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Plant growth and total flavonoid content of *Sisyrinchium palmifolium* after light intensity and gibberellin treatment

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Abstract. *Zuaini PAK, Mudyantini W, Solochatun. 2020. Plant growth and total flavonoid content of* Sisyrinchium palmifolium *after light intensity and gibberellin treatment. Cell Biol Dev 4: 52-63.* Dayak onion (*Sisyrinchium palmifolium* L Syn.: *Eleutherine palmifolia* L. Merr.) was a plant that has the potential to be developed as a traditional medicine because it contains flavonoid compounds. This research aimed to determine the effect of the application of differences in light intensity and gibberellins on the plant growth and flavonoid content of *S. palmifolium*. This research used uniform *S. palmifolium* with a harvest age of 3-4 months and an 8-9 g weight range from Pasir Besar Village, South Pontianak District, Pontianak, Indonesia. The experiment used the Factorial Completely Randomized Design method with two factors treatment and six replications: light intensity (100%, 75%, 50%) and gibberellin concentration (0, 10, 20 ppm). The control was 100% light intensity treatment and 0 ppm gibberellin concentration. The parameters measured were the number of leaves, length, width, time of flowering, number of flowers, and number of bulbs. In the post-harvest, dry and wet weights of bulbs were measured. Then, chlorophyll, carotenoid, and flavonoid contents were assessed using a UV-Vis spectrophotometer, and stomata density was also analyzed. ANOVA analyzed the data, and if the difference was significant, it was continued with the DMRT test at a significance level of 5%. The results showed that the growth of *S. palmifolium* was significantly affected by light intensity and gibberellins on the parameters of leaves length; leaves, midrib, and bulbs wet weight; leaves and midrib wet weight; leaves and midrib dry weight; bulbs dry weight; shoot root ratio; leaves carotenoid content, and bulbs carotenoid content. However, parameters had no significant effect on the number of leaves, leaves width, time of flowering, number of flowers, number of bulbs, chlorophyll contents, flavonoid, and stomata density. The 50% light intensity and 10 ppm gibberellins were the best treatments to increase leaves length, leaves, midrib, bulbs wet weight, leaves, and bulbs chlorophyll content of *S. palmifolium*.

Keywords: Flavonoid, gibberellin, light intensity, plant growth, *Sisyrinchium palmifolium*

INTRODUCTION

Indonesia was a country with abundant biodiversity. One medicinal plant with very little utilization was the *Dayak* onion (*Sisyrinchium palmifolium* L. Syn.: *Eleutherine palmifolia* L. Merr.). Based on several previous studies, *S. palmifolium* bulbs have the potential to be developed as traditional medicine. The *S. palmifolium* bulbs contain secondary metabolites such as phenolics, polyphenols, flavonoids, alkaloids, anthraquinones, tannins, glycosides, steroids, polysaccharides, saponins, and naphthoquinones (Naspiah et al. 2014). Based on empirical data, it was known that *S. palmifolium* could help cure diabetes and hypertension, lower cholesterol, prevent stroke, and treat stomach aches (Galingging 2009). The *S. palmifolium* plants can also act as antibacterial (Harlita et al. 2018), skin antimicrobial (Puspadewi et al. 2013), and agents for lowering blood glucose levels (Galingging 2009). The *S. palmifolium* has a distinctive character, including a smooth bulb surface and a bright red color. *S. palmifolium* leaves have a double pinnate shape that is located in pairs. The midribs of *S. palmifolium* were parallel (rectinervis) with smooth leaf margins (entire). Ribbon leaf shape in the form of a line (linearis). This plant can adapt easily to various climates and soil types. The *S. palmifolium* can be propagated and harvested relatively quickly (Galingging 2009). Harvesting can be done after the plant is 3-4 months after planting (Yusuf 2009).

There were both exogenous and endogenous influences on plant growth. Light intensity was one of the exogenous factors that impact a plant's growth. Indirect or direct, light has a significant impact on the growth and development of plants. Light directly affected plant photosynthesis, while plant growth and development were indirectly affected by light (Fitter and Hay 1998). High light intensity impacts bulb or fruit formation in some plants, while low light intensity reduces bulb and fruit formation, resulting in vegetative overgrowth (Bahruddin 2004). Vegetative organs such as leaves, stems, and roots can expand to a greater volume and impede the growth of generative organs such as flowers and fruit.

Growth regulators can be given to the bulbs to speed up their growth. One class of growth regulators to consider was gibberellins. There are various physiological functions that gibberellins can induce in plants. Numerous vegetable and fruit crops benefit from gibberellins. Leaf growth, root extension, and fruit ripening were examples of these features in action (Miceli et al., 2019).

