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Effects of Mulching and Amount of Water on Yield and Yield Components of Tomato (*Solanum lycopersicum* L.) under Drip Irrigation at Adola Rede District, Southern Ethiopia

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Abstract

Water has been identified as one of the scarcest inputs, which can severely restrict agricultural production and productivity unless it is carefully conserved and managed. This study has investigated the effects of Mulching and Amount of Water on yield and yield components of Tomato (*Solanum lycopersicum* L.) under Drip irrigation at Adola rede District, Southern Ethiopia. The treatments of the study comprised different combinations of three drip irrigation levels (100, 75, and 50% of crop water requirement, ETc) and three mulches (No mulch, white polyethylene sheet, and wheat straw). The yield and yield components in the mulched treatments with high levels of irrigation were significantly higher compared to those in the unmulched treatments. The yield of tomatoes increased with the increasing amount of irrigation water in mulched treatments. The highest marketable fruit yield for each mulch (35478kg ha^{-1} for white mulch and 28831kgha^{-1} for straw mulch) was obtained when 75% of the crop water requirement was applied. With 100% water application, the white plastic mulched treatment produced a lower marketable fruit yield than the straw-mulched treatment. The highest water productivity of (12.915kg m^{-3}) was obtained with 75% water application under white plastic mulch, But statistically non-significant with straw mulch under 75% crop water requirement application. The highest net benefit of 563475.7ETB ha-1 was recorded from white plastic mulch with 75% ETc and followed by 484454.7ETB ha^{-1} with Straw mulch with 75% ETc. The lowest net benefit 285477.3ETB ha^{-1} was obtained from no mulch with 50% ETc. The highest benefit to cost ratio was obtained under treatment straw mulch with 75% ETc (15.04) and followed by no mulch with 100% ETc (14.32). This result revealed that wheat straw mulch with 75% ETc is economically feasible for tomato production in the Adola area of the Guji zone.

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Keywords

Crop water requirement, tomato, drip, mulching, water levels, marketable fruit yield, total fruit yield.

Introduction

Agriculture is the main water-consuming sector worldwide, which accounts for 70 percent of all water withdrawn from aquifers, streams, and lakes (FAO, 2011). The global expansion of irrigated areas to feed the ever-increasing population and the limited availability of irrigation water are not balanced in a different part of the world. Rivers, lakes, groundwater, and different streams are dried due to unbalance between the inflow and outflow of water in the hydrologic cycle of that particular area. In arid and semi-arid areas where moisture stress is the main challenge for crop production, the spatial and temporal variations aggravate the problem.

Mulching practices have pronounced effects on enhancing water use efficiency (WUE). Kader *et al.,* (2017), reported that both plastic and straw mulches increased the water use efficiency by 79% and 58%, respectively, compared to bare soil. Based on six years of experiments on rice crops in China, Wu *et al.,* (2016) observed that the crop water use efficiency was increased by 70 to 80% and irrigation water use efficiency by 274% when the crop was raised under the plastic film mulch conditions compared to the traditional planting. Alongside the potential benefits of soil water conservation, better yield and higher water use efficiency, mulching also control weed infestation (Matković *et al.,* 2015), improve soil texture (Nawaz *et al.,* 2016), improve aeration, modify soil temperature (Ramakrishna *et al.,* 2006), checking surface sealing and crusting of soil by protecting the topsoil surface from raindrop splashes (Brant *et al.,* 2017), decreasing nutrient losses and increase the infiltration rate (Lalljee, 2013), and increase sediment deposition by enhancing roughness of soil surface (Donjadee and Tingsanchali, 2016).

Drip irrigation is an irrigation method that allows precisely controlled application of water and fertilizer by allowing water to drip slowly near the plant roots through a network of valves, pipes, tubing and emitters (Simonne *et al.,* 2009). According to Michael (1978), drip irrigation is one of the latest of the systems and is becoming increasingly popular in areas with water scarcity and salt problems. Water from the source passes through plastic pipes, constituting the main and laterals, into emitters positioned to supply each plant with the calculated water requirement at the same delivery rate.

Pressure head losses are encountered in lines which result in uneven distribution of the discharges from the emitters. Mofoke *et al.,* (2021), reiterated that the most widely accepted hydraulic performance indices for assessing the drip irrigation system are emitter discharge, emitter flow rate variation, uniformity coefficient, and emission uniformity.

