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WATER STRESS INFLUENCE FOR TOMATO (*SOLANUM LYCOPERSICUM*) PRODUCTION

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ABSTRACT

Tomato, also known as *Solanum lycopersicum*, is one of the horticultural commodities that have a good priority to be developed. Tomato production in Indonesia has decreased over five decades. This lack of production is caused by the limitation of water supply during the dry season as to effect of its rooting. One of the ways of ensuring water supply is using an irrigation system, including drip irrigation. The use of drip irrigation will save a lot of water, but the allocation of water to be given will cause to salinity. This phenomenon requires actions to control the water for tomato production. Research in this area is being carried out in the subdistrict of Lubuk Kilangan, Padang City. The current study observes the effect of salinity on the amount of leaf, the productivity, and the sweetness of the tomato fruit. Based on the results, the efficiency of drip irrigation is around 96.28%, and there is no real effect of salinity on the amount of leaf. Additionally, salinity does not affect productivity. The highest productivity is on the treatment of giving water at -15%, amounting to 2.30 kg, and the lowest is at -5%, amounting to 1.72%. Salinity increases the sweetness of tomato, and the highest sweetness level is on the treatment of giving water at -20%, amounting to 5.660^0 Brix, and the lowest sweetness level is at the control treatment, amounting to 5.110^0 Brix.

Keywords: Tomato, Drip Irrigation, Salinity, Sweetness

INTRODUCTION

Background

Water is important for human beings. A surplus, or lack, of water causes the growth of plants to reach a critical point at which they undergo degradation of the physiological process and photosynthesis, thus affecting the productivity and quality of the fruit that is produced. Irrigation is the activity of giving water to plants for the purpose of meeting their water consumption needs. The necessity of water on the plants is different, such as in the case of the tomato. Tomato (*Solanum lycopersicum*) is a horticultural commodity that have a priority to be developed. On an international scale, tomato plays many roles; besides its sweet taste, it also has high nutritional value.

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According to the BPS or Central Bureau of Statistics (2013), the production of tomato over five decades has decreased. In 2009, the production of tomato amounted to 853.061 tons, and in 2013, it amounted to 441.250 tons. This lack of production is caused by the lower water supply during the dry season. Meanwhile, in the rainy season, the supply of water increases and influences the rooting system. The root of tomato, if disturbed, can hinder the process of absorption of nutrients and affect the aero transpiration from the tomato itself. The system of irrigation for meeting the water needs of tomato can affect its growth and, in turn, the taste or sweetness level favored by consumers.

Farmers supply water for tomato by using traditional methods like yells or forecasting the rainfall, which are less effective and inefficient ways of supplying water (Makky, 2016). One type of irrigation system that is effective is drip irrigation. Controlling drip irrigation saves a lot of water, but at the cost of increasing salinity. Salinity is a problem in growing tomato. The provision of water saved is water conservation along with climate change. The lack of water supply is often caused by the competition for water among human beings in addition to the energy, industrial, and mining sectors, among others. As the need for water increases, the cost of irrigation becomes ever higher.

Therefore, there is a study to give force to plants by intermittent water treatment, wherein the provision of water is done intermittently so that the salinity of plants increases at a certain level without disturbing the productivity of the plants, while at the same time minimizing water supply. This phenomenon allows one to control water to fulfill the tomato's water needs. Water needs to be conserved, meaning that the amount of water given is under the needs of water for the growth of tomato. However, the amount of water that is given may have the effect of increasing salinity. Thus, the topic of the limit of water supply for the growth of tomato needs to be researched.

Therefore, the researchers have conducted a study entitled, "The salinity of level testing of planting media tomato toward the quality of fruit produced by parameter of its sweetness."

Research Aim

The aim of this study is to investigate the effect of water deficit percentage on tomato in regard to the level of its sweetness by using micro drip irrigation.

Benefit

The benefit of this study is that it will provide technical information for those who want to manage a tomato garden and as their partners to be implemented.

