Determination of Crop Water Requirement and Irrigation Schedule of Tomato at Jare, South Wollo

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Abstract
The study area, Jare is endowed with different irrigation schemes and water harvesting ponds as an irrigation water source for the surrounding farmers. However, irrigation amount, frequency, net and gross seasonal irrigation requirements were not known for most vegetable crops which are currently growing in the area. Tomato is the second major vegetable produced in the study area. This study was conducted to determine crop water requirement and irrigation scheduling of tomato at Jare. Estimations of crop water requirements and irrigation scheduling were carried out using CROPWAT version 4 software. The field experiments were conducted during 2010 and 2011, at Jare research station. Combination of different levels of irrigation depths and irrigation frequencies were selected on the bases of CROPWAT and local water application experiences of the farmers. Factorial combination of three irrigation intervals (7, 9 and 11 days) and three irrigation depths (75%, 100% and 125% of cropwat geberated depth) were tested in randomized complete block design with three replications. The irrigation was applied using watering cans. Statistically significant difference ($p<0.05$) was observed among treatments in total yield, marketable yield and water productivity. However, fruit diameter and fruit weight showed non-significant difference. Application of 14mm depth of irrigation (i.e. 75% of cropwat generated depth) at 11 days interval gave the highest total yield, marketable yield and water productivity of 63.28 t ha^{-1}, 55.73 t ha^{-1} and 6.18 kg m^{-3} respectively. About 70 mm irrigation water can be saved. Hence, 14mm irrigation depth at 11 days irrigation interval with a total seasonal irrigation requirement of 168 mm is recommended for Jare and areas having similar agro ecology.

Key words: Water productivity, Yield, Irrigation interval, Irrigation depth, Jare

Introduction

In Ethiopia, the population is growing rapidly and is expected to continue growing, which inevitably lead to increased food demand. To maintain self-sufficiency in food supply, one viable option is to raise the unit yield. A favorable method for raising yield per unit is through proper utilization of irrigation water resources and by increasing water productivity per unit of land and water.

Efficient irrigation water utilization techniques can be realized by using irrigation scheduling. Irrigation scheduling is planning when and how much water to apply in order to maintain healthy plant growth during the crop growing season. It is an essential daily management practice for farm managers who are growing irrigated crops. The ultimate economic and environmental consequence of poorly managed irrigation is the eftusvdujpo! pg! bo! bsfb t! qspevdujwf! cbtf! cfdbvtf! bqqmjdbujpo! pg! upp! mjuumf! xbufs! jt! bo! obvious waste as it fails to produce the desired benefit and excessive flooding of the land is still more harmful as it tends to saturate the soil for too long, inhibit aeration, leach nutrients, induce greater evaporation and salinity, and ultimately raise the water table to a level that suppress normal root and microbial activity and that can only be drained and leached at great expense (Daniel, H. , 1997). The issue of efficient use of water and bringing more area under irrigation through available water resources can be achieved by introducing advanced methods of irrigation and improved water management practices (Zaman et al., 2001).

Based on preliminary assessments and survey results tomato is a second major irrigable crop in the study area, Tehuledere woreda. Yet, frequency of irrigation and amount of application per irrigation, seasonal net irrigation requirement and gross irrigation requirements were not determined for tomato and most vegetable crops in the study area. Therefore, information on irrigation water management is an urgent need to improve the existing irrigation production condition. Using climatic data is one of the quickest and fairly reliable means for the determination of when and how much to irrigate. Therefore, this experiment was conducted with the objective of estimating water requirement, net irrigation requirements and irrigation schedule of tomato grown under irrigated conditions in Tehuledere Woreda, Jare.

Materials and Methods

Description of the Study Area

The experiment was conducted during 2010 and 2011 at Jare sub center in South Wollo zone, Tehuledere woreda. Geographically the area lies at 11^{o}32 O! mbujuvef ! 4: ^{o}49 F! longitude and at an altitude of 1680m above sea level. The mean effective rainfall is around 231.5mm in the irrigation period and average annual temperature ranges from 12.20^{0}c to 26.70^{o}c. The soil is texturally clay loam and has pH of 6.8. Average daily evaporation amount is around 3.98 mm/day. The district is endowed with different irrigation schemes and water harvesting ponds, which can be potentially used to bring large amounts of crop land under irrigation. In most of the irrigation schemes, both in traditional and modern schemes, there is poor irrigation water management practices.

Methods

The test crop tomato (Roma VF variety) was selected based on farming system survey reports done on major irrigation schemes found in South Wollo zone. Local climate estimator called New- LocClim software was used for the estimation of meteorological data based on neighbouring metreological stations since there is no class A meteorological station in the study area.