The amount of chlorophyll in plants can be influenced by changes in light intensity. High light levels can reduce chlorophyll content in leaves. According to other studies, carotenoids and nitrogen levels rose when the light

intensity was high (Salisbury and Ross 1995). According to Bruce et al. (2001), the shadow affects plants' physiological and biochemical conditions. Increasing chlorophyll b levels was a strategy for plant survival that reduced the chlorophyll a/b ratio. In addition, increased chlorophyll b concentration benefits the optimal absorption of radiation energy under shady conditions.

According to Handriawan et al. (2016), 50% shade can significantly inhibit soybean plant development compared to 25% paranet shade. The findings of this study indicate that the intensity of light absorption was diminishing because increased shade levels can result in etiolation symptoms. The symptoms of etiolation were produced by light inhibition, which resulted in a rise in the hormone auxin.

According to Ekawati's (2018) research, darkened environments can increase the overall flavonoid content of *Talinum fruticosum* (L.) Juss. Because *S. palmifolium* grows more rapidly in full light than in a shady setting, shallots were classified as C4 plant species that require full light. Therefore, without shade, 50% shade and no shade on the growth of *S. palmifolium* will produce optimal results. The growth of *S. palmifolium* was determined by the number of bulbs, tillers, leaves, flower percentage, and fresh weight of bulbs per sample (Yusuf 2009).

According to Atif et al. (2020), photoperiod and temperature affected the development of garlic bulbs, and phytohormonal signals induced alterations. In addition, the length of the photoperiod has been shown to boost endogenous gibberellin levels. Therefore, light intensity treatment and growth regulators likely affect *S. palmifolium*'s growth characteristics and flavonoid content. With the potential for *S. palmifolium* to be developed as a medicinal plant, it was vital to research the effect of light intensity and growth regulators on the growth and flavonoid levels of *S. palmifolium.*

The aims of this study were: (i) to determine the effect of light intensity on the growth and levels of *S. palmifolium* flavonoids; (ii) to determine the effect of gibberellins on the growth and levels of *S. palmifolium* flavonoids; (iii) to know the effect of the interaction of the combination of light intensity treatment and gibberellin hormone on the growth and levels of *S. palmifolium* flavonoids; (iv) to know the most optimum combination of treatments from the effect of light intensity and gibberellins on the growth and levels of flavonoids of *S. palmifolium.*

MATERIALS AND METHODS

This research was carried out from October 2020 to April 2021 at the (i) Biology Laboratory, Faculty of Mathematics and Natural Sciences, (ii) Integrated Biology Sub-Laboratory, Faculty of Mathematics and Natural Sciences, and (iii) greenhouse of UPT Integrated Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia.

Ingredient

The materials used in this study were *S. palmifolium* bulbs from Pasir Besar village, South Pontianak District, Pontianak, Indonesia, with a harvest age of 3-4 months and a weight range of 8-9 g.

Research design

This study used a completely randomized design (CRD) 2 factorial and 6 replications, namely:

Light intensity:
C50 : 50% light intensity
C75 : 75%light intensity
C100: 100% light intensity
Gibberellin hormone concentration:
G0 : 0 ppm gibberellin hormone (control)
G10 : 10 ppm gibberellin hormone
G20 : 20 ppm gibberellin hormone

The treatment variation was carried out nine times and the repetition six times.

Procedure

Paranet shade making

The treatment of paranet shading was to install 50% black paranet and 75% intensity separately to pass the light on to the plants. The paranet was installed 2 m above the polybag, and the light intensity was measured with a lux meter during installation. Light shade treatment was given from planting time to harvest time.

Preparation of planting media

The composition of the planting media was a mixture of soil and compost in a ratio (1:1) which was put in a polybag. Polybags were arranged in rows under a paranet sheath and left for a week to stabilize the planting medium.

Field capacity test

Polybags containing soil were dried to a consistent weight. Weighing and recording the weight of the sample polybag was done then. Following drying, the soil was thoroughly watered until no water drips. The amount of water required was kept on track. After watering, the soil was weighed again, and the volume was recorded.

Gibberellin solution preparation and planting

In distilled water, the gibberellin hormone was dissolved. Concentrations of 0, 10, and 20 ppm were used. Next, the gibberellin hormone was diluted with one drop of 70% alcohol and dissolved in distilled water until a solution between 10 and 20 ppm was obtained. After the solution had formed, it was stored in an Erlenmeyer flask covered with aluminum foil, and then it was put in a labeled dark bottle in the refrigerator.

The gibberellin stock solution was prepared by calculating the formula:

1 ppm = 1 mg/L
10 ppm = 10 mg/1 L of distilled water
20 ppm = 20 mg/1 L of distilled water

Information:

10 mg and 20 ppm of gibberellins were dissolved in 1 L of distilled water.

The readied bulbs were soaked in a solution of the gibberellin hormone for 40 minutes. Next, soaking 1/3 of the bulbs near the basal plate in water was done. It would promote rapid growth. Polybags filled with planting media were then planted with one bulb.

