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Growth, Yield And Quality Of Tomato Cultivated Under Various Fertilizers And Soil Moisture Levels

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Abstract

This research aimed to study the growth, yield and quality of tomato grown under different fertilizers and soil moisture levels. The green house experiment was set in a Split Plot arranged in Randomized Completely Block Design. The main plot treatments were various types of fertilizer (Liquid Organic Fertilizer/LOF, inorganic fertilizer/AB Mix, LOF+AB Mix) and the sub plot treatments were different soil moisture levels (30%, 45%, 60%, 75%). Tomatoes were planted in polybags and cultivated with treatments according to the experimental design, each treatment was repeated three times. The results showed that the highest plant height was achieved on tomato treated with LOF+AB Mix at 55 dat (days after transplanting) and 62 dat. Plant height and number of leaves of tomato planted on soil with moisture level 60% at 62 dat were significantly higher than those with soil moisture level 30% and 45%, but were not significantly different from those with soil moisture level 75%. Flowering stage was not significantly affected by soil moisture level. The shortest flowering stage was occurred on tomato treated with AB mix. Plant treated with AB Mix yielded the highest number of fruits/plant. Plants fertilized with a combination of LOF+AB Mix under 60% soil moisture yielded fruits with higher content of glucose, vitamin C and Beta carotene. In conclusion, the application of inorganic fertilizer resulted in the highest yield, but a combination of inorganic and organic fertilizers yielded fruits with a better quality.

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

Introduction

The tomato is one of the vegetables that is widely grown in various regions in the world. Tomato fruit is rich of various antioxidants, including beta carotene, lycopene and vitamin C. Tomato fruit is consumed fresh and processed. However, most of the tomato production goes to tomato processing industry. There is a steady increasing demand of tomato for processing industry. It is predicted that there will be a short for tomato production to meet the demand in 2020 (Branthôme, 2019)

Increasing tomato production can be done by increasing the land area and intensification of 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 matter

will cause a decrease in soil quality in the form of decreased soil fertility and micro nutrient content, besides that the soil becomes hard and decreases in porosity (Zhang et al., 2008).

Organic agriculture was developed in response to the demands of maintaining environmental quality and healthy lifestyles. Organic agricultural products are healthier because in the production process they avoid the use of production inputs made of synthetic chemicals. Holistically, the health and sustainability of soil, plants and other living things are maintained in balance in the implementation of organic agriculture (Mayrowani, 2012). Plant health is maintained by providing sufficient nutrients from organic fertilizers. In addition to containing macro nutrients, organic fertilizers also contain micro nutrients, while inorganic fertilizers only provide certain macro nutrients. Organic fertilizers, both solid and liquid, can be made from various fermented plant residues or livestock waste. In addition, market waste can also be used as organic fertilizer.

Research shows that soil fertility increases after long-term use of organic fertilizers (Granstedt&Kjellenberg, 1997; Lazcano et al., 2013). The yields of plants given organic fertilizers were not significantly different from those given inorganic fertilizers. Onion plants fertilized with chicken manure, goat manure or cow manure at a dose of 20 tonnes/ha or 40 tonnes/ha gave results that were not significantly different from plants treated with inorganic fertilizers (Abdelrazzag, 2002; Yoldas et al., 2011).

Soil moisture content also affects the vegetative growth of plants. In tomato plants, drought stress affects the vegetative growth of tomato plants. Tomato plants planted in drought stress (reduction in soil moisture) of 75% gave a lower vegetative growth (plant height, leaf number, wet weight and plant dry weight) compared to tomato plants planted in 50% or 25% drought stress. Tomato plants in drought stress of 75% also absorb the lowest N nutrient compared to tomato plants in drought stress of 50% or 25% (Hara &Saha, 2000). In beans, soil moisture affects plant height, but does not affect the number of leaves and number of stem segments (Bierhuizen& Vos, 1959). Given that the response of plants to fertilizer application and soil moisture conditions varies, it is necessary to conduct a comprehensive study, especially to examine their impacts not only to plant growth but also on the yield quality i.e. content of vitamins and sugar. This study aimed to determine the effect of various types of fertilizers (inorganic and organic) and various levels of soil moisture on the growth, yield and quality of tomato..

