Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(1): 1944-1949
Received: 04-11-2019
Accepted: 06-12-2019

Poornima
Ph.D scholar Soil and Water Engineering, Department, College of Agricultural Engineering, University of Agricultural Science, Raichur, Karnataka, India

Dr. MS Ayyanagowdar
Professor and Head Irrigation and Drainage Engineering, Department, College of Agricultural Engineering, University of Agricultural Science, Raichur, India

Dr. BS Polisgowadar
Professor Irrigation and Drainage Engineering, Department, College of Agricultural Engineering, University of Agricultural Science, Raichur, Karnataka, India

Dr. M Nemichandrappa
Professor Soil and Water Engineering, University of Agricultural Science, Raichur, Karnataka, India

Dr. MV Ravi
Senior Scientist and Head KVK, Gangavati, Karnataka, India

Dr. Lata HS
Assistant Professor, (Department of agronomy), College of Sericulture, Chintamani, Karnataka, Karnataka, India

Ramesh G
Principle scientist AICRP on plastic culture, Soil and Water Engineering, University of Agricultural Science, Raichur, Karnataka, India

Corresponding Author:
Poornima
Ph.D scholar Soil and Water Engineering, Department, College of Agricultural Engineering, University of Agricultural Science, Raichur, Karnataka, Karnataka, India

Estimation of crop water requirement and irrigation scheduling of baby corn using CROPWAT model

Poornima, Dr. MS Ayyanagowdar, Dr. BS Polisgowadar, Dr. M Nemichandrappa, Dr. MV Ravi, Dr. Lata HS and Ramesh G

Abstract
Land and water resources are finite and their management is crucial for improving food security in the country. Adoption of drip irrigation proved to be technically feasible and helps in saving significant amount of water and increase the quality and quantity of produce. Now, there is a need to decrease consumption, improve management of water resources and determine the water requirements of the major crops because agriculture is the first consumer of water in India. The Food and Agriculture Organization (FAO) CROPWAT 8.0 simulation software and the CLIMWAT 2.0 tool attached to it have been used in this research to find the crop water requirements (CWRs) and irrigation scheduling for baby corn crop. Baby corn is a unique cereal with high nutritional value. The demand for baby corn is rapidly increasing in urban areas in India. A field experiment was conducted by using a split plot design with four replications, five irrigation intervals, namely, 100 % ET, 90 % ET, 80 % ET and 70 % ET were used. The results revealed that the estimated crop evapotranspiration baby corn is 244.8 mm.

Keywords: Crop water requirement, irrigation scheduling, baby corn using CROPWAT model

Introduction
Land and water management are central to agriculture and rural development, and are intrinsically linked to challenges of food insecurity and poverty, climate change and adaptation and mitigation as well as degradation and depletion of natural resources. Combination of high yielding varieties, enhanced availability of water and fertilizers, the three key inputs in agriculture, transformed India from a country of begging bowl to one with over-flowing granaries (Singh, 2015)[4]. With a food grain production touching an all-time record level of 263 plus million tonnes (Mt) in 2013-14, Indian agriculture has made stupendous progress in ensuring food security to its vast population. Presently agriculture is the largest consumer of water (82.8%) in the country. It is expected that reduction in size in land holding, decreasing per capita water availability, The availability of water for agricultural sector is bound to decrease due to fierce competition from industrial, power and domestic use in urban areas while the same time food production must be increased to meet the food grain requirement of the growing population will seriously affect the sustainable use of water resources and it will make it difficult to accomplish the largest production. Hence, to ensure sufficient availability of food, fodder, fiber and fuel for the present generation without leaving any stress for the requirement for future generation water use efficiency in agricultural production has to be essentially improved at field level.

Adaptation of drip irrigation and fertigation proved to be technically feasible and economically viable and helps in saving significant amount of water and increase the quality and quantity of produce. Drip irrigation offers a great potential to improve water management by improving cop yield and quality using less water and by localizing fertilizer and chemical applications to enhance their efficient use and to reduce pollution risk (Fischer *et al.*, 2007) [2]. It can be also called as localized irrigation, to emphasize that only part of the soil volume is wetted (Lamm *et al.*, 2007) [3].

Agriculture is the main consumer of water in India, and the irrigation systems require modernization and good management by evaluating water system prerequisites precisely. It is important to know the crop water requirements (CWRs) and irrigation scheduling to take care of the irrigation demand. Software modeling by programs like AQUACROP and CROPWAT 8.0 is a significant practice used by scientists for the assessment of crop evapotranspiration, CWR, and irrigation scheduling. These software programs were developed by the Food and Agriculture Organization (FAO) as tools to assist irrigation engineers and agronomists in performing the usual calculations for water irrigation studies and mainly in the management and design of irrigation schemes.