Tomato (*Lycopersicon esculentum* Mill.) is one of the most common crops belonging to the nightshade family, Solanaceae. The fruit is consumed in diverse ways, including raw, as an ingredient in many dishes, sauces, and drinks. Tomatoes are rich in Vitamins A and B, and iron. Moreover, tomatoes are rich sources of lycopene, which is a very powerful antioxidant and helps prevent the development of many forms of cancer (You and Barker, 2004). Tomato plants are sensitive to water stress and show a high correlation between evapotranspiration and crop yield (Nuruddin *et al.,* 2003).

Farmers in the study area producing vegetable crops especially Tomato one times per dry season using traditional furrow irrigation method for their consumption and market sell. But due to shortage of irrigation water its production and land productivity is reduced and there is conflict among irrigators.

The main reasons for shortage of water are inefficient use of irrigation water as a result of high percolation loss, runoff loss and high evaporation loss which is caused due to over irrigation resulting low water use efficiency. Shortage of capital and new technologies are the main constraints in the study area to implement and use modern irrigation method (especially, drip irrigation method) with water loss minimizing methods.

A number of researches have been done to evaluate performance of drip irrigation under mulching practices in this country (Tegen *et al.,* 2016) and Temesgen *et al.,* (2018). However, no work has been done to study the combined effect of Mulching and Amount of Water on yield and water use efficiency of tomato in the study area. Therefore, the objective of this study was to investigate the combined effects of Mulching and amount of water on yield and water use efficiency of tomato (*Solanum lycopersicum* L.) under drip irrigation.

Materials and Methods

Description of the Study Area

The experiment was conducted at Adola rede District of Guji zone, Oromia Regional State in the 2019 and 2020/21 during off season from December to March. Adola rede District is one of the most important tomato-producing areas of the region. Adola rede District is located between 5°44'10”- 6°12'38” northing latitudes and 38°45'10”- 39°12'37” easting longitudes and at an altitude of 1500-2000 meters above sea level.

The District is bordered by Girja district in the northeast, Anna sora in North West, Oddo shakkiso in the south, and Wodera in the Southeast direction. The long-term (thirty years) mean annual rainfall of the study area was 1126.0 mm with a maximum and minimum temperature of 21.4℃ to 28.5℃ and 9.9℃ to 15.0℃ respectively.

Climatic characteristics

The average monthly climatic data of the study area (Maximum and minimum temperature, relative humidity, wind speed, and sunshine hours) were collected from the near meteorological station. The potential evapotranspiration ETo was estimated using CROPWAT software.

Soil Sampling

To characterize the soil of the experimental field, a representative composite soil sample was taken using an auger from the whole experimental field before planting with two depths, 0-30 cm, and 30-60cm. These samples were randomly collected from 8 different locations of the experimental field by zigzag manner and mixed to form a representative sample. From these samples, selected soil chemicals (pH, total N, available P, OC, OM, and EC) and physical property (Texture, Bulk density, FC, and PWP) were analyzed following standard procedures at the Engineering Corporation of Oromia. The core sample volume was known and the oven-dry weight was computed, and the soil bulk density was determined by dividing the soil dry mass by the volume of the core sample using the following equation (Jaiswal, 2003).

$$Pb = \frac{Ws}{Vc} \quad \ldots(1)$$

where: - Pb is soil bulk-density (g/cm^3), Ws is mass of dry soil (g) and Vc is the volume of soil in the core (cm3).The average value was described (Table 1).

Experimental Design and field management

The experiment has conducted with three rates of irrigation applications, full irrigation (100% ETc), ¾ irrigation (75% ETc) and half irrigation (50% ETc), and three mulching materials No Mulch (NM), Straw Mulch (SM), and white Plastic Mulch (WPM) (Figure 2). Control irrigation was the amount of irrigation water applied following the computed crop water requirement with the aid of the CROPWAT program without mulch. The treatments were arranged in Randomized Complete Block Design (RCBD) in factorial arrangements with three replications and a total of nine treatments. The experimental field plot was plowed using oxen, leveled, and made ready by dividing the field into 27 plots for transplanting. The experiment was conducted on an individual plot size of 3 m x 2 m (6m^2) with 27 such plots. The spacing between adjacent plots and between replications were 1 m and 1.5 m respectively. The spacing between plants and rows was 40 cm and 75 cm, respectively, with a total of four rows per plot. A row consists of 5 plants and a total of 20 plants per plot. The net harvesting area of a plot was 2 m by 1.5 m (3 m^2). More seedlings than those required for transplanting were raised so that vigorous, strong, and healthy ones were selected. The seedlings were transplanted to field plots five weeks after germination on the first week of January 2020 and 2021. Transplanting was done late in the afternoon to reduce the risk of poor establishment. The treatment was randomly applied to the area of each of the blocks (replications) and each treatment was assigned in the blocks. Tomato (*Lycopersicon esculentum* Mill.) seedling variety gelila was used as a test crop. A commonly recommended fertilizer rate at the study area was applied manually in the experimental plots. All plots were received the same amounts of fertilizer consisting of 150 kg ha^{-1} of urea and 242kg ha^{-1} of NPS. The irrigation water used in the study was harvested from the rooftop.

