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Growth and Production of Organic Tomatoes (*Solanum lycopersium*) on the Application of Organic Fertilizer and Mulch Types

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ABSTRACT

This research aimed to analysis the effect of various types of organic fertilizer and mulch types on growth and production of tomato plants. Research was conducted at Liliriaja District, Soppeng Regency, South Sulawesi on January-June 2023. This research used a factorial 2 factor experiment in Randomized Complete Block Design (RCBD) as the environmental design. The first factor is organic fertilizer with 3 types: chicken compost 15 tons ha^{-1}, cow manure 15 tons ha^{-1}, and goat manure 15 tons ha^{-1}. The second factor is mulch with 3 types: without mulch, 10 tons ha^{-1} rice husk mulch, and plastic mulch. The results showed that there was an interaction between chicken compost fertilizer and rice husk mulch at the number of fruit / plot (260.00 fruits), fruit weight / plot (8.00 kg) and production (26.67 tons ha^{-1}). Chicken compost in 15 ton ha^{-1} gave the highest number of fruit /plant (18.93 fruits) and fruit weight/plant (727.00 g).

Keywords: *Mulch; Organic-Fertilizer Tomato.*

1. Introduction

Servo tomato variety is well adapted in lowlands, the fruit is hard with a sweet and slightly sour taste and resistant to Gemini virus (Sulistyowati, 2021). Servo variety has a potential yield of 45-73 tons ha^{-1} and also resistant to *Fusarium oxysporum*, and Gemini Virus (Suryani, 2020; Wahyurini & Lagiman, 2022; Zohoungbogbo et al., 2021).). The Servo variety was a potential variety that could have high production at the research location as a lowland.

To increase yield, there are still many farmers use inorganic fertilizers for nutrient needs for plants that can cause negative impacts in the future for sustainable agriculture. Use inorganic fertilizers in long term have a negative impact on land and plants, because it will damage the physical, chemical and biological of soil, it is less able to store water and it rapidly becomes acidic, its needs solution for this condition. Preventive solution needs to maintain land sustainability. Once is to use organic fertilizer as an aspect of organic cultivation (Yuriansyah, 2020; Adekiya et al., 2022).

Efforts that can be made in tomato production stability are by implementing appropriate cultivation methods including the use of organic fertilizer, because using organic fertilizer can be an appropriate alternative because it is environmentally friendly and easy to find in the market. This is expected to reduce farmers' dependence on inorganic fertilizers (Tipu et al., 2014; Prabha et al., 2016; Sulistyowati, 2021).

Organic plant cultivation is one step to increasing the sustainability of the agricultural system. Sustainable agriculture is a term used to describe alternative approaches to agricultural systems. Sustainable agricultural systems have roles and objectives which reducing negative impacts on the environment, maintaining agricultural productivity, increasing farmer income due to high selling value (Zabadi, 2022; Soni et al., 2022; Gamage et al., 2023).

Improving the quality of tomatoes can be achieved through improving the cultivation system by implementing an organic tomato cultivation system. Organic tomatoes are a grown and produced without use pesticides, chemical fertilizers, or other dangerous chemicals. Organic farming aims to ensure that tomatoes are grown in a natural and environmentally friendly, which focus on natural resources, organic fertilization and practices that support the sustainability of agricultural ecosystems. The yield of tomatoes is healthier, have a more positive environmental impact and have a high selling price (Oliveira et al., 2013; Imani, 2018).

Fertilization is a very important factor in achieving optimal healthy and productive plant growth (Du et al., 2021; Ma et al., 2022). It is important to use the right fertilizer dose to create a balance of nutrients in the soil, which can then be fully utilized by plants, available in the soil that will be absorbed by plants. Therefore, each nutrient aimed to increase agricultural yields without reducing the level of soil fertility. The advantage of using organic fertilizer could increase the content of organic matter and macro-micro nutrients in the soil, so that, it could increase plant production in the long term (Halid, 2021). Based on research by Sudirman et al. (2022), showed that the application of solid organic fertilizer can produce the same growth and production of cauliflower plants, which tends be higher than inorganic fertilizer. Research of Tufailah (2014) also showed that compost from chicken manure at dose of 15 tons ha^{-1} is able to have a better effect in increased the production of cucumber plants.

