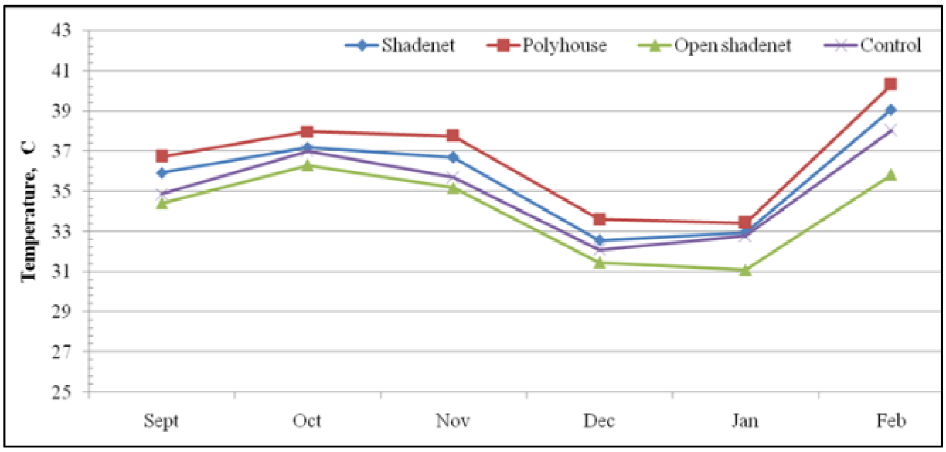

Fig 1: Temperature variation in different protected structures during 2017-19

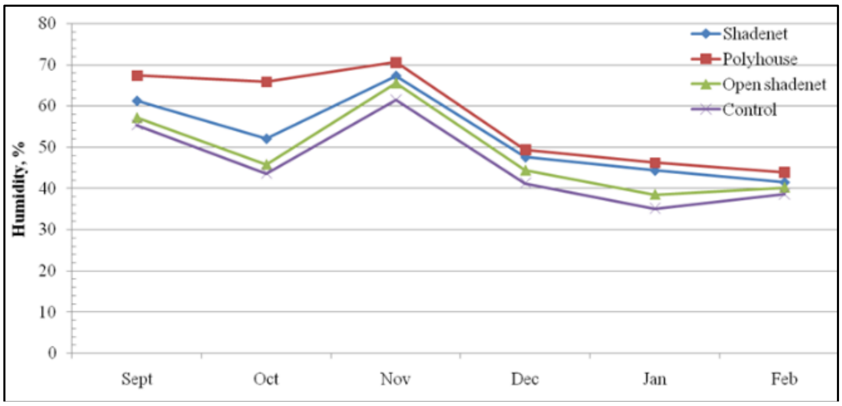

Fig 2: Humidity variation in different protected structures during 2017-19

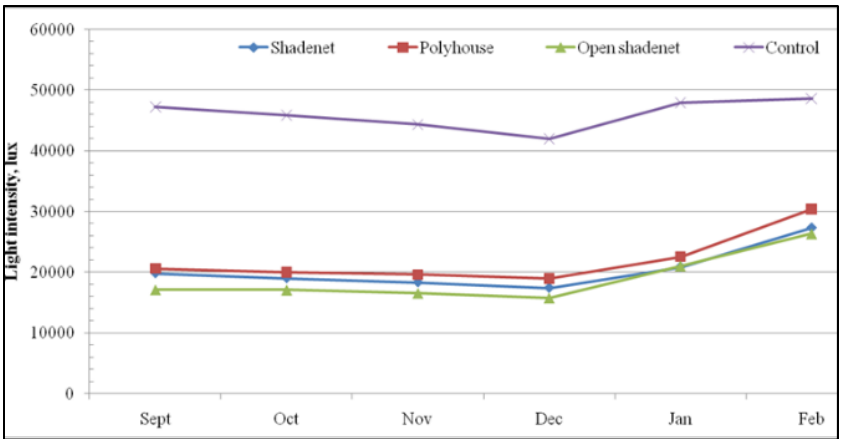

Fig 3: Light intensity variation in different protected structures during 2017-19

