Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 19 Issue 6 Version 1.0 Year 2019
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Evaluation of Irrigation Regime on Tomato (Lycopersicon Esculentum), at Hadero Tunto Zuria Woreda, Ehiopia

By Tamirneh Kifle
Areka Agricultural Research Center

Abstract- Effective irrigation practices, management of irrigation water, amount and time irrigation water application are constraints to improve production, minimize water use, and protect natural resources. The experiment was conducted for three consecutive years at Hadero Tunto Zuria Woreda in farmers' fields to identify the impact of irrigation regime which allow achieving optimum Tomato yield. From the study site soil was collected to determine its physical and chemical properties of the soil, daily climate data were collected from nearest meteorological station. The experiment has four levels of treatments (125% MAD, 100% MAD, 75 % MAD and farmer practice) which were arranged in RCBD with four replications. The long year's climatic data were collected and analyzed by CROPWAT8.0 software to calculation of the right amount of water needed for the irrigation. The treatment was conducted under furrow irrigation method and Parshall flumes were used to measure inflow rates at each field.. The experimental field has 16 plots and each plot size was 4m by 5m dimension.

Keywords: *furrow, MAD, water use efficiency, tomato, RCBD.*

GJSFR-D Classification: *FOR Code: 070399*

EVALUATIONOFIRRIGATIONREGIMEONTOMATOLYCOPERSICONESCULENTUMATHADEROTUNTOZURIAWOREDAEHIOPIA

Strictly as per the compliance and regulations of:

Evaluation of Irrigation Regime on Tomato (Lycopersicon Esculentum), at Hadero Tunto Zuria Woreda, Ethiopia

Tamirneh Kifle

Abstract- Effective irrigation practices, management of irrigation water, amount and time irrigation water application are constraints to improve production, minimize water use, and protect natural resources. The experiment was conducted for three consecutive years at Hadero Tunto Zuria Woreda in farmers' fields to identify the impact of irrigation regime which allow achieving optimum Tomato yield. From the study site soil was collected to determine its physical and chemical properties of the soil, daily climate data were collected from nearest meteorological station. The experiment has four levels of treatments (125% MAD, 100% MAD, 75 % MAD and farmer practice) which were arranged in RCBD with four replications. The long year's climatic data were collected and analyzed by CROPWAT8.0 software to calculation of the right amount of water needed for the irrigation. The treatment was conducted under furrow irrigation method and Parshall flumes were used to measure inflow rates at each field.. The experimental field has 16 plots and each plot size was 4m by 5m dimension. Space between rows 90cm and between the plant 30cm was used. The result shows that maximum total yield (33.94 t/ha) was obtained from 100 % MAD and minimum yield (26.82t/ha) was obtained from 125 % MAD. The results of unmarketable yield has no significant difference (P<0.05) between the three treatment (125% MAD, 100%MAD and 75%MAD). The highest water use efficiency (5.64kg/m3) was obtained from 100%MAD. The highest net income (288116 birr/ha) was obtained at 100 % MAD that received 495.5mm seasonal irrigation water depth. The largest MRR (2156%) was acquired at 100 % MAD. From the result applying the optimum crop water requirement (100%MAD) of tomato was significantly increase the yield, economic benefit, and water use efficiency. Therefore, Appling irrigation water to the right amount at right time was increases yield of Tomato.

Keywords: furrow, MAD, water use efficiency, tomato, RCBD.

I. Introduction

Irrigation scheduling has conventionally aimed to achieve an optimum water supply for productivity, with soil water content being maintained close to field capacity. In many ways irrigation scheduling can be regarded as a mature research field which has moved from innovative science into the realms of use, or at most the refinement, of existing practical applications. Nevertheless, in recent years there has been a wide range of proposed novel approaches to irrigation scheduling which have not yet been widely adopted; many of these are based on sensing the plant response to water deficits rather than sensing the soil moisture status directly (Jones, 1990a).