Manure is easily to decomposed in the soil and has an important nutrient for plants. The purpose of using manure is one of the efforts taken to maximize plant yields, it is relatively cheap and environmentally friendly, and it is often found in the environment. Application of manure can increase soil fertility according to the needs of tomato plants and create more optimal environmental conditions for plant growth (Zhu et al., 2022) . Application manure in the soil will affect the availability of nutrients for plants, which will then encourage plant growth in a better direction (Puahadi, 2021). Pelawi (2020) research show that application of cow manure 15 tons ha^{-1} could increase plant height, total leaf area, seed weight per cob and corn crop yield. Murniati (2022) research also showed that goat manure of 15 tons ha^{-1} also has better flowering time, number of fruits, and fresh fruit weight in cayenne pepper.

To increase maximum yield, using mulch can be an effective method. The application of mulch can reduce the growth of weeds in the planting area so can avoiding competition between cultivated plants and weeds. The use of mulch also contributes as a good soil cover, maximizing the absorption of sunlight by plants. One type of mulch used by farmers, such as black and silver plastic mulch and straw or husk mulch. The benefits of mulching are ability to increase plant growth and yields and prevent leaching fertilizer caused of rainy and evaporated of nutrients by sunlight (Wang & Xing, 2016; Amir, 2022; Akhtar et al., 2023).

Application of organic rice husk mulch could protect plants, maintaining soil moisture, minimizing rainwater that falls directly to the surface of the soil, so minimized erosion and maintaining soil texture. Rice straw, reeds, and rice husks are often used as organic mulch (Cao et al., 2021; Iqbal et al., 2020; Parhizkar et al., 2021; Ramli, 2017). Use of 10 tons ha^{-1} of rice husk mulch showed higher growth than other treatments (Suryani, 2020).

This research also used plastic mulch as a comparison to see the effect on tomato plants during the rainy season. The use of plastic mulch is can be implemented to improve soil quality and water availability for plants. One of the advantages of using plastic mulch is its ability to increase the intensity of light received by plants through the reflection of light from the surface of the mulch, which could help improved the quality of the harvest (Decoteau' et al., 1988). Using plastic mulch is also inhibit weed growth, reduce water loss from the soil, maintain soil temperature and relatively humidity (Isnaini, 2023). The research by Trenaldi (2022) showed that the use of black plastic mulch is the best type of mulch and has a high impact on plant height and the number of leaves of red chili plants, caused by the silver plastic layer on the top could reflect solar radiation and increasing the photosynthesis process.

2. Materials and Methods

2.1 Time and Place

This research was conducted in Liliriaja District, Soppeng Regency, South Sulawesi Province. The research was conducted from January to June 2023. Soppeng is one district at South Sulawesi as a tomato producing area.

2.2 Material

The materials used in this research are cow manure, goat manure, chicken compost, rice husk mulch, plastic mulch and Servo tomato seeds (F1).

2.3 Methods

This research was arrangeed in factorial 2 factor experiment with Randomized Completely Block Design (RCBD). The first factor was organic fertilizers with 3 types, : p1 = Chicken compost (15 tons ha^{-1}), p2 = Cow manure (15 tons ha^{-1}), and p3 = Goat manure (15 tons ha^{-1}). The second factors were types of mulch: m0 = without mulch, m1 = rice husk mulch (10 tons ha^{-1}), and m2 = plastic mulch. The treatment combination was 3 replications.

2.3.1. Research Implementation

Laboratory work. Analysis on the soil content was caried out in the Laboratory of Chemistry and Soil Fertility, Faculty of Agriculture, Universitas Hasanuddin.

