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RESEARCH ARTICLE

Estimation of water requirement for different crops using CROPWAT model in Anantapur region

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SUMMARY : Groundwater exploration for irrigation is a costly and scare input in agriculture and plays an important role in increasing food production. Due to over use of groundwater resources, it has become very important to estimate the Crop Water Requirement for different crops. Unscientific and injudicious application of groundwater in the Anantapur region resulted in depletion of the groundwater table. Anantapur region was chosen as the study area as its sever water problem. To achieve effective utilization of the groundwater resources, there is a need to estimate the crop water requirement for different crops at different management levels to accomplish effective irrigation management in the Ananthapur region. It is important that the water requirements of the crops are known. This study was carried out using CROPWAT 8.0 model. The information about climatic conditions, soil types and cropping pattern were obtained in the study area to estimate the crop water requirement under rainfed condition. The crop water requirement for the different crops of Anantapur region is very essential for effective utilization of the groundwater and also to be increase the crop yield. The maximum quantity of effective rainfall observed during the month of September as 79.5 per cent of the monthly rainfall *i.e.* 101.7 mm and average annual effective rainfall was estimated over the period 1985 to 2012 as 85.5 % of the average annual rainfall *i.e.* 526 mm out of 615.4 mm of average annual rainfall. The crop water requirement for the groundnut *Kharif* and *Rabi* crops in the Anantapur region was estimated as 591.3 mm and 443.3mm, respectively and for the vegetables, cotton, rice, grains and maize in the Anantapur region are to be 594.1 mm, 878.6 mm, 1110.6 mm, 699.9 mm and 679.3 mm, respectively. Efficient water management becomes crucial and critical in normal or deficit rainfall years.

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Key Words : CROPWAT, Effective rainfall, ET0, Crop water requirement, Anantapur region

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The population of India is expected to stabilize around 1640 million by the year 2050. As a result, gross per capita water availability will decline from 1820 m^3 /yr in 2001 to as low as 1140 m^3/yr in 2050. Total water requirement of the country for various activities around the year 2050 has been assessed to be 1450 km^3/yr. This is significantly more than the current estimate of utilizable water resource potential (1122 km^3/yr) through conventional development strategies. Therefore, when compared with the availability of 500 km^3/yr at present the water availability around 2050 needs to be almost trebled. Various options have been considered in quantitative terms, as possible sources to augment the anticipated deficit. Efficient use of water in the state of Andhra Pradesh is becoming an important issue due to increasing irrigation water requirements as well as environmental sustainability. In canal command areas and dry land agriculture, it is very that the water requirements of crops are known at different management levels within the irrigated area to accomplish effective irrigation management. The crop water requirements are met from the effective rainfall, irrigation water applied and the available soil moisture. Assuming that the change in available soil moisture before and after crop seasons is negligible, the water requirement of crop are met from effective rainfall and irrigation

water. The potential evapotranspiration ET_p of a crop is the volume of water required by it to meet its evapotranspirational requirements. The crop irrigation water requirement therefore consists of potential evapotranspiration, $ET_{p,}$ minus the effective precipitation.

Groundwater exploration for irrigation to meet the evapotranspiration is a costly, scare input and plays an important role in increasing food production in dry land agriculture. Unscientific and injudicious application of groundwater as irrigation in the Anantapur region resulted in depletion of the groundwater table. In order to avoid over exploration for irrigation, there is a need to estimate the crop water requirement accurately to apply irrigation water efficiently. Several computer models are now available to estimate crop water requirement. The crop water requirement for the different crops under Anantapur region is very essential for effective utilization of the groundwater and also increases the crop yield. A study was carried out for the Anantapur region using CROPWAT 8.0 model.

EXPERIMENTAL METHODOLOGY

The information about climatic conditions, soil types and cropping pattern were obtained in the study area from the Agricultural Research Station (ARS) Anantapur and various line departments.

