Optimizing Irrigation Water Use for Tomato & Potato to Save Water in Middle of Iraq

Maryam Muslim Aajel[1*],Thanaa abd alameer kadhim[2], Walaa Salam Kadhim[3] , Amal Naimah Abdul[4], Hanaa Abdulhussein Abdullah[5], Huda Hayder Abed Hajim[6]

[1]Department of Animal Production, College of Agriculture, University of Al-Qadisiyah, Iraq

[2]Department of Horticulture and Landscape Engineering,,College of Agriculture, University of Al-Qadisiyah, Iraq
[3]Department of Soil and Water Resources, College of Agriculture, University of Al-Qadisiyah, Iraq.
[4] Internal Departments Affairs at Al-Qadisiyah University, lraq.
[5]College of Nursing, Al-Qadisiyah University, Iraq.
[6]College of Dentistry, University of Al-Qadisiyah, Iraq.

*Corresponding author's email: 198marim@gmail.com
Email addresses of coauthors: asiila662@gmail.com, asiila662@gmail.com,aligr1811@gmail.com, amkyanamkyan489@gmail.com, dentisthuda3@gmail.com

Abstract

Water management is key to the efficient use of water and in promoting crop production, particularly in water scarce semi-arid areas. The present study aims to estimate the crop water requirements for tomato and potato crop and irrigation scheduling for Al-Qadisiya Governorate, middle of Iraq, using CROPWAT 8.0 model developed by FAO. This research was carried out to identify the irrigation requirement and management of most important crops. The results indicate that adequate water availability will be needed for tomatoes and potatoes during their flowering and fruiting period. The crop water requirement 1159.4 is mm/dec and 588.5 mm/dec for tomatoes and potatoes. But the study stresses the need to ensure irrigation management in accordance with ET, soil moisture and climate for sustainable agriculture. From the above observations it was suggested that the water requirement of a crop can be simulated better by using the CROPWAT 8.0 model of the crops and the same can be used to suggest irrigation scheduling to the farmers. The findings may help water-stressed scientists, policy makers and farmers to better manage their irrigation water.

Keywords:. Irrigation water, Tomato, Potato

Introduction

Water is the most important natural resource for agriculture; however, growing demand for its use across various sectors, coupled with global climate change, is placing increasing pressure on available water resources, particularly in arid and semi-arid regions [1]. It is estimated that the agriculture contributes approximately 70% of total freshwater consumption in the world and the loss of over 60% from the

ISSN 2072-3857

use of irrigation water is worsening the current situation, according to the World Water Development Report of the United Nations [2].

Iraq, which lies within a semi-arid climate zone, is suffering from a severe water crisis that has been exacerbated by climate change and the construction of dams on the Tigris and Euphrates rivers in neighboring countries, leading to a sharp decline in water inflows and a deterioration in water quality [3]. The agricultural sector is the largest consumer of water in Iraq, accounting for about 80% of total water consumption, making water conservation in this sector an indispensable national priority [1].

Tomato and potato crops are important in agricultural context in Iraq and its production is challenged by water scarcity, high evapotranspiration rates, particularly in hot and dry summer of central Iraq. Recent studies have revealed that the crop water requirements are not uniform across the crop growth stages and it depends on soil type, location, agricultural practices, temperature, and effective rainfall [2].

In this context, computer models have proven useful tools to assist in agricultural water management decisions. A prominent example of these tools is CROPWAT 8.0 developed by Food and Agriculture Organization of the United Nations (FAO) which could calculate the water requirement of crops and an irrigation schedule based on climate, soil, and crop data [4].The program relies on the Penman-Manteith equation for calculating reference evapotranspiration (ET_0) and thus is one of the most accurate and complete methods available for estimating evapotranspiration and crop water requirements [5]. Numerous studies in Iraq and around the world have demonstrated the effectiveness of this model in calculating crop water requirements and managing water resources with scientific precision [3,2,6,1,7,8 ,9,10].