In the present study, the irrigation water requirements and irrigation scheduling of baby corn crop in CAE, research plot, were studied using the CROPWAT model. Baby corn is a low-calorie vegetable. The demand for baby corn is rapidly increasing in urban areas in India. Baby corn is grown from miniature corn plants, but it is actually just regular corn that has been picked before its matured. Due to its short duration crop can be fitted in an intensive cropping system (Dass *et al.*, 2008) [1] baby corn has a nutritional makeup closer to a non-starchy vegetable. Plus, it is a good source of essential nutrients. Baby corn is a source of sodium. Baby corn is nutrient-rich, iron, and essential vitamins are vitamin A, vitamin C. Keeping this view a field experiment was conducted to compute crop water requirement of baby corn and to know the effect of irrigation scheduling on growth parameters of baby corn.

Materials and Methods

The experiment was carried out at field irrigation laboratory with an area of 1680 m^2 (42m x 40m) CAE, Raichur. It is geographically situated at 16.2036° N, 77.3300° E. The irrigation water was collected from the tube well from which irrigation water was supplied to the crop through drip. The irrigation water quality was analyzed using standard methods P^H, Ecw were found to be 6.68 and 0.41. The experiment was laid out with two main treatments, five sub treatments and replicated four times. Different irrigation schedules were to arrive at optimal irrigation scheduling for enhancing water use efficiency. The irrigation interval proposed was daily irrigation. The amount of irrigation application was planned at 100 % ET, 90 % ET, 80 % ET and 70 % ET. Drip irrigation system was adopted for water supply. The dripper lines were laid at 75cm apart with an emitter spacing of 40cm for discharge rates of 4 l/hr. The end plugs (caps) were fixed to all main, sub main and laterals to facilitate maintenance of the system.

Data Requirement

Four types of data are required for using the CROPWAT software, namely, rainfall data, climatic data, soil data, and crop data. Climatic were gathered from the MARS, Meteorological Station, obtained from the CLIMWAT 2.0 which is a climatic database to be used in association with the CROPWAT program and which allows the calculation of IRs for different crops for a range of climatological stations around the world. CLIMWAT contains seven long-term monthly climatic parameters with the coordinates and altitude of the location. These parameters are monthly maximum and minimum temperature (°C), wind speed (km/h), mean relative humidity (%), sunshine hours (h), rainfall data (mm), and effective rainfall (mm). The crop data for baby corn was obtained from the FAO Manual 56 details and were added to the CROPWAT program, including rooting depth, crop coefficient, critical depletion, yield response factor, and length of plant growth stages.

Reference Evapotranspiration (ET0)

Transpiration (water lost from the plant surface) and evaporation (water lost from the soil surface) occur at the same time and, when combined, are referred to as evapotranspiration (ET). The rate of ET from a hypothetical crop with a height of 0.12 m, albedo (0.23), and fixed canopy resistance (70 sm^{-1}) is called the reference evapotranspiration. The Windows CROPWAT model uses the FAO Penman–Monteith equation for the calculation of the ET0 where most of the parameters are measured from the weather data. The Penman–Monteith equation form is as follows:

$$\lambda \text{ ET} = \frac{\Delta(Rn - G) + Pa\, Cp(\frac{es - ea}{ra})}{\Delta + \gamma\,(1 + rs/\,ra\,)} \quad \text{….(1)}$$

Where,

Rn is the net radiation, G is the soil heat flux, (es − ea) is the vapor pressure deficit of the air, Pa is the mean of air density at constant pressure, Cp is the specific heat of the air, Δ is the slope of the relationship between saturation vapor pressure and air temperature, γ is psychometric constant, and rs and ra are the surface and aerodynamic resistances, respectively. When the theoretical crop traits and the standard height for wind speed (2 m) are applied to calculate the "bulk" surface resistance and the aerodynamic resistance, Equation (1) can be derived as follows:

CROPWAT 8.0 Model Description

CROPWAT 8.0 is a decision-support computer program based on a number of equations, developed by the FAO to calculate reference evapotranspiration (ET0), crop water requirement (CWR), irrigation scheduling, and irrigation water requirement (IR), using rainfall, soil, crop, and climate data The program includes general data for various crop features, local climate, and soil properties and helps improve irrigation schedules and the computation of scheme water supply for different crop patterns under irrigated and rainfed conditions.

