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Evaluation of Tomato Spacing on Irrigated Agriculture at Mirabe Badewacho Woreda, Ethiopia

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Abstract

The study was conducted Mirab Badawacho of Central Ethiopia. This study evaluated the effects of different plant spacing treatments (25 cm, 30 cm, and 35 cm) on the marketable yield (MY), unmarketable yield (UMY), and total yield (TY) of a given tomato Roma VF variety crop. To achieve the objective three treatments were arranged in randomized complete block design with five replications under furrow irrigation method. The highest marketable yield (21.55 t/ha) and total yield (28.47 t/ha) were recorded at the 25 cm spacing (T1), while the highest unmarketable yield (8.2 t/ha) was observed at the 30 cm spacing (T2). Statistical analysis showed no significant differences (ns) at the 5% level for all yield parameters. These findings suggest that closer spacing may lead to slightly higher yields, although differences are not statistically significant. The population number under 25cm spacing was higher than 30cm and 35cm spacing. The size of the fruit under 35cm spacing is better than 25cm and 30cm spacing. Therefore, in area where land resource is sufficient 35 cm spacing is recommended to obtain equivalent yield with large fruit size, but in land scarce area 25cm spacing is recommended to obtain optimum yield.

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Spacing, Tomato, Irrigated Agriculture, Furrow Irrigation.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important edible and nutritious vegetable crops, widely cultivated in tropical, sub-tropical and temperate climates in the world. It ranks 1st with respect to world vegetable production and accounts for 14% (over 100 million tons per year) (Bauchet and Causse, 2010).

Tomato is beneficial to human health being rich in minerals, vitamins, essential amino acids, sugars and dietary fibers (Naika *et al.*, 2005). In Ethiopia Tomato is one of the most important and widely grown vegetable crops, both during the rainy and dry seasons for its fruit

by smallholder farmers, commercial state and private farms (Emana *et al.*, 2014).

The total production of Tomato in Ethiopia has shown an increase in the market and became the most profitable crop providing a higher income to small scale farmers compared to other vegetable crops (Gemetchis *et al.*, 2012).

MoA *et al.*, (2013) indicated that the total production of tomato in Ethiopia has shown a marked increase, indicating that it has become the most profitable crop providing a higher income to smallholder farmers compared to other vegetable crops.

The supply of crops like tomato and onion over whelm the marketing during few months in the dry season, and as a result, the price of the crop drastically decreases. On the other hand, the same crops disappear from the market in the wet season. Disease prevailing during rainy season attributed to the shift of production.

If this situation is to continue, forthcoming medium scale irrigation projects may not justify investment on processing plants that may need year round availability of certain commodities such as tomato (FAO, 2020).

The productivity of tomato is influenced by different factors among which environmental conditions, agronomic practices and varietal potential, however blanket recommendations of agronomic packages for all tomato producing areas could contribute to the yield reduction since the agro ecology of production may be quite different from areas where the recommendation was made (Ashenafi and Demlash, 2020). The objectives of this investigation were to study the plant spacing effect on Tomato yield productivity.

Materials and Methods

Description of the study area

The study was conducted at Hawora Kebele, Mirab Badawacho Woreda, Hadeya zone of southern nation nationality and peoples of Ethiopia. Mirab Badawacho, is one of Woredas (districts) in Hadiya Zone which found in SNNPR. It is bordered with Kambata Tambaro Zone north and north-east and east by Misrak Badawacho and with south by Wolaita Zone and with northwest Kachabira Woreda.

And it is located about 357 km south west of Adis Abeba and 127 km from the regional Capital, Hawassa. The major vegetable crops grown are Tomato, Onion, Head cabbage, Hot-pepper. The experimental site was located at an altitude range of 1700 -1800 m.a.s.l m.a.s.l, latitude range of 07°7'- 07°10'N and longitude range 37°44'- 37°47'E.

