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Research Article

ESTIMATION OF WATER REQUIREMENT OF CAPSICUM CROP GROWN UNDER SHADE NET HOUSE AND INSECT NET HOUSE

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Abstract: Crop water requirement is the amount of water used by a crop for growth and development. Crop water use can be determined on a daily, weekly or growing season basis. The objective of this study was to determine the crop water requirement, to develop irrigation schedule for capsicum (*Capsicum annuum* L.) under shade net house and insect net house and to find out best suitable protected structure type by comparing both of these structures on the basis of water saving and yield obtained. The field study was conducted at plasticulture farm of Soil and Water Engineering, C.T.A.E., Udaipur. The duration of crop was 168 days from January to July. Both of these structures were of same size 64 m2 (16×4 mm) area. Shade net house was fully covered with 75% shade net, and insect net hose is fully covered with 40 mesh insect net. All the treatment including irrigation kept identical for both the structures during the crop period. Amount of irrigation was supplied based on the estimation by FAO 56 method using last 5 year *i.e.*, 2008 to 2012, climatic data, collected from metrological observatory CTAE Udaipur. It was found 800.84 mm or 51254.31 L during entire crop period. Gravity fed drip irrigation method was adopted to minimize the overall cost of the technology. A 1000 L tank was kept at a height on 1.5 m bamboo stand for getting required pressure and uniformity of irrigation. For the convenience of measurement, total irrigation was done in 51 instalments *i.e.* 1000 L each time. Crop evapotranspiration was determined by soil moisture balance method. It was estimated as 527.04 mm in shade net house and 638.81 mm in insect net house. The crop water requirement for outside condition was calculated by FAO 56 method. On the basis of estimated water requirements inside both structures, an irrigation schedule is suggested for each structure and outside condition. It was found that shade net house minimized crop evapotranspiration by 33.43 % as compared to outside crop evapotranspiration.

Keywords: Capsicum, Reference Evapotranspiration, Crop Evapotranspiration, Shade Net House, Insect Net House, Irrigation Schedule

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Introduction

The increasing global demand for food and other agricultural products calls for urgent measures to increase crop production per unit land used and per unit of water applied. Concerning this problem protected cultivation is scientific invention through which protected cultivation can be multiplied many times per unit land and per unit water. Capsicum cv. 'Indira' botanically known as Capsicum annuum placed in Solanceae family and classified as fruit vegetable crop. It is 6-10 months crop. One can take the production advisable to do the greenhouse farming. With the development of protected cultivation, more and more pepper is grown in greenhouse to pursue the maximum economic profits. However, its cultivation is confined to warm and semi-arid countries where water is often a limiting factor for production [2].

Materials and Methods

The experiment was carried out to study at plasticulture farm CTAE Udaipur. In this study the capsicum has been grown under two small size protected structures that is shade net house and insect net house at plasticulture farm CTAE Udaipur. The spacing followed was 50 x 30 cm. Experiment has been laid out in two small size structure of 16 x 4 m size each. Both of these structures comprised of 400 plants of capsicum in four beds of 100 each. Irrigation was given through gravity fed drip irrigation system of 4 laterals in both of these structures. The crop was taken during 29 January 2013 to 15 July 2013.

Experimental Site

The experiment was carried out during the year 2013 at the Plasticulture Farm of College of Technology and Engineering, MPUAT Udaipur (Rajasthan). Udaipur is situated in the southern region of Rajasthan and is close to Gujarat at Longitude 73.44° E and Latitude 24.35° N at an Altitude of 582.17 meters above the mean sea level.