RESEARCH METHOD

Place and Time

This study was conducted at a net house with a measurement (6 x 4) meters and was located in the Lubuk Kilangan subdistrict in Padang City, and at the Laboratory of Food Processing Technique and Crops at the Faculty of Agricultural Technology during the period of July 2016–November 2016.

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Tools and Materials

The materials needed for this study were the following: tomato seeds (*Lycopersicon esculentum*) with a variety of Servo; planting media with a mix of soil, manure, and husk with a composition of 1:1:1; and bamboo, rope, and water supply from a barrel. The tools that used were a PVC pipe, plastic hose, aquarium hose, farm net, refract meter, EC meter, and polybag.

Procedure of the Research

The research procedure involved finding a net house, designing drip irrigation, and planting tomato seedlings.

Net House

Making the net house involved creating a bamboo frame with a length, width, and height of 6 x 4 x 1.6. The frame was paired with a farm net. Then, the farm net was tied to the net house using a rope.

Design of Micro Drip Irrigation

The Food and Agriculture Organization (FAO; 2015) stated that the water supply for growing tomato can be as much as 50 cc/day during the seedling period, 80 cc/day during the vegetative period, and 125 cc/day during the generative period. Four treatments of debits are used: normal (A), in which it is related to FAO, and the others; normal - (normal x 5%) (B), normal - (normal x 10%) (C), normal - (normal 15%) (D), and normal - (normal x 20%) (E). The provision of water is done intermittently through drip irrigation, with the sprinkling of water being conducted in the morning and evening with distance watering 1 x 2 day(s). The disbursement of debit is set to 1 drop/sec, with 1 cc = 20 drops. In the period of seedling, it is given water supply during first 30 days, for vegetative period, it gives second 30 days and for generative period it gives third 30 days of watering.

Table 1. Debit Treatment of Conducting Irrigation

Day	A	B	C	D	E
0–30	2,9 cc/sec	2,8 cc/sec	2,6 cc/sec	2,5 cc/sec	2,3 cc/sec
31–60	5,8 cc/sec	5,6 cc/sec	5,2 cc/sec	5 cc/sec	4,6 cc/sec
61–90	8,7 cc/sec	8,4 cc/sec	7,8 cc/sec	7,5 cc/sec	6,9 cc/sec

The FAO standard uses cc/day, but the standard used in Table 1 is cc/sec. This drip irrigation is agitated to leak, so in this study, the leak can be counted on;

$$\frac{vol\ water\ in - vol\ water\ out}{vol\ water\ in}\ x\ 100\% \ldots\ldots\ldots (1)$$

Planting Tomato Seedlings

As many as 60 polybags measuring 30 x 50 cm were prepared and filled with a planting media blend that contained soil, manure, and husk with a composition of 1:1:1. The amount of water needed for the three growth phases, vegetative, generative, and aging, was calculated.

Measurement Analysis Salinity of Planting Media

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Measurement analysis of the salinity of the planting media using different mechanisms of water provision at the same time was conducted using resistant testing. The measurement of the salinity of the soil was run at 3 times for 30 minutes from the growth of tomato where during 10 days are given once. To measure salinity, the following methods were used: dry soil was mixed with aquades with the comparison 1:1, stir spreadly, and resistance was calculated using an EC meter (Syekhfani, 2014).

Analysis of Seedlings (Germination Rate)

After it was grown, the germination rate on the 7th and 14th days was calculated (Nasruddin, 2009). The equation to analyze the seedlings was as follows:

$$0\% \text{ seedling} = \frac{\text{the number of germinated seeds}}{\text{the number of seeds that germinated}} \ x\ 100 \ \ldots\ldots\ldots \text{(2) (Nasruddin, 2009)}$$

Analysis of the Amount of Leaf

To determine the amount of leaf, manual tally and recording of the amount in one polybag was conducted.

