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Estimation of crop water requirement of maize and cotton using fao cropwat 8.0 model in jagtial district

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Abstract

Aims: To estimate the crop water requirement and irrigation schedules for maize crop in Red sandy soils in Rabi season and cotton crop in Kharif season in Red sandy and black soils.

Place and Duration of Study: The study area selected for the Jagitial District. The total population of the district is 9.85 lakh and soil which are predominant in this area are Red sandy and Black soils. Agriculture remains the predominant activity in Jagtial District.

Methodology: Data is collected from Meteorological observatory, Regional Agricultural Research Station, polasa, Jagtial. In this present study 10 years from 2009 to 2019 of monthly meteorological data were used and Crop data include the number of days at each growth phase, Kc value at each growth phase, root depth, critical depletion value, and crop yield response factor.

Results: Results showed that ET_o varied from 2.34 to 4.89 mm/day and the effective rainfall varied from 1.5 to 141.4 mm. The irrigation requirements were 220.1 and 100.9 mm/dec for Maize and cotton, respectively. There is more water demand for crops during the dry seasons (summer and autumn) and a lesser demand during the wet seasons (winter and spring). The total gross irrigation and the total net irrigation were 368.5 mm and 258 mm for Maize, 342.1 mm and 136.9 mm for Cotton in red sandy soils, 251.5 mm and 100.6 mm for cotton in black soils.

Conclusion: In Rabi Maize crop, available effective rainfall is less to compensate the Crop water requirement. Hence, additional Irrigation requirement is needed to satisfy the Crop water requirement. In red sandy soils cotton crop requires six irrigation schedules and four irrigation schedules in black soils. This paper might be useful to prevent over or under irrigation and planning water management strategies in the Jagtial district for maize and cotton crops.

Keywords: crop water requirement, maize, cotton, irrigation schedules, effective rainfall. cropwat 8.0

Introduction

Severe water shortages will be occur in future in India and water for agriculture is becoming scarce with in light of growing water demands from different sectors (IWMI 2010). Agriculture is the largest (81%) consumer of water in India and hence more efficient use of water in agriculture needs to be top most priority (Surendran *et al.*, 2013) [11]. The dependence on water for food production has become a critical constraint to enhance food productivity. A better understanding of the intricate interactions between climate, water and crop growth needs to be a priority area in India. Water is an essential input for crop production. The productivity of most of the crops in the District remains almost static or lower when compared with the national average. The uneven rainfall distribution pattern and low water holding capacity of soils, soil moisture stress occurs during crop growing season and it is considered as one of the major limiting factors for higher productivity in the District. For better management of available resources and agricultural productions, it is necessary to understand irrigation water requirement and present level of water supplies.

Methods based on ratio of irrigation water to cumulative pan evaporation (Aiyelaagbe and Ogbonnaya, 1996), open pan evaporation rate (Singh, 1987; Manjunath *et al.*, 1994) [9, 8] and soil moisture depletion (Home *et al.*, 2000) [6] have been widely used for scheduling irrigation.

Irrigation scheduling associates deciding when and how much water to apply to a field. Better scheduling will apply water at the right time and in the right quantity in order to optimize production and minimize adverse environmental impacts. Bad scheduling will mean that either not enough water is applied or it is not applied at the right time, resulting in under-watering, or too much is applied or it is applied too soon resulting in over-watering. Under or overwatering can cause reduced yields, lower quality and inefficient use of nutrients. The efficiency of water in agricultural production is usually low. Only 40 to 60% of the water is effectively used by the crop, the rest of the water is lost in the system or in the farm either through evaporation runoff, or by percolation into the groundwater. Irrigation scheduling, if properly managed can offer a better solution to improve water efficiency in the farm. Irrigation scheduling makes sure that water is consistently available to the plant and that it is applied according to crop requirements. Irrigation scheduling using CROPWAT considering method of irrigation timing, irrigation at 100% critical depletion, irrigation at fixed interval per stage and method of irrigation application, Refill soil moisture content to 100% to field capacity.

