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CROP WATER REQUIREMENTS AND IRRIGATION SCHEDULING OF SOME SELECTED CROPS USING CROPWAT 8.0 : A CASE STUDY OF KHADAKWASLA DAM IRRIGATION PROJECT

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ABSTRACT

A study is carried out to determine crop water requirements and irrigation scheduling of some selected crops for Khadakwasla dam irrigation project, in Pune district, Maharashtra. The crop water requirements and irrigation scheduling were determined by using 15-year climatic data using CROPWAT 8.0 model. In addition, information on crop and soil were collected from different literature review. These crops include maize, sugarcane, wheat and sorghum etc. CROPWAT 8.0 model using FAO Penman Monteith method is used to calculate the Reference crop Evapotranspiration (ETo) and USDA S. C. Method is used to calculate the effective rainfall. This study displays results that for study area, reference evapotranspiration varies from 2.46 mm/day to 4.90 mm/day and the effective rainfall varied from 0.2mm to 129.7mm. Crop water requirements are for maize crop 13.7 mm/dec, for sugarcane crop 798.1 mm/dec, for wheat crop 541.7 mm/dec and for sorghum 280.1mm/dec. Total gross irrigation and total net irrigation are for maize 90.1 mm and 63.1, for sugarcane crop 1121.2 mm and 784.8 mm, for wheat crop 798.3 mm and 558.8 mm and sorghum crop 329.2mm and 230.5 mm respectively. Considering above findings, it is suggested that to use CROPWAT model developed for proper irrigation scheduling.

Key words: CROPWAT, Khadakwasla, sugarcane.

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1. INTRODUCTION

Serious water shortage is developing in many nations particularly in India. India being an agricultural economy where 70% of population depends on agriculture is highly susceptible to the impacts of climate. Water arise as a valuable and scarce resource with the growing demand of increasing population and rapid industrialization. The water necessities of crop vary extensively from region to region, crop to crop and during entire crop period of individual crop. In India, Agriculture is the largest consumer of water and hence more effective use of water in agriculture is the highest priority. For better understanding of complicated interaction between climate, water and crop needs to be priority area in India. There is always race between municipal, industry and agriculture for finite amount of available water. So, estimating irrigation water requirements accurately is very important for actual water planning project and management. More recently however man-made desertification and water shortages have intensified natural scarcity while at the same time there is population growing and there is increased competition for water among water user sectors and regions. So, improved management and planning of water resources are needed to ensure proper use and spreading of water among competitive users. A scarce water resources and growing competitions for water will reduce its availability for irrigation.

The primary goal of irrigation is to apply water to maintain crop evapotranspiration whilst precipitation is insufficient. Crop water requirement is the total water needed for evapotranspiration from planting to harvest for given crop in a regime, while adequate soil water is maintained by means of rainfall and or irrigation so that it does not restrict plant growth and crop yield. Pune district located in western part of Maharashtra. It is geographical second largest district in the state. Pune has witnessed very high growth rate in Industry. The annual rainfall of Pune is 950mm. The climate of district is characterized by dry atmosphere except monsoon. Pune district is divided into four agro-climatic zones as described below, Western Ghat Zone, Sub-Mountain Zone, Western Maharashtra Plain Zone, Scarcity Zone. Khadakwasla dam irrigation project belongs from Scarcity zone. So, that more attention is to be given to proper irrigation water management. The summer is moderately high temperatures varies from 36 ℃ to 46℃. The rainfall pattern varies from 457mm to 5080mm. This district forms a part of tropical monsoon land and therefore shows a significant seasonal variation in temperature as well as rainfall conditions. The maximum area of Pune district is categorized as a scarcity zone and agriculture is mainly dependent on monsoon. Khadakwasla dam is used for irrigation, municipal and industrial purpose.

It is necessary to know crop water requirements, irrigation scheduling to meet the irrigation demand and for sustainable development of agriculture. One of the major practices to be implemented by researchers for crop water requirement is software modelling. For determination of crop evapotranspiration, crop water requirement and irrigation scheduling CROPWAT 8.0 model is used. This software was developed by FAO (Food and Agriculture Organization). CROPWAT is a hands-on tool to help agrometeorologists, agronomists and irrigation engineers to carry out typical calculation for evapotranspiration and crop water

usage studies and more particularly the design and management schemes. In this present study, some selected crops are used – Maize, Sugarcane, Wheat, Sorghum.