Analysis of Fruit Productivity

To determine the effect of salinity on the productivity of fruit, the following equation was used:

$$\text{Productivity} = \frac{\text{total harvest (kg)}}{\text{wide of are (ha)}} \text{ x } 100\% \ \ldots\ldots\ldots \text{(3) (Damiri and Ishak, 2015)}$$

Fruit Quality Testing Using Parameter of Sweetness

To test the quality of tomato, the tomato that was harvested was made into a juice until it produced water/smooth granules. Water from the tomato was put into a refractometer. To determine the sugar content using the refractometer, it was held to the light to determine how much the level of sugar content from tomato at some treatment of water provision and the different times of giving water was stated in ^{0}Brix.

Statistical Analysis

To observe the effects of salinity on the taste level of the tomato, SPSS 17 software was used. After data input was completed, it will see the value of ANOVA and the graph produced.

RESULTS AND DISCUSSION

General View of the Research Location

The study was conducted in Batu Gadang, Lubuk Kilangan subdistrict, Padang City, West Sumatera, Indonesia. Batu Gadang shares a border with Solok Regency in the eastern part, with Pauh Sub District in the northern part, with Solok Regency in the southern part, and with Lubuk Begalung subdistrict in the southern part. Batu Gadang is a highland with a sea level of 50–100 masl. Its climate and temperature range from 26^0 to 31^0, and its humidity is around 80–85%. It receives about 347,5 mm/month of rainfall, and on average, it receives about 19 days of rainfall per month (Bappeda, 2014).

Efficiency of Drip Irrigation

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The efficiency of drip irrigation was calculated to estimate the amount and volume of water that can be disbursed to tomato plants. The results are shown in Table 2.

Table 2. Efficiency of Drip Irrigation

Treatment	Volume of Water in (ml)	Volume of Water out (ml)	Efficiency (%)
A	2700	76.5	97.16
B	2700	103.5	96.16
C	2700	108	96
D	2700	81	97
E	2700	81	97
The average efficiency			96.66

Based on the table above, the highest efficiency was about 97.16% (A), or the same as the FAO standard, whereas the lowest efficiency was around 96% (C) (normal - (normal x10%)). The different efficiencies for each treatment were caused by a leak in the hose. The value of efficiency in general from the drip irrigation was 96.66%, indicating that the leak happened less than 5%. The efficiency values show that the system of drip irrigation can be used to grow tomato.

Effect of Water Volume on the Amount of Leaf

The effect of water volume on the amount of leaf was examined to determine the influence of water volume on the tomato plant. The reduction in the amount of water had the function of saving water without reducing the tomato yield. The effect of the reduction of water volume on the amount of leaf can be seen in Fig 1 and 2.