Field work. Plots of 2 m x 1.5 m, 30 cm high were arranged side by side with 20 cm distance between plots. Tomato seeds from Servo F1 variety were sown in trays and transplanted 21 days after sowing (DAS) that already have 3–4 leaves with a planting distance of 50 cm x 50 cm. The application of organic fertilizers was given one week before planting by spreading the fertilizer on the soil followed by the mulching treatment. On 65–70 DAS harvesting was caried out indicated by reddish fruit color. The harvesting was by hand or by cutting using scissors or a knife.

2.4 Parameters

Plant Height (cm), measured from the base of the stem to the growing point of the main stem using a ruler or meter starting from the age of 14 DAS to 56 DAS.
Number of leaves, counted the total number of leaves on the petiole starting from the age of 14 DAS to 56 DAS, counted every two weeks.
Flowering Age (DAS), calculated in 50% of flower appears or blooms in each plot.
Chlorophyll content (μ mol.m^{-2}), using the Content Chlorophyll Meter (CCM 200+) on the 5th–7th leaf from the shoot. At 4 months after treatment. using the formula:

$$\text{Leaf chlorophyll content (y)} = a + b\,(CCI)c,$$

where a, b, and c are Constanta and CCI is the leaf chlorophyll index data read on CCM 200+.

Table 1. Chlorophyll Level Formulas and Constants

Parameters	Constants		
	A	B	C
Chlorophyll a	-421.35	375.02	0.1863
Chlorophyll b	38.23	4.03	0.88
Chlorophyll tot	-283.2	269.96	0.277

Source: Goncalves, 2008.

Stomatal density (n.mm^{-2}). Observed done at 4 months after treatment using the Clear Cuttings Application method and then calculated using a microscope with a magnification of 400 times. Stomatal density is calculated from the number of stomata with a field diameter of 0.52 mm^2. Calculated using formula:

$$Stomatal\ density = \frac{number\ of\ stomata}{field\ of\ view\ area}$$

Number of fruits per plant (fruits), starting from the first harvest to eight harvest.
Number of fruits per plot (fruits), starting from the first harvest to eight harvest.

Fruit weight per plant (g), Fruit weight is calculated from the total harvest per plant from each plot with 8 times harvests.
Fruit weight per plot (kg), calculated from the total weight per plant from each plot with 8 times harvests.
Fruit diameter (mm), measured in each plant sample per plot.
Production (tons ha^{-1})

