

The Implementation of Straw Mulch Experiments to Increase Tomato (*Lycopersicum esculentum* Mill.) Production in Horticulture Learning

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ABSTRACT

The increasingly rapid development of science and technology, as well as the influence of globalization has contributed to updates in educational so that one method taken by apply experiments in horticulture learning activities. This study aims to determine the effect of rice straw mulch on tomato production and the effectiveness of the implementation of this experiment in the horticultural learning process. This research experimental used 144 of tomatoes plants that were divided into four groups. First group is the control group with the thickness of the straw 0%, second group with a thickness of mulch 5%, third group with mulch thickness 10% and fourth group with mulch thickness 15%. The results show there is a significant difference from the average weight of tomatoes after being given various mulch thickness treatments that was continued with the Least Significant Difference test with significant differences seen group 15% straw thickness where group had the highest tomato fruit weight with the average tomato fruit weight per plants 1426.72 g. This experiment is quite effective in implementing horticulture learning because this experiment takes only 116 days and can increase activity, motivation, creativity, foster students' rational and scientific thinking.

1. Introduction

Tomato (*Lycopersicum esculentum* Mill.) is one type of vegetable that is popular with people because of its good nutritional content. In 100 g tomatoes there are substances that are useful for the human body, including 1 g of protein, 4.2 grams of carbohydrates, 0.3 g of fat, 5 mg of calcium, 27 mg of phosphorus, 0.5 mg of iron, 1500 SI of vitamin A, 60 mg of vitamin B and 40 mg of vitamin C. Tomatoes were found to have the increased variability of lycopene, in 1 kg tomatoes contains 104.699 mg [1]. Tomatoes have many benefits including preventing canker sores, eliminating acne, preventing cancer, preventing digestive disorders, and so on. Researchers from the Rowett Research Institute in Aberdeen, Scotland, managed to find other benefits of tomatoes, so the yellow gel that covers the tomato seeds can prevent blood thickening and blood clots that can cause heart disease and stroke [2]. Tomatoes (*Lycopersicum esculentum* Mill.) are the most popular vegetables with high nutritional value and a good source of Potassium and Vitamins A and C [3]. Tomato

(*Lycopersicum esculentum* Mill.) is a type of shrub and belongs to the Solanaceae family.

Tomatoes are an important component in the composition of the daily menu, including being used as table fruit, a mixture of vegetables, chili sauce [4]. Along with the development and improvement of public health, the consumption of tomatoes as a source of vitamins is increasingly in demand for most Indonesians so that the need for tomatoes continues to increase, both as fresh food, vegetables, and as an ingredient in the food industry. In Europe (EU), Italy and Spain are the largest EU fresh tomatoes producers. panish fresh tomatoes are traded to Northern Europe, mainly toward France, United Kingdom, Germany, and Netherlands. In some cases imports from Spain cover a large share of total import of destination countries [5]. Tomato is a widely cultivated horticultural plant. The level of people's need for tomatoes is quite high, because tomatoes are consumed almost every day. The high demand for tomatoes causes tomato cultivation to require serious handling, so that production and fruit quality are always maintained [6].

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Tomato plants need environmental conditions in the form of temperature and soil moisture that can ensure optimum plant growth and production. To be able to optimize the growth of tomato plants, it is necessary to modify the growing environmental conditions in the form of soil temperature and soil moisture by using the right plant cultivation technology, one of which is by giving plant residues in the form of organic mulch. Mulch is defined as a material or mineral that is deliberately spread on the surface of the soil or agricultural land. One of the organic mulches which is an agricultural waste material is rice straw. The use of organic mulch in the form of straw mulch is the right alternative choice because it can improve soil structure, soil fertility and indirectly maintain soil aggregation and porosity, which means, it will maintain soil capacity to hold water after composition. Straw mulch can maintain soil moisture and suppress the growth of weeds and diseases so that it is expected to make tomato plants grow well and optimally.

