Response of Lycopene, β-carotene and yield of determinate and indeterminate type tomatoes in various of parnet colors at plastic house

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The purpose of this research is to find out the response of lycopene, β-carotene and yield tomato on roof color treatment, especially for determinate and indeterminate type of tomato. The research was conducted in Malang, East Java Indonesia, with a height of 515 m asl. The implementation time of November 2016 - February 2017. The experimental design used is Split Plot Design, with 3 replications. Treatment consists of 2 factors, the main plot is 6 treatment of plastic roof and the sub plot 4 varieties of tomato, there are 24 combination of treatment. Observation variables, consisting of sunlight quality, temperature (maximum and minimum), light intensity, plant height, stem diameter, leaf area, total chlorophyll content, fruit weight per plant, simple determination of lycopene and β-carotene content. Giving roof UV + parnet of different color causing differences in quality and intensity received by plants, and minimum and maximum temperature difference around the plant. Highest plant on Golden Sweet varieties in all treatments except UV roof treatment. The highest total leaf chlorophyll content in the treatment of UV + red-paranet and only UV roof. Widest leaf area on UV roof treatment and UV + red-paranet roof. Fruit weight per plant the highest at UV + red-paranet roofs and UV roof only especially for Betavila varieties. The highest lycopene content in plants grown under UV + blue-paranet roof on Juliet varieties. The highest content of β-carotene when roofed by UV + yellow-paranet and UV roof in Golden Shine tomatoes, and without roof on Juliet tomato variety.

Keywords: Lycopene, β-carotene, Yield, Tomato, Roof color paranet.

INTRODUCTION

High rainfall during the rainy season in Indonesia as a tropical country, causing high diseases for plants. Especially seasonal vegetable crops that have soft stems, one of them tomato plants. One way to prevent disease in the rainy season is by providing plastic roof. This plastic roof can suppress the growth of diseases caused by direct rainfall on the plants (Arya, Pulver, & Genuchten, 2001; Higashide, 2007; Korlina et al., 2016). However, the plastic roof will increase the temperature around the plant, this will cause the respiration of the plant will run quickly when the temperature increases, feared will reduce production (Lurie and Klein, 1991; Lamont and Index, 2005). Disease attacks will also remain high, if high temperatures with high humidity also during the rainy season.

One way to reduce high temperatures around our plants try paranet under UV plastic. Giving of the paranet under UV plastic in some previous studies yielded information that the highest crop production when given a roof of pearl white and red on Vedeta varieties (Ilić & Milenković, 2001)
and on varieties of AlfaV, SCX 248 and Irit vareitas (Tinyane, Sivakumar, & Soundy, 2013). In tomatoes the cherry type will decrease the content of lycopene when inside the plastic housing, while the big tomatoes show the opposite (Kuti & H.B. Konuru, 2005).

In addition to optimal production, tomato plants are a source of external antioxidants that can reduce the chances of prostate cancer. The largest relevant diet study, a prospective study of male health experts found that, consumption of two to four servings of tomato sauce per week was associated with approximately 35% reduction in total prostate cancer and a 50% reduction in advanced (extraprostatic) prostate cancer (Giovannucci, 2002). Some other degerative diseases can also decrease with the consumption of this fruit one of them lung cancer (Palozza, R. E. Simone, A. Catalano, & M. C. Mele, 2011), cervical cancer (Peng et al., 1998). Tomato fruit in addition to lowering the risk of cancer pain also plays a role in heart disease, epidemiological studies conducted so far provide convincing evidence for the role of lycopene in protecting against cancer and heart disease (Omoni & Aluko, 2005).

The content of lycopene and β-carotene tomatoes also depends on varieties of tomato plants. Red tomatoes have higher lycopene content than yellow tomatoes Red fruit does not always have the same high lycopene content, depending on the sharpness of fruit color resulting from the ratio of lycopene and β-carotene content (Rosati et al. 2000). How the response of lycopene, β-carotene and tomato production on the roof color treatment, at determinate type and indeterminate type tomato are the objectives of this study.

