Effect of mulching types and varieties on growth, yield and quality of tomato (*Solanum lycopersicum* L.) in Raya Azebo, southern zone of Tigray

By Tsirha Gidey

A Thesis

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Declaration

I, **Tsirha Gidey**, hereby present my thesis entitled **"Effect of mulching types and varieties on growth, yield and quality of tomato (*Solanum lycopersicum* L.) in Mekoni district, southern zone of Tigray"** in partial fulfilment of the requirement for the degree of Masters in Horticulture for consideration by the **Dryland Crop and Horticultural Sciences** Department within the College of Dryland Agriculture and Natural Resources at Mekelle University. I sincerely declare that this thesis is the product of my own efforts. No other person has published a similar study which I might have copied, and at no stage will this be published without my consent and that of the **Dryland Crop and Horticultural Science** Department.

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STATEMENT OF THE AUTHOR

First of all, I declare that this thesis is my work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfilment of the requirements for M. Sc. degree in Horticulture at the Mekelle University and is deposited at the University Library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of the source is made.

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BIOGRAPHICAL SKETCH

Tsirha Gidey was born in February 1997 in central zone of Tigray, Ethiopia. She attended her elementary school at Adikelkel Elementary school from 2005 to 2012. She attended her secondary and preparatory school at Mezbir Ftwi Welday and Dr. Tsegay Berhe Secondary School and preparatory school from 2013 to 2014 and from 2015 to 2016 respectively. She joined the then Mekelle University in 2017 and graduated with B.Sc. degree in Agriculture (Horticulture) in July 2019. After graduation, she was employed by the Raya University, and worked there for one year before joining Mekelle University in March to pursue her postgraduate study in Horticulture.

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ABSTRACT

Tomato (Solanum lycopersicum L.) *is the most significant vegetable crops in the Solanaceae family and one of the most widely consumed fruit vegetables in the world valued for nutritional benefits and economic impacts. However, the cultivation of tomatoes faces various agronomic challenges including low soil fertility, water stress, soil erosion and weed competition, which can adversely affect plant growth and over all yield. The experiment was conducted under irrigation condition from March–July 2024 at Mekelle University, agricultural research and innovation centre Mekoni site, Southern Tigray to evaluate the best mulching types and to screen tomato varieties based on their growth, yield performance and resistance to diseases. It was done in a randomized complete block design with three tomato varieties (Roma VF, Gelilama and Melka shola), three mulching types (white plastic, black plastic, grass) and with as no mulch. Data on plant height, number of primary branches per plant, weed density, soil moisture, disease incidence and severity, fruit diameter, fruit number per plant, total yield per plant, average fruit weight, total yield, marketable yield, unmarketable yield, total soluble solid (TSS) and fruit texture were collected and analysed using GENSTAT, 15th edition. The Duncan's multiple range test was used to compare between treatment means using a significance level of* $\alpha = 0.05$. *The findings showed that strong interactions between mulching types and tomato varieties, while both black and white plastic mulches improved yield and quality parameters. Black plastic mulch appeared the most effective in weed suppression, moisture retention,. In regards to the varieties, Gelilama appeared the most resilient and productive under various mulch conditions, while it may be more prone to disease, its potential for higher economic return due to greater yield fruit quality could make it a viable option for grower, whereas Melka Shola demonstrates high fruit numbers. Based on the current study, white plastic mulch with Gelilama variety is an effective strategy for enhancing tomato yield. However further research on the interaction of drip irrigation with mulching and both breeding and management practices can be conducted to explore its efficiency on tomato production and disease management practices.*

Key words: Grass mulching, Plastic Mulching, Tomato, Variety

DEDICATION

This thesis is dedicated to my beloved late brother, **Leake Gidey**.

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LIST OF ABBREVIATIONS AND ACRONYMS

FAO	Food and Agricultural Organization
TSS	Total soluble solid
RCBD	Randomized complete block design
LSD	Least significance difference
BP	Black plastic mulch
WP	White plastic mulch
G	Grass mulch
C	Control (no mulch)
PH	Plant height
Ha	Hectare
MYH	Marketable yield per hectare
UNMYH	Unmarketable yield per hectare
TYH	Total yield per hectare
DI	Disease incidence
DS	Disease severity
BN	Branch number per plant
FWT	Average fruit weight
D	Fruit diameter
FN	Fruit number per plant
TEX	Fruit texture
WD	Weed density per metre square
YP	Yield per plant

1. INTRODUCTION

1.1. Back ground and justification

Tomato (*Solanum lycopersicum* L.) is the most significant vegetable crops in the Solanaceae family and one of the most widely consumed fruit vegetables in the world that are either consumed fresh or in processed forms and the processed products include tomato preserves, dried tomatoes, and tomato-based foods (Asfaw and Menelek, 2021). It ranks next to potato with respect to world vegetable production but ranks first as a processing crop (Kebede, 2022).

Tomato plays a significant role in human food as a valuable source of vitamins A and C, as well as several minerals, including calcium, iron, manganese, and particularly potassium (Dam *et al.*, 2005). It contains lycopene, which is a carotenoid pigment involved in photosynthesis that gives red colouring to tomatoes (Wafula1, 2023). It is rich source of vitamin A, B and iron. It is mostly used for fresh vegetable, salad and processing products like puree, ketchup, sauce etc. (Pinder *et al.*, 2016).

The application of appropriate field cultural management practices and the choice of cultivars are the two factors that affect the productivity of tomato. In the tropics, the cultivation of most vegetables provides a major source of income and fresh food for small-scale growers (Habtamu *et al.,* 2016). Crop productivity is impacted by the genetic characteristics of the cultivar, the growing environment and management practices (Habtamu *et al.*, 2016). Tomato provides considerable economic returns for farmers in tropical regions especially when grown during the wet season (Degefa *et al*., 2017).

Among various factors responsible for higher yield, supply of nutrient and availability of moisture play vital roles in the production and quality of tomato (Tipu *et al.*, 2015). Its

production can be enhanced by adopting improved cultural practices and mulching is one of the effective methods to mitigate weed infestation, conserve moisture, balances temperature in the root zone and encourages deeper and denser rooting (Tipu *et al.*, 2015). Mulches have been found to reduce soil moisture losses by decreasing soil temperature and evaporation, promoting favourable soil biotic activities, reducing hard soil setting and contributing plant nutrients (Govindappa *et al.,* 2015). Mulching has also been identified by many workers as a method to provide a favourable soil environment by minimizing crusting at the soil surface and keeping it stable (Tipu *et al.*, 2015).

Many abiotic factors such as high winds, elevated temperature levels, harsh climatic conditions, and competing plantation such as weeds are responsible for the loss of moisture from the soil and converting it into barren land and it has been estimated that presence of weeds could result in loss of water up to 25% due to evapotranspiration (Iqbal *et al.*, 2020). Mulches can potentially reduce weed infestation and evaporation losses and enhance the percolation and retention rate of soil (Govindappa *et al.,* 2015).

1.2. Problem statement and justification

Tomato is one of the most cultivated and economically significant vegetable crops globally, valued for nutritional benefits and economic impacts (Kebede, 2022). However, the cultivation of tomatoes faces various agronomic challenges including water stress, soil erosion and weed competition, which can adversely affect plant growth and over all yields. Mulching is an established horticultural practice that can mitigate some of these challenges by enhancing soil moisture retention, regulating soil temperature, suppressing weed growth (Kundu *et al.,* 2019). Despite the potential benefits, the effectiveness of different mulching types (organic vs. inorganic) and tomato varieties on growth parameters and yield are inadequately studied.

Findings from Wafula1 (2023) showed that higher soil moisture content, average fruit weight and total yield in polyethylene mulch in tomatoes than the organic mulched plots and control and also Tylka F1 variety recorded higher total fruit weight per plant. The highest production was found in plots mulched with black polyethylene, according to (Ogundare, 2017). This could be because the black polyethylene completely eradicates weeds, increases soil moisture availability, and regulates soil temperature during cropping seasons. Kena *et al.* (2018) revealed notable variations in marketable yields and average fruit weight per plant on variety. Metadel and Melka Salsa varieties had the highest and lowest average fruit weights (122.1) and (53.5), respectively. This could be because different fruit kinds have varying sizes and shapes.

The average yield (3.93t ha^{-1}) of tomato in Ethiopia is very low as compared in to Africa (15.66 t ha^{-1}) and in to the world average (37.844 t ha^{-1}) (FAO, 2022). Some of the reasons for the low productivity of tomato include inadequate irrigation and fertilizer application, use of low yielding varieties, pests, and disease incidence. Among other factors, tomato is very sensitive to soil–water conditions, as water stress (drought and water logging) leads to a serious reduction in the yield and quality of fruits (Oiganji *et al*., 2019).

In general, the farmers raise tomato crop by adopting surface method of irrigation without any scientific basis in which appreciable quantity of water is lost due to evaporation, lack of poor research and extension services on irrigation agronomy as well as lack of access to water saving technologies and resulting in low application and distribution efficiencies. Attempts have been made on the different water management options like irrigation interval, adjusting planting time etc., however report from Mukherjee and Sarkar (2010) indicates that mulching is the most important cost effective, eco-friendly option in water stressed areas. Mulching not only reduce evaporation but also reduce occurrence of weeds, reduce soil salinization, cools soil temperature and protects soil from erosion (Govindappa *et al.*, 2015).

Mulching is the practice of covering the soil around plants to make conditions more favourable for growth, development and efficient crop production (Nagalakshmi *et al.*, 2002). Tigray is one of the tropical areas with long hours of sunlight Billi (2015) and application of mulching particularly the plastic one by integrating with tomato variety may provide effective contribution to improve tomato production. However, a little information was documented on this kind of research in Tigray, specifically in the study area. This research aims to investigate the combined effects of mulching types and tomato varieties on the growth, yield and quality of tomato plants.