Ecological assets that play an important role for the sustainability of ASEAN countries, namely agricultural for arable land. The role of humans is very important for the environment because various human activities can have a positive impact on the environment and the economy of a country and have a negative impact, namely a decrease in environmental degradation so that it can affect ecological assets for sustainability of ASEAN countries [7].

Organic farming can support sustainable food security and food availability [8] like organic mulches. Organic mulches such as straw, hay, grass or leaves can provide many benefits for organic farming. The use of organic mulch such as straw can reduce soil temperature and produce higher soil moisture compared to using black plastic mulch [9]. Organic mulch can limit weed growth, protect the soil from drought and reduce nutrient leaching, so that it has a positive impact on the yield of cultivated crops and improves their quality [10]. Surface mulching either with synthetic plastic sheets (or films) or natural organic waste materials is now used to protect plants from root-borne diseases and for water conservation. Organic mulch contains sawdust, dry grass (grass clippings), corn cobs, rice and wheat straw, water hyacinth, etc. It is very effective for vegetable growth and yield through increased soil moisture content, heat energy and the addition of some organic nitrogen and other minerals to improve soil nutrient status [3]. The use of various types of mulch on tomato plants is expected to be able to create a suitable microclimate for plants, improve soil physical properties including soil organic material, permeability, soil porosity and growth rate, facilitate nutrient cycling in soil, water, plant systems and improve nutrient availability for plants [11].

There are many factors that influence the progress of a nation, one of which is the condition of education that occurs in the country, so to achieve it, it requires a renewal in the field of education. Updates in education are an effort to improve the quality of national education, including by updating learning methods. In general, learning methods in schools tend to be teacher oriented, i.e. teacher-centered learning. The teacher oriented tradition is still widely used by educators so that it does not empower students. This condition results in low levels of success in students. Updates in the field of education position teachers to have a big role to contribute to the improvement of education

quality in schools. Thus, the learning system must have good planning. According to Sugiyono [12] with the increasingly rapid development of science and technology, as well as the influence of globalization that has contributed to almost all aspects of human life at this time, the demands for schools are growing as well because the school's function has long been used as "*agent of change*" and "*agent of modernization*" by community. This implies demands for teachers to continuously develop teaching materials and teaching methods in order to meet the demands of the developing community. Biology learning basically involves students directly in obtaining knowledge so that curiosity arises. To explore students' curiosity, one method taken is by applying experiments in learning activities. Experiments are able not only to foster students' curiosity, but also to encourage rational and scientific ways of thinking so that the results of experiments can be accepted as scientific products while the steps in its implementation are dealing with scientific processes.

According to the constructivism view, learning that is currently applied must be oriented towards building the knowledge of students independently. Students are trained to find independent learning information and actively create cognitive structures in interaction with their environment so that student-centered learning is realized. One good learning strategy that is in line with the nature of constructivism is the application of a practicum-based learning model. In practicum-based learning, students are more directed at experimental learning (learning based on concrete experiences), discussions with friends, which will then get new ideas and concepts. Therefore, learning is seen as a process of compiling knowledge from concrete experiences, collaborative activities, and reflection and interpretation [13].

Experimental learning is very suitable for learning biology, because it can provide learning conditions that develop optimal thinking and creativity skills. Students are given the opportunity to compose their own concepts in their cognitive structures, which can then be applied in their lives. The use of this experimental method has the aim of making students capable or competent and finding their own answers or problems which are faced by conducting their own experiments. In addition, students can be trained in scientific ways of thinking, by experimenting with students finding evidence of the truth and theory of something that is being studied [14].

From the description above, the research purpose to determine the effect of rice straw mulch on increasing tomato plant production and the effectiveness of the implementation of this experiment in the horticultural learning process.