MATERIALS AND METHODS

The research was conducted at AIAT East Java with height of place 515 m asl. Start from November 2016 till February 2017. The experimental design used is Split Plot, with 3 replications The treatment consists of 2 factors, the main plot are 6 treatment of UV plastic roof, there are without roof, UV plastic roof, UV + yellow paranet, UV + red paranet, UV + green paranet and UV + blue paranet. Sub plot are 4 varieties of tomatoes, there are 2 indeterminate type (Juliet and Golden Sweet) and 2 determinate type (Golden Shine and Betavila). So that it consists of 24 combinations of treatments.

Observation variable consisting of:

The quality of light were absorbed roofing material
Absorption of wavelength of light by UV plastic and each color paranet with a spectrophotometer.

Air temperature (maximum and minimum)
Measurements were made daily during the experiment with the minimum HTC-1 minimum thermometer.

The intensity of sunlight
Measurements inside and outside the roof with Lutron Type LX-107 Light meters

Plant height
Measurement of plant height from base of stem above ground until plant growth point.

Diameter of stem
Measure of stem diameter were performed at the base of the plant crop about 5 cm from the soil, using a sliding range.

Leaf Area
Measurement of leaf samples taken from field in measuring leaf area using Leaf Area Meter brand Licor Type Li 3100, in laboratory of Environmental Resources, Faculty of Agriculture, Universitas Brawijaya, Malang, Indonesia.

Total leaf chlorophyll content
Chlorophyll a and b in the leaves were measured using the Nagata & I. Yamashita method (1992), by introducing the Acetone-hexane solution in the test tube with a ratio of 4: 6, 10ml. Entering a sample or tomato leaf as much as 1 g to the Acetone solution: Hexane. Then mix in the mixture until well mixed with the homogenizer until mixed, then the solution is measured with a spectrophotometer, at a wavelength of 663 nm and 645 nm. The measurement results are calculated by the following equation.

\[ Chlorophyll \text{ total} = Chlorophyll \ a + Chlorophyll \ b \]

\[ Chlorophyll \ a = (0.999A663 - 0.0989A645) \]

\[ Chlorophyll \ b = (-0.328A663 + 1.77A645) \]
The measurement of varieties

carotene

Fruits are harvested and weighed per plant, every 2-5 days 1x, harvested fruits that have been cooked evenly.

Simple determination of lycopene and β-carotene content.

The fruits for this observation parameter are taken on the top branches that have been cooked red / yellow evenly. Entering a sample or tomato fruit as much as 1 g in 10 ml the Acetone solution: Hexane (4:6). Then the mixture was mixed until homogenizer blended evenly, then the solution was measured by spectrophotometer, at wavelength 663 nm, 645 nm, 505 nm and 453 nm (Nagata and Yamasita, 1992). The measurement results are calculated by the equation:

\[
\text{Lycopene} = -0.0458A_{663} + 0.204A_{645} + 0.372A_{505} - 0.0806A_{453}
\]

\[
\beta - \text{carotene} = 0.216A_{663} - 1.22A_{645} - 0.304A_{505} + 0.452A_{453}
\]

The experimental data were analyzed to find out the real difference of treatment. The result of the real difference was continued with Duncan’s α = 0.05, to determine the difference between treatments.

RESULTS AND DISCUSSION

Light quality, sunlight intensity, minimum and maximum air temperature

The results show that the UV + paranet of various colors, continuing different lights, the red-paranet roof absorbs the lowest waves compared to other colors, the greenest paranet that absorbs most of the wavelength of light (Figure 1.). The UV + Paranet treatment shows a higher minimum temperature than without a roof. While the lowest maximum temperature in non-roof treatment due to the implementation of research during the rainy season in November 2016 to February 2017, where the sun during the rainy season is lower than during the dry season. The intensity of light of each roof treatment shows a difference, although the thickness of the roofing material is the same but the different colors turn out to have different intensity effects (Table 1). In previous studies, color paranet studies with different light intensities turned out to be the diverse intensity received by one type of tomato varieties from Vedeta (Ilić & Milenković, 2001).

