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Climate Change impact on Water Requirement of Micro Irrigated Mango Orchard under Climatic Conditions of Udaipur, Rajasthan

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Abstract: A study was carried out to analyze the impact of climate change on crop water requirement (CWR) of mango for Udaipur district of Rajasthan during five years (2014 to 2018). There was significant impact of climate change on daily reference evapotranspiration (ETo), rainfall pattern, crop evapotranspiration (ETc) and CWR. The uneven trend of ETo and Rainfall was for different year. The average daily ETo were maximum for May while, minimum for December months. The ETc was maximum for August, 2015. In this study most of the time, ETc was recorded minimum for month of December. The average CWR for mango tree ranges from 23.3 to 94.7 litre/plant/day during all five years. The trend of ETo, rainfall and CWR of mango crop was found uneven, due to temporal variation in climatic condition of Udaipur region by improper use of natural resources, over industrialization and mining interventions, which results improper future planning for establishment of mango orchard. The result of this study are capable for policy makers and planners of water resources for future planning and helps to conserve water in satisfying crop water requirement of orchard crops.

Keywords: Climate change, Crop water requirement, Reference evapotranspiration, Crop coefficient and perennial crop

Climate change is likely to contribute substantially to food insecurity in the future, by increasing cost of food product and reducing crop yield. Climate changes have possible impactions on the water cycle, accessible fresh water resources and the water required for agriculture (Mansa and Anand 2016). Water required for crop production may become scarcer due to increased water requirement of crops and drought. Water is an important because it is needed for irrigation in agriculture sector. Drip irrigation and sprinkler irrigation are the different types of irrigation methods commonly adopted by the Indian farmers (Sharma and Yadav 2021) in order to mitigate the impact of climate change on water requirement of crop in agriculture sector. Adequate data on irrigation water requirements under drip irrigated orchard crops is not available in developing nations of the world. This is one of the reasons why for the failure of large scale irrigation projects in most developing countries of the world. Mango (*Mangifera indica* L.) belongs to the family Anacardiaceace, also called as the cashew family. It is a highly productive and popular tropical fruit crop which may have originated from India. Despite the Indian sub-continent it has spread to another part of world and is a very choicest fruits of India. The yield depends on the age and cultivar, but generally, about 500-1500 fruits per tree per year may be obtained at three to four years. Mango trees, considered medium-sized with comparatively high water requirements are usually irrigated by surface or drip irrigation methods and their water consumption varies based on many factors, including climate and soil. Crop water requirement may be define as the amount of water that is lost through evapotranspiration (Allen et al 1998). Reference evapotranspiration is the sum of two processes of evaporation from the soil and transpiration from the plants. The FAO-Penman Monteith a standard approach and provide consistent reference evapotranspiration (ET). Therefore a study was undertaken to estimate the crop water requirement of mango crops based on computed reference crop evapotranspiration using weather data of different year.

MATERIAL AND METHODS

Study area: A study on estimation of crop water requirement using CROPWAT model for mango crop under drip irrigation was carried out for Udaipur district of Rajasthan. The study area is located between 24°35'31.5" latitude 73°44'18.2" longitude and at an altitude of 582.17 m above mean sea level (MSL). Udaipur comes under dry, sub-humid agro-climatic region. The average annual rainfall of Udaipur is 637mm, most of the rain received during the period of July to Sep. The hottest month is s May and December is the coolest month. The daily meteorological data i.e. maximum temperature (Tmax, 0C) and minimum temperature (Tmin, 0C), maximum relative humidity (RHmax, %) and minimum

relative humidity (RHmin, %), pan evaporation (Epan, mm), wind speed (WS, $kmhr^{-1}$) at height of 2.0 m, sun shine hours (SSHr, hr), rainfall (R, mm) were collected from meteorological observatory of CTAE, Udaipur.

Estimation of reference evapotranspiration using CROPWA Tmodel: The model used to calculate the reference evapotranspiration, irrigation requirements and crop water requirements under various management conditions. The modified Penman- Monteith method suggested by Allen et al (1998) was used to compute reference evapotranspiration (ETO). The FAO Penman-Monteith method to estimate ETo is given below:

$$ET_0 = \frac{0.408\,\Delta(R_n - G) + \gamma \frac{900}{T - 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 u_2)}$$

Where, ET_O = reference evapotranspiration [mm/day], Rn= net radiation at the crop surface [MJ/ m^2 day], T= air temperature at 2 m height [°C], G= soil heat flux density [MJ/ m^2day], u2=wind speed at 2 m height [m s^{-1}], e_a= actual vapour pressure [kPa],

e_s= saturation vapour pressure [kPa], e_s - e_a=saturation vapour pressure deficit [kPa],

Y=psychrometric constant [kPa°C^{-1}], ∆=slope vapour pressure curve [kPa°C^{-1}],

Estimation of crop water requirement under drip irrigation: The crop water requirement (CWR) is basically the function of evapotranspiration rate, crop coefficient and area covered by plants. The reference evapotranspiration (ETo) for all months during five were derived from CROPWAT model. The water requirement or volume of water to be applied for mango orchard was calculated by the following equation.