Materials and Methods

The research was conducted in a greenhouse in Karangnongko Hamlet, Maguwoharjo Village, Depok District, Sleman Regency, Indonesia. The experiments were arranged in a Split Plot, Randomized Completely Block Design with three replications for each treatment. The main plot treatments were the different types of fertilizer, i.e., liquid organic fertilizer (LOF), inorganic fertilizer (AB Mix), ½ dose LOF + ½

dose AB Mix; the sub plot treatments were the level of soil moisture, i.e., 30%, 45%, 60%, 75%. Liquid organic fertilizer was formulated by the researchers from fermented fruit waste and other materials.

The tomatoes grown were the F1 Liontin hybrid variety. Seedlings were planted in 35 cm-sized polybags, which were given karst soil from GunungKidul, Yogyakarta mixed with compost in a ratio of 2: 1. Fertilizer according to the treatment was given once a week starting from 14 days after transplanting (dat) to 42 dat. Plants was regularly watered and controlling soil moisture was carried out automatically with sensors that utilize information technology. Pest and disease control was not carried out. Observation of plant height and number of leaves was carried out at 47 dat, 55 dat and 62 dat. The number of flowering plants was observed every two days starting when the plants began to flower until all the plants flowered (100%). Flowering stage of plants was determined when the entire cropping population has flowered> 50%. The observed data were analysed for their diversity and continued with Duncan's multiple range test using SPSS for Windows version 15 (α = 5%).

Results and Discussion

The height of the tomato plant at the age of 47 DAS was not significantly influenced by soil moisture and the type of fertilizer used. The height of the tomato plant at 55 days after planting was not significantly affected by soil moisture but it was influenced by the type of fertilizer used. Plants given a combination of AB Mix + LOF (Liquid Organic Fertilizer) were significantly higher than those given AB Mix or LOF fertilizers alone. The height of the tomato plants aged 62 dat and 69 dat was significantly influenced by soil moisture and the type of fertilizer used. Plants given a combination of AB Mix + LOF (Liquid Organic Fertilizer) were significantly higher than those given AB Mix or LOF fertilizers alone. The height of tomato plants planted at 60% soil moisture was not significantly different from plants planted at 75% humidity but was significantly higher than plants planted at 30% or 45% soil moisture (Table 1). The results of this study are in line with the research of Imana et al., (2010) which showed that tomatoes grown at soil moisture 55% and 40% of field capacity had a significantly lower plant height than those planted at 100% field capacity.

Table 1. Tomato plant height at 47-62 days after transplanting (dat) grown under various fertilizer and soil moisture (cm)

Treatments	47 dat	55 dat	62 dat
Fertilizer			
LOF	46,1 a	75,0 b	88,8 c
LOF+AB Mix	46,4 a	82,4 a	100,3 a
AB Mix	45,0 a	77,3 b	94,2 b
Soil moisture			
30%	44,7 p	79,0 p	92,3 q
45%	45,8 p	76,7 p	91,2 q

60%	46,9 p	80,9 p	98,6 p
75%	45,8 p	76,3 p	95,6 pq
Interaction	-	-	-

The mean followed by the same letter in one column shows no significant difference according to Duncan's Multiple Range Test (P≤0.05); (-) indicates that there is no interaction between treatment combinations; LOF = Liquid Organic Fertilizer

The number of tomato leaves at the age of 47 dat was not significantly affected by soil moisture and the type of fertilizer used. The number of tomato leaves aged 55 dat was not significantly affected by soil moisture but was influenced by the type of fertilizer used. Plants given AB Mix fertilizer had significantly more leaves than those given a combination of AB Mix + LOF (Liquid Organic Fertilizer) or LOF alone. The number of leaves of the tomato plant aged 62 dat was significantly influenced by soil moisture and the type of fertilizer used. Plants given AB Mix fertilizer or a combination of AB Mix + LOF (Liquid Organic Fertilizer) have significantly more leaves than those given LOF alone. The number of leaves of tomato plants planted at 60% soil moisture was not significantly different from plants planted at 75% humidity but there were significantly produced more leaves than plants planted at 30% or 45% soil moisture (Table 2). The results of this study are slightly different from the research of Desmarina et al. (2009), which showed that water stress of 25%, 50%, 75%, 100% of field capacity had no effect on the number of leaves of tomato plants. However, the frequency of watering had more effect on the number of leaves. Tomato plants that were watered once every 2 days have more leaves than those watered once every 4 days or every 6 days.