The science of irrigation scheduling has a long and illustrious pedigree. Field monitoring of soil suction began in the 1930's with the development of the tensiometer (Richards and Neal 1936), followed by water content measurement using neutron scattering (Gardner and Kirkham 1952).

The increasing worldwide shortages of water and costs of irrigation are leading to an emphasis on developing methods of irrigation that minimize water use (maximize the water use efficiency). The advent of precision irrigation methods such as trickle irrigation has played a major role in reducing the water required in agricultural and horticultural crops, but has highlighted the need for new methods of accurate irrigation scheduling and control. In recent years it has become clear that maintenance of a slight plant water deficit can improve the partitioning of carbohydrate to reproductive structures such as fruit and also control excessive vegetative growth (Chalmers *et al*., 1981), giving rise to what has been termed by Chalmers *et al*. (1986) as 'regulated deficit irrigation' (RDI).

Tomato (Lycopersicon esculentum Mill.) is one of the most widely grown vegetable crops in the world, second to potato. It originally came from tropical area from Mexico to Peru (Maerere *et al*., 2006; FAO, 2005). Much is known about optimal irrigation for high yields and soluble solids' content of processing tomato (Hanson and May, 2005, 2006; Phene *et al*., 1985).

As many of the low productivity areas have untapped water resources, irrigation development is being suggested as a key strategy to enhance agricultural productivity and to stimulate economic development (Bhattarai et al., 2002).

In the contemporary literature, irrigated farming is recognized as central in increasing land productivity, enhancing food security, earning higher and more stable incomes and increasing prospects for multiple cropping and crop diversification (Hussain *et al*., 2001; Smith, 2004).

Generally soil moisture readings are useful to determine how much water is available for the 4 crop,

Author: Department of Irrigation, Southern Agricultural Research Institute, Areka Agricultural Research Center, Ethiopia.
e-mail: tamiratkifle26@gmail.com

when to start irrigating, and how much water to apply. Soil moisture monitoring can help conserve water and energy, minimize pollution of surface and ground water, and produce optimum crop yields. Efficient scheduling of irrigation water applications gives the highest return for the least amount of water (Werner, 2002). Therefore, this study was conducted to evaluate the effect of irrigation regime on tomato yield and water use efficiency.

II. Materials and Methods

a) Study Area Description

A field experiment was carried out in three seasons of 2016, 2017 and 2018, at Hadero Tunto Zuria Woreda, located at an altitude ranges from 1300m and 2600m a.s.l m.a.s.l, latitude ranges between 07^{0}10'N to 07o12'N and longitude ranges between 037^{0}38' to 037^{0}43''19''. Hadaro Tunto Zuria Worada is bordered by Wolayta Zone in the south, Kacha Bira woreda in the east, Hadiya Zone in the north and Tembaro woreda in the west. The woreda has three distinct agro climate zones, Kolla (1%), Weynadega (87%), which was the dominant agro-climatic zone and Dega (12%). The mean annual rainfall ranges from 800mm - 1200mm and with mean annual temperature of 18^{o}C-32^{o}C.

