Assessing evapotranspiration rate and sesame (*Sesamum indicum*) crop water use under different water table depths

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Abstract: This study was conducted to estimate the evapotranspiration and to probe the seasonal groundwater contribution in total crop water use by the sesame crop under different water table depths. The method of combining lysimeter was executed to investigate the groundwater contribution in total water used by the crop. The water table depths were maintained at 1.60, 2.0 and 2.40 m, respectively. Each water table depth was replicated for three times. Climate conditions under which crop was grown were monitored and all the water balance components were recorded accordingly. The obtained evapotranspiration (*ET*) from lysimeter experiment was compared with the predicted *ET* by CROPWAT model. The experimentally observed *ET* were 457.5, 452 and 428 mm under the water table depths of 1.60, 2.0 and 2.40 m, respectively. The predicted *ET* using CROPWAT model was 434 mm, which was very close to the observed values. Under the lysimeter experiment, the groundwater contribution in total crop water use was observed as 37%. The predicted crop coefficient was ranged from 0.38 to 0.98, whereas the experimental crop coefficient was 1.0. The trend of soil moisture balance predicted by the model revealed the same as that experimentally observed. Thus, the use of CROPWAT model is recommended to redesign irrigation amounts and to prevent soil salinity and waterlogging problems.

Keywords: lysimeter, CROPWAT, sesame crop, evapotranspiration, groundwater use, crop coefficient

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1 Introduction

Sesame (*Sesamum indicum*) is a drought and waterlogging tolerant crop. It is perhaps one of the most ancient oilseed crops (Weiss, 1983). Sesame cultivated area in Pakistan is around 100,000 hectares with production of about 50,000 tons. The average yield of this crop is round about 0.5 M. Ton ha^{-1} (Rao, *et. al*, 2016).

The computer based decision supported models are tools for obtaining more simulations in a very short time. The pre-determined limits of irrigation amounts and their accurate applications always yield a better post-application response. The water requirements of a particular crop could be achieved through three different sources viz, artificial irrigation, precipitation (or rainfall) and groundwater contribution. The contribution of groundwater through evaporation has always been neglected during traditional irrigation events. It has a

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significant role in tangible crop-water use under shallow water table depth, though. For a broad range of ecological influences, lysimeters are used to enumerate the contribution of groundwater to check its role in crop water utilization (Luo and Sophocleous, 2010). Water movement above the water table (groundwater up-flow) displays an imperative role in contribution to the crop-water use. For arid and semi-arid regions, the shallow water table provides ease of access to water movement for completing the crop water requirements (Sepaskhah et al., 2003).

Narrow groundwater must be considered as a prospective water resource for completing the crop water requirements, provided that the evaporation does not respond to soil salinization and limitations to the growth rate of the crop (Benz et al., 1984). One of the optimum methods to reduce the irrigation amount is to include the irrigation times with a considerable proportion of shallow groundwater (Soppe and Ayars, 2003). In field conditions, the accumulation of salts in soil and groundwater capillary rise are tough parameters to determine. Lysimeters provide a choice for simultaneously measuring these factors along with other major components of water budget (Soppe and Ayars, 2003; Zhang et al, 1999; Hermsmeyer, 2002; Kelleners et al., 2005; Durner et al., 2008).

Shallow Groundwater (SGW) is an imperative reserve that can be devoted to irrigate the crops thereby reducing the gap between water supply and demand (Skaggs et al., 2006). Depending on the quality of shallow groundwater and type of the crop grown, this technique can be used to encounter fully or partially the water requirement of crops. So far, abundant research works have been conducted regarding the use of SGW as an additional source of irrigating the crops (Ayars et al., 1999). To address the waterlogging problems tempted by shallow water tables, the clipping-down method of irrigation amount can be efficiently used. However, to protect the soil profile from salinity and waterlogging, the maintaining of the water table at the required level is an essential way of using irrigation water more beneficially (Ayars et al., 1993). The yield for different crops like corn and soybean may possibly be exploited by artificially controlling the water table depths at 0.5 m and 0.75 m as compared to free draining methods (Liu and Luo, 2011).

Crop water modeling studies can supplement the field work by exploring additional irrigation management strategies in a much extensive range of conditions (Hurst et al., 2004). Multiscale simulations could be driven using long meteorological data for the determinations of effective seasonal rainfall. HYDRUS-1D (Simunek et al., 2005) has been sufficiently used to simulate the water movement between the water table and the crop root zone under various conditions (Skaggs et al., 2006; Sommer et al., 2003). The inter-seasonal climatic changes, refilled water in the soil profile (including irrigation water and rainfall), crop root uptake and water table depth are mainly influencing the groundwater evaporation (Luo and Sophocleous, 2010). CROPWAT is an irrigation management tool which simulates composite connections of on-farm parameters like climate, soil, and crop. CROPWAT enables the estimation of crop evapotranspiration, reference evapotranspiration, irrigation schedule and agricultural water requirements with diverse cropping arrangements for irrigation planning (Nazeer, 2009).

Considering the discussed facts, this research work was conducted to determine the contribution of groundwater towards the crop water use under different water table depths and to simulate the CROPWAT model for predicting the evapotranspiration of sesame crop.

