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

**Author Name: Nuzhat Bint Nazir1, Adil Majeed1, Naveed Najam1 and Dr. Purshotam Singh**

**1Ph.D Soil and Water Conservation Engineering, COAE&T, SKUAST-KASHMIR**

**2Professor Agronomy, Directorate of Extension, SKUAST-K, Shalimar**

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# ABSTRACT

Faced with constraints of land holdings of land holdings, fast urbanization, diminishing crop yield, biodiversity, and an ever-increasing population, the demand for food, particularly vegetables, has multiplied. Protected cultivation in a constrained space has therefore provided a new way to produce more. China ranks first in the world in vegetable production followed by India. To overcome the climatic diversity, protected cultivation 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 are favorable for crop growth, resulting in a higher yield and higher-quality produce. Polyhouse, green house, shadow hall shade net house & low tunnels are different types of protected cultivation structures, which are commonly adopted for crop cultivation. During winter season (November to February) vegetables can be grown under greenhouse structure. Further, the vegetables grown under open-field condition does not possess better quality and higher yields than the ones grown under protected cultivation. 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. 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. In comparison to open field conditions (685.49 kg/ha cm and 691.82 kg/ha cm, respectively), polyhouse conditions had a high water use efficiency (1222.36 kg/ha cm and 1135.82 kg/ha cm, respectively) throughout the 2017–18 and 2018–19 academic years. 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, light, humidity and others, are regulated as per the requirement of the crop (www.agrifarming.in).Green house, polyhouse, low tunnels and shade net house are the different types of protected cultivation structures commonly adopted by the Indian farmers (Maheshwara et al., 2020). Indian gardeners particularly those with less land holdings, have begun adopting the idea of producing vegetables beneath covered structures (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).

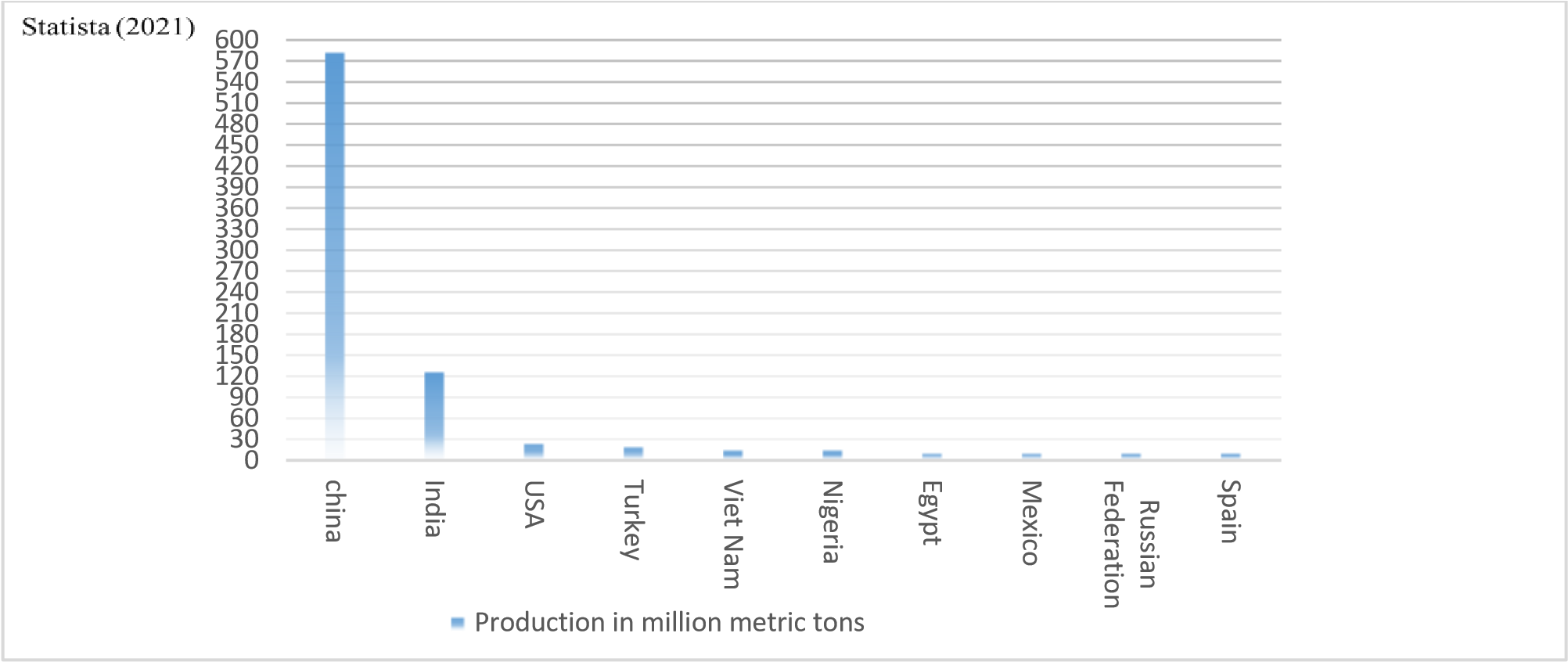
***Need for protected cultivation*** (Wani *et al.,* 2017)

