Journal of Pharmacognosy and Phytochemistry 2020; 9(4): 692-696

Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 692-696
Received: 04-05-2020
Accepted: 06-06-2020

AP Sahu
Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

A Chopda
Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

B Panigrahi
Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

JB Mohapatra
Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

SC Senapati
Institute of Agricultural Sciences, SOA, Bhubaneswar, Odisha, India

Corresponding Author:
AP Sahu
Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Estimation of crop coefficient of green chilli grown under rooftop greenhouse

AP Sahu, A Chopda, B Panigrahi, JB Mohapatra and SC Senapati

Abstract
Rooftop cultivation along with greenhouse technology is now an attractive solution to overcome the problems of land shortage for agricultural production. Proper irrigation management and scheduling for crops grown on rooftops is only possible by knowing the crop coefficient (K_c) values of the crops which need to be estimated. An experiment was conducted at rooftop of the College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar to determine K_c values of green chilli crop for different crop stages. The values of K_c both inside and outside greenhouse were determined under four irrigation management levels i.e. with 10, 20, 30 and 40% of management allowable depletion (MAD) level. In addition, there was a control treatment to find out the values of K_c of green chilli. The findings of the study showed that the plant height and yield of green chilli inside the greenhouse was better as compared to the outside condition. The treatment with 10% MAD level performed best amongst all other treatments and gave maximum yield of 268.5 g/plant. The K_c values for green chilli inside the greenhouse for initial, development and mid-season stages are determined to be 0.33, 0.71 and 0.91, respectively whereas, for outside greenhouse scenario, these are 0.66, 0.92 and 1.12 for the three crop stages mentioned as above serially. These values of K_c can be used for estimation of crop water requirement and irrigation scheduling of green chilli to be grown under rooftop condition.

Keywords: Green chilli, crop coefficient, greenhouse, rooftop, MAD level

Introduction

The unabated rise in population and urbanization has compelled the farmers to produce more food with the progressively shrinking land in order to meet the demands of the nation. The unavailability of sufficient water is also a major issue in almost all parts of the world (Panigrahi *et al.*, 1992) [11]. Despite the fact that more than 80% of the world's fresh water resources are used for agriculture, the lack of water is still one of the most limiting factors to crop production worldwide (FAO, 2013) [6]. Developing countries such as India use 80 to 90% of water for agriculture, out of which 70% of water is wasted due to faulty irrigation practices. Further, global warming is also posing serious challenge as it increases the evapotranspiration and thus, increasing the water requirement of crops. The current situation paves way for rooftop cultivation along with greenhouse technology to combat the problem of land shortage in a greater degree. In an accessible rooftop garden, space becomes available for localized small-scale urban agriculture. At the same time, it has been proved that the green roofs help to mitigate the heat island effect and reduces the energy requirements of the buildings. Moreover, greenhouse farming is one of the present farming systems which significantly changes the radiation balance as compared to external conditions due to attenuation of incident solar radiation, thereby affecting evapotranspiration (Fernandes *et al.*, 2003) [7]. The main advantage of greenhouse farming is the round-year production, which is not possible in the open field farming due to heavy rainfall, wind and natural calamities, especially in tropical regions (Von Zabeltitz, 1999) [15].

Water is required for the absorption of plant nutrients, dissipation of heat and translocation of photosynthesis. With the great expansion of greenhouse cultivation, the need of proper irrigation management is also essential. Soil water is depleted due to evaporation from soil, transpiration from plant body and deep percolation into the soil beyond the root zone. Accurate estimations on the crop water requirement (ET_c) is needed to avoid the excess or deficit water application, with consequent impacts on nutrient availability for plants, soil salinity and groundwater contamination (Blanco and Folegatti, 2004) [3]. This can be done by using appropriate method to determine the K_c values for estimating ET_c. The K_c value integrates the effect of characteristics that distinguish a typical field crop from the grass reference and there can be several values used for a single crop throughout an irrigation season depending on the stage of crop development. In general context of limited water resources, scheduling of irrigation is an important issue for crop management. A correct determination of irrigation scheduling is one of the main factors in achieving high yields and avoiding loss of quality in greenhouse (Yuan *et al.*, 2001) [16]. In many places, availability of information on K_c values of different crops poses serious problems in irrigation scheduling. Hence, it is recommended to find out the K_c values of crops on site specific basis. Doorenbos and Pruitt (1977) [5] have also recommended using regionally estimated values of K_c of different crops for irrigation scheduling. Panigrahi (2008) [12] has determined K_c values of potato on daily basis in sandy loam soil of Western Central Table Land Zone of Odisha, India. A model was developed by him to predict the K_c values on daily basis.

