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The Effect of Various Fertilizer Application and Soil Humidity on Quality of Tomato

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Abstract.

This research aimed to study the quality of tomato grew under different fertilizer applications and soil moisture levels. The green house experiment was set in a Randomized Completely Block Design. The treatments were various types of fertilizers (Liquid Organic Fertilizer/LOF, inorganic fertilizer/AB Mix, LOF+AB Mix) and different soil moisture levels (30%, 45%, 60%, 75%). Tomatoes were planted in polybags in a green house and treated according to the experimental design; each treatment was replicated three times. The results showed that there was an interaction between type of fertilizers and soil moisture in affecting fruit sugar content and fruit diameter. Sugar content of tomatoes harvested from plant treated with AB Mix and grew under 30% soil moisture level was not significantly different from tomatoes grew under 45% soil moisture level and treated with AB Mix or LOF, but the sugar content was significantly higher than those grew under 60% or 75% soil moisture level treated with different type of fertilizer. Tomato plants treated with LOF and grew under 30% soil moisture level significantly produced smaller fruits than those treated with AB Mix only or AB Mix+LOF grew under 45%, 60% or 75% soil moisture except those treated with AB Mix+LOF grew under 45% soil moisture. The percentage of tomatoes infested by fruit rot was not significantly affected by type of fertilizers and but affected by soil moisture. The lowest fruit rot intensity occurred on plant grew under 30% soil moisture level.

Keywords: inorganic fertilizer, liquid organic fertilizer, quality, soil moisture, tomato

1. Introduction

Tomato is widely grown in various regions in Indonesia. Indonesian tomato production in 2016 was 883,233 tons of the harvested area of 57,688 ha with a productivity of 15.31 tons /ha, in 2017 the harvested area drop to 55,623 ha with a production of 962,845 tons, resulting in an increase in production of 9.01 tons and an increase in productivity to 13.06 tons/ha (RI Ministry of Agriculture, 2019). Tomatoes are one of the favorite vegetables consumed by the people of Indonesia. Tomato consumption per person per week was 0.080 kg in 2015 and increased to 0.085 kg in 2016, so the estimated national tomato consumption in 2015 was 1,045,620 tons and in 2016 amounted to 1,149,160 tons (Central Bureau of Statistic, 2017). By comparing the production and consumption data of tomatoes in 2016 it is estimated that there is a shortage of tomato supply to meet domestic needs. With the trend of increasing tomato demand from year to year, it is necessary to increase national tomato production.

Increasing tomato production can be done by increasing the area of land and intensification on existing land. In conventional tomato cultivation, farmers rely on the use of inorganic fertilizers to provide nutrients for plants. The use of inorganic fertilizers continuously without being balanced with the use of organic matters will cause a decrease in soil quality in the form of a decrease in soil fertility and micro nutrients content, in addition to that the soil becomes hard and decreases its porosity (Zhang *et al*., 2008).

Organic fertilizers besides contain macro nutrients also contain micro nutrients, whereas inorganic fertilizers only provide certain macro nutrients. Research shows that soil fertility increases after long-term use of organic fertilizer (Granstedt & Kjellenberg, 1997; Lazcano *et al*., 2013). The results of plants that were given organic fertilizer were not significantly different from plants that were given inorganic fertilizers. Red onions fertilized with chicken manure, goat manure or cow manure at a dose of 20 tons/ha or 40 tons/ha gave yield not significantly different from plants that were given inorganic fertilizer (Abdelrazzag, 2002; Yoldas *et al*., 2011).

Moisture content of the soil also affects the vegetative growth of plants. In tomato plants drought stress affects the vegetative growth of tomato plants. Tomato planted in drought stress (reduction in soil moisture) 75% resulted in vegetative growth (plant height, number of leaves, wet weight and dry weight of plants) lower than tomato planted in drought stress 50% or 25%. Tomato planted at 75% drought stress also absorbed the lowest N nutrients compared to tomato planted at 50% or 25% drought stress (Hara & Saha, 2000). In beans plants soil moisture affected plant height, but did not affect the number of leaves and number of stem segments (Bierhuizen & Vos, 1959). Given that plant responses to fertilizer application and soil moisture conditions vary, a comprehensive study needs to be carried out. This study aimed to examine the effect of applying various types of fertilizers (inorganic and organic) and various levels of soil moisture on the quality of tomato.

2. Materials and Methods

The study was conducted in a greenhouse in Karangnongko Hamlet, Maguwoharjo Village, Depok District, Sleman Regency. The experiment was arranged in a Randomized Completely Block Design (RCBD) with two factors and replicated 3 times. As a treatment, the first factor is the type of fertilizer, i.e., liquid organic fertilizer (LOF), inorganic fertilizer (AB Mix), LOF + AB Mix; the second factor is the soil moisture level, i.e., 30%, 45%, 60%, 75%. Liquid organic fertilizer was formulated by the researchers from fermented fruits waste.