3. Results and Discussion

3.1. *Results*

3.1.1. Plant height (cm), number of leaves and flowering age (DAS)

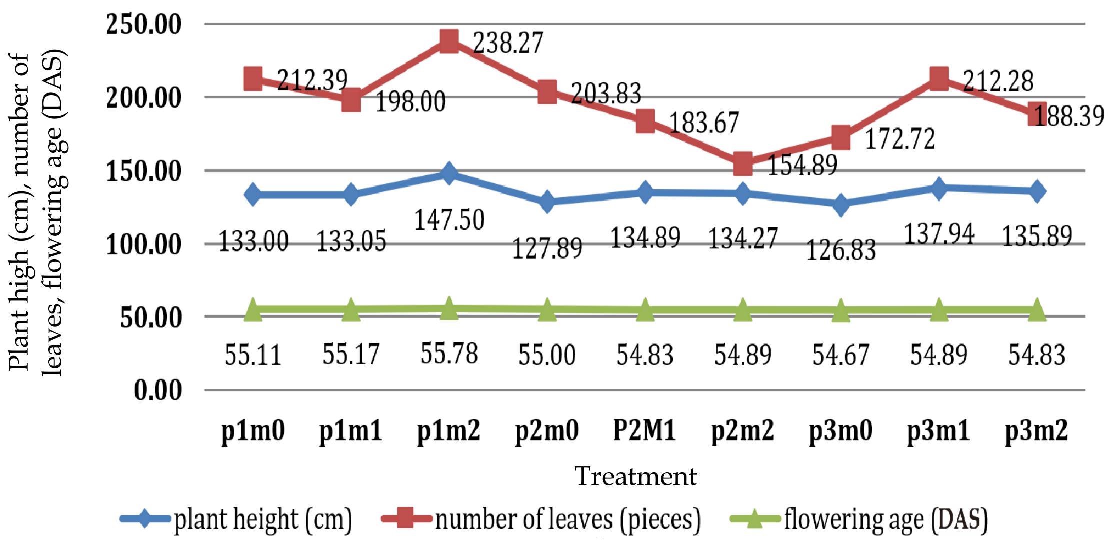

Figure 1. Plant height 56 DAS (cm), leaves number 56 DAS and flowering age (DAS). p1m0 = chicken manure without mulch; p1m1 = chicken manure with rice husk mulch; p1m2 = chicken manure with plastic mulch; p2m0 = cow manure without mulch; p2m1 = cow manure with rice husk mulch; p2m2 = cow manure with plastic mulch; p3m0 = goat manure without mulch; p3m1 = goat manure with rice husk mulch; p3m2 = goat manure with plastic mulch.

Figure 1 showed that the lowest plant height was found in goat manure without mulch (p3m0), at 126.83 cm, and the highest plant height was in chicken manure with plastic mulch (p1m2) about 147.50 cm. The lowest leaves number was in cow manure with plastic mulch (p2m2), about 154.89 and the highest leaves number was in chicken manure with plastic mulch (p1m2), about 238. 27. And the chicken compost fertilizer without mulch (p3m0) have the earlier flowering age, about 54.67 DAS

3.1.2. Chlorophyll a,b and total (µmol.m^{-2})

Figure 2 showed that the lowest chlorophyll a was at goat manure with rice husk mulch (p3m1) about 186.76 and he highest was at chicken manure with plastic mulch (p1m2) which is 210.01. The lowest chlorophyll b was at goat manure with rice husk mulch (p3m1) about 77.78 and the highest chlorophyll b was at chicken manure with plastic mulch (p1m2) about 85.43. The lowest total chlorophyll was found at goat manure with rice husk mulch (p3m1) about 270.71 and the highest total chlorophyll was at chicken manure with plastic mulch (p1m2) which is 302.49.

