TOPIC: “Influence of protected cultivation structures on vegetable crops”

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ABSTRACT

Faced with constraints of land holdings, rapid urbanization, declining crop production, biodiversity and ever increasing population, demand for food, especially vegetables has increased by folds and thus protected cultivation has offered a new dimension to produce more in a limited area. China ranks first in the world in vegetable production followed by India. 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. Protected cultivation structures provide favourable environment for crop growth thereby achieving greater yield and high quality produce. Green house, polyhouse, shadow hall shade net house & low tunnels are different types of protected cultivation structures, which are commonly adopted for crop cultivation. During extreme cold in winter season (November to February) vegetables can be grown under greenhouse structure. Further, the vegetables grown under these structures possess better quality, decreased pesticide residue and higher yields than the ones grown under open-field conditions. As compared to open field cultivation, the reduction in irrigation water requirement was 35.6 % for shadow hall, 35.2 % for polyhouse and 25.5 % shade net house cultivation. The plant height, number of leaves and number of branches in polyhouse increased by 114.93 %, 83.24 % and 355 % respectively over open field condition. Shadow hall is most suited for the cultivation of vegetables as depicted by higher growth and yield parameters, followed by polyhouse, shade net house. The growth and yield parameters were the least when vegetables were grown in open field. During 2017-18 and 2018-19 the water use efficiency (1222.36 kg/ha cm and 1135.82 kg/ha cm, respectively) was high in polyhouse over open field condition (685.49 kg/ha cm and 691.82 kg/ha cm respectively). Severity of powdery mildew was found to be the lowest in closed shade net and highest in open field.

Keywords: Protected cultivation, protected structures, polyhouse, shadow net, vegetables, yield.

Introduction

Protected cultivation or controlled environment agriculture (CEA) is a cropping technique where controlled micro-climate influences the growth and development of a plant (Pattnaik and Mohanty., 2021) .The essential factors such as temperature, humidity, light, and others, are regulated as per the requirement of the crop (www.agrifarming.in).Green house, polyhouse, shade net house and low tunnels are the different types of protected cultivation structures commonly adopted by the Indian farmers (Maheshwara et al., 2020). 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). Opting for protected cultivation, the productivity of vegetable crops can be increased by 3 to 5 times as compared to open environment (Santosh *et al.*, 2017).

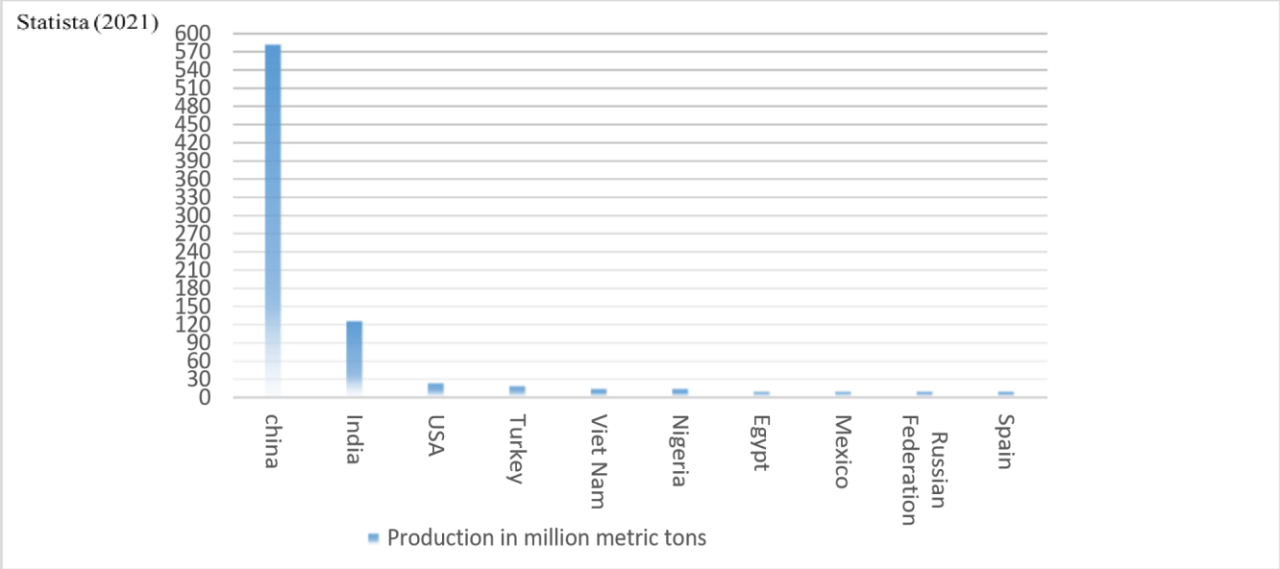
Need for protected cultivation (Wani *et al.*, 2017)