2 Materials and methods

Subsurface evaporation plays a significant role in crop-water use under shallow depth of water table. The experimental setup contains a study of the soil-water-plant relationship under controlled conditions. The crop coefficient (K_c), which correlates the crop ET with reference evapotranspiration (ET_o), was determined. The obtained results were compared with the predicted outputs of CROPWAT model.

2.1 Data

The data set required for this study were mainly lysimeter and meteorological data, including monthly solar radiation, precipitation relative humidity, sunshine time, average yearly air temperature, minimum and maximum air temperature, and wind speed.

2.1.1 Lysimeter conditions

The lysimeter at the experimental field nearby Faculty of Agricultural Engineering, Sindh Agriculture University (Tandojam, Pakistan) is Reinforced Cement Concrete (RCC) made. The setup was made leak proof by bitumen coating in the inner walls and the bottom. There were nine squared shaped lysimeters in the setup all measuring the area of 2.50 × 2.50 × 2.50 m^3. Each lysimeter was provided with river sand, gravel, alter screens and non-calcareous sprawls and drainage outlet below the soil column to facilitate drainage. The water-table depths were maintained through Mariotte bottles, installed on all the lysimeters. The drainage effluent (surplus water) of the lysimeters was allowed to flow into the graduated percolation bottles and measured accordingly. To check the maintenance of desired water tables, each lysimeter was provided with piezometers. Thus, the total water consumed by crop was measured on daily basis.

2.1.2 Experimental design

The experimental site was located at 25.424843 ° N and 68.540755 ° E and at an average altitude of 12.8 m above the mean sea level. The experiment was conducted under randomized complete block design (RCBD) for different treatments (maintained water table depth like 1.60, 2.00 and 2.40 m to the ground surface level) on a non-weighing type lysimeter with nine chambers. Each treatment (water table depth) was replicated three times.

2.1.3 Soil

Silty loam soil containing sand 22%, silt 54%, and clay 24%, respectively and silty-clay loam containing sand 9%, silt 56%, and clay 35%, respectively, were used. The dry bulk density and hydraulic conductivity of silty loam and silty clay loam soil were 1.36 g cm^{-3} and 1.28 g cm^{-3}, and 0.146 m day^{-1} and 0.158 m day^{-1}, respectively.

2.1.4 Crop water requirements

The groundwater contribution was measured using pre-installed piezometers by determining the increase or decrease in water table depth at each phase of crop development. The consumptive use (CU) of the crops which are synonymously referred to as crop water requirement or actual evapotranspiration was calculated by using Equation 1 (Gul et al., 2018; Allen et al., 1998).

$$ETc = I + S + R - D \pm SMD \tag{1}$$

Where, ET_c is the crop evapotranspiration (mm day^{-1}), I is the Surface irrigation (mm day^{-1}), S is the contribution of groundwater (mm day^{-1}), R is the rainfall (mm day^{-1}), D is the drainage effluent (mm day^{-1}) and SMD is the soil moisture difference (mm day^{-1}).

2.1.5 Reference evapotranspiration (ET_O)

The reference evapotranspiration (ET_O) for sesame crop was calculated using the modified Penman equation (Doorenbos and Pruitt 1975; Bouraima et al., 2015)

$$\begin{aligned} ET_o = {} & W\,x\,Rn + (1 - W) \\ & - f\,(U) - (e_a - e_d) \end{aligned} \tag{2}$$

Where, ET_O is the reference evapotranspiration (mm day^{-1}), W is the temperature factor (kPa $℃^{-1}$), R_n is the net radiation in equivalent evaporation (mm day^{-1}), f (U) is the wind function (kPa m sec^{-1}), ($e_a - e_d$) is the difference among the saturation vapor pressure (at mean air temperature) and mean actual vapor pressure (mbar).

2.1.6 Crop coefficient (K_c)

The reference evapotranspiration was calculated on daily basis. Similarly, the crop water requirements (ETc) were also daily measured. The climatic data used in this study was obtained from the nearest observatory installed at Drainage and Reclamation Institute Pakistan (DRIP) in Tandojam. The crop coefficient (Kc) of the sesame crop was calculated using Equation 3, as suggested by Bouraima et al. (2015).

$$Kc = \frac{ETc}{ETo} \tag{3}$$

here, Kc is the crop coefficient (dimensionless), ETc is the crop evapotranspiration or crop water requirements (mm day^{-1}), ETo is the reference evapotranspiration (mm day^{-1}).

2.1.7 Irrigation criteria

A socking dose of 75 mm was applied to all the chambers by flooding method before the sowing of seeds crop in lysimeter. The canal water (3:40 – 4:00 pm) was used for irrigation throughout the experiment and it was collected in a reservoir from where it was pumped to an overhead tank. From this tank, lysimeters were irrigated through a pipeline installed around the lysimeter station. The amount of water applied was measured through a water meter installed on the main pipeline.