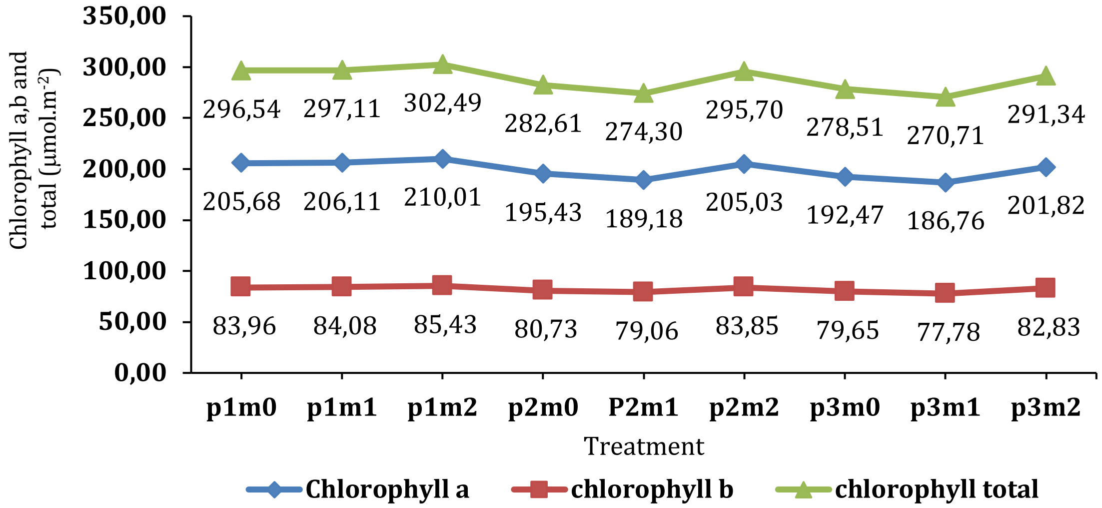

Figure 2. Chlorophyll a, Chlorophyll b and Chlorophyll total (μmol.m-2). p1m0 = chicken manure without mulch; p1m1 = chicken manure with rice husk mulch; p1m2 = chicken manure with plastic mulch; p2m0 = cow manure without mulch; p2m1 = cow manure with rice husk mulch; p2m2 = cow manure with plastic mulch; p3m0 = goat manure without mulch; p3m1 = goat manure with rice husk mulch; p3m2 = goat manure with plastic mulch

3.1.3. Stomatal Density (n.mm-2)

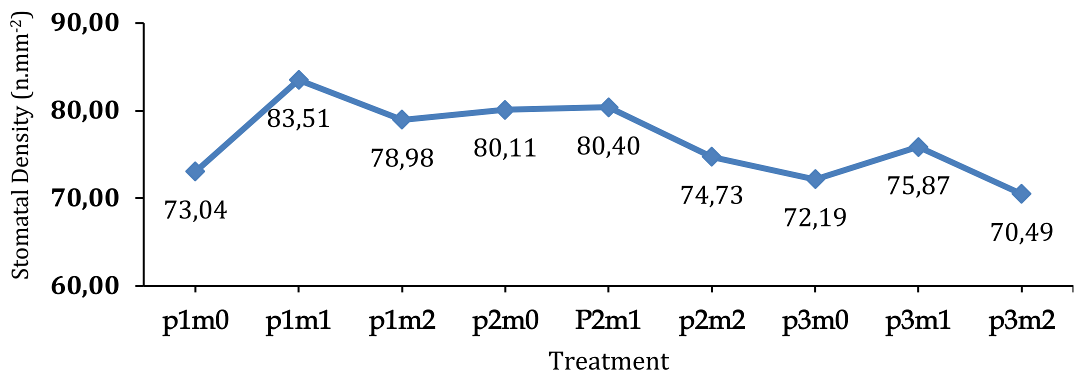

Figure 3. Stomatal density (n.mm-2). p1m0 = chicken manure without mulch; p1m1 = chicken manure with rice husk mulch; p1m2 = chicken manure with plastic mulch; p2m0 = cow manure without mulch; p2m1 = cow manure with rice husk mulch; p2m2 = cow manure with plastic mulch; p3m0 = goat manure without mulch; p3m1 = goat manure with rice husk mulch; p3m2 = goat manure with plastic mulch

Figure 3 showed that the lowest stomata density was at goat manure with plastic mulch (p3m2) about 70.49, and the highest was at the chicken manure with rice husk mulch (p1m1) which is 83.51.

3.1.4. Number of fruits per plants (fruits)

Table 2 showed that the highest number of fruit per plant at chicken compost fertilizer (18.93 fruits) and significantly different to other treatments.

Table 2. Number of fruits per plant (fruits)

Fertilizer Type (p)	Type of Mulch (m)			Average
	Control (m0)	Rice husks (m1)	Plastic(m2)	
Chicken compost (p1)	18.56	20.61	17.61	**18.93a**
Cow manure (p2)	15.28	13.89	14.39	14.52b
Goat manure (p3)	12.50	16.11	16.28	14.96b
CV LSD		0,75		

Remark: CV = Comparison Value, Numbers followed by the different letter in columns (a, b) are significantly different in the LSD test α 0.05.