Growth stages

Four growth stages were considered. They were the initial stage, developmental stage, mid-season stage, and late season stage. The initial stage excluding seedlings at the nursery lasted for 21 days (January 29 – February 18, 2013). The developmental growth stage lasted for 49 days (February 19, 2013 - April 7, 2013). The mid-season growth stage (flowering and fruiting) stage lasted for 70 days (April 8 – June 18, 2010) and the late season stage lasted for 28 days (June 19 - July 15, 2013). The entire crop period was of 168 days. This stage was later characterized by senescence and drying of leaves after the harvesting was over.
Irrigation Scheduling based on Climatic Parameter of Different Structure

Measurement of soil moisture

The available soil moisture content at which irrigation should be applied is a good criterion as it indicates moisture status of the soil and its availability to plants. Many research workers studied these criteria and for capsicum it has been suggested to apply irrigation when 40 percent available soil moisture (ASM) is depleted (*i.e.* when ASM is 60 percent).

The amount of water that is held by a certain mass of soil was calculated on weight basis and can be expressed as –

$$Soil\ moisture\ content\ \%\ by\ weight = \frac{(Weight\ of\ moist\ sample) - (Weight\ of\ dry\ sample)}{(Weight\ of\ dry\ sample)} \times 100$$

The soil samples at different depths have been taken with the help of soil auger and the average soil moisture will be determined by gravimetric method regularly throughout the growing period of capsicum for each structure having the irrigation schedule as per soil moisture depletion. From the point of view of irrigation the root zone depth considered at different stages are required. The soil moisture has been recorded as determined by the gravimetric method. When the soil moisture content depleted by 1000 L; irrigation have been bringing it to back up to field capacity.

$$ASM\ Content = \frac{(Field\ Capacity - Permanent\ wilting\ point)\ \times BD\ \times RD}{100}$$

It was concerned that a common irrigation applied to all the climate controlled structures. The soil moisture depletion method is usually employed to determine the consumptive use of irrigated field crops. This study involves measurement of soil moisture from various depths at a number of times throughout the growth period. Consumptive use (Cu/ET) is calculated from the change in soil water content in successive samples from the following relationship:

$$\mathbf{u} = \sum_{i=1}^{n} \frac{M_{1i} - M_{2i}}{100} . A_i . D_i$$

Where,

u = water use from the root zone for successive sampling period or within one irrigation cycle (mm)

n = number of soil layer sampled in the root zone depth D.

M_{1i} = soil moisture percentage at the time of the first sampling in the i^{th} layer.

M_{2i} = soil moisture percentage at the time of the second sampling in the i^{th} layer.

A_i = apparent specific gravity of the i^{th} layer of the soil.

D_i = depth of i^{th} layer of the soil (mm).

Seasonal consumptive use (Cu=∑u) is calculated by assuming consumptive use values of each sampling interval.

ASM = available moisture content, difference between field capacity and moisture percentage prior to irrigation.

RD = depth of the root zone in cm, at different stages.

The depth of irrigation will be converted in to volume of irrigation water applied per structure. The estimated volume of water has been applied to the structure with the help of calibrated tank.

Water Requirement

The water requirement of plants varies with time and depends on the season and growth of plants. It is essential to irrigate optimally during the stage of flowering to fruit maturity. Water requirement of the plant will be evaluated to design the system and for that the following equation will be used.

$$W_r = \frac{Crop\ Area\ \times ETc \times Kc \times Wa}{E_u}$$

Where,

W_r = peak water requirement, (L day^{-1}plant^{-1})

Crop area = row to row spacing (m) × plant to plant spacing (m) of the crop

Etc = crop evaporation rate, (mm day^{-1})

K_c = crop coefficient

W_a = wetted area, (%)

E_u = emission uniformity of drip system, decimal

Irrigation Scheduling

Irrigation scheduling is the application of water to crops in the proper amount and at the proper time, resulting in maximum crop yield and minimum leaching of water and nutrients to the groundwater. Irrigation scheduling can be accomplished using a water-balance accounting method, by monitoring soil moisture deficit.