It is important to understand the crop water requirements (CWRs) and irrigation scheduling to provide the irrigation demand. Software modeling by programs like AQUACROP and

CROPWAT 8.0 may be significant practice employed by scientists for the assessment of crop evapotranspiration, Crop Water Requirement, and irrigation scheduling. The FAO Penman-Monteith method is used in the present study as it is recommended as the sole standard method for the computation of the reference evapotranspiration. The FAO Penman Monteith method have needs radiation, air temperature, humidity and wind speed data. The irrigation schedule recommendations for various crops should be location-specific, considering the soil types and agro-ecological conditions (Solomon *et al.*, 2018).

The crop water requirement for the (Maize and Cotton crop) under Jagtial region is very essential for effective utilization of the groundwater and also increases the crop yield. In the present study, the crop water requirements and irrigation scheduling for selected crops (Maize and Cotton crop) in Jagtial District, Northern Telangana were studied using the CROPWAT 8.0 model.

Materials and Methods

Study area

The study area selected for the Jagitial District and situated in the northern part of the state Telangana, India. The geographical coordinates of 18.7895° N latitude and 78.9120° E longitude at an average altitude of 243m. Total geographical area of the district is 2,419 km^2 and the average annual rainfall is 1034 mm. The total population of the district is 9.85 lakh and soil which are predominant in this area are Red sandy and Black soils. Agriculture remains the predominant activity in the villages, with 80% of total worker engaged in agriculture, either as cultivators or agricultural labors.

Methodology

For this study Food and Agriculture Organization-CROPWAT 8.0 model is used. CROPWAT was developed by department of Land and Water Resources of FAO.CROPWAT 8.0 is a computer program that integrates several models necessary to predict crop water requirement (CWR), irrigation water management and irrigation scheduling (Smith, 1991) [10]. CWR depends on climatic conditions, crop area and type, soil type, growing season and crop production frequencies (George *et al.*, 2000) [5]. It follows FAO approved Penman-Montieth method to estimate reference evapotranspiration (ETo), crop evapotranspiration (ETc) and irrigation water management (FAO, 1998; Smith, 1991) [10]. It is to be noted that ETc represents amount of water that crop losses due to evapotranspiration while, CWR represent amount of water to be applied. Modelling of crop evapotranspiration and irrigation water requirements were carried out using climatic, crop and soil data. The model required the following data for estimating irrigation water requirements.

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 Meteorological observatory, Regional Agricultural Research Station, polasa, Jagtial. In this present study 10 years from 2009 to 2019 of monthly meteorological data were used. These data include Maximum Temperature Minimum Temperature (°C), Mean Relative Humidity (%), Wind Speed (km/h), Sunshine Hours (Hrs).

Rainfall data

Monthly rainfall data was also collected from Meteorological observatory, Regional Agricultural Research Station, polasa, Jagtial for 10 years from 2009 to 2019 which was used for calculation of effective rainfall. USDA soil conservation method is used in this software.

Crop data

Crop data include the number of days at each growth phase, Kc value at each growth phase, root depth, critical depletion value, and crop yield response factor. The yield response factor (Ky) is the ratio of relative yield reduction to relative evapotranspiration deficit that integrates the weather, crop and soil conditions that make crop yield less than its potential yield in the face of deficit evapotranspiration.

Soil Data

Soil type in this area is Red sandy loam and black cotton soil. This model 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.

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.

Crop Water Requirement (CWR)

The crop water requirement is the amount of water equal to what is lost from a cropped field by the Evapotranspiration and is expressed by the rate of ET in mm/day. Evaluation of CWR is derived from crop evapotranspiration (ETc) which can be calculated by the following equation $ETc = Kc \times ET_0$ where Kc is the crop coefficient. It is the ratio of the crop ETc to the ET_0, and it represents an integration of the effects of four essential qualities that differentiate the crop from reference grass, and it covers albedo (reflectance) of the crop–soil surface, crop height, canopy resistance, and evaporation from the soil. Due to the ET differences during the growth stages, the Kc for the crop will vary over the developing period which can be divided into four distinct stages: initial, crop development, mid-season and late season.

