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The Effect of Paclobutrazol Concentrations in Different Shade Levels on Coleus Plant Leaves Color

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ABSTRACT

Coleus scutellarioides is a leaf ornamental plant that is widely used as an ornamental plant in tourist attractions because it has an interesting leaf color. The purpose of study was to obtain right concentration of paclobutrazol for the brightness of the color of the leaves of the coleus plant in shaded conditions. The method used is a Split Plot Design with two factors, light intensity as the whole plot and paclobutrazol concentration as a split plot. The whole Plot consists of 3 levels, namely I100 (100% sunlight intensity), I75 (75% sunlight intensity) and I50 (50% sunlight intensity) while the split plot consisted of P0 (Without Paclobutrazol), P40 (Paclobutrazol 40 ppm), P80 (paclobutrazol 80 ppm) and P120 (paclobutrazol 120 ppm. The results showed there were interactions from the treatment of paclobutrazol concentrations at various light intensities. The application of paclobutrazol 0 ppm at a light intensity of 75% and 50% gave the same chlorophyll content results as the 100% light intensity treatment and 0 ppm paclobutrazol concentration.The conclusions in addition of paclobutrazol 40-80 ppm at a decrease in light intensity of 75% and 50% gives the result of anthocyanin content and leaf color equal to 100% intensity and paclobutrazol 0 ppm.

1. INTRODUCTION

The existence of tourist villages in Indonesia is now increasingly known by the public. A tourist village is a rural area that has several special characteristics to become a tourist destination area, one of which is the Mejono tourist village. This is in accordance with the opinion of Ahda (2018) who stated that a tourist village is a rural area that offers authenticity both in terms of socio-culture, customs, daily life, traditional architecture, village spatial structure which is presented in a form of integration of tourism components such as attractions, accommodation and supporting facilities. Mejono Village is one of the tourist villages in Kediri Regency that offers authenticity in terms of socio-culture and

traditional architecture. This village, which has natural tourist attractions, offers a variety of comforts in the form of clean and cool air conditions, comfortable temperature and sunlight as well as typical natural views of the river (Afrizal & Oktariyanda, 2021).

Coleus (*Coleus scutellarioides*) has the local name "Miana" is a plant native to India and Thailand. Coleus is a type of leaf ornamental plant, with aesthetic value found in the diverse and attractive color of the leaves (Li, Coneva, Robbins *et al*., 2021). The use of coleus plants as ornamental plants in tourist villages can increase the aesthetic value of the place. The attractive leaves of the coleus plant make the plant often used by the community as a potted ornamental plant, ground cover plant and hedge plant (Pratama & Nihayati, 2021). Coleus is able to grow well at maximum lighting or throughout the day, and maximum lighting is able to make the color of the leaves on coleus plants more brilliant (Li, Coneva, Clark *et al*., 2021).

Mejono tourist village has many large trees that are shady and many bamboo plants are found so the tourist area gets less light intensity. Planting coleus in tourist attractions can increase aesthetic value, but planting coleus plants in areas that have low light intensity causes the appearance of the plant to be less optimal (leaf color is less brilliant or slightly faded) (Arsana & Ambariyanto., 2021). This is because coleus is such a plant that needs full sun ray conditions (Siregar *et al*., 2019). The effort made to maintain the color of plant leaves even though the coleus plant is grown in a shady area is to apply a growth regulator (Paclobutrazol). The application of paclobutrazol is able to increase the anthocyanin content in plants. The increase in anthocyanins is due to an increase in the hormone ABA (Abscisic Acid), the increase in ABA is directly proportional to the increase in anthocyanins because one of the factors of anthocyanin biosynthesis is influenced by ABA (Soumya *et al*., 2017). The application of paclobutrazol 25 ppm in red spinach plants increased anthocyanins by 47.79% (Ichsan & Asmarani, 2019). Several other studies stated that Paclobutrazol increased the anthocyanin content as reported by Nivedithadevi *et al*. (2017) in sweet potatoes, carrots by Murgayanti *et al*. (2019), and *Catharanthus roseus* (doro tread) by Prayoga *et al*. (2019). The purpose of this study was to obtain the right concentration of paclobutrazol to have the maximum the brightness of the leaf color of the coleus plant in shaded conditions.