The irrigation-decision support tool developed by the United Nations Food and Agriculture Organization (FAO) to estimate crop water requirements and to schedule irrigation has been used for deficit irrigation studies in Turkey, Morocco, and Pakistan [9]. It is a one-dimensional volume-balance water model [2], shown in [Fig-1], which solves the water balance equation:

$$\Delta Sm = R + I - Etc - D$$

Where

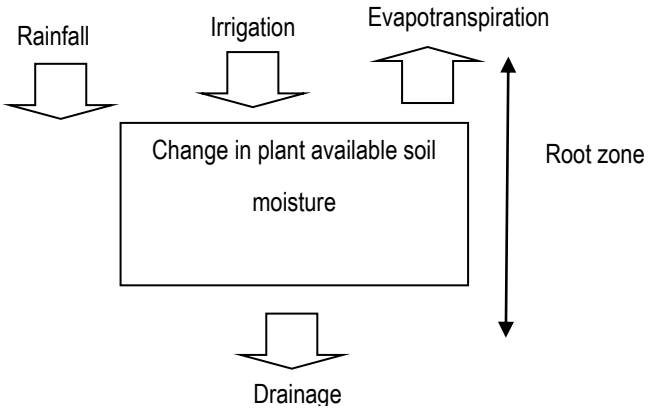
R = rainfall (mm)

I = irrigation (mm)

D = drainage (mm);

Etc = crop evapotranspiration (mm)

ΔSm = change in soil moisture (mm)



Model-1 Diagram of one-dimensional irrigation scheduling model

Result and Discussion

Determine Water Requirement and Decide Schedule before growing crop on the basis of last 5 years data 2008 to 2012

Irrigation scheduling has been decided before growing of the crop by using the last five year data *i.e.* 2008 to 2012 for the months January to July. The mean value of water requirement for the year 2008 to 20012 has been taken to decide the schedule for irrigation of the same crop. It has been found 51254.31 L. for the whole growing period. The available capacity supply tank is 1000 L. So, for the convenience of the supply of measured amount of water, it has been decided, after depletion of 1000 L of water in the root zone of the crop, the irrigation will be provided. According to this, scheduling of irrigation has been done that 1000 L of water will be supplied to the crop total 51 times during the crop period, 2 times in initial stage, 12 times in development stage, 30 times in mid-season and 7 times in late stage. The interval between the two consecutive irrigation has been found 10 days in initial stage, 4 days in development stage, 3 days in mid-season and 4 days in late stage under each structure. Water requirement is graphically represented in the [Fig-2].

Table-1 Total Water Requirement of capsicum crop under different structure and outside condition 2013

Treatment	Total Crop Water Requirement	
	L.	Mm
Shade net house	33731.57	527.04
Insect net house	40884.03	638.81
Outside	50671.24	791.73

Determine Water Requirement under shade net house, insect net house and outside and Decide Schedule for Irrigation

Water Requirement under shade net house, insect net house and outside condition for the crop period have been calculated according to the equation given in previous chapter *i.e.* material and method, by using the daily climatic data under each structure. The total water requirement for the entire cropping period was calculated as 33731.51 L, 40884.03 L and 50671.24 L for shade net house, insect net house and outside respectively. The total water requirement of capsicum crop under these structures and outside condition have been calculated and depicted in [Table-1].