2.1.8 Water measurement

Rainfall contribution (R) to the crop was measured through rain gauge. Arrangement to fill water in each Mariotte bottle was made through a pipeline. The water consumed from the Mariotte flasks (bottles) to maintain the water table depths in the lysimeters was measured regularly as a subsurface irrigation (S), which was the groundwater contribution to crop. The drainage effluent (D) coming out of ach lysimeter was collected in percolation bottles (Jerry canes) and recorded. The soil moisture status of the lysimetric soil prior to sowing of the crop and immediately after harvesting were measured. The exhibited difference in soil moisture is represented as soil moisture difference (*SMD*) in the equation. In this way, all the water inputs (I, S and R) and outputs (D) and *SMD* were measured and used in determination of crop water requirements (Luo and Sophocleous, 2010; Soppe and Ayars, 2003; Durner et al., 2008).

2.1.9 Yield and water use efficiency

The crop yield was measured and averaged. Initially, the yield measurements were made for each lysimeters and converted to kg ha^{-1}. Water use efficiency is a simple estimate to measure how accurately irrigation water has been used for crop production. Any effort that tends to increase crop yield or the amount of water needed without reducing the crop yield increases the water use efficiency. The yield of crop (kg ha^{-1}) was divided by amount of water consumed (m^3) to determine water use efficiency of crops in kg m^{-3} (Gul et al., 2018).

2.1.10 Statistical Analysis

The data obtained was recorded and analysed statistically to find significant difference of the treatments at 95% confidence interval ($\alpha = 0.05$). The statistical test used in the analysis was the standard “t” Test.

2.1.11 CROPWAT model

CROPWAT (version 8.0) program developed by FAO Penman-Monteith method was used to estimate the crop water need and irrigation scheduling of sesame crop. The climatic data was incorporated accordingly, for the simulation run. The meteorological parameters were considered as input and reference crop evapotranspiration was considered as output, in CROPWAT model. The data sets were converted on monthly basis (FAO, 2009).

2.1.12 Input climate data

The CROPWAT model was calibrated accordingly. Monthly average weather data (minimum temperature, maximum temperature, relative humidity, and sunshine hours) of the last ten years (2007 to 2016) was given as input for computation of ET_O. Similarly, the rainfall was also incorporated to simulate the effective rainfall. The crop characteristics such as planting day, K_c values, growth stage, and rooting depth were given. In soil input section soil characteristics, the moisture available in the soil (mm m^{-1}), rain infiltration rate (mm day^{-1}), rooting depth (cm) and preliminary soil moisture depletion (%) were also incorporated, accordingly. Thereafter, the model was simulated for predicting the several irrigation options for scheduling of irrigation. Table 1 shows the average of the climate data obtained from the nearest observatory installed at Drainage and Reclamation Institute of Pakistan (DRIP) Tandojam, which was used as input data in the model to calculate ET_c.

Table 1 Average climate data for 10 years incorporated in CROPWAT model

Month	Average Daily Temperature (℃)		Average Relative Humidity (%)	Average Wind Velocity (Km day^{-1})	Average Sunshine Hours (Hr.)	Average Rain Fall (mm)
	Min.	Max.				
January	10.03	23.50	66	39.56	8	1.46
February	11.85	26.14	62	35.25	9	0.60
March	17.19	33.41	59	50.04	9	0.00
April	22.58	37.55	53	100.48	9	6.45
May	27.43	40.71	59	218.54	9	0.00
June	28.69	38.45	61	223.15	8	16.39
July	28.71	36.13	69	204.55	7	35.60
August	25.70	33.32	74	159.13	7	76.32
September	26.41	34.72	72	108.78	8	49.21
October	21.99	35.18	66	37.47	9	1.28

November	15.80	30.84	60	23.09	9	0.59
December	11.33	23.83	63	55.50	8	7.79

2.1.13 Input crop data

The sowing of sesame crop generally starts in the month of June and is harvested in the month of October. The crop data (K_c, rooting depth, yield response factor, and depletion factor) were obtained from FAO publication (FAO, 1998). The average values of crop coefficient (observed under lysimeter), rooting depth, yield factor (K_y) at different growth phases (such as, initial, development, mid-season, and late-season) and depletion fraction (P) of sesame crop were incorporated in crop input data section of CROPWAT model. In order to get optimum results, the proposed values were compared with obtained values under lysimeter experiment and averages were incorporated in the model. The K_c values were incorporated as 0.35, 1.10 and 0.25 at initial, mid and end stages of crop, respectively. The rooting depth was incorporated in the range of 1.0 m to 1.5 m, yield response factor (K_y) was given as 0.4 and depletion fraction was given as 0.6.

2.1.14 Input soil data

The soil parameters required for irrigation scheduling using the FAO CROPWAT program comprising of total available soil moisture content (SMC), initial soil moisture depletion, maximum rooting depth, and maximum infiltration depth were given as input data accordingly. Initially, available water for silt loam and silt clay loam soils suggested by FAO (FAO, 1998) were used. However, in this study pre-determined value of soil available water during lysimeter experiment was compared with the values given in the table and the average values were incorporated as 180 mm m^{-1} and 145 mm m^{-1} for silt loam and silt clay loam soils respectively, in CROPWAT model.

