Optimal Irrigation Scheduling for Pepper *(Capsicum annuum L.)* at Gidara Sub Center, Central Rift Valley of Ethiopia

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Abstract

The wise use of irrigation water relies on understanding the exact crop water demand and its application which help to boost agricultural water productivity. Proper irrigation scheduling comprises crop water demand and the rifling frequency of the required water amount. Therefore, this activity was aimed at determining the optimal irrigation regime for pepper. The trial was carried out during 2016 and 2017 to determine the optimal irrigation regime of Pepper (Mareko Fana variety) at Gidara trial site of Melkassa Agricultural Research under five soil moisture depletion levels at which the next irrigation is given: 60% ASMDL, 80% ASMDL, 100% ASMDL, 120% ASMDL and 140% ASMDL). The allowable soil moisture depletion level (100% ASMDL) was scheduled to be refilled when 30% of the total available soil moisture was depleted. The result revealed that there was significant difference in plant height, yield and water productivity among treatments at 5% level of significance. The maximum yield and water productivity were observed in 60% ASMDL treatment. Using depletion levels of 60% and 80% of the recommended soil moisture depletion levels has increased the water productivity significantly. Hence, as much as the total water to be applied throughout the growth period is similar it is better to irrigate pepper frequently with smaller amount.

Keywords: Soil moisture depletion, irrigation regime, pepper, water productivity

Introduction

Irrigation basically is the controlled application of water to crops in right amount at the right time reducing water loss. Hence, irrigation scheduling is important for developing best management practices for irrigated areas (Ali *et al.*, 2011).

Proper irrigation scheduling which depends on evapotranspiration of crops improves water use efficiency of crops (Tyagi *et al.*, 2000). Though irrigation has long been practiced in Ethiopia under different farm levels, the management practice is not efficient. There is lack of information and knowledge on proper irrigation water management and agronomic management practices although irrigation farms are expanding in the country.

Pepper (*Capsicum annuum L.*) is one of the vegetable crops commonly grown in Ethiopia, mainly under rainfed agriculture. In Ethiopia rainfall distribution is highly erratic both spatially and temporarily. Sensitivity of the crop to low soil moisture along with the unpredictability of rainfall in the country leads to the use of irrigation. For better irrigation management understanding of optimum irrigation regime is very important for pepper production to optimize yield and water use efficiency.

Nevertheless, there is no exact information for pepper concerning its optimum moisture depletion level for irrigation specific to the study area. Thus, this study aimed at investigating the effects of different soil moisture depletion levels to irrigate and then to determine the irrigation depth and frequency.

Materials and Methods

Description of the experimental site

Field experiment was conducted for two consecutive years, during 2016 and 2017 dry season, at Gidara experimental site, which is a sub-center of Melkassa Agricultural Research Center. The site is located in Oromia region, East Shewa zone in Fentale woreda. The site is geographically located at $08^0$44'55''N and $39^0$47'49" E with altitude of 1112m above sea level.

The long-term weather data collected from the nearby Metrological station revealed that the maximum and minimum monthly average temperature of the sub center is 31.70°C and 16.80°C, respectively. The long-term rainfall of the area is 615mm with main rainy season from July to September when 57% of the annual rain fall is received. The climate water balance of the study area (Figure 1) shows that there is a need for irrigation water for almost the year round except for the months July to September.

The soil texture in the study area was Sandy loam with bulk density of 1.22 g/cm^3. Field capacity (FC) and permanent wilting point (PWP) of the soil were 23.4% and 12.6%, respectively. The textural class of the soil of the study site is sandy loam having pH value of 8.4.

Experimental design and treatment combinations

The experiment was arranged in randomized complete block design (RCBD) with three replications. The experiment included five soil water depletion levels (SMDL) as a treatment, the five level of SMDL are (60% of FAO recommended ASMDL, 80% of FAO recommended ASMDL, 100% FAO recommended ASMDL, 120% of FAO recommended ASMDL and 140% of FAO recommended ASMDL). For Pepper crop recommended allowable soil moisture depletion level used for irrigation is 0.3 and for the other treatments the soil moisture depletion levels were calculated based on this value.