Green chilli is the world's third most important vegetable after potatoes and tomatoes in terms of production, which is 34.5 MT. As of 2016, India is not only the largest producer but also the largest consumer and exporter of green chilli in the world as it contributes about 36% of the total world production. Green chillies are grown in almost all the states of the country with Andhra Pradesh being the largest producer. Odisha covers around 11% of the total area under green chilli cultivation and is the fourth largest producing state of the country (DMI, 2009) [4]. Besides other crops, green chilli (hot pepper) is a popular and demand crop, especially in urban areas and it is generally grown under rooftop gardens. However, green chillies are susceptible to water shortages and due to lack of sufficient data on K_c values, proper irrigation scheduling of the crop is not possible under rooftop cultivation. Miranda *et al.* (2006) [9] determined the ET_c and K_c values for tabasco pepper using the weighing lysimeter in the northeast region of Brazil. In the past, many researchers also studied the effect of various levels of deficit irrigation on the growth of green chilli around the world (Gonzalez-Dugo *et al.*, 2007; Owusu-Sekyere *et al.*, 2010; Akinbile and Yusoff, 2011; Amoah *et al.*, 2013) [8, 10, 1]. Considering the above point, the present study has been undertaken to develop K_c values for green chilli crop under various irrigation practices for both inside and outside the rooftop greenhouse.

Materials and Method

Experimental Site

The experiment was conducted on the rooftop of College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, Odisha. The site is located at 20° 15" N latitude and 85° 52" E longitude and has an elevation of 25.9 m above mean sea level. The location is at about 64 km away from the west of the Bay of Bengal. Elevation difference from the ground surface to the roof top of the college building is 11.3 m. The time period for the study was from December 2014 to March 2015. Bhubaneswar has a tropical climate with an average relative humidity of 84%. The average annual rainfall is about 1451 mm, out of which 80% occurs during the four monsoon months of June to September. The mean temperature varies from 11-14 ºC during winter to 38-40 ºC during summer. The average wind velocity is around 6.5 m/s measured at 2m above the ground level. The green chilli was grown in pots for both inside rooftop greenhouse and outside the rooftop greenhouse to determine the crop coefficients for different stages of the crop under the following treatments.

Treatment Details

Green chilli was grown under four treatments of deficit irrigation practices of 10, 20, 30, 40% of MAD level and one control treatment without any moisture stress for both inside and outside the greenhouse. Each treatment was replicated three times both at inside and outside the rooftop greenhouse house. The treatment details are as follows;

T1: 10% MAD level
T2: 20% MAD level
T3: 30% MAD level
T4: 40% MAD level
T5: Control (farmer's practice)

Greenhouse Specifications

The rooftop greenhouse was constructed on the rooftop of the college building. The orientation of the rooftop greenhouse was in the east-west direction and one exhaust fan was fitted in the east direction of greenhouse. The length, width and height of the greenhouse were kept 4 m, 3 m and 1.5 m, respectively. G.I pipes were used for the stand and arch of the green house and UV film (200 micron) was used as cladding material.

Soil

Before conducting the experiment, soil samples were collected from 0 to 15 cm depth and the Bouyoucos Hydrometer method was employed to analyse its texture. The physical properties (soil texture, bulk density, field capacity and permanent wilting point) and chemical properties (pH, organic carbon, available nitrogen, available phosphorous and available potassium) of the soil were also analysed and is shown in Table 1. The soil used for the present study was found to be loamy sand in texture.

Table 1: Physical and chemical properties of the soil

Soil Parameters	Value
pH	4.66
Organic Carbon (%)	0.48
Available Nitrogen ($kgha^{-1}$)	180.5
Available Phosphorus ($kgha^{-1}$)	47.8
Available Potassium ($kgha^{-1}$)	41.66
1. Soil Texture (Sand: 69.5%, Silt: 20.0%, Clay: 10.5%)	Sandy loam
2. Bulk Density (g/cc)	1.50
3. Field Capacity (% v/v)	18.9
4. Permanent Wilting Point (% v/v)	9.03