The infiltration rate of a particular soil directly affects the water holding capacity or field capacity of the soil. In soil section of CROPWAT model, the required units of these values are mm day^{-1}. Therefore, the selected infiltration rate value from FAO publication (FAO, 1998) was converted in mm day^{-1} and it was inserted as 264 mm day^{-1} for silt loam and 235 mm day^{-1} for silt-clay loam soils.

3 Results

3.1 *ETc* of sesame crop observed under lysimeter experiment

The total *ETc* of sesame crop was measured about 450 mm (Table 2). The ET_c was slightly increased with increased water-table depths. Ground water contribution for the sesame crop was found significant. It ranges from 34% to 40% for silt-loam soil and 33% to 39% for silt clay loam soil. However, groundwater contribution to the ET_c did not show any linear trend across different water-table depths. The average ET_c (average of SL and SCL soils) under the water table depth of 1.60, 2.0 and 2.40 m was observed as 457.50, 452 and 428 mm, respectively.

Table 2 *ETc* of sesame crop and groundwater contribution (mm)

Month	Days	Silt loam (SL)						Silty-clay loam (SCL)					
		1.60 m		2.00 m		2.40 m		1.60 m		2.00 m		2.40 m	
		ET_c	*S*	ET_c	*S*	ET_c	*S*	ET_c	*S*	ET_c	*S*	ET_c	*S*
June	18	56	22	51	24	49	23	55	24	50	19	46	19
July	31	83	26	81	33	78	31	78	32	76	28	72	29
August	31	184	63	174	65	163	68	177	65	172	57	166	47
September	30	139	48	124	42	121	45	129	46	125	44	112	38
October	10	27	7	26	9	25	9	27	14	25	7	24	7
SMD	-	-4	-	0	-	-6	-	5	-	3	-	0	-
Total	120	489	166	456	173	436	176	426	181	448	155	420	140
Average ET_c		457.5 (SL & SCL soil under 1.60 m)											
		452.0 (SL & SCL soil under 2.0 m)											
		428.0 (SL & SCL soil under 2.40 m)											

Note: ET_c = Crop evapotranspiration, S = Ground water contribution, *SMD* = Soil moisture difference before and after the experiment.

3.2 ET_o (mm) of Sesame Crop

All the treatments showed similar trend of ET_o across the soil types and water table depths, i.e. low in October, maximum in August and declined in September (See Figure 1). In August, the ET_o was observed maximum under shallow water table depth (1.60 m) for both the soils, whereas in June and October it was minimum. Rainfall was recorded as 15 mm, throughout the study period. The temperature was recorded maximum in the month of June.

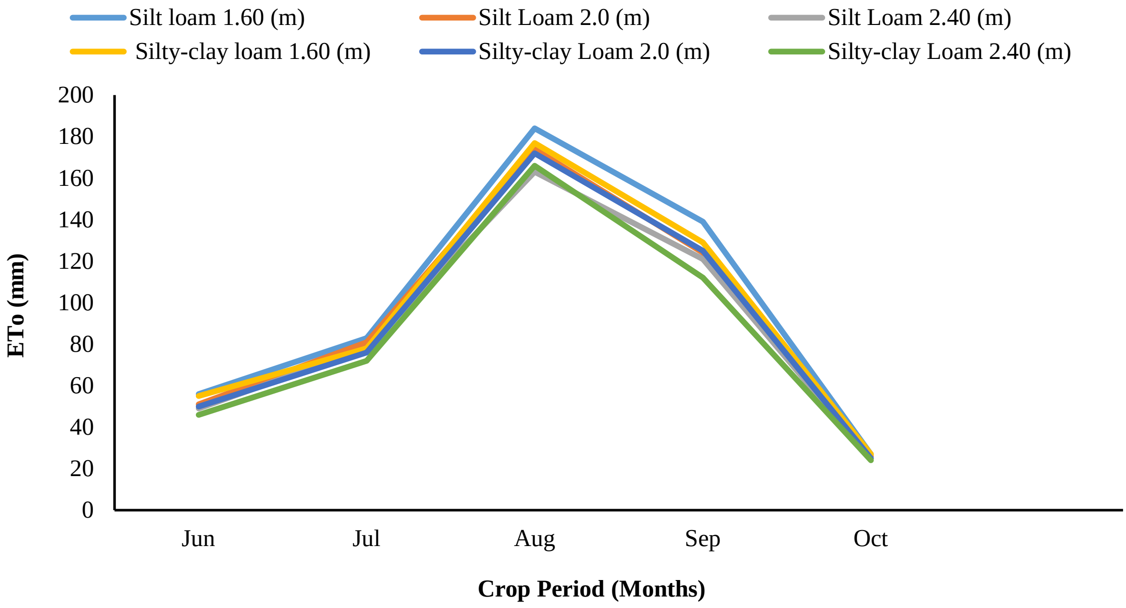

Figure 1 Monthly ET_O of sesame crop under different treatments

3.3 Crop coefficient (*Kc*)

The crop coefficient value was maximum in August due to high potential evaporation. Moreover, as the crop was at maturity stage in August, therefore *Kc* values exceeded 1.0 showing that its evapotranspiration rate was higher than the referenced crop. The sesame crop has better canopy cover and it entirely covers the soil surface and develops high foliage, which resultantly increases the K_c beyond 1.0, as shown in Figure 2.

