Influence Analysis Number of Blue and Red Light Emitting Diode (LED) Variation on Soybean (Glycine Max) Growth

Wilda Prihasty[1, a] , Intan Dwi Kurniawati[1, b] , Iman Ramacaesar Rosohadi[1, c] ,
Achmad Syarif Hidayat[1, d] , Selvy Uftovia Hepriyadi[1, e]

[1]*Department of Engineering Physics, Faculty of Industrial Technology Institut Teknologi Sepuluh Nopember, Indonesia*

[a]prihastywilda@gmail.com
[b]intan.dwikurniawati10@gmail.com
[c]imanrosohadi@yahoo.com
[d]achmadsyarief41@gmail.com
[e]selvyuftoviahepriyadi@gmail.com

Abstract. Soybean (*Glycine Max*) is one of the agricultural commodities that still had particularly low production rate on a national scale in Indonesia. Despite the demand for the soybean it's increasing along with the population growth in Indonesia. Thus, the need of soybean which mainly as main ingredient of tempe and tahu is still filled from importers. These problems can be solved by the research of applying artificial light technology in the agricultural sector so it would help optimize soybean growth. The purpose of this research is determines the effect of Blue Light and Red Light Emitting Diode (LED) lighting on the growth of soybean (*Glycine max*). Soybeans were grown in uniform boxes that had controlled temperature and humidity with regulated soybean seeds, soil, and planting methods. Based on the results from the research that had been conducted on the growth of the soybean, it is determined that most optimum soybean plant is using the lighting ratio of the red LEDs 75% and blue 25% with a height of 15 cm in the ninth day and the chlorophyll concentration is 52,4265953 mg/l. But plant with sun source lighting is better than using LED, it is about 118,8138334 mg/l. Based on the result that had been obtained, this research can be used as reference in the making of modern artificial light for soybean for research development in agriculture especially on soybean commodity which could support government efforts in suppressing important soybeans and meet domestic soybean demand using national production.

Keywords: Soybean, LED, Agriculture

INTRODUCTION

Soybean with the Latin name *Glycine max* is a versatile plant with high protein content. The main utilization of soybean is from the seeds that are rich in protein and fat as well as some other important nutrients, such as vitamins (phytic acid) and lecithin. Processed white beans are widely used as raw material for tempe and tahu (Pusat Data dan Sistem Informasi Pertanian, 2015). During the period of 2002-2014, soybean consumption was quite fluctuated and tended to decline with an average rate of decline is 1.15% per year. The consumption of soybeans in this period is on average by 7.62 kg per capita per year and the highest consumption of 8.63 kg per capita per year occurred in 2007. However, one year later it decreased significantly by 11.16% so the consumption became 7.67 kg per capita per year. The decline of consumption in 2007-2008 was inseparable from the global economic recession and the existence of food demand for alternative energy, the impact is the decreasing of purchasing power of the world community including Indonesia.

Indonesia is a country that has 2 seasons, the dry season and the rainy season. During the rainy season, sunlight is certainly not optimal. This can be an obstacle for soybean growth and give impact on soybean production in Indonesia. The plant growth is strongly influenced by the quality of light refers to the color or wavelength that

reaches the plant surface (Johkan, Shoji, Goto, Hashida, & Yoshihara, 2010). Sunlight is a polychromatic light in which there is blue and red light. The red (R) and blue (B) light have a strong influence on plant growth because red and blue light are the main sources of energy in the assimilation process of carbon dioxide in photosynthesis in chlorophyll (Kasajima, Inoue, Mahmud, & Kato, 2008). With the increasing number of chlorophyll, the assimilation process of carbon dioxide increases, so the soybean growth will also increase. Therefore, we need an artificial light that can replace the sunlight. With the artificial light replacement of sunlight, we can maximize soybean growth despite of constrained weather changes in Indonesia.

Based on the problems that have been described above, this research is expected to be a solution to increase the growth of domestic soybean using artificial light.

METHOD

Variables used in this research are control variable in the form of equal planting media; response variables such as plant height, number of leaves, and chlorophyll content; free variable in the form of variations of red and blue LEDs comparison. The equipments used in this research are Red LEDs, Blue LEDs, Plant Incubator Boxes, Spectrophotometry, Cuvette, Mortar, and Electronic Components. The materials used in this study are as follows; soybean seeds, soil, 1000 ml 85% acetone, and fertilizer. Experimental designs are in the form of planting media and variation of LEDs circuit. Planting media is in the form of plywood box with the dimension of 30 cm x 55 cm x 120 cm. The LEDs circuits are placed parallel in the cover of the boxes. There are 2 kinds of treatment variations; rays come from sunlight and LEDs. There are 5 kinds of LEDs variations in the ratio between the number of red and blue LEDs; 100% blue, 75% blue and 25% red, 50% blue and 50% red, 25% blue and 75% red, and also 100% red. Characterization of the chlorophyll content was done by spectrophotometric method to obtain the absorbance value from chlorophyll solution. So, it can be obtained the value of chlorophyll concentration in mg/l by using empirical formula of previous research.

RESULT AND DISCUSSION

From the observation of the experiment that has been done, the results are obtained in the form of plant height, number of leaves, and chlorophyll concentration as follows:

Plant Height

The observation by measuring the plant height from the ground to the tip of the plant for 9 days, it obtained the data as follows:

TABLE 1. Height Observation

Day	Sun	100% R	75% R 25% B	50% R 50% B	25% R 75% B	100% B
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	1	1	-	-
4	1	-	4	3.8	1	-
5	3.6	1	5.6	5.7	1.5	-
6	5.1	1.8	7.2	7	2.5	1
7	7.9	2.3	9.9	9.8	3.5	2
8	9.5	3.5	13	12	4.3	2
9	11.7	4	15	14	5	2

Note:

R = Red Light LED

B = Blue Light LED

From the data above, it is obtained that the plant height is influenced by the light sources. The optimum plant height is on the variation of red LEDs 75% and blue 25% followed by the variation of red LEDs 50% and blue 50% then the plant under the sunlight.