Plant height

Plant height 12 weeks, there is an interaction between the roof treatment with varieties, of Golden Sweet Tomato varieties at 12 weeks of age have the highest plant height was 205,0 cm when planted in UV + yellow-paranet, and low when planted on the roof of UV. Plant height of Juliet variety, age of 12 weeks did not show much difference in all the treatment color of the paranet. Tomato Golden Shine varieties are highest when grown in UV + red-paranet treatment, and low if planted with UV treatment. The highest variety of Betavila when grown under UV + paranet yellow, and low when planted with UV roof without paranet. Almost as a whole it can be seen that giving UV plastic without paranet has the lowest plant height. This occurs because of the high maximum temperatures around the plants (Table 1), so that respiration progresses more quickly and consequently the result of photosynthesis of plants is reduced (Taiz and Zeiger, 2010). High temperatures also cause many crops to lose water, resulting in slower plant growth (Peet & Welles, 2005). The highest plant height is the Golden Sweet (Figure 2.). These tomato are indeterminate types that are always elongated despite being has entered the generative period (Fridman et al., 2001; Kusumayati, Nurilaeh, and Setyobudi, 2015).

Stem diameter

The diameter of the stems in this experiment showed no interaction between the roof treatment and the varieties used. The treatment of varieties used, Golden Shine and Betavila varieties has the widest diameter of 9,383 mm and 9,228 mm, followed by Juliet and the last Golden Sweet varieties. Golden Shine and Betavila are the type of determinate tomato, which, when it has entered the generative phase, vegetative growth will be slower because the shoot tip is always the flower / fruit (Budijaya, 1997; Fridman et al., 2001). On the roof treatment factor, on the UV plastic roof treatment showed the largest stem diameter of 9,575 mm compared with no roof and UV +

Information:

A663 = wavelength of 663 nm absorbed
A645 = wavelength of 645 nm absorbed

The weight of fruit per plant

Fruits are harvested and weighed per plant, every 2-5 days 1x, harvested fruits that have been cooked evenly.
yellow-paranet. The smallest stem diameter was in UV + green-paranet was 7,982 mm (Table 2).

![Figure 1. Absorption of wavelength of light by UV and paranet roof, with spectrofotometer](image)

**Table 1.** Minimum temperature, maximum temperature and Intensity around the plant on roof color treatment

<table>
<thead>
<tr>
<th>Roof treatment</th>
<th>Parameters observation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum temperature (°C)</td>
</tr>
<tr>
<td>No roof</td>
<td>20.52</td>
</tr>
<tr>
<td>UV</td>
<td>20.94</td>
</tr>
<tr>
<td>UV+ Yellow-Paranet</td>
<td>20.86</td>
</tr>
<tr>
<td>UV+ Red-Paranet</td>
<td>20.71</td>
</tr>
<tr>
<td>UV+ Green-Paranet</td>
<td>20.96</td>
</tr>
<tr>
<td>UV+ Blue-Paranet</td>
<td>21.07</td>
</tr>
</tbody>
</table>