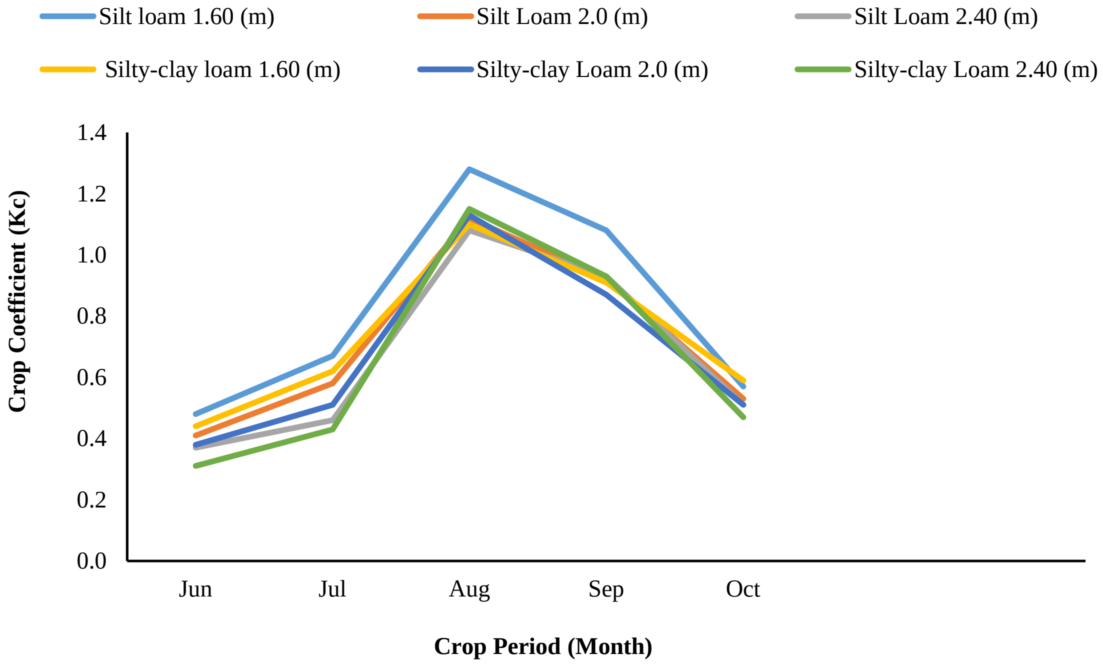

Figure 2 Monthly crop coefficients (K_c) of sesame crop

3.4 Yield of sesame crop and water use efficiency (WUE)

The yield and water use efficiency of sesame crop under different water table depths are illustrated in Table 3. There were no any significant differences ($p > 0.05$) found in the yield and water use efficiency at 1.60 m, 2.0 m and 2.40 m of water table depths. For yield, the P-value was observed as 0.09375 and for WUE the *p*-value was

0.121038. The yield and water use efficiency were found better at deeper water-table depth (2.40 m). The crop, therefore, may not be grown under shallow water tables as it may negatively affect the crop growth and yield. The silty-clay loam soil resulted in better crop yield and water use efficiency mainly due to the better soil texture.

Table 3 Yield and WUE of sesame crop

Water-Table Depth (m)	Silt-loam Soil		Silty-clay-loam Soil	
	Yield ($kg\ ha^{-1}$)	WUE ($kg\ m^{-3}$)	Yield ($kg\ ha^{-1}$)	WUE ($kg\ m^{-3}$)
1.60	776	0.16	837	0.18
2.00	814	0.18	887	0.21
2.40	935	0.22	971	0.24

3.5 Predicted results of CROPWAT model

3.5.1 ET_c of sesame crop Predicted by CROPWAT Model

The water requirement (ET_c) of sesame crop simulated by CROPWAT model is shown in Table 4. The predicted ET_c by the CROPWAT was found the same as observed in lysimeter experiment. The total crop season divided by the model was in four stages, such as initial stage, development stage, mid stage, and late stage. The projected effective rainfall during the whole crop season was 10.6 mm. Water required by the sesame crop at the initial stage (June) was found to be 45.5 mm and the simulated ET_c recorded by the model was relatively the same, as observed under lysimeter experiment. The crop water requirement increased by increasing the growth stage. The highest crop water requirement (ET_c) for sesame crop was simulated as 225 mm in the development stage of growth which was 52% of the total water requirement throughout the crop season.

