

## Production, morphology, physiology and analysis of farming in a simple plastic house with the addition of light at night in some tomato varieties

Lilia FAUZIAH<sup>1</sup>, Rudi Cahyo WICAKSONO<sup>2</sup>, Siti SOFIAH<sup>3</sup>, Mizu ISTIANTO<sup>2</sup>, Evy LATIFAH<sup>2</sup>, Djajadi DJAJADI<sup>1</sup>, Herman SUBAGIO<sup>4</sup>, Mohammad SAERI<sup>5</sup>, Zainal ARIFIN<sup>2</sup>, Yogi SUGITO<sup>6</sup>, Nurul AINI<sup>6</sup>, Setyono Yudho TYASMORO<sup>6</sup>, Dwi SETYORINI<sup>1\*</sup>

<sup>1</sup>National Research and Innovation Agency, Research Center for Estate Crops, Soekarno Science and Technology Area (KST), Jl. Raya Jakarta - Bogor KM 46, Cibinong, West Java 16911, Indonesia; [lili025@brin.go.id](mailto:lili025@brin.go.id); [djaj001@brin.go.id](mailto:djaj001@brin.go.id); [dwisetyorinibrin@gmail.com](mailto:dwisetyorinibrin@gmail.com)  
(\*corresponding author)

<sup>2</sup>National Research and Innovation Agency, Research Center for Horticulture, Soekarno Science and Technology Area (KST), Jl. Raya Jakarta - Bogor KM 46, Cibinong, West Java 16911, Indonesia; [rudicahyo@gmail.com](mailto:rudicahyo@gmail.com); [mizu\\_istanto@yahoo.com](mailto:mizu_istanto@yahoo.com); [epilatip08@gmail.com](mailto:epilatip08@gmail.com); [arifinbtp@gmail.com](mailto:arifinbtp@gmail.com)

<sup>3</sup>National Research and Innovation Agency, Research Center for Biota Systems, Administration Building, Dr. (H.C) Ir. H. Soekarno Science Technology Area, Jl. Raya Bogor KM. 46, West Java 16911, Indonesia; [siti048@brin.go.id](mailto:siti048@brin.go.id)

<sup>4</sup>National Research and Innovation Agency, Research Center for Macro Economics and Finance, Sasana Widya Sarwono Building, Jl. Jenderal Gatot Subroto No. 10, DKI Jakarta 12710, Indonesia; [hermansubagio6006@gmail.com](mailto:hermansubagio6006@gmail.com)

<sup>5</sup>National Research and Innovation Agency, Research Center for Behavioral and Circular Economics Agency, Sasana Widya Sarwono Building, 3rd Floor, Jl. Jenderal Gatot Subroto No. 10, DKI Jakarta 12710, Indonesia; [saerimob@yahoo.com](mailto:saerimob@yahoo.com)

<sup>6</sup>University of Brawijaya, Faculty of Agriculture, Department of Agronomy, Malang, Indonesia, Jl. Veteran, Malang, Ketawanggede, Lowokwaru, Malang City, East Java 65145, Indonesia; [yogi@ub.ac.id](mailto:yogi@ub.ac.id); [nra-fp@ub.ac.id](mailto:nra-fp@ub.ac.id); [tyasmoro@ub.ac.id](mailto:tyasmoro@ub.ac.id)

### Abstract

This study aims to determine the effect of additional compact fluorescent lamp (CFL) light on the production, morphology and physiology of tomato plants, as well as their efficiency. The research also examined the prospects for planting tomatoes in simple plastic houses at the height of the medium in tropical countries. The experiment was conducted in a plastic house in the tropical region of East Java, Indonesia, with a place altitude of 455 m above sea level. The design used was the Split-Plot Design, with 3 replications. The treatment consisted of 2 factors: the main factor was 4 levels of additional CFL light at night (no light/control, 4 hours, 8 hours, and 12 hours), and the sub-factor consisted of four tomato varieties ('Juliet', 'Golden Sweet' and 'Betavila'). Tomato plants of the 'Juliet' cherry variety (indeterminate) showed a higher plant growth rate when given additional CFL light for 8 hours, while the 'Betavila' variety showed a higher plant growth rate when given CFL light for 4 hours. 'Betavila' also produced the highest yields, especially under 4 hours of night lighting. Meanwhile, the 'Juliet' cherry variety achieved the highest yield with 12 hours of CFL light. Farming

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analysis showed that the 'Betavila' variety was more profitable without CFL lights at night, while, 'Juliet' variety was more advantageous when given lights for 4 hours before dawn.

**Keywords:** additional light; tomatoes; simple plastic house; RC ratio

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## Introduction

A fairly high risk also occurs when planting vegetables in the rainy season, is the occurrence of crop failure due to plant pests and diseases (Astuti *et al.*, 2019). Currently, there are many ways to control plant pests and diseases, which can be done by using pest-resistant varieties, changing the planting patterns such as planting in gauze houses or plastic houses cleaning the planting environment, using biological agents, mechanical control and chemical control (pesticides) before or during planting. The control of plant pests and diseases today is usually carried out by a combination of several ways (Sudiono *et al.*, 2012; Ginting *et al.*, 2013; Meilin, 2014; Agastya *et al.*, 2017; Tuhumury and Amanupunyo, 2018; Abadi *et al.*, 2023). Farmers prefer to use chemical methods, particularly the use of pesticides, to reduce pest and disease attacks. This approach is favoured because it is generally considered that the to reduce seasonal crop production costs is faster and easier to implement (Effendi, 2009; Tahyudin *et al.*, 2020; Situmorang *et al.*, 2021).

The current rising price of pesticides, the continued prevalence of pest and disease attacks, and the shift in public perception toward consuming healthy, pesticide-residue-free foods have prompted some farmers to consider growing their produce in plastic houses. Especially farmers who have a sales network for their products to modern markets that can accommodate horticultural products at higher prices (Pua *et al.*, 2014; Kusumo *et al.*, 2020). In recent decades, protected crop cultivation has spread worldwide. Market globalization has increased competitiveness, emphasizing the need for high-quality products. A wide range of greenhouse technology packages is now available, from simple plastic houses to highly sophisticated greenhouses. Information on cultivation strategies that can be implemented to supply the market with high-quality vegetables year-round is available (Castilla and Hernandez, 2007).

Growing plants in greenhouses or plastic houses will reduce the amount of intensity received by the plants. Meanwhile, light is one of the main factors determining plant production, along with CO<sub>2</sub>, H<sub>2</sub>O, O<sub>2</sub>, and soil nutrients. Sunlight is the primary energy source for plants. Plant growth is influenced by its quality and intensity. Light intensity is the amount of energy received by plants per unit area and per unit time (Cal/cm/day) (Sunardi *et al.*, 2004; Maghfiroh, 2017; Timmermans *et al.*, 2020). The term intensity refers to the duration of sunlight, namely the length of time the sun shines in a day. Essentially, sunlight intensity significantly impacts plant morphology. This is because sunlight intensity is necessary for the combination of CO<sub>2</sub> and water to form carbohydrates (Lukitasari, 2012).

