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Estimation of Crop Water Requirement of TS Channel (Tungabhadra Side Channel) Command of Krishna Western Delta using CROPWAT Model

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ABSTRACT

Water requirement estimation is important in cultivation practices of rice. This study was carried out to determine the total water requirement needed for 4165 hectares of paddy and maize crops which are being cultivated in TS Channel of command of Krishna Western Delta (KWD) in Kharif and Rabi seasons respectively. In KWD, water is supplied continuously until about 10 days before harvesting. Water is required to bring the fields to saturation, and to establish a layer of water in the fields to facilitate land preparation. Saturation of water, effective rainfall, and evapotranspiration and seepage percolation were calculated for determination of crop water requirement during the pre-saturation and normal growth periods. The computer simulation model CROPWAT was applied to estimate crop water requirements of rice and maize crops grown in both the seasons. The decennial meteorological data for years 2000 to 2012. The study showed that the total of 274 mm and 374mm of irrigation water for paddy and maize crops during kharif and rabi seasons respectively which clearly show that there is a misutilization of canal water and non-utilization of ground water to the extent recommended hence the area under cultivation is also lower than the actual potential especially during rabi season (3500 ha) as against kharif (4165 ha).

Key words : CROPWAT, Paddy Field, Water Requirement.

Efficient use of water in the state of Andhra Pradesh is becoming an important issue due to increasing irrigation water requirement as well as environmental sustainability. Since 1850s, the Krishna basin has seen an increasing mobilization of its water resources and dramatic development of irrigation, with little regard to limit of available water resources. This progressively lead to closure of basin (zero or minimal discharge to ocean) during 2001-2004 and surface water resources were almost entirely committed to human consumption uses, increasing ground water abstraction contributed to the decrease in surface water base flows and discharge to the ocean was almost zero.

Total annual water requirement for agricultural use are exceedingly large especially for rice. Water required by a rice crop in a given period of time need to be considered for normal growth under field conditions. The amount of water required for a given crop depends on state of development of soil, quantity and type of fertilizer given, quality of water used and the climatic conditions. Measurement or estimation of the rate of crop water use is required for determination of irrigation water requirement. The available water for irrigation, however, is becoming increasingly scarce due to decreasing resources and quality, and increased competition from nonagricultural water users. Recently, the demand of water for industrial, municipal, and other use has been increased as less water will be available for agriculture.

George *et al.* (2000) used two models for irrigation scheduling under various management options for single and multiple fields to predict soil moisture contents and were compared with the measured data both for single and multiple field cases. The two models, ISM and CROPWAT gave similar values of soil moisture, but showed some variation after the second irrigation. However, for both the single and multiple field cases, the bean yield predicted by simulation was found to be slightly higher than the measured yield. Srinivasulu *et al.* (2003) conducted experiments on estimation of crop water requirement through computer simulation and its comparison with actual application of irrigation water in Ponnur channel command of Krishna Western Delta. The farmers have applied 56.9% and 46.9% excess quantities of irrigation water than required in the years 2000-01, 2001-2002 while in the year 2002-03,15.3% less water than the required. In spite of applying more quantities of irrigation water in the years 2000-2001 and 2001-2002, the average yield of paddy crop in those years was less indicating that applying excess water is not at all advantageous and instead it is wastage of valuable resources.

Zhiming *et al.* (2007) studied the crop water requirement and irrigation scheduling of spring maize using GIS and CROPWAT model in Beijing-Tianjin-Hebei region and they were capable of extending the crop models to a regional level to estimate the spatial distribution of the evapotranspiration of spring maize, climatic water deficit and the yield reduction of spring maize under different rain fed and irrigated conditions. Based on the water deficit analysis, supplemental irrigation schedule was developed using CROPWAT model.

MATERIALS AND METHODS

The study area, Tungabhadra side channel, originating from Kommamur branch of Krishna Western Delta in Guntur district of Andhra Pradesh and is located at 16^0 04’ N latitude and 80^0 34’ E longitudes (Fig. 1). The details of the hydraulic particulars of Tungabhadra side command were given in Table 1. The cropping pattern followed was paddy-maize-fallow. The average annual rainfall from 2000 to 2012 was estimated to be 932 mm. As a part of the research, conjuctinve use planning of surface and ground water resources, the crop water requirement for rice and maize both kharif and rabi seasons respectively were estimated using windows based CROPWAT simulation programme model and is reported in this research article.