Table 4 ET_c of sesame predicted by CROPWAT model

Month	Decade	Stage	Kc coeff	ET_c mm day^{-1}	ET_c mm dec^{-1}	Eff rain mm dec^{-1}	Irr. Req. mm dec^{-1}
Jun	2nd	Init	0.38	2.60	20.8	4.2	15.5
	3rd	Init	0.38	2.47	24.7	7.2	17.5
Jul	1st	Deve	0.43	2.68	26.8	8.8	18
	2nd	Deve	0.53	3.10	31.0	10.5	20.5
	3rd	Deve	0.63	3.50	38.5	14.4	24.0
Aug	1st	Deve	0.73	3.83	38.3	20.3	17.9
	2nd	Deve	0.83	4.07	40.7	24.9	15.8
	3rd	Deve	0.93	4.52	49.7	21.7	28.0
Sep	1st	Mid	0.98	4.70	47.0	18.2	28.8
	2nd	Mid	0.98	4.64	46.4	16.2	30.3
	3rd	Mid	0.98	4.37	43.7	10.9	32.8
Oct	1st	Late	0.63	2.65	26.5	1.40	25.1
		Total			434.1	158.8	274.2

3.5.2 Soil moisture balance sheet

Appendix-I shows the daily soil moisture balance for sesame crop developed by CROPWAT model, which includes growth stage, rain, water stress coefficient (Ks), ET_c, depletion percentage, net irrigation, water deficit, loss of water and gross irrigation. The application of irrigation water indicated by the model is based on restocking of soil moisture to the field capacity. Each irrigation event is to be applied at critical soil moisture depletion. The water stress coefficient (Ks) predicted by the CROPWAT model was 1 throughout the crop season. The minimum ET_c projected by the model was 2.5 (observed in initial stage – up to June) and the highest ET_c was 4.7, which is predicted in middle stage (September). However, the depletion percentage fluctuated from 2% to 55% throughout the season and the highest water deficit was observed as 141.4 mm on 25 August (development stage).

3.5.3 Soil Water Retention Graph Developed by CROPWAT model

Figure 3 shows the water retention graph developed by the CROPWAT model. After planting, the maximum soil water retention predicted by the model was 140 mm, which took place after 70 days of sowing (middle stage). The maximum radially available moisture (RAM) was recorded after the 115th day. The predicted total available moisture (TAM) gradually increased from 180 to 270 mm upto the 80th day, which then remains constant throughout the crop season.