Irrigation scheduling

Irrigation was scheduled based on ETc. Reference crop evapotranspiration was estimated by using Penman Monteith method. ETo multiplied by crop coefficient gives crop evapotranspiration. The application rate and irrigation time were calculated by using the following formulae.

$$ET_0 = \frac{0.408\Delta(Rn - G) + \gamma(\,900/\,T{+}273)u2(es - ea)}{\Delta + \gamma(1 + 0.34\, u2)} \quad \text{….(2)}$$

where ET_0 is the reference evapotranspiration (mm/day), T is the mean daily air temperature (°C) at 2 m height, u_2 is the wind speed at 2 m height (ms^{-1}), and e_s and e_a are the saturation and actual vapor pressure (k_{Pa}), respectively.

Crop Water Requirement (CWR)

The crop water requirement is the amount of water equal to what is lost from a cropped field by the ET and is expressed by the rate of ET in mm/day. Estimation of CWR is derived from crop evapotranspiration (ETc) which can be calculated by the following equation

$$ETc = Kc \times ET_0 \quad \text{…(3)}$$

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 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:

$$Dr,i = Dr,i-1 - (P - ROi) - Ii - CRi + ETci + Dpi \ldots\ldots\ldots (4)$$

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 correct measure of water to irrigate and the correct time for watering. The CROPWAT model calculates the ET_0, CWR, and IRs to develop the irrigation schedules for baby corn.

Results and Discussion

The crop water requirement of baby corn was computed using CROPWAT software. CROPWAT is a programme that uses FAO Penman-Monteith equation for calculating reference crop evapotranspiration. The estimated crop evapotranspiration baby corn is 244.8 mm.

The amounts of water conveyed to baby corn under different irrigation levels during 2017-18 and 2018-19 are expressed in Table 5(a) and Table 5(b) respectively. It was observed that during 2017-18, in case of irrigation at 70 per cent ET, the water applied varied from 0.196 to 3.95 mm day^{-1} during the month of June 2018, 1.25 to 3.59 during July 2018, 1.71 to 3.43 during the month of August respectively. In case of drip irrigation at 80 per cent ET, the water applied varied from 0.22 to 4.51 mm day^{-1} during the month of June 2018, 1.43 to 4.52 during July 2018, 1.71 to 3.43 mm during the month August. In case of drip irrigation at 90 per cent ET, the water applied varied from 0.25 to 5.08 mm day^{-1} during the month of June 2018, during July 2018, 1.61 to 5.08 mm and August 2.20 to 4.41.Similarly in case of irrigation at 100 per cent ET, the water applied varied from 0.28 to 5.64 mm day^{-1} during the month of June 2018, 1.78 to 5.64 during the month of July 2018, during August varied from 2.45 to 4.9 mm.

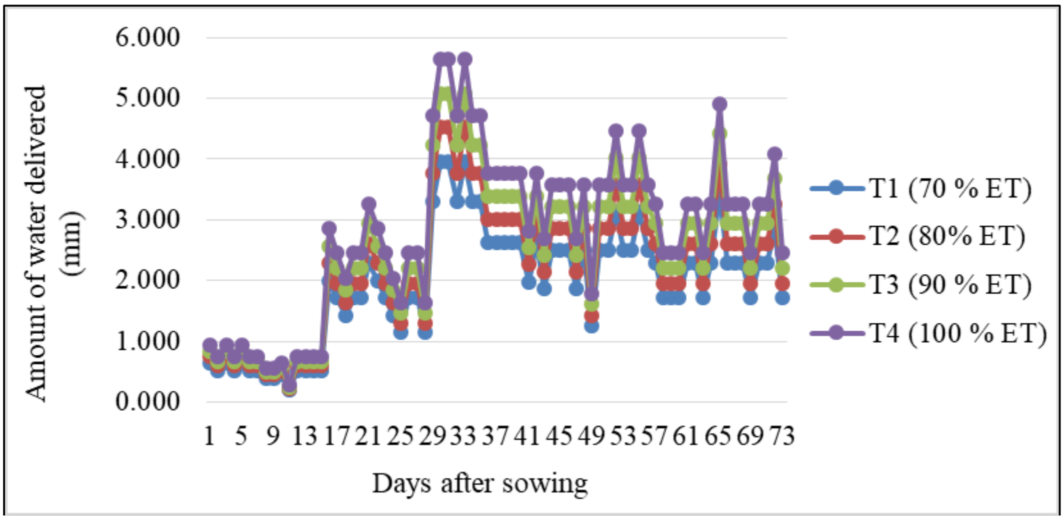


Fig 1: Amount of water delivered during crop growth period during 2017-18

Amount of water applied under drip irrigation based on the crop growth stages during 2018-19 are presented in Table 8 (a) and (b). For the year 2017-18, the highest water requirement was recorded during mid-season stage at 100 per cent ET (127.45 mm) and lowest was found in 70 per cent ET (7.05 mm) during initial stage. The demand of water is more for the mid-season stage during which the development of cob was initiated, hence more water requirement in mid-season stage. These result are in agreement with Sai Manogna *et al.* (2018) [4].

