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Crop Water Requirement and Water use Efficiency of Rice in Thatipudi Medium Irrigation Project Command Area

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ABSTRACT

For agriculture land and water are essential for economic development of any country. Day by day, availability of water is decreasing but the demand for various purposes are increasing so there is need to concentrate on utilization of available water. Accurate assessment of evapotranspiration is essential for better management and allocation of water resources. It is very much essential for knowing the amount of water requirement at different stages of crops at different management levels within the command area to accomplish effective irrigation management. CROPWAT is a computer model, was used to estimate the reference evapotranspiration, effective rainfall, crop water requirement and irrigation water requirement for Thatipudi channel command area in Vizianagaram district of Andhra Pradesh state. Daily meteorological data including rainfall, maximum and minimum temperatures, relative humidity, wind speed were collected for the period of 1989 to 2016 from Global weather data for SWAT and Andhra Pradesh state disaster mitigation society. Sunshine hours are taken from FAO-24 these are used as input data for CROPWAT. Average peak monthly ET_o was observed to be 5.93 mm/day. The average effective rainfall was estimated for the study area as 871.9 mm out of 1183.3 mm annual rainfall. The cropwater requirement and irrigation water requirement were estimated for paddy crop during Kharif season in the study area (Thatipudi) 925.9 mm and 578.9mm, respectively.

Since irrigation is the major user of water resources, so improving of agricultural water management is essential. Efficient agricultural water management requires reliable estimation of crop water requirement. Crop water requirements are normally expressed by the rate of evapotranspiration (ET) in mm day^{-1}. From an agricultural point of view, ET determines the amount of water to be applied artificially. The global consumption of water is doubling every 20 years, more than twice the rate of human population growth. Food and Agriculture organization (Food and Agriculture Organization) reports that 70-80 per cent of the increase in food demand between 2000 and 2030 will have to be met by irrigation. Irrigated agriculture is practiced on about 300 million hectares only or 20 per cent of the cultivable area (Food and Agriculture Organization, 2010), but contributing substantially with more than 40 per cent of world's food production. Irrigation can reduce the risks associated with the unpredictable nature of rain fed agriculture in dry regions. Irrigated agriculture offers great potential for economic growth and poverty reduction. Evaporation demand is projected to increase almost everywhere in the world in future climate scenarios. Thus, the process of evapotranspiration (ET) is of great importance in present and future climates. The measurement of ET from a crop surface is a very difficult and time consuming task. A large number of more or less empirical methods have been developed over the last 50 years by numerous scientists and specialists worldwide to estimate evapotranspiration from different climatic variables..CROPWAT is one of the models that are being extensively used in the field of water management throughout the world which is designed by Smith (1991) of the Food Agricultural Organization (FAO). CROPWAT facilitates the estimation of the crop evapotranspiration, crop water requirements and irrigation schedule with different cropping patterns for irrigation planning (Kuo et al. 2006; Gowda et al. 2013; George et al. 2000; Gouranga and Verma, 2005).The main objectives of this study is to know the crop water requirement, irrigation schedule details and water use efficiency of paddy in command area.

MATERIAL AND METHODS

In Thatipudi command area, farmers are habituated to irrigate the fields through flooding due to availability of irrigation project water so the wastage of water is much higher.

Details of project

The reservoir is located in 18æ%17' N latitude and 83æ%19' E longitudes having 6218.29 ha.The gross capacity of dam is 94.153 Mm^3.

The climate of Vizianagaram district is characterized by high humidity about all around the year with oppressive summer and good seasonal rainfall. Thatipudi is very near to district head quarters .The average air temperature is 25.45ºC, where as the monthly maximum average air temperature is 38.7 ºC and the monthly minimum air temperature is 19.1 ºC, the average relative humidity is 66%.

Water use efficiency (WUE)

An efficient irrigation system implies effective transfer of water from the source to field with minimum possible loss. The objective of the efficiency concept is to identify the nature of water loss and to decide the type of improvement in the system. *(Sources: Development of e-cources for B.Sc by TNAU. http://eagri.tnau.ac.in/eagri50/AGRO103/.)*

WUE is a dimensionless ratio of total amount of water used to the total amount of water applied (Molden ,1997).

$$Water\ use\ efficiency = \frac{\text{Water benificially used}}{\text{Water delivered}}$$

Water productivity

It is the ratio of yield of crop (Y) to the amount of water depleted by crop in evapotranspiration (ET). It is expresses in kg/m^3. (A note on Water use efficiency and water productivity. Ragab Ragab - WP3- W4C).