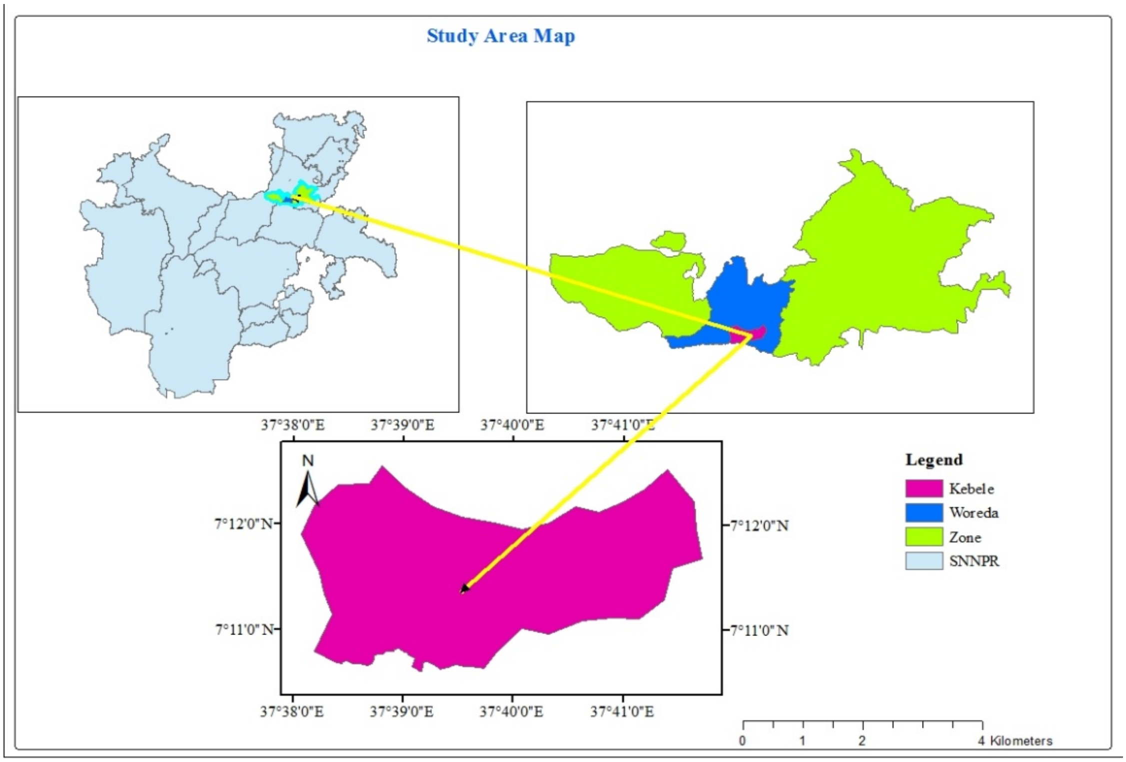

Figure 1: Map of study area

b) Experimental Design

The experiment has four treatments (125 % MAD, 100 % MAD, 75 % MAD and Farmer practice) with four replications. The experiment was laid out in randomized complete block design and the treatment was conducted under furrow irrigation method. The experimental field has 16 plots and each plot size was 4m by 5m dimension. Space between rows and the plants were 90 cm and 30 cm, respectively.

c) Crop Data

Maximum effective root zone depth (RZD) of tomato ranges between 0.7-1.5m and has allowable soil water depletion fraction (P) of 0.40(Andreas *et al*., 2002). Tomato average Kc would be taken after adjustments have been made for initial, mid and late season stage to be 0.6, 1.15 and 0.8, respectively (Allen *et al*., 1998). Yield data like economical yield, unmarketable yield and total yield was measured in the field.

d) Crop Water Determination

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 (Allen et al., 1998). 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). The long term and daily climate data such as maximum and minimum air temperature, relative humidity, wind speed, sunshine hours, and rainfall data of the study area were collected to determine reference evapotranspiration, 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 Cropwat model.

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

Where, ETc = crop evapotranspiration, Kc = crop coefficient, ETo = reference evapotranspiration.

e) Irrigation Water Management

The total available water (TAW), stored in a unit volume of soil was determined by the expression:

$$TAW = \frac{(Fc-PWP)*BD*Dz}{100} \quad (2)$$

The depth of irrigation supplied at any time can be obtained from the equation

$$Inet(mm) = ETc(mm)\text{-}Peff(mm) \quad (3)$$

Gross irrigation (IRg) is the ratio of net irrigation to application efficiency of furrow irrigation (FAO, 2002). According to Raine and Bakker(1996),furrow irrigation application efficiencies normally vary from 45-60%. The gross irrigation requirement will be obtained from the expression:

$$Ig = \frac{In}{Ea} \quad (4)$$

Ea=application efficiency of the furrows (60%)

