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# Validations of CROPWAT Based Irrigation Practice for Tomato Productivity in Lowland Hot Humid Area of Ethiopia

Temesgen F. Adamtie<sup>1\*</sup>, Demeke T. Mitku<sup>1</sup> and Abeba Hassen<sup>1</sup>

# Article Information

ABSTRACT

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#### Keywords

Crop water requirement, Irrigation Scheduling, CROPWAT, Tomato

The efficient management of applied water volume and wise water application is accomplished by irrigation scheduling. Microclimate is the most important factor affecting the irrigation schedule, which determines when and how much irrigation water will be used. The objective of this experiment was to validate the experimental effects of CROPWAT irrigation practice compared to farmer's practice on crop and water productivity of tomato. The CROPWAT Penman-Monteith method was used to calculate crop water requirement and irrigation scheduling of tomato as compared to farmers irrigation practice. The total water applied were 1087.5mm and 1275.5mm for 2020 and 895.3mm and 1242.6mm for 2021 respectively for CROPWAT and farmers' practice. The obtained validated result revealed that farmers' irrigation practices for marketable tomato fruit were 25.8% lower when based on CROPWAT irrigation practice, while those for unmarketable tomato fruit were 46.18% lower. In contrast to farmers' irrigation practices, the CROPWAT irrigation system can reduce loss by 46.1 percent for the production of tomato fruit. Similarly for tomato water productivity, CROPWAT-based irrigation systems received an incremental 37.5 percent advantage over farmers' practices. As a result, this study came to the conclusion that CROPWAT-based irrigation practices are crucial for field crop irrigation scheduling and crop water requirements. The study will contribute to bettering tomato fruit productivity and water resource management. This study might serve as a guide for making choices regarding upcoming planning.

# INTRODUCTION

The FAO created the decision-support software CROPWAT 8.0 to compute reference evapotranspiration (ET0), crop water requirements (CWR), irrigation scheduling, and irrigation water requirements (IR) using rainfall, soil, crop, and climate data (Ewaid et al., 2019). Irrigation scheduling is a water management strategy to prevent over-application of water while minimizing yield loss due to water shortage or drought stress area (Marković et al., 2014; Jones, 2006; Jha et al., 2016; Adametie and Mitku, 2021). The efficiency of water use in agriculture is low with poor management and improper designs of water application systems (Evans and Sadler, 2008; Sharma and Bhambota, 2022). The irrigation schedule which determines the timing and amount of irrigation water is governed by many complex factors, but microclimate plays the most vital role (Stevens, 2007; Nikolaou et al., 2020; Raine et al., 2007). High water loss results in lesser yield and reduced irrigated areas that are linked to ineffective water use (Ewaid et al., 2019). But the improved irrigation practices lead to more uniform water distribution, minimize water application, irrigation costs, nutrient leaching, and result in the economic viability of irrigated agriculture (Ismail and Ozawa, 2009; Jones, 2006). However, in Ethiopia traditionally anyone understood that irrigating more water for the crops means getting more yield (Adametie and Mitku, 2021). In addition to this, in Ethiopia, poor irrigation scheduling practices have been considered as the major challenge for the sustainability of irrigation schemes

because of the lack of simple and practical scheduling techniques, cost, inaccessibility of soil water monitoring tools, lack of local climate data and soil-water parameters (Yohannes et al., 2019; Eshete et al., 2020). Therefore, it is important to develop irrigation scheduling techniques under prevailing vital conditions to utilize scarce and expensive water efficiently and effectively for crop production. To tackle those problem Several studies were carried out in the past on the development and evaluation of irrigation scheduling techniques under a wide range of irrigation systems and management, soil crop and climate conditions. Software modeling with programs such as AQUACROP and CROPWAT 8.0 is a significant practice used by scientists for crop evapotranspiration, CWR, and irrigation scheduling. The Food and Agriculture Organization (FAO) created those software programs as tools to assist irrigation engineers and agronomists in performing the standard calculations for water irrigation studies, as well as in the management and design of irrigation schemes (Ewaid et al., 2019; Poornima et al., 2020). For this study CROPWAT model was used to investigate the irrigation water requirements and irrigation scheduling tomato in lowland hot humid area of Ethiopia. Because of this model a lot of previous tests showed locally applicable and satisfactory performance in number of worldwide locations under varying climate circumstances including Ethiopia (Allen et al., 1998a; Eshete et al., 2020; Ewaid et al., 2019; Yohannes et al., 2019; Adametie and Mitku, 2021).