Irrigation Water Requirement (IR)

The CROPWAT 8.0 Model can compute the daily water balance of the root zone as far as root zone depletion at the day's end by the following equation

$$Dr,i = Dr,i-1 - (P - ROi) - Ii - CRi + ETci + Dpi$$

where Dr, i is the root zone depletion at the day's end i (mm), Dr,i-1 is the water content in the root zone at the previous day's end (mm), Pi is the precipitation on day i (mm), ROi is the surface soil runoff on day i (mm), Ii is the net irrigation depth on day i which infiltrates the soil (mm), CRi is the capillary rise from the groundwater table on day i (mm), ETci is the crop evapotranspiration on day i (mm), and DPi is the lost water of the root zone on day i (mm).

Irrigation Schedule
Irrigation scheduling determines the right measure of water to irrigate and the right time for watering. The CROPWAT model calculates the ET_0, CWR, and Irrigation Requirements to develop the irrigation schedules under different administration conditions and water supply plans.

Results and Discussion
Maize crop
Estimation of the crop water requirement was carried out by using the historical weather data of the observatory data of Regional Agricultural Research Station, Polasa, Jagtial district (Table 2). The data which was entered in the CROPWAT software included the details like country (India), climatic station (Polasa), type of crop, date of cultivation, and soil type (Red sandy loam). Automatically software will compute the ET_0, effective rainfall, and total irrigation requirement for the respective crop once the data is fed to the model.

Table 1: Details of the crop required as per the CROPWAT model

Crop Name	Planting date	Harvesting date	Critical depletion	Rooting depth	Crop growth periods				
					Initial	Development	Mid	Late	Total
Maize	01-11	05-03	0.55	1.2 m	20	35	40	30	125

Table 2: Climate characteristics, rainfalls, and ET_0 of Polasa area (average for 2009–2019 period) obtained using CROPWAT software.

Month	Min Temp °C	Max Temp°C	Humidity %	Wind km/day	Sun hours	Rad MJ/m²/day	ET_0 mm/day	Rainfall mm	Effective Rainfall mm
January	14.2	30.3	56	2	7.2	16.0	2.34	10.4	10.2
February	17.6	33.0	55	2	7.8	18.5	2.98	10.8	10.6
March	20.1	36.1	50	2	7.6	20.0	3.55	11.8	11.6
April	23.2	38.9	49	2	8.0	21.7	4.12	9.3	9.2
May	28.3	43.6	46	4	8.5	22.7	4.89	15.1	14.7
June	25.8	36.9	60	10	5.4	17.9	4.11	115.0	93.8
July	23.9	32.2	73	9	3.4	14.8	3.30	216.0	141.4
August	23.5	31.4	78	7	3.9	15.4	3.27	185.4	130.4
September	24.3	32.1	77	4	5.4	17.0	3.51	145.4	111.6
October	21.4	33.9	71	1	7.0	17.8	3.50	82.3	71.5
November	16.9	31.9	64	1	7.3	16.4	2.83	10.1	9.9
December	13.8	30.3	58	5	7.2	15.4	2.36	1.5	1.5
Avg	21.1	34.2	61	4	6.6	17.8	3.40	813.1	616.4

Crop Water Requirement
Crop water requirement is a given amount of water lost due to crop evapotranspiration (ETc). In other word, the value of the crop water requirement is given equally to the amount of plant evapotranspiration.

The value of daily or decadal crop water requirements for maize can be seen in Table 3. The largest crop water requirement occurs in the midseason phase, which is the third decade of January. While the lowest water demand value occurs in the initial phase because at this time the plants required water is not much needed. The plants need the most water when it occurs in the process of forming the cobs as requires more energy to make cob formation in the phase towards the late-season.

The crop water requirement for the maize crop 249 mm and irrigation requirement was of 220.1 mm respectively (Table 3). Whereas, the detailed results of total gross irrigation, total net irrigation, actual water use by crop and potential water use by crop is given in the Table 4.