![Figure 2. The height of the 12-week-old tomato plant on the paranet colors treatment (A0 = No roof; A1 = UV roof; A2 = UV roof + yellow-paranet; A3 = UV roof + red-paranet; A4 = UV roof + green-paranet; A5 = UV roof + blue-paranet)](image)
Table 2. Total content of tomato plants on roof parnet plants age 12 weeks.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stem diameter (mm)</th>
<th>Leaf area (cm²)</th>
<th>Chlorophyll Total (mg.g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No roof</td>
<td>9.184</td>
<td>2291</td>
<td>184.7</td>
</tr>
<tr>
<td>UV</td>
<td>9.575</td>
<td>2687</td>
<td>205.7</td>
</tr>
<tr>
<td>UV+ Yellow-Paranet</td>
<td>8.840</td>
<td>1966</td>
<td>260.6</td>
</tr>
<tr>
<td>UV+ Red-Paranet</td>
<td>8.343</td>
<td>2905</td>
<td>273.6</td>
</tr>
<tr>
<td>UV+ Green-Paranet</td>
<td>7.698</td>
<td>1902</td>
<td>242.5</td>
</tr>
<tr>
<td>UV+ Blue-Paranet</td>
<td>7.982</td>
<td>1843</td>
<td>238.9</td>
</tr>
<tr>
<td>Juliet</td>
<td>8.621</td>
<td>2083</td>
<td>257.5</td>
</tr>
<tr>
<td>Golden Sweet</td>
<td>7.183</td>
<td>1893</td>
<td>253.5</td>
</tr>
<tr>
<td>Golden Shine</td>
<td>9.383</td>
<td>2812</td>
<td>200.7</td>
</tr>
<tr>
<td>Betavila</td>
<td>9.228</td>
<td>2275</td>
<td>225.6</td>
</tr>
</tbody>
</table>

Remark: The numbers followed by different letters in the same column, are significantly different from Duncan’s advanced test (α = 0.05).

Figure 3. Fruit weight on the parnet colors treatment (A0 = No roof; A1 = UV roof; A2 = UV roof + yellow-paranet; A3 = UV roof + red-paranet; A4 = UV roof + green-paranet; A5 = UV roof + blue-paranet) on four varieties of tomatoes

Leaf area

Leaf area no interaction between roof treatment and varieties used. Although each treatment factor influences the area of tomato plant leaves. The widest leaf area on the Golden Shine varieties with an average leaf area of 2812 cm², the most narrow is the 1893 cm² Golden Sweet varieties. In parnet color treatment, the tomato plant that has the widest leaf area is a plant that grows under the UV + red-paranet and under the UV roof. This occurs because both of these have the same relative minimum and maximum temperatures (Table 1 Tomato planting under UV + yellow-paranet, green-paranet and blue-paranet have low leaf area with average of 1966 cm²; 1902 cm² and 1843 cm² (Table 2).

The highest chlorophyll content is a plant given UV + red-paranet that is 273.6 mg.g⁻¹ fresh weight and yellow-paranet + UV 2606 mg.g⁻¹ fresh weight, compared without roof and UV roof. This is due to the reduced intensity of light received by the plants, stimulating the plants to increase leaf chlorophyll levels, and this is one way of plant adaptation, in accordance with the results of research conducted by Baharuddin et. Al. (2014) and Sulistyowati et. Al. (2016). The highest total leaf chlorophyll content in the treatment of tomato varieties is the Juliet tomato varieties 257.5 mg.g⁻¹.
fresh weight and the Golden Sweet varieties 253.5 mg.g\(^{-1}\) fresh weight compared to the Golden Shine.

**Weights per plant**

The Betavila variety shows the highest fruit weight, when planted on the roof of UV + red-paranet and paranet yellow + UV is 2463 g.plant\(^{-1}\) and 2131 g.plant\(^{-1}\) (Figure 3). The weight of tomatoes per plant from the Juliet variety reached a high yield when grown in UV and UV + red-paranet, compared without a roof. Golden Sweet varieties showed no difference in weight of fruit per plant with different paranet color treatment. Golden Shine varieties produce higher fruits when given a UV + red-paranet than an unhindered treatment of 227 g.plant\(^{-1}\), since tomatoes planted without a roof during the wet season will produce low tomato yields (Higashide, 2007; Korlina et al 2016).