2. MATERIALS AND METHEODOLOGY

2.1. Study Location

The present study is carried out on the command area of khadakwasla dam irrigation project in Pune district Maharashtra. The khadakwasla dam was constructed in Pune district of Maharashtra in 1875. Khadakwasla dam is live storage across river Mutha constructed in Mawal taluka of Pune district. This dam is located at 20 km from the city of Pune. This dam is the existing source of water supply of Pune city since long period. This dam lies in latitude 18^0, 23'to 18^0, 28' and longitude 73^0, 35'to73^0, 46'. The khadakwasla irrigation scheme comprises three dams- Panshet dam, Warasgaon dam, Temghar dam. The first two, being upstream dams, are used for power generation and for feeding the downstream Khadakwasla dam, which is used for irrigation, municipal and industrial water supply. New Mutha right bank canal (NMRBC) is a 202 km-long contour canal, serving a gross command area of about 97,100 hectares.

2.2. Data Requirement

For this study, four types of data are required for this software. Those are meteorological data, rainfall data, crop data and soil data.

Meteorological data: This data is collected from India Meteorological Department(IMD), Pune. To get more accuracy and effective development of irrigation project long term data was to be collected. In this present study 15 years from 2001 to 2015 of monthly meteorological data were used. These data include Maximum Temperature & Minimum Temperature (℃), Mean Relative Humidity (%), Wind Speed (km/h), Sunshine Hours (Hrs).

Rainfall data: Monthly rainfall data was also collected from India Meteorological Department, Pune for 15 years from 2001 to 2015 which was used for calculation of effective rainfall. USDA soil conservation method is used in this software.

Crop data: This modelling needs some information of some selected crops like Maize, Sugarcane, Wheat and Sorghum. This information was obtained from FAO manual 56 for these crops including crop name, planting date, crop coefficient, rooting depth, length of plant growth stages, critical depletion and yield response factor.

Soil Data: Soil type in this area is black cotton soil. This modelling needs some general soil data like total available moisture, maximum rain infiltration rate, maximum rooting depth, initial soil depletion and initial available soil moisture. This information was collected from FAO manual 56.

2.3. Cropwat 8.0 Details

There are several versions of CROPWAT have been released till now. The latest version of this software after modification is CROPWAT 8.0. This software uses monthly climatic data (temperature, relative humidity, wind speed, sunshine hours and rainfall) for calculation of reference evapotranspiration, crop water requirement and irrigation scheduling. This modelling allows for the development of irrigation schedules under different management and water supply conditions and to evaluate rain fed production, drought effects and efficiency of irrigation practices.

2.4. Estimation of Crop Water Requirement

Crop evapotranspiration and crop water requirement are undistinguishable, crop evapotranspiration refers to the amount of water that is lost through evapotranspiration, while crop water requirement means the amount of water which needs to be supplied. The crop water requirement module includes calculations, producing the irrigation water requirement of the crop daily and over the total growing season as variance between the crop evapotranspiration under standard conditions. The effective rainfall is called as crop water requirement in mm/day. The model calculates ETc. as ETc = Kc × ETo.

Where, Kc is crop coefficient and ETo is evapotranspiration (mm/day).

2.5. Reference crop evapotranspiration (ETo)

As water is abundantly available at the reference evapotranspiring surface, soil factors do not affect ET. Linking ET to a specific surface provides a reference to which ET from other surfaces can be related. ETo values measured or calculated at different locations or in different seasons are comparable as they refer to the ET from the same reference surface. The only factors affecting ETo are climatic parameters. So, ETo is a climatic parameter and can be calculated from weather data. ETo expresses the evaporating power ofthe atmosphere at a specific location and time of the year and does not consider the crop characteristics and soil factors.