Table 1: Crop evapotranspiration of babycorn in various growth stages

Month	Amount of water applied at different irrigation levels, mm day^{-1}			
	I_1(70 % ET)	I_2(80 % ET)	I_3(90 % ET)	I_4(100 % ET)
Initial	4.93	5.64	6.34	7.05
Development	49.56	56.64	61.18	67.98
Middle	89.23	101.97	114.72	127.47
Harvest	29.67	33.91	38.15	42.39
Total	173.39	198.16	220.39	244.88

Table 2: Climate characteristics, rainfalls, and ET_0 obtained using the CLIMWAT tool attached to the CROPWAT software

Monthly ETo Penman-Monteith - C:\Program Files (x86)\CLIMWAT 2.0 for CROPWAT V2.0\RAI...

Country: Location 198 | Station: RAICHUR

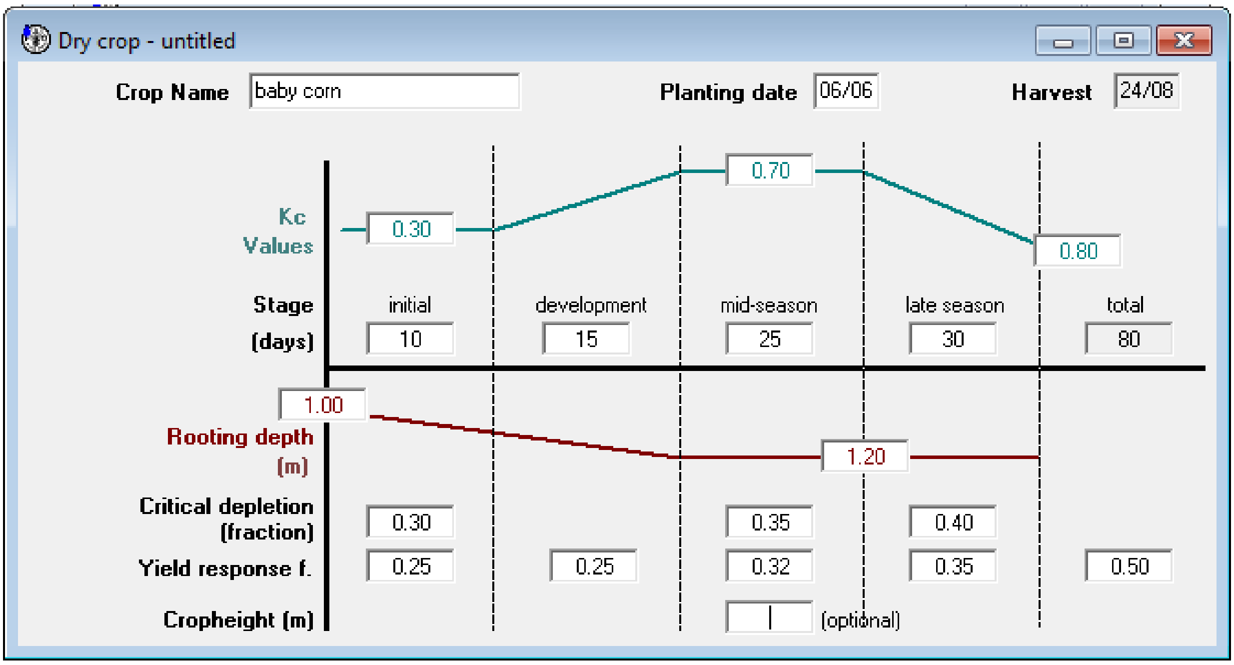
Altitude: 400 m. | Latitude: 16.20 °N | Longitude: 77.35 °E