Tomatoes planted were hybrid variety Liontin F1. Seedlings were planted in 35 cm-sized polybags filled with soil from Gunung Kidul mixed with compost in a ratio of 2: 1. Fertilizers, according to treatment, were given once a week starting at 2 weeks after planting (WAP) up to 6 weeks after planting. Plant watering was set according to soil moisture treatment. Soil moisture control was done automatically with sensors that utilized information technology. Pest and disease control was not carried out.

Tomato fruits were harvested at full maturity shown by the reddish orange of fruit skin color. Observation for tomato quality was conducted on sugar content (Brix number), fruit weight, fruit diameter, and fruit rot intensity (%). Harvested fruits were kept in room temperature (27 ±2°C) then the sugar content was measured at 13 days, 15 days, and 17 days after storage. The observed data were subjected to Analysis of

Variance (ANOVA, α = 5%) and followed by Duncan's Multiple Range Test using SPSS for Windows version 15 (α = 5%).

3. Results and Discussion

Sugar content in tomato fruit was shown in brix number (total soluble solids). The results showed that there was an interaction between type of fertilizers and soil moisture in affecting tomato sugar content. Tomato treated with AB MIX with 30% soil moisture or treated with LOF or AB MIX with 45% soil moisture produced fruit with the highest sugar content in comparison to other treatments. Liquid Organic fertilizer (LOF) and AB MIX provide sufficient nutrients to support sugar formation in tomato (Table 1).

Several studies showed that to some extent water stress could increase the quality of tomato. In comparison to tomato with full irrigation, plants with less irrigation or under water stress produced tomato with higher color intensity, lower water content, higher sugar content although fruit yield, size and number were decreased (Pulupol *et al*., 1996; Nuruddin *et al*., 2003; Johnstone *et al*., 2005; Favati *et al*., 2009; Chen *et al*., 2013).

Table 1. Sugar content (brix number) of tomato grew under different type of fertilizer and soil moisture

Type of fertilizers	Soil Moisture				Mean
	30%	45%	60%	75%	
LOF	10,86 cde	11,51 ab	11,04 bcd	10,73 cde	11,04
LOF+AB Mix	10,84 cde	10,96 cd	10,56 de	10,86 cde	10,80
AB Mix	11,67 a	11,17 abc	10,84 cde	10,39 e	11,02
Mean	11,12	11,21	10,81	10,66	(+)

Means followed by same letter is not significantly different subjected to DMRT (P≤0,05);
(+) There was an interaction between treatments; LOF= Liquid Organic Fertilizer

Fruit storage life can be used as an indicator to find out how long a commodity can be stored while still having good fruit quality. In this study, tomato fruits were harvested when the color of skin fruit was reddish orange, indicating that the fruit has reached its maturity. Tomatoes harvested from plants treated with LOF significantly contained highest sugar content that those treated with LOF+AB MIX or AB Mix at 13 days of storage, However, type of fertilizers did not significantly affect the sugar content at 15 days and 17 days of storage. Plants grew under 30% soil moisture produced fruits contained the highest sugar content than those grew under higher soil moisture (45%, 60% or 75%) at 13 days, 15 days and 17 days of storage (Table 2). It was observed that in comparison to sugar content of tomato at harvest time, the sugar content of tomatoes decreased steadily over the duration of storage (13 days, 15 days, 17 days of storage) (Table 1, Table 2). This result was similar to those of Islam *et al*. (1996).

Table 2. Sugar content (brix number) of tomato of storage in room temperature

Treatment	13 days of storage	15 days of storage	17 days of storage
Fertilizer			
LOF	10,95 a	10,58 a	10,32 a
LOF+AB Mix	10,58 b	10,28 a	10,09 a
AB Mix	10,65 b	10,34 a	10,04 a

Soil Moisture			
30%	11,44 p	11,14 p	10,89 p
45%	11,02 q	10,78 q	10,61 p
60%	10,38 r	10,10 r	9,79 q
75%	10,07 r	9,59 s	9,31 r
Interaction	-	-	-

Means in the same column followed by same letter is not significantly different subjected to DMRT (P≤0,05); (-) No interaction between treatments; LOF= Liquid Organic Fertilizer

Tomatoes after harvesting still carry out metabolic processes using food reserves available in the fruit. The reduction in food reserves cannot be replaced because the fruit is already separated from the plant, so storage accelerates the loss of the nutritional value of the fruit and accelerates the ripening process. Post-harvest ripening will change the chemical composition of fruit, including sugar content (total soluble solids). Islam *et al*. (1996) found that total soluble solids in tomato harvested at vine-ripened stage (deep pink color) decreased linearly over the duration of storage (0-16 days). However, Duma *et al*. (2017) found that soluble solids in tomato fruits harvested at green stage of maturity increased after 24 days of storage and decreased after 36 days of storage. The differences between these studies could be because of the state of tomato fruits when harvested was different. When tomatoes are harvested at mature green, during ripening polysaccharides are degraded into simple sugar. In addition, starch is hydrolyzed into sugar, thereby the sugar content is increase. This phenomenon was also observed by Mulindwa *et al*. (2018) and Sta. Iglesia *et al*. (2013).