Experimental Procedure

For the set-up, 30 uniformly-sized burnt clay pots were used, out of which 15 pots were kept inside the greenhouse and the remaining 15 were kept outside the greenhouse. The diameter and height of each pot was 27 cm and 30 cm, respectively. Soil along with FYM, in the ratio 2:1, was filled with sandy loam soil up to 20 cm leaving 5 cm above the soil surface. The volume of soil in each pot stood at 68671.80 cm^3. Green chilli variety Utkal Ava (*Capsicum annum* L.) was selected for this study. The green chilli seedlings of 25 days old were taken from the nursery of OUAT and planted on 1st December, 2014. Total 30 number of seedlings were transplanted in 30 pots, i.e., one seedling per each pot. These pots were subjected to five treatments with three replications. The total fertilizer requirements of each pot were 1.5 gm of Nitrogen, 1 gm of Phosphorus and 1.2 gm of Potash which were given in form of urea, SSP and MOP. Further, manual weeding practices and plant protection measures were also carried out at specific intervals following the standard agricultural practices during the growing period of green chilli.

Determination of Crop Coefficient (K_c) Values

Based on measured values of temperature, relative humidity, sunshine hours and wind velocity, reference evapotranspiration (ET_0) was determined by following Modified Blaney-Criddle formula (Panigrahi, 2013) [13]:

$$ET_0 = C[p(0.46T + 8)] \quad (1)$$

Where, ET_0 = reference evapotranspiration for the month considered (mm/day); T = mean daily temperature over the month considered (ºC); P = mean daily percentage of total annual daytime hours for given month and latitude; and C = adjustment factor which depends on minimum relative humidity, sunshine hours and daytime wind estimates.

Temperature and relative humidity were measured using digital thermometer cum hygrometer. Similarly, wind velocity was measured daily by digital anemometer. Daily ET_0 was calculated by using nomograph graphs. These graphs were used to estimate ET_0 using the calculated values of [p(0.46T+8)] in the Eqn. 1, and knowing the levels of minimum humidity, actual to maximum possible sunshine hours and daytime wind conditions at 2 m height. The crop stage-wise ET_0 was determined by averaging the daily evapotranspiration values for both inside and outside condition.

Considering each pot as a lysimeter, crop evapotranspiration (ET_c) was determined (for both inside and outside condition) using digital weighing balance. The difference in the weight of pot is the amount of water evaporated and transpired from the pot in one day i.e. the crop evapotranspiration in mm/day. The crop coefficient (K_c) of green chilli at different stages of growth was determined using the following formula (Panigrahi, 2011) [14]:

$$K_C = \frac{ET_C}{ET_0} \quad (2)$$

Where, K_c= crop coefficient; ET_C = crop evapotranspiration (mm/day); and ET_0 =reference evapotranspiration (mm/day).

Stage-wise K_c value was determined by averaging the daily K_c values for each stage. Irrigation was applied to each pot when the moisture content maintained on the basis of different MAD levels lowers from the predetermined values, which was being recorded by a digital moisture meter. Plant height and yield was observed for each treatment and the treatment corresponding to maximum yield of green chilli was selected for screening of crop coefficient for the three stages of growth i.e. initial stage, crop development stage and mid-season stage.

Results and Discussion

Variation of Plant Height and Yield

The height of green chilli crop was measured in every around 30 days interval for both inside and outside the greenhouse condition. The plant heights under different treatments for both scenarios have been shown in Table 2. It is quite clear that the plant height of green chilli of 30 days after transplanting (DAT) in the open condition varies from 9.6 cm to 12.0 cm. The treatment T_1 showed the maximum plant height of 12.0 cm followed by T_2 (11.50 cm), T_3 (10.73 cm), T_5 (10.45 cm) and T_4 (9.60 cm).Similarly, the plant height observed after 60 days of transplanting for T_1, T_2, T_3, T_4 and T_5 treatments are 26.90, 24.30, 22.60, 20.80 and 22.40 cm, respectively. After 88 days of transplanting, the plant heights vary from a minimum value of 35.2 cm in T_4 to a maximum value of 47 cm in T_1.