Various input parameters fed to CROPWAT program were average monthly minimum maximum temperature, relative humidity, sunshine hours, rainfall and wind speed. The meteorological data were collected from the RARS, Lam, and Guntur. The climatic data highlighted main window of CROPWAT is shown in Fig.2

CROPWAT is a programme that uses the Penman-Monteith methods for calculating reference crop evapotranspiration. This estimate was used in estimating gross/net crop water requirements and irrigation scheduling calculations. CROPWAT calculates the irrigation water requirements (either for a month or for a week period or as required) of a cropping pattern in an irrigated area at various stages of crop development throughout the crop growing season. The input data of CROPWAT were organized through three files, *a data file* on the irrigated area, *a meteorological data file* and *a cropping pattern data.* CROPWAT output the tables and graphs showing reference/ potential evapotranspiration, crop irrigation requirements, effective precipitation and scheduling on a seven day or monthly basis etc. The main window of the model which shows the basic input file menu is given in Fig. 2.

The weather data contains the average value of 12 years of data. The soil data corresponding to the study area was also incorporated. The cropping pattern was separately fed for rice and maize. The standard crop coefficient values were fed for arriving at crop evapo-transpiration at various stages of crop growth. The results obtained after running the model separately for kharif and rabi is reported and discussed in the next section.

RESULTS AND DISCUSSION

The model calculated the effective rainfall in mm for each month taking the average monthly rainfall values for the study area. The weather data fed in the model was used to calculate the effective rainfall duly deducting the evapotranspiration and infiltration and deep percolation losses. The values of effective rainfall (mm) are given in Table 2.

The same values are represented through histogram (Fig. 2). In the study area, the average annual rainfall is found to be 932.3mm. Lowest rainfall is found in April and May months, highest average rainfall being in August month. As there is no source of irrigation either through rainfall or through canal releases, farmers keep their lands fallow during summer season.

From the literature, collected from FAO publication 56, the crop coefficients for initial, mid and end crop growth periods for paddy and maize crops are given in Table 3. The same values were fed in the cropping pattern file in CROPWAT software model.

The summary of various input parameters which were incorporated in CROPWAT window are briefly summarized in Table 4. In the table, no. of days each crop growth stage, nursery area, critical depletion etc., were summarized and was

Table 1. Particulars of the study area.

Sl.No.	Details of the study area	Quantity
1	Name of the Canal	Tungabhadra side Channel
2	Command Area	4165 ha
3	Length of the Canal	19.8 Km
4	Average Discharge of the Canal	361cusecs
5	Number of Branch Canals	13
6	Vents at head sluice	4 (Size 1.22 x 1.06 m)

Table 2. Average monthly rainfall and corresponding effective rainfall (mm).

Sl. No.	Month	Average Rain (mm)	Effective rain (mm)
1	January	6.1	6.0
2	February	14.4	14.1
3	March	16.2	15.8
4	April	12.5	12.3
5	May	51.7	47.4
6	June	107.9	89.3
7	July	169.6	123.6
8	August	190.4	132.4
9	September	167.6	122.7
10	October	127.2	101.3
11	November	51.3	47.1
12	December	17.4	16.9
	Total	932.3	728.8

Fig. 1. Map showing TS Channel command area-Improved map).