India is second largest after China in vegetable production of 113.5 million tons. However annual requirement of vegetables is estimated to be about 135 million tons by the end of 2020. Low production and productivity of vegetable has been attributed to the extremes of temperatures ranging from 0 to 48℃ during the year. Use of water is optimized and there's reduction in the consumption by 40-50%. Reduces diseases, pests and viruses due to biotic stress during rainy and post rainy season. Increasing demand of high quality vegetables.

Scope of protected cultivation in India (Panda *et al.*, 2008)

1. Cultivation in problematic agricultural zones.
2. Greenhouses around massive cities.
3. Export of farming turn out.
4. Plant propagation.
5. Biotechnology.
6. Economic returns.

Production of vegetables worldwide in 2019



Total area of Kashmir under vegetable cultivation in August 2018 was 48160.92 ha with a production of about 1539.59 MTs (diragrikmr.nic.in, August 2018), which has increased from 48000 ha to 51000 ha, from 1500 MTs to 1638 MTs (Ziraat Times, August 2020).

Protected structures Polyhouse:

- Framed structure having 200 micron UV stabilized transparent polyethylene.
- Creates greenhouse effect making microclimate favourable for plant growth and development.

Shade net house*:*

- Framed structure used to protect plants from highly intense solar radiation.
- Materials such as GI pipes, angle iron, wood or bamboo are used.
- Used for hardening of fruit orchard planting material raised under greenhouse.

Insect proof net house:

- Covered with UV stabilized insect proof net of 40-50 mesh.
- Used for effective control of pests and diseases.

Shadow hall:

- Framed structure made of GI pipes.
- Covered with nets of different shades.
- This structure protects crop from devastating rains.

Plastic low tunnels:

- Generally known as row covers.
- Plastic mulches and drip irrigation may be used in conjunction with low tunnels.
- Crops grown under low tunnel conditions are melons, cucumber, tomato, strawberry.

Area under protected cultivation (Hassan., 2017)

	World scenario		Indian scenario	
S.No	Country	Area (ha)	State	Approximate area (ha)
1	China	2,760,000	Maharashtra	15,000
2	South Korea	57,445	Karnataka	10,000
3	Spain	52,170	Himachal Pradesh	5000
4	India	50,000	Punjab	4000
5	Japan	49,059	Uttarakhand	3000
6	Turkey	33,515	Tamil Nadu	2100
7	Italy	26,500	North Eastern	2000
8	Mexico	11,759		
9	Netherland	10,370		
10	France	9,620		
11	USA	8,425		

Area achieved under different protected cultivation structures in India (Prakash *et al.,* 2019*)*

Protected cultivation	Total area(ha)	Percent share
Greenhouse structure	298.62	0.14
Naturally ventilated polyhouse	4136.81	1.92
Shade net house	4827.5	2.24
Plastic tunnel	4868.35	2.26
Walk- in tunnel	3.84	0.00
Plastic mulching	191472.4	88.72
Total	215809.97	100