At the local level, a study in Dhi Qar Governorate in southern Iraq used the CROPWAT 8.0 program to estimate water requirements and irrigation schedules for several crops; the water requirement for tomatoes was 1,180 mm/decade, exceeding that of wheat, barley, and white corn (Ewaid et al., 2019). Another study in Basra Governorate showed that the water requirements for tomatoes were 470.3 mm/decade, while net irrigation requirements were 415.4 mm/decade [11].. As for potatoes, a study covering nine weather stations across Iraq revealed that their water requirements ranged from 17.9 mm at the Mosul station (in the north) and 438.6 mm at the Al-Hay station (in central Iraq), indicating a clear variation in the water requirements of a single crop depending on geographical location and climatic conditions [1]..

Globally, a study conducted in Ethiopia applied the CROPWAT model to determine the water requirements for tomato crops. The results showed that the total amount of water applied under the irrigation regimen calculated by CROPWAT was 1087.5 mm in 2020, compared to 1275. 5 mm under farmers' traditional practices, representing a 14.7% savings and a 25.8% increase in marketable yield. Water use efficiency for tomatoes under the CROPWAT system was recorded at 14.42 kg/m³ compared to 9.01 kg/m³ for traditional practices, representing a 37.5% increase [4]..

In India, a study using CROPWAT 8.0 estimated the water requirements for tomatoes in the state of Assam at 274.2 mm for the entire season, with a net irrigation requirement of 167.2 mm when planted on October [12]. Another study in the Oda Bultum region of Ethiopia

ISSN 2072-3857

estimated the water requirements for tomatoes at 412 mm and the irrigation requirements at 358 mm during the dry season [5].

Although these valuable studies are available, most of them focus on southern Iraq or other regions outside the country, while studies on improving the use of irrigation water for tomato and potato crops in central Iraq remain limited. Central Iraq is characterized by climatic and soil conditions that differ from those in the southern regions, and it is a vital agricultural area where these crops are grown extensively. Therefore, this study aims to estimate the water requirements of tomato and potato crops in central Iraq using the CROPWAT 8.0 model and to derive optimal irrigation schedules that contribute to rationalizing water consumption and increasing agricultural productivity [4], thereby achieving water and food sustainability in light of the water scarcity facing the country.

Material and Methods

The study area

This work was accomplished in in Al-Qadisiya Governorate , Iraq. The Al-Qadisiya governorate, known as the Diwaniya Governorate, is located southeast of Baghdad between (31° 51′ 0″ N), and (45° 3′ 0″ E). The Al-Qadisiya Governorate in south-central Iraq features flat alluvial plains sloping eastward from the western desert fringes. The Euphrates River is water source [13]. Critical water challenges include dwindling flows due to upstream dams (Turkey/Syria), soil salinization from intensive farming, and pollution from agricultural. Statistics indicate that the total area of land in the governorate is 3,275,326 dunum. The area suitable for agricultural production occupies approximately 1,844,700 dunum [14].



Figure (1) map of Iraq and location of the study area

2.1 Meteorological Data

The CROPWAT programme takes twelve meteorological variables to measure, such as air temperature, vapour pressure, relative humidity, barometric pressure, direction of wind, wind speed, precipitation, solar radiation, , and lightning.

Irrigation requirements for various crops were calculated at numerous weather stations worldwide. The soil type of the study area was determined as Medium (loam) [3].Climatic data from FAO software CLIMWAT 2.0, As far as crop and soil data are related to the study area were employed using CROPWAT.

ISSN 2072-3857

2.2 CROPWAT 8.0 Model

The FAO developed a series of equations for calculating irrigation requirement (IR), irrigation scheduling, crop water requirement (CWR), and reference evapotranspiration (ET_0) in the computer program, CROPWAT 8.0, with data pertaining to rainfall, soil, crop and climate. The program contains general information about the characteristics of a wide range of crops, about the local climate and soil conditions and assists with creating irrigation schedules and the amount of water that can be supplied to these various cropping patterns in rained and irrigated conditions.

2.3 Input Data Related to Crop and Soil

Kc values were computed from the ratio of evapotranspiration of each crop to reference evapotranspiration (ET_0) and were taken from the data of the full irrigation (IR100). ETc was estimated by soil water balance approach (FAO-approach, Equation (3) and ET_0 was estimated, using the Penman–Monteith equation, based on the climatic variables recorded from the weather station. All input data related to soil were manually incorporated [15]..