3.1.5. Number of fruits per plot (fruits)

Table 3. Number of fruits per plot (fruit)

Fertilizer Type (p)	Type of Mulch (m)			CV LSD
	Control (m0)	Rice husk (m1)	Plastic (m2)	
Chicken compost (p1)	228.67 a q	**260.00 a p**	212.67 a r	
Cow manure (p2)	184.67 b p	163.67 b q	163.33 b q	30.16
Goat manure (p3)	146.67 c r	182.33 b q	197.67 a p	
CV LSD		9.05		

Remark: CV = Comparison Value, Numbers followed by the different letter in columns (a, b) and in row (p, q) are significantly different in the LSD test α 0.05.

Table 3 showed that the highest number of fruit per plot in chicken compost fertilizer (p1) and rice husk mulch with 260.00 fruits and was significantly different to the other treatments.

3.1.5. Fruit weight per plant (g)

Table 4. Fruit weight per plant

Fertilizer Type (p)	Type of Mulch (m)			Average
	Control (m0)	Rice husks (m1)	Plastic (m2)	
Chicken compost (p1)	726.22	779.72	675.06	**727.00a**
Cow manure (p2)	589.33	502.28	509.11	533.57b
Goat manure (p3)	467.22	607.67	589.33	554.74b
CV LSD		28.89		

Remark: CV = Comparison Value, Numbers followed by the different letter in columns (a, b) are significantly different in the LSD test α 0.05.

Table 4 showed that the highest fruit weight per plant in chicken compost fertilizer treatment was about 727.00 g and was significantly different to the other treatments.

3.1.6. Fruit Weight per plot (kg)

Table 5. Fruit weight per plot (kg)

Fertilizer Type (p)	Type of Mulch (m)			CV LSD
	Control (m0)	Rice husks (m1)	Plastic (m2)	
Chicken compost (p1)	7.71$^{a}_{q}$	**8.00**$^{\mathbf{a}}_{\mathbf{p}}$	7.18$^{a}_{r}$	
Cow manure (p2)	6.41$^{b}_{p}$	5.36$^{c}_{q}$	5.12$^{b}_{q}$	0.97
Goat manure (p3)	5.17$^{c}_{q}$	6.60$^{b}_{p}$	6.57$^{a}_{p}$	
CV LSD	0,28			

Remark: CV = Comparison Value, Numbers followed by the different letter in columns (a, b) and in row (p, q) are significantly different in the LSD test α 0.05.

Table 5 showed that the highest fruit weight per plot in the chicken compost fertilizer and rice husk mulch (p1m1) about 8.00 (kg) and significantly different to the other treatments.