The lycopene and beta-carotene content in tomatoes is quite high and is greatly influenced by the light received by the fruit. Providing shade to tomato plants will increase the lycopene content in tomatoes (Cox *et al.*, 2003; Ilić *et al.*, 2012; Pizarro and Stange, 2009; Setyorini *et al.*, 2018). Planting tomatoes in plastic houses is expected to increase the lycopene content of the fruits, but on the other hand, it will reduce the photosynthetic energy of the plant. So that the addition of light at night is expected will increase production but not reduce the lycopene content of the fruit. The light intensity of some of the lamp colours that gives the best effect is the white lamp (Aulia *et al.*, 2019). Therefore, it is necessary to know the effect of additional light from the Compaq Fluorescent Lamp (CFL) on the production, morphology and physiology of tomato plants, as well as their efficiency.

## Materials and Methods

The research was conducted in a simple plastic house (Figure 1) at the Assessment Institute for Agricultural Technology, East Java, located at an elevation of 455 m above sea level, for a period of 12 months. The design used was the Split-Plot Design, with 3 repetitions (Figure 2). The treatment consisted of 2 factors: the main factor was CFL (Compact Fluorescent Lamp) light at night, with four treatments namely: without light application (control/0 hours), 4 hours of additional light (6-10 pm), 8 hours of additional light (6 pm - 2 am) and 12 hours of additional light (6 pm - 6 am); and the sub-factor consisted of four tomato varieties ('Juliet', 'Golden Sweet', 'Golden Sweet' and 'Betavila'). Additional measurements of the night light were carried out for each treatment using a lux meter. The measurement distance from the lamp/light source was 1-2 meters, and the measurement result was 70-90 lux. Irrigation was performed by watering each plant with 0.5 litres of water twice a day, with a planting distance of 60 cm x 50 cm.



Figure 1. Simple plastic house

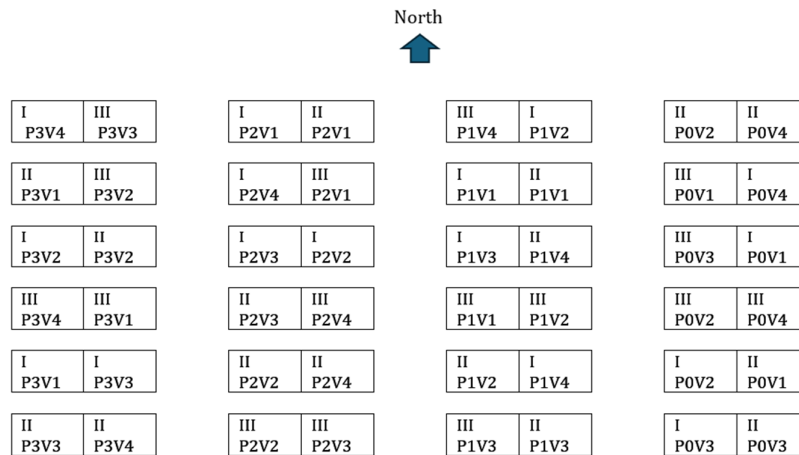


Figure 2. Experiment plan

Note: I-III= replication; P0= Control/no add light; P1= 4 hours add light; P2= 8 hours add light; P3= 12 hours add light; V1= 'Juliet' Variety; V2= 'Golden Sweet' Variety; V3= 'Golden Sweet' Variety; V4= 'Betavila' variety)

*Light intensity, temperature and air humidity*

The intensity of instantaneous sunlight was measured using a Lutron LX-107 brand light meter, compared to the intensity of light outside the screen house. Maximum and minimum air temperature measurements are taken daily, out of shade and in shade, using the HTC-1 digital maximum and minimum air thermometer/hygrometer.

*Plant height, stem diameter and leaf area index*

When transplanting, plant height measurements and stem diameter measurements are carried out to determine the initial growth of plants before treatment. Furthermore, the measurement of plant height and stem diameter on 2 sample plants for each combination of treatment. Observations were conducted at the beginning of planting (7 days) until the age of 14 weeks. Sample leaves from the field were measured using a LICOR brand Leaf Area Meter, type Li 3100. The measurement was carried out in the Environmental Resources laboratory, Faculty of Agriculture, Brawijaya University, Malang

The results of measuring the area of planting leaves are divided by planting area (planting distance).

$$LAI = \frac{LA}{PA}$$

Where *LAI* = Leaf Area Index; *PA*= Planting Area (planting distance); *LA*=Leaf Area

*Size and density of leaf undersurface stomata*

Stomata size parameters were measured by applying Sahara-brand transparent nail polish to the abaxial surface of the fourth branch of mature leaves at 09:00 AM (Haryanti and Meirina, 2009). After drying, the leaf samples were cut and brought to the laboratory. A single observation was conducted on 9-week-old plants using an Olympus BX51 microscope and an Olympus DP24 camera at 400× magnification, at the Breeding Laboratory, Faculty of Agriculture, Brawijaya University, Malang.

*Flowering age 50% and harvest age.*

Observations are carried out every day from planting until the plant flowers 50%

*Dry weight of the plant and production per plant*

Plant dry weight is obtained by drying the plants until their weight was stable (this takes 2-3 days for the plants to be in an oven at 70 °C). Production per plant sample was recorded from each harvest until the plants ceased production and data was conducted once a week, starting from the first fruit.

*Determination of chlorophyll a, chlorophyll b, lycopene and beta-carotene content in a simple method.*

Acetone-Hexane solution (4:6) is put into a test tube as much as 10-20 ml. Put 1 gram of the tomato sample into the Acetone: Hexane solution, stir until evenly mixed with a homogenizer until smooth, then the solution was measured with a spectrophotometer, at wavelengths of 663 nm, 645 nm, 505 nm and 453 nm (Nagata and Yamashita, 1992), The measurement results were calculated by the equation:

$$\begin{aligned} \text{Lycopene (mg/100ml)} &= -0,0458A_{663} + 0,204A_{645} + 0,372A_{505} - 0,0806A_{453} \\ \beta - \text{karoten(mg/100ml)} &= 0,216A_{663} - 1,22A_{645} - 0,304A_{505} + 0,452A_{453} \\ \text{Chlorophyll a (mg/100ml)} &= 0,999A_{663} - 0,0989A_{645} \\ \text{Chlorophyll b (mg/100 ml)} &= -0,328A_{663} + 1,77A_{645} \end{aligned}$$

*Farming Analysis*

To determine whether the farming activity was profitable or not, the R/C ratio was calculated with using the following formula:

$$\frac{R}{C} \text{ ratio} = \frac{\text{Total Sales Revenuen}}{\text{Total Costs incurred}}$$