Crop water requirement

Crop water requirements were estimated with the CROPWAT computer software program using climatic, soil, and crop data as input. In this experiment, the reference evapotranspiration (ETo) and crop water requirement (ETc) were estimated from 15 years (2004-2018) climatic data collected from the National Meteorological Agency of Adola Station. Based on FAO CROPWAT output, crop water requirement (ETc) of tomato crops was found as 380mm for growing periods of 135 days at full irrigation level (100% ETc). Accordingly, for treatment three-fourth (75% ETc) and a half (50% ETc), irrigation levels crop water requirements were deduced as 285 mm and 190 mm, respectively.

Drip irrigation system installation

The drip irrigation system was used for applying irrigation water. The drip system consists of Polyvinyl Chloride main lines, sub-main, and laterals. The plots were leveled manually to create uniform plots within the given treatment. The drip laterals were installed in such a way that the spacing between rows is equal to that between the lateral and spacing between plants is equal to emitters spacing. There were 27 plots laid out in 2 m length, four laterals per plot. Hence, each plot consisted of four drip lateral lines; each lateral has 2 m length with 5 emitters so that each emitter drops water to a single plant. The water from the source was collected in a water tanker of 1000 liters capacity, which was placed at a height of 2m above the ground surface to supply the required irrigation water to the experimental field. The water distribution system components (mainline) were laid and connected to the water container and to the sub-main pipe which is connected to individual drip lines. The drip lines (laterals) of 16mm diameter were unrolled and laid along the crop rows and each lateral served one row of the crop. The end of the laterals, sub-main pipe, and main lines were closed with end cups to avoid direct soil contact and thus prevent clogging.

Application of mulches

The mulching rate of 5 ton/ha wheat straw and white plastic mulch with 30 microns thickness were applied. White Plastic mulches were applied before transplanting tomato seedlings by making small holes at the desired intra row spacing and the seedlings were transplanted.

However, straw mulches were applied immediately after the transplanting of seedlings. Transparent plastic mulch was selected because it provides more yields than black plastic mulch and it is characterized by the occurrence of higher soil temperature that it permits early germination, and increases water use efficiency than black plastic mulch (Ramalan and Oyebode, 2010).

Irrigation water application

Light irrigations were applied before the start of treatments applications for fifteen days. Water applications for full irrigation treatments (100% ETc) were based on the estimated crop water requirement calculated over the growing period and those water deficit treatments 75% and 50% ETc were executed as planned. Irrigation frequencies were the same for all treatments under drip irrigation, which was five days interval in the whole growing season.

Water productivity

Crop water productivity (WP) simply refers to the output (for example, crop yield or economic return) concerning water input during production. This means the output may be expressed either as physical production in kilograms per unit area or economic return in dollars per area. The water input is the amount of water applied to the cropped area per season. In this study crop, water productivity was estimated as the ratio of tomato yield to net irrigation depth applied to each treatment plot. It is expressed as:

Water use efficiency (Kg/ m^3)

$$= \frac{\text{Marketable grain yield}\left(\frac{kg}{ha}\right)}{\text{Seasonal net amount of water }\left(\frac{m3}{ha}\right)} \quad \text{....(2)}$$

Data collection

Related growth, yield, and yield components (plant height, number of fruits per plant, Marketable fruit yield, Unmarketable fruit yield, and Total fruit yield) data were collected. The agronomic data was collected from the middle rows to avoid border effects.

Plant height (cm)

The mean height of the plants was taken from the ground level to the tip of the uppermost part of 9 randomly selected plants at the first harvest and final harvest.

Marketable fruit yield (kg ha^{-1})

Recorded by weighing all harvests of marketable fruits from the two middle rows of each plot and calculated to kilogram per hectare

Unmarketable fruit yield (kg ha^{-1})

Recorded by weighing all harvests of unmarketable fruits from the two middle rows of each plot and calculated to kilogram per hectare considering the reason for un-marketability.