Crops grown under protected cultivation (Pattnaik and Mohanty., 2021)

Flowers	**Chrysanthemum, Carnation, Gerbera, Rose, Lilium, Orchid, Gladiolus, etc.**
Vegetables	Tomato, Coloured Capsicum (Yellow and Red Bell Peppers), Cucumber, Broccoli, Red Cabbage, Leafy vegetables, Radish, etc.
Fruits	Strawberry
Seedling and Nurseries	Vegetables, Flowers, Tissue Culture, Clonal for Forestry, Fruit Grafting (like Lemon, Citrus, Mango, Guava, Litchi, etc.)

Case Study 1: Influence of Different Protected Cultivation Structures on Water Requirements of Winter Vegetables (Santosh *et al.*, 2017)
Study area: Experimental farm of Agricultural and food Engineering Department, IIT Kharagpur, India

Objective: To determine crop water requirement of winter vegetable crop under different protected cultivation structures.

Material used: Three types of protected structures (polyhouse, Shade net house with 75% shade and modified shade net house with 75% shade and 200 micron UV stabilizes film).

Winter vegetables: Tomato, Capsicum, Cucumber and Cabbage

The minimum and maximum temperature and relative humidity ranges from 9.6℃ to 27℃ and 27.2℃ to 41.8℃ and 19 to 78% and 79 to 99 % in Kharagpur

Methodology

The daily irrigation water requirement for the vegetable crops were estimated by using the following relationship

$WR = ET_0 \times Kc \times Wp \times A$

Where,

WR = Crop water requirement (l day^{-1})

ETO = Reference evapotranspiration (mm day^{-1})

Kc = Crop Coefficient

Wp = Wetting fraction (taken as 1 for close growing crops)

A = Plant area, m^2 (i.e. spacing between rows (m) × spacing between Plants (m))

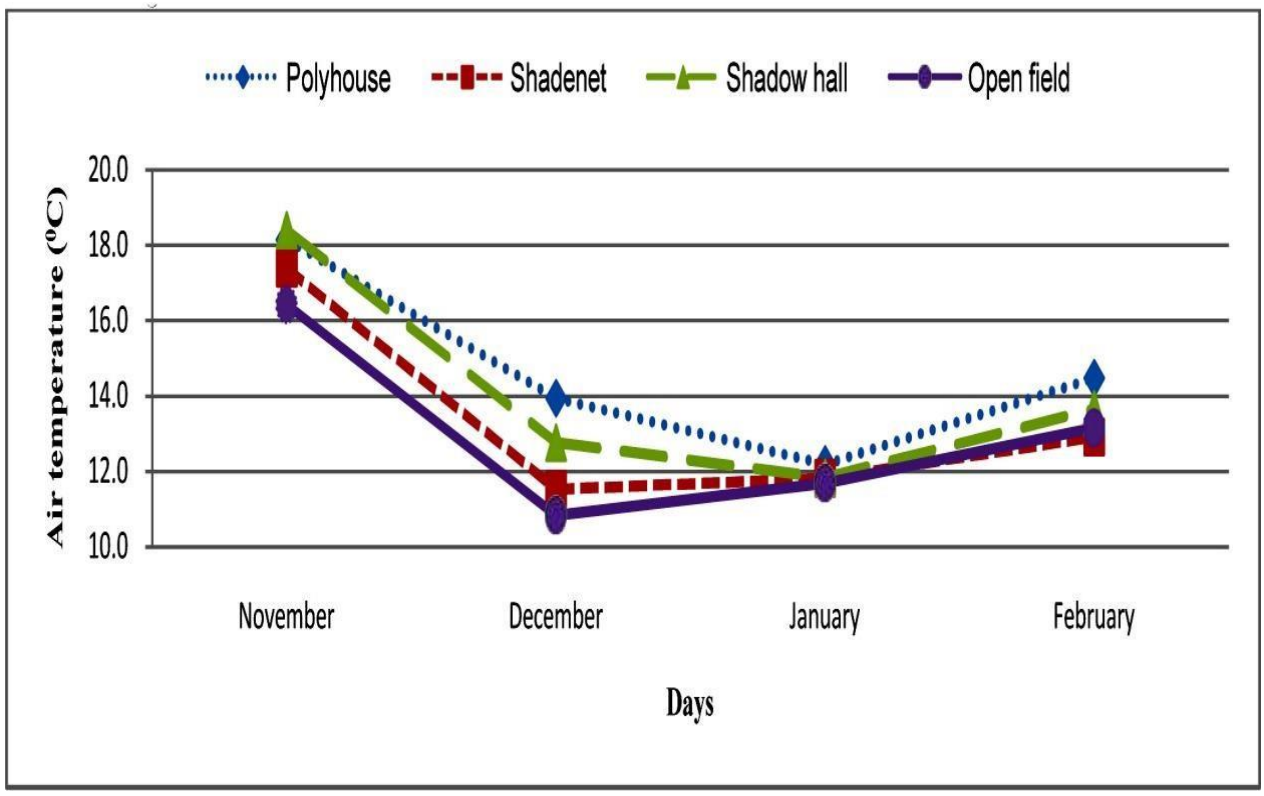
Daily meteorological data recorded during the year 2014-2015 were used to compute reference evapotranspiration (ETO).