Table 3: Daily and Decadal Crop Water Requirement of maize in the study area

Month	Decade	Stage	Kc Coeff	Etc mm/day	Etc mm/dec	Eff rain mm/dec	Irr. Req mm/dec
Nov	1	Init	0.10	0.31	3.1	8.5	0.0
Nov	2	Init	0.10	0.28	2.8	0.8	2.0
Nov	3	Deve	0.27	0.71	7.1	0.7	6.4
Dec	1	Deve	0.57	1.43	14.3	0.8	13.5
Dec	2	Deve	0.87	2.05	20.5	0.0	20.5
Dec	3	Mid	1.13	2.65	29.2	0.8	28.4
Jan	1	Mid	1.16	2.71	27.1	2.7	24.4
Jan	2	Mid	1.16	2.70	27.0	3.8	23.3
Jan	3	Mid	1.16	2.95	32.5	3.7	28.8
Feb	1	Late	1.10	3.04	30.4	3.5	26.9
Feb	2	Late	0.90	2.69	26.9	3.5	23.4
Feb	3	Late	0.72	2.28	18.3	3.6	14.6
Mar	1	Late	0.59	1.98	9.9	1.9	8.0
					249.0	34.3	220.1

Table 4: Total gross net irrigation and rain efficiency –Maize

Total gross irrigation	368.5 mm	Total rainfall	34.9 mm
Total net irrigation	258.0 mm	Effective rainfall	27.0 mm
Total irrigation losses	0.0 mm	Total rain loss	7.9 mm
Actual water use by the crop	247 mm	Moist deficit at harvest	4.0 mm
Potential water use by the crop	247 mm	Actual irrigation requirement	220.0 mm
Efficiency irrigation schedule	100.0%	Efficiency rain	77.5 mm

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 80%. The table 5 given below indicates the irrigation scheduling of the maize crop in Rabi season in the different stages like developing stage, mid stage and end stage. As per irrigation scheduling shows that total gross irrigation of maize crop is 368.5 mm and total net irrigation is 258 mm.

Eight irrigation schedules have been scheduled for maize crop (Table 5).

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.

Rainfall efficiency was 77.5% with total effective rainfall of 27 mm. The total net irrigation varied from the irrigation requirement due to change in effective rainfall efficiency.

Higher temperatures lead to increase in evapotranspiration and water requirements more frequent irrigation schedule. Shift in crop sowing and planting dates show a shift in crop production periods in turn which has impact on crop water requirement.

Table 5: Irrigation schedules for maize crop during the study period as per the CROPWAT model

Date	Day	Stage	Rain mm	Ks fraction	Eta %	Depletion%	Net Irrigation	Deficit mm	Loss mm	Gross Irrigation mm
1 Nov	1	Init	1.00	100	50	42.3	0.0	0.0	60.4	6.99
15 Dec	45	Dev	1.00	100	41	34.1	0.0	0.0	48.7	0.13
30Dec	60	Mid	1.00	100	43	35.9	0.0	0.0	51.3	0.40
14 Jan	75	Mid	1.00	100	43	35.9	0.0	0.0	51.3	0.40
28 Jan	89	Mid	1.00	100	41	34.2	0.0	0.0	48.8	0.40
10 Feb	102	End	1.00	100	43	35.7	0.0	0.0	51.0	0.45
1 Mar	121	End	1.00	100	47	39.8	0.0	0.0	56.9	0.35
5Mar	End	End	1.00	0	5					

Cotton Crop

Estimation of the crop water requirement was carried out by using the historical weather data of the observatory data of Regional Agricultural Research Station, Polasa, Jagtial district (Table 6). The data which was entered in the CROPWAT software included the details like country (India), climatic station (Polasa), type of crop, date of cultivation, and soil type (Red sandy loam). Automatically software will compute the ET_0, effective rainfall, and total irrigation requirement for the respective crop once the data is fed to the model.

Table 6: Details of the crop required as per the CROPWAT model

Crop Name	Planting date	Harvesting date	Critical depletion	Rooting depth	Crop growth periods				
					Initial	Development	Mid	Late	Total
Cotton	15-06	01-12	0.65	1.4 m	30	40	55	45	170

Crop Water Requirement

The largest crop water requirement occurs in the late season phase, which is the second decade of November. While the lowest water demand value occurs in the initial phase because at this time the plants required water is not much needed in red sandy and black soils. The plants need the most water when it occurs in the process of forming the bolls development as requires more energy to make bolls development in the phase towards the late-season.