2. MATERIALS AND METHODS

The research was carried out in Mejono Tourism Village located on RT 002 / RW 005, Mejono Village, Plemahan District, Kediri Regency, East Java with an altitude of ± 132 m above sea level. The average temperature is at least 23°C and the maximum temperature is 33°C, and has an average rainfall of 1652 mm/day according to BMKG data in 2020. The study was conducted from June to September 2020 (Afrizal & Oktariyanda, 2021).

2.1. Materials and Equipment

The tools used in this study are stationery, LAM (Leaf Area Meter), spectrophotometer, analytical scales, ruler, centrifuge, calipers, ovens, RHS colour charts, Lux meters, polybags, measuring cups and digital cameras. While the materials to be used are coleus plants, plant media mixed with husks and soil, paclobutrazol (Goldstar, 25% paclobutrazol), water and NPK fertilizer (15:15:15).

2.2. Design of Experiment

The method used in this study is a Split Plot Design with two factors, namely light intensity as the whole plot and paclobutrazol concentration as the sub plot. The whole plot is the intensity of sunlight which consists of 3 levels, namely:

I100 = 100% sunlight intensity
I75 = 75% sunlight intensity
I50 = 50% sunlight intensity

While the sub plot is a concentration of paclobutrazol which consists of:

P0 = Without paclobutrazol
P40 = Paclobutrazol concentration 40 ppm
P80 = Paclobutrazol concentration 80 ppm
P120 = Paclobutrazol concentration 120 ppm

The tool used to measure the intensity of sunlight is a lux meter. The part of the lux meter that is sensitive to light is directed at the reflection of the incoming light, the magnitude of the intensity can be seen on the scale. Lux meter works with light sensor. Lux meter is enough to be held as high as 75 cm above the forest floor. The pointer screen will display the luminance level at the metering point.

2.3. Data Analysis

Data analysis uses variance analysis (F test) at a level of 5% (Table 1). If there is a significant influence, further testing is carried out by using the Honestly Significant Difference (HSD) test (Tukey test) at the level of 5%. Data analysis was carried out at the time before and after the study. Preliminary observations before the study aim to find out the uniformity (homogeneity) of the plants to be observed. If the data from the initial observations are significantly different, the data in the next observations use covariance analysis by calculating the growth gain (delta) of plants, while if the data from the initial observations are not significantly different, the data in the next observations use variance analysis (Kuznetsov *et al*., 2019).

3. RESULTS AND DISCUSSION

3.1. Chlorophyll Content

From the analysis of variance, it is known that there is an interaction of chlorophyll content due to the treatment of paclobutrazol concentration and sunlight intensity (Croft *et al*., 2017). The effect of paclobutrazol concentration treatment on various intensities of sunlight on the chlorophyll content of coleus plants is presented in Table 1.

At the age of 28 and 56 dap the decrease in light intensity of 75% and 50% gives the same chlorophyll content results with a light intensity of 100% at all concentrations of paclobutrazol (0 ppm, 40 ppm, 80 ppm and 120 ppm). An increase in the concentration of paclobutrazol at all intensities gives a value of chlorophyll content equal to the concentration of paclobutrazol 0 ppm (El-Aal & Mohamed, 2017). The addition of paclobutrazol 0 ppm at a light intensity of 75% and 50% results in chlorophyll content equal to the light intensity of 100% and paclobutrazol 0 ppm.

At the age of 84 dap the 75% decrease in light intensity provides chlorophyll content equal to 100% light intensity, while a 50% decrease in intensity is able to increase chlorophyll content compared to 100% light intensity at all paclobutrazol concentrations (Tesfahun, 2018). The application of paclobutrazol 120 ppm at a light

intensity of 75% is able to increase the chlorophyll content by 11.72%. When compared with the control treatment (light intensity 100% and paclobutrazol concentration 0 ppm) the administration of paclobutrazol 0 ppm at a light intensity of 75% gave the average of the same chlorophyll content (Sharaf-Eldien *et al*., 2017). While at a light intensity of 50% paclobutrazol with a concentration of 0 ppm was able to increase the chlorophyll content by 14.13% compared to the control treatment.