2.6. Penman-monteith method

Penman combined the energy balance with the mass transfer method in 1948 and derived an equation to calculate evaporation from open water surface from standard meteorological parameter of sunshine, temperature, humidity and wind speed. This supposed combination method was further industrialized by many investigators and extended it to interpret the equation as the maximum water which could be evapotranspiration due to solar and wind energy within the system, at given air and surface characteristics. The Penman-Monteith method of the combination equation is,

$$\text{Eto} = \frac{0.408\Delta(Rn-G)+\gamma\left(\frac{900}{T+273}\right)u_2(e_s-e_a)}{\Delta+\gamma(1+0.34u2)}$$

Where, ETo= Reference evapotranspiration (mm day -1),Rn= Net radiation at the crop surface, G= Soil heat flux density (MJ m-2 day-1), T=Air temperature at 2 m height (℃),u_2= Wind speed (m/s), e_s= saturation vapour pressure(kPa), e_a= Actual vapour pressure(kPa),e_s-e_a= Saturation vapour pressure deficit (kpa), Δ = Slope vapour pressure curve [kPa °C-1],γ = Psychrometric constant [kPa °C-1].

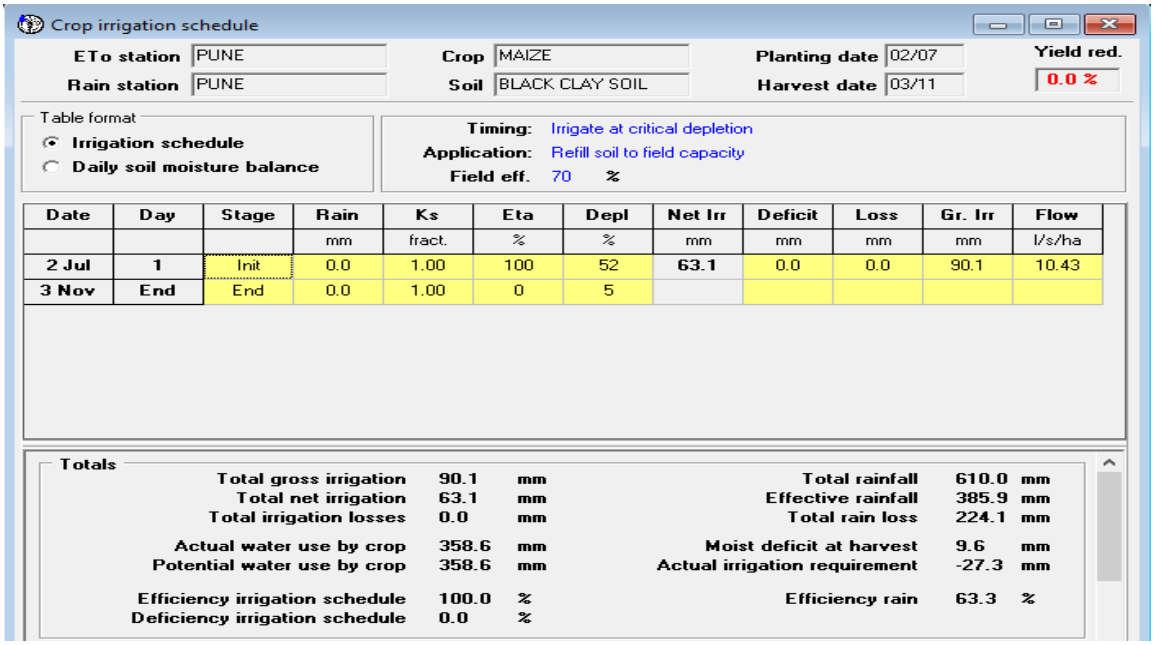
3. RESULTS AND DISCUSSIONS

Crop water requirement and irrigation scheduling of some selected crops are given as below.

3.1. Maize Crop

CROP WATER REQUIREMENT- The result obtained from the 15 years' climatic data was used in the CROPWAT 8.0. In this area maize is generally planted in kharif season. Crop water requirement of this crop is 13.7mm/dec which varies from 0.0mm/dec to 5.2 mm/dec and crop evapotranspiration varies from 1.64 mm/day to 3.61 mm/day respectively.

IRRIGATION SCHEDULING- As per irrigation scheduling carried out by CROPWAT it shows that total gross irrigation of maize crop is 90.1 mm and total net irrigation is 63.1mm. Figure 1 shows irrigation scheduling of maize crop.