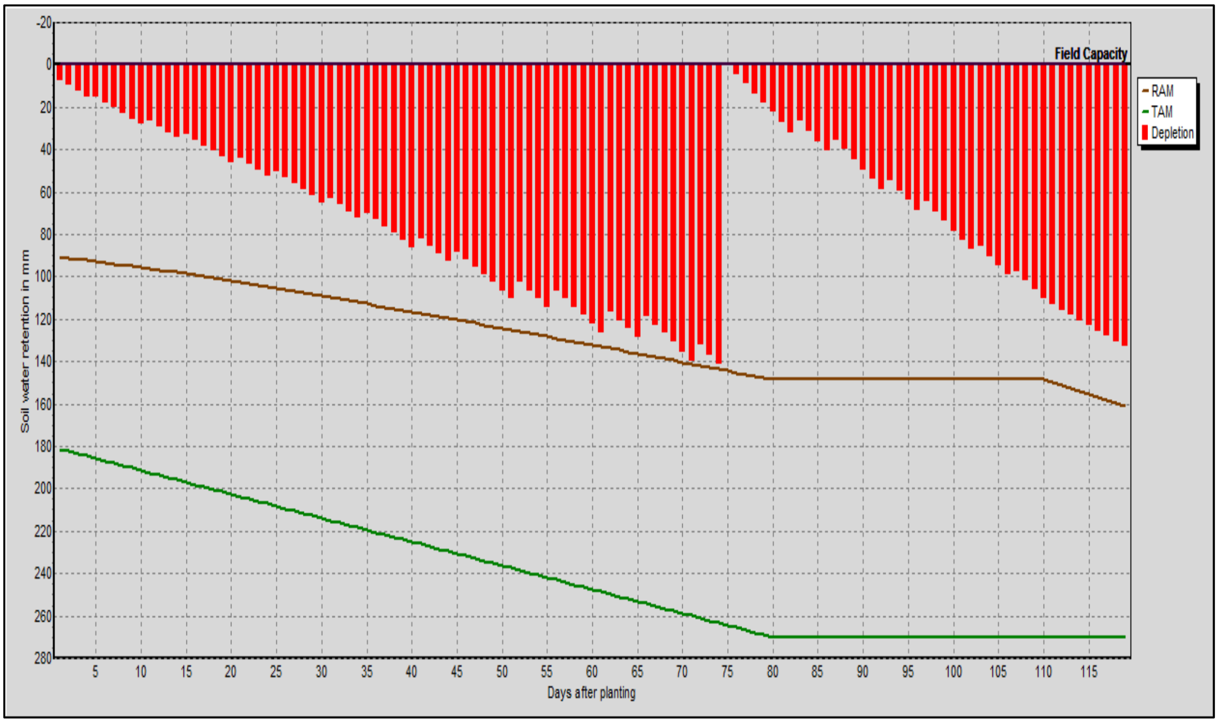

Figure 3 Soil water retention graph developed by CROPWAT model

4 Conclusions

The predicted ET_c by CROPWAT model is 2.38% less (or almost the same) than the observed ET_c. The approaches of CROPWAT model are likely optimum and hence this model is proposed to be used for revising the current irrigation applications where soil, climate and crop data is available. The irrigation applications for a particular crop like sesame, are dominantly depending on the climate and soil conditions. Therefore, for every climate region it should not be the same and may be revised according to the soil and climate conditions. Under the lysimeter experiment, it could be visualized that the water requirements of a crop are partially met by the groundwater contribution. On an average (of silt loam and silty-clay loam soils) about 37% of the required water can be obtained through groundwater evaporation, where the water tables are nearly 2.0 m beneath the surface. Therefore, on the basis of results drawn from this study, it is clinched that, for the shallow water table depth irrigation requirement needs to be modified to use the irrigation water efficiently and to control waterlogging and salinity. There is enormous potential of water saving if irrigation is applied rotationally as per the crop water requirements. Thus, the CROPWAT model is suggested to be used as a management tool to overcome the salinity and waterlogging problems caused by over irrigation.

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Appendix-I Daily soil moisture balance sheet for sesame crop developed by CROPWAT model

Date	Day	Stage	Rain mm	Ks fract.	ET mm day^{-1}	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l s^{-1} ha^{-1}
13-Jun	1	Initial	2.7	1	2.6	4	0	7.2	0	0	0
14-Jun	2		0	1	2.6	5	0	9.8	0	0	0
15-Jun	3		0	1	2.6	7	0	12.4	0	0	0
16-Jun	4		0	1	2.6	8	0	15.1	0	0	0
17-Jun	5		2.7	1	2.6	8	0	15	0	0	0
18-Jun	6		0	1	2.6	9	0	17.7	0	0	0
19-Jun	7		0	1	2.6	11	0	20.3	0	0	0
20-Jun	8		0	1	2.6	12	0	23	0	0	0
21-Jun	9		0	1	2.5	13	0	25.5	0	0	0
22-Jun	10		0	1	2.5	15	0	28	0	0	0
23-Jun	11		3.8	1	2.5	14	0	26.8	0	0	0
24-Jun	12		0	1	2.5	15	0	29.3	0	0	0
25-Jun	13		0	1	2.5	16	0	31.8	0	0	0
26-Jun	14		0	1	2.5	18	0	34.3	0	0	0
27-Jun	15		3.8	1	2.5	17	0	33.1	0	0	0
28-Jun	16		0	1	2.5	18	0	35.6	0	0	0
29-Jun	17		0	1	2.5	19	0	38.1	0	0	0
30-Jun	18		0	1	2.5	20	0	40.6	0	0	0
01-Jul	19	Development	0	1	2.7	22	0	43.3	0	0	0
02-Jul	20		0	1	2.7	23	0	46.1	0	0	0
03-Jul	21		4.5	1	2.7	22	0	44.3	0	0	0
04-Jul	22		0	1	2.7	23	0	47	0	0	0
05-Jul	23		0	1	2.7	24	0	49.7	0	0	0
06-Jul	24		0	1	2.7	25	0	52.4	0	0	0
07-Jul	25		4.5	1	2.7	24	0	50.6	0	0	0
08-Jul	26		0	1	2.7	25	0	53.3	0	0	0
09-Jul	27		0	1	2.7	27	0	56.1	0	0	0
10-Jul	28		0	1	2.7	28	0	58.8	0	0	0
11-Jul	29		0	1	3.1	29	0	61.9	0	0	0
12-Jul	30		0	1	3.1	30	0	65.1	0	0	0
13-Jul	31		5.4	1	3.1	29	0	62.8	0	0	0
14-Jul	32		0	1	3.1	31	0	66	0	0	0
15-Jul	33		0	1	3.1	32	0	69.1	0	0	0
16-Jul	34		0	1	3.1	33	0	72.3	0	0	0
17-Jul	35		5.4	1	3.1	32	0	70	0	0	0
18-Jul	36		0	1	3.1	33	0	73.1	0	0	0
19-Jul	37		0	1	3.1	34	0	76.3	0	0	0
20-Jul	38		0	1	3.1	36	0	79.4	0	0	0
21-Jul	39		0	1	3.5	37	0	83	0	0	0
22-Jul	40		0	1	3.5	38	0	86.5	0	0	0
23-Jul	41		7.9	1	3.5	36	0	82.2	0	0	0
24-Jul	42		0	1	3.5	38	0	85.7	0	0	0
25-Jul	43		0	1	3.5	39	0	89.3	0	0	0
26-Jul	44		0	1	3.5	40	0	92.8	0	0	0
27-Jul	45		7.9	1	3.5	38	0	88.5	0	0	0
28-Jul	46		0	1	3.5	40	0	92	0	0	0
29-Jul	47		0	1	3.5	41	0	95.6	0	0	0
30-Jul	48		0	1	3.5	42	0	99.1	0	0	0
31-Jul	49		0	1	3.5	44	0	102.7	0	0	0
01-Aug	50		0	1	3.8	45	0	106.5	0	0	0
02-Aug	51		0	1	3.8	47	0	110.4	0	0	0
03-Aug	52		11.5	1	3.8	43	0	102.8	0	0	0
04-Aug	53		0	1	3.8	45	0	106.6	0	0	0
05-Aug	54		0	1	3.8	46	0	110.5	0	0	0
06-Aug	55		0	1	3.8	47	0	114.4	0	0	0
07-Aug	56		11.5	1	3.8	44	0	106.7	0	0	0
08-Aug	57		0	1	3.8	45	0	110.6	0	0	0
09-Aug	58		0	1	3.8	47	0	114.5	0	0	0
10-Aug	59		0	1	3.8	48	0	118.4	0	0	0
11-Aug	60		0	1	4.1	49	0	122.5	0	0	0