Table 1. Chlorophyll Content of Coleus Plant Due to Paclobutrazol Concentration Treatment at Various Light Intensities

Plant age (dap)	PBZ (ppm)	Chlorophyll Content (mg g^{-1})		
		Light Intensities (%)		
		100	75	50
28	0	1,748 a	1,795 a	2,007 ab
	40	1,782 a	1,866 ab	2,042 ab
	80	1,865 ab	1,945 ab	2,071 ab
	120	1,922 ab	2,025 ab	2,183 b
HSD 5%			0,3681	
56	0	1,945 a	1,984 a	2,283 ab
	40	1,986 a	2,047 ab	2,306 ab
	80	2,017 a	2,183 ab	2,383 ab
	120	2,053 ab	2,210 ab	2,464 b
HSD 5%			0,4284	
84	0	1,860 a	1,891 a	2,166 bcde
	40	1,893 a	1,961 ab	2,217 cde
	80	1,936 ab	2,044 abc	2,263 de
	120	1,994 abc	2,142 bcd	2,379 e
HSD 5%			0,2331	

Note : Number followed by the same letter in the same column and row, no significant difference on the 5% of Tukey (HSD) test.

In shaded plants, the color of the leaves will tend to be higher chlorophyll content, it is also seen in coleus plants with a light intensity of 75% and 50% . Shade can affect the quality of leaf color because the shaded leaves have a higher chlorophyll content so that the leaf color will appear greener (Virtanen *et al*., 2020). The increase in chlorophyll content in shaded plant leaves is a form of plant adaptation that aims to be able to optimize light capture in low-light conditions (Sirait, 2018). The increase in chlorophyll is related to the increase in light harvesting complex (Light Harvesting Complex II) as well as the enlargement of the antennae in photosystem II which results in an increased light capture (Liem & Herawati, 2021). The form of physiological adjustment to the leaves condition is indicated by an increase in chlorophyll b in plants, the increase occurs because chlorophyll b acts directly as a light harvester, while chloroyl a participates in the conversion of radiation energy captured by chlorophyll b into chemical energy (Sirait, 2018). Nakamura *et al*. (2018) states that shaded leaves have more grana pervolume chloroplasts, chloroplasts are larger and produce larger chlorophyll-like plant pigments than leaves that develop in conditions of full sunlight. So that the color of the leaves of the shaded plant will appear greener because the chlorophyll pigment produced by the plant is shaded more (has more grana) (Sutejo *et al*., 2020).

3.2. Anthocyanin Content

Analysis of the variety at observational ages of 28, 56 and 84 DAP showed there was an interaction in the anthocyanin content of coleus plants between the treatment of paclobutrazol concentration and sunlight intensity (Priska *et al*., 2018). The effect of paclobutrazol concentration treatment on various light intensities on the anthocyanin content of coleus plants is presented in Table 2.

Table 2. Anthocyanin Content of Coleus Plant Due to Paclobutrazol Concentration Treatment at Various Light Intensities

Pant Age (dap)	PBZ (ppm)	Anthocyanin Content (mg g^{-1})		
		Light Intensities (%)		
		100	75	50
28	0	0,701 cd	0,594 a	0,577 a
	40	0,705 cd	0,636 ab	0,594 a
	80	0,738 d	0,664 bc	0,671 bc
	120	0,743 d	0,695 cd	0,668 bc
Tukey 5%			0,0547	
56	0	0,750 de	0,642 abc	0,607 a
	40	0,752 de	0,672 abcd	0,624 ab
	80	0,788 e	0,699 abcde	0,713 bcde
	120	0,786 e	0,741 cde	0,712 bcde
Tukey 5%			0,103	
84	0	0,702 bc	0,601 a	0,582 a
	40	0,738 bc	0,660 ab	0,593 a
	80	0,768 c	0,688 bc	0,709 bc
	120	0,762 c	0,722 bc	0,704 bc
Tukey 5%			0,0798	

Description : Number followed by the same letter in the same column and row, no real difference on the 5% HSD test.