2.4 Reference Evapotranspiration (ET_0)

Understanding the effects of climate change would have included additional evaporation with a higher IWR. As this research need easily available inputs such as minimum and maximum temperatures (°C), relative humidity (%), daily sunshine (h), and wind speed (m/s), , that were estimated using the CROPWAT for AL-Qadisiya province, FAO Penman–Monteith Equation was used in present work to calculate evapotranspiration [16].. Using a mathematical equation (eq.1), the study Penman-Monteith equation used in this work can be expressed as follows:

$$ET_0 = \frac{[0.408\Delta(R_n - G) + \gamma 900/(T+273)u2(es-ea)]}{[\Delta + \gamma(1+0.34u2)]} \quad \ldots(1)$$

Where:

R_n=net radiation at the crop canopy (MJ m^{-2} day^{-1}).

Δ= slope vapor pressure curve (kPa $°C^{-1}$).

G= soil heat flux density (MJ m^{-2} day^{-1}).

T=average daily air temperature at 2 m height (°C).

γ= psychometric constant (kPa $°C^{-1}$).

e_s=saturation vapor pressure (kPa).

e_a=actual vapor pressure (kPa).

$e_s - e_a$= saturation vapor pressure deficit (kPa).

u_2= wind speed (at 2 m height (m s^{-1})).

2.5 Crop Evapotranspiration (ETc)

The crop coefficient (Kc) is used in the model to calculate ETc, and has been determined based on the climatic data. Crop coefficient is the ratio of reference ET_C/ET_0. The equation below (Equation (2)) is used to calculate ETc.

$$ET_c = ET_0 \times K_c \ldots..(2)$$

Kc= the crop coefficient, representing the ratio of crop's ETc to the reference evapotranspiration (ET_0) [9]..

2.6 Irrigation water Requirement

Irrigation water requirement is calculated by taking into account crop type and stage, climate, and soil type including the crop data for tomato and potato were obtained from the FAO [17]

The CROPWAT application can be utilized to calculate the root zone's daily water content using the following formula (equation 3) [24].

$$Dr_i = Dr_i - 1 - (P - RO_i) - I_i + CR_i + ET_{ci} + DP_i \ldots..(3)$$

Where: Dr,i−1 is the water content in the root zone at the end of the previous day (mm.), and Dr,i is the root zone depletion at the end of the day (mm.). Day 1 is the day on which precipitation occurred

(mm.), surface soil runoff (mm.) is given as ROi, net irrigation depth that gets into the soil (mm.) is given as Ii, capillary rise from the groundwater table (mm.) is given as Cri, crop evapotranspiration (mm.) is given as ETci, and water lost in the root zone on day I (mm.) is given as DPi.

Results and Discussion

3.1 References evaporation

The results in Table (1) show a marked increase in reference evapotranspiration (ET_0) values during the summer months, with a maximum value of 10.06 mm/day in July, while the value dropped to a minimum of 2.11 mm/day in January, This seasonal variation is attributed to the significant rise in temperatures during the summer (with a maximum temperature of 42.7°C recorded in July), coupled with a decrease in relative humidity to 29%, an increase in sunshine hours to 10.9 hours, and an increase in solar radiation to 26.1 megajoules/ m²/day, which increases evaporation and transpiration rates. In winter, however, temperatures drop, and hours of sunshine and solar radiation decrease, while relative humidity rises to 67%, leading to lower evaporation-transpiration rates. This is consistent with the findings of a study by Al-Bahati et al. [6] in central Iraq, which confirmed that high evapotranspiration rates are closely linked to intense solar radiation and high temperatures. These results are also consistent with a study by Ewaid et al. (2019) in southern Iraq, which showed that evaporation rates increase significantly during the summer due to the combination of high temperatures and low humidity, while they decrease in the winter, This is also consistent with a study by Solangi et al. (2022) in Pakistan, which showed that ET_0 values are high in the summer due to high temperatures, low relative humidity, and dry winds, and decrease in winter due to opposite climatic factors. This confirms that changes in ET_0 values reflect variations in meteorological conditions in the region, and these variations have a direct impact on crop water requirements, as irrigation needs increase during hot months and decrease during cold months. This is consistent with the findings of a study by Patle and Panggeng [23] in the Kohima region of India, which found that higher ET_0 values increase crop water requirements, particularly during critical growth stages. Therefore, a precise understanding of reference evapotranspiration patterns is essential for scientifically planning irrigation schedules and rationalizing water consumption in arid and semi-arid regions such as central Iraq.