1.3. Significance of the study

The purpose of this study was to identify the optimal mulching strategies and to screen tomato varieties that enhance agronomic performance, providing valuable insights for tomato growers to improve sustainable production practices and increase crop productivity.

1.4. Limitation of the study

A potential limitation of the study lies in the irrigation method used was furrow irrigation method, while drip irrigation is a common practice in conjunction with mulch. A higher severity of disease was observed in plots with black plastic mulch compared to white plastic mulch. This unexpected outcome presents a limitation in interpreting the overall benefits of black plastic mulch. While black plastic is often used to increase soil temperature and supress weed growth, the increased disease pressure may have negated some of these potential advantages. The higher soil temperature under the black plastic may have created a more favourable environment for certain pathogens. Future research should investigate the specific disease that were prevalent and explore strategies to mitigate disease pressure in black plastic mulch system.

1.5. Objective

1.5.1. General objective

- To evaluate the effect of different mulching materials and varieties on the growth, yield and quality of tomato (*Solanum lycopersicum* L.)

1.5.2. Specific objective

- To evaluate the performance of different tomato varieties in Mekoni
- To identify the best mulching type for tomato production
- To evaluate the interaction of variety and mulching type in tomato production

2. LITERATURE REVIEW

2.1. The general description of tomato (*Solanum lycopersicum* L.)

Tomato is a member of the Solanaceae family and other well-known species in this family include the potato, tobacco, peppers, and eggplant (Tigist *et al.*, 2012 and Dam *et al*., 2005). The Andes of South America are where tomatoes first appeared. The Spanish conquistadors introduced the cultivated tomato to Europe in the sixteenth century, and it later spread from Europe to southern and eastern Asia, Africa, and the Middle East and wild tomatoes have lately spread to various regions of Mexico and South America (Dam *et al*., 2005).

The growth habit of tomatoes is categorized into two types; determinate and indeterminate. They describe determinate vine growth to mean that the plant will grow a certain amount of foliage and then future growth is directed towards fruit production. The determinate ones that are both processing and fresh market varieties are more compact and have smaller plants; they grow to a certain size, then produce flowers, and set fruit within a relatively shorter period. This makes it possible to harvest all fruits in a relatively less number of picks (Mengesha, 2017). Determinate, or bush, types bear a full crop all at once and top off at a specific height; they are often good choices for container growing (Kebede, 2022).

Indeterminate tomatoes are those that once planted continue to grow, and grow, and the vines can get 15 to 30 feet long, and the root systems are vigorous and spread several feet. Once these tomatoes set flowers and fruit they continue fruiting until the plant dies from frost or disease in the fall (Amina *et al.*, 2012. Whereas the determinate cultivars have synchronized flower and fruit production, which allows mechanical harvesting in the tomato processing industry. Determinate types stop growing after flowering and they require less labour, so they are popular for commercial cultivation, they have a relatively concentrated fruit set which lasts only two or three weeks and the fruits ripen much faster than those from indeterminate

types (Dam *et al*., 2005).

The indeterminate ones have more vegetative growth with continuous flower and fruit formation, being thus preferred for fresh market tomato production (Vicente *et al.,* 2015). The vines will not bear fruit for the entire length unless carefully pruned. These tomatoes are well suited to being grown on a trellis or on wires like grapes. They need support (staking) using local materials like wood or bamboo that can be afforded by small and large scale farmers (Amina *et al.*, 2012).

Indeterminate varieties continually produce new leaves and flowers, grow very tall, set fruit over a longer period and needs staking and pruning. This longer harvest period is an advantage if market prices fluctuate, because income tends to even out (Hanson *et al.*, 2000). The tall types have to be staked, caged or trellised while the short types usually support themselves and need no staking (Dam *et al*., 2005). Under severe weather conditions such as typhoons, however, staking may be advisable (Hanson *et al.*, 2000).

The lateral shoot that extends a single main branch and continues to grow is referred to as indeterminate and are cultivated mainly for the fresh product market. In contrast, plants with a self-pruning growth habit with only short sympodial branches that form flower trusses are described as determinate (Ohta and Ikeda, 2015).

A new apex can differentiate from the highest node below the terminal flower bud in this branching type and these cultivars are mainly grown for processing tomatoes (Ohta and Ikeda, 2015). In general, unless strong growth of shoots from some nodes occurs lateral shoots of indeterminate tomato cultivars need to be removed before becoming elongated; this helps to prevent nutrient competition between vegetative and reproductive. Because the sink strength of lateral shoots with flower trusses is stronger than that of the main stem, and strong growth

of some lateral shoots may cause uneven distribution of photosynthetic products, resulting in undesirable effects on fruit production (Ohta and Ikeda, 2015).

2.2. Economic importance of tomato (*Solanum lycopersicum L.*) production in Ethiopia

Tomato (*Solanum lycopersicum* L.) is a high yield cash crop which can be a source of income for small-scale farmers and provides employment opportunities in the production, distribution, and processing industries (Menelek and Asfaw, 2021). Tomatoes play an important role in Ethiopia's poverty reduction and food security programs because they have a short harvesting season, relatively high production per unit area and provide employment in the production and processing industries (Degefa *et al.*, 2017). It is one of the strategic commodities prioritized by the Ethiopian government for agro-industry development and it also strengthens the national economy as a source of raw materials for value-added agro-processing industries and foreign currency for an exportable tomato to international markets (Menelek and Asfaw, 2021).

Tomato is not only sold fresh but also processed as paste, soup, juice, sauce, powder, concentrate or whole (Bergougnoux, 2014). Tomato is one of the most consumed vegetables in the world, after potatoes and before onions and probably the most favoured garden crop (Keskse *et al.*, 2019). With worldwide production reaching almost 160 million tons in 2011, tomato is the seventh most important crop species after maize, rice, wheat, potatoes, soybeans and cassava (Bergougnoux, 2014).

Tomato is one of the regional export crops of the country and it serves in various raw and processed materials (Kebede, 2022). Fresh tomatoes are essential ingredients in all around the

world and processed tomatoes are used to make soup, juice and other products (Yana and Rahima, 2023). It is one of the most important vegetables produced in the country and is one of the sources of income generation crops of rural areas (Kebede, 2022). The importance of tomato is increasing since it is a high value commodity, and has been given first priority in vegetable research in Ethiopia (Yana and Rahima, 2023). Small-scale farmers and commercial growers could grow the crop for its fruits in different regions of the country and it is produced both during the rainy and dry seasons under supplemental irrigation (Kebede, 2022).

2.3. Ecological requirements of tomato (*Solanum lycopersicum* L.)

Tomato is warm season crop although it can thrive under wide range of climate and soil conditions both in the tropics and temperate regions, and it is not affect by day length and sets fruit in photoperiods ranging from 7–19 hours (Dam *et al.*, 2005). Tomato requires clear and dry weather, i.e. warm weather and abundant sunshine for its best growth. It is affected by both extreme high and low temperatures; resulted in low germination of seeds, poor plant growth, flower drop, poor seed set and ripening (Kebede 2022). At high temperature, quality of tomato fruits is poor and there is high incidence of sunscald. Under extreme high and low temperature conditions, the yield and quality of fruits is reduced. For optimal yields, the crop requires plenty of sunshine, moderately cool nights and warm days and well-drained soil. The optimum day and night temperatures for tomato are 25-28 ℃ and 10-15 ℃ respectively (Zeleke and Derso, 2015) as cited by Kebede, (2022). Fruit setting is reduced by temperatures that are either low below (13 ℃) or high (above 35℃) (Dam *et al.*, 2005).

Tomato can be cultivated up to 700-2,200 meter above sea level; it performs well in areas that receive over 600-650 mm of annual rainfall with well distributed throughout the growing season. Nevertheless it is mainly cultivated by irrigation (Freeman *et al.*, 2019). Total water

requirements after transplanting, of a tomato crop grown in the field for 90 to 120 days, are 400 to 600 mm, depending on the climate and strives better well drained sandy loam, or clay loam soils and optimal soil pH between 5.5 to 7.5 (Freeman *et al.*, 2019).

2.4. Mulching and its importance

The materials used to cover the soil's surface are called mulches. There exist two categories of mulches: inorganic and organic. Mulching is a common practice that involves applying materials to the field before, during, or soon after sowing in order to support and spread over the soil surface, such as plastic material, crop residues, livestock manure, sands, rocks, stone, dry grass and etc. (El-Beltagi *et al.*, 2022). Mulches are used in the cropping rows so as the basal part of plant is completely covered. The mulching was highly advantageous in crop production with minimized soil moisture transpiration, weed control, optimum soil temperature, increase in soil microbial activity and soil organic carbon (Govindappa *et al.*, 2015).

Mulching has several benefits for soil, including lowering evaporation, keeping soil cooler in warmer months, protecting roots and soil from direct sunlight (Ray and Biswasi, 2016). Cool soil encourages earthworms to burrow, which improves air porosity and increase organic soil content, and adding nutrients to the soil through the breakdown of organic mulches. Mulching offers physical protection to soil against wind and rain (Telkar *et al.*, 2017).

Depending on the amount of light transmission through the mulch, plastic mulches provide a range of weed control levels. Plastic mulch reduced weed emergence by 64% to 98% during the growing season (Krishi and Sewa, 2020).

Mulch helps keep fruits clean from contacting the ground, reduces soil rot, fruit cracking and blossom end rot in many cases. Fruits tend to be smoother with fewer scars. Properly installed

plastic mulch helps keep soil from splashing onto the plants during rainfall, which can reduce grading time (Krishi and Sewa, 2020).

Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Thus, it facilitates for more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Krishi and Sewa, 2020. Ray and Biswasi (2016) reported that mulching boosts the yield by 50-60 per cent over no mulching under rain fed situations. Before planting, cover the planting bed with black mulch to warm the soil and encourage faster development in the early season, which will usually result in an earlier harvest. In tomato crops under control, organic mulches promoted early flowering, fewer days till fruit set, and earlier harvest (Krishi and Sewa, 2020).

The mulching was highly advantageous in crop production with minimized soil moisture transpiration, weed control, optimum soil temperature, increase in soil microbial activity and soil organic carbon (Choudhary and Choudhary, 2021). Mulching enhances soil moisture content and decreases soil erosion, improve in soil structure and decrease in the weed growth. It increases yield levels in both fruit crops and vegetable crops. The percentage yield increase in fruit crops ranged from 12.61 to 64.24 percent and in vegetable crops it was from 17.39 to 60.74 % (Govindappa *et al.*, 2015).

Main role of mulching is to limit first stage of drying which helps in optimum moisture status, reducing soil temperature, also minimizing seedling mortality and improving crop stand. It also suppresses weed-flora and lessens weed competition with crop for water and nutrients making them available in larger amounts for crop plants (Prem *et al.*, 2020).

2.4.1. Effects of mulching on growth and yield of tomato

Some authors claim that natural organic mulch eventually breaks down and becomes a part of the soil and a source of plant nutrients, which as a result improve plant growing conditions (Edyta, 2014). These results concurred with those of Makus *et al*. (1994) as cited by Edyta (2014) who observed that plant height was significantly affected by different mulching materials. According to the authors, the application of mulch increased plant height due to higher soil moisture conservation and reduced water stress (Edyta, 2014). According to Edyta (2014) soil mulching dramatically raised the overall production of tomato fruits in the Samaila *et al*. (2011) trials when compared to non-mulched plots.

Krishi and Sewa (2020) showed that improved yield and chemical composition of tomatoes, cucumbers, muskmelons, eggplant in mulched than control (bare soil), because mulching reduces fruit contact with the soil which cause blossom end rot and fruit cracking.

Tipu *et al.* (2015) tested five mulching types that as compared to bare plants, mulching greatly enhanced the overall number of fruit produced per tomato plant. The rice husk had the most fruit number/ plant (31.70), while the area without mulch had the least amount of fruits/plant (27.73). Weight of fruit/plant showed a similar trend, with the lowest weight (2.11kg) without mulch and the greatest (2.42kg) with rice husk mulch. Singh *et al.* (2017) found that more number of fruits/plant in double shaded plastic mulch and black colour plastic mulch; respectively than the other mulching materials he was tested. Awodoyin *et al*. (2007) as cited by Mutoro (2015) reported that mulched tomato plants had more branches than the un-mulched plants. Tomato yield was higher with mulch than it was without. With rice husk mulch, the yield was highest (76.03 t/ha), and lowest (64.47 t/ha) without mulch. Statistics showed that the tomato yield found in rice husk mulch was comparable to that of sawdust and garden leaves. Fruit with rice husk mulch had the greatest total soluble solids (TSS) at 6.17, while fruit without mulch had the lowest TSS at 4.58 (Edyta, 2014).

Krishi and Sewa (2020) has shown that mulch provides many benefits to crop production such as protecting the roots of the plants from heat and cold, creating congenial condition for the plant growth by temperature moderation, reducing salinity and weed control and thereby improving the yield and quality of the crop. According to Krishi and Sewa (2020), the yield of tomatoes and broccoli in the plastic-mulched region were 37.26% and 60.7% respectively and the results were higher than the control. White plastic mulch recorded the highest plant height value followed by black plastic mulch and, plants grown on grass mulch and no mulch recorded significantly lowest plant height values (Habtamu, *et al.*,2016).

Variations in tomato plant height have been noted under various mulches; plastic mulch exhibited a greater rise in plant height than other mulch types (Mutoro, 2015). Mulches could accelerate the time of harvesting by 4 to 5 days. The reason was that fruits get ripe quicker in following mulches because of increase in temperature of soil and it thereby contributes to the absorption and transfer of minerals to the plant through its roots. Significantly higher number of nodes/plant (39.5), minimum internodal length (6.4cm) and maximum plant height (245.8cm) were recorded in double shaded plastic mulch treatments. The more number of nodes/plant in double shaded plastic mulch can be attributed to more plant height which is result of high canopy temperature due to reflecting nature of double shaded mulch that in turn increases photosynthesis activity that result in more growth and development. Furthermore, during more growth and development, short internodal distances increases the number of nodes/plants that ultimately enhance the yield. Working on tomatoes attributed these findings to the mulch colour's effects on internodes length suggesting a role for surface reflected light on plant development (Singh *et al.*, 2017).

2.4.2. Role of mulching on soil moisture conservation

Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Thus, it facilitates for more

retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, and organic mulching adds nutrients to the soil and ultimately enhances the growth and yield of crops (Shirish *et al.,* 2016, Choudhary and Choudhary, 2021 and Mohiuddin *et al.,* 2020). Organic mulches may impact soil pH, with strong acid components like pine needles lowering it over time, while high alkalinity components like wood ash increase it (Demo and Bogale, 2024).

Plastic mulch helps maintaining the moisture content of the soil which can aid in reducing evaporation, which would allow plants to absorb as much moisture as possible (Mutoro, 2015). Mulch reduces the kinetic energy of rain and slows down the movement of rain water, which prevents runoff and giving the soil more time to absorb the rain water. The additional moisture cheers growth of plant roots, which further stabilizes of soil and it also protect soil from wind erosion (Prem *et al.,* 2020). Organic mulching has influence on soil moisture content at different stages and yield of sesame as the yield increased with mulch compared to no mulch (Teame *et al*., 2017).

2.4.3. Role of mulching on improving soil nutrients

Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Thus, it facilitates for more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, and organic mulching adds nutrients to the soil and ultimately enhances the growth and yield of crops(Shirish *et al.,* 2016 and Mohiuddin *et al., 2020*). Organic mulches may impact soil pH, with strong acid components like pine needles lowering it over time, while high alkalinity components like wood ash increase it (Demo and Bogale, 2024).

Plastic mulch entertains as impermeable to the gassy movement which act as a greater wall for the process of solarisation and fumigants and also show an astonishing role in increasing soil health and control of pests. Thus, it supports in keeping the nutrient around the root of plant for effective use of nutrient and also helps in decreasing of leaching of fertilizer (Prem *et al.*, 2020). Mulching offers a good habitat for beneficial organisms like earthworms, insects, and bacteria, which play a critical role in soil health and nitrogen cycling, hence boosting nutrient availability and ecosystem health (Demo and Bogale, 2024). Mulch, especially organic mulch derived from plant residues, contributes to carbon sequestration in soil by supplying organic matter and boosting soil organic carbon concentration (Mohiuddin *et al.,* 2020). This not only enhances soil fertility and structure but also helps avoid climate change by absorbing carbon dioxide.

2.4.4. Effect of mulching types on yield and quality of tomato

Organic mulches can be made from naturally occurring various substances which contains organic matter in it. Common examples of organic mulching are bark or dry grass clippings, compost, dry leaves, wood chips, pine needles, , paddy straw, dry leaves, saw dust, grass clipping, etc (Mohiuddin *et al.*, 2020 and Prem *et al.*, 2020). Inorganic Mulches are made up of inorganic substances which do not contain organic matter in it. Inorganic mulches include stones and gravels, polyethylene films, landscape materials and rubbers (Prem *et al.*, 2020).

Organic mulch attracts insects, slugs and the cutworms that eat them. They get decomposed easily and need frequent replacements (Shirish *et al.*, 2016). Results from Tesfaye *et al.* (2016) showed that total yield, fruit length, fruit diameter, fruit firmness and fruit weights of tomato plants treated with plastic mulch were not significantly different among treatments but were significantly different from the control group. Highly significant variation was recorded between control and all plastic mulches for average fruit weight (Tesfaye *et al.*, 2016).

Polyethylene mulch, irrespective of surface colour, had significant beneficial effect on vegetative growth of tomato plants. However, the difference in shoot growth due to mulch colour was small and statistically insignificant, although black and red polyethylene mulches were slightly better than other colours (Chakraborty and Sadhu, 1994). The natural mulching materials (water-hyacinth or rice straw) also stimulated vegetative growth, but to a lesser extent than the polyethylene mulches and the difference of these natural mulches from the control were not statistically significant (Chakraborty and Sadhu, 1994). Findings from Yana and Rahima (2023) shows that the fruit weight per tomato plant tends to be greater with the use of rice husk mulch reaching (606.14 g) compared to the use without mulch and straw. The lightest fruit is found in the use of straw, which is (566.82 g).

Mulch type and mulch colour influenced the flowering in tomato (Chakraborty and Sadhu, 1994). In general, mulching advanced the flowering of tomato by more than 1 week. The flowering was advanced by 10 and 9 days when the crop was mulched with black and red polyethylene respectively compared with the control. Among the natural mulches, water hyacinth was better than rice straw for increased fruit number and size (Chakraborty and Sadhu, 1994).

Findings from Aliabadi *et al.* (2019) showed that lowest vitamin C was observed in fruit of the plants not treated with mulch and fruit of the plants treated with wood chip mulch had the lowest TSS content than the plastic mulch and composted wood chip mulch. In addition, the lowest pH, titratable acidity, and fruit firmness were measured in the fruit of plants treated with Wood chip mulch.