3.1.7. Fruit diameter (mm)

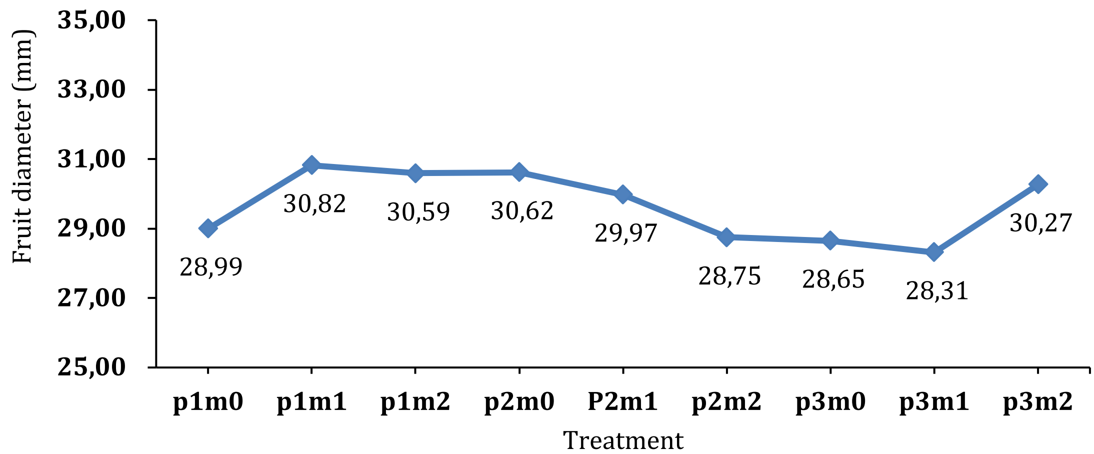

Figure 4. Fruit diameter (mm). p1m0 = chicken manure without mulch; p1m1 = chicken manure with rice husk mulch; p1m2 = chicken manure with plastic mulch; p2m0 = cow manure without mulch; p2m1 = cow manure with rice husk mulch; p2m2 = cow manure with plastic mulch; p3m0 = goat manure without mulch; p3m1 = goat manure with rice husk mulch; p3m2 = goat manure with plastic mulch

Figure 4 showed that the lowest fruit diameter was at goat manure with rice husks (p3m1), about 28.31, and the highest fruit diameter was at chicken manure with rice husk mulch (p1m1) which is 30.82.

3.1. Production (tons ha-1)

Table 6 showed that the highest production was in chicken compost fertilizer and of husk mulch (p1m1) about 26.67 tons ha^{-1} and significantly different to the other treatments.

Table 6. Production (tons ha^{-1})

Fertilizer Type (p)	Type of Mulch (m)			CV LSD
	Control (m0)	Rice husks (m1)	Plastic (m2)	
Chicken compost (p1)	25.71 a p	**26.67 a p**	23.92 a q	
Cow manure (p2)	21.35 b p	17.86 c q	17.06 b q	3.21
Goat manure (p3)	17.24 c q	22.00 b p	21.89 c p	
CV LSD	0,96			

Remark: CV = Comparison Value, Numbers followed by the different letter in columns (a, b) and in row (p, q) are significantly different in the LSD test α 0.05.

3.2. Discussion

The results in Table 3 showed that there was an interaction between the treatment of organic fertilizer and mulch. The treatment of chicken compost fertilizer with rice husk mulch gave the best effect on the number of fruits per plot on tomato plants. This is because the application of chicken compost 15 tons ha^{-1} and rice husk mulch 10 tons ha^{-1} has been able to provide complete nutrients in sufficient and balanced amounts. In addition, the application of compost fertilizer from chicken manure can also help improve soil physical properties and include making the soil looser, facilitating better plant root growth, and allowing plant roots to penetrate more easily. Synergistic with the provision of rice husk mulch that effectively protects the soil from the impact of rainwater runoff and controls weed growth so that it gives an influence on the number of fruits. This is in line with the opinion of Meutia et al. (2022) which states that rice husk mulch contains nutrients such as nitrogen (N), phosphorus (P), and potassium (K), so that it can provide significant support for plant growth and yield. The use of rice husk mulch is also believed to have an effect on soil moisture, with the potential to lower temperatures and increase water content at the soil surface. This can have a positive impact on crop growth and yield.

Furthermore, there was an interaction between the treatment of organic fertilizer and mulch as shown in Table 5. The treatment of chicken compost fertilizer with rice husk mulch gives the best effect on the weight of fruit per plot in tomato plants. Giving chicken compost fertilizer at a dose of 15 tons ha^{-1} gives a very real effect, this is because the availability of nutrients in the soil was available for tomato plants so that it affects the weight of fruit and so increase production. Jailani and Almukarramah (2022) mentioned that the importance of effective fertilization is very relevant. Fertilizer application is one of the keys in improving soil fertility and agricultural yields. Fertilizer contains various nutrients needed by plants. The amount of nutrients needed by plants in each phase of their growth is different, so fertilizer application is important to these nutritional needs. Synergistic with the treatment of organic fertilizers and mulch so that the presence of rice husk mulch can improve the environment of plant growth with the presence of organic matter contained in the rice husk. It will provide sufficient nutrients and easily decomposed. The use of organic mulch can also reduce soil temperature. Sari et al. (2021) explained that the use of husk mulch or mulch made from the remains of organic matter has a low heat conduction ability. So that the mulch is able to reduce the level of evaporation of water from the soil, which will reduce the heat of soil surface. The impact of this heat reduction can have a positive impact on fruit weight and overall crop production.