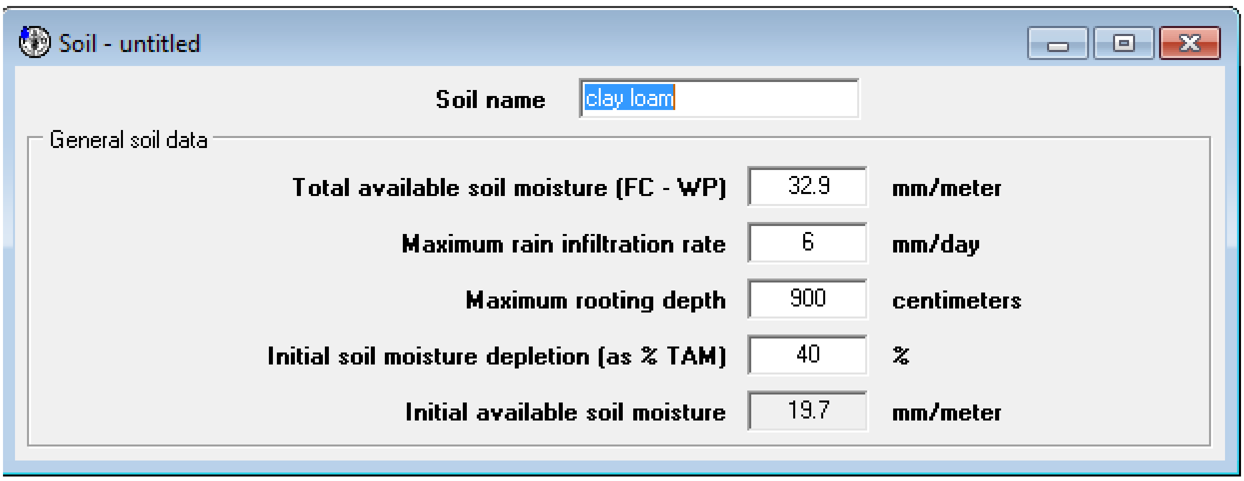
Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	18.5	30.2	45	164	8.7	18.5	4.59
February	20.5	33.2	39	156	9.1	20.8	5.33
March	23.7	36.6	37	173	8.9	22.3	6.42
April	26.2	38.7	40	173	8.7	22.9	6.91
May	26.5	39.6	43	242	7.9	21.7	7.77
June	24.1	35.1	58	346	5.0	17.1	6.57
July	22.9	32.0	66	346	3.7	15.2	5.28
August	22.8	31.9	64	302	4.8	16.7	5.34
September	22.7	31.6	64	233	5.2	16.8	4.87
October	22.5	31.7	57	156	7.1	18.3	4.75
November	20.0	30.1	49	156	8.0	17.9	4.53
December	18.0	29.1	46	156	7.9	16.9	4.21
Average	22.4	33.3	51	217	7.1	18.8	5.55