The crop water requirement for the cotton crop in red sandy and black soils 456.2 mm and irrigation requirement was of 527.1 mm respectively. (Table 7, 9). Whereas, the detailed results of total gross irrigation, total net irrigation, actual water use by crop and potential water use by crop is given in the Table 8, 10.

Table 7: Daily and Decadal Crop Water Requirement of Cotton in the study area

Month	Decade	Stage	Kc coeff	Etc mm/day	Etc mm/dec	Eff rain mm/dec	Irr. Req mm/dec
Jun	2	Init	0.35	1.44	8.6	19.6	0.0
Jun	3	Init	0.35	1.34	13.4	37.5	0.0
Jul	1	Init	0.35	1.25	12.5	43.7	0.0
Jul	2	Deve	0.39	1.28	12.8	49.9	0.0
Jul	3	Deve	0.57	1.89	20.7	47.7	0.0
Aug	1	Deve	0.77	2.52	25.2	44.9	0.0
Aug	2	Deve	0.96	3.12	31.2	43.8	0.0
Aug	3	Mid	1.09	3.65	40.2	41.6	0.0
Sep	1	Mid	1.10	3.76	37.6	39.9	0.0
Sep	2	Mid	1.10	3.85	38.5	38.1	0.4
Sep	3	Mid	1.10	3.85	38.5	33.4	5.1

Oct	1	Mid	1.10	3.85	38.5	28.9	9.5
Oct	2	Late	1.09	3.82	38.2	24.8	13.3
Oct	3	Late	0.99	3.23	35.6	17.7	17.9
Nov	1	Late	0.86	2.62	26.2	8.5	17.7
Nov	2	Late	0.73	2.08	20.8	0.8	20.0
Nov	3	Late	0.61	1.63	16.3	0.7	15.6
Dec	1	Late	0.54	1.37	1.4	0.1	1.4
					456.2	521.7	100.9

Table 8: Total gross net irrigation and rain efficiency –Cotton

Total gross irrigation	342.1 mm	Total rainfall	707.6 mm
Total net irrigation	136.9 mm	Effective rainfall	335.8 mm
Total irrigation losses	0.0 mm	Total rain loss	371.9 mm
Actual water use by the crop	454.9 mm	Moist deficit at harvest	24.2 mm
Potential water use by the crop	454.9 mm	Actual irrigation requirement	119.1 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	47.4 mm