Table 2: Measured plant height inside and outside the greenhouse

Treatments	Plant height in cm					
	Inside Greenhouse			Outside Greenhouse		
	30 DAT	60 DAT	88 DAT	30 DAT	60 DAT	88 DAT
T_1	14.10	35.00	59.00	12.00	26.90	47.00
T_2	13.70	32.20	54.30	11.50	24.30	43.50
T_3	13.40	31.20	46.30	10.73	22.00	42.00
T_4	12.80	27.20	39.00	9.60	20.80	35.20
T_5	13.30	28.80	43.40	10.45	22.40	41.32

Similarly, the green chilli height inside the greenhouse is observed to be the highest for T_1 treatment as compared to all other treatments. The maximum average plant height recorded for the treatment T_1 are14.10 cm (30 DAT), 35 cm (60 DAT) and 59 cm (88 DAT), respectively. The minimum plant heights are recorded in case of T_4 treatment which are 12.80, 27.20 and 39 cm for 30 DAP, 60 DAP and 88 DAT, respectively. Comparing the green chilli plant height for inside and outside greenhouse conditions, it was found that the plant heights are higher for inside scenario than for outside under all treatments. This is because plants inside the greenhouse utilized water more effectively than the outside condition. After 88 DAT, the green chilli plant height inside the greenhouse is 12 cm more than for outside condition in case of T_1 treatment.

The average yield per plant for both inside and outside the greenhouse has been presented in Fig. 1. It is evident that the green chilli yield inside the greenhouse for different treatments i.e. T_1, T_2, T_3, T_4 and $T_5$are observed to be 268.50, 230.36, 198.60, 170 and 188.30 grams per plant, respectively. Maximum yield of 268.5 grams per plant is recorded for treatment T_1 followed by treatment T_2, T_3, T_5 and T_4 (170 grams per plant) treatments. Similarly, the yield for outside conditions is found to be highest for the treatment T_1 at 196.68 grams per plant. The yield for treatment T_2, T_3 and T_5 are 175.15, 155.80 and 148.75 grams per plant, respectively. The lowest yield is observed for the treatment T_4 with yield of 136.20 grams per plant.

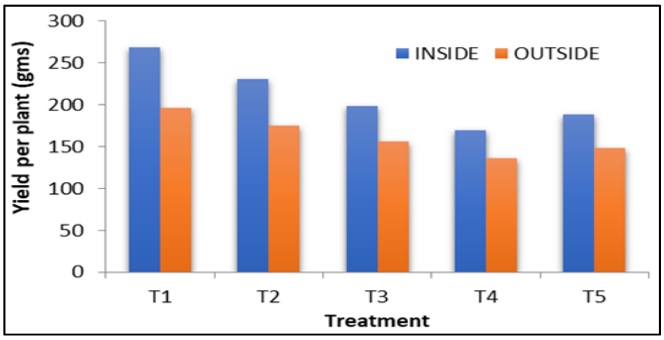

Fig 1: Comparison of yield of green chilli inside and outside the greenhouse

In spite of consuming lesser amount of water, the yield was higher inside the greenhouse as compared to outside condition, which may be due to the fact that the plants utilized water more effectively inside the greenhouse. Owing to the climatic parameters like wind velocity, solar radiation, etc., evaporation was dominant than the transpiration in outside condition which resulted in increased evapotranspiration outside the greenhouse.

Crop Coefficient (K_c) Values

The values of K_c of each treatment during three crop stages (initial, development and mid-season) both inside and outside the greenhouse are presented in Table 3. The values of the crop coefficient inside the greenhouse varies from 0.33 to 0.91 for treatment T_1, 0.29 to 0.80 for treatment T_2, 0.26 to 0.68 for treatment T_3, 0.20 to 0.55 for treatment T_4 and 0.34 to 0.63 for treatment T_5. Similarly, the crop coefficients outside the greenhouse ranges from 0.66 to 1.12 for treatment T_1, 0.46 to 1.04 for treatment T_2, 0.35 to 0.93 for treatment T_3, 0.25 to 0.88 for treatment T_4 and 0.32 to 0.90 for treatment T_5. The crop coefficient values for treatment T_1ismoreas compared to the other treatments for each scenario. This is because of the sufficient water which was available in soil was used for evapotranspiration process which resulted in higher crop evapotranspiration.