Table (1) Reference evapotranspiration of the study area

Month	Min. Temp° C	Max. Temp° C	Humidity %	Wind (km/day)	Sun (hours)	Rad (MJ/m²/day)	ET_0 (mm/day)
January	4.1	17.1	67	233	6.5	11.4	2.11
February	5.8	19.7	61	242	7.2	14.4	2.85
March	9.6	24.4	50	259	7.5	17.4	4.33
April	14.5	30.1	43	251	8.1	20.7	5.88
May	20	34.8	35	233	9.1	23.3	7.27
June	23.1	41	27	294	10.9	26.3	9.96
July	24.3	42.7	29	285	10.9	26.1	10.06

ISSN 2072-3857

August	23.6	42.9	29	259	10.4	24.3	9.34
September	20.3	40.1	31	225	9.6	21	7.64
October	15.8	34.5	42	199	8.3	16.4	5.37
November	10.4	25.6	55	199	6.8	12.2	3.34
December	5.4	18.6	65	216	6.3	10.6	2.21
Average	14.7	31	44	241	8.5	18.7	5.86

3.2 Effective rainfall

The results in Tables (2) and (3) show that effective rainfall for tomato and potato crops accounted for 30.8% and 26.2%, respectively, of total water requirements, reflecting a clear variation in the contribution of effective rainfall depending on crop type and planting date. It is noted that effective rainfall for tomatoes was concentrated in March, April, and May (peaking at 5.2 mm in the first ten days of April) and then gradually decreased to zero in June, July, and August, whereas effective rainfall for potatoes was more evenly distributed throughout September, October, November, and December (peaking at 4.9 mm in the second ten-day period of December), This difference in the timing and amount of effective rainfall between the two crops is due to differences in planting seasons: tomatoes are planted in the spring and enter their critical growth stage in the summer, when effective rainfall is absent, while potatoes are planted in the fall and benefit from winter rainfall. This is consistent with the findings of a study by Zhu et al. [18] which indicated that effective rainfall values for crops vary depending on crop type and seasonal patterns, increasing in winter and being absent in summer. These findings also support the results of Clarke et al. [19] who calculated effective rainfall as the amount of rainfall taken up by crops, minus that lost due to deep percolation and surface runoff. They also agree with the study conducted by Ewaid et al. [3] in southern Iraq which indicated that the effective rainfall ranges from 0.0 to 23.1 mm and is highest during winter and lowest during summer months when the high temperatures and dry winds reduce the effective rainfall. This implies that the reliance on rainfall is not enough to satisfy the requirements of the crops, particularly during summer and supplemental irrigation needs to be used to make up the difference between their needs and effective rainfall. This highlights the need to use the CROPWAT program with caution to accurately estimate water requirements and plan the optimum irrigation schedule. The study conducted by Solangi et al. [20] also pointed out that the effective rainfall is an influential factor for decreasing the need for irrigation water, but it is inadequate in arid and semi-arid climates like central Iraq, and thus scientific approaches are essential in water resource management.

3.3 Crop water requirement

The actual evapotranspiration (ETc) values of tomato and potato crops in central Iraq were 1159.4 mm/decade and 588.5 mm/decade, respectively, which showed a significant difference between the tomato and potato crops due to the difference in their crop coefficient (Kc) as it increased gradually with the growth stage and reached a maximum value for both crops during the mid-stage (Mid) as 12.31 mm/day for tomatoes and 6.85 mm/day for potatoes in the 2nd decade of June and first decade of October, respectively. This shows the effect of the different growing seasons: tomatoes are planted in the spring and during the