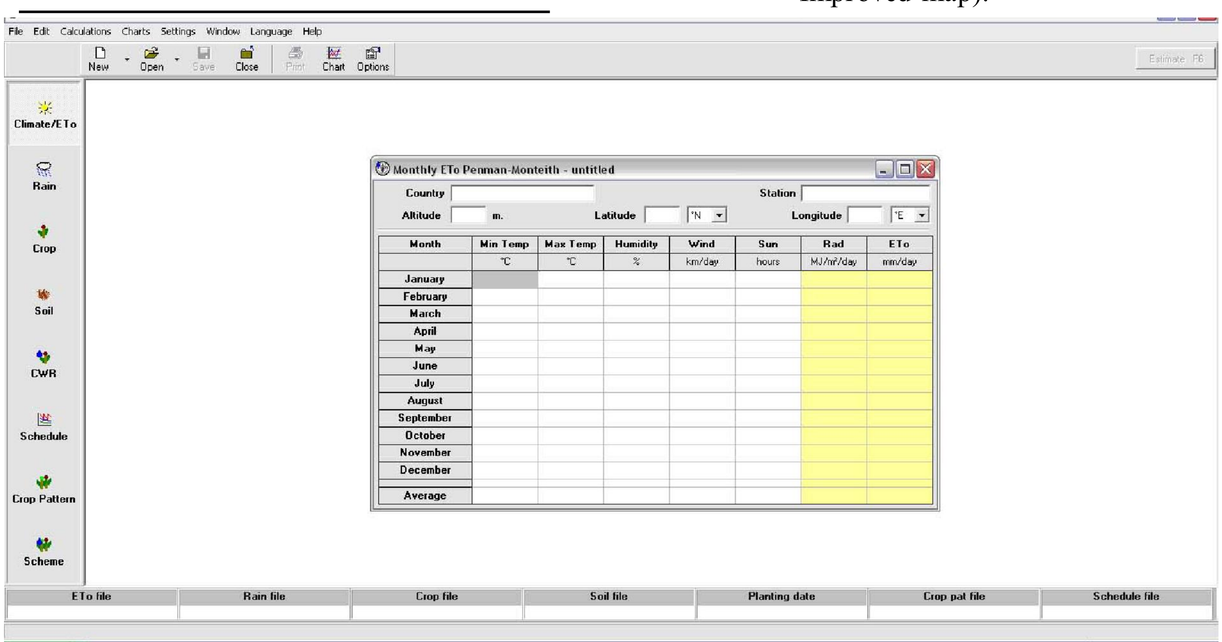

Fig. 2. The main window of CROPWAT model.

Table 3. Crop coefficients for different crops grown in KWD.

SI.No	Crop	K_{ini}	K_{mid}	K_{end}
1.	Paddy	1.05	1.2	0.9
4.	Maize	0.7	1.2	0.6

Table 4. Summary of various input parameters used in CROPWAT model for rice crop.

Sl. No	Crop Name: Rice Parameter/Stage	Nursery	land prep total	Paddling	Transplanting date :25/7 initial	develop	mid	late	Total
1	Length(days)	30	20	5	20	30	40	30	150
2	K_c dry	1.05	1.2		1.2	-	0.9	0.9	
3	K_c wet	1.2	1.05		1.1	-	1.2	1.05	
4	Rooting depth(m)				0.1		0.6	0.6	
5	Puddling depth(m)			0.4					
6	Nursery area(%)	10							
7	Critical depletion	0.2			0.2		0.2	0.2	
8	Yield response f				1	1.09	1.32	0.05	1.1
9	Crop height (m)						1		

Table 5 Summary of various input parameters used in CROPWAT model for maize crop.

Crop Name: Maize			Transplanting date :07/12		
Stage	initial	develop	mid	late	Total
Length(days)	20	40	35	30	125
Kc values	0.7		1.2	0.6	
Rooting depth(m)	0.3		1.4	1.4	
Critical depletion	0.6		0.5	0.8	
Yield response f	0.2	0.4	0.55	0.2	0.9
Crop height,m			1.5		

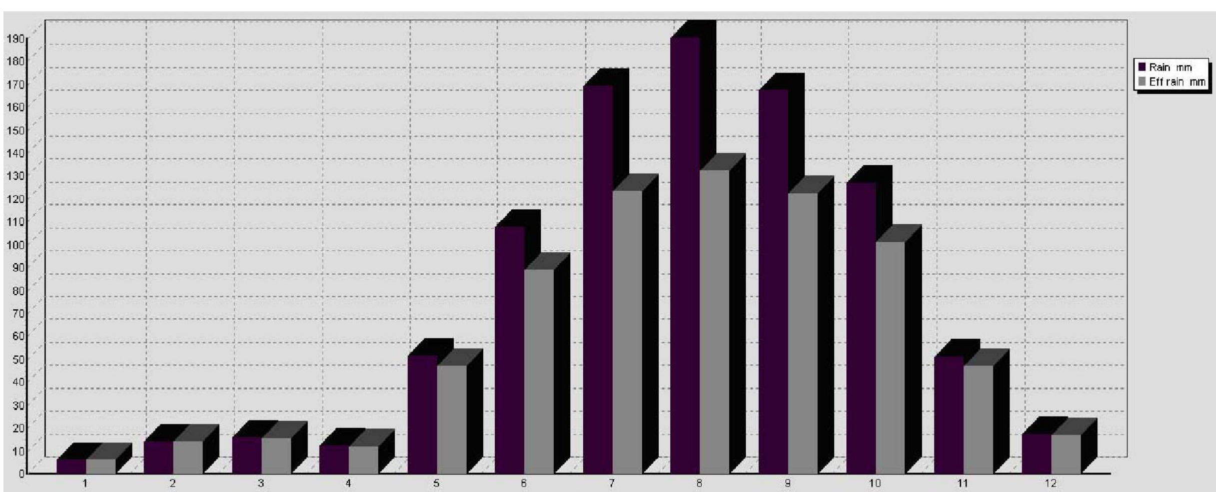

Fig. 3. Histogram showing the average monthly rainfall and effective rain (mm) in study area.