India is second largest after China in vegetable production of 113.5 million tons. By the end of 2020, however, it is predicted that the annual demand for vegetables will be at 135 million tons. Low production and productivity of vegetable has been attributed to the extremes of temperatures ranging from 0 to 48 ͦC during the year. There is reduction in the consumption by 40-50% and use of water is optimized and reduces diseases, pests and viruses due to biotic stress during rainy and post rainy season and therefore 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:***

* A frame made of UV-stabilized transparent polyethylene with a 200 micron thickness.
* It creates greenhouse effect, making microclimate favourable for plant growth and development.

***Shade net house****:*

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

***Insect proof net house:***

* It is covered with 40-50 mesh UV stabilized insect proof net.
* Used for effective control of pests and diseases.

***Shadow hall:***

* A framed structure made of GI pipes.
* Covered with different shades of nets.
* This structure protects crop from devastating rains.

***Plastic low tunnels:***

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

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

***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, modified shade net house with 75% shade and 200 micron UV stabilizes film and shade net house with 75% shade)

Winter vegetables: Tomato, Capsicum, Cucumber and Cabbage

The minimum and maximum temperature and relative humidity ranges from 9.6 ͦC to 27 ͦC and

27.2 ͦC to 41.8 ͦC and 19 to 78% and 79 to 99 % in Kharagpur

*****Methodology***

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

WR = ET0× Kc ×Wp × 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)

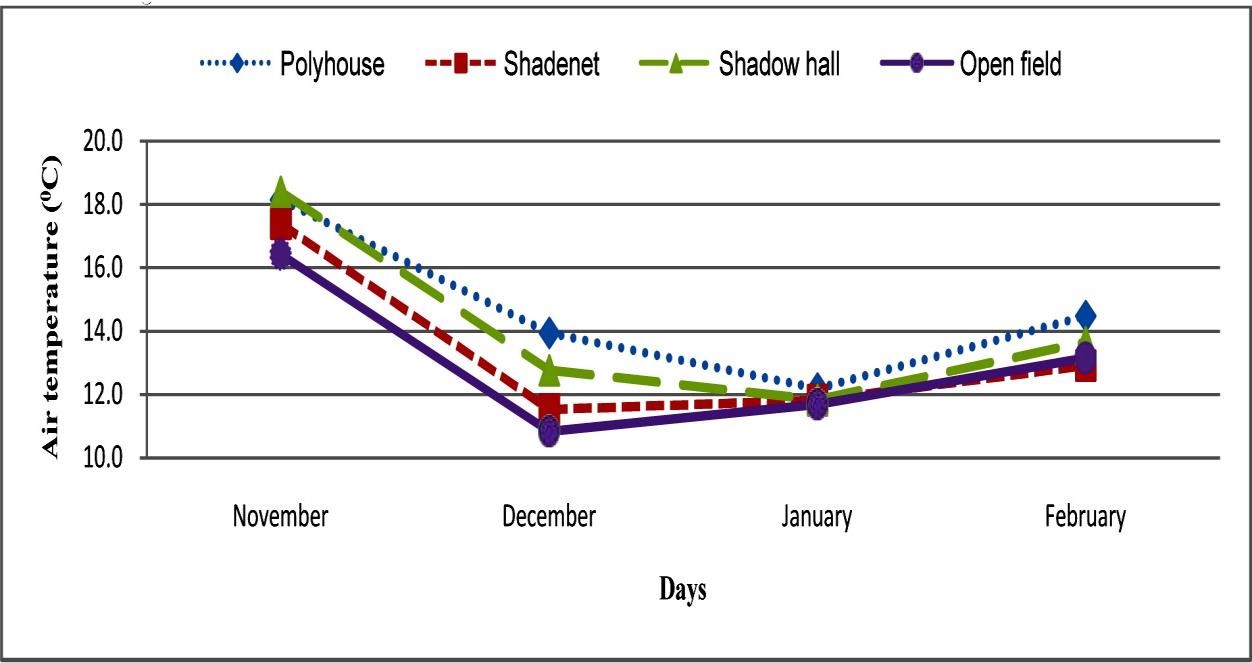
A = Plant area, m2 (i.e. spacing between rows (m) × spacing between Plants (m))