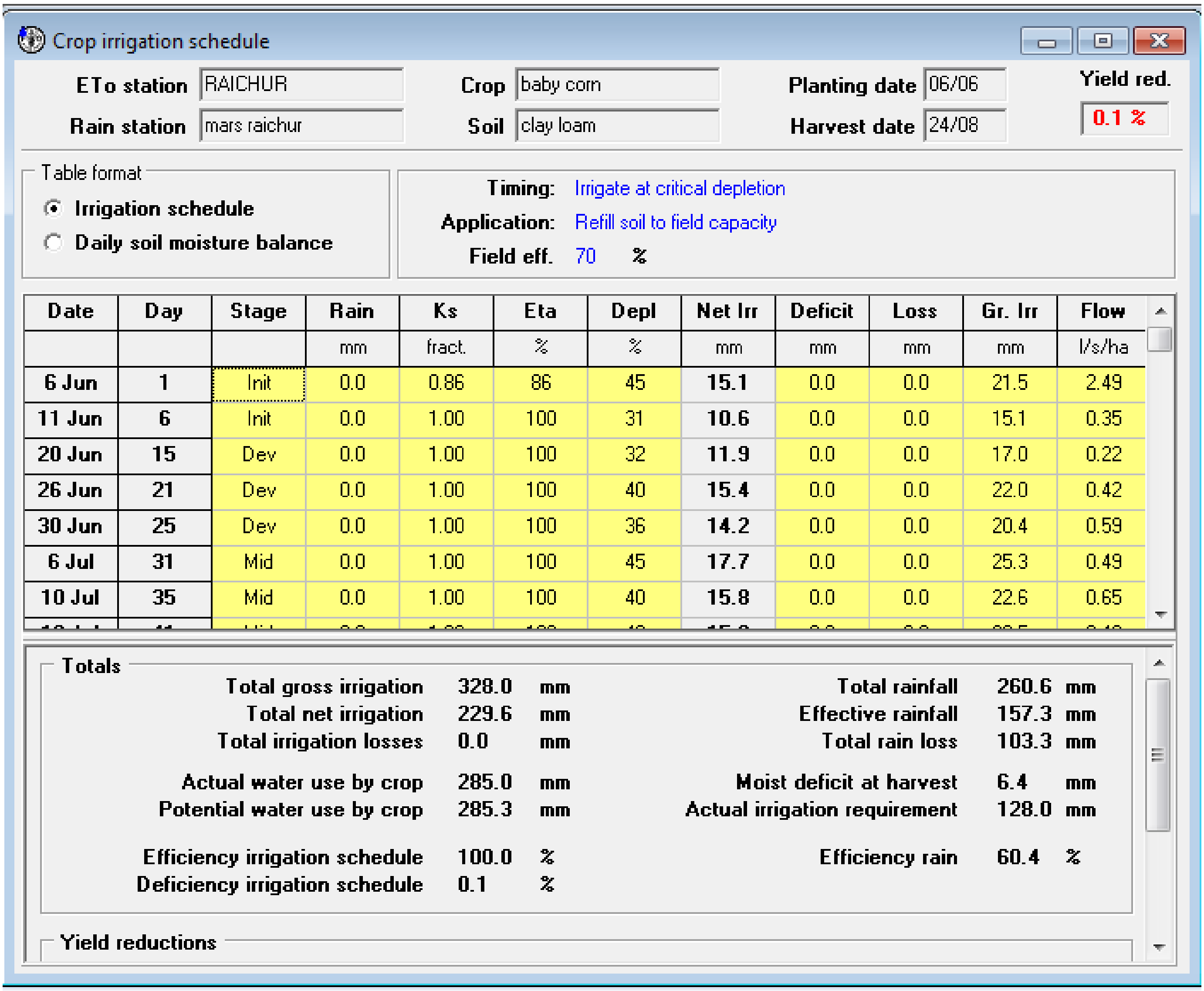
Reference Evapotranspiration and Effective Rainfall Estimation

The ET0 was estimated from alfalfa, the reference standard crop which has an actively growing, uniform surface of grass shading the ground completely. The ET of the crop under consideration (ETc) can be obtained by adjusting ET0 using crop coefficient (Kc) as in Equation (2) as follows,