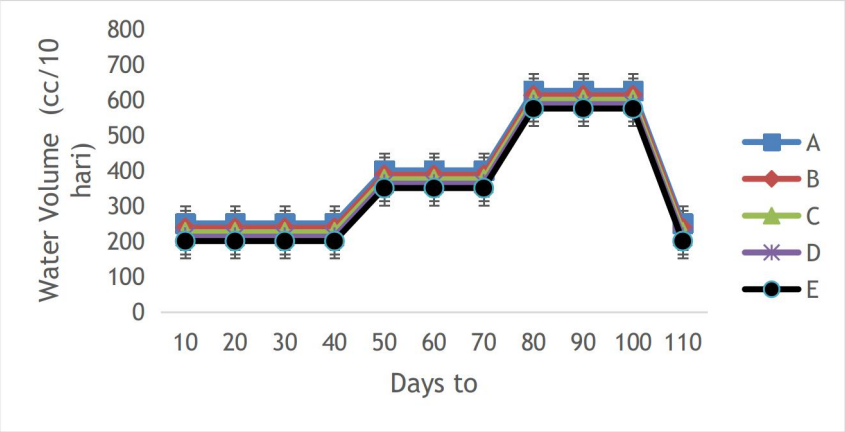

Fig. 1. A Graph of Giving Water Volume to Tomato

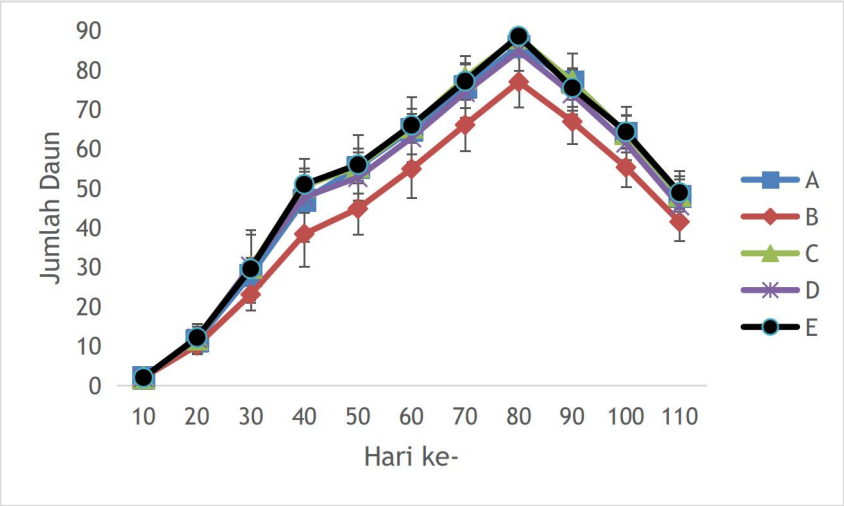

Fig. 2. A Graph of Water Volume on the Amount of Leaf

As the figures above show, there was a different scheme of the amount of leaf after the reduction of water volume. To determine the real effects of water volume on the amount of leaf, an ANOVA testing was conducted, the results of which can be seen in Table 3.

Table 3. The Effect of Water Volume on the Amount of Leaf

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25446.730	33	771.113	1.282	.487
Within Groups	1805.000	3	601.667		
Total	27251.730	36			

According to Table 3, the significant value = 0.487> 0.05 (a real standard of 5%). This indicates that there is no real effect of the reduction of water volume on the amount of leaf.

The analysis of water volume's effects on tomato was conducted from the growth to harvest periods. The reduction of water volume had an impact on soil salinity. Sipayung (2003) stated that the provision of water, when reduced, will increase the salinity of the soil, but the lowest value of it will not affect the amount of leaf. Additionally, Chookhampaeng et al. (2008) stated that salinity in small contents does not affect vegetative growth parameters.

Effect of Water Volume on Productivity of Sweetness

This analysis determined the effects of water volume on the productivity and taste of tomato. The effects can be seen in Figures 3 and 4.