Total Fruit yield (kg ha^{-1})

Recorded by weighing all harvests of marketable and unmarketable fruits from the two middle rows of each plot and calculated to kilogram per hectare.

Data analysis

The collected data were statistically analyzed using Genstat 8th Edition software for the variance analysis. The two years' data were subjected to combined analysis over years and least significant difference (LSD) at 5% probability level was carried out for means separation.

Economic analysis

To assess the costs and benefits associated with drip and mulch materials the partial budget technique as described by CIMMYT (1988) was applied to the yield results. The net income (NI) was calculated by subtracting total variable cost (TVC) from total Return (TR) as follows:

$$NI = TR - TVC \quad \ldots (3)$$

Results and Discussion

Physical and water properties of the soil at the experiment site

Laboratory analysis of particle size distribution indicated that the soil texture was clay. The average soil bulk density of 0-60cm soil depth was 1.38 g cm^{-3}. A representative value of TAW (102.7mm m^{-1}) was obtained by considering the average of the upper 0 - 60 cm soil depth.

Average available soil moisture content for the top (0-30 cm) and lower (30-60 cm) soil depths were observed as 116 mm and 130 mm respectively. The basic infiltration rate in this experiment was found to be 5 mm/hr, which is within the range of clay soil (1 to 5) mm/hr.

Selected Chemical Properties of Experimental Plot Prior to the Experiment

The representative value of the soil pH (1:2.5 soil to water) was 5.9. As laboratory result shows the electrical conductivity (EC) of the soil was 0.099 ds/m (Table 4).

The weighted average organic matter content of the soil was about 3.69%. As cited in Staney and Yerima (1992), the organic matter content of the soil is of medium class. The average value of total nitrogen were found about 0.32%.

Yields and Yield Components

Plant Height

The results of the study showed that the different levels of drip irrigation and plastic mulching were non-significantly influenced the plant height of tomatoes.

Among the treatments, white plastic mulch with 75% ETc recorded maximum plant height (62.69 cm) and the minimum height (54.64 cm) was recorded in no mulch plot with 50% ETc (Table 4). Similarly, Yaghi (2013) obtained faster crop development and earlier yields in cucumber with the application of plastic mulching.

The number of fruits per plant

A maximum of 28.9 numbers of fruits per plant was obtained for the treatment of white plastic mulch with 75% ETc. The study revealed that the use of plastic mulch resulted in a maximum numbers of fruits per plant but, its effect was not statistically significant from straw mulching (Table 5). The minimum (17.13) number of fruits per plant was recorded at no mulch with 50% ETc. These results were in line with the findings of Deepa *et al.*, (2021) who indicated that the treatment combination receiving drip irrigation at 80% Etc along with polythene mulch was recorded with the highest fruit yield per plant.

Marketable Fruit yield

The result of this study revealed that the Combined effect of mulching and irrigation levels under drip exhibited a significant ($P<0.05$) influence on the marketable fruit yield. The highest marketable fruit yield (35478 Kg ha^{-1}) was obtained from the combined application of treatment received white plastic mulch with 75% ETc whereas the lowest marketable fruit yield (17463 Kg ha^{-1}) was obtained from treatment received no mulch with 50% ETc. However, there was no significant difference observed in marketable fruit yield between white plastic mulch with 75% ETc and straw mulch with 75% ETc (Table 5). For each mulching technique, the marketable yield was decreased with an increase in irrigation deficit levels. The trend tended to indicate marketable yield was significantly higher as the soil moisture stress decreased. Increased yield in mulched plots could be largely attributed to the increase in soil temperature and due to application of plastic mulch which resulted in an enhancement of soil environment around roots of tomato plants, which led to increased plant growth and, hence, increasing nutrient uptake. The increment of marketable fruit yield as irrigation levels increased is similar to the Temesgen *et al.*, (2018), which indicated that yield reduction was associated with an increase in soil moisture tension which when allowed continuing resulted in the loss of turgidity, cessation of growth and yield reduction. On the other hand, a favorable environment for the growth of tomato plants maintained by application of plastic mulch followed by plots treated with straw mulch than no mulch along with the increased irrigation levels may have contributed to the production of the highest marketable yield. The present finding is also in agreement with the results of Baye (2011), who reported that the highest marketable yield was obtained through black plastic mulch followed by straw mulch (56.43 tons/ha) in tomato crop.