2. Methods

2.1. Materials

The population of this study was all tomato plants in the nursery with length, width and height (150 x 40 x 10) cm. After 10 days, the tomato plants are transferred to new media in a small 5 cm diameter plastic bag that has been prepared previously. At three weeks of age, the seedlings were transferred from the plastic bag media to the plot of the study area, where each plot was filled with six plants. In one block where the research was located there were four plots according to the number of experimental groups, namely (1) the control group with the thickness of the straw (0%); (2) the

group with the thickness of the mulch (5%); (3) the group with the thickness of the mulch (10%) and (4) the group with the thickness of the mulch (15%). There are six blocks according to the number of repetitions. The total tomato plants used in the sample in this study were 6 x 4 x 6 tomato plants, equal to 144 tomato plants.

2.2. Data Analysis

This type of research is experimental, using a completely randomized design. The obtained data were the weight of ripe tomatoes which were picked three times, starting from 96 days to 116 days. The results of weighing the tomato fruit were then recapitulated, the results of the recapitulation were tested for normality and homogeneity using the SPSS software version 22. The normality test was performed using the Kolmogorov-Smirnov and Shapiro-Wilk statistics with SPSS software version 22. Meanwhile, the homogeneity test was carried out with the Levene test. Significance level (α) was set at 0.05.

The criteria used for the normality and homogeneity test was if the significance number (sig.) was greater than the significance level (α) then the statistical numbers obtained were not significant, meaning that the sample data came from a normally distributed population, vice versa. If the requirements for normality and homogeneity have been met, then a parametric analysis is carried out using the ANOVA test. If there were significant differences, it was necessary to carry out further tests to determine which treatment groups were significantly different. Further tests were carried out with the Least Significant Difference (LSD) test. Student learning outcomes using experiment-based learning methods were evaluated using normative assessments.

3. Result

After the tomatoes reached 96 days from the nursery, the ripe fruit picking was carried out to calculate the weight of the tomatoes produced per plants, the fruit picking was done three times until the tomatoes were 116 days old. The results of weighing the tomato fruit were then recapitulated, the results of the recapitulation can be seen in Table 1.

Based on table 1 above, it can be described the average weight of tomatoes (g) plants at various thicknesses of straw mulch, as shown in Figure 2.

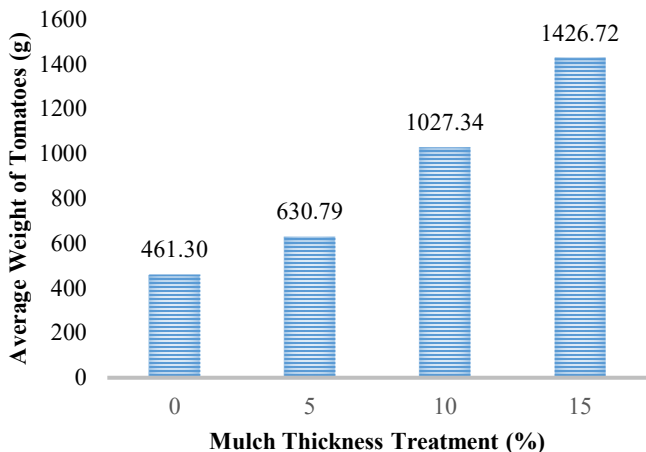


Figure 1. Average Tomato Fruit Weight (g) plants at various thicknesses of mulch

Table 1: Average Tomato Fruit Weight (g) plants at various thicknesses of straw mulch

TREATMENT Symbol	Straw Thickne ss	BLOCK					
		I	II	III	IV	V	VI
(1)	0%	917,5 0	690,8 3	1095, 00	683,3 3	658,3 3	608,3 5
(2)	5%	1010, 35	1176, 00	1334, 33	846,6 6	116,6 6	977,1 7
(3)	10%	1514, 17	1183, 83	1790, 33	1825, 83	1789, 50	1475, 50
(4)	15%	1878, 30	2216, 50	2303, 35	2091, 00	2121, 83	2140, 00
Total		5320, 32	5266, 66	6523, 01	5446, 82	5686, 32	5201, 02
Average		1330, 08	1316, 67	1630, 75	1631, 71	1421, 58	1300, 26

3.1. Prerequisite Test

Before conducting the Anova test, a prerequisite test was carried out in the form of a normality test and a homogeneity test. Based on the results of the normality test with SPSS software version 22, data is obtained as in Table 2.