Preparation of S. palmifolium *to be planted*

The *S. palmifolium* bulbs to be planted were opened and cleaned of dirt. Onion bulbs to be planted were sorted based on uniform clove size. Basal plates of *S. palmifolium* were kept from being damaged. The onion cloves were weighed, and the cloves with a bulb weight of 8-9 grams were selected.

Plant maintenance

In the morning, the polybags containing the bulbs were hydrated. If there were weeds in the soil, they were weeded out. Fungi are removed from the mushroom soil media and discarded before the polybag soil media is progressively scraped to the bottom so air can flow through it. Biosoil was applied if the media was still infested with fungus.

Observation

Every week, the daily growth of *S. palmifolium*, including the number of leaves, length and width of the leaves, the time of flower appearance and the number of flowers, and the number of tillers, was documented. First, dry and wet bulb weights were detected as post-harvest characteristics. Next, wet and dry bulbs' chlorophyll and carotenoid content were analyzed. Finally, the wet and dry weights of bulbs were measured after harvest. The wet weight was the weight of produce at harvest, whereas the dry weight was derived after baking at a temperature of 60ºC to maintain a constant weight.

Compound analysis

Chlorophyll and carotenoid pigments

The amounts of chlorophyll a, chlorophyll b, and carotenoids were determined using spectrophotometric techniques. This study tested chlorophyll and carotenoids in *S. palmifolium* leaves and bulbs. Onion bulbs and leaves were cut into little pieces that weighed no more than 0.1 g each and were utilized in the experiment. The leaves and bulbs were mashed separately into a pulp in a mortar and pestle, and then 20 mL of 70% alcohol was added. After some time, the filter paper collected the fluid in a test tube. Aluminum foil was placed over the test tube to prevent the fluid from evaporating. Three milliliters of the filtrate were added to the cuvette. The cuvette was analyzed using a spectrophotometer. The absorbance of the solution was measured using three wavelengths (A). The formula for calculating chlorophyll content can be found here:

Chlorophyll a = [(12.7 x (A663) – (2.69 x (A645))) µmol
Chlorophyll b = [(22.9 x (A645) – (4.68 x (A663))) µmol
Total Chlorophyll = [(8.02 x (A663)) + (20.2 x (A645))] µmol

The following formula can calculate carotenoid content:

$$\frac{[(A480)+0.114(A663)-0.638(A645)]\ x\ 3\ ml\ x\ 1000\ \mu mol}{112.5\ x\ 10}$$

Information:
A480 = absorbance value at a wavelength of 480 nm
A645 = absorbance value at a wavelength of 645 nm
A663 = absorbance value at a wavelength of 663 nm

Flavonoid content test

The onion bulbs were washed and then sliced into thin pieces to begin the extraction process. The bulbs were kept in an oven at 60ºC for three days. Next, the bulbs were taken out of the oven and pulverized into a fine powder using a blender. Next, five grams of simplicia powder was macerated with 10 mL PA 96% ethanol until completely submerged with slow stirring. Next, 10 mL of PA ethanol was added to the macerated bulb powder and allowed to sit for a while before filtering. It was then re-macerated in PA ethanol (96 %) and filtered.

The flavonoid content of simplicia powder can be measured by dissolving 5 g in 10 ML of 96% PA ethanol. The solution was macerated and filtered. The sample solution was mixed with 1 mL of potassium acetate solution containing 120 mM potassium and 1 mL of $AlCl_3$ solution containing $AlCl_3$ 2 % for 30 minutes in a test tube.

The amount of $AlCl_3$ 2% content was made by the formula:

$$\text{Total volume x } \frac{2}{100} = 18 \text{ x } \frac{2}{100} = 0.36 \text{ gram}$$

The formula made the total content of Potassium Acetate:

$$M = \text{mol x } V = \frac{m}{Mr}\ x\ \frac{1000}{ml}$$

Information:
M = molarity (mmol/L)
V = volume of solvent required (mL)
m = weight of potassium acetate (mg)
Mr = molecular mass of potassium acetate (gr/mol)
mL = required volume (mL)

The absorbance of the solution was measured at a wavelength of 435 nm. The mean absorbance was considered the y value in the standard curve equation of quercetin. Therefore, the x value was the equivalent of quercetin milligrams in 100 mg of sample (QE / Quercetin Equivalent).

$$\text{Flavonoid content} = \frac{c\ x\ v\ x\ fp\ x\ 10^{-3}}{m}\ x\ 100\%$$

Information:
C = concentration of flavonoid levels (mg/L)
V = total volume of ethanol extract (mL)
fp = dilution factor
m = sample weight (mg)

Quercetin standard curve creation

Quercetin was made into solution concentrations of 6 ppm, 8 ppm, 10 ppm, 12 ppm, and 14 ppm. Quercetin was weighed as much as 0.06 mg, 0.08 mg, 0.10 mg, 0.12 mg, and 0.14 mg and dissolved in 10 ml of aquabidest. Then 1 mL of 120 mM potassium acetate was added, 1 mL of 2% $AlCl_3$ was added, and incubated for 30 minutes in a test tube. The absorbance of the sample was measured by UV-Vis spectrophotometry at a wavelength of 435 nm.