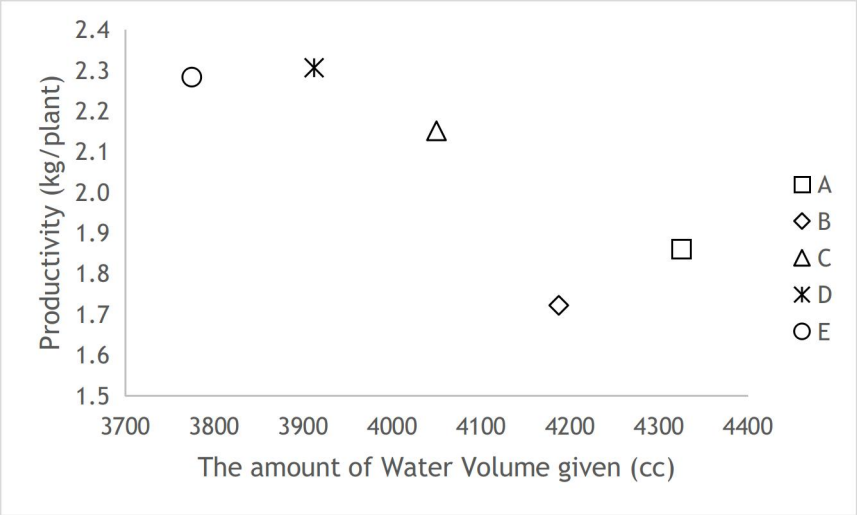

Fig. 3. Effect of Water Volume on Productivity

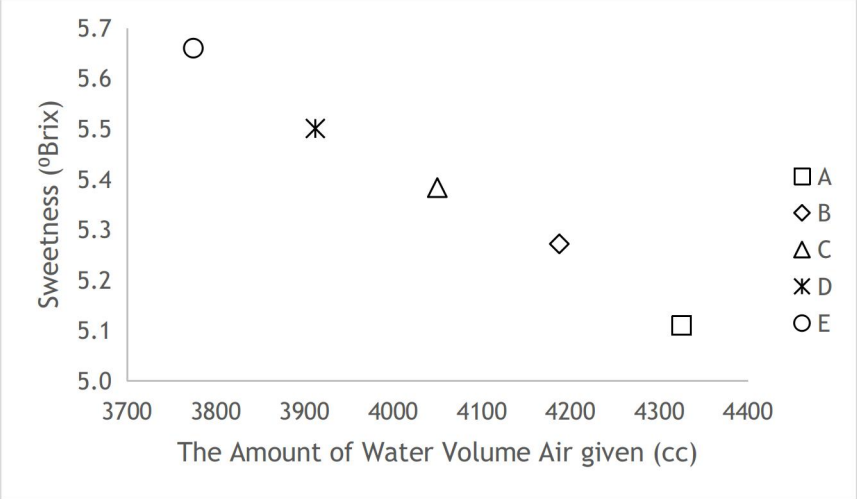

Fig. 4. Effect of Water Volume on Sweetness

The different productivity and sweetness levels for each treatment were caused by the reduction of water supply. The reduction of water supply increased salinity, thus intensifying the level of sweetness of the tomato without affecting productivity. According to Chookhampaeng et al. (2008), an increase in salinity will intensify the sucrose content in a fruit so that the fruit becomes sweeter. The effects of water volume on productivity and sweetness can be seen in Table 4.

Table 4. The Effect of Water Volume on Productivity and Sweetness

		Sum of Squares	df	Mean Square	F	Sig.
Sweetness	Between Groups	.801	12	.067	3.366	.005

	Within Groups	.476	24	.020		
	Total	1.278	36			
Productivity	Between Groups	.053	12	.004	.831	.619
	Within Groups	.170	32	.005		
	Total	.222	44			

Based on Table 4, it gets a significant value from water volume toward the productivity is around 0.619, indicating that water volume does not significantly affect productivity. This is because the significant value is greater than 0.05 (a real standard of 5%). Further, the significant value for the effect of water volume on sweetness was 0.005, indicating that water volume affects the level of taste. This is because the significant value is smaller than 0.05.

Salinity Effect on the Amount of Leaf

The salinity effect on the amount of leaf was examined to understand the influence of salinity on the increase in the amount of tomato. The effects can be seen in Figure 5 below.