Table 3: Crop coefficient for green chilli inside and outside the greenhouse

Crop Stages	Inside Greenhouse					Outside Greenhouse				
	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5
Initial	0.33	0.29	0.26	0.20	0.34	0.66	0.46	0.35	0.25	0.32
Development	0.71	0.60	0.55	0.47	0.52	0.92	0.76	0.69	0.62	0.65
Mid-Season	0.91	0.80	0.68	0.55	0.63	1.12	1.04	0.93	0.88	0.90

Comparison of K_c Inside and Outside the Greenhouse

The comparison has been done among the K_c values under all treatments for inside and outside the greenhouse conditions (Fig.2). For treatment T_1, the crop coefficient for initial, development, and mid-season stages outside the greenhouse are 100%, 29.58% and 23.08% more than the crop coefficients inside the greenhouse, respectively. Similarly, the crop coefficients during the three stages for outside scenario are observed to be 58.62%, 26.67% and 30% higher than the inside scenario in case of the treatment T_2. Similar results are observed in case of the treatment T_3 as the crop coefficients during the crop stages for the outside condition are found to be 0.35, 0.69 and 0.93 whereas, the same for the inside condition are observed to be 0.26, 0.55 and 0.68. For treatment T_4, the crop coefficients for outside scenario are seen to be 25%, 31.91% and 60% higher than for inside scenario during initial, development and mid-season stages, respectively. For treatment T_5, the crop coefficient outside the greenhouse is found to be 25% higher than the outside situation during development stage and 42.86% higher than the outside situation during mid-season stage. However, during the initial crop stage, the crop coefficient inside the greenhouse is 6.25% higher than the outside condition.

The results obtained in the study showed lower crop coefficient values during initial stage and higher crop coefficient values during mid-season stage. Apart from the initial stage results of T_5 treatment, the crop coefficients outside the greenhouse are found to be more than the crop coefficients inside the greenhouse. This is because of the increased amount of crop evapotranspiration outside the greenhouse (evaporation is dominant) as compared to the inside greenhouse condition.

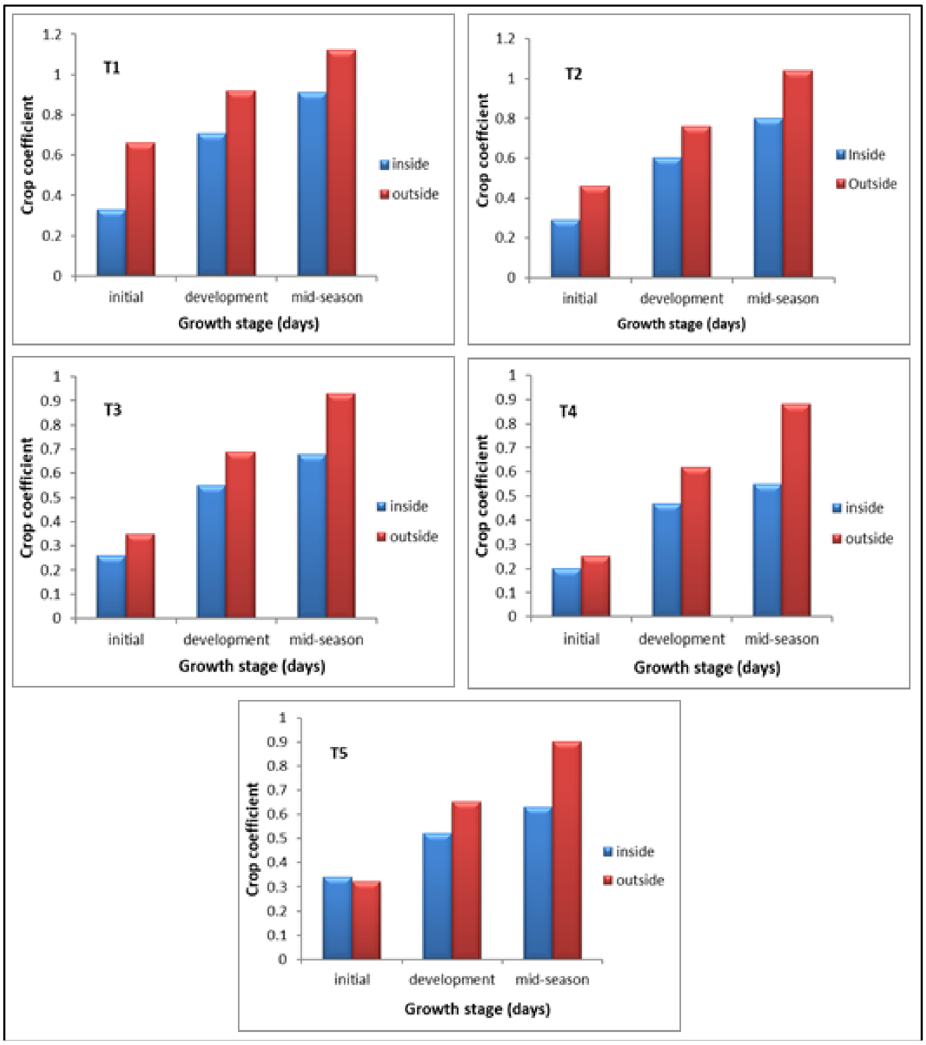

Fig 2: Comparison of crop coefficients of green chilli under inside and outside the greenhouse