The time required to deliver the desired depth of water into each furrow will be calculated using the equation:

$$t = \frac{Ig*l*w}{6*Q} \quad (5)$$

Where: Ig= gross depth of water applied (cm), t= application time (min), l= furrow length in (m), w= furrow spacing in (m), and Q= flow rate (discharge) (l/s)

The amount of irrigation water to be applied at each irrigation application was measured using Parshall flume.

f) Data collection

Daily climate like maximum and minimum air temperature, relative humidity, wind speed, sunshine hours and rainfall data was collected to calculate crop water requirement. Soil moisture was determined gravimetrically. Amount of applied water per each irrigation event was measured using calibrated pareshall flume. During harvesting Stand count, weight of economical yield, fruit number of economical yield, unmarketable fruit weight and unmarketable fruit number were measured from the net harvested area of each plot.

g) Economic analysis

Economic evaluation of deficit irrigation is analyzing the cost that invested during growing season and benefit gained from yield produced by application of water. Marginal Rate of Return (MRR) was used for analysis following the CYMMYT method (CIMMYT, 1988). Economic water productivity was calculated based on the information obtained at the study site: the size of irrigable area, the price of water applied and the income gained from the sale of onion yield by considering the local market price. Yield and economic data was collected to evaluate the benefits of application of different manageable depletion level of the treatment. Economic data includes input cost like cost for water (water pricing), seeds, fertilizers, fuel and labor. However, the only parameter that was vary between the treatment is amount of irrigation water. The net income (NI) treatments were calculated by subtracting total cost (TC) from gross income (GI) and were computed as:

$$NI = GI - TC \quad (6)$$

The difference between net income of a treatment and its next higher variable cost treatment termed as change in net income (ΔNI). Higher net benefits may not be attractive if they require very much higher costs (CIMMYT, 1988). Hence, it is required to calculate marginal costs with the extra marginal net income. The marginal rate of return (MRR) indicates the increase of the net income, which is produced by each additional unit of expenditures and it is computed as follows:

Where, MRR= marginal rate of return, ΔNI= change in net income, ΔVC= change in variable cost

h) Statistical Analysis

The collected data were analyzed using Statistical Agricultural Software (SAS 9.0) and least significance difference (LSD) was employed to see a mean difference between treatments and the data collected was statistically analyzed following the standard procedures applicable for RCBD with single factor. The treatment means that were different at 5% levels of significance were separated using LSD test.

III. Results and Discussion

a) Physical and Chemical properties of Soil

The laboratory result in the table shows that according to the USDA soil textural classification, the percent particle size determination for experimental site revealed that the soil texture could be classified as clay soil. The average soil bulk density (1.21g/cm^3) is below the critical threshold level (1.4 g/cm3) and was suitable for crop root growth. The critical value of bulk density for restricting root growth varies with soil type (Hunt and Gilkes,1992) but the general bulk density greater than 1.6 g/cm3 tend to restrict root growth (McKenzie *et al*., 2004).

Average moisture content at field capacity of the experimental site soils were 27.83% and at permanent wilting point had 17.05% through one meter soil depth. The total available water (TAW) that is the amount of water that a crop can extract from its root zone is directly related FC and PWP. The representative value of TAW was 180 mm/m and the TAW range of 190 – 260 mm/m is the characteristic for clay soil (Brouwer *et al*., 1985). Soil pH was found to be at the optimum value (6.15) for tomato and other crops. Tomato can be grown on a wide range of soil but a well-drained, with pH of 5 to 7 is preferred (Doorenbos *et al.*, 1979). The value of EC (1.01) ds/m) was lower considering the standard rates in literature (Landon, 1991). Generally, according to USDA soil classification, a soil with electrical conductivity of less than 2.0 dS/m at 25°C and pH less than 8.5 are classified as normal soil. Therefore, the soil of the study area was normal soils.