Crop irrigation schedule

ETo station: PUNE | Crop: MAIZE | Planting date: 02/07 | Yield red.: 0.0 %
Rain station: PUNE | Soil: BLACK CLAY SOIL | Harvest date: 03/11

Table format: Irrigation schedule / Daily soil moisture balance
Timing: Irrigate at critical depletion
Application: Refill soil to field capacity
Field eff.: 70 %

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
2 Jul	1	Init	0.0	1.00	100	52	63.1	0.0	0.0	90.1	10.43
3 Nov	End	End	0.0	1.00	0	5					

Totals

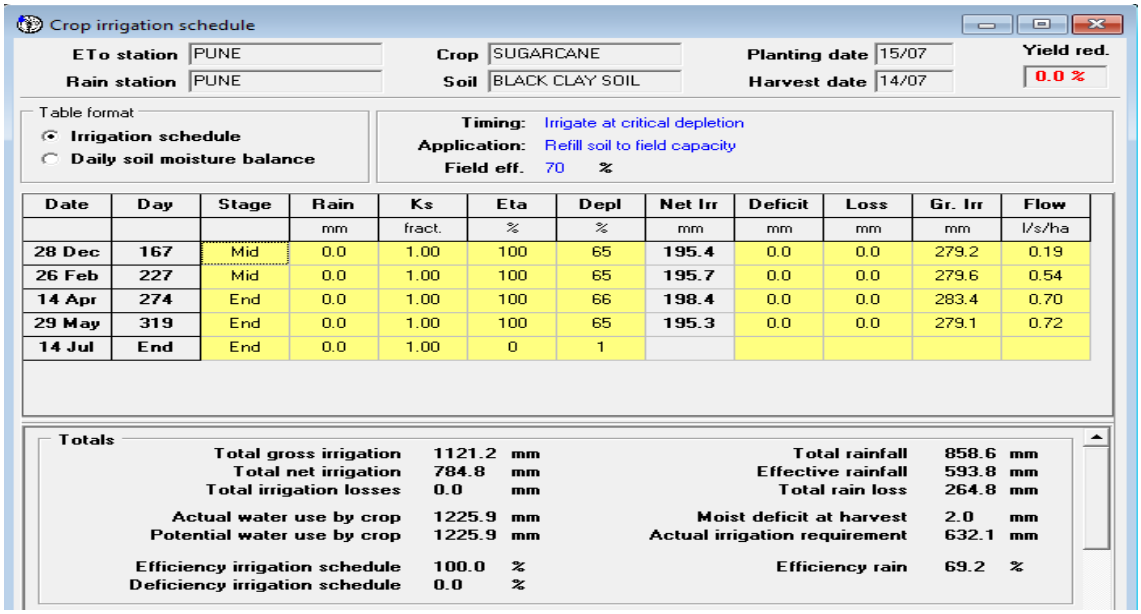
Total gross irrigation	90.1	mm	Total rainfall	610.0	mm
Total net irrigation	63.1	mm	Effective rainfall	385.9	mm
Total irrigation losses	0.0	mm	Total rain loss	224.1	mm
Actual water use by crop	358.6	mm	Moist deficit at harvest	9.6	mm
Potential water use by crop	358.6	mm	Actual irrigation requirement	-27.3	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	63.3	%
Deficiency irrigation schedule	0.0	%			

Figure 1 Irrigation Scheduling of Maize

3.2. Sugarcane crop

CROP WATER REQUIREMENT-In this area maize is mostly planted in kharif season. Crop water requirement of this crop is 798.1 mm/dec which varies from 0.0 mm/dec to 48.7 mm/dec and crop evapotranspiration varies from 1.22 mm/day to 5.10 mm/day respectively.

IRRIGATION SCHEDULING- As per irrigation scheduling carried out by CROPWAT it shows that total gross irrigation of Sugarcane crop is 1121.2 mm and total net irrigation is 784.8 mm. Figure 2 shows irrigation scheduling of sugarcane crop.