Stomata observation

Observation of stomata on the leaf surface was the imprinting method. *S. palmifolium* leaves that have been harvested are lightly smeared on the lower surface with clear nail polish. Wait until the nail polish dries. The tape was attached to the nail polish that had dried until it was glued. After feeling sticky enough, the tape was peeled off, placed on a glass object, and labeled. Glass objects were arranged in the preparation box. Furthermore, the preparations can be observed per field of view with a light microscope with a magnification of 400 times. The Fiji application calculated the number of stomata and their density values.

Stomata density was the field of view used at a magnification of 10x40 with a diameter of 0.5 mm. The following was the formula for stomatal density (Lestari 2006):

$$\text{Stomata density} = \frac{\text{number of stomata}}{\text{width of field of view}}$$

Where:

Width of field of view $= \frac{1}{4} \times 3.14 \times d^2$

$= \frac{1}{4} \times 3.14 \times 0.52$

$= 0.19625\ mm^2$

Data analysis

The research data were analyzed by two-way ANOVA (Analysis of Variance) to determine the effect of light intensity and gibberellins on the growth and levels of *S. palmifolium* flavonoids from all treatments given. Significantly different characters were tested using DMRT (Duncan's Multiple Range Test) at a significance level of 5%.

RESULTS AND DISCUSSION

This study used two combinations of treatments, namely light intensity and gibberellins. The light intensity treatments include paranet with 50% light intensity, which produces 15,000-18,000 lux of light, paranet with 75% light intensity produces 6,000-7,000 lux of light, and 100% light intensity produces 18,000-20,000 lux of light. The gibberellins were treated with 0 ppm concentration (control), 10 ppm concentration, and 20 ppm concentration. The basal plate of this study includes the effect of light intensity and gibberellins on leaf length and width, flowering time, number of flowers, number of tillers, wet and dry weight of plants, shoot root ratio, chlorophyll and carotenoid levels in leaves, and bulbs, bulb flavonoid content, and leaf density of *S. palmifolium* plant (Figure 1).

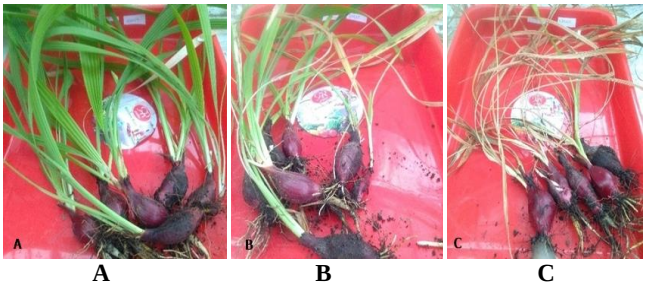

Figure 1. The condition of the Dayak onion plants at the time of harvest treatment: A. 50% paranet light intensity, B. 75% paranet light intensity, and C. 100% light intensity

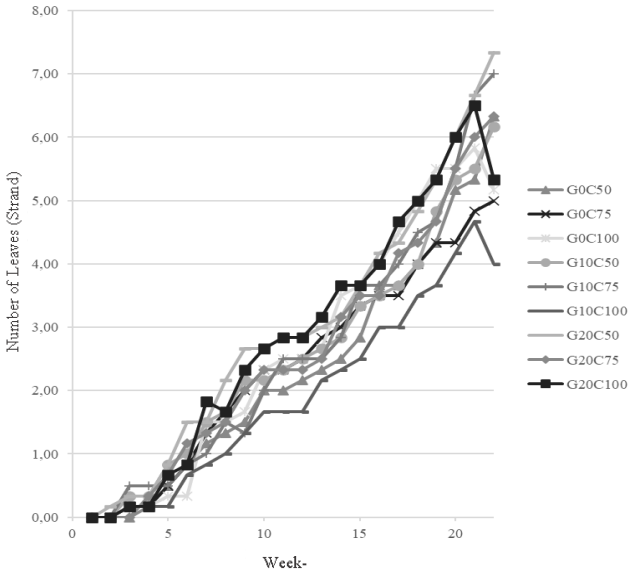

Figure 2. The average number of leaves of *Sisyrinchium palmifolium* during 22 weeks of planting

Number of leaves

The number of leaves of *S. palmifolium* in the light intensity treatment tended to increase weekly. The average number of leaves in Figure 2 shows that the highest number of leaves was treated with 50% paranet light intensity and 20 ppm gibberellin hormone (G20C50) on as many as 7 leaves. The least number of leaves was 100% light intensity treatment and 10 ppm gibberellin hormone (G10C100). The average number of leaves in the shade was higher than the light control treatment (100% light intensity). The gibberellin concentration control treatment showed a higher mean number of leaves than the 10 ppm and 20 ppm gibberellin concentrations. The growth of the number of leaves in the last week before harvest decreased due to the control of light intensity plants so that the leaves dry.