Kundu *et al.* (2019) showed that significant effects were obtained on weight of mature tomatoes in Rocky cultivars that were treated with different types of mulches. Among mulch treatments, black polyethylene mulch significantly increased the weight of the fruits over

control. The maximum test fruit weight was in black polythene mulch (784.0 g in the year 2017- 2018, and 778.5 g in 2016-2017) which was at par with straw mulch (test weight of 10 fruits were 704.0 g and 699.9 g in 2017- 2018 and 2016-2017 respectively) and found bigger the rest of the treatments; whereas minimum weight observed from treatments without mulch (641.6 g and 629.0 g in back to back experimental seasons) (Kundu *et al.*, 2019). Different level of yield hike was signified by the various types of mulching. In two consecutive years maximum yield were recorded from black polythene mulched treatment (60.3 t/ha and 58.7t/ha). While the minimum yields 38.7 t/ha in 2016- 2017 and 36 t/ha in 2017-2018 were obtained from the non-mulched plots of farmer's practices. Maximum marketable yield was found in black polythene mulched plot (58.7 t/ha) followed by straw mulched plot (51.8 t/ha) (Kundu *et al.*, 2019).

2.5. Effect of varieties on growth and yield of tomato

Research revealed that for the majority of the characteristics, the effect of variety was shown to be quite significant. Tipu *et al.* (2015) tested two tomato varieties for their number of fruits per plant and BARI Tomato 15 had 32.55which was higher than 27.76 BARI Tomato 14 and the difference was highly significant. The weight of fruit per plant was highly significant in that the highest (2.34) was obtained in BARI Tomato 14 and lowest (2.13) in BARI Tomato 15. Similarly, length and diameter of fruit and individual fruit weight were found to be highly significant. It was discovered that, BARI Tomato 15 had a more yield (74.85ton ha^{-1}) than BARI Tomato 14 (67.12ton ha^{-1}), and the difference was highly significant. Fruit's TSS, which varied from 5.13 to 5.67, was also found to be significant (Tipu *et al.*, 2015). Other studies showed that significant variations were observed on weight of immature/ green tomatoes cultivars.

Kebede (2022) tested 17 tomato varieties, and significant performance difference was recorded among genotypes for growth, yield and quality parameters with Chali (59.62 ton ha^{-1}), Eshet (51.95 ton ha^{-1}), and Metadel (51.12 ton ha^{-1}) identified as most promising tomato genotypes for their marketable fruit yields and fruit quality such as juice content, fruit juice pH and titratable acidity.

Results from Tigist *et al.* (2012) indicated that fresh market tomato varieties of indeterminate growth were low yielder as compared to determinate types of both fresh market and processing types of tomato varieties tested. The result indicated that the fresh market tomato variety Fetane had more yield than Roma VF and Melkashola. However, Melkasalsa remained at par with Fetane. The variation in yielding ability of the tomato varieties studied could be attributed to fruit set and number of marketable fruits, which is genetically controlled.

3. MATERIAL AND METHODOLOGY

3.1. Description of the study area

The experiment was conducted under irrigated condition from March–July 2024 at Mekelle University, agricultural research and innovation centre Mekoni site, Southern Tigray. It is located 120 kilometres from Mekelle. Geographically the experimental site is located at 12° 51'50" North and 39° 68'08" East at an altitude of 1578 m.a.s.l. The site receives a mean annual rainfall of 300 mm with an average minimum and maximum temperature of 18 and 32°C, respectively. The soil textural class of the experimental area is clay with pH of 7.1 - 8.1(Tamiru, 2015). Major crops grown Mekoni area includes tomato, potato, watermelon, papaya, straw berry, pepper, onion and maize as irrigated horticultural crops and sorghum, maize and teff as rain fed crops.

3.2. Treatments, design and procedure

The experiment was done in a randomized complete block design with three tomato varieties (Roma VF, Gelilama and Melka shola) and three mulching types (white plastic, black plastic, grass) and control as no mulch. Treatments were replicated three times. The experiment was consisted 12 treatments and had a total of 36 experimental units. Each treatment combination was assigned randomly to the experimental units within a replication.

Suitable location with an adequate sunlight and proper drainage for tomato cultivation was selected. The soil was prepared by removing weeds, loosening it with a tiller or hoe. The site was divided into plots, ensuring uniformity in soil characteristics. Plot size was 3m *3 m with 1m and 1.5m spacing between plots and blocks respectively. The plot was dvided in to four rows and six plants per row was planted. Seeds of the three tomato varieties were sown in green house, and the seedlings were grown there for one month. Tomato seedlings were transplanted at spacing of 75cm and 50 cm between row and between plants respectively. The tomato seeds

used in the experiment were determinante type and needs narrow spacing than the determinate types. Seedlings were transplanted after one month. Transplanting was done late in the evening. The experimental site was irrigated by furrow irrigation method uniformly for all plots.

Recommended agronomic practices such as weeding, cultivation, fertilizer application, and disease management were carried out uniformly during the growing season for all plots. Similarly, blended fertilizer NPK at a rate of 150 kg ha^{-1} and urea fertilizer at rate 150 kg ha^{-1} was applied (Mengesha, 2017). Full dose of NPK was applied during transplanting and the half dose of urea was applied during flowering stage of the tomato.

3.3. Experimental materials

Three tomato varieties and three mulching materials were used for the experiment. The variety Roma VF is imported and locally adopted variety and Gelilama and Melka shola are released by Melkasa agricultural research centre. The tomato seeds were obtained from Shire and Maitsebri research centres. The first Roma VF tomato variety is typically characterized by its elongated, pear or plum-shaped fruits. It is resistance to Verticillium and Fusarium which are common soil-borne diseases that affect tomatoes. Roma VF tomatoes are meaty and dense, making them ideal for processing purposes. It has determinate growth habit and due to their firm texture and intense flavor, Roma VF tomatoes are commonly used for canning, making sauces, salsas, and pastes. They are also suitable for fresh consumption, adding depth of flavor to salads and sandwiches and has potential yield of 400 qt ha^{-1} and it needs 95 – 100 days after transplanting for maturity (Freeman *et al.*, 2019).

The second tomato variety used for comparisons was Gelilama. It is determinate type and tolerant to tomato Yellow leaf Curl Virus, early and late blight. It has firm and oval fruit shape and has yield potential up to 500 qt ha^{-1}. It takes 80-92 days after transplanting for

maturity. The third variety tested Melka shola is also determinate type and is suitable both for fresh and processing market. It has cylindrical shape. The yield potential of Melka shola reached up to 450 qt ha^{-1} and it needs 100 – 110 days for maturity (Freeman *et al.*, 2019).

Three mulching materials viz., white plastic, black plastic and organic grasses were used for this experiment. The black and white plastic mulch was obtained from local market and the grass was obtained from Raya University

3.4. Mulching application

Different mulching types were tested in the experiment these were organic mulch (grass), inorganic mulch (white plastic and black plastic). The thicknesses of the mulching materials were 50 mm and 0.03 mm for grass and plastics respectively. Plastic mulching was applied before transplanting the seedlings and the grass mulching was applied 12 days after transplanting of seedlings. The control plots were left without mulch. Each variety was grown in each of the mulching materials and the control.

3.5. Data collection and analysis

Six plants were commonly used for the following growth, yield and quality parameters by randomly selected from the centre of the experimental plot.

Plant height: The plant height from each experimental unit was measured from six randomly selected plants from the ground level to the tip of the main stem at terminate growth stage.

Number of primary branches per plant: Number of primary branches per plant was counted from six randomly selected plants from each experimental unit at the flowering stage and average was taken.

Weed density: Weed samples were collected from 50 cm × 50 cm quadrates randomly laid per plot and as expressed as number of weeds in m^2. Weed species were not recorded.

Soil moisture: Soil moisture was measured before transplanting of seedlings and at different growth stages of tomato by gravimetric method by taken a soil sample at a depth of 15 and 20 cm. The sampling method was diagonal and the collected samples of a soil from plot were composited in one and weighed immediately. The collected samples of soils were dried in an oven at 105^0c for 24 hours. Then the dry soil was subtracted from the fresh soil and multiplied by the fraction of bulk density over density of water. This process is a gravimetric method of soil moisture measurement.

Disease incidence and severity: Field inspection was taken and any visible symptom was recorded as the number of infected plants and the percentage of the crop affected.

Fruit diameter: Fruit diameter of six sample plants; five fruits from each plant was measured using digital calliper and average was taken.

Fruit number per plant: Number of fruits per plant was determined by counting the fruits from six randomly selected plants of each experimental unit at harvesting time and average was taken.

Total yield per plant: Total yield per plant was measured by harvesting total fruits from each six randomly selected plants and average was taken.

Average fruit weight: Fruit weight was measured by weighing of five fruits from each six randomly selected plants from each experimental unit at harvesting time and average was taken.

Total yield: The total yield was recorded by weighing all harvests of marketable and unmarketable fruits of each plot in tons per hectare.

Marketable yield: Marketable yield was measured by weighing all fruits which are disease free, physically not defected, and large (≥25 g/fruit) from each experimental unit in tons per hectare.

Unmarketable yield: Unmarketable yield was measured by weighing all fruits which are disease infected physical defected and small (<25 g / fruit), from each experimental unit in tons per hectare**.**

TSS: TSS of six randomly selected plants from each experimental unit was measured using refracto-meter.

Fruit texture: Fruit texture of six randomly selected plants of each experimental unit was measured using penetrometer.

3.6. Data analysis

Data were subjected to analysis of variance (ANOVA) using the GENSTAT statistical program (GENSTAT 15th edition). The Duncan's multiple range test was used to compare between treatment means using a significance level of $\alpha = 0.05$.