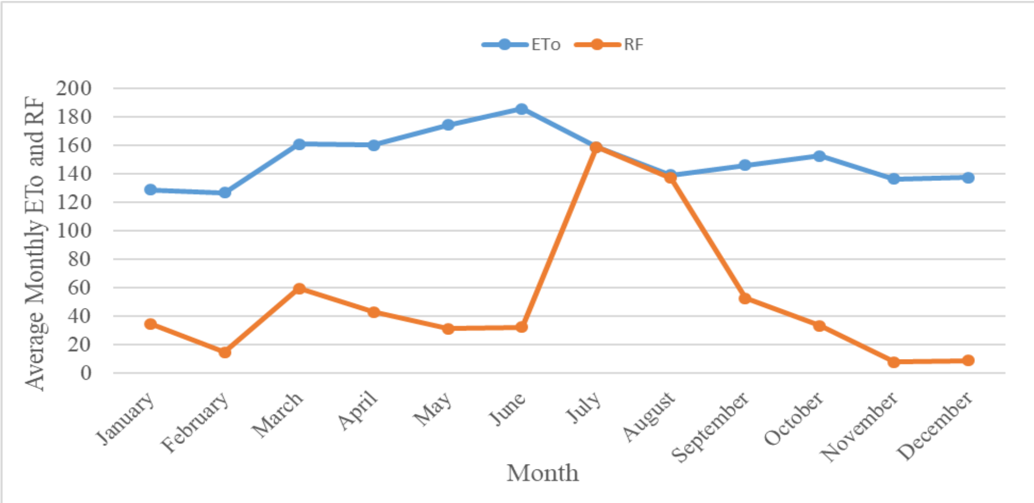

Figure 1. Climate water balance

Table 1: Treatment combinations

Treatment	Description
SMDL 1	60% of ASMDL
SMDL 2	80% of ASMDL
SMDL 3	ASMDL* (control)
SMDL 4	120% of ASMDL
SMDL 5	140% of ASMD

ASMDL (allowable soil moisture depletion level)

Agronomic management practices

Pepper *(Capsicum annuum L.*), *Mareko Fana* variety was sown on a 1m by 5m seed bed in December each year and after about 30 days the seedlings were transplanted in January. The experimental plot sizes used were 4.5 m wide and 5 m long with 75 cm row spacing and 30 cm plant spacing. The number of planting rows in each plot were five of which the middle three were sampling rows and the other two are guard rows. All agronomic practices were kept normal and performed at the appropriate time. The experimental treatments were started after two irrigations were given for establishment. It was harvested after about 125 days from transplanting.

Irrigation management

Depth of irrigation water applied was estimated using CROPWAT 8 model from daily climate data. Daily climatic data (maximum and minimum temperatures, humidity, wind speed and actual sunshine hours), and geographical information (coordinates and altitude of the location) were used to calculate ETo using CROPWAT model following FAO Penman-Montieth equation (Allen et al., 1998). Thus, daily Evapotranspiration (ETc) was estimated by multiplying the ETo by the crop coefficient (Kc). Amount of irrigation applied at each irrigation time was determined from climatic, crop and soil data as well as precipitation data. The estimation was on daily water balance basis as indicated in Allen et al., (1998).

For each experimental treatment the amount of water applied at each irrigation interval was determined following the respective soil moisture depletion level of each treatment. Accordingly, the average irrigation intervals and depth of irrigation used for treatment at each growth stage is indicated in table 2.

Irrigation water was taken to the experimental plots by an open channel and water measurement was conducted using Parshall flume of 3-inch throat width (Kandiah, 1981). Measured amount of water was given at each irrigation day.

Data collection

From the total of five plating rows the interior three sampling rows were harvested. All the necessary data of yield and other parameters were collected.

Water productivity

Water productivity (WP) was estimated as a ratio of yield to the total ETc through the growing season and it was calculated using the following equation (Zwart and Bastiaanssen, 2004; Molden, 2010).

$$WP = (Y/ET)$$

where, WP is water productivity (kg/m^3), Y is crop yield (kg/ha) and ET is the seasonal crop water consumption by evapotranspiration (m^3/ha).

Table 2. Average Irrigation Interval and Depth of Application

Treatments / Growth stages	60% of ASMDL		80% of ASMDL		100% of ASMDL		120% of ASMDL		140% of ASMDL	
	Ii (day)	Id (mm)	Ii (day)	Id (mm)	Ii (day)	Id (mm)	Ii (day)	Id (mm)	Ii (day)	Id (mm)
Initial	3	10.5	4	14.4	5	16.4	6	19.6	7	23.0
Development	4	19.0	6	26.2	7	33.9	9	38.6	11	48.7
Mid	4	23.4	5	28.7	6	35.0	7	40.8	8	45.8
Maturity	4	23.8	5	30.0	7	38.7	8	44.2	9	53.5

Id = Irrigation Depth, Ii = Irrigation Interval

Data analysis

The collected data were statistically analyzed using statistical analysis system (SAS) software version 9.0 using the general linear programming procedure (GLM). Mean separation using least significant difference (LSD) at 5% probability level was employed to compare the differences among the treatments mean.