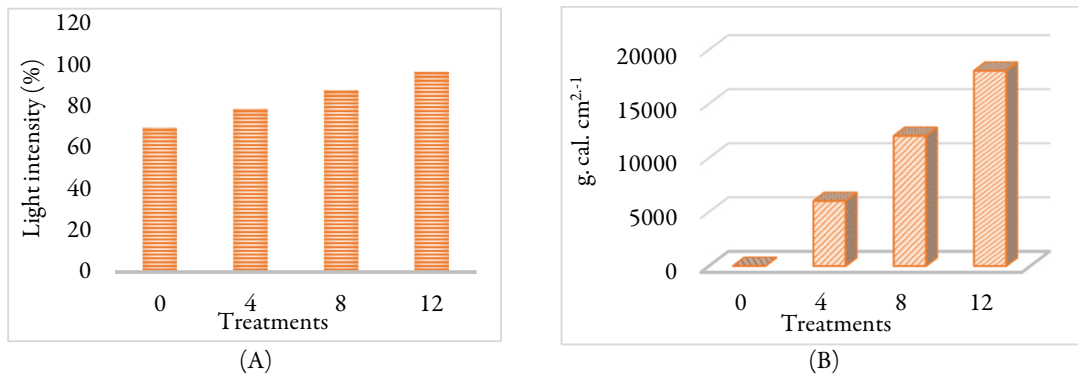
*Research data analysis*

Data analysis was performed using analysis of variance (ANOVA), followed by Duncan's test if there was any significant difference. Data analysis was performed using Excel 2016, MacBook iOS.

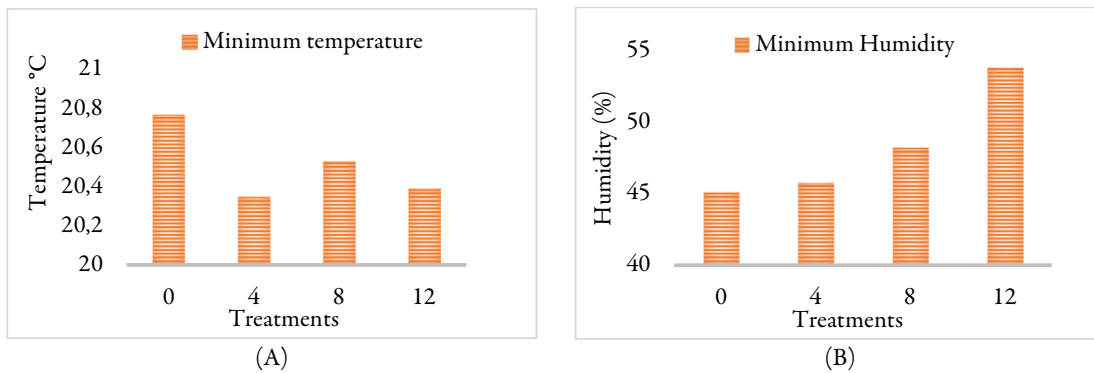
**Results**

*Light intensity, temperature and air humidity*

The light intensity inside the plastic house was 68.85% of the light outside the plastic house. An additional 4 hours of night light resulted in intensity of 78.87% of the light intensity outside the plastic house. The additional 12 hours of night light resulted in a light intensity of 96.91% (Figure 3). The treatment with additional night light had a lower minimum temperature around the plants being lower than the control and higher minimum humidity than the control (Figure 4).



**Figure 3.** Light intensity (%) in plastic house treatment compared to light outside the screen house (100%) (A), and additional night light (g cal. cm<sup>-2</sup>) (B)

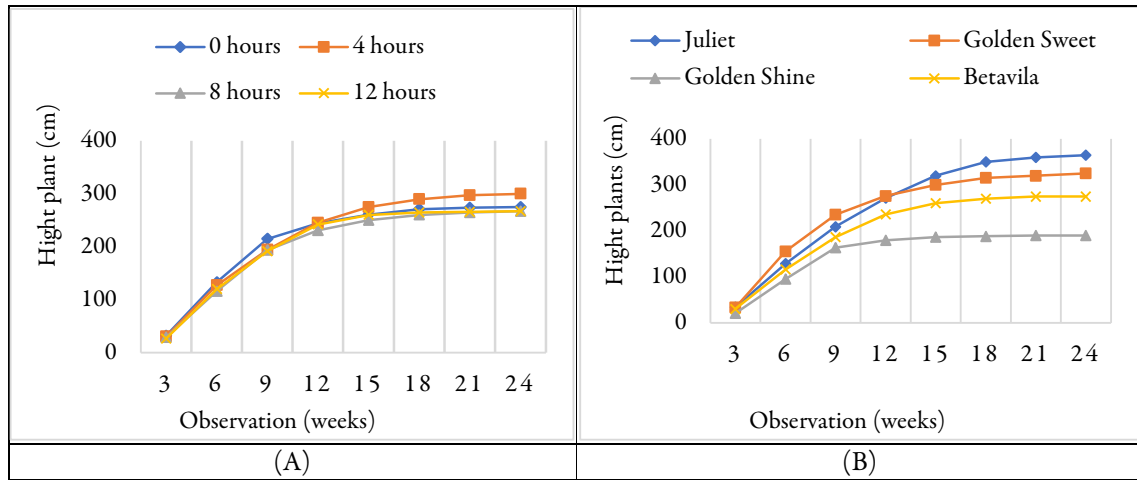


**Figure 4.** Minimum air temperature (A) and minimum air humidity (B), around tomato plants at CFL light addition treatment

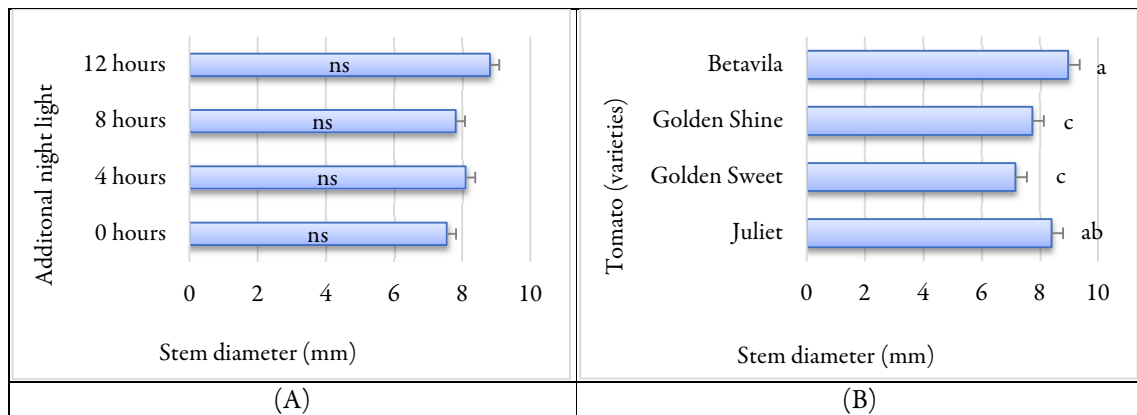
*Plant height, stem diameter and leaf area index*

The highest plant heights were found in the ‘Golden Sweet’ and ‘Juliet’ varieties (Figure 5). This was significantly influenced by the treatment of adding sunlight and the variety used, although there was no interaction between the two factors. The largest stem diameter was found in the ‘Betavila’ variety, followed by

'Juliet', 'Golden Shine', and 'Golden Sweet'. There was a difference in stem diameter between the control treatment (without additional light) and the treatment with 12 hours of night light (Figure 6). The leaf area index was affected by the addition of a night light, but not by the variety used. Plants given 12 hours of additional sunlight had a wider leaf area than plants not given additional light (control) (Figure 7).

