Determination of irrigation water requirement and scheduling of onion at low land area of Wag-Himra.

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Abstract

Irrigation technologies that save water are necessary to assure the economic and environmental sustainability of commercial agriculture. Precision irrigation scheduling is critical to improving irrigation efficiency. A field experiment was conducted in two consecutive years at Abergelle irrigation schemes. The aim of the study was to determine crop water requirement and irrigation schedule of onion (when and how much to irrigate) for most market-oriented crops. The treatments were arranged with a factorial randomized complete block design with three replications. Three levels of CROPWAT, fixed application depth (125, 100 and 75%) and three levels of irrigation interval (3, 4, and 5days) were used as experimental treatments. Additionally, one treatment, farmer practices irrigation depth and interval were included as a control. These results showed that 75% CROPWAT fixed depth in 3-day interval achieved high WP values as compared to others, and it saved 2873m^3 ha^{-1} and 253.8 m^3 ha^{-1} of irrigation water as compared to farmers' practices and 100% of CROPWAT fixed application depth in 3-day interval (optimum irrigation) respectively. That would irrigate an additional land of 0.84ha and 0.074ha with a yield gain of 10.44ton ha^{-1} and 1ton ha^{-1} respectively. Therefore, 75 % of irrigation water depth every 3 days of irrigation interval was recommended for the optimum yield and water productivity of onion crop.

Key words: Irrigation, Onion, Water productivity, Yield

Introduction

In arid and semiarid areas, irrigation may supply all or most of the crops water needs (Pejić et al., 2008). All crops require certain amount of water during each stage of development mainly their initial stage, crop development stage, mid-growing and maturity stage and will transpire water maximum rate when the soil water is at field capacity. However, the amount, intensity, duration, frequency and distribution of rain needed to meet the actual water requirement of the crop to achieve full production potential is rarely realized in nature (Shaibu et al., 2015, Bossie et al., 2009). To ensure the highest crop production with the least water use, that is important to know the water requirement of the crop. The right amount of water for the crop appropriate irrigation scheduling can be designed, which can lead to improvements in yield, income, and water-saving (Dirirsa et al., 2020, Woldetsadik, 2003).

Determination of crop yield response to irrigation is crucial for crop selection, economic analysis, and for practicing effective irrigation management strategies. This enables to know the time of irrigation as well as to optimize yield, water use efficiency, and ultimate profit (Payero et al., 2009). Water scarcity is the most common factor for crop production in the dry-land areas of the Abergele district. Lack of crop water requirement studies for major crops is a challenge for appropriate utilization of water resources in irrigated agriculture and it leads to low water use efficiency through improper irrigation scheduling.

Determination of water requirement of the crop, appropriate irrigation scheduling can be designed, which can lead to improvements in the yield, income, and water-saving (Bossie et al., 2009, Mebrahtu et al., 2019). The management of water is important for getting optimizing crop production per unit of water and sustaining irrigated agriculture on permanent foot sustaining irrigated alea9 1 70.824 302.57 Tm0 (K Ggrd6(te)4(l)-11l.,24(l., 2009))] TJETQq0.00000887

(PWP) of the sites are 20.46, 23.3 and 24.29, and 12.61, 15.65, and 15.05 percent respectively for Abergelle at bare small scale irrigation scheme.