At the age of 28 dap a 50% decrease in light intensity resulted in a lower anthocyanin content compared to 100% light intensity at all concentrations of paclobutrazol (0 ppm, 40 ppm, 80 ppm and 120 ppm). The of paclobutrazol 80 ppm at a light intensity of 75% and 50% resulted in a higher anthocyanin content compared to paclobutrazol 0 ppm (Ashraf & Ashraf, 2020). To obtain the same anthocyanin content with a light intensity treatment of 100% and paclobutrazol 0 ppm at a light intensity of 75% and 50% it is necessary to add paclobutrazol with a concentration of 80 ppm.

At the age of 56 dap a decrease in light intensity of 75% and 50% at a concentration of 0 ppm gave a decrease in anthocyanin content compared to a light intensity of 100%. At a light intensity of 50% paclobutrazol 80 ppm gives a higher anthocyanin content compared to paclobutrazol 0 ppm. The administration of paclobutrazol 40 ppm at a light intensity of 75% and 80 ppm at a light intensity of 50% gave the same anthocyanin content results with a light intensity treatment of 100% and an apclobutrazol concentration of 0 ppm. At the age of 84 dap a decrease in light intensity of 75% and 50% at a paclobutrazol concentration of 0 ppm was able to reduce the anthocyanin content by 14.39% and 17.09%, respectively (Iqbal *et al*., 2020). An increase in the concentration of paclobutrazol at an intensity of 100% gives a result equal to a concentration of 0 ppm. Meanwhile, the application of paclobutrazol with a concentration of 80 ppm at a light intensity of 75% and 50% was able to increase the

anthocyanin content by 12.64% and 17.91% respectively compared to a concentration of 0 ppm. To obtain the same anthocyanin content as the control plants (light intensity 100% and paclobutrazol concentration 0 ppm) at a light intensity of 75% it is necessary to add paclobutrazol with a concentration of 40 ppm while at a light intensity of 50% it is necessary to add paclobutrazol with a concentration of 80 ppm.

In the leaves of the coleus plant, the purple color that appears is caused by the high content of anthocyanins (Zhu *et al*., 2017). In conditions of low sunlight intensity anthocyanins function to protect chloroplasts. Anthocyanins themselves are a type of flavonoid that increases when exposed to light directly (Ahammed & Yang, 2022). Based on the mechanism of action of paclobutrazol which is able to inhibit the synthesis of Giberelin, paclobutrazol is also able to increase the production of Abscisic Acid because more precusors in the terpenoid pathways are accumulated and used for the formation of ABA (Soumya *et al*., 2017). ABA is one of the hormones that is a factor in the increase in PAL enzymes, which is one of the important enzymes in the anthocyanin biosynthesis process because it is the first enzyme used in the biosynthesis process (Zhu *et al*., 2017). So that the application of paclobutrazol is known to be able to increase the anthocyanin content in coleus plants.

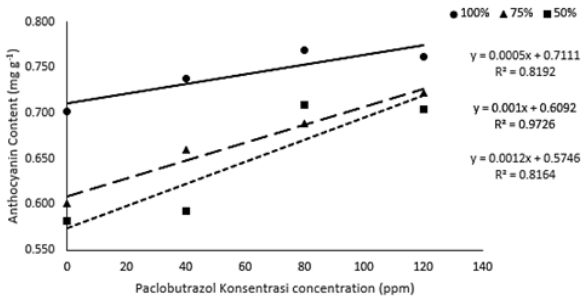

Figure 1. Relationship of Paclobutrazol Concentration with Coleus Anthocyanin Content at Three Levels of Light Intensity (Marshel *et al*., 2015)