Table 2. Number of tomato leaves at 47-62 days after transplanting (dat) grown under various fertilizer and soil moisture

Treatments	47 dap	55 dap	62 dap
Fertilizers			
LOF	10,3 a	13,3 c	15,7 b
LOF+AB Mix	9,9 a	15,1 b	19,9 a
AB Mix	9,9 a	17,0 a	21,1 a
Soil moisture			
30%	9,9 p	15,0 p	17,7 b
45%	10,1 p	14,9 p	17,6 b
60%	10,4 p	15,6 p	20,3 a
75%	9,9 p	15,1 p	20,1 a
Interaction	-	-	-

The mean followed by the same letter in one column shows no significant difference according to Duncan's Multiple Range Test (P≤0.05); (-) indicates that there is no interaction between treatment combinations; LOF = Liquid Organic Fertilizer

Plant growth can be shown through the increase in plant height and number of leaves. This study indicated that in the early stages of growth, both inorganic fertilizers and organic fertilizers provide sufficient nutrients for plant growth. However, the older the plant was, the need for nutrients for vegetative growth was higher. Liquid organic fertilizer (LOF) contains macro and micro nutrients, whose availability for plants depends on the raw materials used. Inorganic Fertilizer (AB Mix) contains only macro nutrients. Tomato plants given a combination of inorganic and organic fertilizers (LOF + AB Mix) get a more complete intake of macro and micro nutrients to support their growth.

Table 3. Flowering stage (days), where >50% plants were flowering and yield

Treatments	Flowering stage (days)	Number of fruits/plant	Fruit diameter (mm)	Fruit weight (g)
Fertilizers				
LOF	56.3 b	29.45 b	34,3 a	31,10 a
LOF+AB Mix	57.6 b	32.59 b	32,4 a	26,11 a
AB Mix	54.0 a	46.65 a	32,8 a	25,83a
Soil moisture				
30%	57.1 p	27.17 c	29,1 r	21,07 q
45%	55.7 p	33.89 bc	32,7 q	25,04 q
60%	55.0 p	39.91 ab	35,0 p	32,48 p
75%	56.1 p	43.96 a	35,7 p	32,13 p
Interaction	-	-	-	-

The mean followed by the same letter in one column shows no significant difference according to Duncan's Multiple Range Test (P≤0.05); (-) indicates that there is no interaction between treatment combinations; LOF = Liquid Organic Fertilizer

The flowering stage of the plant is indicated by> 50% of the plant population is already flowering. Flowering stage of tomato plants was not significantly affected by soil moisture but is influenced by the type of fertilizer used. Plants given AB Mix fertilizers were significantly having flowering stage faster than plants given a combination of AB Mix + LOF (Liquid Organic Fertilizer) or LOF (Table 3). This shows that only

inorganic fertilizers that provide macro nutrients can produce flowers more quickly. Furthermore, plants treated with AB Mix were significantly producing more fruits/plant than those treated with a combination of AB Mix + LOF (Liquid Organic Fertilizer) or LOF. Soil moisture significantly affected the production of fruits/plant. The number of fruits/plant was significantly higher on plants cultivated under 60% soil moisture than those cultivated under 30% soil moisture, although it did not significantly different from those with 75% or 45% soil moisture. Tomato fruit size and fruit weight was not significantly affected by type of fertilizers, but was significantly affected by soil moisture. Plants treated with 60% or 70% soil moisture was produced fruits significantly with bigger size (diameter and weight) than those treated with lower soil moisture (Table 3).

These results suggest that plant growth and yield is determined by the availability of balanced soil nutrients and moisture. To support vegetative growth, plants need nitrogen, an essential nutrient that plays an important role in protein synthesis for plant cells development (Lawlor, 2002). Furthermore, plants also need phosphorous nutrient to support the development of energy, nucleic acid synthesis, photosynthesis, glycolysis, respiration, membrane synthesis and stability, activation / inactivation of enzymes, redox reactions, carbohydrate metabolism, and nitrogen fixation (N) (Vance et al., 2003). Moreover, plants need potassium (Kalium) to support biochemical and physiological processes that affect plant growth and plant metabolism. In addition, plant resistance against environmental stress, including drought, salinity, pests and diseases attacked can be increased with the provision of potassium (Wang et al., 2013). Enzyme activation and absorption of nutrients and water from the soil and transport of photosynthate from leaves to other plant tissues is facilitate by potassium (Marschner, 2012).