Crop irrigation schedule

ETo station: PUNE | Crop: SUGARCANE | Planting date: 15/07 | Yield red.: 0.0 %
Rain station: PUNE | Soil: BLACK CLAY SOIL | Harvest date: 14/07

Table format: Irrigation schedule / Daily soil moisture balance
Timing: Irrigate at critical depletion
Application: Refill soil to field capacity
Field eff.: 70 %

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
28 Dec	167	Mid	0.0	1.00	100	65	195.4	0.0	0.0	279.2	0.19
26 Feb	227	Mid	0.0	1.00	100	65	195.7	0.0	0.0	279.6	0.54
14 Apr	274	End	0.0	1.00	100	66	198.4	0.0	0.0	283.4	0.70
29 May	319	End	0.0	1.00	100	65	195.3	0.0	0.0	279.1	0.72
14 Jul	End	End	0.0	1.00	0	1					

Totals

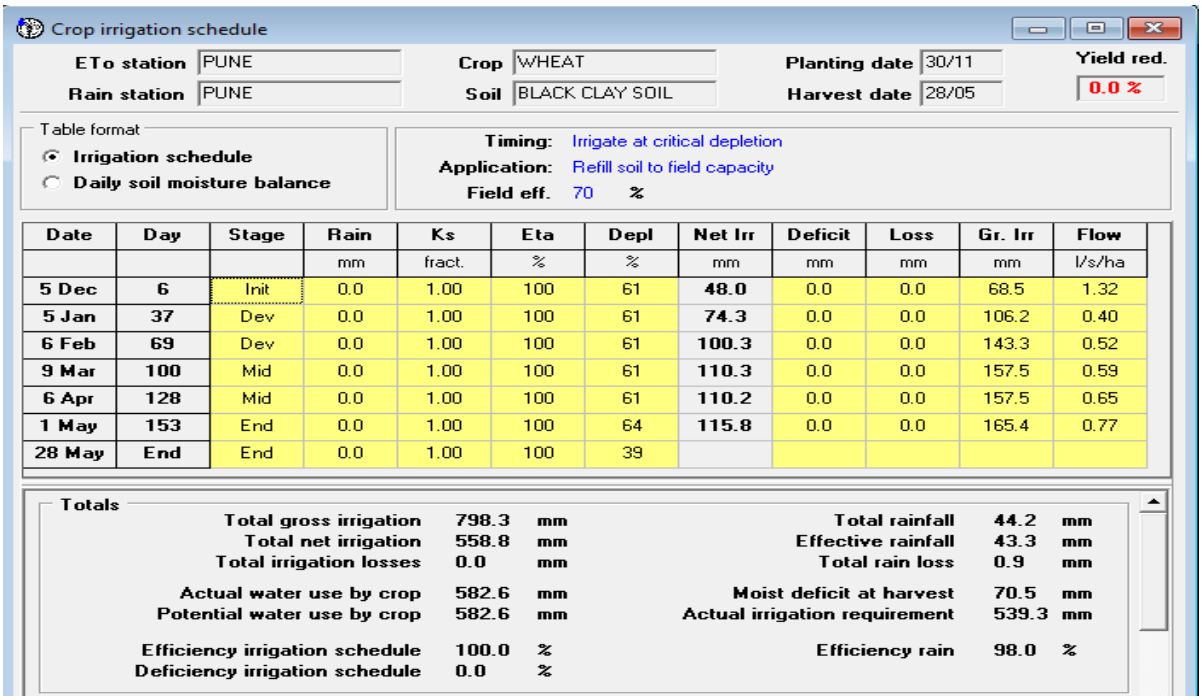
Total gross irrigation	1121.2	mm	Total rainfall	858.6	mm
Total net irrigation	784.8	mm	Effective rainfall	593.8	mm
Total irrigation losses	0.0	mm	Total rain loss	264.8	mm
Actual water use by crop	1225.9	mm	Moist deficit at harvest	2.0	mm
Potential water use by crop	1225.9	mm	Actual irrigation requirement	632.1	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	69.2	%
Deficiency irrigation schedule	0.0	%			

Figure 2 Irrigation Scheduling of Sugarcane

3.3. Wheat Crop

CROP WATER REQUIREMENT- In this area maize is planted in rabi season. Crop water requirement of this crop is 541.7 mm/dec which varies from 1.9 mm/dec to 46.7 mm/dec and crop evapotranspiration varies from 1.72 mm/day to 5.00 mm/day respectively.