Tomato (Lycopersicon esculentum) is an important

<sup>&</sup>lt;sup>1</sup>Department of Irrigation and Drainage, Pawe Agricultural Research Center, Ethiopian Institute of Agricultural Research, Ethiopia. \* Corresponding author's e-mail: temesgenfentahun09@gmail.com



horticultural crop used by many for stew like in Amharic (Wote) and other recipes in Ethiopia. As the population continues to increase the demand for tomato in Ethiopia is also increasing; however, the yield is far below expectation that observed in some other countries and the fruits are with poor quality (Yeshiwas et al., 2016). The reason showed farmers still practice traditional irrigation system in Pawe district lowland hot humid area of Ethiopia's. For such condition, well managed and scheduled irrigation practice with respective crop stage is very necessary. The irrigator needs knowledge of the efficient use of water resources with crop management practices and irrigation scheduling techniques. These traditional practice needs improved technology like validation and demonstration for applicability of CROPWAT8. So, the objectives of this study were (1) To determine tomato crop water requirement and irrigation scheduling for local climate condition (2) To validate the experimental effects of CROPWAT irrigation scheduling compared to farmer's practice on crop and water productivity in area.

# METHODOLOGY

# Study Area description

This study was conducted on Pawe district it is located in the lowland hot humid area of Northwest Ethiopia (Figure 1). It lays between 360 151 and 360 301 and 110 231 north longitude and latitude respectively. The altitude ranges from 1000-1220 m.a.s.l. it is characterized by long rain season (from May to October). According to long term rainfall and climate data the mean annual rainfall is 1586 mm and amount are reliable from year to year and its average minimum and maximum temperature is 16.5 c0 and 32.66 c0 respectively. However, variation ranges from 8 co in the coolest period especially in July and August and around 40 c0 in the hottest period, March and April.

Pawe district also part of Beles basin included two main rivers namely Main and Gilgel Beles. The head water of Beles River starts from the area close to the western periphery of Lake Tana. Along its way it collects many major and minor tributaries. Gezhig, Burzhi and Chankur, Bula (keteb) and Giligile Beles are the major tributaries. All of the tributary also located on Pawe district each



Figure 1: Study Area of experiment

of them have annually flow water that farmers used irrigation for dry season crops like tomato, onion, pepper, maize, soyabean and perennial crops.

According Dieci and Viezzoli (1992) as cited by (Mariyea et al.)Pawe district are broadly categorized as vertisols soil (black clay soils), and account for 40–45% of the area; Nitisols (red or reddish-brown laterite soils) which account for 25–30%; and intermediate soils of a blackish-brown color, which account for 25–30%. This experiment was conducted on Vertisols (black clay soils) of Pawe district lowland hot humid area of Ethiopia humid area of Ethiopia

#### Experimental setup

The experiment was laid out a paired t-design to validate tomato productivity using CROPWAT 8 model crop water requirement and irrigation schedule as compared to farmer's practice. The paired t-test is mathematically powerful in comparing two-paired measurements that have intrinsic relationships and allows good control of individual differences without necessarily having a large sample size (Eng, 2003). De Winter (2013) proved the applicability of paired t-test as low as two replicates. Several studies including Assefa et al. (2021) Yimam et al. (2020), Belay et al. (2020), and Assefa et al. (2019) have used paired-t design for comparation purposes. So, in this experiment CROPWAT 8 model is the treatment to validated with farmer's practice for the productivity of tomato.

Furrow irrigation system was used for both CROPWAT 8 irrigation water management versus farmers irrigation practice. In farmer's irrigation practice, the farmers use their own irrigation scheduling system, with irrigation water management for tomato. Whereas in irrigation scheduling practice, we use the CROPWAT version 8 model to calculate irrigation water requirement and irrigation scheduling.