Results:

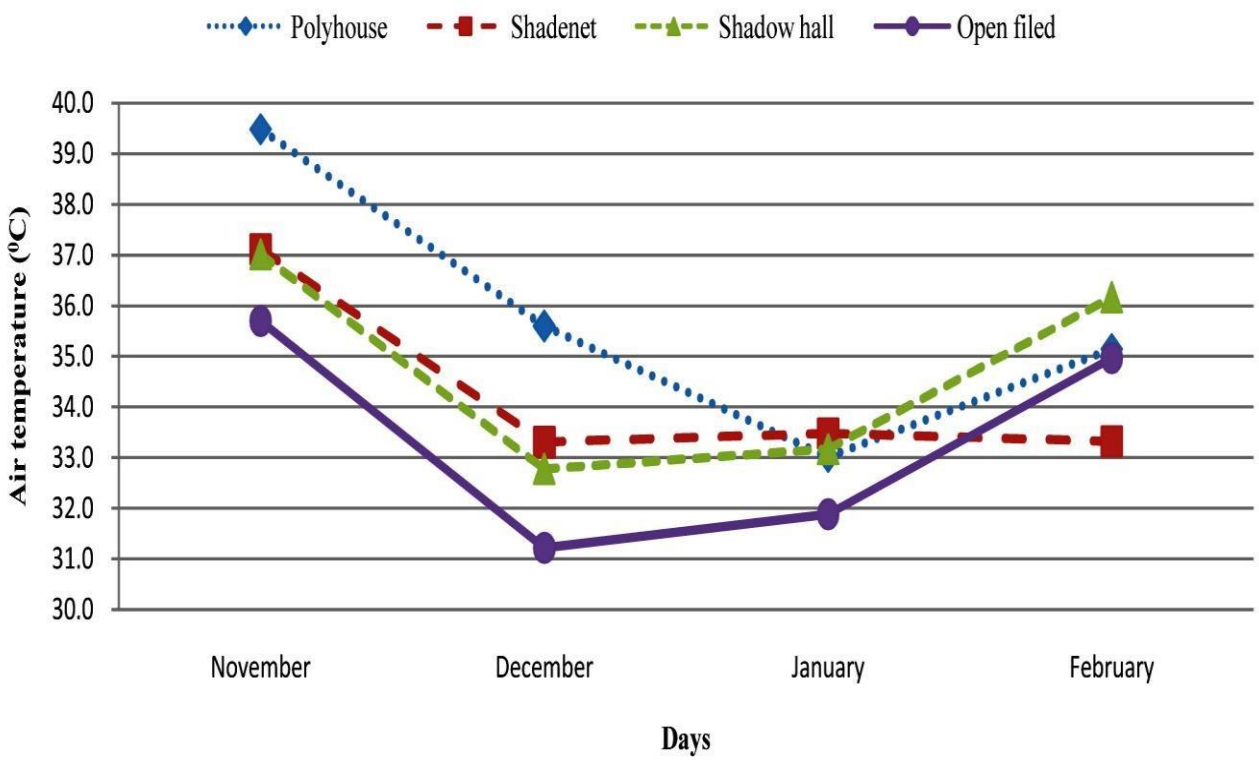
Crop coefficients (Kc) and plant area (m^2) of different vegetables