Table 6. Crop water requirements of Tungabhadra side channel command area for paddy.

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jun	3	Nurs	1.2	0.45	2.7	20.3	0
Jul	1	Nurs/LPr	1.12	2.51	25.1	38.1	93.4
Jul	2	Nurs/LPr	1.06	3.78	37.8	42.3	90
Jul	3	Init	1.09	3.83	42.1	42.9	51.6
Aug	1	Init	1.1	3.84	38.4	43.7	0
Aug	2	Deve	1.1	3.8	38	45	0
Aug	3	Deve	1.1	3.84	42.2	43.6	0
Sep	1	Deve	1.1	3.87	38.7	42.3	0
Sep	2	Mid	1.1	3.9	39	41.4	0
Sep	3	Mid	1.1	3.82	38.2	38.8	0
Oct	1	Mid	1.1	3.74	37.4	37.2	0.2
Oct	2	Mid	1.1	3.66	36.6	35.3	1.3
Oct	3	Late	1.08	3.47	38.2	28.8	9.4
Nov	1	Late	1.04	3.19	31.9	21	10.9
Nov	2	Late	0.99	2.93	29.3	14.6	14.7
Nov	3	Late	0.96	2.74	2.7	1.2	2.7
					518.3	536.6	274.3

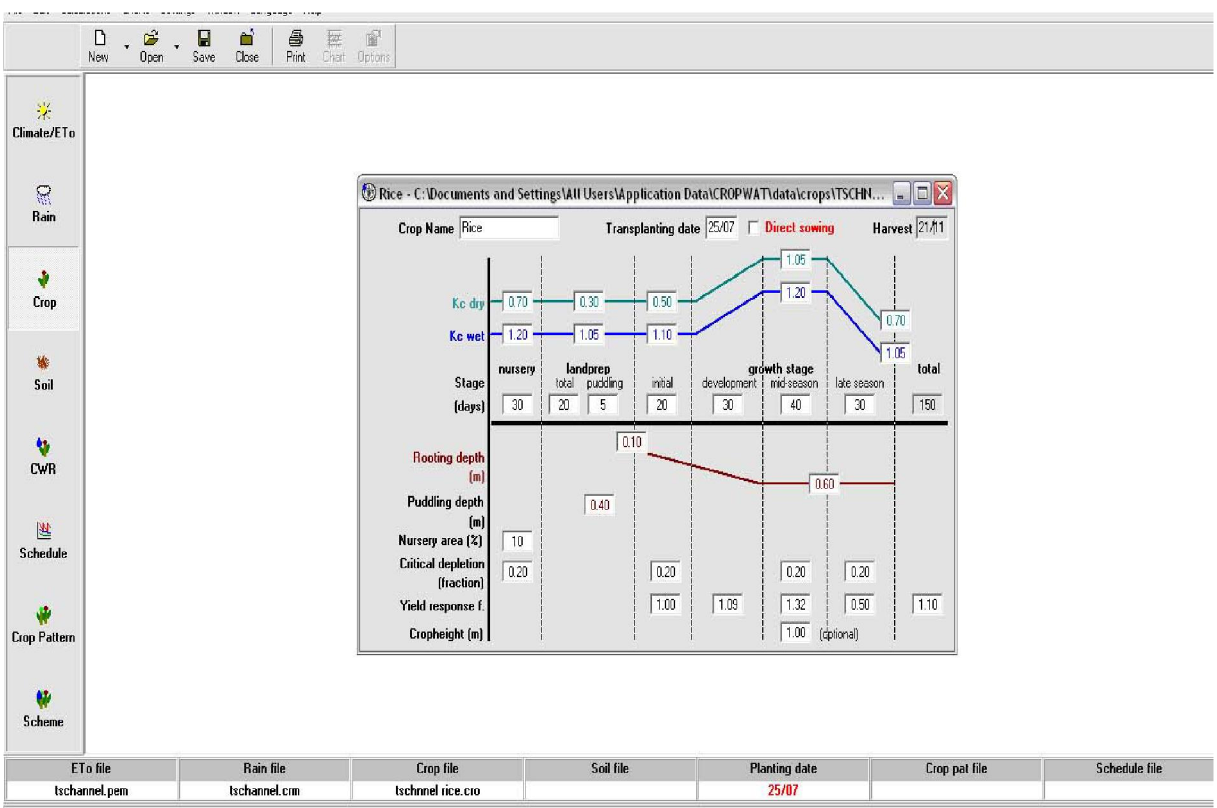

Fig. 4. Cropping pattern file options widow of CROPWAT model.