Table 2: Summary of Normality Test

Straw Thickness(%)	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
0	0.339	6	0.030	.831	6	0.110
5	0.274	6	0.180	.858	6	0.183
10	0.277	6	0.165	.865	6	0.208
15	0.239	6	0.200 [*]	.939	6	0.651

Based on the results of the Shapiro-Wilk normality test, all treatments obtained Sig. above the predetermined significance value of 0.05. This means that the data is normally distributed so that Anova testing can be done.

The next test is the homogeneity test which is also carried out with the help of SPSS. The results of the homogeneity test are shown in Table 3.

Table 3: Homogeneity Test Results

Levene Statistic	df1	df2	Sig.
1.401	3	20	0.272

Based on the results of the homogeneity test with the Levene test, the Sig. equal to 0.272. This value is much greater than the predetermined significance value of 0.05. Thus it can be said that the fourth variant of the mulch thickness treatment is homogeneous, so that anova testing can be carried out.

3.2. One Way Anova Test

Based on the one-way ANOVA test that has been carried out with the help of SPSS software version 22 can be seen in Table 4.

Table 4: Summary of One Way Anova Test Results

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	7110075.329	3	2370025.110	31.593	0.000
Within Groups	1500343.171	20	75017.159		
Total	8610418.500	23			

Based on the table above, it is known that the F value is 31.593 with a Sig. amounting to 0.000. This means that there is a significant difference from the average weight of tomatoes after being given various mulch thickness treatments. Because there is a significant difference, it is necessary to carry out further tests to find out which treatment pairs are significantly different. Further tests were carried out with the LSD test, the results of which can be seen in Table 5.

Table 5: Summary of LSD Test Results

(I) Straw Thick ness (%)	(J) Straw Thickn ess (%)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
0	5	-134.63833	158.13197	0.405	-464.4958	195.2192
	10	-820.88667*	158.13197	0.000	-1150.7442	-491.0292
	15	-1349.60667*	158.13197	0.000	-1679.4642	-1019.7492
5	0	134.63833	158.13197	0.405	-195.2192	464.4958
	10	-686.24833*	158.13197	0.000	-1016.1058	-356.3908
	15	-1214.96833*	158.13197	0.000	-1544.8258	-885.1108
10	0	820.88667*	158.13197	0.000	491.0292	1150.7442
	5	686.24833*	158.13197	0.000	356.3908	1016.1058
	15	-528.72000*	158.13197	0.003	-858.5775	-198.8625
15	0	1349.60667*	158.13197	0.000	1019.7492	1679.4642
	5	1214.96833*	158.13197	0.000	885.1108	1544.8258
	10	528.72000*	158.13197	0.003	198.8625	858.5775

*. The mean difference is significant at the 0.05 level.

Based on the LSD further test with the help of SPSS, it was found that all pairs of mulch thickness treatments were significantly different except for pairs of 0% and 5% thickness of mulch. That is, the mulch treatment with a thickness of 0% and 5% has no difference in affecting the average weight of tomatoes. Or there is a significant difference between group (3) with 10% straw thickness and group (4) 15% straw thickness where group (4) has the highest tomato fruit weight.

3.3. Evaluation of learning outcomes

Evaluation of the learning outcomes of students who participated in this experiment showed that: (1) there was an increase in activity, creativity, motivation and involvement of students in the learning process; (2) students gained real experience that was able to strengthen their understanding of theoretical concepts; (3) It helped students to foster their rational and scientific thinking; (4) students can hone cognitive, psychomotor and affective skills in identifying problems, and developing problems and finding effective solutions to solve problems; (5) students can cultivate collaboration and acquire leadership skills.