Calibrated two-inch throat width Parshall flume was used to measured irrigation water for both CROPWAT 8 irrigation scheduling and farmers' irrigation scheduling practice. The water discharge measured with partial flume. For each irrigation, the amounts of watering date and amount of watering were recorded in both farmer's irrigation practice and CROPWAT 8 irrigation scheduling practice.

# **CROPWAT 8.0 Model Description**

CROPWAT for Windows version 8.0 is a decision support system developed by the Water Resources Development and Management Service of 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 (Ewaid et al., 2019; Gabr, 2021; Kuo et al., 2001; Smith, 1992). The model is important at worldwide including Ethiopia (Bokke and Shoro, 2020; Adametie and Mitku, 2021).



#### Data Requirement

Four types of data are required for using the CROPWAT software, namely, rainfall data, climatic data, soil data, and crop data (Smith, 1992).

Climatic data for thirty-two years (1987–2019) were gathered from the Ethiopian National Meteorological Agency (ENMA) at Pawe meteorology station (Table 3). 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 tomatoes 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 (Allen et al., 1998b). Planting dates was decided accordingly effective rainfall of Pawe area.

The soil parameters obtained from the FAO CROPWAT 8.0 model include detailed information on the soil experimental site was sampled, such as field capacity (FC ), permanent welting point (PPT) and total available moisture content were done from Pawe agricultural research center (PARC) soil innovated laboratory. The rest specification initial moisture depletion, maximum rain infiltration rate, and maximum rooting depth were taken from FAO irrigation and drainage paper 56.

#### Estimations of Reference Evapotranspiration (ETo)

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 CROPWAT 8 model was used to estimate the reference evapotranspiration (ETo) using the Penman-Monteith method (Zotarelli et al., 2010). 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:

Where:

ETo = reference evapotranspiration [mm day-1], Rn = net radiation at the crop surface [MJ m-2 day-1], G = soil heat flux density [MJ m-2 day-1], T = mean daily air temperature [°C], U2 = wind speed at 2 m height [m s-1], es = saturation vapour pressure [kPa], ea = actual vapour pressure [kPa], es-ea = saturation vapour pressure deficit [kPa],  $\Delta$  = slope vapour pressure curve [kPa °C-1],  $\gamma$  = psychrometric constant [kPa °C-1]

#### Rainfall Data and estimation of effective rainfall

Similarly, climate data 32 years for monthly rainfall data was collected from the Ethiopian National Meteorological Agency (ENMA) at Pawe meteorology station. Effective rainfall (Pe) was determined using the United States Department of Agriculture Soil Conservation Service (USDA-SCS) method (Bos et al., 2008) and (Allen et al., 1998a) as shown in (Equation 2). The effective rainfall was used to determine irrigation water requirement for tomatoes.

(Pe=0.8P-25 P>75 mm/month)

(Pe=0.6P-10 P<75 mm/month)

Where Pe and P are effective rainfall and precipitation in mm/month, respectively

(2)

# Crop Water Requirement (CWR)

Crop water requirement refers to the amount of water that needs to be supplied, while crop evapotranspiration refers to the amount of water that is lost through evapotranspiration. For the determination of crop water requirement, the effect of climate on crop water requirement, which is the reference crop evapotranspiration (ETo) and the effect of crop characteristics (Kc) are important (Doorenbos and pruitt, 1977). As estimated reference evapotranspiration of the study area, crop data like crop coefficient, growing season and development stage, effective root depth, critical depletion factor of tomato and maximum infiltration rate and total available water of the soil was determined to calculate crop water requirement using cowpat model. (ETc=Kc×ETo) (3)

where Kc is the crop coefficient. It is the ratio of the crop ETc to the ET0, 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 (Allen et al., 1998b).

### Irrigation Water Requirement (IR)

The irrigation requirement (IR) is the main parameter for the planning, design, and operation of irrigation and water resources systems. According to Savva and Frenken (2002), irrigation water requirement is the optimal allocation of water resources for policy and decision-makers during the operation and management of irrigation systems. Missed management of irrigation requirements may lead to inappropriate capacities storage reservoirs, low water uses efficiency, reduction of the irrigated area, and increased development costs. The CROPWAT Model can compute the water balance of the root zone as far as root zone depletion by the following equation (Ewaid et al., 2019).