Table 7. Crop water requirements of Tungabhadra side channel command area for maize crop.

Month	Decade	Stage	Kc Coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Dec	1	Init	0.7	1.91	7.6	3.4	3.4
Dec	2	Init	0.7	1.83	18.3	4.7	13.5
Dec	3	Deve	0.72	1.91	21	3.8	17.2
Jan	1	Deve	0.82	2.24	22.4	2.7	19.7
Jan	2	Deve	0.93	2.6	26	1.2	24.8
Jan	3	Deve	1.04	3.17	34.9	2.3	32.5
Feb	1	Mid	1.13	3.72	37.2	4	33.3
Feb	2	Mid	1.14	4.02	40.2	4.9	35.2
Feb	3	Mid	1.14	4.22	33.8	5	28.7
Mar	1	Mid	1.14	4.43	44.3	5.2	39
Mar	2	Late	1.05	4.26	42.6	5.5	37.1
Mar	3	Late	0.84	3.57	39.3	5	34.3
Apr	1	Late	0.63	2.8	28	3.3	24.7
					395.6	51	343.8

read as the output of the model. The corresponding cropping pattern file options widow is also shown in Fig.4.

The summary of various input parameters which were incorporated in CROPWAT window for maize crop in rabi season are briefly summarized in Table 5. In the table, no. of days each crop growth stage, nursery area, critical depletion etc., were summarized and was read as the output of the model.

The crop coefficients for various growth periods for paddy and maize crops (FAO-56) were drawn.The same values were incorporated in the model for the two crops for Kharif and Rabi seasons respectively for arriving at irrigation water requirements on decade basis. The irrigation requirement for paddy and maize crops as estimated by the model are given in Table 6 & 7 respectively. These Kc values for different crop growth stages ie.intial mid and last for both the crops chosen viz paddy &maize were incorporated in the cropwat model.

The model predicts the water require for once in ten days interval considering the irrigation scheduling of conventional methods. The mode designates 10 days period as one decade and 3 decade and 3decads per month. For paddy crop, the irrigation requirement is found to be more during 1st decade of July fallow of by 2 decade 3 decade. Again during November it is to be more become of the inherent rainfall conditions of the region as well as the crop needs. Similarly for maize crop the irrigation requirement is found to be more during February followed by January months as per the crop needs. It could be observed from the above tables that during kharif season, the effective rainfall is concentrated relatively higher than in rabi season. Hence the irrigation requirement is more in rabi season though maize is less water requiring crop than paddy.

CONCLUSIONS

The computer simulation model CROPWAT was applied to estimate crop water requirements of rice and maize crops grown in both the seasons. The decennial meteorological data for years 2000 to 2012 is averaged and given as input to the model. The study showed that a total of 275mm and 344 mm of water is required to be supplemented through irrigation for paddy and maize crops respectively. The area under cultivation is also lower than the actual potential especially during rabi season (3500 ha) as against kharif (4165 ha). Because of non-advisory services regarding crop selection, the effective utilization of ground and surface water is not followed in the command as against the recommendations of the Ground Water Board. This type of exercise would give the planners to recommend for any crop shifts for better income for the farming community.

LITERATURE CITED

Allen R G, Pereira L S, Raes D and Smith M 1998 Crop evapotranspiration: Guidelines for computing crop requirements. *FAO Irrigation and Drainage paper No. 56*, FAO, Rome, Italy, 300 pp.

Bhandarkar D M, S S Dhakad, K S Reddy and R Singh 2004 Estimation of crop water requirement for important field and vegetable crops in Bhopal region. *Proceedings of XXXVI ISAE Annual Convention & Simposium Dr. BSKKV, Dapoli*, 16-18 January 2004:61.

George B A, S A Shende and N S Raghuwanshi 2000 Development and testing of an irrigation scheduling model. *Journal of Agricultural Water Management*, 46: 121-136. http:// www.gisdevelopement.com

Srinivasulu A, Satyanarayana T V, Ravi Kumar M and Sai Sudha J L N 2003 Crop water requirement in comparison to actual applied in some canal commands of Krishna Western Delta. *Journal of Agricultural Engineering,* 40(4): 43-50.

Zhiming F, L Dengwei and Y Zang 2007 Water requirements and irrigation scheduling of spring maize using GIS and Crop Water model in Beijing-Tianjin-Hebei region. *Chinese Geographical Science*, 17: 56-63.

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