4. RESULT AND DISCUSSION

4.1. Effect of mulching and variety on growth of tomato

Plant Height: The interaction effect showed a significant variation (at $p<0.05= <0.001$) on plant height. The highest average height was recorded for Melka shola with Black Plastic (96.73 cm) (Table 1). The results show that mulching, particularly with Black Plastic, can enhance the growth of specific varieties, indicating the positive impact of this combination on plant stature. Black plastic mulch may create a favourable microclimate, increasing soil temperature and moisture retention; suppress weeds, which can enhance tomato growth which may have benefited Melka Shola more than other varieties. Thus, the result disagrees with Yana and Rahima (2023) who stated that, no significant differences were found in the interaction among mulching and variety on plant height. This may be due to the differences of environmental conditions in relation to soil nutrients, soil moisture, sun light and the variety.

Table 1. Interaction effect of mulching and variety on plant height of tomato

Mulching * variety	PH (cm)
Gelilama * Black Plastic	86.63 [b]
Melka shola *Black Plastic	96.73 [d]
Roma VF * Black Plastic	84.73[ab]
Gelilama *White Plastic	94.47 [d]
Melka shola *White Plastic	89.13[bc]
Roma VF * White Plastic	85.00[ab]
Gelilama * Grass	95.93 [d]
Melka shola * Grass	92.73 [cd]
Roma VF* Grass	79.30 [a]
Gelilama * Control	87.53[bc]
Melka shola *Control	84.60[ab]
Roma VF * Control	83.27[ab]
LSD	5.394
CV%	1.0
P (0.05)	<.001

Means with the same letters in column are not significantly different (P>0.05), PH=plant height, LSD= least significant difference at 5% and CV= coefficient of variation

Plant height on varieties showed a highly significant difference (at p<0.05= 0.001). Gelilama being slightly taller (91.64 cm), followed by Melka shola (90.80 cm) and Roma VF (83.08 cm). Mutoro (2015) tested two tomato varieties and he found that a significance variation among the two varieties which was Tylka F1 variety was taller than Cal-J variety. The results agrees with Yana and Rahima (2023) showed that the tomato variety factor has a very significant effect on plant height Jelita has (102.06 cm) statically similar with Permata (98.06 cm) but significantly different from Rempai (70.39 cm). This may be inherent growth habit of tomato variety which determined genetically.

As compared to the control all mulched treatments (black and white plastic as well as grass) resulted in similar plant heights (approximately 89-90 cm), while the control showed the lowest height (85.13 cm). However, the black plastic and white plastic showed statistically significant differences, with white plastic being slightly taller. In un mulched plots weeds thrived and competing with tomato plants for nutrients, water, and light and also evaporation is high. In agreement to Mutoro, (2015) the black and white polythene mulches led to the tallest plants at 60 days after transplanting with minimal and inconsistent differences recorded at 25 days after trans-planting. In agreement to results Ogundare (2017) that plastic mulch produced higher plant height, when compared with other mulches. Though, organic mulch (grass) also stimulated vegetative growth compared to un-mulched plots but to a lesser extent than the polyethylene mulches. In agreement to results Yana and Rahima (2023) showed that the average height of tomato plants was higher in the use of rice husk (92.08) than in the use of straw mulch (89.56) and without mulch (88.86). This may be mulching increases soil moisture and reduces weed growth which results to compute water, nutrients, space and light and affects the growth of tomato.

Branch Number per Plant: There was no significant difference in the interaction effect. The main effect of mulching also does not show significant difference. In disagreement with Mutoro (2015) tested two tomato varieties in two seasons during the first season, the white plastic mulching material had significantly the highest number of branches (6.00) per plant compared to the other treatments. However, during the second season, the mulching materials did not show significant differences.

In main effect of variety there was a significant difference (Figure 1). The variety Melka shola had the highest branch number per plant with an average of 7.250, followed by Roma VF with 6.833 and Gelilama with 6.333. The superior branching of Melka Shola may be attributed to its inherent growth characteristics, which may include more vigorous vegetative growth and a

greater capacity for photosynthesis. In agreement to results of Mutoro (2015) tested two tomato varieties in two seasons a significant difference was computed on the number of branches per plant among the two varieties; Cal-J had the higher number (7.00) in both seasons. This may be inherent growth habit of the tomato variety, which is genetically determined.

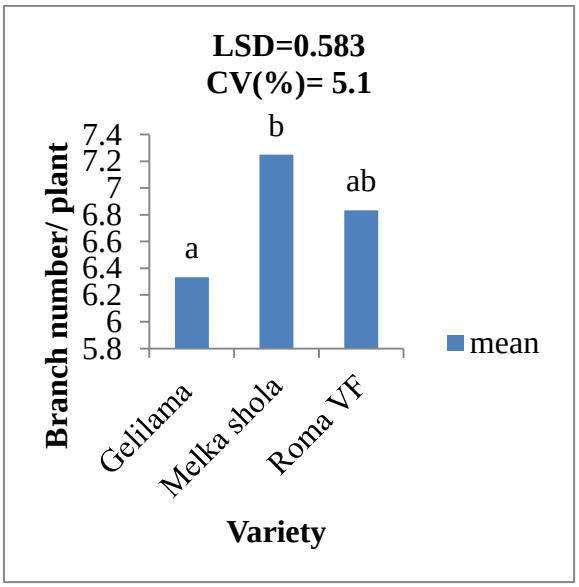

Figure 1. Effect of variety on branch number per plant

4.2. Effect of mulching and variety on yield and yield related components of tomato

Fruit Weight: There was significant differences in interaction effect of mulching and variety in fruit weight**.** Gelilama * Black Plastic had the highest fruit weight at 91.07 g, while the Melka shola * Black Plastic variety demonstrated higher weight among the White and Grass mulch treatments with 70.15 g, indicating that the mulching type can affect how different varieties perform regarding fruit weight (Table 2). However, Gelilama under White Plastic also produced similarly high weight fruits. Black plastic mulch may create a favourable microclimate, increasing soil temperature and moisture retention; suppress weeds growth and germination, prevents evaporation, which can enhance tomato growth and yield Mutoro

(2015). Different varieties may exhibit varying levels of adaptability to specific growing conditions (soil type, climate, etc.) and Gelilama may be better suited to the environmental conditions of the study area, which can enhance its growth and yield. In disagreement to results from Tipu *et al.* (2015) showed that the highest average fruit weight was obtained from control with BARI tomato 14 (87.64 g) and the lowest was found from Garden leaves mulched with BARI tomato 15 (63.73g). In disagreement to results from Yana and Rahima (2023) showed that there was no significant interaction among three tomato varieties and different organic mulching types they were tested on average fruit weight, fruit diameter, and fruit number per plant. This may be due to difference of the mulching materials and varieties that I was used in my experiment and also environmental conditions of the study area in relation to soil nutrients, soil moisture, plant variety, sun light.

In terms of variety fruit weight showed significant differences. Gelilama also performed best, yielding an average weight of 88.56 g, while Melka shola and Roma VF showed lower weights of 67.97 g and 70.50 g, respectively. This suggests that the Gelilama variety has a higher potential for producing heavier fruits, thereby improving overall yield. Different tomato varieties possess unique genetic makeups that influence their growth patterns, fruit development, and overall yield potential. Gelilama may have genetic traits that enhance its ability to produce larger fruit compared to the other varieties. And also different varieties may exhibit varying levels of adaptability to specific growing conditions (soil type, climate, etc.) and Gelilama may be better suited to the environmental conditions of the study area, which can enhance its growth and yield. In agreement to results of Kena *et al.* (2018) the highest and the lowest average fruit weight were recorded from Metadel (122.1g) and Melka Salsa (53.5g) varieties, respectively. Mulching showed that all treatments maintained similar weight levels with no significant statistical differences. Similar trend was obtained Tipu *et al.* (2015)

diameter of fruit and individual fruit weight was insignificant. Different varieties have different traits in relation to fruit weight.

Fruit Number: The interaction effect showed a highly significant difference in fruit numbers, confirming that some varieties, particularly Melka shola and Roma VF, thrive under specific mulching conditions. The fruit number per plant varied notably, with Melka shola * Black Plastic producing the highest count (111.30 fruits per plant) and Melka shola * Grass yielding the least (62.08 fruits per plant). Roma VF * White Plastic also showed a commendable number of fruits (109.67 fruits per plant) (Table 2), demonstrating that both variety and mulch type interact positively to enhance fruit set. The increased fruit number in plastic mulched plots may be due to better availability of soil moisture and weed growth and development suppression. In agreement to results of Tipu *et al.* (2015) Saw dust with BARI tomato 15 had the highest fruit number (34.60) and sawdust with BARI tomato 14 had the lowest fruit number per plant (28.13). Mulching enhances soil moisture, supress weed growth, reduces soil moisture evaporation and soil erosion; which may increases the fruit numbers per plant.

Mulching showed a significance difference in number of fruits produced per plant, the highest was for White Plastic mulch (104.67 fruits /plant) and followed by Black Plastic with 92.11 fruits per plant. The Grass mulch produced the lowest number of fruits (85.43fruits per plant), whereas the Control showed an intermediate number (87.44 fruits per plant). This indicates that using different mulches can significantly impact fruit set and development, with White Plastic effectively enhancing fruit production through reduction of weed infestation and improving of soil moisture. In disagreement to results of Yana and Rahima (2023) was tested three mulching types and three tomato varieties and he showed that the number of fruits per tomato plant tends to be higher with the use of Rice Husk reaching 6.33 fruits compared to the use of Without Mulch (6.17) and Straw (5.66). Different mulching materials can affect plant

height in a different ways, by influencing soil temperature, moisture retention, nutrient availability, weed control, and even soil biology.