#### $IRn = ETc - (Pe + Ge + Ws) + LR \quad (4)$

Where, IRn = Net irrigation requirement (mm), ETc = Crop evapotranspiration (mm), Pe = Effective dependable rainfall (mm), Ge = Groundwater contribution from water table (mm), Ws = Water stored in the soil at the beginning of each period (mm) and <math>LR = Leaching requirement (mm)

#### Irrigation Scheduling

Irrigation scheduling determines the correct measure of water to irrigate and the correct time for watering. The CROPWAT model calculates the ETo, CWR, and IRs to develop the irrigation schedules under different administration conditions and water supply plans (Poornima et al., 2020).

### Crop parameter Data

For both treatment, tomato (melkashote) variety was cultivated two consecutive years in the 2020 and 2021 dry season (November to April). For tomato production recommended spacing is 30cm between plants and 70 cm between row was used (Markos and Mekonen; Salau et al., 2019). For both treatments blanket recommended Urea (46: N) fertilizer at a rate of 100 kg ha-1 were applied. Crop characteristics such as plant height and crop yield were recorded. Plant height was monitored at harvesting. The measuring tape was used to measure plant height. The digital balance was used to determine the weight of the fruit yield of tomato.

### **RESULT AND DISCUSSION**

#### Soil physical characteristics

The soil sample was taken before the planting of tomato takes place and analyzed using laboratory procedure. Hydrometer method to determine particle size of the sample (Bouyoucos, 1962). The result as shown the soil texture was varied in the study site (Table 1).

2019). For both treatments blanket recommended Urea Table 1. Soil physical characteristics texture, field capacity **Table 1:** Soil physical characteristics texture, field capacity (FC %), permanent wilting point (PWP %) and soil water

availability (SWA %) of experimental site							
Depths(cm)	Sand (%)	Silt (%)	Clay (%)	Soil class	FC (%)	PWP (%)	AWS (%)
15	22	10	68	Heavy Clay	45.61	27.66	17.95
30	14	18	68	Heavy Clay	36.8	25.11	11.69
60	18	14	68	Heavy Clay	39.04	26.37	12.67
90	24	12	64	Clay	39.9	26.94	12.96
120	22	12	66	Clay	44.18	27.39	16.79

(FC %), permanent wilting point (PWP %) and soil water availability (SWA %) of experimental site

The obtained soil physical characteristics is similar for pervious work of (Tefera and Mitku, 2017) (Table 2). Who was reported that the soil type of the study area is characterized by heavy clay soil with initial available soil moisture depletion level 111-129 (mm/meter depth) and total available soil moisture level was 222-259 (mm/meter depth) varying with soil depth? Hence; the soil is heavy clay; a mean infiltration rate was recorded 70 mm/day

Table 2: Source (Tefera and Mitku, 2017) soil physical characteristics of bleak Klay soil in Metekele zone

Soil texture	Heavy Clay to clay loam
Total available soil moisture	222.30-259.15 (mm/meter depth)
Percentage of initial soil moisture depletion	50%
Initial available soil moisture depletion	111.15-129.575(mm/meter depth)
Maximum infiltration rate	50-90 (mm/day)
Maximum rooting depth	Up to 1.5m
Bulk density	1.12-1.31gm/cm3

and the bulk density was varying from 1.12-1.31gm/cm3 across the depth of 1.2 meter 3.2.

# Monthly Rainfall, Effective rainfall and Evapotranspiration of Pawe

From long term mean monthly rainfall data Pawe district showed they have rainfall for each month (Table 3). The maximum rainfall Contrary minimum evapotranspiration (Eto) month June to October (Figure 2). However, the rainfall to be effectively used for crop production is only May to October the rest (November to April) there is no effective rainfall so that the irrigation is required. In this area May to October is wet season or rainfall season that applies rainfall system agriculture and also November to April is dry season known as irrigation time. This was used to guide the experiment conducted time depending on the effective rainfall and reference evapotranspiration to compute irrigation water requirement and irrigation