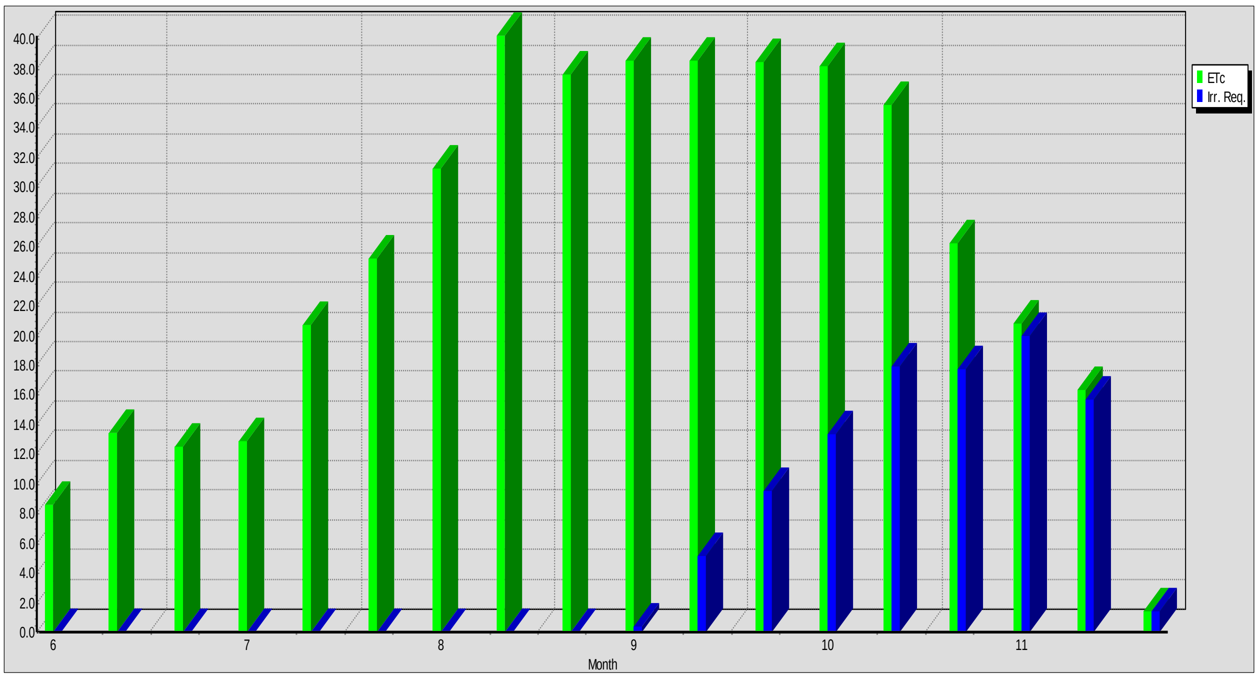

Fig 1: Crop water requirement of the cotton crop

Table 9: Daily and Decadal Crop Water Requirement of Cotton in the study area

Month	Decade	Stage	Kc coeff	Etc mm/day	Etc mm/dec	Eff rain mm/dec	Irr. Req mm/dec
Jun	2	Init	0.35	1.44	8.6	19.6	0.0
Jun	3	Init	0.35	1.34	13.4	37.5	0.0
Jul	1	Init	0.35	1.25	12.5	43.7	0.0
Jul	2	Deve	0.39	1.28	12.8	49.9	0.0
Jul	3	Deve	0.57	1.89	20.7	47.7	0.0
Aug	1	Deve	0.77	2.52	25.2	44.9	0.0
Aug	2	Deve	0.96	3.12	31.2	43.8	0.0
Aug	3	Mid	1.09	3.65	40.2	41.6	0.0
Sep	1	Mid	1.10	3.76	37.6	39.9	0.0
Sep	2	Mid	1.10	3.85	38.5	38.1	0.4
Sep	3	Mid	1.10	3.85	38.5	33.4	5.1
Oct	1	Mid	1.10	3.85	38.5	28.9	9.5
Oct	2	Late	1.09	3.82	38.2	24.8	13.3
Oct	3	Late	0.99	3.23	35.6	17.7	17.9
Nov	1	Late	0.86	2.62	26.2	8.5	17.7
Nov	2	Late	0.73	2.08	20.8	0.8	20.0
Nov	3	Late	0.61	1.63	16.3	0.7	15.6
Dec	1	Late	0.54	1.37	1.4	0.1	1.4
					456.2	521.7	100.9

Table 10: Total gross net irrigation and rain efficiency –Cotton

Total gross irrigation	**251.5 mm**	**Total rainfall**	**707.6 mm**
Total net irrigation	100.6 mm	Effective rainfall	447.4 mm
Total irrigation losses	0.0 mm	Total rain loss	260.2 mm
Actual water use by the crop	454.9 mm	Moist deficit at harvest	46.8 mm
Potential water use by the crop	454.9 mm	Actual irrigation requirement	7.4 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	63.2%

Irrigation Scheduling

Knowledge of crop water requirements and irrigation schedules improves irrigation management in the field. Water management is about controlling the amount, timing and rate of irrigation in an efficient and well planned manner. Tables 11&12 and Figures 2&3 illustrate the field crop irrigation schedules for the cotton crop in red sandy soils and black soils. The total gross irrigation mean and the total net irrigation mean are 342.1 mm and 136.9, 251.5 mm and 100.6 mm for cotton in red sandy soils and black soils. There are six irrigation schedules for cotton in red sandy soils and four irrigation schedules for cotton in black soils. The table 9&12 given below indicates the irrigation scheduling of the cotton crop in red sandy soils and black soils the different stages like developing stage, mid stage and end stages. In the below figures 2&3, is the total available moisture or the total amount of water available to the crop. There is the readily available water or the portion of that the plant can get from the root zone without facing water stress. 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. Rainfall efficiency was 47.4% with total effective rainfall of 335.8 mm in red sandy soils and in black soils Rainfall efficiency was 63.2% with total effective rainfall of 447.4 mm.