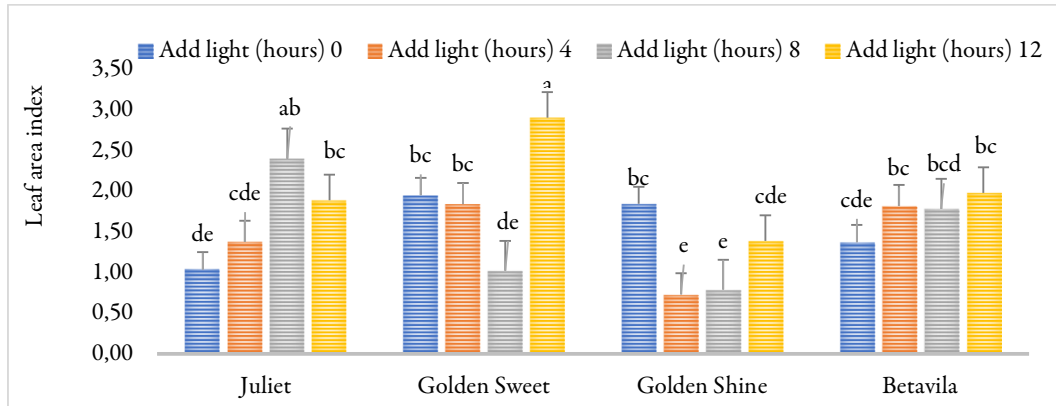


**Figure 5.** Plant height under the different CFL light treatment (hours) (A); plant height based on variety (B)



**Figure 6.** Tomato stem diameter under nighttime CFL light addition treatment (A), and under tomato varieties (B)

Note: ns = non-significant; Data are presented as mean  $\pm$  SE. Different letters between denote significant differences (Duncan test,  $p < 0.05$ )



**Figure 7.** Leaf area index of 4 tomato varieties with 4 additional treatments night light

Note: Data are presented as mean ± SE. Different letters between denote significant differences (Duncan test,  $p < 0.05$ )

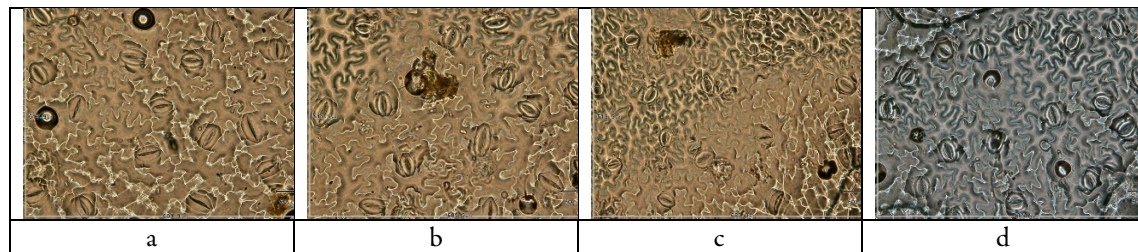
*Size and numbers of leaf undersurface stomata*

The length and width of the stomata of the ‘Juliet’ variety are minimally affected by the long treatment of additional light. However, the ‘Golden Sweet’, ‘Golden Sweet’, and ‘Betavila’ varieties decreased in size and length and width of stomata when given additional light for 8 and 12 hours (Table 1 and Figure 8) and different numbers of stomata (Figure 9)

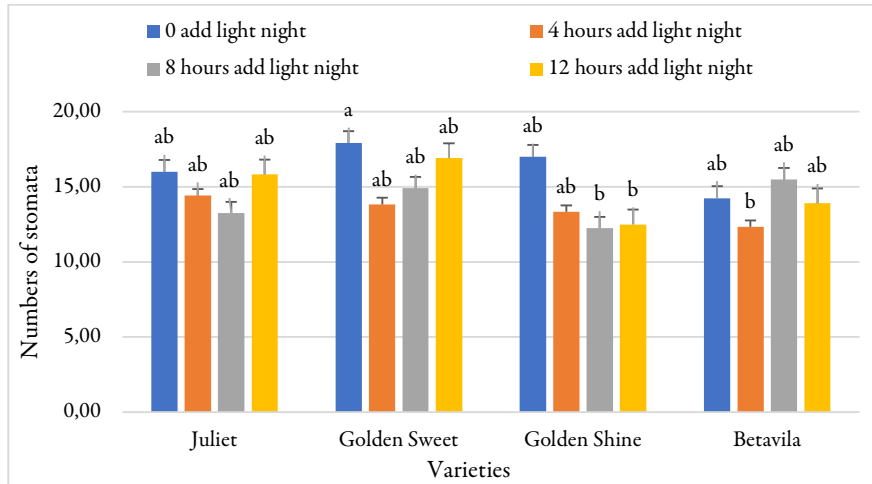
**Table 1.** Length and width of stomata treatment of the addition of night light to 4 varieties of tomatoes

Tomato varieties	Treatment of adding night light (hours)			
	0	4	8	12
Stomata length (µm)				
‘Juliet’	62.09 ± 7.37bcde	65.94 ± 7.01 abcd	64.00 ± 6.08 bcd	56.72 ± 7.74 def
‘Golden Sweet’	66.55 ± 3.57 abc	68.34 ± 4.65 abc	50.23 ± 6.41 f	52.37 ± 6.41 f
‘Golden Sweet’	64.18 ± 8.39 bcd	59.14 ± 2.12 cdef	50.29 ± 3.51 f	54.23 ± 4.12 ef
‘Betavila’	73.86 ± 3.02 a	70.28 ± 4.16 ab	53.59 ± 3.15 ef	54.05 ± 1.26 ef
Stomata width (µm)				
‘Juliet’	37.21 ± 0.50 cdef	40.59 ± 1.68 abc	42.20 ± 1.17 ab	36.98 ± 3.81 cdef
‘Golden Sweet’	38.89 ± 2.41 bcde	39.01 ± 1.16 bcde	35.24 ± 1.67 ef	34.26 ± 2.78 f
‘Golden Sweet’	39.31 ± 1.48 bcd	39.62 ± 5.84 bcd	36.28 ± 2.17 def	35.13 ± 2.17 ef
‘Betavila’	43.71 ± 1.38 a	43.96 ± 0.65 a	37.96 ± 2.44 cdef	38.72 ± 1.04 bcde