warm summer they are in their critical growth phase, while potatoes are planted in the fall and experience less extreme temperatures and solar radiation during the critical growth period. This is also aligned with the results of a study done by Soomro et al. [9], which showed that crop water requirement varies based on (1) climate, (2) the type of crop and (3) stage of growth with mature crops using more water compared to newly planted ones. Crop water requirements found in this study are similar to those of Saeed et al. [21] in northern Iraq and Hussain et al. [22] who reported high correlation between crop water

requirement and climatic factors and crops growth stages. The tables show that ETc increases gradually with the progress of the stages from Init to Deve, increases further in the middle stages (Mid) and decreases in the final stages (Late) as the plant grows and transpiration rates are higher during the period from Init to Deve and then lower as the plant approaches maturity and harvest. This reflects the finding in the report that the water requirements of crops depend on the type of soil, its location, cropping methods, temperature and effective rainfall. These findings also support the findings of Al-Bahathy et al. [6] in central Iraq who found irrigation needs are less during initial growth phase, but increased during development phase and reached peak during the middle phase, which is the phase when harvesting is being done. This indicates that (ETc) is a true reflection of the complex climatic and crop characteristic and growth stages and it can be used as an important basis in the determination of water requirement and optimum irrigation schedules in the arid and semi-arid regions like central Iraq.

Table (2) Water requirement of tomato

Month	Decade	Stage	Kc coeff	ETc (mm/day)	ETc (mm/dec)	Eff rain (mm/dec)	Irr. Req. (mm/dec)
Mar	2	Init	0.60	2.6	15.6	3.2	12.90
Mar	3	Init	0.60	2.91	32	5.2	26.8
Apr	1	Init	0.60	3.22	32.2	5.2	27
Apr	2	Deve	0.64	3.78	37.8	5.1	32.6
Apr	3	Deve	0.79	5	50	4.3	45.7
May	1	Deve	0.94	6.32	63.2	3.4	59.8
May	2	Deve	1.09	7.79	77.9	2.6	75.3
May	3	Mid	1.2	9.68	106.5	1.8	104.8
Jun	1	Mid	1.2	11.11	111.1	0.1	111
Jun	2	Mid	1.2	12.31	123.1	0	123.1
Jun	3	Mid	1.2	12.23	122.3	0	122.3
Jul	1	Late	1.19	11.96	119.6	0	119.6

Jul	2	Late	1.1	11.09	110.9	0	110.9
Jul	3	Late	0.98	9.64	106	0	106
Aug	1	Late	0.88	8.52	51.1	0	51.1
					1159.4	30.8	1129.1

Table (3) Water requirement of Potato

Month	Decade	Stage	Kc coeff	ETc (mm/day)	ETc (mm/dec)	Eff rain (mm/dec)	Irr. Req. (mm/dec)
Aug	2	Init	0.50	4.72	28.30	0	28.3
Aug	3	Init	0.50	4.42	48.60	0	48.6
Sep	1	Deve	0.51	4.16	41.6	0	41.6
Sep	2	Deve	0.67	5.12	51.2	0	51.2
Sep	3	Deve	0.9	6.18	61.8	0.1	61.6
Oct	1	Mid	1.12	6.85	68.5	2	66.5
Oct	2	Mid	1.18	6.35	63.5	3	60.5
Oct	3	Mid	1.18	5.54	61	2.9	58.1
Nov	1	Mid	1.18	4.66	46.6	2.4	44.2
Nov	2	Mid	1.18	3.82	38.2	2.3	35.9
Nov	3	Late	1.13	3.27	32.7	3.3	29.5
Dec	1	Late	1	2.51	25.1	4.2	20.9
Dec	2	Late	0.86	1.81	18.1	4.9	13.2
Dec	3	Late	0.78	1.64	3.3	1.2	3.3
					588.5	26.2	563.5