Based on the analysis of variance, light intensity and gibberellins did not affect the number of leaves of *S. palmifolium* plants. Therefore, complete data on the number of leaves of *S. palmifolium* was presented in Table 1.

Table 1. *Sisyrinchium palmifolium* parameters treated by light intensity and gibberellin concentration at yields time

Light intensity (%)	Giberelin concentration ± SD (ppm)		
	0	**10**	**20**
Number of leaves average			
50	6.33 ± 2.50	6.17 ± 1.47	7.33 ± 2.07
75	5.00 ± 0.89	7.00 ± 2.37	6.33 ± 2.50
100	5.17 ± 1.17	4.00 ± 2.83	5.33 ± 1.86
Leaf length average (cm)			
50	43.13 ± 1.25^{a}	61.43 ± 0.59^{b}	48.03 ± 0.61^{a}
75	46.93 ± 3.00^{a}	56.60 ± 0.36^{b}	45.03 ± 5.28^{a}
100	44.67 ± 0.91^{a}	45.73 ± 6.28^{a}	41.93 ± 5.35^{a}
Leaf width average (cm)			
50	1.47 ± 0.57	1.57 ± 0.06	1.57 ± 0.12
75	1.60 ± 0.17	1.50 ± 0.10	1.57 ± 0.12
100	1.57 ± 0.06	1.60 ± 0.40	1.00 ± 0.87
Flowering time (days)			
50	127 ± 73.32	0	0
0	0	0	0
0	0	0	112 ± 77.98
Amount of flower			
50	3.00	0	0
75	0	0	0
100	0	0	6.00
Number of tillers			
50	0	0	4.00 ± 1.16
75	2.00 ± 1.16	3.00 ± 1.73	4.00 ± 1.16
100	2.00 ± 1.16	2.00 ± 1.16	6.00 ± 0.00
Wet weight of leaves, midribs, and bulbs (gram)			
50	12.60 ± 0.0^{bcd}	13.25 ± 0.12^{d}	12.47 ± 0.53^{bcd}
75	12.03 ± 1.69^{bcd}	12.97 ± 1.58^{cd}	10.28 ± 1.52^{a}
100	11.75 ± 0.91^{bc}	11.48 ± 0.59^{ab}	12.85 ± 1.32^{bcd}
Average wet weight (grams) of leaves and midribs			
50	3.94 ± 0.00^{e}	2.51 ± 0.00^{c}	2.78 ± 0.00^{cd}
75	3.03 ± 0.99^{d}	4.33 ± 0.00^{e}	1.93 ± 0.00^{b}
100	0.50 ± 0.00^{a}	0.53 ± 0.00^{a}	1.55 ± 0.00^{b}
Average wet weight (grams) of bulbs			
50	8.83 ± 0.00^{a}	10.21 ± 0.00^{bc}	9.02 ± 1.27^{ab}
75	9.25 ± 1.54^{ab}	10.65 ± 0.61^{cd}	8.81 ± 1.15^{a}
100	11.20 ± 0.98^{cd}	10.03 ± 1.06^{abc}	11.50 ± 1.08^{d}
Average dry weight (grams) of leaves and midribs			
50	3.94 ± 0.00^{h}	2.51 ± 0.00^{f}	2.80 ± 0.02^{g}
75	2.12 ± 0.00^{e}	4.32 ± 0.00^{i}	1.93 ± 0.00^{d}
100	0.50 ± 0.00^{a}	0.53 ± 0.00^{b}	1.55 ± 0.00^{c}
Average dry weight (grams) of bulbs			
50	8.83 ± 0.00^{a}	10.21 ± 0.00^{b}	9.02 ± 0.00^{a}
75	8.77 ± 0.36^{a}	10.65 ± 0.61^{bc}	8.64 ± 0.00^{a}
100	10.93 ± 0.82^{cd}	10.03 ± 1.06^{b}	11.45 ± 0.00^{d}
Average shoot root ratio			
50	0.44 ± 0.00^{g}	0.24 ± 0.00^{d}	0.30 ± 0.00^{e}
75	0.24 ± 0.01^{d}	0.40 ± 0.02^{f}	0.22 ± 0.00^{c}
100	0.04 ± 0.00^{a}	0.05 ± 0.00^{a}	0.13 ± 0.00^{b}
Average leaf chlorophyll content (µmol)			
50	4.19 ± 0.57	6.66 ± 4.57	3.66 ± 0.72
75	5.30 ± 1.00	3.40 ± 0.26	4.77 ± 0.57
100	4.14 ± 2.23	5.39 ± 5.63	1.88 ± 0.17
Average chlorophyll content (µmol) of bulbs			
50	1.44 ± 0.05	1.63 ± 0.59	1.17 ± 0.21
75	1.18 ± 0.31	1.46 ± 0.53	1.07 ± 0.03
100	1.28 ± 0.36	0.75 ± 0.41	1.11 ± 0.19
Average carotenoid content (µmol) of leaves			
50	11.84 ± 1.52^{bc}	12.01 ± 3.13^{bc}	10.74 ± 1.60^{bc}
75	14.97 ± 1.99^{c}	8.28 ± 0.83^{ab}	10.86 ± 1.00^{bc}
100	11.84 ± 6.23^{bc}	3.17 ± 5.47^{a}	8.28 ± 1.09^{ab}
Average bulbs' carotenoid content (µmol)			
50	43.28 ± 2.99^{c}	38.78 ± 4.58^{bc}	37.25 ± 3.76^{bc}
75	36.41 ± 7.92^{bc}	39.99 ± 7.99^{bc}	30.04 ± 3.85^{ab}
100	32.06 ± 7.77^{bc}	19.97 ± 4.66^{a}	31.92 ± 8.87^{bc}
Average percentage of bulbs' flavonoid content (%)			
50	0.65 ± 0.01	0.66 ± 0.01	0.65 ± 0.02
75	0.66 ± 0.02	0.67 ± 0.01	0.65 ± 0.02
100	0.65 ± 0.01	0.64 ± 0.03	0.66 ± 0.01
Average stomatal density (/mm^{2})			
50	122.29 ± 35.67	105.30 ± 7.78	118.89 ± 22.98
75	139.27 ± 23.53	122.29 ± 40.45	135.84 ± 29.48
100	183.43 ± 30.57	149.46 ± 31.13	149.46 ± 10.61