Table 3: Monthly rainfall and effective rainfall of Pawe

Pawe meteorology setation				
Month	Rain (mm)	Eff rain (mm)	Eto (mm/month)	
January	0.7	0	116.4	
February	0.6	0	122.96	
March	7.8	0	154.51	
April	27.8	6.68	161.46	
May	93.2	49.56	155.65	



June	289.8	206.84	125.14
July	361.4	264.12	106.23
August	396.3	292.04	106.57
September	261.1	183.88	111.98
October	132.6	81.08	115.69
November	14.4	0	110.71
December	0.7	0	114.54

Note: Eff rain and mm were effective rain fall and millimeter respectively.



Figure 2: Mean monthly distributions of rainfall, effective rainfall and evapotranspiration of Pawe scheduling of dry season (ETo) were used as input data of

# Crop water requirement and irrigation scheduling of tomato in the study area of Pawe Theinput of crop, rainfall and reference evapotranspiration

(ETo) were used as input data of CROPWAT to simulates crop water requirement (ETc), and irrigation water requirement with respective crop growth stages of tomatoes (Table 4). Hence, this simulated tomato crop water requirement with respect to growth stage was used

 Table 4: Tomatoes cultivated season growth stage, crop coefficient (KC), crop evapotranspiration (ETc), effective rainfall and irrigation requirements

Month	Decade	Stage	Kc Coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Nov	2	Init	0.6	2.15	12.9	0	12.9
Nov	3	Init	0.6	2.14	21.4	0	21.4
Dec	1	Init	0.6	2.12	21.2	0	21.2
Dec	2	Deve	0.63	2.21	22.1	0	22.1
Dec	3	Deve	0.77	2.7	29.7	0	29.7
Jan	1	Deve	0.91	3.24	32.4	0	32.4
Jan	2	Deve	1.05	3.75	37.5	0	37.5
Jan	3	Mid	1.15	4.34	47.7	0	47.7
Feb	1	Mid	1.16	4.58	45.8	0	45.8
Feb	2	Mid	1.16	4.81	48.1	0	48.1
Feb	3	Mid	1.16	5.04	40.3	0	40.3
Mar	1	Late	1.16	5.26	52.6	0	52.6
Mar	2	Late	1.08	5.13	51.3	0	51.3
Mar	3	Late	0.96	4.67	51.4	0.1	51.2
Apr	1	Late	0.84	4.23	33.8	0.3	33.5
Total					548.2	0.4	547.7

to validate farmers applied water to each growth stage.

**CROPWAT system Irrigation scheduling of Tomato** Accordingly, FAO recommendation in this study irrigation scheduling was worked out using CROPWAT 8.0 windows by selecting without yield reduction and water loss; and the 100% readily available soil moisture depletion the simulated was follow (Table 5 and 6) as

Day	Stage	Rain (mm)	Net Irr (mm)	Gr. Irr (mm)	Flow (l/s/ha)
1	Init	0	27.7	46.1	5.34
7	Init	0.1	19.7	32.9	0.63
15	Init	0	26.6	44.3	0.64
25	Init	0	33.8	56.4	0.65
36	Dev	0	40.5	67.5	0.71
48	Dev	0	52.8	88	0.85
61	Dev	0	69.6	115.9	1.03
75	Mid	0	81.7	136.2	1.13
90	Mid	0	83.1	138.6	1.07
105	Mid	0	82	136.7	1.05
125	End	0	88.2	146.9	0.85
End	End	0			

**Table 5:** Tomatoes irrigation scheduling, net irrigation requirement, gross irrigation requirement and flow speed of irrigated water in 2020

Table 6: Tomatoes irrigation scheduling, net irrigation requirement, gross irrigation requirement and flow speed of irrigated water in 2021

Day	Stage	Rain (mm)	Net Irr (mm)	Gr. Irr (mm)	Flow (l/s/ha)
1	Init	0	22.4	37.3	4.32
6	Init	0	15.1	25.2	0.58
13	Init	0	21	34.9	0.58
21	Init	0	23.6	39.3	0.57
31	Dev	0	29.9	49.9	0.58
43	Dev	0	40.3	67.2	0.65
56	Dev	0	51	85	0.76
70	Dev	0.1	64.7	107.8	0.89
85	Mid	0	66.5	110.9	0.86
99	Mid	0	66.8	111.4	0.92
112	Mid	0	65.5	109.2	0.97
126	End	0	70.3	117.2	0.97

compared with farmer's practice.