There was also an interaction between the treatment of organic fertilizer and mulch as shown in Table 6. The treatment of chicken compost fertilizer with rice husk mulch gave the best effect on the production of tomato. The high phosphorus (P) content in chicken compost has great potential to increase plant productivity. In addition, organic fertilizer is very suitable for use in agriculture because it has a sustainable positive impact in improving soil fertility. Hadi (2023) explained that manure contains macro and micro elements, can be considered a complete fertilizer, and has natural properties that do not damage the soil. In addition, manure plays a role in increasing water resistance, microbiological activity in the soil, and improving soil structure. Synergistic with the provision of rice husk mulch which contains nutrients such as N, P and K so that it can support growth and production. Rice husk mulch treatment have significant differences in treatment compared to other types of mulch. This is influenced by the level of light intensity received by plants. The higher the light intensity received by plants, the biomass production will also increase so that it can affect plant production (Putra et al., 2021).

Based on the description of the variety F1 Servo, the production in this research was not optimal. This is due to environmental influences including high rainfall and strong winds at the beginning of planting so that it makes plants quickly fall and some tomatoes are attacked by fruit rot, but the way to overcome this is by adding poles or stakes so that the tomatoes did not fall to the ground. Adhiana (2021) said that which states that production is influenced by several factors involving plants, soil conditions, and seasonal factors. In the rainy season, excess water can cause root rot in plants. At the beginning of the study, the high intensity of rainfall can cause plant growth to not be optimal because the need for water is excessive, thus disrupting the growth process and plant production. Yuni (2019) said that rainfall has a major impact on water availability. An increase in rainfall in an area could cause flooding, while a decrease from normal conditions caused drought. Both situations will certainly have a negative impact on plant health and potentially reduced production.

The results showed that there was a very significant effect on the observation parameters of the number of fruits per plant (Tabel 2) and the weight of fruits per plant (Tabel 4) on the organic fertilizer treatment, namely chicken compost. This is because the content of nutrients contained in chicken manure is very high so that the content of these nutrients works synergistically to support plant growth to give results with the highest number of fruits per bunch among no fertilizer, cow and goat manure. According to Bhoki et al., (2021) which states that fertilizers derived from chicken manure contain more nutrients such as nitrogen (N), phosphorus (P), and potassium (K) compared to fertilizers derived from other livestock pens. Therefore, fertilizer from chicken manure has a faster reaction. This makes it particularly suitable for short-lived crops.

The results showed that rice husk mulch and plastic mulch had no significant effect on all parameters. However, the rice husk mulch treatment tended to give the best plant height results at the age of 28 DAS - 14 DAS, and the plastic mulch treatment gave the best results at the age of 42 DAS - 28 DAS and 56 DAS - 42 DAS. This is due to the high rainfall factor at the beginning of planting, so the rice husk mulch is leaching by rainwater and the treatment without mulch nutrient content is also leaching. which states that the use of black plastic mulch shows faster plant height than the treatment without mulch. This happens because the soil that is not covered with plastic mulch tends to grow weeds faster, so there is competition in the absorption of nutrients, which in turn can inhibit the growth of plant height (Juanda et al., 2022).

4. Conclusion

In this study, interactions occurred when using chicken compost organic fertilizer combined with rice husk mulch on growth and production of tomatoes. Parameter such as showed increased number of fruits per plot (260.00 fruits), fruit weight per plot (8.00 kg) and production (26.67 tons ha^{-1}). Chicken compost had the best effect on the growth and production of tomatoes in the number of fruits per plant (18.93 fruits) and the fruit weight per plant (727.00 g). However, mulch treatment did not have any significant effect.

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