Note: Numbers accompanied by the same letter in the same column show no significant difference in the DMRT = 5% test. SD: Standard deviation

Light intensity was important in leaf growth and development (Fan et al., 2013). The 50% paranet light intensity showed the highest value of the other treatments (Table 1). It was presumably due to etiolation, which causes plants to grow faster so that the number of leaves was more. The highest concentration of gibberellin hormone that affects the number of plant leaves was the 20 ppm gibberellin hormone presented in Table 1. Gibberellin hormones generally accelerate stem growth and cell propagation in plants but have no effect because the concentration is too small (Putrasamedja and Permadi, 2004). Other influencing factors are genetic and environmental (Gardner et al. 1991). Genetic factors were also thought to affect the growth of the number of plant leaves so that the leaves begin to appear after the third week of planting *S. palmifolium* bulbs. In addition, media that was too wet because it was exposed to raindrops affects the plants treated with 100% light intensity.

Leaf length

The mean leaf length of *S. palmifolium* (Table 1) showed that the highest leaf length was treated with 50% paranet light intensity and 10 ppm gibberellin hormone concentration along 56.60 cm. The lowest light intensity treatment was 100% light intensity treatment and 20 ppm gibberellin hormone due to plant leaves drying in the final week. As a result, the average leaf length growth was lower before harvest at the control light intensity (100%). The average leaf length growth data is presented in Figure 3.

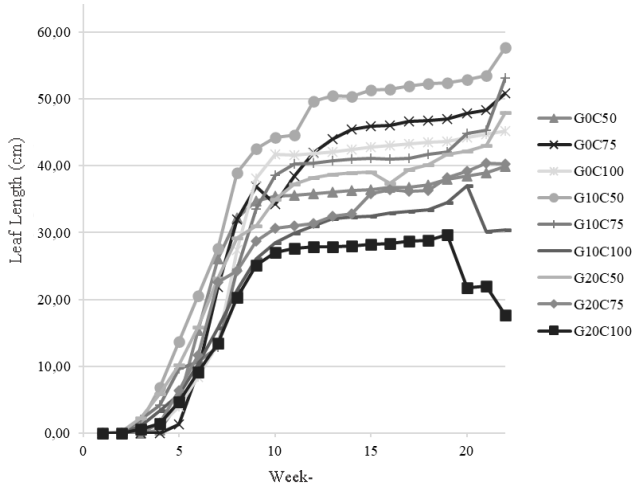

Figure 3. Average leaf length of *Sisyrinchium palmifolium* during 22 weeks of planting

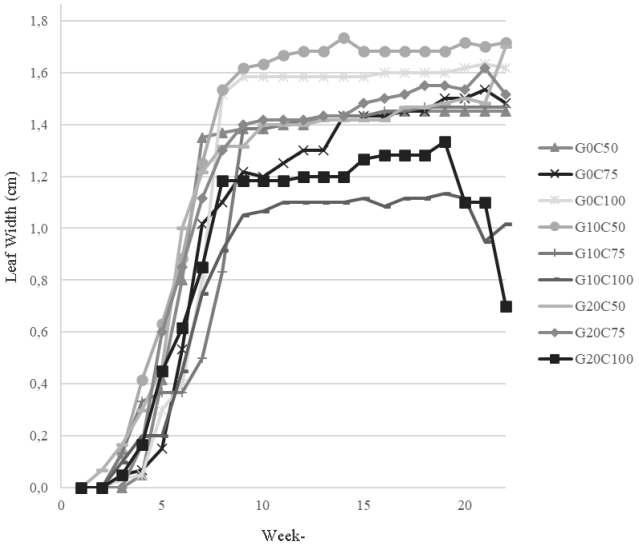

Figure 4. Average leaf width of *Sisyrinchium palmifolium* plants during 22 weeks of planting