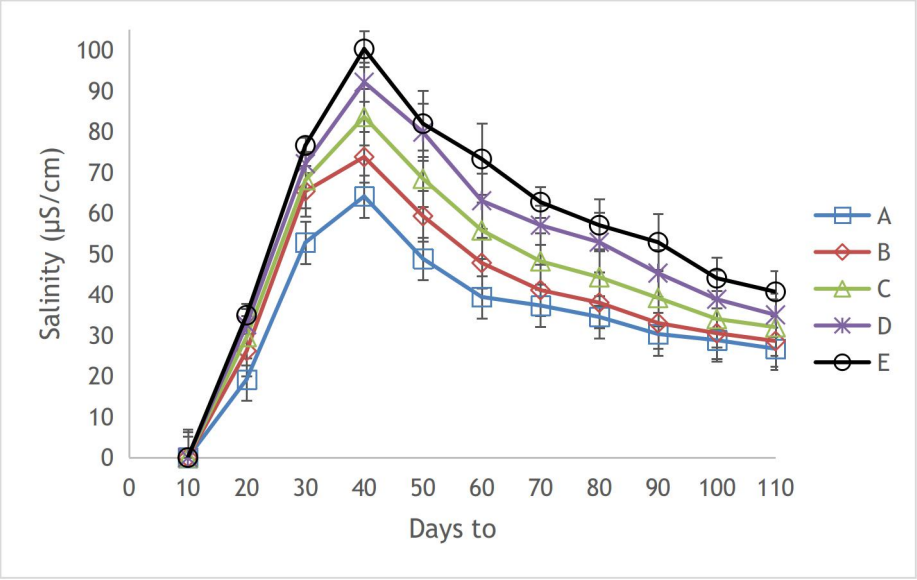

Fig. 5. Effects of Salinity Value on the Amount of Leaf

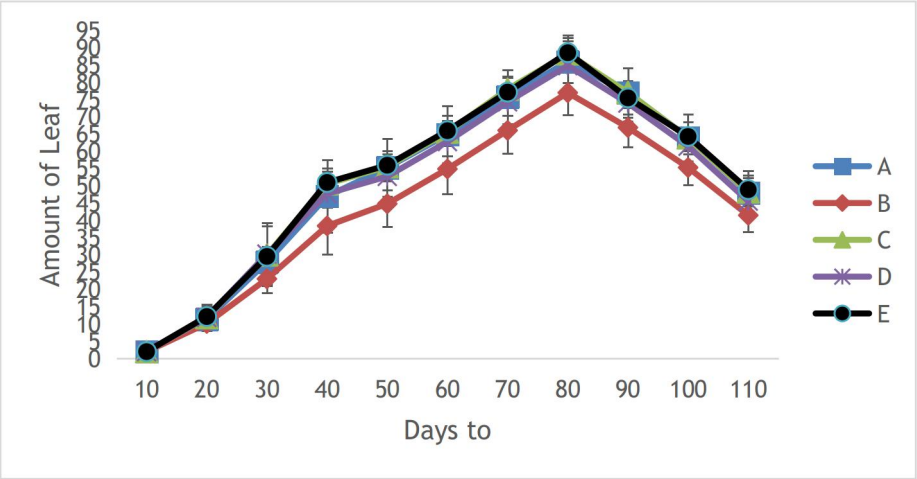

Fig. 6. Salinity Effects on the Amount of Leaf

This figure indicates that there was a salinity effect on the amount of leaf from the 10th day to the 110th day. Salinity jacks up osmotic tension in the rooting zone, reducing the absorption of water by the plant. This inhibition of water absorption will cause disruption growth of the plant from the vegetative to generative periods. In the vegetative period, it will see the amount of leaf in which the different value of salinity causes the amount of leaf which is not significantly different. Chookhampaeng et al. (2008) stated that salinity at a lower content level does not have the effect of obstructing the vegetative growth parameter. The effect of salinity on the amount of leaf can be seen in Table 5.

Table 5. Effect of Salinity on the Amount of Leaf

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	25446.730	33	771.113	1.282	.487
Within Groups	1805.000	3	601.667		
Total	27251.730	36			

Based on the table above, the salinity value of the amount of leaf is 0.487, indicating that salinity does not affect the amount. This is caused by the significant value > 0.05.

Effect of Salinity on Productivity

Analysis of the effects of salinity on productivity was conducted to determine the effect of increasing salinity on the productivity of tomato. The effects can be seen in Figure 7.

Fig. 7. Salinity Effect on Productivity

According to Figure 7, there is a difference in productivity at each treatment level. Productivity from treatment that has been controlled is 1.86 kg. Treatment B had a productivity of 1.72 kg, treatment C had a productivity of 2.15%, treatment D had a productivity of 2.30, and treatment E had a productivity of 2.28%. The difference in these productivities was caused by salinity. The higher the level of salinity is, the more the fruit will experience shrinkage and it affects to the amount of it at each treatment applied. A side effect of salinity is that it makes tomato harsher, but overall, the factor of salinity in regard to tomato does not affect to all of the treatment. Chookhampaeng et al. (2008) stated that the enhancement of salinity reduces the amount and size of a fruit, but a salinity value that is not much different will not affect the productivity too much. The influence of the salinity effect can be seen in Table 6.