Table1: Soil physical and chemical properties result

Soil properties	Bulk density (gm/cm^3)	Infiltration rate(mm/hr)	Soil texture	EC(ds/m)	pH	Fc (%)	PWP (%)	TAW (mm/M)
Average value	1.21	42	Clay	1.01	6.15	27.83	17.05	13.04

b) Response of tomato to Irrigation regime

As shown from (Table 2) that highest marketable yield (29 t/ha) was obtained from 100%MAD and minimum marketable yield (22.2t/ha) was obtained from 125% MAD. Maximum unmarketable yield (5.35t/ha) was achieved from 75% MAD. The experiment results show that there is a significant difference on total yield of tomato between the treatments. Maximum total yield (33.94 t/ha) was obtained from 100% MAD and minimum yield (26.82t/ha) was obtained from 125% MAD. It is very important a shift from maximizing productivity per unit of land to maximizing productivity per unit of water consumed. The results showed that there were significant differences in water use efficiency between treatments. The highest water use efficiency (5.64 kg/m^3) was obtained from 100% MAD and minimum water use efficiency (4.3kg/m^3) was obtained from 125% MAD.

Table 2: Effect of irrigation regime on tomato yield and water use efficiency

TRT	MY(t/ha)	UMY(t/ha)	TY(t/ha)	WUE(kg/m^3)
125% MAD	22.2^{b}	4.6^{ba}	26.82^{b}	4.3^{b}
100% MAD	29^{a}	4.87^{ba}	33.94^{a}	5.64^{a}
75% MAD	23.9^{b}	5.35^{a}	29.32^{b}	4.81^{ba}
Farmer practice	22.95^{b}	4.21^{b}	27.2^{b}	5.46^{a}
Cv	23.2	24.7	18.0	27.7
Lsd	4.7	0.97	4.4	1.2

c) Economic Analysis

Cost benefit ratio for each treatments were analyzed and income was computed based on the current local market price of tomato at Hadero Tunto Zuria Worda. At the time of harvest the market price of tomato was 11 birr per kg. To analyze by the producer of dominance analysis, the treatments were set in their sort of increasing variable cost and their equivalent benefits were put aside.T3 and T1 showed the minimum and maximum variable cost respectively. Based on the current prices of tomato yield produced and input costs required for production, the economic analysis was carried out. The highest net income (288116 birr/ha) was obtained at T2 (Appling at 100%MAD) that received 495.5mm seasonal irrigation water depth and the least net income (210190 birr/ha) was obtained at T1 (125%% of MAD) that received 619.3 mm depth of irrigation water. However, as it is indicated in table the largest MRR (2156%) was acquired at T2. The MRR tell us that the amount of additional income obtained for every 1 birr spent. Hence, T2 (100% MAD) acquired additional 21.56 birr for every 1birr spent. The minimum acceptable marginal rate of return (MRR) should be between 50 and 100% (CIMMYT, 1988).

Table 3: Economic analysis

Trt	Ay (kg/ha)	GI (birr/ha)	FC (birr/ha)	VC (birr/ha)	TC (birr/ha)	NI (birr/ha)	MRR (%)
75% of MAD	26395.2	290347	18200	22296	40496	249851	-
Farmer practice	24458.4	269042	18200	26760	44960	224082	D
100%MAD	30549.6	336046	18200	29730	47930	288116	2156
125% of MAD	24140.7	265548	18200	37158	55358	210190	D

MAD = maximum allowable depletion, Ay = Adjusted yield, GI=Gross income, FC= Fixed cost, Trt= treatment, VC=Variable cost, TC=Total cost, NI=Net income, MRR=Marginal rate of return, D=Domination

IV. Conclusion and Recommendation

Maximum total yield (33.94 t/ha) was obtained from 100% MAD and minimum yield (26.82t/ha) was obtained from 125%MAD. The highest water use efficiency (5.64kg/m^3) was obtained from 100%MAD. The highest net income (288116 birr/ha) was obtained at T2 (applying at 100%MAD) that received 495.5mm seasonal irrigation water depth and the least net income (210190 birr/ha) was obtained at T1 (125%% of MAD) that received 619.3 mm depth of irrigation water. However, as it is indicated in table the largest MRR (2156%) was acquired at T2 (applying at 100%MAD). From the result applying at 100% MAD for tomato was significantly increase the yield, economic benefit and water use efficiency in the study area. Therefore, applying irrigation water too high interval and too low interval reduces tomato yield and water use efficiency.