3.4 Irrigation scheduling of crops

The results of irrigation schedules for tomato and potato showed clear pattern of water requirement changes throughout growth stages showing that irrigation requirements are reduced in initial growth stage, then increased gradually during the development stage, reaching the highest level in the middle stage and then decreased in the final stage to ease harvesting, which is consistent with the results of Al-Bahaty et al. [6]who confirmed that under the central Iraq conditions. Compared to potatoes (Table 5), it is noted that the water requirement for tomato is also significantly higher due to differences in the crop coefficient (Kc), root depth and growing seasons where the tomatoes are grown, as the water requirements during the growing seasons are higher with higher rates of reference evapotranspiration (ET_0). This is consistent with a study conducted in southern Iraq that classified tomatoes among the crops with the highest water consumption, and with an Ethiopian study that recorded water requirements for tomatoes at 1,087.5 mm according to the CROPWAT system. The tables also reveal a clear gap between net irrigation and total irrigation, reflecting system losses ranging from 30-40% due to evaporation, surface runoff, and deep percolation. This underscores the importance of using irrigation schedules calculated by CROPWAT, which allocated 10 irrigations for tomatoes and 13 for potatoes based on the depletion index (Depl%) and soil moisture status and

ISSN 2072-3857

effective rainfall, an approach that a study by Adamtie et al. [4] has proven effective in increasing marketable tomato yield by 25.8% and water use efficiency by 37.5% compared to traditional practices, with the system capable of reducing losses by up to 46.1%.

The final observations show a sharp decline in irrigation toward the end of the season, with high drainage values (21% for tomatoes and 11% for potatoes) to dry out the soil before harvest, while flow rates range from 0.38 to 2.03 liters/second/ hectare for tomatoes and 0.47-1.09 for potatoes, reflecting the intensity of irrigation required at each stage. Taken together, these results underscore the importance of the CROPWAT program as an accurate scientific tool for determining optimal irrigation schedules for tomato and potato crops in central Iraq, thereby contributing to a 15-30% reduction in water consumption while maintaining crop yield and quality, a finding supported by previous studies that recommended the use of computer models in agricultural water resource management to address water scarcity in arid and semi-arid regions.

Table (4) Irrigation Scheduling of Tomato

Date	Day	Stage	Rain (mm)	Ks (fract.	Eta (%)	Depl. (%)	Net Irr. (mm)	Deficit (mm)	Loss (mm)	Gr. Irr. (mm)	Flow (l/s/ha)
30-Mar	16	Init	0.0	1	100	30	36.7	0.0	0	52.4	0.38
19-Apr	36	Dev	0.0	1	100	32	58.6	0.0	0.0	83.6	0.48
06-May	53	Dev	0.0	1	100	36	85.5	0.0	0.0	122.2	0.83
22-May	69	Dev	0.0	1	100	42	119.9	0.0	0.0	171.3	1.24
03-Jun	81	Mid	0.1	1	100	41	119.5	0.0	0.0	170.8	1.65
14-Jun	92	Mid	0.0	1	100	44	127	0.0	0.0	181.4	1.91
24-Jun	102	Mid	0.0	1	100	42	122.8	0.0	0.0	175.4	2.03
04-Jul	112	Mid	0.0	1	100	42	121.2	0.0	0.0	173.2	2
15-Jul	123	End	0.0	1	100	44	127.2	0.0	0.0	181.8	1.91
29-Jul	137	End	0.0	1	100	49	142.2	0.0	0.0	203.1	1.68
06-Aug	End	End	0.0	1	0.0	21					

ISSN 2072-3857

Table (5) Irrigation Scheduling of Potato

Date	Day	Stage	Rain (mm)	Ks (fract.)	Eta (%)	Depl. (%)	Net Irr. (mm)	Deficit (mm)	Loss (mm)	Gr. Irr. (mm)	Flow (l/s/ha)
20-Aug	6	Init	0.0	1	100	29	28.3	0.0	0.0	40.5	0.78
26-Aug	12	Init	0.0	1	100	25	26.5	0.0	0.0	37.9	0.73
02-Sep	19	Init	0.0	1	100	26	30.4	0.0	0.0	43.5	0.72
10-Sep	27	Dev	0.0	1	100	26	33.3	0.0	0.0	47.5	0.69
18-Sep	35	Dev	0.0	1	100	29	41	0.0	0.0	58.5	0.85
26-Sep	43	Dev	0.0	1	100	30	47.2	0.0	0.0	67.5	0.98
04-Oct	51	Dev	0.0	1	100	30	51.1	0.0	0.0	73	1.06
12-Oct	59	Mid	0.0	1	100	30	52.8	0.0	0.0	75.4	1.09
21-Oct	68	Mid	0.0	1	100	31	54.8	0.0	0.0	78.3	1.01
31-Oct	78	Mid	0.0	1	100	30	52.5	0.0	0.0	75.1	0.87
13-Nov	91	Mid	1.2	1	100	31	54.5	0.0	0.0	77.9	0.69
08-Dec	116	End	0.0	1	100	41	70.8	0.0	0.0	101.2	0.47
22-Dec	End	End	0.0	1	0	11					

