

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 4, April 2018

Study on Water Requirement of Selected Crops and Irrigation Scheduling Using CROPWAT 8.0

Mehanuddin H¹, Nikhitha G R², Prapthishree K S³, Praveen L B⁴, Manasa H G⁵,

U.G. Student, Department of Civil Engineering, STJIT Engineering College, Ranebennur, Karnataka, India^{1,2,3,4}

Assistant Professor, Department of Civil Engineering, STJIT Engineering College, Ranebennur, Karnataka, India⁵

ABSTRACT: A study was carried out to determine the crop water requirement of few selected crops for the commanded area in the Shimoga Taluk in Karnataka state, India. The crops include cotton, maize for two seasons and sugarcane. By using the 10-year climatic data, Crop evapotranspiration (ET_c) and Reference crop evapotranspiration (ET₀) for each crop were determined using CROPWAT 8.0. The study shows that for both cotton and maize crops in Rabi season effective rainfall is not sufficient to fulfil the crop water requirement. Hence irrigation requirement is needed to satisfy Crop water requirement. But for the same crops in Kharif season effective rainfall is enough to compensate crop water requirement. The crop sugarcane is a perennial crop for its crop period effective rainfall is sufficient to compensate the crop water requirement.

KEYWORDS: Crop water requirement; Crop evapotranspiration; Reference evapotranspiration; Effective rainfall. CROPWAT

I. INTRODUCTION

Water is the basic need for agricultural and the economic development of any country. There is a competition between municipal, industrial and agriculture users for the water available in reservoirs. Actual water shortages are observed in many countries particularly in India and there is no life without water. It is important that the water requirements of crops are known at different management levels within the irrigated area to accomplish effective irrigation management. More than 80% of water resources have been exploited for agricultural irrigation. To cope with the water –shortage, it is necessary to adopt water saving agriculture counter measures as efficient use of irrigation water is becoming increasingly important. The main objective of irrigation is to apply water to soil to meet crop evapotranspiration requirement when rainfall is insufficient to raise crop till harvesting. Irrigation includes application of the right quantity or amount of water at the right time to the soil for plant growth. Hence estimating irrigation water requirements is necessary for water project planning and management. So, the term crop water requirement means the total amount of water required by the crop and the way in which it requires water from the time of planted up to the time which is harvested. Therefore, the objective of this study was to determine crop water requirement of cotton, maize and sugarcane in both Rabi and Kharif season.

CROPWAT is one of the models extensively used in the field of water management throughout the world. CROPWAT facilitate the estimation of crop evapotranspiration, irrigation schedule and agricultural water requirements with different cropping patterns for irrigation planning and management. Different crops have different water use requirements under the same weather condition.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 4, April 2018

II. LITERATURE REVIEW

K.Saravan and R. Saravan .,(2014) “Determination of Water requirements of Main Crops in the Tank Irrigation Command area using CROPWAT 8.0”. A Study was carried out to determine the water requirement of main crops in the perumal tank irrigation command area in cuddalore district .The main crops include rice , groundnut and sugarcane. The crop water requirement were determined using 15 year climatic data using CROPWAT 8.0 . In the method reference crop evapotranspiration (ET_o) was determined using the FAO Penman - Monteith method and the effective rainfall was calculated using USDA S.C method. The study shows that the dam can conveniently supply the water requirement for irrigation in the area used at present and also in the entire land area. The results obtained from the study can be used as a guide by farmers for selecting the amount and frequently of irrigation water for the main crop.

Nithya K B et.al.,(2016) “Study on water requirement of selected crops using CROPWAT 8.0” is carried out to determine the crop water requirement of few selected crops for the command area Tarikere. The crops include arecanut, coconut, and cotton, banana for two seasons, sweet pepper, onion, potato, rice, pulses, mango, cotton, sugarcane and millet (ragi). Crop water requirement for each crop was determined by using 30-year climatic data in CROPWAT. Reference crop evapotranspiration (ET_o) was determined using the FAO Penman-Monteith method. For all the crops considered, three decades: decades I, II, and III and seven crop growth stages: nursery, nursery/land preparation, initial stage, development stage, mid-season and late season stage were considered. The study shows that reference evapotranspiration (ET_o) varies from 2.5 to 3.36 mm/day for the area under study. The gross water requirement was 342.42 mm/year with an application efficiency of 70% and hence the entire crop area of 4466 ha requires 16 MCM. Thus the dam can conveniently supply the water required for irrigation in the area.