$$WP = \frac{Y}{ET}$$

Where,

WP = Crop water use efficiency
Y = Crop yield
ET = Evapotranspiration

Application of CROPWAT 8.0

Computerized program can easily access databases for climate and crop characteristics to allow for speedy determination of irrigation water requirements. In the event, real data is unavailable, an indicative schedule can be worked out based on averaged climatic conditions experienced in the study area for a significant length of time

The Food and Agricultural Organization (FAO) CROPWAT model for irrigation scheduling offers the possibility to:

- Design an indicative irrigation schedules and its impact over yield.
- Evaluate field irrigation program in terms of efficiency of water use and yield reduction.
- Simulate field irrigation program under water deficiency conditions, rain-fed conditions, supplementary irrigation, etc

Input required in this software includes three types of data

To work out irrigation scheduling, the CROPWAT 8.0 demands meterological data, crop data and soil data to be input in the program (Table 1). This is facilated by a number of windows that pop up one after another to let user feed a particular set of data. CROPWAT computes Et_0 by applying Penman-Monteith method which recommended By FAO.

Meteorological data

- Climate data: The meteorological data were collected for 37 years (1989-2015) from Global weather data for SWAT and Andhra Pradesh state development planning society. These data include daily maximum and minimum temperature, daily relative humidity, daily wind speed. Daily sunshine hours are taken from FAO-24 daily average of all these data were calculated and used in the model.
- **Rain data:**

  The daily rainfall data were collected Directorate of economics and statistics (DES) for Sixteen years (2000-2015) and the average of Sixteen years data was used in CROPWAT software to obtain effective rainfall which was calculated in the software using USDA soil conservation service method.
- **Crop data**

  The software needs some information like crop name, planting date, harvesting date, crop coefficient (Kc), rootingdepth, length of plant growth stages, critical depletion and yield response factor. Sowing date was considered as June 20 and harvest date was considered as October 17 the values for crop data is mentioned in Table 2.

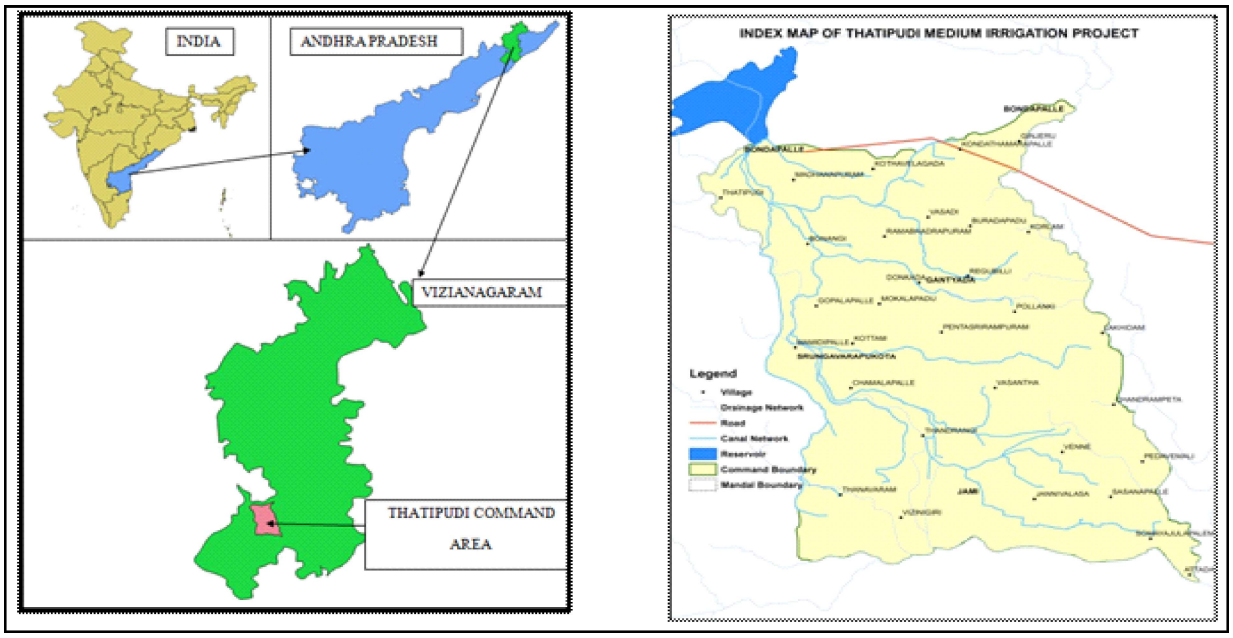

Fig. 1 Location and Index map of Thatipudi medium irrigation project command area