There was an interaction between type of fertilizers and soil moisture in affecting the glucose, vitamin C and Beta carotene content in tomato fruit. The application of LOF or a combination of LOF+AB Mix under 60% soil moisture produced tomato fruit with the highest glucose content (Table 4). Moreover, plants treated with a combination of LOF+AB Mix under 60% soil moisture produced tomato fruit with the highest Vitamin C content (Table 5). This results is similar to those of Ilupeju et al. (2015) that found combination use of organic and inorganic resulted in higher Vitamin C content in tomato fruits than when it was use each alone. However, Toor et al. (2006), found that plant treated with organic fertilizer (Chicken manure and grass clover mulch) produced tomato fruit with Vitamin C content 29% higher than plant fertilized with mineral nutrient solution. In addition, these results indicated that the content of Vitamin C in tomato fruits did not necessarily in adversary to glucose content. This results is in agreement with Massot et al. (2010) that found that the Vitamin C content in tomato was not determined by the sugar content.

Table 4. Glucose Content in Tomato Fruit (%)

Treatment	Soil Moisture				Mean
	30%	45%	60%	75%	
P1 (LOF)	1,10 c	0,90 d	1,30 a	1,20 b	1,1
P2 (LOF+AB MIX)	1,20 b	1,20 b	1,30 a	0,90 d	1,1
P3 (AB MIX)	1,30 a	1,20 b	0,80 e	0,80 e	1,0
Mean	1,2	1,1	1,1	1,0	(+)

The mean followed by the same letter shows no significant difference according to Duncan's Multiple Range Test (P≤0.05); (+) indicates that there is an interaction between treatment combinations; LOF = Liquid Organic Fertilizer

Table 5. Vitamin C Content in Tomato Fruit (mg/100 g)

Treatment	Soil Moisture				Mean
	30%	45%	60%	75%	
P1 (LOF)	28,97 def	31,16 cd	24,65 g	20,05 h	26,21
P2 (LOF+AB MIX)	22,58 gh	30,30 cde	36,58 a	32,47 bc	30,48
P3 (AB MIX)	33,67 b	30,77 cd	27,46 f	27,83 ef	29,93
Mean	28,41	30,74	29,56	26,78	(+)

The mean followed by the same letter shows no significant difference according to Duncan's Multiple Range Test (P≤0.05); (+) indicates that there is an interaction between treatment combinations; LOF = Liquid Organic Fertilizer

Plants grown with a combination of LOF+AB Mix under 45% soil moisture resulted in tomato fruits the highest content of Beta Carotene than plants fertilized with LOF or AB Mix each alone. Combination of inorganic and organic fertilizer provide more balance nutrient than each alone, thus plants will grow better resulted in higher yield with higher quality including the content of antioxidants (Vitamin C and Beta Carotene) (Ilupeju et al., 2015). Fertilizers with higher content of phosphorus increased the content of Beta carotene, but higher content of potassium resulted in the lowest content of Beta carotene (Zdravković et al., 2007).

Table 6. Beta Carotene Content in Tomato Fruit (µg/100 g)

Treatment	Soil Moisture				Mean
	30%	45%	60%	75%	
P1 (LOF)	14455,20 f	16248,63 d	15096,67 e	18126,01 b	15981,626

P2 (LOF+AB MIX)	12519,93 h	18518,52 a	12582,35 h	10568,77 j	13547,390
P3 (AB MIX)	15163,55 e	11981,22 i	17158,71 c	13109,37 g	14353,211
Mean	14046,22	15582,79	14945,91	13934,72	(+)

The mean followed by the same letter shows no significant difference according to Duncan's Multiple Range Test (P≤0.05); (+) indicates that there is an interaction between treatment combinations; LOF = Liquid Organic Fertilizer

Conclusion

the application of inorganic fertilizer resulted in the highest yield, but a combination of inorganic and organic fertilizers yielded fruits with a better quality.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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