Unmarketable Fruit Yield

The analysis of variance showed that combination treatment of mulching and water amount resulted statically non-significant ($P<0.05$) effect on unmarketable fruit yield (Table 5). The highest unmarketable fruit yield (34060 Kg ha^{-1}) was recorded from plants grown under White plastic mulch with 75% ETc followed by the treatment that received Straw mulch with 75% ETc. The highest unmarketable fruit yield was recorded from the plot that received plastic mulch followed by straw mulch under increased water application levels. The lowest unmarketable tomato fruit yield was recorded under treatment no mulch with 50% ETc. This finding is disagreed with

Total Fruit yield

Analysis of variance showed that the total fruit yield of tomatoes was significantly ($P<0.05$) influenced by the interaction effect of water amount and mulching techniques. Accordingly, the maximum total yield (38883 Kg ha^{-1}) was obtained from the treatment that received white plastic mulch with 75% ETc, followed by treatment Straw mulch with 75% ETc (30902 Kg ha^{-1}). The minimum total fruit yields (19750 Kg ha^{-1}) were recorded at the treatment of no mulch with 50% ETc. For each deficit irrigation level, maximum total yield was obtained from plots treated with plastic mulch which was followed by plots treated with straw mulch than that was obtained from no mulch (Table 5).

Water productivity

The Interaction Effect of irrigation levels with mulch type on water productivity of tomato under drip irrigation has shown a significant ($p<0.001$) influence on water productivity of tomato (Table 6). Results indicated that the maximum water productivity (12.915kg/m^3) was observed at white plastic mulch with 75% ETc which was statistically non-significant with white plastic mulch with 50% ETc (12.448 kg/m^3). The minimum water productivity (5.993 kg/m^3) was observed at white plastic mulch with 100% ETc (Table 6). Mulches with irrigation gave higher water productivity over-irrigation alone under all levels of irrigation. Mulches reduced the rate of water loss through evaporation from the soil surface. So, the soil-water-plant relationship was better in low irrigation regimes than high irrigation regimes that might help produce higher yields and thereby higher water productivity. The lower water productivity might be attributed to higher irrigation water depth applied, much of which was lost through soil deep percolation. The higher amount of irrigation water application is associated with lower water productivity and the lower amount of irrigation water amount is associated with higher water use efficiency. The results were similar to the findings of Ayars *et al.,* (1999), who reported that low irrigation regime reduced deep percolation and increased water use from root zone

Economic Comparison of Treatments

Data concerning economic comparison is presented in Table 7. Accordingly, the highest net benefit of 563475.7ETB ha^{-1} was recorded from white plastic mulch with 75% ETc and followed by 484454.7ETB ha^{-1} with Straw mulch with 75% ETc. The lowest net benefit 285477.3ETB ha^{-1} was obtained from no mulch with 50% ETc. The highest benefit to cost ratio was obtained under treatment straw mulch with 75% ETc (15.04) and followed by no mulch with 100% ETc (14.32). This result revealed that wheat straw mulch with 75% ETc is economically feasible for tomato production in adola area of the Guji zone.

Correlation of tomato yield, yield component, and water productivity

The calculated values of correlations coefficient (r) between yield, yield components, and water productivity are presented in Table 8. The number of fruits per plant was statistically no-significant ($p<0.01$) associate with all the studied parameters, but it shows a positive correlation. The highest Pearson correlation coefficient in the result provided a relationship between total fruit yield with marketable fruit yield ($r = +0.92$) followed by correlations between marketable fruit yield and water productivity ($r = +0.80$).

The correlation was showed that plant height, unmarketable fruit yield, marketable fruit yield, and water use efficiency were correlated positively with marketable fruit yield. Marketable fruit yield (kg ha^{-1}) positively and significantly associated with plant height ($r = 0.48^{**}$), unmarketable fruit yield ($r = 0.41^{**}$), total fruit yield ($r = 0.58^{*}$) and water productivity ($r = 0.99^{**}$). These results were in lined with findings of Shamsi *et al.,* (2010) reported WUE positively correlated with grain yield and yield components.