Crop Water Requirements

ETo station: Thatipudi | Crop: Rice

Rain station: thatipudi | Planting date: 20/06

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
May	3	Nurs	1.05	0.77	8.5	25.5	0.0
Jun	1	Nurs/LPr	0.97	4.21	42.1	36.0	58.1
Jun	2	Init	0.93	6.38	63.8	44.1	184.8
Jun	3	Init	1.05	7.19	71.9	41.9	30.0
Jul	1	Deve	1.05	7.17	71.7	37.3	34.4
Jul	2	Deve	1.08	7.32	73.2	35.6	37.7
Jul	3	Deve	1.12	7.43	81.7	39.1	42.6
Aug	1	Deve	1.16	7.52	75.2	43.7	31.5
Aug	2	Mid	1.19	7.51	75.1	46.9	28.3
Aug	3	Mid	1.19	7.39	81.3	47.7	33.6
Sep	1	Mid	1.19	7.26	72.6	49.3	23.3
Sep	2	Late	1.18	7.07	70.7	50.9	19.8
Sep	3	Late	1.05	6.07	60.7	48.0	12.7
Oct	1	Late	0.89	4.93	49.3	45.6	3.7
Oct	2	Late	0.75	4.00	28.0	30.6	0.0
					925.9	622.2	540.5

Fig. 2 Daily and decadal ET_c and Irrigation requirement

Totals:

Total gross irrigation	1374.8	mm	Total rainfall	863.6	mm
Total net irrigation	962.4	mm	Effective rainfall	712.1	mm
Total irrigation losses	0.0	mm	Total rain loss	151.6	mm
Total percolation losses	689.2	mm			
Actual water use by crop	813.8	mm	Moist deficit at harvest	0.0	mm
Potential water use by crop	813.8	mm	Actual irrigation requirement	101.7	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	82.4	%
Deficiency irrigation schedule	0.0	%			

Fig. 3 Irrigation Scheduling for Paddy crop

Table 1. Inputs required for CROPWAT

S.No	Parameter or variable	Unit
1	Location data	
2	Country	
3	Station	
4	Latitude	
5	Longitude	
6	Altitude	M
7	Daily meteorological data	
8	Maximum temperature	æ%C
9	Minimum temperature	æ%C
10	Relative air humidity	%
11	Wind speed	m/s
12	Bright sunshine	H
13	Precipitation	Mm
14	Soil data	
15	Total available soil water	Mm/m depth
16	Maximum rain infiltration rate	Mm/d
17	Maximum rooting depth	M
18	Initial soil water depletion	%
19	Crop data	
20	Planting date	Day/month
21	Harvesting date	Day/month

Table 2. Crop data : Paddy

S.No.	Crop parameter	Land creep	Intial	Development	Mid season	Late	Total
1	K_c	0.9	1.05	-	1.20	0.7	-
2	Length days	20.0	30.00	35.00	35.00	30.0	150
3	Rooting depth,m	-	0.10	-	0.50	0.5	-
4	Critical depletion factor	-	0.20	-	0.20	0.2	-
5	Yiels response factor	-	1.00	1.09	1.32	0.5	1.1
6	Crop height	-	-	-	1.00	-	-

(Source: Choudary et al.2013 and FAO56,2012)

Table 3. Soil data: Medium Soil

S.No	Parameter	Value
1	Total available soil moisture (FC-PWP)	150 mm/m
2	Maximum infiltration rate	72 mm/day
3	Maximum rooting depth	50 cm
4	Intial soil moisture depletion (as % TAM)	0%

These parameters are essential to calculate ETo. CROPWAT calculate radiation and ETo depending on climate data.

Soil data:

Presence of sand, silt, and clay in various proportions determines the type of soil, and its moisture holding capacity. The soil type considered in present study is classified in the software as medium soil (Red clay loamy) which is predominant in Vizianagaram district. The software needs some general soil data like total available soil moisture, maximum rain infiltration rate, maximum rooting depth, initial soil moisture depletion and initial available soil moisture which is presented in Table 3.

RESULTS AND DISCUSSION

The CROPWAT 8.0 was used to prepare the irrigation requirement of Paddy in Thatipudi command area. The model was run for Red clay loamy (medium soils) under same level of water availability. The model predicted the decadal as well as monthly crop water requirement at different growing stages of Paddy.

The Gross irrigation and net irrigation for paddy is found as 1374.7 mm and 962.4mm depth of water. Actual water utilized by the crop was computed as 813.8 mm. **Water use efficiency:**

The results revealed that the gross irrigation for paddy as 1374.7 mm and the actual water utilized by the crop is 813.8 mm so the water use efficiency is computed as 59.19 %.**Water Productivity:**

The average yield observed from Thatipudi command area is 5953 Kg/ha and the water utilized by the crop is observed as 8138 m^3/ha. So water productivity is observed as 0.73 Kg/M^3.

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