Figure 1 shows the extent of the relationship between paclobutrazol concentration (x) and anthocyanin content (y) in regression tests. An increase in the concentration of paclobutrazol is able to increase the anthocyanin content in plants (Priska *et al*., 2018). The results of regression analysis at 100% sunlight intensity show that every increase of 10 ppm of paclobutrazol, the anthocyanin content will increase by 0.07%. Furthermore, the results of regression analysis at a sunlight intensity of 75% showed that every increase in paclobutrazol by 10 ppm, the anthocyanin content would increase by 0.2%. Meanwhile, at a sunlight intensity of 50% the result was obtained that every increase in paclobutrazol 0 ppm, the anthocyanin content will increase by 5.1% (Ahammed & Yang, 2022). Based on the regression chart, it can be seen that, to achieve the same value of anthocyanin content as the control treatment (light intensity 100% with a paclobutrazol concentration of 0 ppm) a decrease in light intensity of 75% to 50% it is necessary to add paclobutrazol with a concentration of 100 -120 ppm.

3.3. Leaf Color

Leaf color measurement was carried out using the Royal Horticultural Society (RHS) Colour Chart tool. Based on the results of observations, it was found that at the age of

56 and 84 DAP had different leaf colors in some treatments (Shen *et al*., 2018). The colors obtained are dark purple red and dark pink red with codes 53 A, 53 C, 59B and 59 A. Faded red is indicated by code 53 C while bright red is indicated by codes 53 A, 59B and 59 A. Different concentrations of paclobutrazol at light intensities of 75% and 50% have an influence on the color of coleus plant leaves (Table 3).

Table 3. Coleus Plant Leaf Color Due to Paclobutrazol Concentration Treatment at Various Light Intensities

Plant Age (dap)	PBZ (ppm)	Leaf Color		
		Light Intensities (%)		
		100	75	50
28	0	53 A	53 C	53 C
	40	53 A	53 C	53 C
	80	53 A	53 A	53 A
	120	53 A	53 A	53 A
56	0	53 A	53 C	53 C
	40	53 A	53 C	53 C
	80	53 A	59 B	59 B
	120	53 A	59 A	59 A
84	0	53 A	53 C	53 C
	40	53 A	53 C	53 C
	80	53 A	59 B	59 B
	120	53 A	59 A	59 A

Description: Numbers and letter codes are the result of comparison with RHS (Royal Horticultural Society) Colour Chart

53A = *Dark Purple Red*
53C = *Dark Pink Red*
59B = *Dark Purple Red*
59A = *Dark Purple Red*

At the age of 28 dap and 56 dap the decrease in light intensity of 75% and 50% is able to change the color of the leaves to fade (Dark Pink Red) at concentrations of 0 ppm and 40 ppm. While at concentrations of 80 ppm and 120 ppm the decrease in light intensity is 75% and 50% gives the same color as the light intensity of 100% (Dark Purple Red) (Shen *et al*., 2018). The application of paclobutrazol 80 ppm at a light intensity of 75% and 50% gives the same leaf color as the light intensity treatment of 100% and paclobutrazol 0 ppm. At the age of 84 dap the decrease in light intensity of 75% and 50% is able to change the color of the leaves of the coleus plant to be more faded (Muthahara *et al*., 2018). At paclobutazol concentrations of 0 ppm and 40 ppm, the color of the leaves of the coleus plant fades to Dark Pink Red 53 C, while at paclobutrazol concentrations of 80 ppm and 120 ppm the decrease in light intensity is 75% to 50% each of them is able to increase the brightness and concentration of the red color of the leaves of the coleus plant to Dark Purple Red 59 B and Dark Purple Red 59 A. At a light intensity of 75% and 50% the application of paclobutrazol with a concentration of 80 ppm is able to increase the brightness of the leaf color to Dark Purple Red 59B (Iqbal *et al*., 2020). So that when compared with the control treatment (light intensity 100% and paclobutrazol concentration 0 ppm), the administration of paclobutrazol with a concentration of 80 ppm at a light intensity of 75% and 50% was able to increase the brightness and color concentration of the leaves.