Table.1 Long-term (2004-2018) monthly climatic data of the experimental area

Month	T_{min}(℃)	T_{max}(℃)	RH (%)	Wind speed (m/s)	Sunshine hour(hr)	ETo (mm/day)
January	9.5	29.5	49.1	0.4	7.9	3.17
February	11.0	30.4	47.1	0.5	7.6	3.4
March	13.7	30.0	52.1	0.4	7.0	3.6
April	15.5	27.5	61.4	0.3	5.6	3.36
May	16.2	25.8	73.0	0.3	5.1	3.18
June	14.4	24.0	71.1	6.2	3.3	2.63
July	14.0	22.9	71.1	0.5	2.3	2.34
August	13.9	24.0	72.9	0.4	3.8	2.74
September	14.1	26.0	70.5	0.4	4.8	3.08
October	14.2	25.5	73.6	0.5	4.3	2.9
November	12.4	26.2	68.5	0.5	6.5	3.12
December	10.4	27.0	59.4	0.3	7.6	3.08
Average	13.3	26.6	64.2	0.9	5.5	3.05

Source: National meteorological station
(Tmin= Minimum temperature, Tmax= Maximum temperature, RH= Relative humidity, ETo = Reference Evapotranspiration)

Table.2 Details of treatment combination

Treatments	Descriptions
T_1	Without mulch with 100% ETc
T_2	Without mulch with 75% ETc
T_3	Without mulch with 50% ETc
T_4	White plastic mulch with 100% ETc
T_5	White plastic mulch with 75% ETc
T_6	White plastic mulch with 50% ETc
T_7	Straw mulch with 100% ETc
T_8	Straw mulch with 75% ETc
T_9	Straw mulch with 50% ETc

Table.3 Physical and water properties of the soil at adola rede District, experimental site.

Parameters	Results
Basic Infiltration rate (mm/hr)	5
Bulk density (gcm^{-3})	1.38
Field Capacity (%)	25.9
P.W.P (%)	16.6
Total Available Soil Water (TAW)(mm)	102.7
Sand%	50
clay%	28.75
Silt%	21.25
Soil textural class	Clay

Table.4 Soil chemical characteristics of the experimental site

Parameters	Chemical analysis
$pH(H_2O)$	5.9
Total N (%)	0.32
Organic carbon (%)	2.14
Organic matter (%)	3.69
EC (ds/m)	0.099