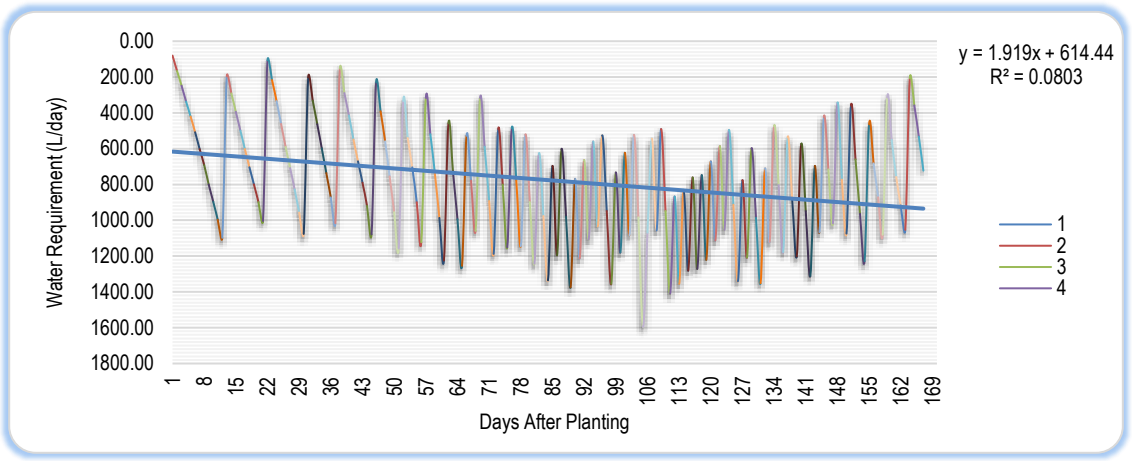


Fig-1 Mean water requirement for last five the year *i.e.* 2008-2012

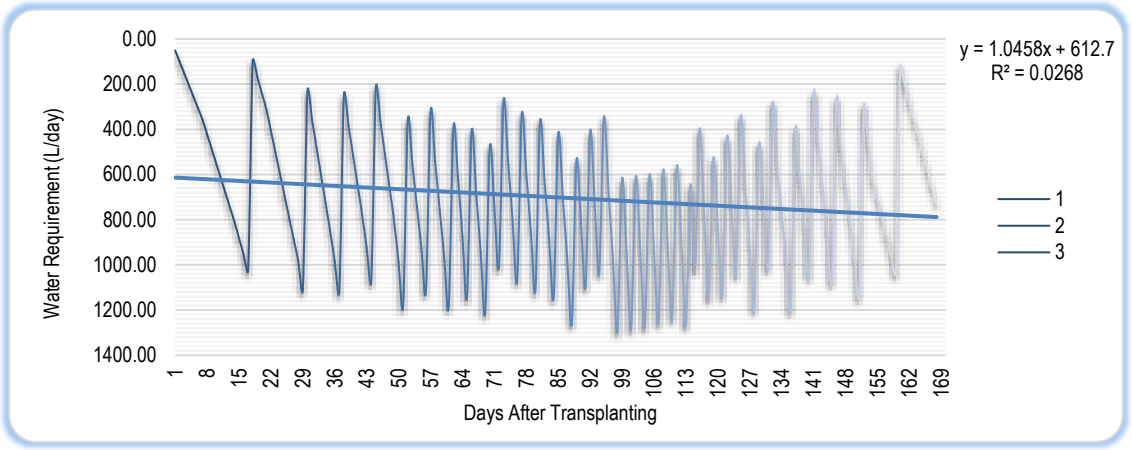


Fig-2 Water requirement under shade net house for 2013

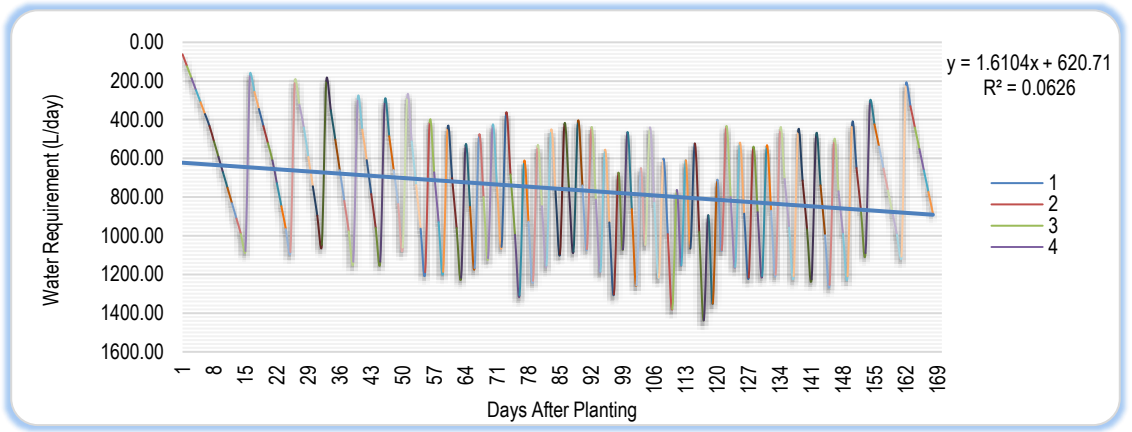


Fig-3 Water requirement under insect net house for 2013

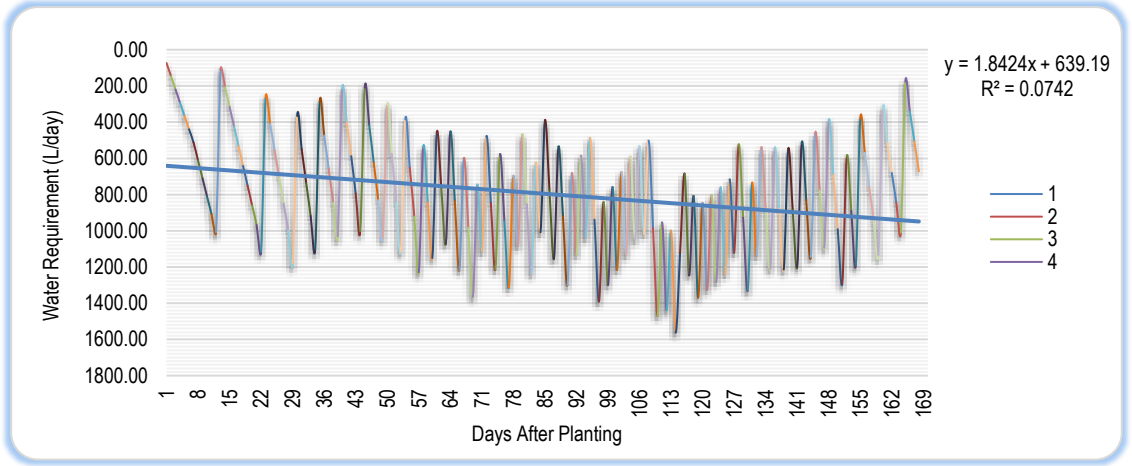


Fig-4 Water requirement of outside the structure

Table-2 Developed irrigation schedule under shade net house, insect net house and outside condition for 2013

Shade net house			
Name of Growth Stages	Length of Growing Period (days)	No. of Irrigation	Interval (days)
Initial	21	2	11
Development	49	7	7
Mid-season	70	21	3
Late	28	3	9
Total	168	33	
insect net house			
Growth Stages	Length of Growing Period (days)	No. of Irrigation	Interval (days)
Initial	21	2	10
Development	49	10	5
Mid-season	70	24	3
Late	28	4	7
Total	168	40	
Outside			
Growth Stages	Length of Growing Period (days)	No. of Irrigation	Interval (days)
Initial	21	3	7
Development	49	10	5
Mid-season	70	30	2
Late	28	7	4
Total	168	50	