**Lycopene and \(\beta\)-carotene content in a simple way**

In the lycopene tomato content parameter, there is an interaction between the roof color treatment and the tomato varieties used. In the Juliet variety, the high lycopene content when the plant is given UV + green-paranet (1.642 mg.g\(^{-1}\) fresh weight) and UV + blue-paranet (1.933 mg.g\(^{-1}\) fresh weight). In this diverse treatment with low lycopene content when grown under UV + red-paranet (0.967 mg.g\(^{-1}\) fresh weight), UV + yellow-paranet (1.068 mg.g\(^{-1}\) fresh weight) and UV without paranet (1.043 mg.g\(^{-1}\) fresh weight). The lycopene content of the Golden Sweet and Golden Shine varieties on all roof color treatments showed no difference. In the Betavila variety showing different lycopene content, tomato varieties grown under UV roofs have the highest lycopene content (1,347 mg.g\(^{-1}\) fresh weight) similar to those grown under UV + green-paranet (1,206 mg.g\(^{-1}\) fresh weight) or UV + blue-paranet (1,203 mg.g\(^{-1}\) fresh weight). The lowest lycopene content in the Betavila variety is when the plant is grown without a roof (0.539 mg.g\(^{-1}\) fresh weight) and given UV + yellow-paranet (0.974 mg.g\(^{-1}\) fresh weight) or UV + red-paranet (1.128 mg.g\(^{-1}\) fresh weight) (Figure 4). This is in contrast to research conducted by Ilić and Milenković (2001) on AlfaV, SCX 248 and Irit varieties, as they use different varieties.

The content of tomato \(\beta\)-carotene shows that there is an interaction between the color treatment of the roof and the varieties used. In the Juliet varieties it has a high \(\beta\)-carotene content in the non-roof treatment of 0.123 mg.g\(^{-1}\) fresh weight, followed by UV and UV + green-paranet. Golden Sweet varieties showed no difference between the roof color treatment. Golden Shine varieties that have an orange color, have the highest average beta-carotene content when given yellow UV + paranet yellow is 0.136 mg.g\(^{-1}\) fresh weight, followed by UV or without roof treatment. The Betavila variety shows that the content of \(\beta\)-carotene is high when grown with UV + yellow-paranet, followed by UV roof treatment.

![Figure 4. Tomato lycopene content of paranet colors treatment (A0 = No-roof; A1 = UV roof; A2 = UV roof + yellow-paranet; A3 = UV roof + red-paranet; A4 = UV roof + green-paranet; A5 = UV roof + blue-paranet) and four varieties of tomatoes](image-url)
CONCLUSION
Different UV + paranet roofs of color cause differences in the quality and intensity received by plants, as well as the minimum and maximum temperature differences around the plant. The highest crop on Golden Sweet varieties (indeterminate) in all treatments except UV roof treatment. The highest total leaf chlorophyll content in UV + red-paranet treatment and only UV roofing. The widest leaf area on UV roof treatment and red UV + paranet roof. The highest fruit weight per plant on UV + red-paranet treatment and UV roof on Betavila variety (determinate). The highest lycopene content in plants grows under UV + blue-paranet roof on Juliet varieties. The highest β-carotene content is in yellow UV + paranet treatment and on the UV roof in Golden Shine tomatoes (determinate), and without roofs on the Juliet tomato varieties (indeterminate).

CONFLICT OF INTEREST
Authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEDGEMENT
Financial support by the Agency for Agricultural Research and Development. Thanks also to the staff of Assessment Institute for Agricultural Technology, East Java and the students who practice field work there.

AUTHOR CONTRIBUTIONS
The article is part of the Dissertation of Doctoral and all the authors have contributed: DS conducted experiments, data collection, data analysis and writing manuscript, Prof. YS contributed to the experimental design, the determination of the research treatment and the field survey, Dr. NA and Dr. SYT contributes to experimental design, determination of research treatment and review of manuscripts.

REFERENCES
Baharuddin, R., M.A. Chozin, and M. Syukur.