S.No	Crop	Kc initial	Kc middle	Kc end	Plant Area, m^2

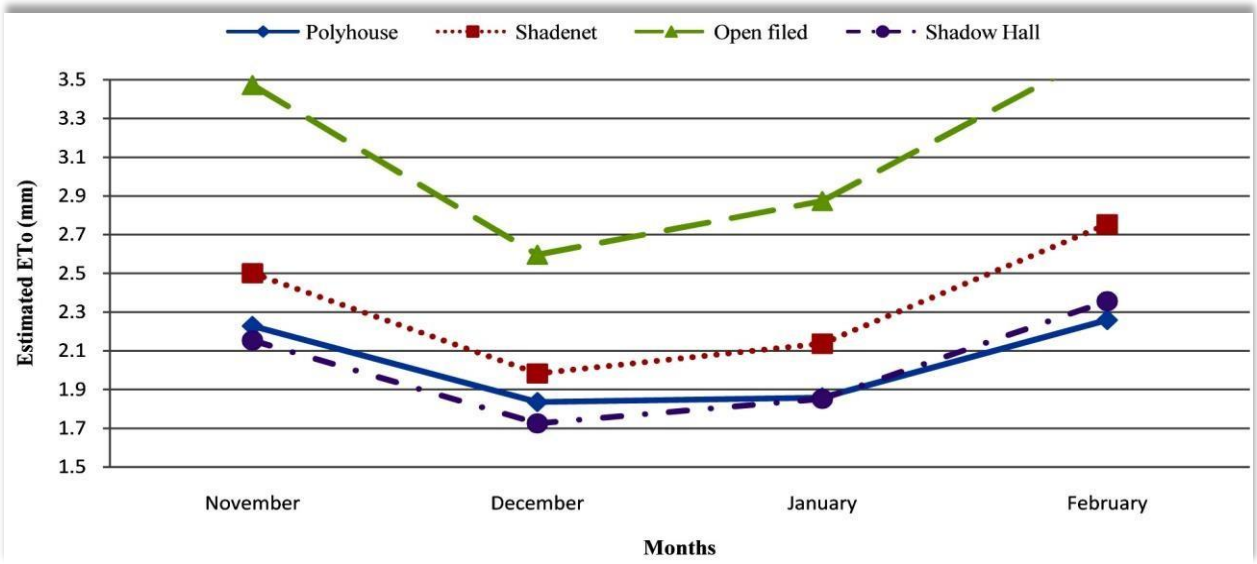
1	Tomato	0.6	1.15	0.80	0.5 × 0.5 = 0.25
2	Capsicum	0.6	1.05	0.90	0.45× 0.5 = 0.23
3	Brinjal	0.6	1.05	0.90	0.5 × 0.5 = 0.25
4	Cucumber	0.6	1.00	0.75	0.5 × 0.25 = 0.13
5	Cabbage	0.7	1.05	0.95	0.6 × 0.45 = 0.27
6	Broccoli	0.7	1.05	0.95	0.6 × 0.45 = 0.27
7	Cauliflower	0.7	1.05	1.00	0.6 × 0.45 = 0.27