Table 3. Fruit weight (gram) of tomato grew under different type of fertilizer and soil moisture

Type of fertilizers	Soil Moisture				Mean
	30%	45%	60%	75%	
LOF	8,67	28,28	39,44	30,67	26,76 a
LOF+AB Mix	18,56	15,33	28,44	34,44	24,19 a
AB Mix	18,67	23,83	29,56	31,28	25,83 a
Mean	15,30 q	22,48 pq	32,48 p	32,13 p	(-)

Means followed by same letter is not significantly different subjected to DMRT (P≤0,05); (-) No interaction between treatments; LOF= Liquid Organic Fertilizer

Tabel 4. Fruit diameter (mm) of tomato grew under different type of fertilizer and soil moisture

Type of fertilizers	Soil Moisture				Mean
	30%	45%	60%	75%	
LOF	10,47 b	32,13 a	37,47 a	36,27 a	29,08
LOF+AB Mix	26,79 a	21,44 ab	33,89 a	36,57 a	29,68
AB Mix	29,12 a	33,95 a	33,53 a	34,39 a	32,75
Mean	22,13	29,17	34,96	35,74	(+)

Means followed by same letter is not significantly different subjected to DMRT (P≤0,05); (+) There was an interaction between treatments; LOF= Liquid Organic Fertilizer

Tomato fruit weight was not significantly affected by type of fertilizers, but fruit weight was affected by soil moisture content. Plants grew under 30% soil moisture produced fruit with significantly lighter weight than those grew under 60% or 75% soil moisture (Table 3). Tomato fruit size was significantly affected by interaction between type of fertilizer and soil moisture. Plants fertilized with LOF and grew under 30% soil moisture produced significantly the smallest fruit than plants with other treatment (Table 4). Plant grown under water stress or low soil moisture content will produced smaller fruit and lower yield (Pulupol *et al*., 1996; Nuruddin *et al*., 2003; Johnstone *et al*., 2005; Favati *et al*., 2009; Chen *et al*., 2013).

Water is needed by plants to dissolve nutrients in the soil. Besides that water is also an important component in photosynthesis, so lack of water will reduce the rate of photosynthesis so that the photosynthate produced to form fruit is also less. Macro nutrients NPK (Nitrogen, Phosphor, Kalium) found in organic fertilizers and inorganic fertilizers have the same function in plant growth. Nitrogen plays a role in protein synthesis for the formation of plant cells and serves to encourage vegetative growth with plants (Lawlor, 2002). Phosphor is needed in energy formation, nucleic acid synthesis, photosynthesis, glycolysis, respiration, synthesis and membrane stability, activation / inactivation of enzymes, redox reactions, carbohydrate metabolism, and nitrogen fixation (N) (Vance et al., 2003). Potassium (Kalium) plays a role in biochemical and physiological processes that affect plant growth and plant metabolism. Potassium also functions to increase plant resistance to environmental stress, such as drought, salinity, pests and diseases (Wang et al., 2013). Potassium helps the activation of enzymes and absorption of nutrients and water from the soil and photosynthate transportation from leaves to other plant tissues (Marschner, 2012).

Tabel 5. Fruit rot intensity (%) of tomato grew under different type of fertilizer and soil moisture

Type of fertilizers	Soil Moisture				Mean
	30%	45%	60%	75%	
LOF	30,3	27,8	16,7	25,3	25,0 a
LOF+AB Mix	15,1	33,2	21,2	21,7	22,8 a
AB Mix	13,9	22,4	31,7	27,9	24,0 a
Mean	19,8 q	27,8 p	23,2 p	25,0 p	(-)

Means followed by same letter is not significantly different subjected to DMRT (P≤0,05); (-) There was no interaction between treatments; LOF= Liquid Organic Fertilizer

Type of fertilizers did not significantly affect fruit rot intensity on tomato. However, soil moisture content was significantly affected the fruit rot intensity. Plant grew under 30% soil moisture significantly has the least infestation of fruit rot (Table 5). Tomato fruit rot disease is caused by *Rhizoctonia solani* Kiihn. Pathogen infestation is usually high when micro-climate around the plant is humid. Therefore, when soil moisture increase fruit rot intensity also increase.

4. Conclusions

Sugar content of tomato fruit harvested from plant treated with AB Mix and grew under 30% soil moisture level was not significantly different from tomato grew under 45% soil moisture level and treated with AB Mix or LOF, but the sugar content was significantly higher than those grew under 60% or 75% soil moisture level treated with different type of fertilizer. Tomato plant treated with LOF and grew under 30% soil moisture level significantly produced smaller fruit than those treated with AB Mix only or AB Mix+LOF grew under 45%, 60% or 75% soil moisture except those treated with AB Mix+LOF grew under 45% soil moisture. The percentage of fruit infested by fruit rot was not significantly affected by type of fertilizer but affected by soil moisture. Plants with the lowest soil moisture (30%) suffered from the lowest fruit rot.

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