Experimental Design and Treatment

The experiment has three treatments (25cm, 30 cm and 35 cm b/n the plant) with five replications (farmers were used as a replication). The experiment was laid out in randomized complete block design and the treatment was conducted under furrow irrigation method. The size of each plot was 10m by 10m, between plot is 1m and space between rows were 100 cm.

Soil Data

The soil was analyzed in laboratory, gravimetric method, pH meter method, soil and water ratio method were used to determine soil moisture content, pH value and electrical conductivity respectively.

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(13). 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 (Lemma and Yayeh, 2003). Yield data like economical yield, unmarketable yield and total yield was measured in the field.

Climatic characteristics of the study area

The average climatic data (Maximum and minimum temperature, relative humidity, wind speed, and sun shine hours) on monthly basis of the study area were obtained from meteorological station.

The potential evapotranspiration ETo was estimated using CROPWAT software version 8.

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 (Lemma and Yayeh, 2003). 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 (Lemma, 2002). 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.

$$ETc = ETo * Kc$$

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

Irrigation water management

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

$$TAW = \frac{(F_c - PWP) * BD * Dz}{100}$$

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

$$I_{net}(mm) = ET_c(mm) - P_{eff}(mm)$$

The gross irrigation requirement will be obtained from the expression:

$$I_g = \frac{I_n}{E_a}$$

E_a=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:

$$t = \frac{d * l * w}{6 * Q}$$

Where: d= 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)

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 parashall flume. During harvesting, weight of marketable yield and unmarketable fruit weight were measured from the net harvested area of each plot.

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.

Results and Discussion

Physical and Chemical properties of Soil

The critical value of bulk density for restricting root growth varies with soil type (Allen *et al.*, 1998). But the general bulk density greater than 1.6 g/cm³ tend to restrict root growth (Doorenbos and Pruitt, 1977). 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. The laboratory result shows that the experimental site soil textural class was clay according to USDA textural classification with average composition of sand 32%, silt 17.5% and clay 50.5%. The average soil bulk density (1.14g/cm³) is below the critical threshold level (1.4 g/cm³) and was suitable for crop root growth. The PH of soil was strongly acidic with average pH value of 4.77 which is slightly affect the yield of Tomato. EC critical value for agricultural use according to (Hunt and Gilkes, 1992) is < 2.0 ds/m. thus, the experimental site soil were less than this value (1.005 ds/m) so it is suitable for onion growth.

Tomato Response to Spacing

The results reveal that closer plant spacing (25 cm) produced higher marketable and total yields compared to wider spacing's. T1 (25 cm) resulted in the highest MY (21.55 t/ha), which may be attributed to better plant population per unit area, enhancing total productivity. However, this also corresponds to a moderately high unmarketable yield (6.91 t/ha), indicating possible competition or quality issues due to denser planting.

Interestingly, T2 (30 cm) had the highest UMY (8.2 t/ha), suggesting that while plant competition may reduce overall marketable quality, intermediate spacing does not necessarily optimize total yield, which was slightly lower (27.39 t/ha) than T1. The widest spacing (T3 at 35 cm) showed a reduction in both MY and TY, which may be due to underutilization of available land area despite better air circulation and individual plant development.

Despite these differences, statistical analysis (CV% and LSD at 5%) indicated no significant variation among treatments, suggesting that yield differences may be due to natural variability or other environmental factors.