4. Discussion

Based on the results of the one-way ANOVA analysis, it is known that the F value is 31.593 with a Sig. amounting to 0.000. This means that there is a significant difference from the average weight of tomatoes after being given various mulch thickness treatments. This is because organic mulch is able to suppress weeds, regulate soil moisture and soil surface temperature. Organic mulch can improve overall soil quality by increasing soil organic matter, soil porosity, water holding capacity while stimulating life in the soil and increasing nutrient availability [10]. Organic mulch is very effective for vegetable growth and yield through increasing soil moisture content, heat energy and adding some organic nitrogen and other minerals to improve soil nutrient

status [3]. The use of various types of mulch on tomato plants is expected to be able to create a suitable microclimate for plants, improve soil physical properties including soil organic matter, permeability, soil porosity and growth rate, facilitate nutrient cycling in soil, water, plant systems and improve nutrient availability for plants [11]. From the above quotations we can conclude that rice straw mulch can (1) reduce the growth of weeds, (2) reduce water evaporation so as to maintain soil moisture content and soil temperature; (3) preventing the appearance of soil scales so that the soil remains loose and soil aeration is maintained; and (4) rotting straw mulch will increase soil nutrients, especially organic nitrogen and other minerals.

Based on the LSD further test with the help of SPSS, it was found that all pairs of mulch thickness treatments were significantly different except for pairs of 0% and 5% thickness of mulch. This means that mulch treatment with a thickness of 0% and 5% does not differ significantly in influencing the average weight production of tomatoes. Meanwhile, mulch treatment with a thickness of 10% and 15% had a significantly different effect on the average weight production of tomatoes, where mulch treatment with a thickness of 15% had a better effect than mulch treatment with a thickness of 10% [11].

Why does mulch treatment with a thickness of 10% and 15% have a significant different effect on the average weight production of tomatoes and mulch treatment with a thickness of 15% is a better effect than mulch treatment with a thickness of 10%? Because in the mulch treatment with a thickness of 15% weeds cannot grow at all, so there are absolutely no disturbing plants, consequently water and the elements present in the soil are only used by tomato plants. The impact is better tomato growth and is able to produce fruit more optimally.

Hay weeds, especially weeds with a thickness of 15%, evaporate less than treatment with a thickness of 10% straw, so that the soil moisture content and soil temperature are better preserved in the treatment with a thickness of 15% straw. Water has a vital function for living things, including plants. This is closely related as the basic material to be used in the photosynthesis process, which is a plant physiological process for the formation of carbohydrates [15]. Water is one of the environmental factors that has a big influence on the decrease in the production of a plant and from an ecological point of view, it is the main limitation in the terrestrial environment or in the aquatic environment is water.

Straw mulch, especially mulch with a thickness of 15%, is better able to prevent the appearance of soil scales so that the soil is more loose and soil aeration is more maintained than the straw mulch with a thickness of 10%. This is very important for maintaining the progress of the metabolic processes that take place in the root cells, especially the respiration of root cells, which greatly affects root growth and transport of soil nutrients from the soil to the leaves. With good aeration will affect crown growth and ultimately will increase the production of tomato plants. For tomatoes with a straw mulch thickness of 15%, the amount of straw is clearly higher than that of 10% straw mulch, so that the addition of organic nitrogen in the treatment with a straw thickness of 15% is more than tomatoes with a thickness of 10% mulch. Since organic nitrogen is obtained from rotting straw mulch. This organic nitrogen is indispensable for growth, especially in the

vegetative phase, namely the growth of branches, leaves and stems. Nitrogen is also useful in the process of forming green leaves or chlorophyll. Chlorophyll is very useful to help the photosynthesis process. In addition, nitrogen is useful in the formation of proteins, fats and various other organic compounds. Lack of nitrogen can cause abnormal or stunted plant growth. The leaves will turn yellow and then dry out. If a lot of nitrogen deficiency (severe) can cause plant tissue to dry out and die. Fruits that lack nitrogen have imperfect growth, ripen quickly and have low protein content. So the increase in tomato weight in straw mulch with a thickness of 10% and 15% occurs because straw mulch can add adequate organic nitrogen elements to the soil. This optimal organic nitrogen makes tomato fruit growth perfect and its protein content increases [8].