Location of the study area :

The study area is Anantapur district lies between 13^0 40' and 15^0 15' Northern latitude and 76^0 50' and 78^0 30' Eastern longitude. It is bounded by Kurnool district on the North Bellary on the West, Kadapa on the East and Chittoor, Tumkur and Maddikere district of Karnataka on the South, respectively with a total geographical area of 19.13 lakh hectares. Agriculture remains the predominant activity in the villages, with 80% of total worker engaged in agriculture, either as cultivators or agricultural labors. Being located in the rain shadow region of Andhra Pradesh, the district is drought-prone.

Climatic conditions :

The Anantapur region is considered as one of the arid areas with low precipitation and high evaporative demand. The average air temperature is 28.42^0 C, where as the maximum air temperature is 40.3^0 C and the minimum air temperature is 15.5^0 C. The average minimum relative humidity is 41 per cent, and the average maximum relative humidity is 89 per cent. The average wind speed is equal to 10.3 km/hr while the annual precipitation ranges from 256-1089 mm.

Soil description :

The Most of the Anantapur region is characterized by sandy loam soils with gravel. A total effective soil depth is in average about 180 cm while the depth of the top layer is about 40-50 cm representing about one-third of the whole soil profile.

CROPWAT :

CROPWAT 8.0 is a programme that uses the Smith (1992) Penman (1948) and Monteith (1965) methods for calculating reference crop evapotranspiration. These estimates are used in crop water requirements and irrigation scheduling calculations. CROPWAT 8.0 calculates the irrigation water requirements (either per month or per week period or as required) of a cropping pattern in an irrigated area, for various stages of crop development throughout the crops' growing season.

Different scenarios of good/normal/deficit rainfall years :

Good year, normal year and deficit years were identified based on the rainfall data. When the total rainfall for a year exceeds 600 mm then it was considered as good year and when the total rainfall of a year is between 400 to 600 mm, it was considered as normal year and if the total rainfall in a year is below 400 mm then it was considered as deficit year. After identification of good, normal and deficit years, the climate data for different scenario were fed into the CROPWAT model for good year, normal year and deficit years. Crop water requirements of the different crops were estimated for the different scenarios.

EXPERIMENTAL FINDINGS AND DISCUSSION

Based on the climate data (Table 1), the evapotranspiration was calculated using Penman (1948) Monteith (1965) equation in CROPWAT model. The values of monthly evapotranspiration and effective rainfall were presented in Table 1. The maximum ET_o observed during the month of May as 8.27 mm/day and minimum ET_o during the month of November as 4.08 mm/day. The average annual ET_o was estimated for the period 1985 to 2012 as 2219.20 mm/year (6.08 mm/day). The maximum quantity of effective rainfall observed during the month of September as 79.5 per cent of the monthly rainfall *i.e.* 101.7 mm and average annual effective rainfall was estimated over the period 1985 to 2012 as 85.5 per cent of the average annual rainfall *i.e.* 526 mm out of 615.4 mm of average annual rainfall.

Crop water requirement :

Climate data, rainfall data, crop data, cropping pattern data and soil data were fed to the CROPWAT 8.0 model for the estimating the crop water requirements in Anantapur region. The crop water requirements were presented in Table 2 and the crop water requirement for each dec. *i.e* for 10 days at different stages of groundnut crop shown in the Table 3. The crop water requirement of the Anantapur region was estimated

for the groundnut *Kharif* and *Rabi* crop as 591.3 mm and 443.3 mm, respectively. In addition to that estimated crop water requirement for the vegetables, cotton, rice, pulses and maize of the Anantapur region as 594.1 mm, 878.6 mm, 1110.6 mm, 659.9 mm and 679.3 mm, respectively. The similar studies were carried out by Srinivasulu *et al.* (2003) for Krishna Western Delta, Khandelwal *et al.* (1996) estimated the crop water requirement for Mahi right bank canal command and Singandhupe and Sethi (2005) estimated the evapotranspiration of wheat under semi arid environment.