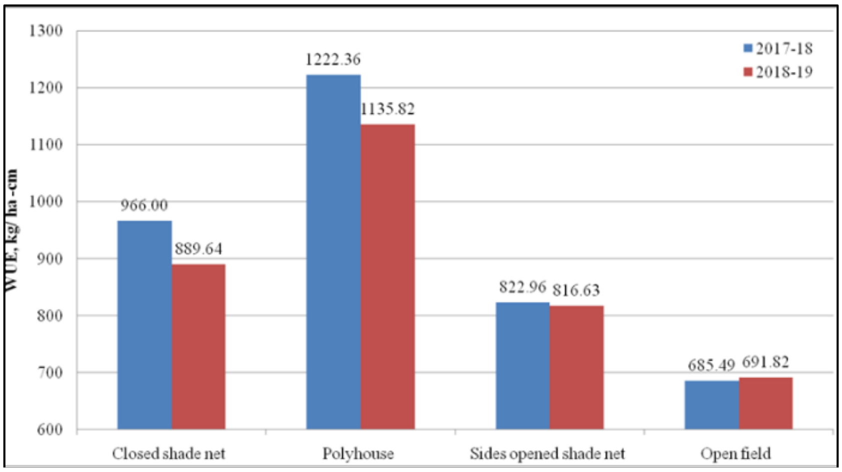

Fig 4: WUE of Capsicum grown under protected structures during 2017-19

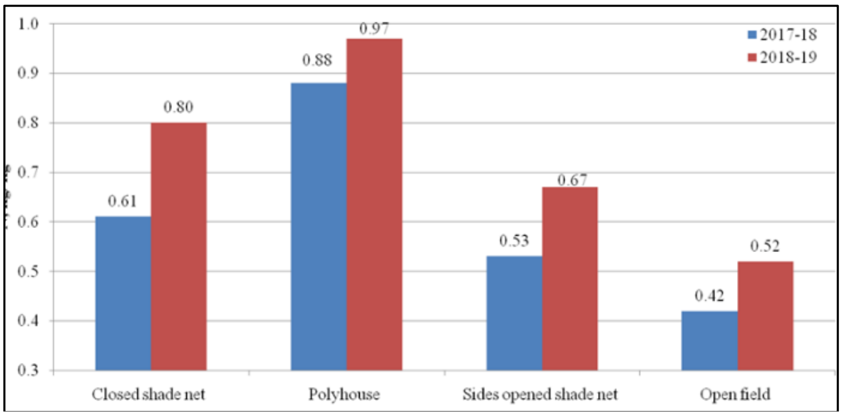

Fig 5: Nitrogen use efficiency of Capsicum grown under protected structures during 2017-19

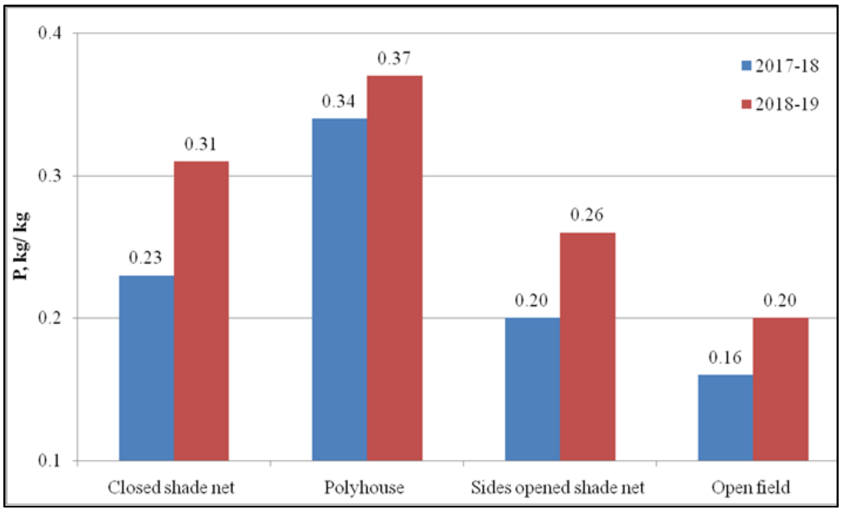

Fig 6: Phosphorous use efficiency of Capsicum grown under protected structures during 2017-19

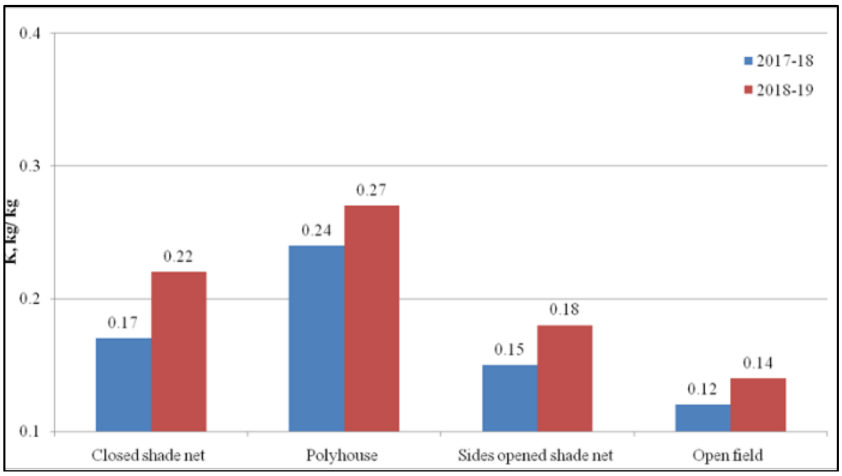

Fig 7: Potassium use efficiency of Capsicum grown under protected structures during 2017-19

Conclusion

Playhouse, is most suited for the cultivation of capsicum in Raichur agro-climatic condition as depicted by higher growth and yield parameters. This is followed by shade net house and open shade net. The growth and yield parameters were the least when capsicum was grown in open field.