Note: Data are presented as mean ± STDEV. Different letters between denote significant differences (Duncan test,  $p < 0.05$ )



**Figure 8.** Stomata ‘Betavila’ additional treatment of night light: no additional night light(a); additional 4 hours (b); an additional 8 hours(c); additional 12 hours(d)



**Figure 9.** Number of stomata

Note: Data are presented as mean ± SE. Different letters between denote significant differences (Duncan test,  $p < 0.05$ )

*Flowering age 50% and harvest age.*

The addition of 8 and 12 hours of night light generally delayed the flowering period by 50%, ranging from 2 to 4 days, compared to no night light. The final harvest age was observed at 186 days, i.e., plants given 4 hours of additional light per day showed a longer observed harvest age than the other treatments (Table 2) (Osnato *et al.*, 2022).

**Table 2.** Flowering age 50% and the last harvest of tomatoes on additional treatment of night light

Tomato varieties	Addition night light	Flowering age 50% (days)	Last harvest age (days)
'Juliet'	0 hours	28.67 ± 1.15 gf	178.00 ± 7.21 abc
	4 hours	28.00 ± 0.00 g	183.70 ± 4.04 a
	8 hours	31.00 ± 0.00 de	181.30 ± 4.04 ab
	12 hours	28.00 ± 1.00 g	183.70 ± 4.04 a
'Golden Sweet'	0 hours	28.00 ± 0.00 g	181.30 ± 4.04 ab
	4 hours	30.33 ± 0.57 ef	183.70 ± 4.04 a
	8 hours	31.67 ± 1.53 bcd	181.30 ± 4.04 ab
	12 hours	32.67 ± 1.53 bcd	181.30 ± 4.04 ab
'Golden Sweet'	0 hours	33.00 ± 1.00 abc	162.30 ± 16.74 bc
	4 hours	33.33 ± 1.15 abc	162.70 ± 20.21 bc
	8 hours	34.67 ± 0.57 a	179.00 ± 0.00 abc
	12 hours	34.02 ± 1.41 ab	161.30 ± 17.50 c
'Betavila'	0 hours	30.33 ± 0.57 ef	171.00 ± 18.03 abc
	4 hours	33.33 ± 1.15 abc	186.00 ± 0.00 a
	8 hours	32.67 ± 1.15 cde	181.30 ± 4.04 ab
	12 hours	34.00 ± 1.00 abc	181.30 ± 4.04 ab

Note: Data are presented as mean ± STDEV. Different letters between denote significant differences (Duncan test,  $p < 0.05$ )

*Dry weight of the plant and production per plant*

The total dry weight of the plant is influenced by the addition of night light and plant varieties. The addition of night light 4, 8, or 12 hours a higher dry weight than without the addition of night light. Tomato

production was highest in the treatment with the addition of night light for 12 hours, and the result was similar to the addition of 8 or 4 hours of night light. The addition of a night light also means increasing the intensity of light received by plants, so that it will increase the photosynthesis results produced by plants. The four varieties used in the experiment, the ones with high yields were 'Betavila' and 'Juliet' (Table 3).

The weight of fresh fruit per plant, there is an interaction between the additional CFL light treatment, and the variety used. For the 'Juliet' variety, an additional CFL lamp for 4-12 hours can increase the weight of fresh fruit per plant. The "Golden Sweet" variety increases the weight of fresh fruit per plant with the addition of 12 hours of night light. The weight of the fresh fruit of "Golden Sweet" shows no difference with the addition of CFL light. In the 'Betavila' variety, the weight of fresh fruit per plant increases by 4-8 hours, and the weight of fresh fruit per plant decreases by an additional 12 hours (Table 3).

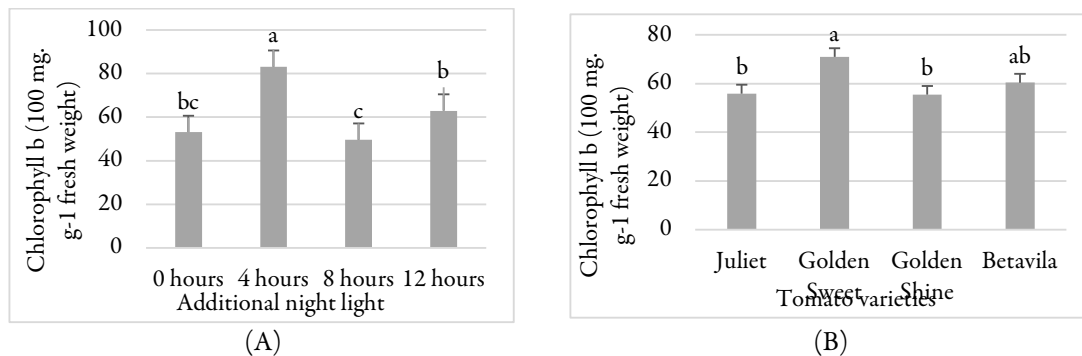
**Table 3.** Dry weight and production per tomato plant

Tomato varieties	Additional night light	Dry weight of plants (g)	Fruit production per plant (g)
'Juliet'	0 hours	75.01 ±23.32 cdef	421.89 ±172.89 gh
	4 hours	94.52 ±30.47 bcdef	1,363.40 ±238.89 de
	8 hours	115.63 ±12.55 abcde	1,487.05 ±327.79 cd
	12 hours	135.67 ±54.69 abc	1,522.84 ±342.27 cd
'Golden Sweet'	0 hours	56.08 ±16.18 ef	122.75 ±71.38 h
	4 hours	97.31 ±35.78 bcdef	414.92 ±199.45 gh
	8 hours	74.74 ±36.27 def	632.35 ±294.41 fg
	12 hours	120.48 ±35.20 abcd	991.08 ±154.21 ef
'Golden Sweet'	0 hours	71.21 ±49.01 def	83.62 ±19.47 h
	4 hours	48.31 ±28.49 f	182.91 ±60.03 h
	8 hours	68.24 ±8.31 def	86.00 ±49.57 h
	12 hours	97.75 ±19.37 bcdef	134.91 ±87.08 h
'Betavila'	0 hours	86.11 ±8.89 cdef	1,835.72 ±419.73 abc
	4 hours	162.73 ±9.78 a	2,156.65 ±478.75 a
	8 hours	145.26 ±12.76 ab	2,015.65 ±175.69 ab
	12 hours	139.72 ±27.48 abc	1,663.42 ±405.50 bcd

Note: Data are presented as mean ± STDEV. Different letters between denote significant differences (Duncan test, p < 0.05)