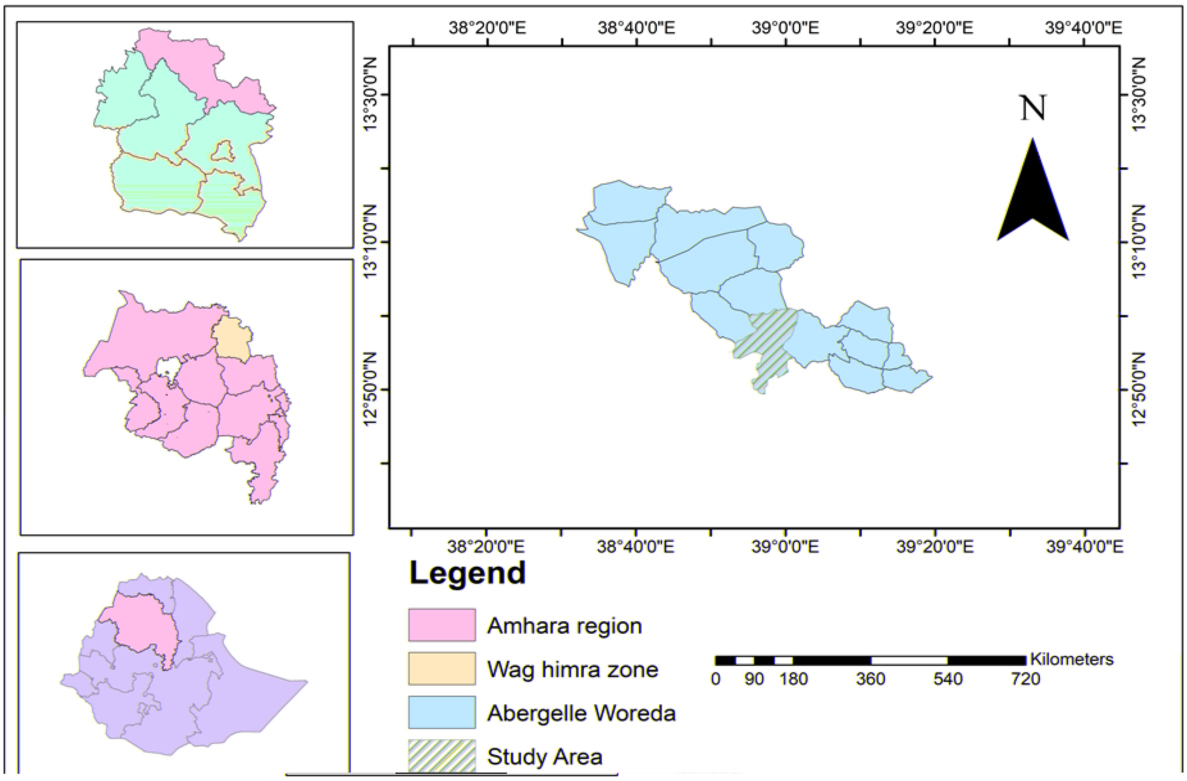

Figure1. Location map of the study area

The Input requirements for CROPWAT 8.0 model

The CROPWAT under windows version 8.0 interfaces was used for determining the irrigation scheduling. The CROPWAT 8.0 version with an input of climatic parameters, soil type, root depth, depletion fraction, crop data (crop type, planting date, crop coefficient/Kc values, stage days) was used. Then, ETC was calculated as the product of reference evapotranspiration (ETo) and crop coefficient (Kc) (Equation 1). Climate data as inputs for ETo determination

$$ETc = Kc \times ETo \quad (1)$$

Crop type and growth stage

Due to the lack of actual Kc of onion in the study area, it was accessed from FAO irrigation and drainage paper No. 56 (Allen et al., 1998). The total period of onion from the instant of planting was fixed as 120 days (25 initial stages, 40 development stages, 30 mid-stage, and 25 late stages).

Experimental procedures and design

The experiment was designed with three irrigation depths (75, 100, and 125% of the CROPWAT 8.0 generated depth) and three-irrigation frequency (3, 4 & 5 days) with a randomized complete block design. The treatments and their arrangements in the experimentation are shown in Table 1. The treatments were replicated three times. All agronomic practices were carried out uniformly for each treatment. The plot size of 2.4m x 3m double row planting of onion variety Bombay red with a spacing of 40cm x 20cm x10cm. Urea fertilizer was applied at a rate of 92 $kgha^{-1}$ half at planting and half at 45 days after planting.

The mode of applying water used in this experiment was a canning system. The ETC of onion were determined from CROPWAT 8.0 and the treatments were set by using the model as a reference. Common irrigation was applied up to the onion vegetative as per the treatments code arrangement. Then, the set treatments were applied accordingly to each plot. Unexpected rainfall was recorded with a rain gauge and it was converted to effective rainfall by USDA methods in the CROPWAT 8.0 model.

$$NIR = ETC - Pe \qquad (2)$$

$$GIR = NIR + \text{losses, or } GIR = NIR/Ea \qquad (3)$$

Where ETC is evapotranspiration of the crop (mm/Season), Pe is effective rainfall in mm/Season, NIR is net irrigation requirement in mm/Season, GIR is gross irrigation requirement in mm/Season and Ea is application efficiency (taken as 70%)

Data collection

The data collected were number of stand count, plant height, bulb diameter, bulb weight, marketable yield, unmarketable yield, and water use efficiency. Water use efficiency was calculated as the ratio of total yield (kg) to total water delivered up to the harvesting (m^3) (Equation 4).

$$\text{Water use efficiecy} = \frac{\text{Total yield of onion}}{\text{water delivered up to harvesting}} \qquad (4)$$