Average monthly minimum temperature recorded in different protected cultivation structures



Average monthly maximum temperature recorded in different protected cultivation structures



Average monthly estimated reference evapotranspiration in different protected cultivation structures

Water requirement of winter vegetables under different protected structures (litres day^{-1} Plant^{-1})

1) Tomato

Month	Tomato			
	Poly house	Shade net house	Open	Shadow hall
Nov	0.41	0.45	0.63	0.39
Dec	0.46	0.51	0.66	0.44
Jan	0.52	0.61	0.82	0.53
Feb	0.45	0.55	0.73	0.47
Total	56.64	65.12	**87.45**	**56.27**

2) Capsicum

Month	Capsicum			
	Poly house	Shade net house	Open	Shadow hall
Nov	0.37	0.42	0.58	0.36
Dec	0.34	0.37	0.49	0.32
Jan	0.38	0.45	0.61	0.39
Feb	0.52	0.63	0.84	0.54
Total	49.20	56.64	**76.45**	**49.11**

3) Cucumber

Month	Cucumber			
	Poly house	Shade net house	Open	Shadow hall
Nov	0.19	0.21	0.29	0.18
Dec	0.18	0.20	0.26	0.17
Jan	0.21	0.25	0.33	0.22
Feb	0.25	0.30	0.40	0.26
Total	25.16	29.05	**38.99**	**25.08**

4) Cabbage

Month	Cabbage			
	Poly house	Shade net house	Open	Shadow hall
Nov	0.46	0.51	0.71	0.44
Dec	0.43	0.47	0.62	0.41
Jan	0.49	0.58	0.79	0.51
Feb	0.60	0.73	0.97	0.62
Total	60.54	69.92	**93.89**	**60.36**

Case study 2: Influence of different protected structures on growth, yield and severity of powdery mildew of capsicum (Capsicum annuum L.) in semi-arid region (Maheshwara *et al.*, 2019)**.**

Study area: Experimental field of the Department of Soil and Water Conservation Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka, India.

Objective: To investigate the influence of different protected structures on growth and yield of capsicum cv. Indira.

Material used: Three types of protected structures (closed shade net, polyhouse, and sides opened shade net).

Crop: Seedlings of Capsicum (cv. Indira).

Methodology:

- The experiment consisted of four treatments comprising of closed shade net, polyhouse, sides opened shade net and open field condition.
- Raised beds of 1m width and 18m length were prepared with a gap of 50 cm between two beds in all the structures and in open field
- 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. Yield parameters were recorded during harvest.