*Chlorophyll a, chlorophyll b, lycopene and beta-carotene content.*

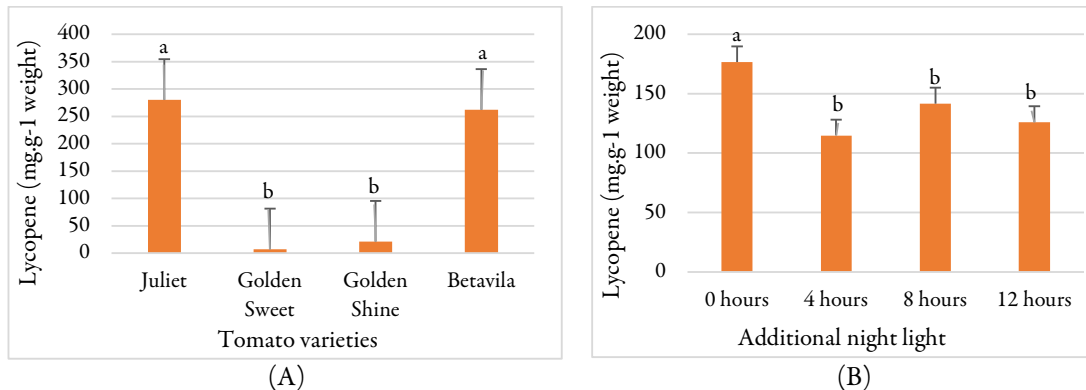
The chlorophyll a content was not affected by the treatment of the additional night light and the varieties used in the study. However, the content of chlorophyll b was affected by the additional treatment of night light and the variety used (Figure 10).



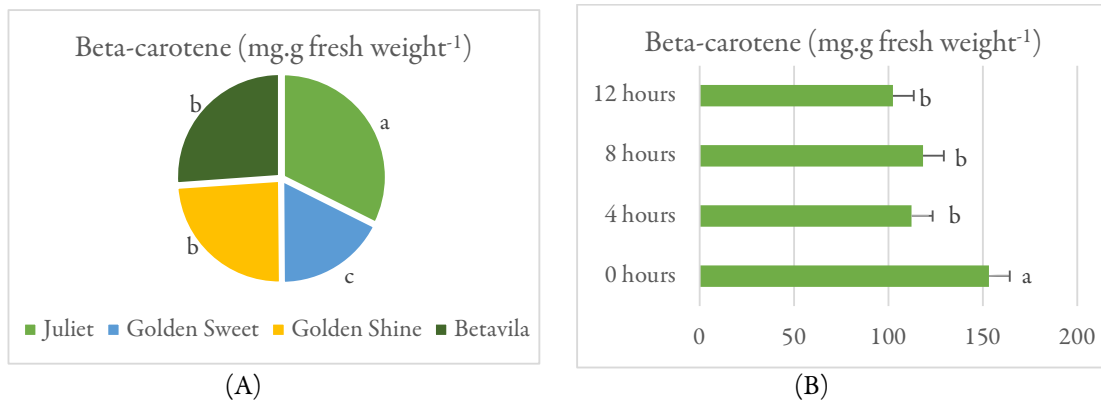
**Figure 10.** Chlorophyll b in night light treatment (A) and some tomato varieties (B)

Note: Data are presented as mean  $\pm$  S.E. Different letters between denote significant differences (Duncan test,  $p < 0.05$ )

In the analysis of lycopene content, it was observed that plants treated with additional light at night tended to have lower lycopene content (Figure 11). Varieties that have a higher lycopene content are tomato varieties with red fruits. However, the variety with higher beta-carotene was 'Juliet', which also has red fruits. The results obtained showed that plants that were not given additional light at night had a greater beta-carotene content (Figure 12).



**Figure 11.** Lycopene content (third harvest) in 4 varieties of tomatoes (A) and light addition even (B). Note: Data are presented as mean  $\pm$  S.E. Different letters between denote significant differences (Duncan test,  $p < 0.05$ )



**Figure 12.** Beta-carotene content (third harvest) in 4 varieties of tomatoes (A) and light addition even (B). Note: Data are presented as mean  $\pm$  S.E. Different letters between denote significant differences (Duncan test,  $p < 0.05$ )

The mercury spectral lines in the CFL, which are 436 nm and 546 nm, respectively, are extremely near to the two peaks in the spectrum at 435 nm and 550 nm. The powdered calcium halo phosphate phosphor inside the CFL glass is the source of the third peak at 580 nm (Tanushevski and Rendevski, 2016). The spectrum of 436 nm or blue light is useful for the process of photosynthesis, and 546 nm or green light helps to distribute light more evenly throughout the plant (Balegh and Biddulph, 1970; Hosseini *et al.*, 2019; Smith *et al.*, 2017). While the 580 nm spectrum is green-yellow light, chlorophyll a and b do not absorb green-yellow light well, so direct photosynthesis from 580 nm is quite low, can help with an even distribution of light, especially when used in conjunction with other spectrums (blue and red) (Kasajima, 2019). The decrease in

Lycopene and Beta-carotene content in Figures 8 and 9, due to the addition of light from CFLs, occurs due to the disruption of plant photoperiodism.

#### *Farming Analysis*

The analysis of 4 tomato varieties showed that the 'Betavila' and 'Juliet' varieties had an R/C ratio of more than 1 (Tables 4 and 5). Analysis of four tomato varieties showed that the 'Betavila' and 'Juliet' varieties had R/C ratios greater than 1 (Tables 4 and 5). The 'Betavila' variety had an R/C ratio of 1.7 without additional light, and the 'Juliet' variety had an R/C ratio of 1.2 without additional light and 1.3 with additional light for 4 hours.

**Table 4.** Analysis of tomato farming in plastic houses with the addition of 4 hours of CFL light and control on the variety 'Betavila'