Manasa H G and Anand V Shivapur .,(2016) “Implications of Climate change on cropwater requirements in hukkeri taluk of belagavi district, karnataka, india”. The objective of this is to verify the amount water requirement for major crop grown in the command area using CROPWAT 8.0 software. For this analysis they used the following data : Daily climatic data like minimum temperature, maximum temperature, humidity, sunshine hours, wind speed and rainfall data used in addition to crop data and soil data. They collected the climate data for future 30 years (2021-2050) using precise model. Reference evapotranspiration of crop was calculated using monthly average of climatic data with the help of CROPWAT 8.0 software and then crop water requirement is calculated. Finally they concluded that it will help for policy makers and planners of water resources for future planning and to save the water in satisfying crop water requirement. Also they found that the reference evapotranspiration values are increased in the future period as compared to present condition due to increase in temperature.

Shakeel Ahmad Bhat, et.al.,(2017) “Water requirements and irrigation scheduling of maize crop using CROPWAT model”. The study aims to develop an optimal irrigation scheduling, to increase crop yield under water scarcity conditions. The research shows that the irrigation management model can effectively and efficiently estimate the crop water requirements, allows the development of recommendations for improved irrigation practice, the planning of irrigation schedules under varying water supply condition and yields reduction under various condition. From the results, it was found that the yield reduction will not occur at any growing stage with maximum rainfall efficiency as predicted with irrigation at 100% critical depletion and by refilling the soil to the field capacity.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 4, April 2018

III. STUDY AREA

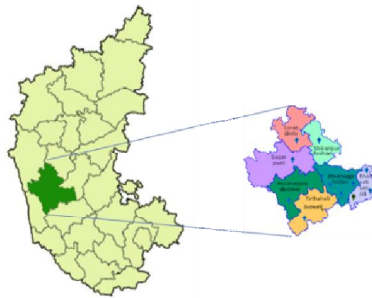


Fig.1: Location map of study area

The above figure represents the location map of study area taken for the study. The area selected is Shimoga; the city is the district headquarter, located on the bank of the River Tunga. It is situated at a longitude of 76° 27' E and latitude of 13° 50' N and at altitude of 578.89 metres above MSL (Mean sea level). As the district lies in the tropical region, rainy season occurs from June to October, with an average of 86 days in the year being rainy days. Tunga has been life saving water source for irrigation, it has catchment area of 2, 24,096 ha (fig.1).

IV. METHODOLOGY

In this study, meteorological data were collected from meteorological station located at Shimoga. Crop and soil details were collected from agricultural and statistical department Shimoga.

CROPWAT 8.0

CROPWAT 8.0 has been developed by Joss Swennenhuis for the Water Resources, Development and Management Service of FAO. CROPWAT 8.0 is based on the DOS versions CROPWAT 5.7 of 1992 and CROPWAT 7.0 of 1999. The most common version now is CROPWAT 8.0 Edition (2009), which was developed under the assistance from the university of Southampton and Institute of Irrigation and Development studies. CROPWAT is a computer program which uses the FAO Penman-Monteith procedure for the estimation of reference crop evapotranspiration (ET_o), crop evapotranspiration (ET_c) and irrigation scheduling (FAO 1992). Major input parameters of the program are Meteorological data, crop growth data & soil data.