Number of Leaves

The observation by measuring the number of leaves for 9 days, it obtained the data as follows:

TABLE 2. Number of Leaves

Day	Sun	100% R	75% R 25% B	50% R 50% B	25% R 75% B	100% B
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	2 (primary)	2 (primary)	-	-
4	2 (primary)	-	2 (primary)	2 (primary)	2 (primary)	-
5	2 (primary)	2 (primary)	2 (primary)	2 (primary)	2 (primary)	-
6	4	2 (primary)	2 (primary)	2 (primary)	2 (primary)	2 (primary)
7	4	2 (primary)	4	4	2 (primary)	2 (primary)
8	8	2 (primary)	4	4	2 (primary)	2 (primary)
9	8	2 (primary)	5	4	2 (primary)	2 (primary)

Note:
R = Red Light LED
B = Blue Light LED

From the data above, it is obtained that the number of leaves are influenced by the light sources. The optimum number of leaves is on the variation of red LEDs 75% and blue 25% followed by the variation of red LEDs 50% and blue 50%.

Chlorophyll Concentration

From the measurement of chlorophyll concentration by using spectrophotometric method, we get the intensity value as follows:

TABLE 3. Intensity Value (Watt)

Sample	$\lambda = 645$ nm	$\lambda = 663$ nm
Acetone 85%	3.40158×10^{-5}	3.39286×10^{-5}
Sun	1.03446×10^{-6}	1.01314×10^{-6}
75% R 25% B	8.06401×10^{-6}	6.99219×10^{-6}
50% R 50% B	2.03000×10^{-5}	2.86000×10^{-5}

Note:
R = Red Light LED
B = Blue Light LED

From the data above, it is obtained that the highest intensity value for $\lambda = 645$ nm and $\lambda = 663$ nm is at red LEDs 50% and blue 50%, followed by variations of red LEDs 75% R and blue 25%, then the sun. The acetone intensity value is used as the reference value.

The calculation of the absorbance value can be obtained by using the formula:

$$\text{Absorbance} = \log \frac{I_0}{I}$$

Where:
I_0 = Intensity of acetone 85%
I = Intensity of the test solution

So, it is obtained the absorbance value as follows:

TABLE 4. Absorbance Value

Variation	$\lambda = 645$ nm	$\lambda = 663$ nm
Sun	1.516966987	1.524896477
75% R 25% B	0.625129632	0.685952719
50% R 50% B	0.223519813	0.074629858

From the data above, it is obtained that the highest absorbance value for $\lambda = 645$ nm and $\lambda = 663$ nm is at the sun lighting, followed by the variation of red LEDs 75% and blue 25%, then followed by the variation of red LEDs 50% and blue 50%.

The value of chlorophyll concentration in mg/l can be obtained by using the formula:

$$Total\ Chlorophyll\ Concentration = 20,2\ D(\lambda 645) + 58,02 D(\lambda 663)\ \left(\frac{mg}{l}\right)$$

Where:

D　　　= Absorbance value from the test solution

So, it is obtained the result as follows:

TABLE 5. Chlorophyll Concentration Value

Variation	Chlorophyll Concentration (mg/l)
Sun	118.8138334
75% R 25% B	52.42659530
50% R 50% B	8.845124595

From the data above, it is obtained that the highest chlorophyll concentration for $\lambda = 645$ nm and $\lambda = 663$ nm is at the sun lighting, followed by the variation of red LEDs 75% and blue 25%, then followed by the variation of red LEDs 50% and blue 50%.

CONCLUSION

Optimum plant growth can be affected by several things. One of the factors that influence the soybean growth is the source of lighting which is the most important factor for photosynthesis. In this study, observed variables were plant height, leaf number, and chlorophyll concentration. From these data, it can be obtained that the optimum growth is generated by sunlight and followed by variation of red LEDs 75% and blue 25% based on the number of leaves and the chlorophyll concentration. Meanwhile, the plant under the lighting of red LEDs 75% and blue 25% is higher than the plant under the sunlight. The plant under red LEDs 75% and blue 25% lighting has high rate of growth based on plant height, while it has weak plant conditions, small leaves, and stems that are not firm enough. It is known as etiolation because the lighting under LEDs variations is less of light intensity than the sun. For the variations of red LEDs 100% and blue LEDs 100% do not grow well and there is no leaf, so it can not be used for the test of chlorophyll concentration.

ACKNOWLEDGEMENTS

REFERENCES

Johkan, M., Shoji, K., Goto, F., Hashida, S., & Yoshihara, T. (2010). Blue light-emitting diode light irradiation of seedlings improves seedling quality and growth after transplanting in red leaf lettuce. *HortScience*, *45*(12), 1809–1814.

Kasajima, S., Inoue, N., Mahmud, R., & Kato, M. (2008). Developmental Responses of Wheat cv. Norin 61 to Fluence Rate of Green Light. *Plant Production Science*, *11*(1), 76–81. https://doi.org/10.1626/pps.11.76

Pusat Data dan Sistem Informasi Pertanian. (2015). *Outlook komoditas pertanian subsektor tanaman pangan : Kedelai*. Jakarta: Kementrian Pertanian.