IRRIGATION SCHEDULING- As per irrigation scheduling carried out by CROPWAT it shows that total gross irrigation of Wheat crop is 798.3 mm and net irrigation is 558.8 mm. The number of irrigation are presented. Figure 3 shows Irrigation scheduling of wheat crop.



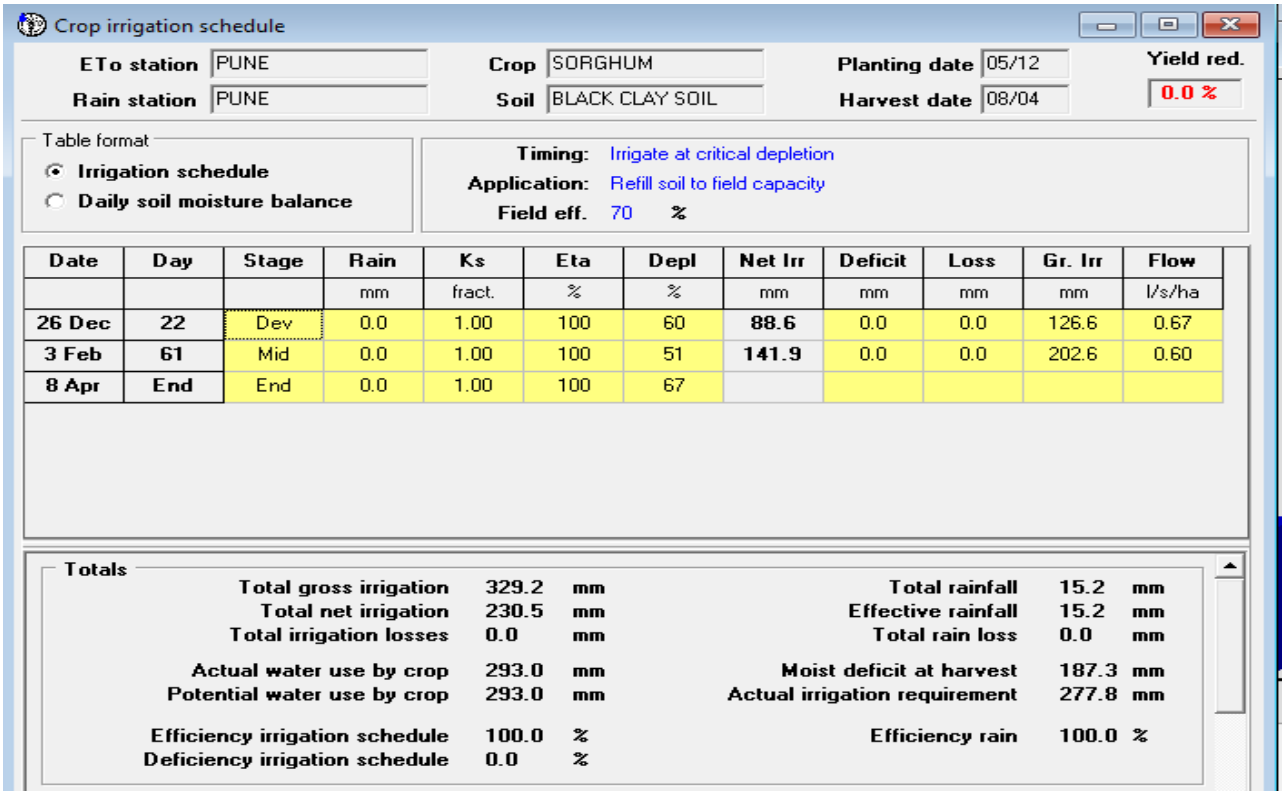
Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
5 Dec	6	Init	0.0	1.00	100	61	48.0	0.0	0.0	68.5	1.32
5 Jan	37	Dev	0.0	1.00	100	61	74.3	0.0	0.0	106.2	0.40
6 Feb	69	Dev	0.0	1.00	100	61	100.3	0.0	0.0	143.3	0.52
9 Mar	100	Mid	0.0	1.00	100	61	110.3	0.0	0.0	157.5	0.59
6 Apr	128	Mid	0.0	1.00	100	61	110.2	0.0	0.0	157.5	0.65
1 May	153	End	0.0	1.00	100	64	115.8	0.0	0.0	165.4	0.77
28 May	End	End	0.0	1.00	100	39					