Description	No lights			With 4-hour light		
	Physical (quantity)	Unit (IDR)	Amount (IDR)	Physical (quantity)	Unit (IDR)	Amount (IDR)
Saprodi	-	-	-	-	-	-
Seed	167	25,000	4,166,667	167 g	25,000	4,166,667
Bactomycin (bactericide)	1	500,000	250,000	1 kg	500,000	250,000
Agrisan (fungicide)	30	25,000	750,000	30 kg	25,000	750,000
Topsin (fungicide)	20	35,000	700,000	20 kg	35,000	700,000
Confidor (insecticide)	1	180,000	90,000	1 L	180,000	90,000
Bulldog (insecticide)	15	110,000	1,650,000	15 L	110,000	1,650,000
Manure (organic fertilizer)	20,000	500	10,000,000	20,000 kg	500	10,000,000
Silver black mulch	16	30,000	480,000	16 m	30,000	480,000
Curacron (insecticide)	6	130,000	780,000	6 L	130,000	780,000
Antracol (fungicide)	8	49,999	399,992	8 kg	49,999	399,992
NPK (fertilizer)	1,000	10,000	10,000,000	1,000 kg	10,000	10,000,000
Ajir (bambu poles)	18,000	150	2,700,000	18,000 pcs	150	2,700,000
Saprodi Fees	-	-	31,966,659	-	-	31,966,659
Labor <sup>1</sup> (HR)	-	-	-	-	-	-
Nursery	20 HR	50,000	1,000,000	20 HR	50,000	1,000,000
Tillage	76 HR	50,000	3,800,000	76 HR	50,000	3,800,000
Making beds	50 HR	50,000	2,500,000	50 HR	50,000	2,500,000
Fertilization	102 HR	50,000	5,100,000	102 HR	50,000	5,100,000
Plant	64 HR	50,000	3,200,000	64 HR	50,000	3,200,000
Weeding	56 HR	50,000	2,800,000	56 HR	50,000	2,800,000
Pest control	64 HR	50,000	3,200,000	64 HR	50,000	3,200,000
Watering	236 HR	50,000	11,800,000	236 HR	50,000	11,800,000
Navigation and crew	165 HR	50,000	8,250,000	165 HR	50,000	8,250,000
Harvesting	103 HR	50,000	5,150,000	103 HR	50,000	5,150,000
Labor costs	-	-	46,800,000	-	-	46,800,000
Electricity subscription	-	-	-	17,059 kW	3,750	63,972,000
The cost of light bulbs	-	-	-	3,750 pcs	25,000	93,750,000
switch	-	-	-	2 pcs	300,000	600,000
cable	-	-	-	7,500 m	2,000	15,000,000
Total electricity cost	-	-	-	-	-	173,322,000
Total production cost	-	-	78,766,659	-	-	252,088,659
Yield per ha	45,900 kg	3,000	137,698,623	53,924 kg	3,000	161,773,382
	-	-	-	-	-	-

Description	No lights			With 4-hour light		
	Physical (quantity)	Unit (IDR)	Amount (IDR)	Physical (quantity)	Unit (IDR)	Amount (IDR)
Profit	-	-	58,931,964	-	-	(90,315,276)
R/C ratio	-	-	1.7	-	-	0.6

Note: IDR=Rupiah Indonesia; R/C ratio=Revenue Cost Ratio; HR=human resources; L=Liter; kg=kilogram; g=gram; pcs=pieces; kW=kilowatt; m=meter

**Table 5.** Analysis of tomato farming in plastic houses with the addition of 4 hours of CFL light and control on the variety 'Juliet'

Description	No lights			With 4-hour light		
	Physical (quantity)	Unit (IDR)	Amount (IDR)	Physical (quantity)	Unit (IDR)	Amount (IDR)
Saprodi	-	-	-	-	-	-
Seed	400 g	25,000	9,999,900	400 g	25,000	9,999,900
Bactomycin (bactericide)	1 kg	500,000	250,000	1 kg	500,000	250,000
Agrisan (fungicide)	30 kg	25,000	750,000	30 kg	25,000	750,000
Topsin (fungicide)	20 kg	35,000	700,000	20 kg	35,000	700,000
Confidor (insecticide)	1 L	180,000	90,000	1 L	180,000	90,000
Buldog (insecticide)	15 L	110,000	1,650,000	15 L	110,000	1,650,000
Manure (organic fertilizer)	20,000 kg	500	10,000,000	20,000 kg	500	10,000,000
Silver black mulch	16 m	30,000	480,000	16 m	30,000	480,000
Curacron (insecticide)	6 L	130,000	780,000	6 L	130,000	780,000
Antracol (fungicide)	8 kg	49,999	399,992	8 kg	49,999	399,992
NPK (fertilizer)	1,000 kg	10,000	10,000,000	1,000 kg	10,000	10,000,000
Ajir (bambu poles)	18,000 pcs	150	2,700,000	18,000 pcs	150	2,700,000
Saprodi Fees	-	-	37,799,892	-	-	37,799,892
Labor <sup>ha</sup> (HR)	-	-	-	-	-	-
Nursery	20 HR	50,000	1,000,000	20 HR	50,000	1,000,000
Tillage	76 HR	50,000	3,800,000	76 HR	50,000	3,800,000
Making beds	50 HR	50,000	2,500,000	50 HR	50,000	2,500,000
Fertilization	102 HR	50,000	5,100,000	102 HR	50,000	5,100,000
Plant	64 HR	50,000	3,200,000	64 HR	50,000	3,200,000
Weeding	56 HR	50,000	2,800,000	56 HR	50,000	2,800,000
Pest control	64 HR	50,000	3,200,000	64 HR	50,000	3,200,000
Watering	236 HR	50,000	11,800,000	236 HR	50,000	11,800,000
Navigation and crew	165 HR	50,000	8,250,000	165 HR	50,000	8,250,000
Harvesting	103 HR	50,000	5,150,000	103 HR	50,000	5,150,000
Labor costs	-	-	46,800,000	-	-	46,800,000
Electricity subscription	-	-	-	17,059 kW	3,750	63,972,000
The cost of light bulbs	-	-	-	3,750 pcs	25,000	93,750,000
Switch	-	-	-	2 pcs	300,000	600,000
Cable	-	-	-	7,500 m	2,000	15,000,000
Total electricity cost	-	-	-	-	-	173,322,000
Total production cost	-	-	84,599,892	-	-	257,921,892
Yield per ha	10,550	10,000	105,498,945	34,075	10,000	340,746,593
Profit	-	-	20,899,053	-	-	82,824,700
R/C ratio	-	-	1.2	-	-	1.3

Note: IDR=Rupiah Indonesia; R/C ratio=Revenue Cost Ratio; HR=human resources; L=Liter; kg=kilogram; g=gram; pcs=pieces; kW=kilowatt; m=meter

## Discussion

The low daily minimum temperature causes the respiration process to drop. Decreasing the respiration process will increase the accumulation of photosynthesis results, one of which is that there are more leaves in the leaves that contain leaf chlorophyll (Sulistiyowati *et al.*, 2016; Taiz and Zeiger, 2002). Meanwhile, the 'Golden Sweet' variety has a higher chlorophyll content per m.g. of leaves, because of the small leaf size compared to other varieties, and to support large plants, one of which is with, a high amount of chlorophyll per unit gram of leaves.

The tallest plants are the 'Golden Sweet' and 'Juliet' varieties, both of which are indeterminate species, which are always elongated even after bearing fruit (Fridman *et al.*, 2002; Kusumayati *et al.*, 2015) so they will always experience high growth (Table 1). The diameter of the stem of the plant of the 'Betavila' variety is the largest. followed by 'Juliet'. 'Golden Sweet' and 'Golden Sweet' have the smallest diameters. This shows that the variety has a high response to the provision of additional light for its growth. Dry weight of plants with a 12-hour night light addition treatment showed a difference from control care (without adding light). The addition of 10%-night light intensity from CFL can increase the photosynthesis yield of plants, so that it can increase plant vegetative growth, including, in this case, the dry weight of plants is greater when given additional light at night. This is in accordance with the results of research conducted by (Hurd, 1973). Of the four tomato varieties tried, the 'Betavila' variety had the highest dry weight, and the 'Golden Sweet' variety had the lowest dry weight.