Results and Discussion

Effect of soil moisture depletion levels on pepper yield, plant height and water productivity

To investigate the effect of different soil moisture depletion levels on plant height, it was measured from ground level to apex stem. The result revealed that plant height was significantly ($P < 0.05$) affected as a result of the difference in soil moisture depletion level of irrigation. Significantly higher plant height was obtained from the frequently irrigated pepper (60% & 80% ASMDL). Lower plant height was observed for pepper irrigated at higher soil moisture depletion level of higher irrigation interval as shown in Table 3.

The effect of soil moisture depletion level on pepper yield is analyzed and presented in Table 3. The analysis result of the two-years and the over year combined data was similar and showed significant ($P < 0.05$) difference on pepper yield as treated by the different soil moisture depletion levels. Accordingly, the highest yield of 19.05 t/ha was recorded from the frequently irrigated plot and the lowest yield of 15.41 t/ha was recorded from the treatment irrigated with wider interval.

The analysis result of water productivity is depicted in Table 3. Significantly ($P < 0.05$) higher water productivity (3.19 kg/m^3) was obtained under 60% ASMDL with no significant difference with 80% ASMDL treatment; while the lowest (2.74 kg/m^3) was obtained under 140% ASMDL.

Table 3. Pepper Yield, Plant Height and Water Productivity as Affected by Irrigation Regime

Treatments	2016			2017			Over Year		
	Plant Height (cm)	Yield (Qt/ha)	WP (Kg/m^3)	Plant Height (cm)	Yield (Qt/ha)	WP (Kg/m^3)	Plant Height (cm)	Yield (Qt/ha)	WP (Kg/m^3)
SMDL 1	53.80^a	18.93^a	3.17^a	53.53^a	19.17^a	3.20^a	53.67^a	19.05^a	3.19^a
SMDL 2	53.67^a	18.42^a	3.08^a	52.27^a	18.40^a	3.08^a	51.97^a	18.41^{ab}	3.07^{ab}
SMDL 3	47.80^b	16.53^b	2.76^b	48.67^{ab}	16.95^{ab}	2.83^{ab}	48.23^b	16.74^{bc}	2.80^{bc}
SMDL 4	46.73^b	16.22^b	2.71^b	46.93^b	15.42^b	2.58^b	46.83^b	15.82^c	2.75^c
SMDL 5	45.27^b	16.13^b	2.70^b	45.00^b	14.68^b	2.45^b	45.13^b	15.41^c	2.74^c
CV (%)	4.17	4.82	4.76	5.35	8.84	8.83	6.13	9.13	9.11
$LSD_{0.05}$	3.85	1.56	0.25	4.97	2.82	0.47	3.65	1.89	0.32

*Means followed by different superscripts are statistically different,

References

Ali MH, Paul H and Haque MR. 2011. Estimation of evapotranspiration using a simulation model. J. Bangladesh Agril. Univ. 9(2): 257–266.

Allen RG, Pereira LS, Raes D and Smith M. 1998. Crop Evapotranspiration. Guidelines for Computing Crop Water Requirements. FAO Irrigation & Drainage Paper 56. Food and Agricultural Organization of the United Nations, Rome, Italy 300 pp.

Molden D, Oweis T Steduto P Bindraban P, Hanjra MA and Kijne J. 2010. Improving agricultural water productivity: Between optimism and caution. Agric. Water Manag. 97, 528–553.

Tyagi NK, Sharma DK and Luthra SK. 2000. Determination of evapotranspiration and crop coefficients of rice and sunflower with lysimeter; Agricultural Water Management; 45:41–54.

Bakker DM, Raine SR and Robertson MJ. 1999. A preliminary Investigation of Alternate Furrow Irrigation for Sugar Cane Production. http://www.usq.edu.au/users/raine/index fiels/ASSCT 97.Bakkeret al., pdf.

Kandiah A. 1981. Guide for measurement of irrigation water using Parshall flumes and siphons: Technical bulletin No 1. Addis Ababa, Ethiopia. p. 2.

Valipour M. 2014. Pressure on renewable water resources by irrigation to 2060. Acta Advances in Agricultural Sciences 2(8):23-42.

Zwart SJ and Bastiaanssen WGM. 2004. Review of measured crop water productivity values for irrigated wheat, rice, cotton and maize, Agricultural Water Management, 69(2), 115-133.