Table 11: Irrigation schedules for Cotton crop during the study period as per the CROPWAT model

Date	Day	Stage	Rain mm	Ks fraction	Eta %	Depletion %	Net Irrigation	Deficit mm	Loss mm	Gross Irrigation mm
15 Jun	1	Init	0.0	1.00	100	53	22.7	0.0	0.0	56.9
2 Sep	80	Mid	0.0	1.00	100	31	25.8	0.0	0.0	64.5
12 Oct	120	Mid	0.0	1.00	100	32	26.8	0.0	0.0	66.9
30 Oct	138	End	0.0	1.00	100	35	29.3	0.0	0.0	73.1
16 Nov	155	End	0.0	1.00	100	38	32.3	0.0	0.0	80.7
1 Dec	End	End	0.0	1.00	0	29				

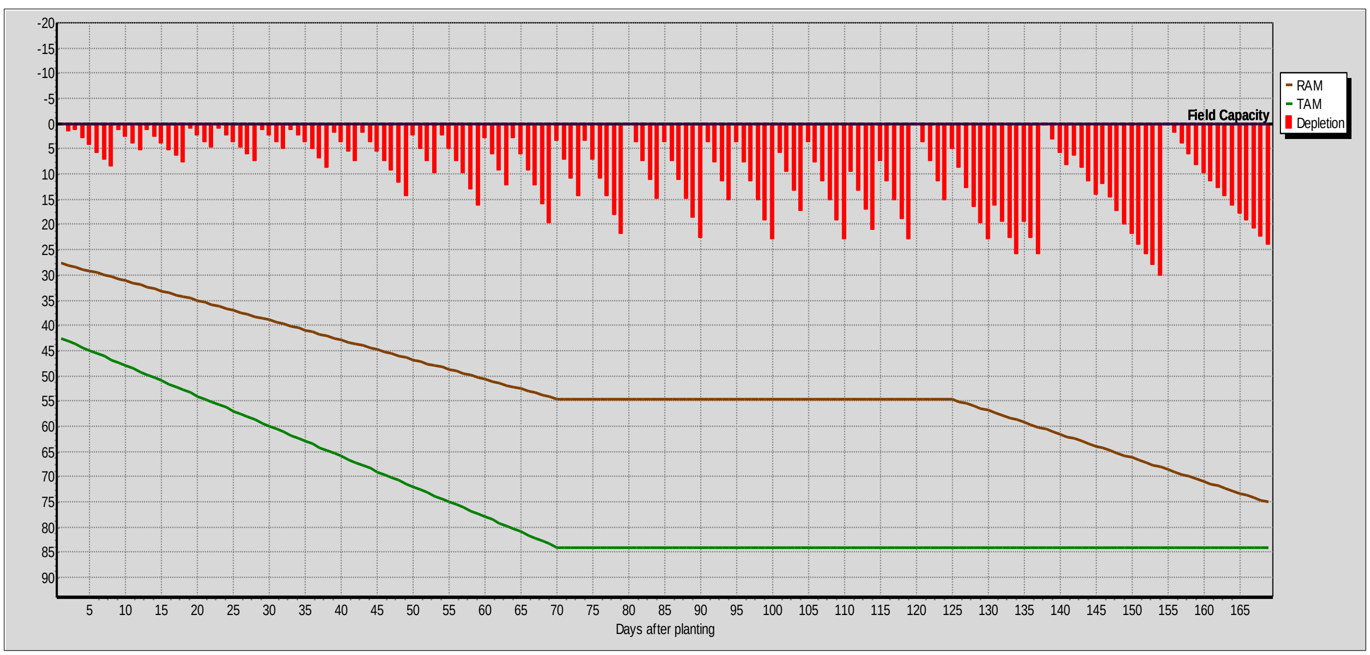

Fig 2: Irrigation scheduling graph for cotton in Red Sandy soil

Table 12: Irrigation schedules for Cotton crop during the study period as per the CROPWAT model