The results of the ANOVA showed that the light intensity treatment affected the leaf length of *S. palmifolium* plants. In contrast, the gibberellin hormone treatment did not affect the leaf length growth of *S. palmifolium* plants. The interaction of the two treatments affected the leaf length growth of *S. palmifolium*. The light intensity of 50% paranet and 10 ppm gibberellin hormone was the most influential combinations on *S. palmifolium* leaf length.

Light intensity affects leaf growth. *S. palmifolium* leaf length that produces the most optimal length was 50% paranet light intensity. It was following the research of Rezai et al. (2018) that the light level under 50% shade has the largest leaf size. Plant leaf length growth decreased at 100% light intensity because the leaves were dry in the final weeks before harvest.

Leaf width

The growth of the leaf width of *S. palmifolium* tends to increase during the planting period. The most significant growth occurred in the eighth week of planting for *S. palmifolium* (Figure 4). Based on Table 1, the highest leaf width of *S. palmifolium* was treated with 100% light intensity and 10 ppm gibberellin hormone. Treatment of 50% light intensity and 0 ppm gibberellin hormone was the lowest mean leaf width of *S. palmifolium* plants. The mean leaf width of *S. palmifolium* was almost evenly distributed with 100% light intensity control treatment and 0 ppm gibberellin concentration.

The analysis of variance showed that the light intensity affected the leaf width of *S. palmifolium.* At the same time, the gibberellin hormone did not affect the leaf width of the *S. palmifolium* plant. Therefore, the interaction between light intensity treatment and gibberellin hormone did not affect the growth of leaf width of *S. palmifolium* plants.

The application of gibberellins did not affect the leaf width of *S. palmifolium* plants. The concentration of gibberellins would have an effect if the appropriate dose were given. In general, gibberellins function to increase leaf length and width (Salisbury and Ross 1995). Growth regulators must be given at the right dose so as not to inhibit plant production and work properly (Farida and Rohaeni 2019).

The intensity of light affects the leaf width of *S. palmifolium* plants. The quantity and quality of light can affect leaf morphology (Xu et al., 2011). The leaf width of plants at 100% light intensity decreased because the leaves dried up in the final weeks before harvest. The results of the average leaf width and length of *S. palmifolium* plants were thought to be genetically influenced. Endogenous hormones act as precursors (Wiraatmaja 2017). Plants will grow and develop as influenced by the environment. The environment will stimulate hormones to express genes so that they can change the development and metabolism of these plants.

Flowering time

The flowering stage of *S. palmifolium* plants begins with the formation of flower buds on the newly grown leeks. Based on Table 1, flowering plants of *S. palmifolium* were treated with 100% light intensity and 20 ppm gibberellin hormone and 50% paranet light intensity treatment and 0 ppm gibberellin hormone. The fastest flowering time of *S. palmifolium* was treated with 100% light intensity and 20 ppm gibberellins. The 50% light intensity treatment was a light treatment that can stimulate flowers compared to the 100% light intensity control treatment. In addition, a gibberellin concentration of 20 ppm can stimulate flower formation more than the control treatment.

The results of ANOVA showed that light intensity treatment and gibberellins did not affect the flowering time of *S. palmifolium* plants. Furthermore, the interaction between the treatment combinations did not affect the flowering time of *S. palmifolium* plants.

Flowers on plants were used as a parameter to determine the speed of the growth cycle from vegetative to

generative (Sari et al., 2020). The *S. palmifolium* plants that do not flower were thought to be caused by internal and external factors. External factors include the length of irradiation of plants. The length of irradiation can accelerate the plant to flower in large quantities. In addition, the length of irradiation depends on the type of plant (Lakitan 1996). Plant genetics also affects the time of flower emergence on the growth of *S. palmifolium* (Sari et al. 2020). Another factor was that the concentration of gibberellins was too low. The gibberellins concentration used for flowering in onions was between 500-1,000 ppm (Corgan and Motano 1975). The flowering process of the plant begins with the appearance of flower buds on the stem. The fastest flowering time was 112 days after planting. Flowering time on *S. palmifolium* was about 3-4 months after planting (Yusuf 2009). These factors cause the generative growth cycle of plants to be delayed.

Amount of flower

The *S. palmifolium* plants that were able to flower were plants that received treatment with 50% paranet light intensity and 0 ppm gibberellin hormone (G0C50) and 100% light intensity and 20 ppm gibberellin hormone (G20C100). Most flowers were treated with 100% light intensity and 20 ppm gibberellin hormone (Table 1). The treatment which stimulated flower formation was better than the control treatment (100% light intensity and 0 ppm gibberellin hormone).