Fig.1 Location Map of the study area

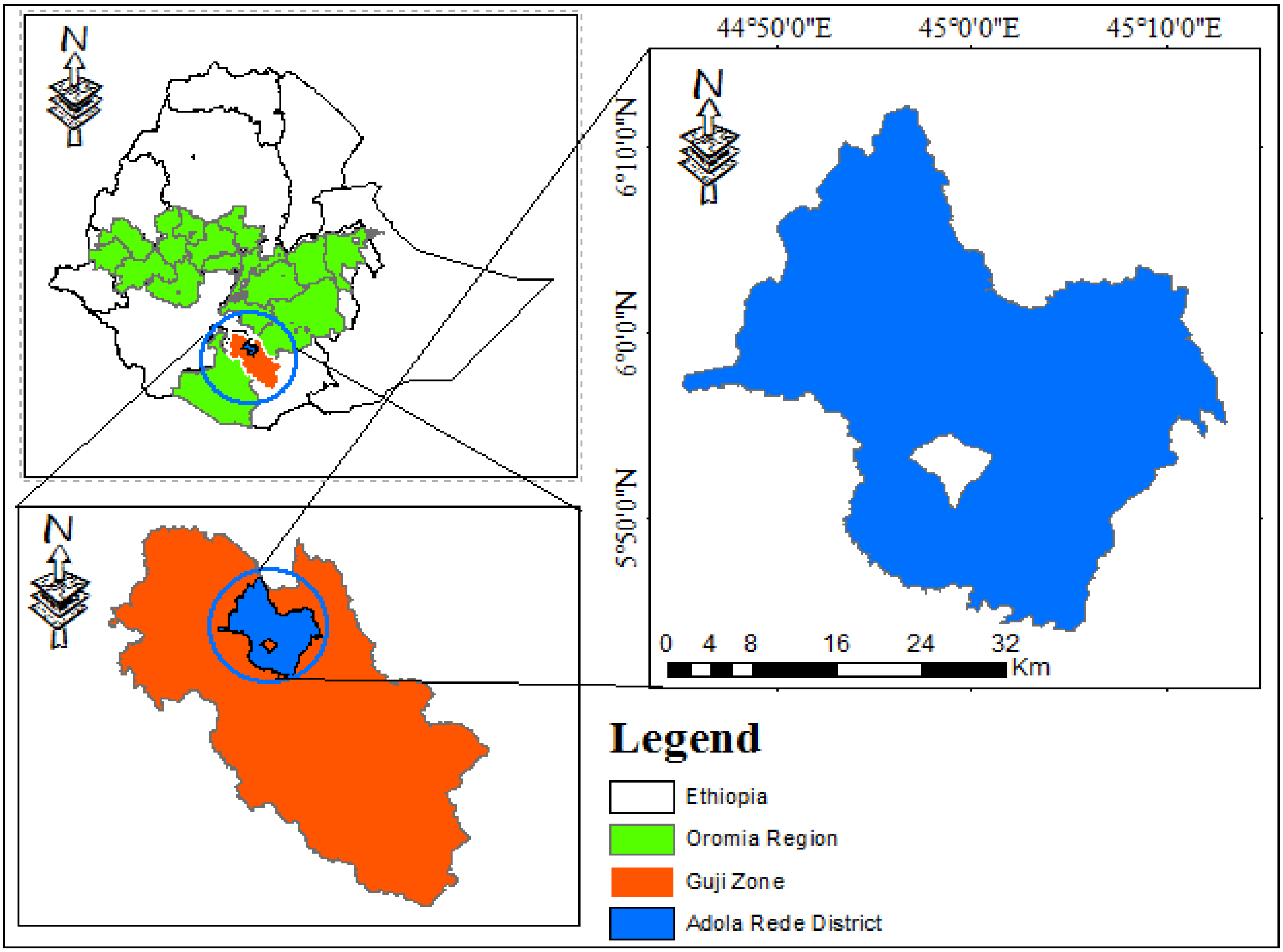

Table.5 Effect of drip Irrigation level and plastic mulching techniques on yield attributes and fruit yield of tomato

Treatment Combination	Plant Height (cm)	Number of fruits per plant	Unmarketable fruit yield (Kg ha^{-1})	Marketable fruit yield (Kg ha^{-1})	Total Fruit yield(Kg ha^{-1})
T1; Without mulch with 100% ETc	60.39ns	20.77bc	2554ns	24570bc	27124b
T2; Without mulch with 75% ETc	58.88ns	25.37ab	2071ns	19291bc	25861b
T3; Without mulch with 50% ETc	55.64ns	17.13c	1974ns	17463c	19755b
T4; White plastic mulch with 100% ETc	61.51ns	23.13abc	2727ns	22772bc	25500b
T5; White plastic mulch with 75% ETc	62.69ns	28.90a	3406ns	35478a	38883a
T6; White plastic mulch with 50% ETc	59.89ns	24.00ab	2512ns	24538bc	26512b
T7; Straw mulch with 100% ETc	59.96ns	19.18bc	2001ns	23349bc	21292b
T8; Straw mulch with 75% ETc	57.26ns	19.67bc	3361ns	28831ab	30902ab
T9; Straw mulch with 50% ETc	61.05ns	23.13abc	2292ns	22474bc	25835b
$LSD_{0.05}$	6.92	6.01	1488.98	9607.1	9952.20
CV (%)	9.9	23.0	49	33.9	31.8
Mean	59.7	22.4	2544.3	24307.1	26851.4

*Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at $p < 0.05$ level of significance, ns = non-significant at 5% probability level, LSD (%) = Least significant Difference at 5% of significance and CV (%) = Coefficient of variation.

Table.6 Interaction effect of irrigation levels with mulch type on water productivity of tomato under Drip irrigation.

Treatments	WP (kg/m^3)
T1; Without mulch with 100% ETc	6.466bc
T2; Without mulch with 75% ETc	6.769bc
T3; Without mulch with 50% ETc	9.191abc
T4; White plastic mulch with 100% ETc	5.993c
T5; White plastic mulch with 75% ETc	12.915a
T6; White plastic mulch with 50% ETc	12.448a
T7; Straw mulch with 100% ETc	6.144bc
T8; Straw mulch with 75% ETc	10.116ab
T9; Straw mulch with 50% ETc	11.828a
$LSD_{0.05}$	3.615
CV (%)	34.1
Mean	9.10

*Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at ($P<0.05$)

Table.7 Economic analysis of marketable fruit yield of tomato under different treatments.