Table 1 : The average evapotranspiration of the Anantapur region over the period of 28 years from 1985 to 2012

Month	Min. temp (^{O}C)	Maxi. temp (^{O}C)	RH (%)	Wind speed (km/day)	Sunshine hours	Rainfall (mm)	Effective rain fall (mm)	ET_o mm/day
January	16.7	31.3	55	181	10.0	2.0	2.0	4.85
February	19.2	34.5	49	189	10.1	0.3	0.3	5.82
March	22.0	37.6	41	193	7.0	6.2	6.1	6.28
April	25.6	39.3	38	207	9.9	18.7	18.1	7.69
May	25.8	38.9	42	290	9.4	49.4	45.5	8.45
June	24.4	35.7	51	388	7.6	64.6	57.9	7.85
July	23.6	33.7	57	394	7.4	96.4	81.5	7.05
August	23.1	32.9	61	353	9.3	109.4	90.3	6.80
September	22.9	32.9	61	252	8.2	127.9	101.7	5.94
October	21.9	32.0	63	152	6.8	100.1	84.1	4.62
November	19.1	31.0	64	146	5.6	34.5	32.6	3.90
December	16.5	30.1	63	164	5.5	5.9	5.8	3.72
Average annual rain fall						615.4	526	6.08

Table 2 : Crop water requirement (CWR) for the different crops of Anantapur district

Sr. No.	Type of the crop	Sowing date	Harvesting date	Crop period (days)	CWR (mm)
1.	Ground nut (*Kharif*)	22/06	09/10	110	591.3
2.	Ground nut (*Rabi*)	10/11	27/02	110	443.3
3.	Vegetable	18/06	20/09	95	594.1
4.	Cotton	06/06	02/12	180	878.6
5.	Rice	12/06	09/10	150	1110.6
6.	Pulses(Millet)	30/06	11/12	165	659.9
7.	Maize	12/06	14/10	125	679.3

Table 3 : Crop water requirement for *Kharif* groundnut crop based on the historical weather data of Anantapur region (*Hear 1 dec is equal to 10 days)*

Month	Dec.	Stage	Crop co-efficient Kc	ETc mm/day	ETc mm/dec	Effective rainfall mm/dec	Irr. Req. mm/dec
June	3	Init	0.40	3.03	27.3	19.4	5.7
July	1	Init	0.40	2.93	29.3	25.0	4.3
July	2	Deve	0.51	3.63	36.3	27.8	8.5
July	3	Deve	0.78	5.46	60.0	28.6	31.5
August	1	Deve	1.05	7.24	72.4	29.0	43.3
August	2	Mid	1.17	7.93	79.3	30.0	49.3
August	3	Mid	1.17	7.60	83.6	31.3	52.3
September	1	Late	1.10	7.05	70.5	33.5	37.0
September	2	Late	0.92	5.81	58.1	35.3	22.8
September	3	Late	0.75	4.47	44.7	32.8	11.8
October	1	Late	0.63	3.32	29.9	27.9	0.0
		Total			591.3	320.7	266.5

Table 4 : Crop water requirement at different stages for the Anantapur region good year (*Kharif* groundnut)

Month	Dec.	Stage	Crop co-efficient Kc	ETc mm/day	ETc mm/dec	Effective rainfall mm/dec	Irr. req. mm/dec
June	3	Init	0.4	2.91	26.2	25.4	0.0
July	1	Init	0.4	2.69	26.9	35.1	0.0
July	2	Deve	0.51	3.18	31.8	40.8	0.0
July	3	Deve	0.78	4.71	51.8	40.9	10.9
August	1	Deve	1.05	6.20	62.0	40.5	21.6
August	2	Mid	1.16	6.67	66.7	41.2	25.5
August	3	Mid	1.16	6.46	71.1	41.6	29.5
September	1	Late	1.12	6.06	60.6	43.1	17.5
September	2	Late	0.97	5.05	50.5	44.1	6.4
September	3	Late	0.81	4.01	40.1	39.7	0.3
October	1	Late	0.65	3.08	27.7	32.4	0.0
Total					515.3	424.7	111.8