Results

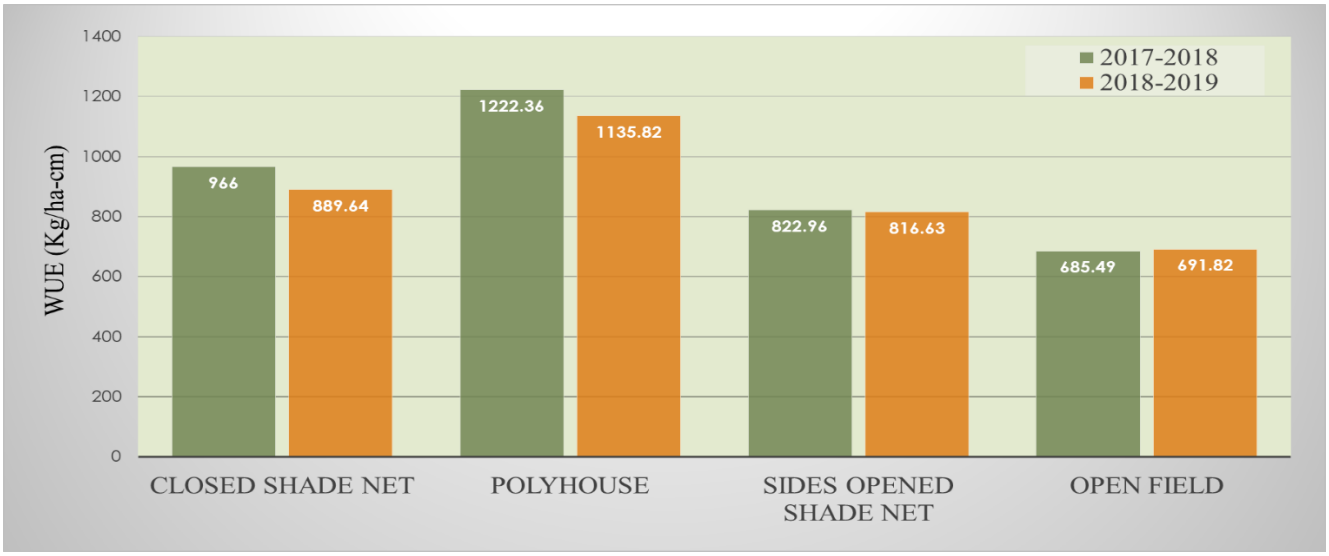
Growth parameters of capsicum as influenced by protected structures						
Treatment	**Plant height (cm)**		**Number of leaves**		**Number of branches**	
	2017-2018	**2018-2019**	**2017-2018**	**2018-2019**	**2017-2018**	**2018-2019**
Closed shade net	50.47	70.45	61.78	68.06	8.55	9.64
Polyhouse	65.06	**78.29**	74.03	**77.11**	12.97	**14.83**
Opened shade net	32.59	62.45	50.48	54.83	4.96	5.38
Open field	30.59	54.13	40.40	43.62	2.85	3.42

Effect of different protected structures on the yield of capsicum

Treatment	Yield per plant(kg)		Yield(tons/ha)	
	2017-2018	2018-2019	2017-2018	2018-2019
Closed shade net	1.46	2.11	56.22	74.16
Polyhouse	2.28	**3.12**	81.35	**89.42**
Opened shade net	1.21	1.65	48.83	61.57
Open field	0.9	1.22	39.18	47.61

Effect of different protected structures on the severity of powdery mildew

Treatment	Severity of powdery mildew (%)
	2017-2019
Closed shade net	**16.00**
Polyhouse	48.40
Opened shade net	16.40
Open field	52.60



Water Use Efficiency (WUE) of capsicum grown under protected structures

Conclusion:

- ET_0 estimated outside the protective covering structures show lower values than those for ET_0 values estimated inside.
- Due to increased temperature in protected cultivation structures, ET_0 also varies according to temperature and radiation.
- Winter vegetable production in open field condition requires higher irrigation water requirement for all the crops comparing to other protective covering structures.
- As compared to open field cultivation, the reduction in irrigation water requirement was 35.6 % for shadow hall, 35.2 % for polyhouse and 25.5 % shade net house cultivation.
- During 2017-18 the plant height, number of leaves, number of branches in polyhouse increased by 114.93 %, 83.24 % and 355 % respectively over open field condition.
- During 2018 -19 the plant height, number of leaves, number of branches in polyhouse increased by 44.63 %, 76.78 % and 333 % respectively over open field condition.
- During 2017-18, the yield/plant (kg) and yield/m^2 (kg/m^2) in polyhouse increased by 153.33 % and 107.93 %, respectively, over open field condition.
- During 2018-19, the yield per plant (kg) and yield/m^2 (kg/m^2) in polyhouse increased by 155.74 % and 87.82 % respectively, over open field condition.
- During 2017-18 and 2018-19 the water use efficiency (1222.36 kg/ha cm and 1135.82 kg/ha cm, respectively) was high in polyhouse over open field condition (685.49 kg/ha cm and 691.82 kg/ha cm respectively).
- Severity of powdery mildew was found to be the lowest in closed shade net and highest in open field.

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