The fruit number per plant varied between varieties. Melka shola producing the most (95.4) fruits per plant, followed closely by Roma VF with 94.94 fruits per plant. Gelilama produced the fewest fruits at 86.92 fruits per plant. Despite the higher number of fruits from Melka shola, the overall yield achieved by this variety was lower due to lighter average fruit weights. The range of fruit number suggests that while Melka shola may be productive in terms of quantity, other attributes such as weight must be considered for total yield calculations. In agreement to results of Kena *et al.* (2018) and Tipu *et al.* (2015) who reported number of fruits per plant varies across varieties. This may be due to genetic differences of the variety in ability to produce number of fruits per plant.

Table 2. Interaction effect of mulching and variety on fruit weight and fruit number of tomato

Mulching * variety	FWT(g)	FN(number)
Gelilama * Black Plastic	91.07^{d}	87.28^{abcd}
Melka shola *Black Plastic	70.15^{b}	111.30 ^{e}
Roma VF * Black Plastic	73.49^{bc}	89.00^{bcd}
Gelilama *White Plastic	91.03^{d}	95.33 c^{d}
Melka shola *White Plastic	67.50^{ab}	99.00 ^{d}
Roma VF * White Plastic	67.25^{ab}	119.67 ^{e}
Gelilama * Grass	90.8^{d}	82.67^{ab}
Melka shola * Grass	62.08^{a}	76.00^{a}
Roma VF* Grass	71.68^{bc}	86.33^{abc}
Gelilama * Control	78.64^{c}	93.67^{bcd}
Melka shola *Control	72.15^{bc}	84.00^{abc}
Roma VF * Control	69.57^{ab}	84.67^{abc}
LSD	7.027	10.95
CV%	2.0	1.7
P (0.05)	0.001	<.001

Means with the same letters in column are not significantly different at (P>0.05), FWT= fruit weight, FN= fruit number per plant, LSD= least significant difference at 5%, CV= coefficient of variation

Fruit Diameter: The results showed that no significant difference on the interaction effect. The main effect of mulching also does not show a significant difference in fruit diameter, with values ranging from 4.216 cm White Plastic to 4.372 cm Control. Similar trend was obtained from Tipu *et al.* (2015) diameter of fruit and individual fruit weight was no significant variations among types of mulch they tested. This may be mulch does not have direct impact on fruit diameter of tomato or the mulching materials that we tested

Among the three varieties tested, there was highly significant difference on fruit diameter among treatments. Gelilama achieved the largest fruit diameter; averaging 4.632 cm. Melka shola and Roma VF had smaller fruit diameters, measuring 4.212 cm and 4.111 cm, respectively (Figure 2). The significance difference in fruit diameter indicates that Gelilama produces larger fruits, potentially enhancing market appeal and profitability. This might be fruit size varies significantly across varieties. Gelilama variety may have superior genetic traits associated with fruit development compared to Melka Shola and Roma VF varieties. In agreement to previous studies have indicated that certain tomato varieties exhibit significant variability in fruit size due to genetic differences and environmental interactions (Yana and Rahima, 2023). This may be the genetic character of the variety in relation to diameter of the fruit. Fruit diameter varies across varieties.

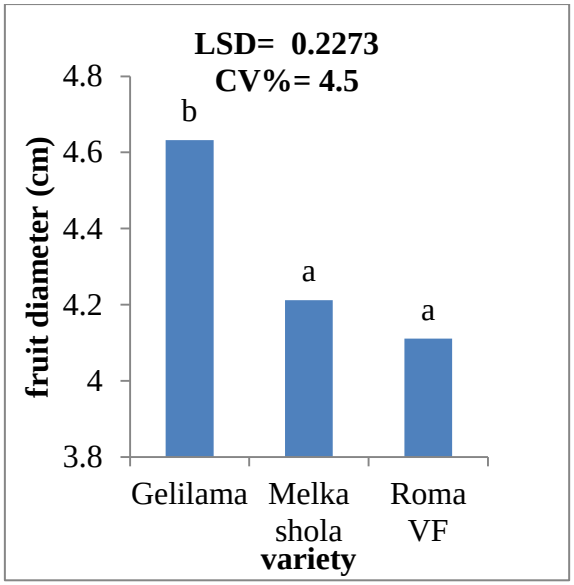

Figure 2. Effect of variety on fruit diameter

Total Yield per plant and per hectare: The total yield per plant and per hectare did not show a significance difference on the interaction effect. However total yield per plant and per hectare showed a significant difference in the main effect of mulching. Total yield per plant showed that white plastic mulch (3.253 kg) produced significantly higher yields than the control (2.908 kg) and the yield from white plastic was comparable to black plastic (3.127 kg) and grass mulch (3.078 kg) (Figure 3). This implies that mulching with white plastic may enhance the overall productivity of tomato plants due to better availability of soil moisture, suppression of weed growth and development, and prevention of disease infestation. And the black plastic mulch was torn due to high sunlight. This implies that the black plastic mulch which is located in the local market, Mekelle is not recommended for mulching of low land areas like Mekoni. While the black plastic mulch which is available in the local market were used for green house to raise seedlings in nursery like Tigray biotechnology however it is not functional in open field either its ingredients or layers of the plastic. White plastic mulch also reflects sunlight and helps maintain a cooler soil temperature that ultimately can facilitate a more stable moisture level in the soil. The lower yield in organic mulch compared to white and black polyethylene mulches could be due to relatively poor weed control. This is in

agreement with Ferdouse *et al*. (2021) the greatest yield/plant and yield/ha (2.94 kg) (98. ton ha^{-1}) were obtained in Silver over black followed by Black plastic (2.10 kg and yield 70.13 ton ha^{-1}, respectively) indicating plastic mulches can better regulate temperature and enhance soil moisture, control weeds and reduce competition for nutrients, reduce root damage and disease problems; thereby increases crop yield. The control plot was the least performer in yield per plant and yield per hectare 1.63 kg and yield 54.34 ton ha^{-1} respectively. This may be the overall effect of mulching reducing evaporation, supressing weed growth, maintaining soil temperature and reducing of soil erosion and this increase the yield of tomato.

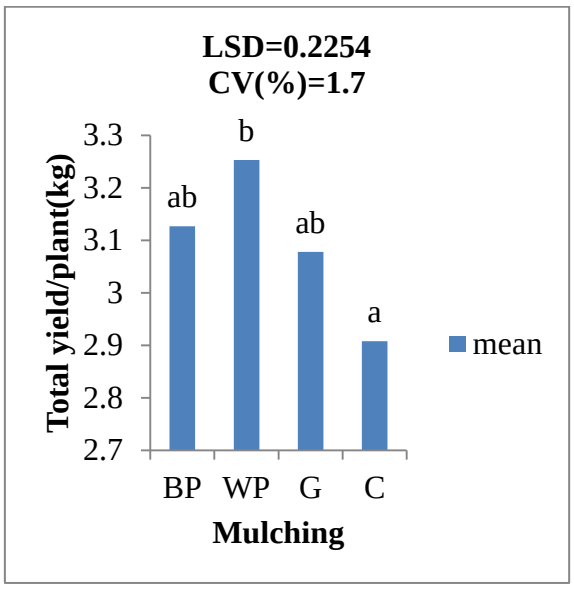

Figure 3. Effect of mulching on total yield per plant

In the main effect of variety showed a highly significant difference in total yield per plant and per hectare. Total yield per plant was highest for Gelilama (3.478 kg), followed by lower yields from Melka Shola and Roma VF 3.061 kg and 2.735 kg, respectively (Table 3). The total yield per hectare has shown similar trend, with Gelilama yielding 92.79 ton ha^{-1}, which is significantly higher than the yields of Melka Shola (81.75 ton $ha^{-1)}$ and Roma VF (73.08 ton ha^{-1}) (Table 3). This indicates that Gelilama is the more productive variety under the experimental conditions; possibly due to its combination of fruit size and weight. In

agreement with results to Tipu *et al.* (2015) obtained significant variations in total yield per hectare which was 74.85 ton ha^{-1} and 67.12 ton ha^{-1} in two different tomato varieties. This may be due to different genetic traits and varieties have different levels of adaptability to specific growing condition.

Marketable yield per hectare: The main effect of variety showed highly significance difference in terms of marketable yield per hectare. Gelilama led with 87.53 ton ha^{-1}, while Melka Shola and Roma VF recorded 76.10 ton ha^{-1} and 66.83 ton ha^{-1}, respectively (Table 3). This trend suggests that Gelilama not only yields the most fruit but also produces fruit that meets market standards better than the other varieties. The superior performance of the Gelilama variety can be attributed to several factors, including its genetic characteristics, adaptability to local growing conditions. This suggests that Gelilama may have inherent qualities that enhance its growth and fruit production capabilities. In agreement to results from Etan *et a l.* (2019) found that average of marketable fruit yield in ton per hectare was highly significant difference in variety Melka salsa (33.01ton ha^{-1}) and followed by Miya (28.25 ton ha^{-1}). The maximum marketable yield ha^{-1} was obtained from Melka shola, Melka salsa, Fetene and Miya, respectively while the minimum was obtained from Metadal (Kena *et al.,* 2018). Unmarketable yield per hectare does not show significance differences among varieties.