From the [Table-1], it was found that the water saving under shade net house, insect net house was 33.43 % and 19.32%, respectively, compare to outside condition. The lesser water saving was observed under insect net house; on the other hand, relatively, higher water saving was found under shade net house. Irrigation scheduling has been decided after growing of the crop on the basis of different climatic condition under shade net house, insect net house and outside of the structure. It has been found that 1000 L of water should be supplied to the crop total 33 times under Shade net house, 40 times under insect net house and 50 times for open condition during the entire crop period. For Shade net house, it has been found that 1000 L of water will be supplied to the crop total 33 times during the crop period, 2 times in initial stage, 7 times in development stage, 21 times in mid-season and 3 times in late stage. The interval between the two consecutive irrigation has been found 11 days in initial stage, 7 days in development stage, 3 days in mid-season and 9 days in late stage. For insect net house, it has been found that 1000 L of water will be supplied to the crop total 40 times during the crop period, 2 times in initial stage, 10 times in development stage, 24 times in mid-season and 4 times in late stage. The interval between the two consecutive irrigation has been found 10 days in initial stage, 5 days in development stage, 3 days in mid-season and 7 days in late stage. The results are in line those with the findings of Sammis *et al*. (2012) [8], Madile *et al*. (2012) [7] and Kurubetta and Patil (2009) [6] And for outside of the structure, it has been found that 1000 L of water will be supplied to the crop total 50 times during the crop period, 3 times in initial stage, 10 times in development stage, 30 times in mid-season and 7 times in late stage. The interval between the two consecutive irrigation has been found 7 days in initial stage, 5 days in development stage, 2 days in mid-season and 4 days in late stage. This is depicted in [Table-2]. Water holding capacity and permissible depletion of moisture content of experimental field has been calculated as 7.83 cm and 3.92 respectively for 45 cm of root zone depth. It has been found that there will not be any adverse effect on crop growth and yield if the moisture content of root zone soil depleted up to 2505.6 L per structure. The given irrigation intervals between two consecutive irrigation are suggested to the farmer for shade net house, insect net house and outside condition by considering this permissible moisture depletion value *i.e*. 2505.6 L per structure (64 m^2). The water requirement under shade net house, insect net house and outside condition for the year 2013 has been graphically shown in [Fig-2], [Fig-3], and [Fig-4] respectively. The results were in conformity of Iwena (2002) [5] in capsicum, Huguez and Philippe (1998) [4] and Agodzo *et al*. (2003) [1].

Summary and Conclusion

The crop evapotranspiration was determined under both structures by gravimetric method. The crop evapotranspiration for outside condition was determined by FAO 56 method. It was found that the crop evapotranspiration was 1391.54 mm for outside condition and under the shade net house and insect net house it was like 926.34 mm and 1122.76 mm respectively. It has been concluded that shade net house minimize crop evapotranspiration and it is lower by 33.43 % than that of outside the structure. Similarly, the crop evapotranspiration is lower by 19.32 % in comparison to the outside *Etc*, for insect net house. The crop evapotranspiration was recorded higher in insect net house than in shade net house. Before, growing capsicum crop the water requirement for capsicum crop was calculated by FAO-56 method. The last 5 year *i.e*., 2008 to 2012, climatic data was used for calculation, collected from metrological observatory CTAE Udaipur. It was found 800.84 mm or 51254.31 L for both structures during entire crop period. Schedule to irrigate capsicum under each structure was done that 1000 L of water will be supplied to the crop total 51 times during the crop period, 2 times in initial stage, 12 times in development stage, 30 times in mid-season and 7 times in late stage. The interval between the two consecutive irrigation has been found 10 days in initial stage, 4 days in development stage, 3 days in mid-season and 4 days in late stage under both structures. The crop water requirements in both of these structures were determined by gravimetric method during the crop period. It was estimated 527.04 mm, 638.81 mm, 606.96 mm, and 545.65 mm under each structure. The crop water requirement for outside condition was calculated by FAO 56 method, it was 791.73 mm for entire crop duration. It was concluded that the water saving under shade net house and insect net house were 33.43 % and 19.32% respectively, compare to outside condition. The crop water requirement observed under shade net house (527.04 mm) was remarkably lesser than the water requirement found under insect net house (638.81 mm). On the basis of estimated water requirements for different structures, an irrigation schedule is suggested for each structure as 1000 L of water should be supplied to the crop total 33 times under shade net house, 40 times under insect net house and 50 times for open condition during the entire crop period. The irrigation interval between two consecutive irrigation at initial stage (21 days) has been suggested as 11 days for shade net house, 10 days for insect net house and 3 days for open condition. For development stage (49 days) it is suggested as 7 days for shade net house, 5 days for insect net house and 5 days for open condition. For mid-season stage it was suggested as 3 days for both of these structures and 2 days for open condition. For late stage it was suggested as 9 days for shade net house, 7 days for insect net house and 5 days for outside.

Application of research: Getting higher qualitative yield with optimum water.

Research Category: Water management and vegetable sciences

Abbreviations:

Cu-Consumptive use
ET- Evapotranspiration
ASM- Available Soil Moisture

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