# Validations of CROPWAT versus farmer practice for gross irrigation water applied and irrigation scheduling

Irrigation scheduling is handling the amount of water applied and sensible application of water efficiently. For this study gross irrigation depth was estimated considering field irrigation application efficiency of 60% for CROPWAT whereas for farmers practice their own traditional practice. As (figure 3) showed gross irrigation applied of each stage of tomato production CROPWAT versus farmer's practice. Thus, obtained result showed that applied water for initial stage CROPWAT irrigation system 179.7mm and 137.7mm whereas farmers practice 462 mm and 447.2mm for 2020 and 2021 respectively. Farmers practice at initial stage 61.1% for 2020 and 69% for 2021 more water applied than CROPWAT. The remaining development, mid and late stage also 7.7%, -33.9% and -36.4% for 2020 and 29.2%, -17.0% and -46.5 for 2020 and 2021 respectively. This result told farmers water application system were not careful when to irrigate much water and when to irrigate minimum water time.

For this two-year consecutive experiment farmers were applied water deficit at mid and late stage. Studies showed mid stage of tomato is fruit initiation stage thus stage is sensitive to water stress (Kuşçu et al., 2014) it might be affects quality of marketable fruit. Even though, the total water applied were 1087.5mm and 1275.5mm for 2020 and 895.3mm and 1242.6mm for 2021 were CROPWAT and farmers practice respectively. It shows farmers practice was more water for 14.7 % in 2020 and 27.9% in 2021 as compared to CROPWAT. This finding indicates farmers scheduling and watering system is still under way. The main problem for this area was not shortage of water resource but misunderstanding of crop, water and soil relationship. i.e., soil infiltration rate when we observed practically at initial stage or transplanting time the soil infiltration rate was high farmers also supply high flow rate of water. However, the rest stage of the soil is stable it decreases infiltration rate that crates high speed of water or runoff hear the farmers understand plenty. Similarly, a lot of report have shown Ethiopian irrigation in field water management system is traditional. e.g., as reported by Beyene (2018) the farmers applied over irrigation (applied irrigation was





**Figure 3:** Initial, development, mid, and late-stage gross water applied in 2020 and 2021 for CROPWAT and farmers practice respectively

50 to 80% higher than CWR at early stage) during early growth stages and under irrigation (CWR was 12 to 40% higher than applied irrigation at mid stage. Consequently, also the overall farmers' seasonal irrigation application was comparable (seasonal applied irrigation was about 10% higher than seasonal CWR) with the seasonal CWR estimated by CROPWAT model. This validation showed that CROPWAT irrigation scheduling system at initially minimum water applied and then increased depends on root depth, vegetative, soil water holding as well as climate conditions.

# Validations of CROPWAT versus Farmers practice for Fruit of tomato

This article compares the impact of farmers' irrigation practices and CROPWAT-based irrigation scheduling on tomato fruit yield and water use efficiency (Table 6). The effects of tomato fruit on farmers' irrigation practices for the CROPWAT irrigation system were examined using a one-tailed paired t-test. The combined analysis result for 2020 and 2021 revealed that CROPWAT and farmers' practices were responsible for the marketable fruit of tomato yields of 15.3 tons/ha and 11.35 tons/ ha, respectively. While tomato unmarketable fruit showed 5.25 and 9.75 ton/ha for CROPWAT and farmers' practices, respectively. According to the results, CROPWAT irrigation was 25.8% more effective than farmers' practices for marketable tomato fruit, while it was 46.1 percent less effective for unmarketable fruit. This demonstrates that, when compared to farmers' irrigation practices, a CROPWAT-based irrigation system can increase marketable tomato fruit yield by 25.8% while reducing non-marketable fruit yield by 46.1%. In contrast to farmers' irrigation practices, the CROPWAT irrigation system can reduce loss by 46.1 percent for the production of tomato fruit. The variations of tomato fruit for CROPWAT and farmers' practices were unplanned, i.e., excess at the beginning and development deficit at the middle and end stages. Water stress in the middle of tomato production has an impact on the fruit's quality. Studies have shown that the tomato's mid-stage is the fruit-initiation stage, making this stage sensitive to