In the treatment of high sunlight intensity, the color of the leaves will look redder than the color of the leaves with low sunlight intensity (Figure 2), this condition

indicates that the presence of anthocyanin color pigments dominates more than chlorophyll color pigments so that the red color is visible to the eye. In line with the opinion of (Rezai *et al*., 2018), who stated that anthocyanins are a type of flavonoid that increases when exposed to light directly. In addition, anthocyanins have the function of protecting chloroplasts against high light intensity. Shade can affect the quality of leaf color because the shaded leaves have a higher chlorophyll content so that the leaf color will appear greener (Ilić *et al*., 2017). The increase in chlorophyll content in shaded plant leaves is a form of plant adaptation that aims to be able to optimize light capture in low-light conditions (Sirait, 2018). The increase in chlorophyll content occurs due to the inhibition of the gibberellin biosynthesis process due to the application of paclobutrazol resulting in several substances or chemicals in plants accumulating and switching to support the formation of abscisic acid which is the same as supporting the formation of phytol, one of the important parts of the chlorophyll molecule, the increase in phytophylls that are getting higher also affects the increase in chlorophyll content in plants (Soumya *et al*., 2017). Physiologically, paclobutrazol has been shown to be able to suppress stem elongation, promote flowering, promote the formation of pigments (chlorophyll, xanthophiles, anthocyanins) (Akramov & Mukhitdinova, 2020). This is in accordance with the opinion of Fan *et al*. (2020) who stated that paclobutrazol is able to increase the content of ABA, the increase in ABA is directly proportional to the increase in anthocyanins because one of the factors of anthocyanin biosynthesis is influenced by ABA.

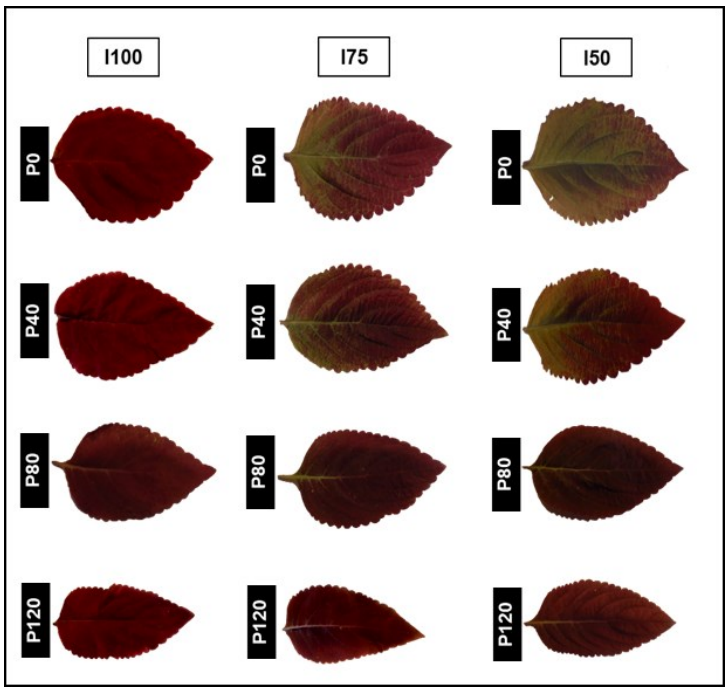

Figure 2. Differences in the color of the leaves of the coleus plant due to the treatment of paclobutrazol concentration and light intensity. (Description: I = Light Intensity, P = Paclobutrazol concentration)

4. CONCLUSIONS

The addition of paclobutrazol 80 ppm to the coleus plants with a reduction in light intensity from 100% to 50% also had an influence on the increase in chlorophyll

content (5.17%) and an increase in anthocyanin content (13.02%) compared to paclobutrazol 0 ppm. The addition of paclobutrazol 40-80 ppm at a 50% decrease in light intensity gives the same Leaf Color and Anthocyanins with a light intensity treatment of 100% and paclobutrazol 0 ppm.

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