Figure 3 Irrigation Scheduling of Wheat

3.4. Sorghum crop

CROP WATER REQUIREMENT-In this area Sorghum is planted in rabi season. Crop water requirement of this crop is 280.1 mm/dec which varies from 2.6 mm/dec to 33.7 mm/dec and crop evapotranspiration varies from 0.74 mm/day to 3.58 mm/day respectively.

IRRIGATION SCHEDULING-As per irrigation scheduling carried out by CROPWAT it shows that total gross irrigation of Sorghum crop is 329.2 mm and total net irrigation is 230.5 mm. Figure no. 4 shows irrigation scheduling of Sorghum crop.



Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
26 Dec	22	Dev	0.0	1.00	100	60	88.6	0.0	0.0	126.6	0.67
3 Feb	61	Mid	0.0	1.00	100	51	141.9	0.0	0.0	202.6	0.60
8 Apr	End	End	0.0	1.00	100	67					

Figure 4 Irrigation Scheduling of Sorghum

3.5. Irrigation Scheme Supply

The net irrigation water requirement is 600.1 mm/year. This is addition of Net scheme irrigation requirement in mm/ month values from January to December. Using irrigation application efficiency of 70%, The gross water requirement of 857.28 mm/year is obtained. Therefore, the entire land area of 97100ha requires 832.4 MCM. Khadakwasla dam irrigation supply is 849.30MCM. The result shows that the dam can conveniently supply the water required for irrigation in this area.

4. CONCLUSIONS

This study is carried out to determine crop water requirement of some selected crops of Khadakwasla dam irrigation project. These crops include Maize, Sugarcane, Wheat, Sorghum. The following conclusions are made:

1. The crop water requirement for Sugarcane is more as compared to other crops. The sugarcane is a perennial crop and grown throughout season. Hence this crop is major contributor of irrigation water from dam.
2. Hence during dry years, the sugarcane crops should not be encouraged to grow in this study area to provide irrigation water to food crops.
3. The results showed that the dam can conveniently supply the water required for irrigation in present command area.
4. The results were obtained from this study for average rainfall year can be used as a guide by farmers for selected the amount and frequency of irrigation water for crops.

REFERENCES

[1] **FAO** (1979). Yield response to water. Irrigation and Drainage Paper No.33. Rome, Italy.

[2] **FAO** (1992). CROPWAT. A computer program for irrigation planning and management. Irrigation and Drainage Paper No. 46. Rome.

[3] **FAO** (2002). Crop Evapotranspiration Guidelines for Computing crop water requirement. Irrigation and Drainage Paper No. 56.

[4] **Adeniran K. A., Amodu M.F., Amodu M.O. and Adeniji F.A.** (2010). Water requirement of some selected crops in Kampe dam irrigation project, Ausralian Journal of Agriculture Engineering (AJAE), Vol. 1, No.4: 119-125.

[5] **Saravanam K and Saravanam R.**(2014). Determination of Water Requirement of Main crops in the Tank Irrigation Command area using CROPWAT 8.0. International Journal of interdisciplinary and Multidisciplinary Studies (IJIMS), Vol.1, No.5: 266-272.

[6] **U. Surendran, C.M. Sushanth, George Mammen, and E.J. Joseph**. (2015). Modelling the crop water requirement using FAO-CROPWAT and assessment of water resources for sustainable water resource management: A case study in Palakkad district of humid tropical Kerala, India. ICWRCOE: 1211-1219.

[7] **P.V.Shah, R.N.Mistry, J.B.Amin, A.M.Parmar, Moh.R.A.Shaikh** (2015) Irrigation scheduling using cropwat. IJAREST, volume 2, Issue 4.

[8] **Nithya B.K., R. Shreedhar, A.V.Shivapur**.(2015) Water requirements of selected crops in kunigal command area. Journal on Civil Engineering. Vol.5,No.2.