During the year 2014-2015, daily meteorological data were recorded, used to compute reference evapotranspiration (ETO).

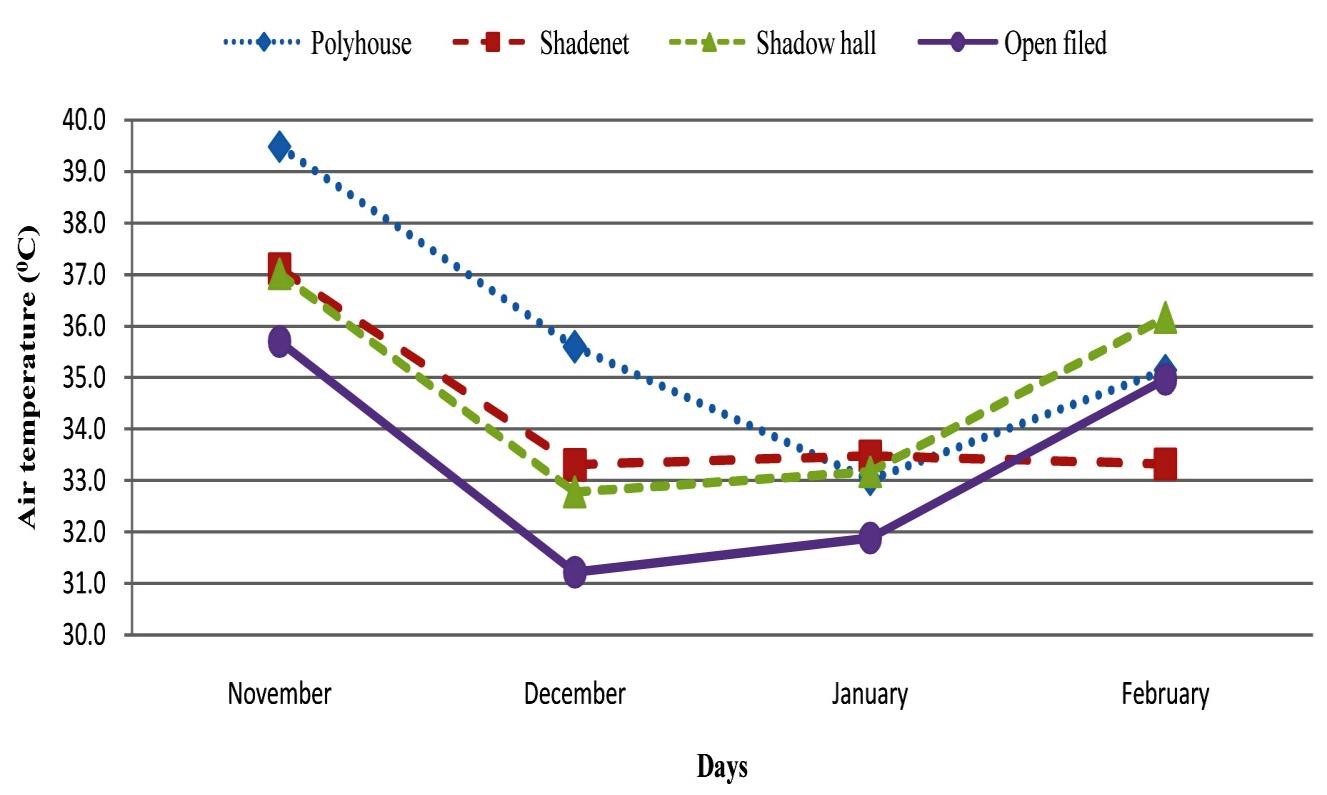
***Results****:*

Crop coefficients (Kc) and plant area (m2) of different vegetables

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No | Crop | Kc initial | Kc middle | Kc end | Plant Area, m2 |
| 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 |

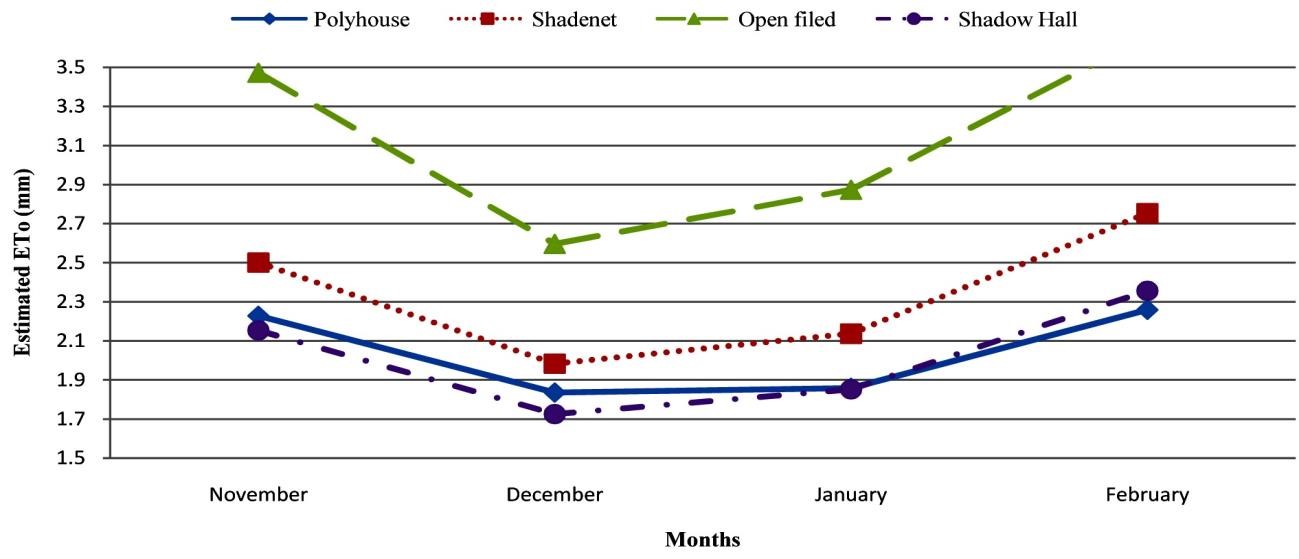
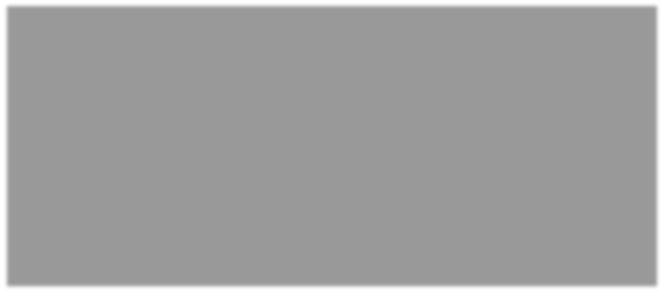


*Monthly average minimum temperature recorded in different protected cultivation structures*



*Monthly average maximum temperature recorded in different protected cultivation structures*

*Monthly average 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** |

1. ***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** |

1. ***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** |

1. ***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 (polyhouse, closed shade net, and sides opened shade net).

Crop: Seedlings of Capsicum (cv. Indira).