The use of technology in the suitability of peatlands for cultivation in a certain area is optimally carried out using methods based on of the Food and Agriculture Organization (FAO) guidelines. The system test results showed an accuracy rate of 92.86% with the application of land suitability evaluation for planting other types of plants besides lowland rice. Based on the results of future land suitability evaluations, farmers can develop horticultural crops, namely cultivating tomatoes on peatlands [16].

Evaluation of the learning outcomes of students who participated in this experiment showed that: (1) there was an increase in activity, creativity, motivation and involvement of students in the learning process; (2) students gained real experience that enabled them to strengthen their understanding of theoretical concepts; (3) it helped students to foster their rational and scientific thinking; (4) students can hone cognitive, psychomotor and affective skills in identifying problems, and developing problems and finding effective solutions to solve problems; (5) students can cultivate collaboration and acquire leadership skills. This happens because students were involved directly in obtaining knowledge so that curiosity arose. Experiments are able not only to foster students' curiosity, but also to encourage rational and scientific ways of thinking so that the results of experiments can be accepted as scientific products while the steps in its implementation are as scientific processes. Experimental learning is able to provide learning conditions that develop optimal thinking and creativity skills. Students are given the opportunity to compose their own concepts in their cognitive structures, which can then be applied in their lives. The use of this experimental method has a goal that students are able to find their own answers or problems by conducting their own experiments. In addition, students can be trained in a scientific way of thinking, by experimenting with students finding evidence of the truth and the theory of something being studied [14].

Biology being the center of scientific learning is needed in studying advanced domains such as medicine, genetics, zoology, etc. For successful dissemination of biological science, integration of high-tech communication practices in teaching of biology is applied in education, teachers familiarize themselves with the pedagogical principles and management strategies used in classroom instruction [17].

This is in line with what was stated by [18] which stated that good learning is learning that requires student activity and meaning (*meaningful discovery learning*). In active learning (*discovery*

learning), students are no longer placed in a passive position as recipients of teaching materials given by teachers / lecturers, but as subjects who are active in thinking processes, seeking, processing, unraveling, combining, concluding, and solving problems. Education is a lifelong process of cultivating and empowering students, where in this process there must be educators who provide role models and are able to build will, and develop the potential and creativity of students. This principle causes a paradigm shift in the educational process, from the teaching paradigm to the learning paradigm. Teaching paradigm which emphasizes more on the role of educators in transforming knowledge to their students has shifted to learning paradigm which gives more roles to students to develop their potential and creativity. In the learning process, the ability for creativity is obtained through: Observing, Questioning, Associating, Experimenting, and Networking.

Therefore, teachers/ lecturers need to design a learning process that prioritizes personal experience through the process of observing, asking questions, reasoning, and trying [observation based learning] to increase the creativity of students. In addition, it is accustomed for students to work in a network through collaborative learning.

5. Conclusions

Based on the research results and the description above, it can be concluded that: (1) straw mulch affects tomato production; (2) straw mulch with a thickness of 5% gave no significant difference, while straw mulch with a thickness of 10% and 15% had a significantly different effect, where straw mulch with a thickness of 15% had a higher yield of tomatoes than mulch straw with a thickness of 10%; and (3) This experiment is quite effective in implementing horticultural learning because this experiment takes only 116 days, it can increase activity, motivation, creativity, rational and scientific thinking of students. Besides, this experiment also involves students in the learning process, provides real experience, improves cognitive, psychomotor, affective abilities, and fosters collaboration and leadership skills.

Conflict of Interest

The authors declare no conflict of interest.

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