CWR = ETo × A × Kc × Wp

Where,

CWR = Water requirement of crop, litre/day/plant,ETo = Reference evapotranspiration, mm/day

A = Area of the crop (m2) = row to row (m) × plant to plant spacing (m),Kc = Crop coefficient;

Wp = Percentage wetted area, decimal.

The crop coefficient (Kc) varies by month based on phonological stages of plant and percentage of the growth shaded by the tree canopy. In the present study the phonological stage wise values of crop coefficient for perennial fruit crops were taken as given by Kisekka et al (2010) (Table 1). In this study mango crop was selected as perennial crop with row to row (m) × plant to plant spacing (m) 8×8 meters and percentage wetted area under drip irrigation was consider as 40% of area of crop.

Irrigation scheduling for mango orchard: In this study an irrigation scheduling for mango orchard was developed for a standard size of drip system on the basis mean of average daily crop water requirement for different months.

Specification of drip irrigation system: In this study crop water requirement of mango tree was estimated in order to developing irrigation scheduling (including number of irrigation and operating time of standard size of drip system for mango orchard). The specifications of drip system are as follows: Size of mainline-63 mm, Size of sub mainline-32 mm, Size of lateral-16 mm, Dripper type-Online dripper

RESULTS AND DISCUSSION

The maximum annual ETo was for year 2015 (1410 mm/year) and maximum annual rainfall was for 2016 (747 mm/year) (Fig. 1). The minimum annual ETo and annual rainfall were years 2017 (1259, mm/year) and 2018 (556 mm/year) respectively. The uneven trend of ETo and rainfall was for different year due to change in climatic conditions with respect to time. There are various factors responsible for this and replacement of agricultural land by urban land can be a major factor, evapotranspiration of moisture from soil and vegetation are often diminished, leading to decreased atmospheric humidity and potentially suppressing precipitation. Jha et al(2021) has reported uneven trend of rainfall with respect to time.

Reference evapotranspiration by CROPWAT Model: The daily meteorological data during all months for five year were used to estimate the average daily reference evapotranspiration (mm/day) for Udaipur district of Rajasthan through CROPWAT model. The average daily reference evapotranspiration were maximum for May, minimum were for December during all five year (Fig. 2). The maximum temperature (Tmax, ^{0}C) and minimum temperature (Tmin, ^{0}C), pan evaporation (Epan, mm), wind speed (WS, $kmhr^{-1}$) at height of 2.0 m, sun shine hours (SSHr, hr), rainfall (R, mm) was also minimum in winter season which results lowest value of average daily reference

Table 1. Crop coefficient (Kc) for perennial mango crop

Month	January	February	March	April	May	June
Crop coefficient (Kc)	0.60	0.50	0.45	0.45	0.50	0.50
Month	July	August	September	October	November	December
Crop coefficient (Kc)	0.60	0.80	0.80	0.70	0.70	0.60

evapotranspiration. It is also indicates that, during winter season less amount of water was evaporated from soil surface and plant canopy. It is probably due to lower intensity of solar radiation as well as more relative humidity in atmospheric air.

The crop evapotranspiration was almost highest for August months during all years. During year 2014 to 2018 the maximum crop evapotranspiration was recorded for August 2015 with of 3.698 mm/day (Fig. 3). In this study most of the time crop evapotranspiration was recorded minimum for month of December. Similar results were reported by (Morgan et al 2017). It shows that peak crop evapotranspiration due to high atmospheric temperature.

Crop water requirement of mango orchard: The result shows that daily CWR ranges from 23.3 l/p/day to 94.7 l/p/day during year 2014 to 2018 (Table 2). The maximum CWR was in August and September followed by May and June during all years. The rainfall mainly occurs during August and September months in Udaipur region consequently the irrigation requirement for mango tree were less as compared to irrigation requirement during May and June. In Udaipur region during water scarcity condition which occurred mainly in May and June, at this time mango tree feel water stress so it is very essential to irrigate the mango orchard as per crop water requirement obtained from the study. Similar finding was reported by Yadav et al (2017). The average daily CWR was minimum under December and January for all five year. It is probably due to less atmospheric temperature in winter season. The average daily CWR for perennial mango tree normally varies from 29 to 83 litre/plant/day under different months in a year (Fig. 4). The mean value of CWR was maximum for September