Table 1. Treatment combination and amount of applied water (mm)

Treatments	Amount of applied water (mm)
125% Cropwat fixed depth and optimal time of application at 3 days interval	507.3
100% Cropwat fixed depth and optimal time of application at 3 days interval	368.2
75% Cropwat fixed depth and optimal time of application at 3 days interval	342.95
125% Cropwat fixed depth and optimal time of application at 4 days interval	457.35
100% Cropwat fixed depth and optimal time of application at 4 days interval	354.3
75% Cropwat fixed depth and optimal time of application at 4 days interval	336.65
125% Cropwat fixed depth and optimal time of application at 5 days interval	440.1
100% Cropwat fixed depth and optimal time of application at 5 days interval	358.1
75% Cropwat fixed depth and optimal time of application at 5 days interval	331.7
Farmer practice irrigation depth and irrigation interval in days	630.25

NB. Farmers practice are not at fixed days interval, rather than own interest of users.

Data analysis

Analysis of variance (ANOVA) and correlation was performed using SAS (Statistical Software
Version 9.1). Mean comparison was done by using least significant difference test at 5% probability level.

Result and Discussion

Crop growth and physiology parameter

Analysis of variance has shown non-significant ($P< 0. 05$) in plant height and unmarketable yield and significant in bulb diameter and bulb weight yield of onion (Table 2 & 3). Numerical among the treatments the highest plant height, bulb diameter, bulb weight and unmarketable yield of onion were recorded from 75 and 125% with 3 days interval, 75% with 5 days interval and 100% cropwat fixed application depth using 4days irrigation interval with the values of 45.8cm, 46.5mm, 61.97gm and 1.34tha^{-1} respectively. The shortest plant height, bulb diameter, bulb weight and unmarketable yield of onion was obtained from 125% in 3 days, 100% in 4 days and 125% cropwat fixed application depth using 5 days irrigation interval with the values of 42.8cm, 43.0cm, 54.88gm and 0.7814 tha^{-1} respectively. In plant height there is numerical difference among treatments but there is no statically significance difference.

Table 2. Interaction effect of depth and frequency on plant height and bulb diameter of onion.

Frequency	Plant height (cm)				Bulb diameter (mm)			
	Depth				Depth			
	125%	100%	75%	F_d	125%	100%	75%	F_d
3 days	42.8	43.6	45.8		46.5	45.9	44.5	
4 days	43.0	45.5	44.3		46.2	43.0	44.9	
5 days	43.7	44.3	42.8		44.2	44.8	43.7	
Ff				45.5				61.15
LSD(0.05)	Ns				3.5			
CV(%)	6.19				6.65			

***NB:** f_d = farmer practice irrigation depth, F_f = farmer practice irrigation interval*

Table 3. Interaction effect of depth and frequency on bulb weight and unmarketable yield.

Frequency	Bulb weight (gm)				Unmarketable yield (tha^{-1})			
	Depth				Depth			
	125%	100%	75%	F_d	125%	100%	75%	F_d
3 days	59.19	59.15	58.15		1.16	1.14	1.06	
4 days	56.66	54.88	55.97		0.98	1.34	1.04	
5 days	56.26	55.14	61.97		0.78	0.96	0.99	
Ff				61.15				1.12
LSD(0.05)	6.79				Ns			
CV(%)	10.04				53.15			

Marketable yield

The marketable yield of onion was highly significant (P< 0. 05) difference on the different treatment of irrigation depth and frequency. The highest marketable yield of onion recorded from 125% CROPWAT fixed application depth using a 3 days irrigation interval with the value of 11.88 tha^{-1}and The least marketable yield of onion was obtained from 125% CROPWAT fixed application depth using a 5 days irrigation interval with the result of 8.96 tha^{-1} (Table 4). The interaction effect of irrigates depth and frequency on marketable yield (Table 4). The results of 75% CROPWAT fixed application depth using 3 days irrigation interval best marketable yield of onion crop production. This result was line with the finding of Taha et al. (2019)they reported that to meet the requirements of full irrigation with the crop that develop sufficient biomass and root system leading to increase in marketable yield under deficit irrigation.