Treatments	Marketable fruit yield (Kg ha^{-1})	Total Return (ETB /ha)	Total cost (ETB /ha)	Net Income (ETB /ha)	Benefit-cost ratio
T1; Without mulch with 100% ETc	24570	442260	30893.3	411366.7	14.32
T2; Without mulch with 75% ETc	19291	347238	29853.3	317384.7	11.63
T3; Without mulch with 50% ETc	17463	314334	29856.7	284477.3	10.53
T4; White plastic mulch with 100% ETc	22772	409896	75138.3	334757.7	5.46
T5; White plastic mulch with 75% ETc	35478	638604	75128.3	563475.7	8.50
T6; White plastic mulch with 50% ETc	24538	441684	75121.7	366562.3	5.88
T7; Straw mulch with 100% ETc	23349	420282	34513.3	385768.7	12.18
T8; Straw mulch with 75% ETc	28831	518958	34503.3	484454.7	15.04
T9; Straw mulch with 50% ETc	22474	404532	34506.7	370025.3	11.72

ETB = Ethiopian Birr and MRR = Marginal Rate of Return. Note: - The price of tomato taken was 18 ETB Kg

Table.8 Pearson's correlation coefficients (r) of tomato yields, yield component, and water use efficiency

	NFPP	PH	UMFY	MFY	TFY	WP
NFPP	1					
PH	0.160^{ns}	1				
UMFY	0.149^{ns}	0.482^{**}	1			
MFY	0.102^{ns}	0.405^{**}	0.414^{**}	1		
TFY	0.084^{ns}	0.415^{**}	0.491^{**}	0.921^{**}	1	
WP	0.098^{ns}	0.415^{**}	0.376^{**}	0.797^{**}	0.765^{**}	1

*. and **. = Correlation is significant at 5 and 1% level,*. NFPP =Number of fruits per plant, PH = Plant Height, UMFY =Unmarketable Fruit yield, MFY =Marketable Fruit yield, TFY =Total Fruit yield and WP =water product

Fig.2 Pictures of No Mulch (NM), Straw Mulch (SM), and white plastic Mulch (WPM) of treatment

Recommendation

An experiment was conducted at Adola rede District of Guji zone for two consecutive years in the 2018/2019 and 2020/2021 cropping season. This study was aimed to evaluate the effects of mulching and the amount of water on yield and yield components of tomato (*Solanum lycopersicum* L.) under drip irrigation. The experiment has conducted with three rates of irrigation water application; - full irrigation (100% ETc), ¾ irrigation (75% ETc) and half irrigation (50% ETc), and three mulching materials No Mulch (NM), Straw Mulch (SM), and white Plastic Mulch (WPM). The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications. No mulch with 100%crop water requirement was considered as a control for this experiment. The parameters for experimentation include yield and yield components: such as plant height, number of fruit per plant, marketable and unmarketable fruit yield, total fruit yield.

The results of this experiment indicated white plastic mulch with 75% ETc recorded maximum plant height (62.69 cm) and the minimum height (54.64 cm) was recorded in no mulch plot with 50% ETc. The study revealed that the use of plastic mulch resulted in a maximum number of fruits per plant but, its effect was not statistically significant from straw mulching. The highest marketable fruit yield (35478 Kg ha^{-1}) was obtained from the combined application of treatment received white plastic mulch with 75% ETc whereas the lowest marketable fruit yield (17463 Kg ha^{-1}) was obtained from treatment received no mulch with 50% ETc. However, there was no significant difference observed in marketable fruit yield between white plastic mulch with 75% ETc and straw mulch with 75% ETc. The high total fruit yield was obtained from a high depth of water applied under plastic and straw mulch respectively and this was significantly different from a relatively low depth of water applied treatments. The Interaction Effect of irrigation levels with mulch type under drip irrigation has shown a significant ($p<0.001$) influence on the water productivity of tomatoes. Results indicated that the maximum water productivity (12.915kg/m^3) was observed at white plastic mulch with 75% Etc which was statistically non-significant with white plastic mulch with 50% ETc (12.448 kg/m^3). The minimum water productivity (5.993kg/m^3) was observed at white plastic mulch with 100% ETc. Based on the partial budget analysis, the highest net benefit of 563475.7ETB ha^{-1} was recorded from white plastic mulch with 75% ETc and followed by 484454.7ETB ha^{-1} with Straw mulch with 75% ETc.

In conclusion, the present study points out that wheat straw mulch with 75% ETcis economically more profitable than the other mulch treatments around Adola rede District and similar areas.

Finally, we recommend that farmers can use wheat straw mulch with 75% Etc under drip irrigation, especially in drought-prone areas where water is very scarce to produce tomato crops. The test crop of the experiment was galila variety tomato.

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