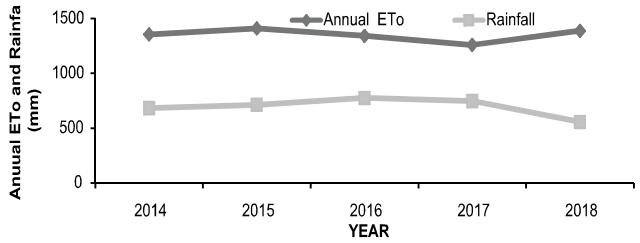

Fig. 1. Impact of climate change on Annual ETo and Annual Rainfall (mm/year) for 2014 to 2018 for Udaipur region

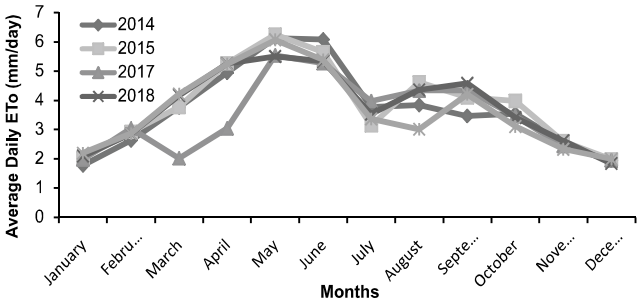

Fig. 2. Average daily reference evapotranspiration for different month during five year

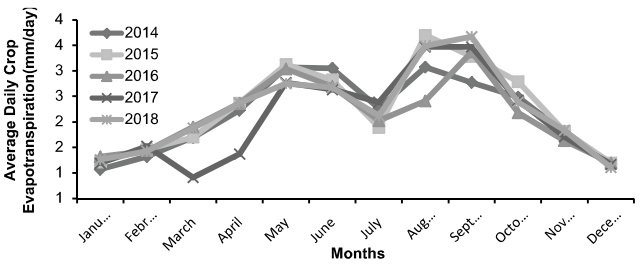

Fig. 3. Average daily crop evapotranspiration (ETc) for different month during five year

Table 2. Average daily crop water requirement (litre/plant/day) of mango orchard for different month

Months	Average daily crop water requirement (litre/plant/day)					
	2014	2015	2016	2017	2018	Mean
January	27.4	31.1	33.8	30.4	32.2	31.0
February	33.7	37.4	36.7	39.0	36.6	36.7
March	43.4	43.5	48.7	33.3	48.1	41.4
April	57.0	60.7	60.5	35.1	60.6	54.8
May	78.5	80.0	77.7	70.9	70.5	75.5
June	78.0	72.3	68.9	67.4	68.4	71.0
July	58.0	48.3	51.8	61.1	54.3	54.7
August	78.7	94.7	61.7	88.8	89.4	82.6
September	71.0	84.0	86.2	88.8	94.0	84.8
October	63.6	71.3	55.8	62.0	61.2	62.8
November	45.9	46.6	41.8	43.7	47.0	45.0
December	29.9	30.5	30.6	29.9	28.3	29.9

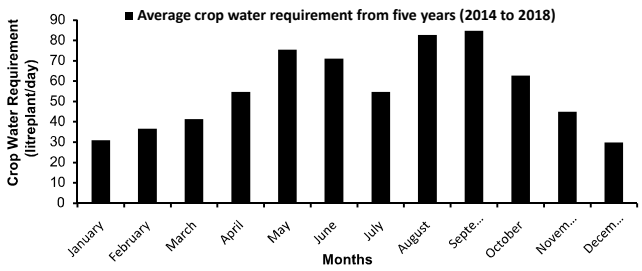

Fig. 4. Mean value of average daily crop water requirement (litre/plant/day) of mango orchard for different months

(84.8litre/plant/day) while, minimum CWR was for December (29.9 litre/plant/day).

CONCLUSIONS

The average daily reference evapotranspiration were maximum for May during all five year while, minimum average daily reference evapotranspiration were or December months during all five year. The average daily CWR ranges from 23.3 l/p/day to 94.7 l/p/day during 2014 to 2018. The maximum CWR was in August and September. In Udaipur region during water scarcity condition which occurred mainly May and June, it is very essential to irrigate the mango orchard as per crop water requirement. It has been concluded from the results and analysis that in future years crop water requirement will change unevenly in the study area. The reason for this may be due to uneven trend of maximum and minimum temperature and decrease in relative humidity in future years. The results of this study will be useful for policy makers and planners of water resources for the future planning and suggest water saving techniques to satisfy varying crop water requirement for orchard.

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