Tomato plant blooming is slower in the treatment of adding a night light. This is related to the comparison of infrared light with the red light that plants receive. According to Taiz and Zeiger (2002). This is related to the performance of plant phytochromes. The same is true of the results of research on chrysanthemums to extend flower stalks by providing additional light at night, so that they do not flower quickly (Higuchi *et al.*, 2012). This happened in this study also because the flowering age of plants was 3 days slower than plants without the addition of CFL lamp light.

An additional 10% of the sunlight intensity of CFL in the treatment of adding night light can increase the photosynthesis process higher with more chlorophyll content. which is used by plants for plant growth. One of them is to increase the area of plant leaves so that it can increase or increase photosynthesis yields, namely glucose/energy. In accordance with the results of research conducted by (Hurd, 1973; Grimnes, 1994; Terashima *et al.*, 2009; Locke *et al.*, 2024). A sizable leaf area (Figure 7) can cause the temperature around the plant to be lower. This is because the area of the leaf covers the area exposed to light, so the temperature around the stem of the plant becomes lower (Breshears *et al.*, 2014; Bueno *et al.*, 2014).

In previous studies, it was found that plants shaded with lower light intensity can increase lycopene content (Ilić *et al.*, 2012). The addition of additional light at night means increasing the intensity of sunlight received by plants, so that lower lycopene yields are obtained, because plant adaptation will reduce the number of light recipients, both chlorophyll and lycopene, when the light received is quite large (Baharuddin *et al.*, 2014; Setyorini *et al.*, 2018), because beta-carotene also functions as a light receiver and chlorophyll protector, If the light received is enough, the plant will adapt to reduce its number, as in chlorophyll (Baharuddin *et al.*, 2014).

The production of 'Juliet' tomatoes is lowest in plants that are not given additional CFL light. The same thing also happened in previous research: the use of LED (Light Emitting Diode) lights increased the growth of tomato plants (Yasar *et al.*, 2022). High fruit production when CFL lamps are added for 12 hours in the 'Golden Sweet' variety, occurs because the addition of CFL light provides additional energy for the plant's

photosynthesis process, so that it can increase tomato fruit production (Dusenge *et al.*, 2019). However, the response of each plant is highly dependent on the individual variety; in this case, the 'Juliet' variety is more sensitive to the slight addition of CFL light (4 hours), which can directly provide additional fruit production. The duration of the addition does not affect the additional production, due to the increased process of plant respiration (Dusenge *et al.*, 2019). Meanwhile, the 'Golden Sweet' variety is less sensitive and requires 12 hours of CFL light to show the real effect of increased fruit production. The provision of a 12-hour night light with CFL on the 'Betavila' tomato variety has the lowest effect on fruit production. Production will be higher if added with CFL lamps for only 4 hours, although it does not differ significantly with plants without the addition of CFL lamps and the addition of CFL lamps for 8 hours.

Plants treated with a 4-hour night light have the highest content of chlorophyll b. This is because chlorophyll b is greatly affected by the light that plants receive. The lower the light the plant receives, the higher the chlorophyll b content (Juhaeti, 2001). Meanwhile, plants that are not added to night light are also low because the low light received by plants affects the results of plant photosynthesis (Taiz and Zeiger, 2002). This causes a lower leaf area of the plant so in the temperature around the plant is higher than the treatment of adding a night light for 4 hours, so that respiration is higher than the additional light of the 4-hour lamp. This is because plastic houses with the addition of 4-hour night lights have a lower average daily minimum temperature than other treatments (Figure 2A).

The lycopene content decreases with the addition of night light. This supports the results of previous research that tomatoes, if they get more light, will reduce the lycopene content in the fruit (Setyorini *et al.*, 2018). The beta-carotene content in this study also decreased with the addition of night light (Figure 9). Yellow varieties do not always have a higher beta-carotene content compared to red varieties. The results obtained showed that plants that were not given additional light at night had a greater beta-carotene content (Figure 9). Fruit colour does not indicate the high or low levels of lycopene and beta-carotene, which determines the colour of the fruit is the comparison of lycopene and beta-carotene content of the fruit. The increase in total carotenoid content is related to the parent line. This increase occurred without a large variation in endogenous carotenoid gene expression (Rosati *et al.*, 2000).

The results of the cultivation analysis showed that the 'Juliet' tomato variety was more profitable if CFL light was added for 4 hours before sunrise, with an R/C ratio of 1.3. Meanwhile, the 'Betavila' tomato plant variety is more profitable without the addition of a night light, with an R/C ratio of 1.7 (Tables 2 and 3). Although there was an increase in tomato production with the addition of CFL lamps, this was due to the additional cost of electricity use, which reduced profits for the 'Betavila' tomato variety.

## Conclusions

The addition of a night light can increase the yield of fruit per plant, especially indeterminate tomatoes. The results of the study can be concluded that in tropical areas, cherry tomato plants (indeterminate type) plus CFL light from 4 and up to 12 hours can increase fruit production, while in determinate varieties ('Betavila') plus CFL light for 4 hours can increase production, but is not economically profitable. The results of the cultivation analysis calculation show that the 'Betavila' variety is more advantageous without CFL lights at night and 'Juliet' is more advantageous if it is given light for 4 hours before sunrise. The addition of night light decreased the lycopene content in 'Juliet' tomatoes (indeterminate red fruits), but not in the 'Golden Sweet' (determinate orange fruit colour) and 'Betavila' (determinate red fruits) tomato varieties.  $\beta$ -carotene decreased at 4-12 hours of night light addition in 'Juliet' tomatoes and 8 hours of addition in 'Golden Sweet' tomatoes (indeterminate yellow fruit colour). The  $\beta$ -carotene content did not decrease in determinate tomatoes ('Golden Sweet' and 'Betavila').

### Authors' Contributions

Conceptualization :DS; YS; NA; SYT; Data curation :DS; SS; LF; YS; NA; SYT; Formal analysis: LF; SS; RCW; EL; DD; MS; HS; Funding acquisition: DS; LF; Investigation: MI; YS; NA; SYT; DS; Methodology: YS; NA; SYT; DS; Project administration; Resources: MI; DS; LF; SS; Software: DS; EL; RCW; ZA; LF; Supervision: YS; NA; SYT; DS; Validation: RCW; SS; MI; YS; NA; SYT; DD; DS; Visualization: LF; RCW; SS; MI; MS; YS; NA; SYT; DD; DS; Writing - original draft: LF; SS; DD; ZA; MI; MS; HS; YS; NA; SYT; DS; Writing - review and editing: LF; RCW; SS; EL; MI; DD; ZA; MS; HS; YS; NA; SYT; DS.

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### Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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