Total yield

The total yield of onion was a highly significant (P< 0. 05) difference on the different treatment of irrigation depth and frequency. The highest total yield of onion was recorded from 125% CROPWAT fixed application depth using a 3 days irrigation interval with the value of 13 tha^{-1}. On the other hand, the lowest total yield of onion was recorded from 125% CROPWAT fixed application depth using a 5 days irrigation interval with the result of 9.74 tha^{-1} (Table 4). The interaction effect of irrigates depth and frequency on total yield (Table 4). The results showed that 75% CROPWAT fixed application depth using 3 days irrigation interval was the best yield (12.5 tha^{-1}) and the yield-related component of onion crop production. Farmer's practice irrigation depth and irrigation intervals are low yields because of excess irrigation water to irrigate and irrigation intervals. The result was in agreement with the finding of Taha et al. (2019) they reported that to meet the requirements of full irrigation along the crop to develop sufficient biomass and root system leading to an increase in marketable yield under deficit irrigation, Demelash (2013) reported that applying the right depth of irrigation and frequency of application increased the total tuber yield of potato production.

Water productivity

The interaction effect of depth and frequency was significant (P< 0.05) on water productivity of the crop. As shown in Table 4, the highest (4.29 kgm^{-3}) and the minimum (2.44 kgm^{-3}). The water productivity of onions was recorded from the fixed application depth of CROPWAT at 75% and 125% using irrigation intervals of 3 and 5 days, respectively. These results showed that 75% CROPWAT fixed depth in 3 day interval achieved high WP values as compared to others, and it saved 2873m^3ha^{-1} and 253.8 m^3ha^{-1} of irrigation water as compared to farmers' practices and 100% of CROPWAT fixed application depth in 3 day interval respectively. That would irrigate an additional land of 0.84ha and 0.074ha with a yield gain of 10.44 t ha^{-1} and 1 tha^{-1} respectively.

The result was in agreement with the finding of Bekele and Tilahun (2007) and (2003) reported that water productivity decrease with increasing irrigation depth. Demelash (2013)reported that deficit irrigation strategies it is possible to increase WUE and save water for irrigation.

Table 4. Interaction effect of depth and frequency on marketable yield, total yield and water productivity.

Frequency	Marketable yield (tha^{-1})				Total yield (tha^{-1})				Water productivity (kgm^{-3})			
	Depth				Depth				Depth			
3 days	125%	100%	75%	Fd	125%	100%	75%	Fd	125%	100%	75%	Fd
4 days	11.87	11.67	11.40		13.03	12.81	12.46		3.03	4.11	4.29	
5 days	9.45	10.62	11.28		10.44	11.95	12.33		2.59	4.08	4.22	
Ff	8.96	10.34	9.66		9.74	11.31	10.57		2.44	3.97	3.86	
LSD(0.05)	0.97				1.27				0.48			
CV(%)	7.97				9.42				11.56			

Table 5. Correlation coefficient of plant height, bulb diameter, bulb weight, marketable yield, unmarketable yield, total yield and water productivity from the study data.

	PH	BD	BW	MY	UMY	TY	WP
PH	1						
BD	0.236895386ns	1					
BW	0.108385009ns	0.098121835ns	1				
MY	0.36135229ns	0.41670998ns	0.073847643ns	1			
UMY	0.473049228**	0.521414195**	0.146233718ns	0.197240809ns	1		
TY	0.424763217*	0.485519357**	0.045249925ns	0.985890561***	0.358544502*	1	
WP	0.208950034ns	0.18009817ns	0.118680048ns	0.668471291***	0.136289697ns	0.659530619***	1

*(p<0.05) *** Very highly significant, ** highly significant, * significant and [ns] non-significant*

Conclusion and recommendation

The irrigation depth and schedules had a significant effect on the yield and water productivity of crops. The study shows that the interaction of irrigation scheduling and depth had a significant effect on the yield and water productivity of onion at bare small-scale irrigation schemes. The result showed that 12.5 tha^{-1} within 3 days intervals and 4.3 kgm^{-3} water productivity was achieved with appropriate depth and schedule in 75% CROPWAT, fixed application depth at bare irrigation scheme. Therefore, the irrigation schedule is aimed at maximized yield per unit of irrigated area, 75% CROPWAT fixed application depth using a 3 days irrigation interval saved 2873 m^3ha^{-1} and 253.8 m^3ha^{-1} of irrigation water, that would irrigate an additional land of 0.84ha and 0.074ha with a yield gain of 10.44 tha^{-1} and 1tha^{-1} as compared to farmers' practices and 100% of CROPWAT fixed application depth in 3 day interval respectively. Key policy for the control of agricultural water management for dry land and water scarcity areas primary to improve agricultural productivity and thus income farmers applying an optimum amount of water and saving a significant amount of water for irrigation additional onion cropland. Considering this, 75% of CROPWAT fixed application depth using a 3 days irrigation in

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