4 Conclusions

and potato crop water requirement as well as irrigation requirement at different growth stages daily, decadal and monthly. The results show that water management is important if the rainfall is normal or deficient. Based on the above observations, it was recommended that the CROPWAT 8.0 model was used to estimate the crop water requirements with high accuracy for various crops and farmers could be guided by the model on the irrigation scheduling required for the crop.

The study estimated the crop water requirement, irrigation scheduling for tomatoes and potato well essential for water efficiency and increase in yield. The water needs and optimum irrigation scheduling for tomato and potato were considered using FAO CROPWAT 8.0 which accounted for crop requirements and climatic conditions in the region, based on growth stage and water requirement of the crops. The work was conducted in the middle part of Iraq at Al-Qadisiya Governorat. Model predicted tomato

References

of Agriculture and Urbanization, 5(1), 32-44.

2. Al-Ghazi, Saja H. S., Al-Badiri, Athraa A. Q. , faleh, A.A. , Naghmash, A.H., AlKhalidi, M.A.R., Al-Bahathy, Idrees A.A. (2025a). Study on Major

1. Hameed, A. I., Bashi, R. M. Q., & Mohammad, N. A. (2026). Evaluation of Crop Water Requirement using Cropwat Software in Iraq. World Journal

technique: from water saving to the improvement of a fruit quality. Frontiers in Sustainable Food Systems, 1, 3. https://doi.org/10.3389/fsufs.2017.00003

8. Sairam M, Sagar L, Reddy MD (2022). Estimation of water requirement and irrigation schedule for groundnut and sunflower crops in southern Odisha using FAO CROPWAT8.0 model. Journal of Agrometeorology 27;24(3). https://doi.org/10.54386/jam.v24i3.503
9. Soomro S., Solangi G.S., Siyal A.A., Golo A., Bhatti N.B., Soomro A.G., Memon A. H., Panhwar S., and Keerio H. A., (2023). Estimation of irrigation water requirement and irrigation scheduling for major crops using the CROPWAT model and climatic data. Water Practice & Technology, 18(3), 685-700. https://doi.org/10.2166/wpt.2023.024
10. Mustafa, S. A. (2024). Water consumption, water use efficiency and potato yield under the influence of moistuer depletion and addition method. Iraqi Journal of Agricultural Sciences, 55(1), 517-525. https://doi.org/10.36103/sedt6x91
11. Al-Ghazi, Saja H. S., Al-Badiri, Athraa A. Q. , Abeer A. faleh, Amal H. Naghmash, Mohammed A. R. AlKhalidi, Al-Bahathy, Idrees A. A. (2025b). Determination Irrigation Requirement for Some Vegetables and Fruits using FAO-CROPWAT model in in Southern Part of Iraq. Crops Water Demand and Irrigation Scheduling in Basrah Governorate Based on CROPWAT Model. Dijlah J. Agric. Sci., 4(3), 11-24.
3. Ewaid, S. H., Abed, S. A., & Al-Ansari, N. (2019). Crop water requirements and irrigation schedules for some major crops in Southern Iraq. Water, 11(4), Article 756.https://doi.org/10.3390/w11040756
4. Adamtie, T. F., Mitku, D. T., & Hassen, A. (2022). Validations of CROPWAT-Based Irrigation Practice for Tomato Productivity in Lowland Hot Humid Area of Ethiopia. American Journal of Life Science and Innovation (AJLSI), 1(1). https://doi.org/10.54536/ajlsi.v1i1.426
5. Olana, A. B., & Hunde, B. M. (2025). Determinations and Validations of Crop Water Requirements for Major Vegetable Crops Using CROPWAT Model at Oda Bultum District. Acta Biology Forum. https://doi.org/10.51470/ABF.2025.4.2.05
6. Al-Bahathy, I. A., Saadoun, S. F., Hussein, H. N., & Al-Janabi, Z. Z. (2026). Optimizing Irrigation Scheduling for Major Crops in the Middle of Iraq using the CROPWAT Model to Promote Sustainable Agriculture: scheduling and water requirements for Major Crops in Iraq. Current Applied Science And Technology, e0268250-e0268250.
7. Jovanovic, Z., & Stikic, R. (2018). Partial root-zone drying