Conclusions

The overall growth of green chilli in terms of plant height and fruit quality inside the greenhouse was better as compared to the outside rooftop condition. The plant height inside the greenhouse at harvest was 25.57% more for T_1treatment (10% MAD level), 24.80% more for T_2 treatment (20% MAD level), 10.30% more for T_3treatment (30% MAD level), 10.86% more for T_4 treatment (40% MAD level) and 5.03% more for control (T_5) treatment (farmers practice) than the outside greenhouse condition. Similarly, the T_1 treatment performed the best amongst all inside the greenhouse providing 36.51% more yield than the outside condition. The maximum yield is observed to be 268.50 grams per plant for 10% MAD level irrigation treatment and the minimum yield is observed for 40% MAD level treatment with 170 grams per plant. The screened crop coefficient for green chilli inside the greenhouse for initial, development and mid-season stages are 0.33, 0.71 and 0.91, respectively at 10% MAD level of deficit irrigation practice, whereas for outside greenhouse scenario, these are 0.66, 0.92 and 1.12 for the three crop stages, which can be used for crop water requirement estimation and irrigation scheduling of green chilli to be grown under similar climatic conditions of East and South East Coastal Plain zone of Odisha.

References

1. Akinbile OCR, Yusoff MS. Growth, yield and water use pattern of chilli pepper under different irrigation scheduling and management. Asian Journal of Agricultural Research. 2011; 5(2):154-163.
2. Amoah SKL, Darko OR, Sekyere JDO. Water requirement, deficit irrigation and crop coefficient of hot pepper (capsicum frutescens var legon18) using irrigation interval of two days. ARPN Journal of Agricultural and Biological Science. 2013; 8(2).
3. Blanco FF, Folegatti MV. Evaluation of evaporation-measuring equipments for estimating evapotranspiration within a greenhouse. Revista Brasileira de Engenharia Agricola e Ambiental. 2004; 8:184-188.
4. DMI. Post harvest profile of chilli. Directorate of Marketing & Inspection, Government of India, Nagpur, India, 2009.
5. Doorenbos J, Pruitt WO. Crop Water Requirements. FAO Irrigation and Drainage Paper 24, FAO, Rome, Italy, 1977.
6. FAO. Water development and management unit. Food and Agriculture Organization of the United Nations, Rome, Italy, 2013
7. Fernandes Carolina, Cora1 Eduardo Jose and Jairo Augusto Campos de Araujo. Reference evapotranspiration estimation inside greenhouses. Scientia Agricola. 2003; 60(3):591-594.
8. Gonzalez-Dugo V, Orgaz F, Fereres E. Responses of pepper to deficit irrigation for paprika production. Scientia Horticulturae. 2007; 114:77-82.
9. Miranda FR, Gondim RS, Costa CAG. Evapotranspiration and crop coefficients for Tabasco pepper (*Capsicum frutescens* L.). Agric. Water Management. 2006; 82:237-246.
10. Owusu-Sekyere JD, Asante P, Osei-Bonsu P. Water requirement, deficit irrigation and crop coefficient of hot pepper (*Capsicum frutescens*) using irrigation interval of four (4) days. ARPN J. Agric. Biol. Sci. 2010; 5:72-78.
11. Panigrahi B, Sharma SD, Behera BP. Irrigation water requirement models of some major crops. Water Resources Management. 1992; 6(1):69-77.
12. Panigrahi B. Development of crop coefficient model of potato under plant-furrow treatment. Indian Journal of Soil Conservation. 2008; 36(1):24-30.
13. Panigrahi B. A Handbook on Irrigation and Drainage. New India Publishing Agency, New Delhi, 2013, 601.
14. Panigrahi B. Irrigation Systems Engineering. New India Publishing Agency, New Delhi, 2011.
15. Von Zabeltitz. Greenhouse Structures, Ecosystems of the World’s 20 Greenhouses. Elsevier, Amsterdam, 1999.
16. Yuan B, Kang Y, Nishiyama S. Drip irrigation scheduling for tomatoes in unheated greenhouses. Irrig. Sci. 2001; 20:149-154.