Table 6. Salinity Effect on Productivity

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.145	47	.003	1.316	.478
Within Groups	.007	3	.002		
Total	.152	50			

Based on the table above, the significant value is 0.478 because it is >.05. Thus, there is no real effect of the enhancement of salinity on the productivity of tomato.

Effect of Salinity on the Taste of Tomato

Sweet taste is a factor in enhancing the quality of tomato. The effects of salinity on taste can be seen in Figure 8.

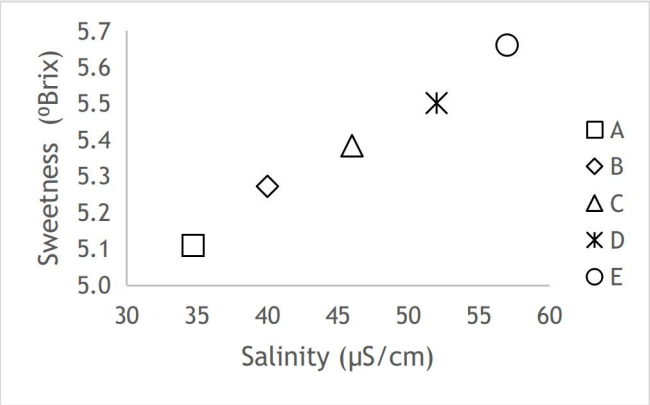

Fig. 8. Salinity Effect on Sweetness

The enhancement of salinity can enhance sweetness. A plant that is controlled has a higher outcome of photosynthesis compared to a plant given by reducing water supply. The result of photosynthesis is becoming central to enhancing the size of fruits and not much changing to have sugar content in tomato so as the level of sweetness becomes low, in contrast to the plant given by reducing water supply, although the result of photosynthesis produced lower but it is changed to have more sugar content, therefore the taste of it enhancing.

One of the adaptation forms of salinity in tomato is osmoregulation (osmotic potential regulation). This form engages with synthesis and an accumulation of organic compounds to reduce osmotic potential cells and enhance turgor pressure. A synthesis organic compound is a direct response to salinity, including sugar compounds, organic acids, and amino acids (Saito et al. 2008). These compounds protect enzymes from being hindered by low internal water activities (Sipayung, 2003). This leads to the enhancement of sweetness of tomato which is given a reducing water supply. This effect can be seen in Table 8. Saito et al. (2008) stated that salinity can enhance dissolved solids (sweetness), surface color density, and hardness of fruit flesh, but the fruit enlargement emphasized.

Table 7. Salinity Effect on Sweetness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.794	47	.081	13.023	.028
Within Groups	.019	3	.006		
Total	3.813	50			

In Table 7, the significant value from salinity to sweetness is 0.028, indicating that salinity has an effect on the level of sweetness. This is because it is < 0.05.

Effect of Salinity on Germination

Analysis of germination was conducted to determine how many germinated plants can grow. The first germination grown is 60 stems. Reducing the water supply enhanced the salinity of the ground; the enhancement of salinity without too much amount does not affect the growth of plant. Cuartero and Fernandez (1999) stated that a tomato can easily suffer from cell damage and become depressed because of high salinity, but it will still survive by reducing its economical yield. On the 50th day, the 10th and 11th polybags were found to have a leaf curling virus, so they were placed separately from the other plants. This virus attacked no more than 58 tomato stems.

CONCLUSIONS AND SUGGESTIONS

Conclusion

1. Reducing the supply of water leads to higher salinity but does not affect growth.
2. Enhancement of salinity will enhance the grade of sweetness without affecting productivity.
3. Salinity with treatment E (normal - (normal x 20%)) of water is the best form of treatment and saves more water (as much as 20%).

Suggestion

1. The effect of salinity on the enhancement of tomato's taste can serve as basic material for tomato plantation and for enhancing harvesting quality.
2. Further research can investigate the maximum limitations for reducing water supply and salinity to enhance the quality of tomato and achieve a perfect yield.

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