Date	Day	Stage	Rain mm	Ks fraction	Eta %	Depletion %	Net Irrigation	Deficit mm	Loss mm	Gross Irrigation mm
15 Jun	1	Init	0.0	1.00	100	52	33.0	0.0	0.0	82.6
21 Jun	7	Init	0.0	1.00	100	17	13.9	0.0	0.0	34.6
5 Nov	144	End	0.0	1.00	100	19	53.7	0.0	0.0	134.3
1 Dec	End	End	0.0	1.00	0	17				

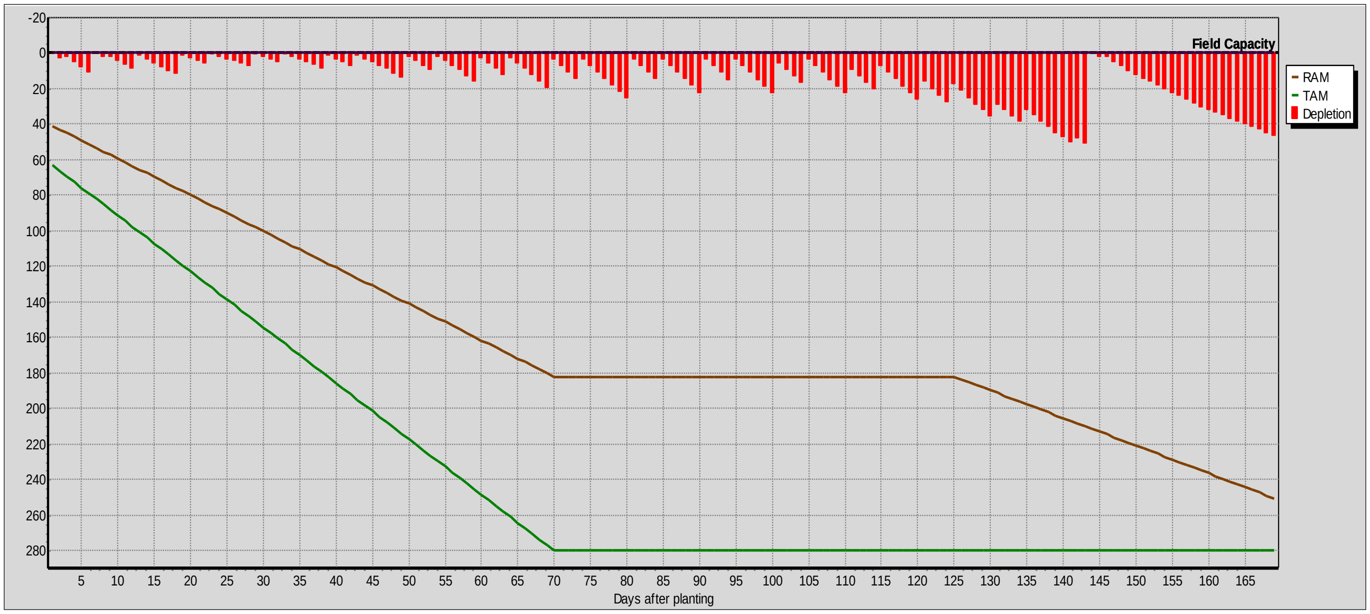

Fig 3: Irrigation scheduling graph for cotton in Black Soil

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. In Rabi Maize crop, available effective rainfall is less to compensate the Crop water requirement. Hence, additional irrigation requirement is needed to satisfy the Crop water requirement. In red sandy soils cotton crop requires six irrigation schedules and four irrigation schedules in black soils. 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.

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Competing Interests
Authors have declared that no competing interests exist.

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