12-Aug	61	Middle	0	1	4.1	51	0	126.6	0	0	0
13-Aug	62		14.3	1	4.1	47	0	116.4	0	0	0
14-Aug	63		0	1	4.1	48	0	120.5	0	0	0
15-Aug	64		0	1	4.1	49	0	124.6	0	0	0
16-Aug	65		0	1	4.1	51	0	128.7	0	0	0
17-Aug	66		14.3	1	4.1	47	0	118.5	0	0	0
18-Aug	67		0	1	4.1	48	0	122.6	0	0	0
19-Aug	68		0	1	4.1	49	0	126.8	0	0	0
20-Aug	69		0	1	4.1	51	0	130.9	0	0	0
21-Aug	70		0	1	4.5	52	0	135.4	0	0	0
22-Aug	71		0	1	4.5	54	0	140	0	0	0
23-Aug	72		12.3	1	4.5	51	0	132.3	0	0	0
24-Aug	73		0	1	4.5	52	0	136.8	0	0	0
25-Aug	74		0	1	4.5	54	0	141.4	0	0	0
26-Aug	75		0	1	4.5	55	146	0	0	208.5	24.13
27-Aug	76		12.3	1	4.5	2	0	4.5	0	0	0
28-Aug	77		0	1	4.5	3	0	9	0	0	0
29-Aug	78		0	1	4.5	5	0	13.5	0	0	0
30-Aug	79		0	1	4.5	7	0	18.1	0	0	0
31-Aug	80		0	1	4.5	8	0	22.6	0	0	0
01-Sep	81		0	1	4.7	10	0	27.3	0	0	0
02-Sep	82		0	1	4.7	12	0	32	0	0	0
03-Sep	83		10	1	4.7	10	0	26.6	0	0	0
04-Sep	84		0	1	4.7	12	0	31.3	0	0	0
05-Sep	85		0	1	4.7	13	0	36	0	0	0
06-Sep	86		0	1	4.7	15	0	40.7	0	0	0
07-Sep	87		10	1	4.7	13	0	35.4	0	0	0
08-Sep	88		0	1	4.7	15	0	40.1	0	0	0
09-Sep	89		0	1	4.7	17	0	44.8	0	0	0
10-Sep	90		0	1	4.7	18	0	49.5	0	0	0
11-Sep	91		0	1	4.6	20	0	54.1	0	0	0
12-Sep	92		0	1	4.6	22	0	58.8	0	0	0
13-Sep	93		8.7	1	4.6	20	0	54.8	0	0	0
14-Sep	94		0	1	4.6	22	0	59.4	0	0	0
15-Sep	95		0	1	4.6	24	0	64	0	0	0
16-Sep	96		0	1	4.6	25	0	68.7	0	0	0
17-Sep	97		8.7	1	4.6	24	0	64.7	0	0	0
18-Sep	98		0	1	4.6	26	0	69.3	0	0	0
19-Sep	99		0	1	4.6	27	0	73.9	0	0	0
20-Sep	100		0	1	4.6	29	0	78.6	0	0	0
21-Sep	101		0	1	4.4	31	0	83	0	0	0
22-Sep	102		0	1	4.4	32	0	87.3	0	0	0
23-Sep	103		5.9	1	4.4	32	0	85.9	0	0	0
24-Sep	104		0	1	4.4	33	0	90.2	0	0	0
25-Sep	105		0	1	4.4	35	0	94.6	0	0	0
26-Sep	106		0	1	4.4	37	0	99	0	0	0
27-Sep	107		5.9	1	4.4	36	0	97.5	0	0	0
28-Sep	108		0	1	4.4	38	0	101.9	0	0	0
29-Sep	109		0	1	4.4	39	0	106.2	0	0	0
30-Sep	110		0	1	4.4	41	0	110.6	0	0	0
01-Oct	111	End	0	1	2.7	42	0	113.3	0	0	0
02-Oct	112		0	1	2.7	43	0	115.9	0	0	0
03-Oct	113		0.7	1	2.7	44	0	117.9	0	0	0
04-Oct	114		0	1	2.7	45	0	120.5	0	0	0
05-Oct	115		0	1	2.7	46	0	123.2	0	0	0
06-Oct	116		0	1	2.7	47	0	125.8	0	0	0
07-Oct	117		0.7	1	2.7	47	0	127.8	0	0	0
08-Oct	118		0	1	2.7	48	0	130.4	0	0	0
09-Oct	119		0	1	2.7	49	0	133.1	0	0	0
10-Oct	End		0	1	0	49					