Table 3. Effect of variety on total yield per plant, total yield per hectare and marketable yield per hectare

Variety	TY/P(kg)	TY/Ha(tonha^{-1})	MY/H (tonha^{-1})
Gelilama	3.478^{c}	92.79^{c}	87.53^{c}
Melka shola	3.061^{b}	81.75^{b}	76.10^{b}
Roma VF	2.735^{a}	73.08^{a}	66.83^{a}
LSD	0.1952	2.51	5.68
CV%	1.7	1.7	1.8
P (0.05)	<.001	<.001	<.001

Means with the same letters in column are not significantly different (P>0.05), TY/P= total yield per plant, TY/Ha= total yield per hectare, MYH= marketable yield per hectare, LSD= least significant difference at 5% and CV= coefficient of variation

Total yield per hectare: Total yield per hectare mirrored the yield per plant results in the main effect of mulching, with both white plastic (86.88 ton ha^{-1}) and black plastic (83.40 ton ha^{-1}) yielding significantly more compared to the control (77.66 ton ha^{-1}). There were no significant differences between the grass mulch, (82.22 ton ha^{-1}), and the control (77.66 ton ha^{-1}) (Table 4). This indicates that the type of mulch can influence not only the plant-level yield but also translate into substantial differences at the hectare level, particularly favouring the white plastic treatment. This increase in tomato yield may be due to the better development of roots and vegetative growth, better nutrients uptake in mulched plots, and prevention of weed infestation. It is also apparent that, plastic mulches prompts moisture retention, reduces runoff, and enhance plant uptake, that in turn significantly reduce the leaching of nitrogen. This is in agreement with Ferdouse *et al*. (2021) the greatest yield/plant and yield/ha (2.94 kg) (98. ton ha^{-1}) were obtained in Silver over black followed by Black plastic (2.10 kg and yield 70.13 ton ha^{-1}, respectively) indicating plastic mulches can better regulate temperature and enhance soil moisture, control weeds and reduce competition for nutrients, reduce root damage and disease problems; thereby increases crop yield. The control plot was the least performer in yield per plant and yield per hectare 1.63 kg and yield 54.34

ton ha^{-1} respectively. This may be the overall effect of mulching reducing evaporation, supressing weed growth, maintaining soil temperature and reducing of soil erosion and this increase the yield of tomato.

Marketable vs. Unmarketable Yield: The interaction effect does not show a significance difference on marketable and unmarketable yield per hectare. However the main effect of mulching showed a significant difference (Table 4). The results indicate that, though there were no significant differences between white (81.94 ton/ha) and black plastic (78.04 ton/ha) mulches; the use of White Plastic mulch provided the highest marketable yield (81.94 ton/ha) compared to the other treatments. Black Plastic and Grass treatments also performed well, but were not significantly different from each other. The Control treatment yielded the least (70.72 ton/ha), indicating that mulching significantly enhances marketable yields compared to no mulch. The application of mulches can affect soil temperature, moisture retention, and weed suppression, thus influencing crop productivity. White plastic mulch may reflect sunlight and helps maintain a cooler soil temperature and facilitate a more stable moisture level than the black plastic. This can prevent root and plant heat stress, which can enhance tomato growth and fruit quality. And the black plastic mulch was torn due to high sunlight. This implies that the black plastic mulch which is located in the local market, Mekelle is not recommended for mulching of low land areas like Mekoni. While the black plastic mulch which is available in the local market were used for green house to raise seedlings in nursery like Tigray biotechnology however it is not functional in open field either its ingredients or layers of the plastic. Lower yield in organic mulch compare to white polyethylene may be due to poor weed control. The control group had the highest unmarketable yield (6.946 ton/ha), significantly different from the other treatments, which suggests that the lack of mulch contributes to increases in unmarketable yield. Black Plastic and Grass mulches showed similar average unmarketable yields, and the differences were not statistically significant (as

indicated by the letter groupings); they performed better than the un-mulched (control). This may be application of mulches can affect soil temperature, moisture retention, and weed suppression, thus influencing crop productivity.

Table 4. Effect of mulching on total yield per hectare, marketable and unmarketable yields per hectare of tomato

Mulching	MYT/Ha (tonha^{-1})	UMYT/HA (tonha^{-1})	TY/H (tonha^{-1})
Black Plastic	78.04^{b}	5.361^{a}	83.40^{ab}
White Plastic	81.94^{b}	4.939^{a}	86.88^{b}
Grass	76.58^{ab}	5.638^{ab}	82.22^{ab}
Control	70.72^{a}	6.946^{b}	77.66^{a}
LSD	6.56	1.427	6.02
CV (%)	1.8	3.8	1.7
P (0.05)	0.015	0.045	0.034

Means with the same letters in column are not significantly different (P>0.05), MYT/Ha= marketable yield ton per hectare, UMYT/Ha= unmarketable yield ton per hectare, LSD= least significance difference at 5% and CV%=coefficient of variations

Total soluble solid (TSS) and fruit texture: In terms of fruit quality attributes like total soluble solids and texture, no significant differences were observed across most treatments. However, Gelilama under grass mulch produced reasonably good TSS levels, emphasizing that while mulching generally improves growth, it may have a limited effect on certain quality parameters. This result is in contrary with Tipu *et al.* (2015) who found that the greatest TSS had in BARI tomato 14 with Rice husk (6.67) and the smallest had in BARI tomato 15 with control (4.33 9.79). All treatments in mulching effect exhibited similar TSS and fruit texture scores, indicating that mulching did not significantly affect these two quality parameters.

Variety showed a significant difference in terms of TSS, Gelilama had the highest value (4.508), indicating sugars, acids, and other soluble compounds. Melka Shola followed at 4.157, while Roma VF had the lowest TSS at 4.100 (Table 5). Gelilama exhibited the highest fruit texture score (1.433), suggesting that it produces the firmest and most robust fruit among the varieties tested. Melka Shola followed with a score of 1.325, which indicates a moderate

level of firmness. Roma VF had the lowest fruit texture score (1.267), indicating that it produces softer fruit compared to the other two varieties. Different tomato varieties have distinct genetic makeups that influence their biochemical pathways, affecting the synthesis of sugars and organic acids, which contribute to TSS and fruit flavor. The Gelilama variety may have a genetic predisposition for higher sugar accumulation, leading to its superior quality in sugars, acids, and other soluble compounds. A similar trend was obtained from Tipu *et al.* (2015) TSS of fruit was found to be significant among the two tomato varieties they were tested which ranged from 5.13 to 5.67.

Table 5. Effect of variety on total soluble solid and fruit texture

Variety	**TSS (^{0}Brix)**	**Texture**
Gelilama	4.508^b	1.433^b
Melka shola	4.157^a	1.325^{ab}
Roma VF	4.100^a	1.267^a
LSD	0.3324	0.1361
CV%	2.1	9.0
P (0.05)	0.038	0.055

Means with the same letters in column are not significantly different (P>0.05), MY/Ha= marketable yield per hectare, TY = total yield per hectare, TSS= total soluble solid, LSD= least significance difference at 5% and CV%=coefficient of variations

4.3. Effect of mulching and variety on weed density, soil moisture, disease incidence and severity of tomato

Weed Density: Interaction effect of mulching and variety does not show a significance differences on weed density. However the main effect of mulching showed a significant difference in weed density (Table 6). Compared to Grass Mulch (0.87 weeds /m^2) and Control (65.93 weeds /m^2) weed density was significantly lower in both White Plastic (0.16 weeds /m^2) and black plastic (0.10 weeds /m^2) treatments. The Control showed significantly higher weed density, indicating that without any form of mulching, weeds thrived, competing with

tomato plants for nutrients, water, and light. Weeds reduce yields by competing for space, light, water and nutrients, weakening crop stand. Some weeds can also increase pest problems by serving as hosts for diseases or nematodes. The high weed density in the control group likely contributed to the lower branch numbers observed on the control. The reductions in weed density via plastic mulching can be linked to the physical barrier created by the mulch, inhibiting weed growth and development. A similar trend was observed in Agarwal *et al.* (2022) where weed density was the lowest (2 weeds/m^2) in black polythene and the highest in control (80 weeds /m^2). This may be effect of mulching in in relation to weed growth suppression due to physical barrier or breaking of sunlight to the soil surface. The effect of variety was insignificant in weed density (Table 6).

Table 6. Effect of mulching on weed density of tomato

Mulching	**WD (m^{-2})**
Black Plastic	0.10^{a}
White Plastic	0.16^{a}
Grass	0.87^{a}
Control	65.93^{b}
LSD	3.997
CV (%)	7.5
P (0.05)	<.001

Means with the same letters in column are not significantly different (P>0.05), WD= weed density, CV= coefficient of variation and LSD= least significant difference at 5%

Soil Moisture: Soil moisture content varied significantly across the interaction effect of mulching and variety, with values ranging from 25.78% (Control treatment with Roma VF) to 41.14% (Black Plastic with Melka shola) (Table 7). The highest moisture retention was achieved under plastic mulches, which suggest that they limit evaporation and maintain better soil moisture levels and contributing positively to plant growth. This reinforces the effectiveness of mulching, particularly with Black Plastic and its influence on moisture retention, beneficial for the tomato varieties tested. Mulching also showed a significance difference on soil moisture. The highest soil moisture content was recorded under black

plastic mulch (38.075%). The white plastic and grass mulches had similar moisture contents 34.37% and 34.54%, respectively, which were still higher than the control (26.68%). It suggests that mulching helps retain soil moisture, with black plastic mulch being the most effective. In agreement to results of Ogundare (2017) has observed in his experiment higher soil moisture in plot with black (14.3%) and white plastic mulch (13.6%) when compared with plots with organic (10.8%) mulch and the control (8.3%). Variety also showed significant variation in soil moisture. Soil moisture levels varied significantly among the varieties. Gelilama recorded the lowest moisture level (34.01%), while Melka shola exhibited the highest 35.92%). This may be due to branching characteristics as I mentioned above Melka shola variety has high branch number and it helps to reduce evaporation around the root surface.

Disease Severity: The interaction effect showed a significant variation in disease severity (Table 7). Melka shola with Grass exhibited the lowest disease severity (13.33%), highlighting its potential resilience when combined with adequate mulching. The diseases observed in the experiment were Fussarium wilt virus. This may be organic materials can release substances that inhibit pathogen growth or competition and this can lead to lower disease incidence. In contrast, higher severity levels were noted in the Control group treatments, particularly for Gelilama (64.99%) followed by Gelilama with black plastic (64.77%) and Gelilama with grass (50.89%). This showed that Gelilama varietie is more susceptible the disease than the other varieties. This may be due to inherent characteristics of the varieties in relation to disease resistance traits. Higher disease severity in the control may also mulch effectively suppresses weeds that can harbour pathogens and disrupt pest life cycles and can aid in preventing pest infestations. Weeds can serve as a reservoir for disease-causing organisms, so reducing their presence through mulch can minimize potential disease outbreaks.