***Methodology****:*

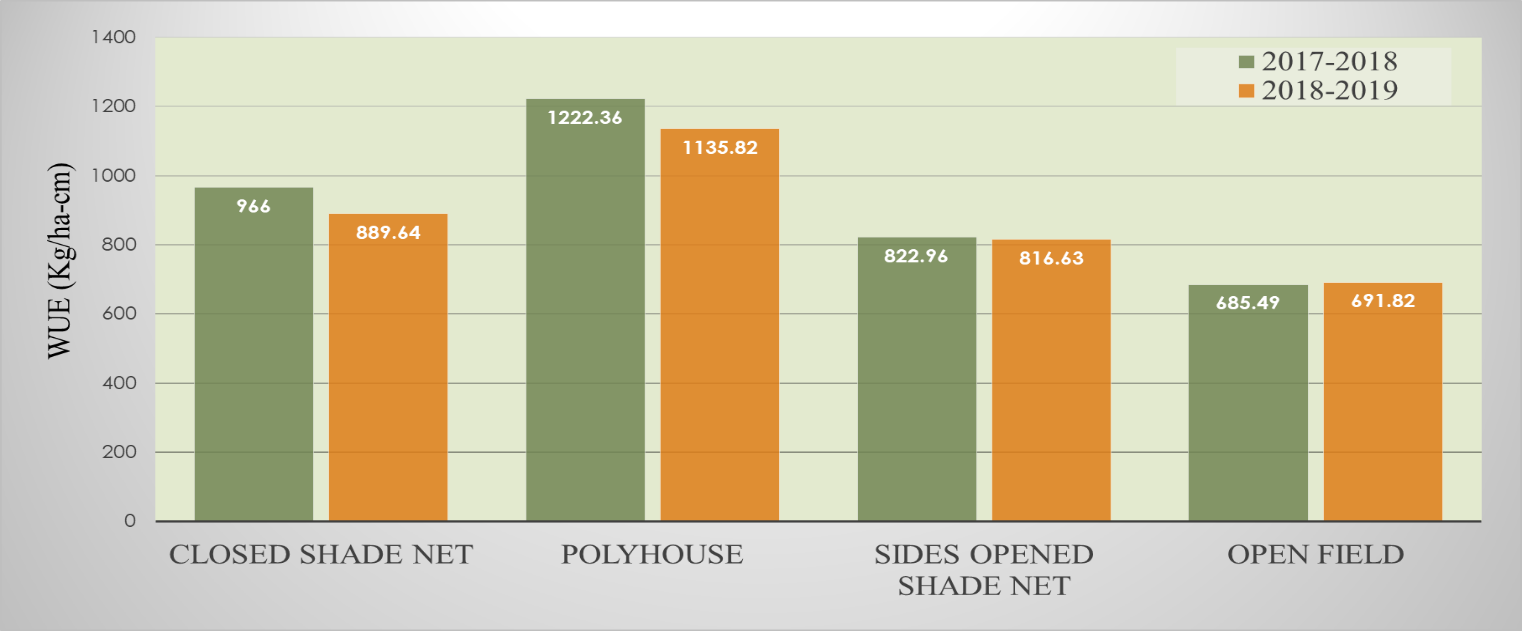
* Experiment consisted of four treatments comprising of polyhouse, closed shade net, sides opened shade net and open field condition.
* Raised beds of 18m length and 1m width were prepared in open field with a gap of 50 cm between two beds in all the structures.
* Seedlings were selected and they were transplanted in the raised beds at a spacing of 45 cm between plants and 60 cm between rows and 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:***

* ET0 estimated outside the protective covering structures show lower values than those for ET0 values estimated inside.
* Due to increased temperature in protected cultivation structures, ET0 also varies according to temperature and radiation.
* In open field condition winter vegetable 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 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 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, yield/plant (kg) and yield/m2 (kg/m2) in polyhouse increased by 153.33 % and 107.93 %, respectively, over open field condition.
* During 2018-19, the yield per plant (kg) and yield/m2 (kg/m2) in polyhouse increased by 155.74 % and 87.82 % respectively, over open field condition.
* Water use efficiency (1222.36 kg/ha cm and 1135.82 kg/ha cm, respectively) was high during 2017-2018 and 2018-19 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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