water stress(Kuşçu et al., 2014) This could have an impact on the tomato's marketable fruit's quality. While for CROPWAT based system water applied was dependent on soil, crop, and climate relationship i.e., when and how much to be applied water with respective growth stage was applied this is the advantage to increase quality of tomato fruit. As a result, this validation output indicated that CROPWAT-based irrigation water management is

 Table 6:
 t-Test: Paired Two Sample for means of marketable and unmarketable tomato fruit

t-Test: Paired Two Sample for means of tomato fruit					
Marketabl	le fruit	(t/ha)	Unmarketable fruit (t/ha)		
CROPWAT Farmers			CROPWAT	Farmer	
Mean	15.3	11.35	5.25	9.75	
Variance	8	14.045	1.125	0.125	
t Stat		6.0	-4.5		
$P(T \le t)$		0.051	0.06		
one-tail					

suitable for this region.

### Validations of CROPWAT versus Farmers practice for water productivity of tomato

A one-tailed paired t-test analysis result showed that the CROPWAT irrigation system was significantly affected for water productivity of tomato fruit as compared to farmers irrigation practice at a 95 percent confidence level (Table 7). For CROPWAT and farmer irrigation practices, respectively, the obtained combined analysis result of tomato water productivity was 14.42 kg/m3 and 9.01 kg/m3. This demonstrated that CROPWAT-based irrigation systems received an incremental 37.5 percent advantage over farmers' practices. Similarly, a lot of studies reported that CROPWAT based irrigation practice and water resource management system is can increases water productivity of crops and wisely use of water for agricultural fields (Ewaid et al., 2019; Poornima

 Table 7: t-Test: Paired Two Sample for means tomato

 fruit water productivity

t-Test: Paired Two Sample for Means of Tomato water				
productivity				
	CROPWAT	Farmers practice		
	(Kg/m3)	(Kg/m3)		
Mean	14.42	9.014733		
Variance	18.31	8.860042		
t Stat	5.87			
P(T<=t) one-tail	0.053			

et al., 2020; Roja et al., 2020; Savva and Frenken, 2002).

#### CONCLUSION AND RECOMMENDATION

This study confirmed the effectiveness of the FAO CROPWAT-based irrigation system for tomato fruit production as well as crop water requirements and irrigation scheduling when compared to local farmers' irrigation practices. The total water applied were 1087.5mm and 1275.5mm for 2020 and 895.3mm and 1242.6mm for 2021 were CROPWAT and farmers practice respectively. It shows farmers practice was more water for 14.7 % in 2020 and 27.9% in 2021 as compared to CROPWAT. For farmers irrigation practice water applied system for crop was not careful when to irrigate much water and when to irrigate minimum water time the result shows excess water in stage of initial and development deficit at mid and late stage consequently affected marketable fruit of tomato. Even if farmers' seasonal irrigation water application was 10% greater than their seasonal CWR for CROPWT. The obtained validated result revealed that farmers' irrigation practices for marketable tomato fruit were 25.8% lower when based on CROPWAT irrigation practice, while those for unmarketable tomato fruit were 46.18% lower. In contrast to farmers' irrigation practices, the CROPWAT irrigation system can reduce loss by 46.1 percent for the production of tomato fruit. Similar results were obtained for tomato water productivity, which were 14.42 kg/m3 for CROPWAT and 9.01 kg/m3 for farmers' irrigation practices. This demonstrated that CROPWATbased irrigation systems received an incremental 37.5 percent advantage over farmers' practices. As a result, this study came to the conclusion that CROPWAT-based irrigation practices are crucial for field crop irrigation scheduling and crop water requirements. The study will contribute to bettering tomato fruit productivity and water resource management. In areas with limited water resources, the CROPWAT tool can assist in determining the crop water requirements and irrigation scheduling for field crops. This study might serve as a guide for making choices regarding upcoming planning.

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