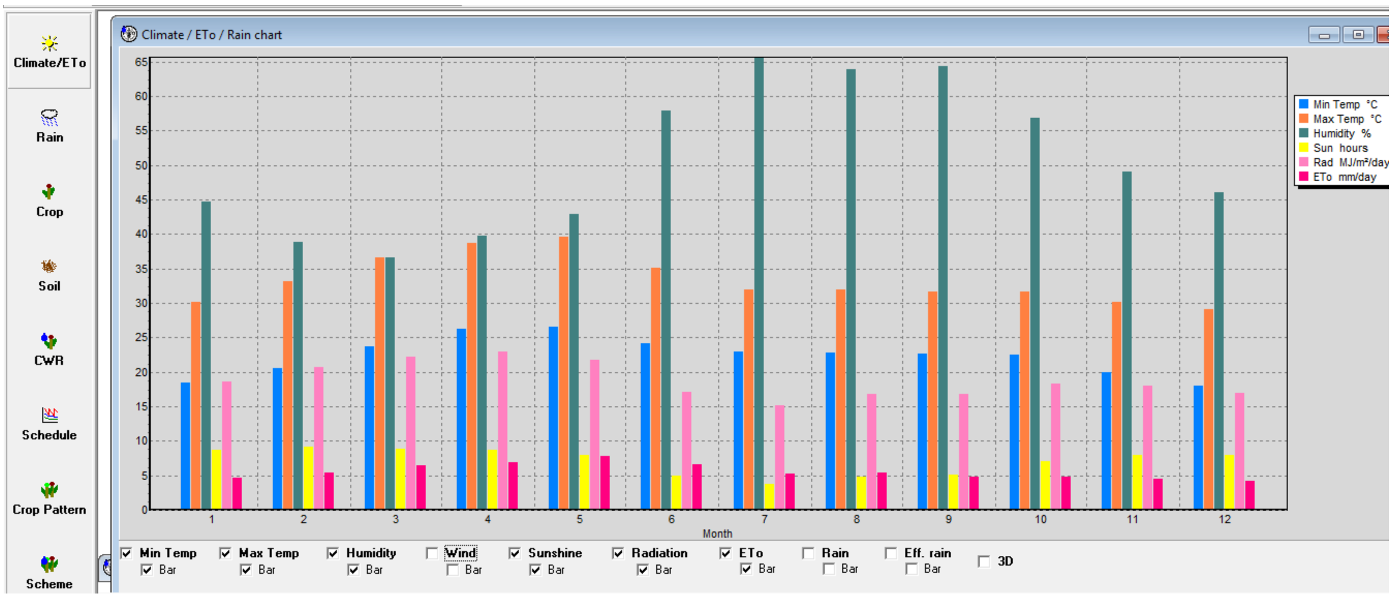
$$ET_0 = ETc/Kc \qquad (2)$$

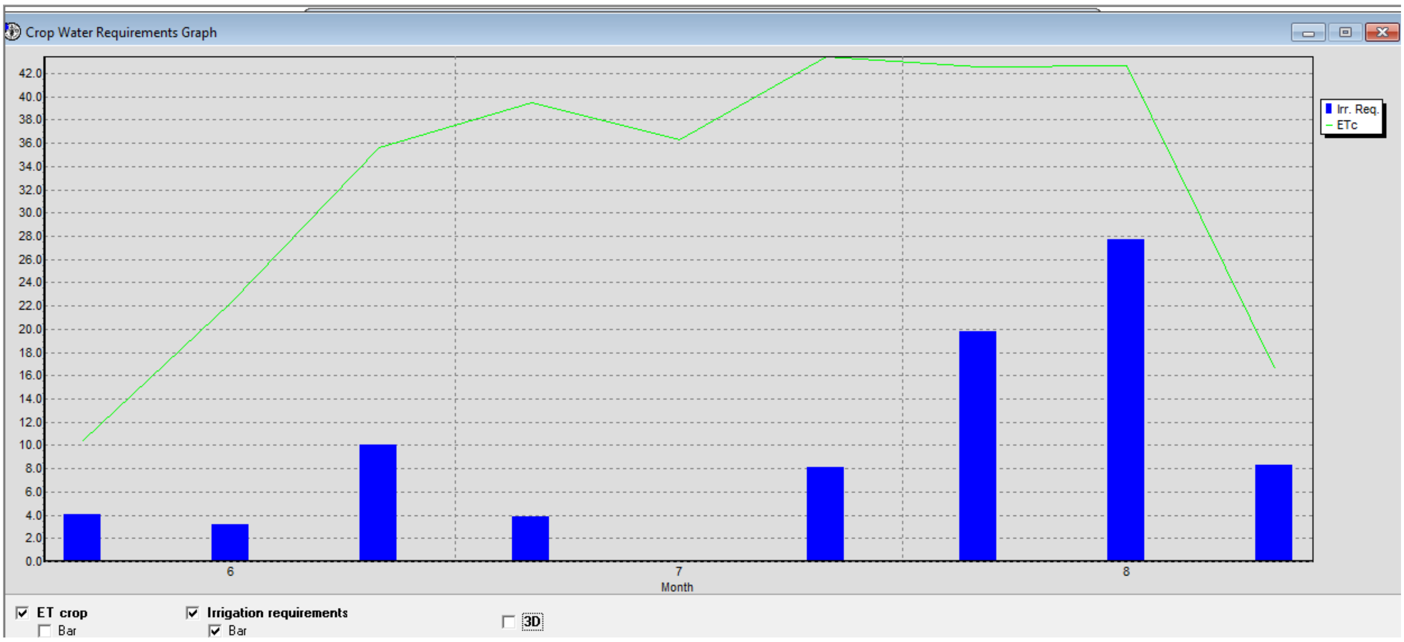


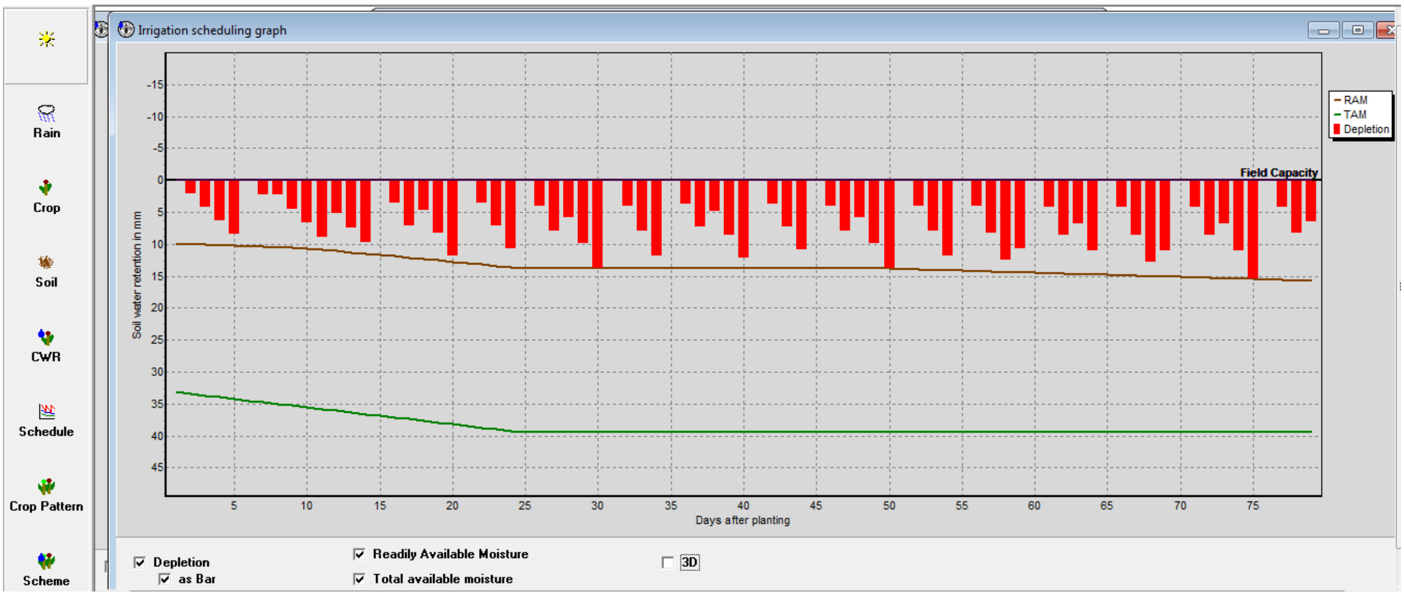




Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
6 Jun	1	Init	0.0	0.86	86	45	15.1	0.0	0.0	21.5	2.49
11 Jun	6	Init	0.0	1.00	100	31	10.6	0.0	0.0	15.1	0.35
20 Jun	15	Dev	0.0	1.00	100	32	11.9	0.0	0.0	17.0	0.22
26 Jun	21	Dev	0.0	1.00	100	40	15.4	0.0	0.0	22.0	0.42
30 Jun	25	Dev	0.0	1.00	100	36	14.2	0.0	0.0	20.4	0.59
6 Jul	31	Mid	0.0	1.00	100	45	17.7	0.0	0.0	25.3	0.49
10 Jul	35	Mid	0.0	1.00	100	40	15.8	0.0	0.0	22.6	0.65







Conclusions

Using the FAO CROPWAT 8.0 model, it can readily be seen that crop water requirements and schedules were specific to the local study area, the irrigation was applied based on daily evaporation, plant canopy and plant coefficient during the experimental period. Therefore one has to be careful in applying these results because the contributing factors to the water requirement are location specific. Therefore, if similar conditions exist, one can use these results with suitable allowance so that crop growth and yield are not adversely affected. The use of scientific tools like CROPWAT and CLIMWAT can assess the CWRs with a high degree of accuracy and suggest the crop pattern