FAO Penman-Monteith Procedure

The crop Evapotranspiration (ET_c) is also estimated by FAO Penman-Monteith Equation:

$$ET_o = 0.408 \Delta (R_n - G) + \gamma \left[\frac{900}{T + 273} \right] u_2 \frac{(e_s - e_a)}{\Delta} + \gamma (1 + 0.34 u_2) \dots (1)$$

$$ET_c = K_c (ET_o) \dots (2)$$

Where,

- ET_o = Reference evapotranspiration [mm/day]
- R_n = Net radiation at the crop surface [$MJ m^{-2} day^{-1}$]
- G = Soil heat flux density [$MJ m^{-2} day^{-1}$]
- T = Mean daily air temperature at 2m height [$^{\circ}C$]
- u_2 = Wind speed at 2 m height [$m s^{-1}$]
- E = Actual vapour pressure [$K Pa$]
- $e_s - e_a$ = Saturation vapour pressure deficit [KPa]
- D = Slope vapour pressure curve [$K Pa C^{-1}$]
- G = Psychometric constant [$K Pa C^{-1}$]
- K_c = Crop Factor

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 4, April 2018

Irrigation scheduling

In this step, we can determine irrigation schedules by loading the relevant input data like climate/ET₀, rainfall, crops and soil details. Irrigation requirement indicatively represents the fraction of the water requirements that needs to be satisfied through irrigation contributions in order to guarantee the crop optimal growing conditions.

V. RESULTS AND DISCUSSION

Reference Crop Evapotranspiration.

The following table (1) gives the Reference Evapotranspiration (ET₀) for all the months in a year, in which the highest reference evapotranspiration is found in the month May (4.82 mm/ day) and the lowest Reference evapotranspiration is found in the month July (2.93 mm/ day) and December (2.94 mm/ day) due to differential changes occurs in the weather conditions like temperature, sunshine hours, humidity and wind speed.

Table 1: Reference crop evaporation

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
ET ₀ (mm/day)	3.26	3.6	4.14	4.71	4.82	3.28	2.93	3.2	3.82	3.56	3.25	2.94

Crop Water Requirement, Effective rainfall and Irrigation Requirement

The Indian cropping season is classified into 2 main seasons- 1) Kharif and 2) Rabi based on the monsoon. The Kharif cropping seasons is from July to October during the south-west monsoon and the Rabi cropping is season is from October – March (winter). The crops grown between March and June are summer crops.

Table 2: Crop water Requirement, Effective Rainfall, Irrigation Requirement.

Sl.No	Crops	Season	Crop Water Requirement mm	Effective Rainfall mm	Irrigation Requirement mm
1	Cotton	Rabi	625.0	126.7	509.2
		Kharif	526.2	591.8	119.6
2	Maize	Rabi	327.6	38.9	298.4
		Kharif	311.2	466.3	21.8
3	Sugarcane	–	281.7	743.1	640.4

The above table (2) represents the Crop water requirement, effective rainfall and irrigation requirement (in mm) for the crops cotton, maize (in both Rabi and Kharif season) and sugarcane.

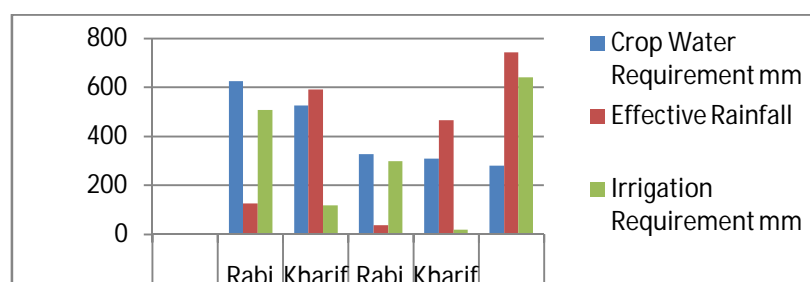


Fig 2: Bar Chart Indicating the Crop Water Requirement, Effective Rainfall and Irrigation Requirement.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 4, April 2018

The above figure (2) represents the bar chart including Crop water requirement, effective rainfall and irrigation requirement of cotton, maize (in Rabi and Kharif season) and sugarcane.