Table.1

Month	Min Temp°C	Max Temp°C	Humidity%	Wind km/day	Sun hours	ETo mm/day
January	13.3	29.1	77	95	8.1	3.91
February	14	29.7	75	104	7.6	4.18
March	13.8	28.8	81	173	7.5	4.35
April	13.5	28.1	92	130	7.1	3.95
May	13.1	26.3	93	104	6.1	3.47
June	12.8	24.2	94	104	5.9	3.19
July	12.3	22	92	95	3.7	2.65
August	12.1	22.5	90	104	4.2	2.82
September	12.8	25.5	97	86	5.6	3.23
October	12.8	27.2	87	95	7.2	3.71
November	13	29.2	87	69	8.8	3.96
December	12.8	29	72	69	8.3	3.78
Average	13	26.8	86	102	6.7	3.6

Table.2

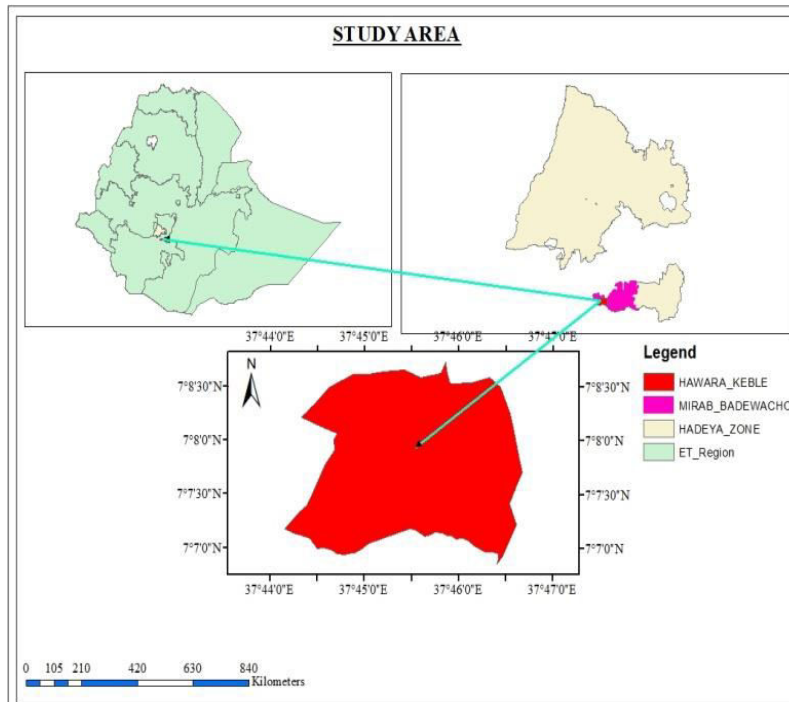
Soil properties		Soil depth in (cm)				
		0-20	20-40	40-60	60-80	average
Particle size distribution	Clay %	46	50	52	54	50.5
	Sand %	36	30	34	28	32
	Silt %	18	20	14	18	17.5
Textural class		Clay	clay	clay	clay	clay
BD (g/cm ³)		1.15	1.16	1.14	1.10	1.14
% Moisture		11.48	29.53	23.92	30.04	23.74
pH		4.52	4.8	4.75	5.02	4.77
EC (ds/m)		1.63	1.49	1.50	1.37	1.4975

Table.3

Treatment	MY(t/ha)	UMY(t/ha)	TY(t/ha)
T1(25cm)	21.55	6.91	28.47
T2(30cm)	19.19	8.2	27.39
T3(35cm)	20.17	7.3	27.49
Cv(%)	13.08	28.74	13.03
Lsd(5%)	Ns	Ns	Ns

MY- marketable yield, UMY- un marketable yield, TY- total yield

Figure.1



Conclusion and Recommendation

Among the three spacing treatments, the 25 cm spacing (T1) yielded the highest marketable and total yields, indicating potential agronomic benefits of closer spacing. However, due to the lack of statistically significant differences, all spacing treatments performed comparably under the conditions of this study.

Although T1 (25 cm spacing) demonstrated slightly superior performance in yield, further research is recommended to confirm these results across different seasons and locations. Farmers may consider using 25 cm spacing for potentially higher yields, but should also weigh factors such as crop type, soil fertility, and management practices. A cost-benefit analysis considering labor and input costs should also be undertaken to optimize planting density for maximum economic return.

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Conflict of Interest

There is no conflict of interest between authors

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