and crop rotation that farmers can readily accept. The results of this study can be used by agronomist and irrigation engineer for calculating irrigation scheduling and crop water requirement assessment, thereby helping to save water in meeting the CWRs, and can be used as a guide for farmers to select the amount and frequency of irrigation for the crops being studied.

Reference

1. Dass S, Yadav VK, Jat ML, Kaul J, Singh I, Rakshit S *et al*. Single cross hybrid seed production in maize. Directorate of maize Research, Tech Bul. DMR. 2008; 1:11.
2. Fischer G, Tubileo FN, Velthuizen VH, Wiberg D. Climate change impacts on irrigation water requirements: Effects of mitigation, 1990-2080. Tech. Forecasting Soc. Ch., 2007; 74:1083-1107.
3. Lamm FR, Ayars JE, Nakayama FS. Micro irrigation for crop production – Design, operation and Management. Elsevier Publications. 2007, 608p.
4. Sai Manogna K, Srinivas Rao M, Sai Ram M, Durga Bhavani T, Mani A. Effect of Irrigation Scheduling on Crop Growth Parameters of Baby corn under Drip Irrigation. Int. J Curr. Microbiol. App. Sci. 2018; 7(4):407-413.
5. Singh G, Kumar S, Singh R, Singh SS. Growth and yield of baby corn (*Zea mays* L.) as influenced by varieties, spacing's and dates of sowing. Indian J Agric. 2015; 49(4):353-357.