Table 5 : Crop water requirement at different stages for the Anantapur region normal year (*Kharif* groundnut)

Month	Dec	Stage	Crop co-efficient Kc	ETc mm/day	ETc mm/dec	Effective rainfall mm/dec	Irr. req. mm/dec
June	3	Init	0.40	2.97	26.8	16.6	8.4
July	1	Init	0.40	2.90	29.0	13.4	15.5
July	2	Deve	0.52	3.64	36.4	10.3	26.1
July	3	Deve	0.79	5.37	59.1	12.2	46.9
August	1	Deve	1.06	6.99	69.9	13.7	56.3
August	2	Mid	1.17	7.50	75.0	14.5	60.5
August	3	Mid	1.17	7.32	80.5	20.2	60.3
September	1	Late	1.14	6.92	69.2	28.3	40.9
September	2	Late	0.98	5.81	58.1	34.4	23.7
September	3	Late	0.82	4.50	45.0	31.5	13.5
October	1	Late	0.66	3.36	30.2	25.0	2.5
Total					579.2	220	354.6

Table 6 : Crop water requirement at different stages for the Anantapur region bad year (*Kharif* groundnut)

Month	Dec	Stage	Crop co-efficient Kc	ETc mm/day	ETc mm/dec	Effective rainfall mm/dec	Irr. Req. mm/dec
June	3	Init	0.40	3.21	28.8	10.2	17.5
July	1	Init	0.40	3.04	30.4	19.9	10.5
July	2	Deve	0.52	3.71	37.1	26.0	11.2
July	3	Deve	0.79	5.42	59.7	26.4	33.3
August	1	Deve	1.06	6.90	69.0	27.6	41.4
August	2	Mid	1.17	7.26	72.6	29.4	43.2
August	3	Mid	1.17	7.37	81.0	24.4	56.6
September	1	Late	1.14	7.37	73.7	15.7	58.0
September	2	Late	0.99	6.48	64.8	10.0	54.8
September	3	Late	0.83	5.01	50.1	17.8	32.3
October	1	Late	0.67	3.72	33.4	28.5	1.7
Total					600.7	235.8	360.6

Similarly, Smith (1992) was used CROPWAT for irrigation planning and management.

Crop water requirement for different scenarios :

Estimation of the crop water requirement was carried out by using the historical weather data of the Anantapur district *i.e.* the average climate and rainfall data sets of good, normal and bad years, together with soil and crop data files and the corresponding planting dates. Based on the climate data, rainfall data, crop data, cropping pattern data and soil data fed to the CROPWAT model, the crop water requirements for each dec *i.e.* for 10 days were estimated for the good, normal and bad years for the groundnut crop of the Anantapur region. The crop water requirements for different scenarios are presented in the Tables 4, 5 and 6. Similar work related to the topic was also done by Raut and Jadhav (2012)

Conclusion :

The average effective rainfall was estimated for the Anantapur region as 543.9 mm out of 603.13 mm annual rainfall. The crop water requirement of the Anantapur region was estimated for the groundnut *Kharif* and *Rabi* crop as 591.3 mm and 443.3 mm, respectively. In addition to that estimated crop water requirement for the vegetables, cotton, rice, pulses and maize of the Anantapur region as 594.1 mm, 878.6 mm, 1110.6 mm, 659.9 mm and 679.3 mm, respectively. Crop water requirement was estimated for good, normal and bad years for the *Kharif* groundnut crop to optimize the benefits through application of groundwater as irrigation accurately. From the results it is clear that efficient water management becomes crucial and critical in normal or deficit rainfall years. There is a need to create awareness on the effective utilization of groundwater to the farmers of the Anantapur region.

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