Calculations of the crop water requirements and irrigation schedule were carried out by using CropWat version 4 software using climatic, crop and soil data. First, crop water requirement was determined by inserting crop data and climatic data. Irrigation amount and schedules were determined by using soil data **(**total available moisture (TMA), maximum infiltration rate (8mm/hr), maximum rooting depth (70cm) and initial soil moisture depletion. Irrigation scheduling criteria were set based on the allowable depletion which enables the calculation of the readily available soil moisture content in the root zone (RAM). Prior to planting all plots were irrigated with equal amount of water up to the field capacity to ensure the survival of transplanted tomato seedlings.

The experiment was conducted in randomized complete block design with three replications. Experimental plot size was 3m*3m and the spacing between plants, rows, plots and blocks were 35cm, 75cm, 1m and 1.5m, respectively. Urea was split applied at a rate of 100 kg/ha of which half at planting and remaining half after 45 days of planting and 50 kg/ha DAP was applied at planting. During the two experimental years, planting was carried on similar dates. Harvesting of tomato fruit made four times in the growing season. Factorial combination of three irrigation depths and three irrigation intervals were tested.

Table1. Experimental treatments used at Jare in 2010 and 2011

Treatments	**Net irrigation depth (mm)**	**Seasonal irrigation requirement (mm)**
75% of CWGD at 11 days interval	14	168
75% of CWGD at 9 days interval	14	196
75% of CWGD at 7 days interval	14	266
CWGD at 11 days interval	19	228
CWGD at 9 days interval	19	266
CWGD at 7 days interval	19	361
125 % of CWGD at 11 days interval	24	286
125 % of CWGD at 9 days interval	24	336
125 %of CWGD at 7 days interval	24	456

CWGD-cropwat generated depth

Irrigation water is applied using watering cans and its irrigation application efficiency was estimated to be 80%. Irrigation water use efficiency is generally defined as crop yield per water used to produce the yield (Viets, 1962; Howell, 1996). Thus, IWUE was calculated as fresh weight (kg) obtained per volume of irrigation water applied (m^3).

$$\frac{Yield}{Water\ applied} = IWUE$$

IWUE is an important factor when considering irrigation systems and water management, and probably will become more important as access to water becomes more limited (Shdeed, 2001). For statistical analysis GenStat 9.1 software was used. In bee jujpo !Evodbo t!n vmjqmf!n f bo!uf tu! were used to compare treatment means.

Results and Discussion

Even though there was variability in measured parameters over years, the general trend is more or less similar in both years. Amount of effective rainfall estimated by the model was 231.2mm but the actual effective rain fall occurred in the 1st and 2nd year varied from 110mm to 180mm. This implies that the net irrigation depth actually applied during the experimental period was likely underestimated. Moreover, the occurrence of varied rainfall during the first and second year significantly affected the yield and yield components of tomato.

As can be seen in tab1e 2, treatments and treatments by year interaction effects were significant. In 2010, treatment effects were significant ($p<0.05$) in all parameters except for average fruit weight. Maximum and minimum marketable yield of 31.3 t/ha and 24.41t/ha were obtained by applying 24mm irrigation water at 11 days interval and 19mm at 9 days interval, respectively. The highest water productivity value of 4.7 kg/m^3 was obtained by applying 14mm at 7 days interval (Table 3).

Table 2. Mean squares of fruit diameter, fruit weight, marketable yield, total yield and water productivity at Jare in 2010 and 2011

Sources of variation	**df**	**Fruit diameter (cm)**	**Fruit weight (g)**	**Marketable yield (t ha^{-1})**	**Total yield (t ha^{-1})**	**WUE (kg m^{-3})**
Trt	8	0.11ns	51.96ns	116.47**	126.02**	5.42*
Yr	1	109.14**	9348.34**	1909.14**	2357.63**	17.01**
Yr*Tret	8	0.08ns	69.78ns	99.23**	167.94**	4.55*
Error	34	0.10	87.47	4.49	6.03	1.8

* Significant ** Highly significant NS-non significant

In 2011, total and marketable yields were statistically different among the treatments ($p<0.01$). The highest marketable yield of 55.7 t/ha was obtained by applying 14mm irrigation depth at 11 days interval (Table 4). There was no statistically significant difference in fruit diameter and fruit weight. The highest water productivity (6.18 kg/m^3) was recorded by the application of 14mm irrigation depth at 11 days interval. About 60mm irrigation water was saved per one irrigation season. Hence, application of 14mm irrigation depth at 11 days interval (i.e. 75% of CWGD at 11 days interval) can be considered optimal for Jare and similar areas having the same agro-ecology.

Table 3. Effect of irrigation amount and frequency on total yield, marketable yield, water productivity, fruit weight and fruit diameter in 2010

irrigation season. The seasonal irrigation water was 168mm irrigation water. About 400mm total crop water requirement of tomato for the growing length of 125 days is estimated. Hence, application of 75% of Cropwat generated depth (14mm) at 11 days irrigation interval with a total (seasonal irrigation requirement of 168mm) can be recommended for Jare and areas with similar agro ecology. Moreover, due to effects of climate change the rainfall distribution in the area is becoming unpredictable from time to time.

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