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References

1. Akhileshwari SV, Amaresh YS, Naik MK, Kantharaju V, Shankergoud I. Survey and surveillance of sunflower powdery mildew in eastern Karnataka., Journal of Plant Disease Sciences. 2012; 7:117-119
2. Ashtaputre, Sudheendra, Kulkarni, Srikant, Shivaprasad, M, Rao MS *et al*. Survey and surveillance for incidence of powdely mildew of chilli in Northem Karnataka. Annals of Biology. 2007; 23:177-183.
3. Aust HJ, Jurgen HH. Microclimate in relation to epidemics of powdery mildew. Annual Revieu,of Phytopatholoey. 1986; 29:144-145.
4. Brar GS, Sabale RN, Jadhav MS, Nimbalkarand CA, Gawade BJ. Effect of trickle irrigation and light levels on growth and yield of Capsicum under polyhouse conditions. J Maharashtra Agric. Univ. 2005; 30:325-328.
5. Burke JI, Finnan JM, Donnelly A, Jones MB. The effects of elevated concentrations of carbon dioxide and ozone on potato (*Solanum tuberosum* L.) yield, 2001. http://www.teagasc.ie/research/reports/crops/4661/eopr-4661.pdf.
6. Cemek B, Demir Y, Uzun S. Effects of greenhouse covers on growth and yield of aubergine. European Journal of Horticultural Science. 2005; 70:16-22z22.
7. Díaz-Pérez JC. Bell pepper crop as affected by shade level: Microenvironment, plant growth, leaf gas exchange, and leaf mineral nutrient concentration. Hort Sci. 2013; 48(2):175-182.
8. Hunter B, Drost D, Black B, Ward R. Improving growth and productivity of early season high-tunnel tomatoes with targeted temperature additions. Hort. Sci. 2012; 47:733-40.
9. Jensen MH. Controlled environment agriculture in deserts tropics and temperate regions – A world review. Acta Hort. 2002; 578:19-25.
10. Kallo G, Pandey AK. Commendable progress in research. The Hindu: Survey of Indian Agric, 2009, 159-163.
11. Kanwar MS, Sharma OC, Performance of Capsicum under protected cultivations in cold arid region. J Hill Agric. 2010; 1:88-89.
12. Kumar M, Verma V. Bell pepper (*Capsicum annuum* L.) production in low cost naturally-ventilated polyhouses during winters in the mid hills of India. Acta Horticulturae. 2009; 807:389-94. doi:10.17660/ActaHortic.2009.807.55.

13. Kumar S, Singh N, Chaudhari DJ. Profitability of capsicum cultivation under protected condition. Chem. Sci. Rev. Lett. 2018; 7(28):900-904.
14. Kurubetta Y, Patil AA. Performance of coloured capsicum hybrids under different protected structures. Karnataka J Agric. Sci., 2009; 22:1058-1061.
15. Lorenzo P, Sanchez-Guerrero MC, Medrano E, Garcia ML, Caparros I, Coelho G *et al*. Climate control in the summer season: a comparative study of external mobile shading and fog system. Acta Hort. 2004; 659:189-194.
16. Mahajan G, Singh KG. Response of greenhouse tomato to irrigation and, 2006.
fertigation. www.elseviercom/locate/agwat.
17. Manna DC, Ray P. Determination of transplanting time of the Capsicum seedlings for yield and profit maximization, Int. J Bioresource Sci. 2015; 2:71-72.
18. Naved S, Singh BR, Protected cultivation of vegetables in global arena: A review. Indian Journal of Agricultural Sciences. 2013; 83(2):123-35
19. Nikki B, Sanjeev K, Chaudhari VL. Economic analysis of protected cultivation of Bell Pepper (Capsicum annuum L.) in response to different PGRs under south Gujarat conditions. Indian J Agric. Res. 2017; 51(5):488-492.
20. Panda NK, Paul JC, Panigrahi B, Mishra JN. Energy requirement for capsicum cultivation in naturally ventilated greenhouse in coastal Orissa. Agricultural Engineering Today. 2008; 32:23-27.
21. Patil Ramesh Bheemaraya MB, Naik MK, Abbas Hussain, Amaresh YS. A Survey on the incidence of chilli powdery mildew in TBP and UKP- Command Areas of Karnataka, Research Journal of Agricultural Sciences. 2012; 3:192-195.
22. Singh A, Sirohi A. Effect of some weather parameters on the developmerrt of powdery mildew (*Erysiphe polygoni*) in black gram. Plant Disease Research. 2003; 18:63-64.
23. Singh AK, Singh AK, Gupta MJ, Shrivastav R. Effect of polyhouse on insect pest incidence, fruit quality and production of vegetable and fruit crops. Proceeding of the National Symposium on Frontier areas of Entomological Res. IARI, New Delhi, 2003, 94.
24. Singh AK, Singh B, Gupta R. Performance of sweet pepper (*Capsicum annuum*) varieties and economics under protected and open field conditions in Uttarakhand. Indian J Agric. Sci. 2011; 81(10):973-975.
25. Singh B, Singh AK, Tomar B. Inperi-urban areas protected cultivation technology to bring prosperity. Indian Horticulture. 2010; 55(4):31-33.