Disease Incidence: The disease incidence parameter also demonstrated significant variation in the interaction effect. The highest disease incidence was noted in the Control treatments, particularly for Gelilama (10.333%), while lower incidence rates (4.833%) were observed in Melka shola with Black Plastic (Table 7). Higher disease incidence in the Gelilama varieties showed that it is more susceptible to the disease than the other varieties of Melka shola and Roma VF. It may be also due to mulch withstand radiation and regulate soil microclimate. This also appropriate mulching can mitigate disease pressure and those incorporating resistant varieties further complements disease management strategies. Higher disease incidence in the control may be due to the presence high weed infestation that can harbour pathogens and disease-causing organisms.

Table 7. Interaction effect of mulching and variety on soil moisture, disease incidence and severity of tomato

Mulching * variety	SM (%)	DI (%)	DS (%)
Gelilama * Black Plastic	39.16 ^{de}	6.000^{ab}	64.77 ^{g}
Melka shola * Black Plastic	41.14 ^{e}	4.833 ^{a}	22.20^{bc}
Roma VF * Black Plastic	33.92^{bc}	5.000 ^{a}	31.44 ^{d}
Gelilama *White Plastic	34.59 ^{c}	7.333^{bc}	37.67 ^{e}
Melka shola * White Plastic	38.41 ^{de}	6.000^{ab}	27.89 ^{cd}
Roma VF * White Plastic	30.11 ^{b}	5.333 ^{a}	27.00^{bcd}
Gelilama * Grass	36.50 ^{cd}	6.000^{ab}	50.89 ^{f}
Melka shola * Grass	33.74^{bc}	5.333 ^{a}	13.33 ^{a}
Roma VF* Grass	33.37^{bc}	6.333^{bc}	42.74 ^{e}
Gelilama * Control	25.78 ^{a}	10.333 ^{d}	64.99 ^{g}
Melka shola *Control	30.39 ^{b}	6.000^{ab}	21.64 ^{b}
Roma VF * Control	23.88 ^{a}	7.667 ^{c}	31.21 ^{d}
LSD	3.478	1.424	5.641
CV%	1.9	1.0	3.3
P (0.05)	0.025	0.002	<.001

Means with the same letters in column are not significantly different (P>0.05), SM=soil moisture, DS= disease severity, DI= disease incidence, LSD= least significant difference at 5% and CV= coefficient of variation

CONCLUSION AND RECOMMENDATION

Conclusion

The results of this field experiment indicated that using White plastic mulch with Gelilama variety is an effective strategy for enhancing crop yield. These findings suggest that adopting this practice could significantly benefit farmers seeking to improve their productivity. The findings suggest strong interactions between mulching types and tomato varieties. In this study the mulches (both black and white) generally improved soil moisture, fruit number per plant, average fruit weight and plant height. The Gelilama variety appears to be the most resilient and productive under white plastic mulch conditions, whereas Melka Shola demonstrates high fruit numbers. Nevertheless Roma VF, which is considered as popular variety, may require more consideration in terms of site and treatment selection to optimize its yield and marketability.

Gelilama emerged as the best performing variety in terms of fruit diameter, weight, total yield per plant, and marketable yield per hectare, making it a strong candidate for growers aiming for high productivity. Melka shola, despite producing more fruit, yielded lighter weights, leading to a lower total yield. While fruit quality in terms of TSS was slightly higher in Melka shola, and this does not compensate the overall yield reduction per hectare. With regard to Roma VF's its low yielding capacity, particularly in terms of marketable yield and overall weight, makes it the least to be chosen. However, this variety may be suitable in certain traits compared to the superior ones that compensate its low yielding.

Gelilama variety exhibited higher disease severity and incidence compared to Melka shola and Roma VF varieties. Interestingly, while Gelilama variety may be more prone to disease, its potential for higher economic return due to greater yield fruit quality could make it a viable option for grower, provided that effective disease management strategies are employed.

The results consistently demonstrate the effectiveness of different mulching materials in enhancing tomato crop performance. The use of plastic mulches, particularly black plastic significantly reduces weed density and enhances soil moisture content, which likely contributes to the higher brunch number and plant height observed.

Recommendation

Gelilama variety presents a unique opportunity for agricultural production, balancing a higher susceptibility to disease with significant gains in fruit quality, thereby warranting further exploration in both breeding and management practices.

Based on the current study I strongly recommend that black plastic mulch which is located in the local market, Mekelle is not recommended for mulching open fields of low land areas of Tigray, like Mekoni.

Gelilama with white plastic produced higher yields. Further research on the interaction of drip irrigation with mulching should be conducted to explore its efficiency on tomato production at irrigation level. This method could potentially provide better water management, reduce water wastage, and improve overall tomato growth and yield and from incorporating additional growth parameters and environmental factors, such as temperature variations, and nutrient content, to create a more holistic understanding of how mulching and irrigation systems interact to affect tomato production.

My study focused on specific varieties, future experiments should test a broader range of tomato varieties to identify those best suited for different mulching types and irrigation systems. This can help in selecting varieties that optimize yield and quality under varying agricultural practices.

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APPENDIX

Appendix table 1. Analysis of variance for fruit diameter, branch number per plant and weed density

Source of variation	DF	D	P (0.05)	BN	P (0.05)	WD	P (0.05)
Variety	2	0.91546 ***	<.001	2.5278*	0.013	1.83 ns	0.897
Mulching	3	0.04350 ns	0.620	0.8426 ns	0.181	9671.96 ***	<.001
Mulching * Variety	6	0.12522 ns	0.160	0.7870 ns	0.179	3.22 ns	0.976
Error	22	0.07210		0.4747		16.71	

The sign *, **, and **** indicate, P< 0.05, P < 0.01, and P < 0.001, respectively, whereas ns indicates a non-significant difference (P > 0.05) DF stand for degree of freedom, D for fruit diameter, BN for branch number per plant and WD for weed density

Appendix table 2. Analysis of variance for total yield per plant, total yield per hectare and total soluble solid

Source of variation	DF	TY/P	P (0.05)	TY/Ha	P (0.05)	TSS	P (0.05)
Variety	2	1.66075 ***	<.001	1171.05 ***	<.001	0.5872 *	0.038
Mulching	3	0.18346 *	0.034	130.34 *	0.034	0.0465 ns	0.824
Mulching * Variety	6	0.04130 ns	0.597	31.00 ns	0.568	0.0089 ns	0.999
Error	22	0.05315		37.91		0.1541	

The sign *, **, and **** indicate, P< 0.05, P < 0.01, and P < 0.001, respectively, whereas ns indicates a non-significant difference (P > 0.05) DF stand for degree of freedom, TY/P for total yield per plant, TY/Ha for total yield per hectare and TSS for total soluble solid

Appendix table 3. Analysis of variance for fruit texture, marketable yield per hectare and unmarketable yield per hectare

Source of variation	**DF**	**TEX**	**P (0.05)**	**MY/Ha**	**P (0.05)**	**UMY/Ha**	**P (0.05)**
Variety	2	0.08583 ns	0.055	1291.21 ***	<.001	3.048 ns	0.260
Mulching	3	0.00991 ns	0.766	194.97 *	0.015	6.744 *	0.045
Mulching* Variety	6	0.00435 ns	0.983	34.37 ns	0.606	0.428 ns	0.973
Error	22	0.02583		45.00		2.130	

The sign *, **, and **** indicate, P< 0.05, P < 0.01, and P < 0.001, respectively, whereas ns indicates a non-significant difference (P > 0.05) DF stand for degree of freedom, TEX for fruit texture, MY/Ha, for marketable yield per hectare and UMY/Ha for unmarketable yield per hectare

Appendix table 4. Analysis of variance for plant height, fruit weight and fruit number per plant

Source of variation	**DF**	**PH**	**P (0.05)**	**FWT**	**P (0.05)**	**FN**	**P (0.05)**
Variety	2	267.54 ***	<.001	1513.37 ***	<.001	272.49 **	0.006
Mulching	3	46.95 *	0.012	24.82 ns	0.258	671.26 ***	<.001
Mulching* variety	6	68.80 ***	<.001	93.47 ***	0.001	435.73 ***	<.001
Error	22	10.15		17.22		41.82	

The sign *, **, and **** indicate, P< 0.05, P < 0.01, and P < 0.001, respectively, whereas ns indicates a non-significant difference (P > 0.05) DF stand for degree of freedom, PH for plant height, FWT for fruit weight and FN for fruit number

Appendix table 5. Analysis of variance for soil moisture, disease incidence and disease severity

Source of variation	**DF**	**SM**	**P (0.05)**	**DI**	**P (0.05)**	**DS**	**P (0.05)**
Variety	2	0.0097194 ***	<.001	10.6319 ***	<.001	3477.40 ***	<.001
Mulching	3	0.0207661 ***	<.001	11.6366 ***	<.001	153.72 ***	<.001
Variety * Mulching	6	0.0012917 *	0.025	3.7060 **	0.002	311.84 ***	<.001
Error	22	0.0004219		0.7077		11.10	

The sign *, **, and **** indicate, P< 0.05, P < 0.01, and P < 0.001, respectively, whereas ns indicates a non-significant difference (P > 0.05) DF stand for degree of freedom, SM for soil moisture, DI for disease incidence and DS for disease severity