From the above results (Table 2), It shows that for the crop Cotton in Rabi season, it requires 625.0mm crop water requirement, 126.7mm effective rain fall and 509.2 mm irrigation requirement. For the same crop in Kharif season, requires 526.2 mm crop water requirement, 591.8 mm effective rainfall and 119.6 mm irrigation requirement. It shows that for the crop Maize in Rabi season it requires 327.6 mm crop water requirement, 38.9 mm effective rain fall and 298.4 mm irrigation requirement. For the same crop in Kharif season it requires 311.2 mm crop water requirement, 466.3 mm effective rainfall and 21.8 mm irrigation requirement.

The crop Sugarcane requires 1281.7 mm crop water requirement, 743.1 mm effective rain fall and 640.4 mm irrigation requirement. .since sugarcane is a perennial crop it requires more irrigation requirements as compared to other crops like maize, cotton, ragi etc. So, it needs more irrigation requirement.

So, from the results, in the Rabi season both the crops Maize and Cotton requires more Crop water and irrigation requirement because of insufficient availability of the effective rainfall. But in Kharif season it is vice versa. And for the perennial crop sugarcane effective rainfall is enough to fulfil the irrigation requirement.

Irrigation Scheduling

The irrigation scheduling can be done at critical depletion timing and the irrigation application option is of refill soil to field capacity at 70%.

The table given below indicates the irrigation scheduling of the different crops in Kharif and Rabi season in the different stages like developing stage, mid stage and end stage.

Table 3: Irrigation Scheduling

	CROPS	SEASON	STAGES	NET IRRIGATION (mm)	GROSS IRRIGATION (mm)	FLOW L/s/ha
1	SUGARCANE		Dev.	196.7	281.0	0.66
			Mid	196.8	281.1	0.54
			Mid	199.4	284.9	0.72
			End	-	-	-
2	COTTON	Kharif	End	0	0	0
		Rabi	Dev.	114.2	163.1	0.45
			Mid	184.6	263.8	0.66
			Mid	182.6	260.9	0.70
			End	-	-	-
3	MAIZE	Kharif	End	0	0	0
		Rabi	Mid	102.1	145.9	0.27
			Mid	101.5	144.9	0.62
			End	-	-	-

From the above results (Table 3), it shows that for the Sugarcane crop in the developing stage it requires Net irrigation of 196.7 mm, Gross irrigation of 281.0 mm and flow of 0.66 L/s/ha. And at the 109th day of mid stage it requires Net irrigation of 196.8mm, Gross irrigation 281.1mm and Flow of 0.54 L/s/ha and at the 155th day of the mid stage it requires Net irrigation of 199.4mm, Gross irrigation of 284.9mm and Flow of 0.72 L/s/ha.

For the crop Cotton, in Rabi season at the developing stage it requires Net irrigation requirement of 114.2 mm, Gross irrigation requirement of 163.1 mm and flow of 0.45 L/s/ha. And at the 88th day of the mid stage it requires Net irrigation of 184.8mm, Gross irrigation of 263.8mm and Flow of 0.66L/s/ha and at the 131th day of the mid stage it requires Net irrigation of 182.6mm, Gross irrigation of 260.9mm and Flow of 0.70L/s/ha.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 4, April 2018

For the crop Maize, in Rabi season at the 63rd day of the mid stage maize requires net irrigation of 102.1 mm, gross irrigation of 145.9 mm and flow of 0.27 L/s/ha and at the 90th day of the mid stage it requires Net irrigation of 101.5mm, Gross irrigation of 144.9mm and Flow of 0.62L/s/ha.

Hence, by the results obtained above, for both the crops cotton and maize in Kharif season, there is no need to supply the water through irrigation.

VI. CONCLUSION

From the study, it is concluded that Reference Evapotranspiration, Effective Rainfall, Crop water requirement and Irrigation water requirement can be estimated using CROPWAT 8.0 Software with the input of climatic data like rainfall, maximum and minimum temperature, relative humidity, wind speed and sunshine hours. By the application of CROPWAT 8.0 to the study area, the following conclusions are obtained.

Cotton (Kharif and Rabi): In the Kharif season available effective rain fall is enough to compensate the Crop water requirement. So, there is no any extra irrigation requirement is needed and in the Rabi season, available effective rain fall is less to compensate the Crop water requirement. So, in order to maintain the crop water requirement, it requires flow from the other water resources.