References Références Referencias

1. Allen, .R., Pereira, L.A., Raes, .D. and Simth, M., (1998). Crop Evapotranspiration Guidelines for Computing Crop Water Requirement. FAO Irrigation and Drainage Paper Number 56, FAO, Rome, Italy.
2. Brouwer, C., Goffeau, A. and Heibloem, M., (1985). Irrigation Water Management: Introduction to irrigation. Training manual no. 1. FAO. Rome, Italy.
3. Chalmers DJ, Burge G, Jerie PH, Mitchell PD. 1986. The mechanism of regulation of 'Bartlett' pear fruit and vegetative growth by irrigation withholding and regulated deficit irrigation. *Journal of the American Society of Horticultural Science* 111, 904–907.
4. Cimmity (International Maize and Wheat Improvement Center). 1988. From Agronomic data to Farmer Recommendations: An Economics Training Manual. Completely Revised Edition. Mexico. D.F.
5. Doorenbos J, Pruitt WO., 1977. Crop water requirements. FAO Irrigation and Drainage Paper No. 24, Rome.
6. FAO (Food and Agricultural Organization), 2002. Localized irrigation system planning, design operation and maintenance .Irrigation manual, volume IV, Harare, Zimbabwe.
7. FAO (Food and Agricultural Organization), (2005). AQUASTAT.FAO's Information System on Water and Agriculture. http://www.fao.org/ag/agl/aglw/aquastat /countries/ethiopia/index. stn.
8. Gardner, W. and Kirkham, D. 1952. Determination of soil moisture by neutron scattering. Soil Sci. 73 391.
9. Hanson, B.R. and D.M. May. 2005. Crop coefficients for drip-irrigated processing tomato. *Agr. Water Mgt*. 81, 381–399.
10. Hussain I., Marikar F. and Thrikawala. S. 2001. Impact of Irrigation Infrastructure Development on Poverty Alleviation in Sri Lanka and Pakistan. *Journal of Development Studies 21.* 2, 29-31.
11. Jones, Richard M. 1990a. Waste Characteristics and Treatability. Anaerobic Treatment of High Strength Waste, 3–4 December, University of Wisconsin, Milwaukee, WI.
12. Landon J. R., (1991). Booker Tropical Soil manual: A handbook for Survey and Agricultural Land Evaluation in the Tropics and Sub Tropics. Longman Scientific and Technical Press, Essex, New York, USA, 474p.
13. Phene, C.J., R.L. McCormick, and J.M. Miyamoto. 1985. Evapotranspiration and crop coefficient of trickle-irrigated tomatoes. Proc. Third Intl. Drip/Trickle Irr. Congr. Drip/Trickle Irrigation in Action. 18–21 Nov. 1985. Fresno, CA. p. 823–831.
14. Raine,S.R. and D.M.Bakker.1996. Increased furrow irrigation efficiency through better design and management of cane fields. Proceedings of Australian Society of Sugercane Technologists. pp.119-124.
15. Richards, L.A. and Neal O.R. 1936. Some field observations with tensiometers. Soil Sci. Soc. Am. Proc. 1 71.
16. Smith LED (2004). Assessment of the Contribution of Irrigation to Poverty Reduction and Sustainable Livelihoods. Int*. J. Water Resourc. Dev. 20*(2), 243-257.
17. Werner, H. 2002. Measuring Soil Moisture for Irrigation Water Management. Coprative extension servise/FS 876, 5.

This page is intentionally left blank