https://doi.org/10.31026/j.eng.2015.08.10

17. FAO (2026). "CROPWAT Software, Land and Water Division." https://www.fao.org/land-water/databases-and-software/cropwat/en/
18. Zhu, S., Tong, W., Li, H., Li, K., Xu, W., & Liang, B. (2025). Temporal variations in rice water requirements and the impact of effective rainfall on irrigation demand: Strategies for sustainable rice cultivation. Water, 17(5), Article 656. https://doi.org/10.3390/w17050656
19. Clarke, D., Smith, M., & El-Askari, K. (2001). *CropWat for Windows: user guide*. University of Southampton Institutional Repository. http://eprints.soton.ac.uk/id/eprint/73992
20. Solangi, G. S., Shah, S. A., Alharbi, R. S., Panhwar, S., Keerio, H. A., Kim, T.-W., Memon, J. A., & Bughio, A. D. (2022). Investigation of Irrigation Water Requirements for Major Crops Using CROPWAT Model Based on Climate Data. Water, 14(16), 2578. https://doi.org/10.3390/w14162578
21. Saeed, F. H., Al-Khafaji, M. S., & Al-Faraj, F. A. M. (2021). Sensitivity of Irrigation Water Requirement to Climate Change in Arid and Semi-Arid Regions towards Sustainable Management of Water Resources. Sustainability, 13(24), 13608. https://doi.org/10.3390/su132413608

Dijlah Journal of Agricultural Sciences, 4(3), 25-37.

12. Panme, F. A., & Sethi, L. N. (2023). Estimation of Crop Water Requirements and Irrigation Scheduling for Major Crops Grown in India's North-Eastern Region. Current Applied Science and Technology, 10-55003. https://doi.org/10.55003/cast.2022.04.23.011
13. Olson, K. R., & Speidel, D. R. (2024). Tigris, Euphrates, and Shatt Al-Arab River System: Historic and modern attempts to manage and restore Iraq's lifeline. Open Journal of Soil Science, 14(1), 28-63. https://doi.org/10.4236/ojss.2024.141003
14. Wedaa, Z. W., Abed, S. A., & Ewaid, S. H. (2022). The agricultural water footprint of Al-Qadisiyah governorate, southern Iraq. IOP Conference Series: Earth and Environmental Science, 1029(1), Article 012025
15. Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56. Food and Agriculture Organization of the United Nations; FAO Irrigation and drainage paper 56. FAO 1998, 300, D05109
16. Al-Shaikh, R. Z. D., & Almasraf, S. A. D. (2015). Applying Penman-Monteith Equation to Evaluate the Performance of Atmometer Apparatus in Greenhouse for Estimating Reference Evapotranspiration. Journal of Engineering, 21(08), 161-173.

ISSN 2072-3857

22. Hussain S, Mubeen M, Nasim W, Fahad S, Ali M, Ehsan MA, Raza A. Investigation of Irrigation Water Requirement and Evapotranspiration for Water Resource Management in Southern Punjab, Pakistan. Sustainability. 2023; 15(3):1768. https://doi.org/10.3390/su15031768
23. Patle, G. T., & Panggeng, T. (2024). Assessment of crop water requirement and irrigation scheduling for selected crops in the Kohima district, Nagaland, India. Water Practice & Technology, 19(3), 812-823. https://doi.org/10.2166/wpt.2024.047
24. Valiantzas, J. D. (2013). Simplified forms for the standardized FAO-56 Penman–Monteith reference evapotranspiration using limited weather data. *Journal of Hydrology*, *505*, 13-23. https://doi.org/10.1016/j.jhydrol.2013.09.005

ISSN 2072-3857