Maize (Kharif and Rabi): In the Kharif season available effective rain fall is enough to compensate the Crop water requirement. So, there is no any extra irrigation requirement is needed and in the Rabi season, available effective rain fall is less to compensate the Crop water requirement. Hence, additional irrigation requirement is needed to satisfy the Crop water requirement.

Sugarcane: As sugarcane is a perennial crop, for its crop period effective rain fall is enough to compensate crop water requirement.

The outcomes of this study are capable for planners of water resources for future planning and helps to save water in satisfying crop water requirement and it can be used as a guide by the farmers for selecting the amount and frequency of irrigation for the crops studied under the consideration.

REFERENCES

1. Allen, R.G., Pereira, L.S., Raes, D., Smith, M., "Crop evapotranspiration: Guidelines for computing crop water requirements". FAO Irrigation and Drainage Paper 56, FAO, Rome, Italy. (1998).
2. A. Y. Arku, S. M. Musa and A. L. E. Mofoke., "Determination of Water Requirement and Irrigation Timing for Amaranthus hybridus in Maiduguri metropolis, north-eastern Nigeria". ISSN: 1743-3541., pp.: 279-289. (2012).
3. Jose cavero, Inmafarre, Philippe Debaeke, and Jose M. Faci., "Simulation of Maize Yield under Water Stress with the EPICphase and CROPWAT Models". Published in Agron. J. 92:679-690 pp: 679-689. (2000).
4. K.Saravanan and R.Saravanan. (2014) "Determination of Water Requirements of Main crops in the Tank Irrigation area using CROPWAT 8.0". International Journal of Interdisciplinary and Multidisciplinary Studies (IJIMS), Vol 1, No.5, 266-272. ISSN: 2348-0343., pp.: 266-272.
5. Lincoln Zotarelli, Michael D. Dukes, Consuelo C. Romero, Kati W. Migliaccio, and Kelly T. Morgan., "Step by Step Calculation of the Penman-Monteith Evapotranspiration (FAO-56 Method). (2010).
6. Mansa H.G., Anand V.Shivpur. "Implications of Climate Change On Crop Water Requirements in Hukkeri Taluk of Belagavi District". International Journal of Research in Engineering and Technology. eISSN: 2319-1163., pISSN: 2321-7308., pp: 236-241. (2016).
7. Nitya K B and Shivpur AV., (2016) "Study on Water Requirements of Selected Crops UnderTarikere Command Area using CROPWAT". Irrigat Drainage Sys Eng., ISSN: 2168-9768 IDSE. pp: 1-4. (2016).
8. Poudyal Khem N., Bhattarai Binod K., Sapkota Balkrishna and Kjeldstad Berit., "Estimation of Global Solar Radiation Using Sunshine Duration in Himalaya Region"., International Science Confress Association., ISSN : 2231-606X., pp: 20-25. (2012)
9. R. Ganesh Babu, G. Ravi Babu and H.V. Hema Kumar. "Estimation of Crop Water Requirement, effective rainfall and irrigation water requirement for vegetable crops using CROPWAT". International Journal of Agricultural Engineering, Volume 8, Issue 1, pp.:15-20. (2015).
10. Rathna Raju., Yella Readdy K., Satyanarayana T.V and Yogitha P. "Estimation of Crop water requirement using CROPWAT software in Appapuram channel command under Krishna western delta". International jernoul of Agriculture sciences.ISSN:0975 and e-ISSN:0975-9107, Volume 8, Issue 31, (2016).
11. Shakeel Ahmad Bhat, B. Pundit. J.N. Khan, Kumar and Rehana Jan., "Water Requirements and Irrigation Scheduling of Maize Crop using CROPWAT Model". pp.: 1662-1670. (2017).
12. Srinivasa Prasad, A., Uma Mahesh, N.V and Viswanath, G.K. "Optimal irrigation planning under water scarcity". J.Irrig .and Drain. Engg., 132(3): 228-237., (2006).