The analysis of variance showed that the light intensity treatment did not affect the number of flowers of *S. palmifolium* plants. Likewise, the gibberellin hormone did not affect the number of flowers of *S. palmifolium* plants. Therefore, the interaction between light intensity and gibberellins did not affect the number of flowers of *S. palmifolium* plants.

The number of *S. palmifolium* flowers resulted from a combination of 2 treatments (Table 1). Flowers that appear as markers of plant growth end from the vegetative period to become generative, requiring sufficient nutrients to carry on their lives (Sari et al. 2020). Factors that could affect the hormone gibberellins in *S. palmifolium* plants were the concentration of substances, the response of plant parts to the given regulatory substances, and external environmental factors (Salisbury and Ross 1995). However, the unstable endogenous plant hormone caused the gibberellin hormone not to affect the number of *S. palmifolium* flowers (Hidayati et al. 2019).

Number of tillers

Based on Table 1, *S. palmifolium* tillers on 20 ppm hormone treatment tended to be more numerous than other hormone treatments. The treatments that produced the highest number of tillers were 100% light intensity and 20 ppm gibberellin hormone (G20C100). The combination of light intensity treatment and gibberellin hormone resulted in a higher average number of tillers than the control treatment.

The results of ANOVA showed that light intensity affected the number of tillers, while gibberellin hormone treatment did not affect the number of tillers of Sisyrinchium palmifolium. Furthermore, the interaction between light intensity and gibberellins did not affect the number of tillers of *S. palmifolium* bulbs.

With full light intensity treatment, *S. palmifolium* plants produced the most dominant number of bulbs. A large number of bulb tillers was caused by the plants' photosynthesis rate, which was proportional to the high light intensity. If the light intensity received were low, it caused slow plant growth because the photosynthesis process causes much water loss during respiration (Lakitan 1996). The small number of tillers was suspected because photosynthate was distributed for plant vegetative growth and development, such as leaf length, so the production of tiller bulbs was inhibited (Ekawati 2020). The number of tillers will affect the wet and dry weight of the plant.

The treatment of gibberellins did not affect the number of tillers, but a concentration of 20 ppm resulted in a higher number of tillers than other concentrations. One of the functions of gibberellins was the formation of bulb tillers. Sufficient hormone concentrations will stimulate assimilation so that the number of tillers increases within a certain limit (Wicaksono et al., 2016).

Wet weight of leaves, midribs, and bulbs

Wet weights of leaves, midribs, and bulbs were determined following harvest. According to Table 1, the 50% light intensity treatment resulted in the maximum wet weight, leaf, and midrib. The maximum value of wet leaf, midrib and bulb of *S. palmifolium* was obtained after treatment with 50% paranet light intensity and 13.25 grams of gibberellin hormone at a concentration of 10 ppm. At 10.28 grams, the lowest wet weight was treated with 75% paranet light intensity and 20 ppm gibberellin hormone. The combination of shade treatment and gibberellin administration resulted in a larger wet weight than neither shade treatment nor exogenous hormone administration.

The analysis of variance results indicated that light intensity affected the moist weight of *S. palmifolium* leaves, midribs, and bulbs. On the other hand, gibberellin treatment did not affect the moist weight of *S. palmifolium* leaves, midribs, or bulbs. However, the interaction between the two treatments affected the moist weight of S. palmifolium leaves, midribs, and bulbs. The most effective treatments were 50% paranet light intensity and 10 ppm gibberellin hormone.

Wet weight parameters of plants were used to show the ability of nutrient and water uptake in plants and their distribution to all plant parts (Ekawati 2020). Nutrients and water in the tissue would be used for plant metabolic activities so that plants would be able to maintain their lives. Treatment under paranet shade yielded higher weight yields than under 100% light intensity. In addition, not much water was lost in the respiration process, so the photosynthesis process of plants was not hampered, and the accumulation of photosynthate became more (Lakitan 1996).

The treatment of gibberellins did not affect the wet weight, midrib, and bulb of *S. palmifolium* plants. This condition showed that plants were not affected by gibberellins, so photosynthetic translocation was not

inhibited (Putrasamedja and Permadi 2004). Furthermore, applying external hormones to plants has a good physiological process, so it will not affect them significantly because the hormone functions well as a stimulant for plant physiological processes (Sitanggang et al. 2015).

Wet weight of leaves and midribs

Wet weight of leaf and midrib was obtained after harvest and separated from *S. palmifolium* bulbs. The heaviest wet weight of leaves and midribs resulted from treatment with 75% shade light intensity and 10 ppm gibberellin hormone. On the other hand, 100% light intensity treatment and 0 ppm gibberellin hormone were the lowest average. The data on the average wet weight of leaves and midribs of *S. palmifolium* are presented in Table 1.

The analysis of variance showed that the light intensity treatment affected the wet weight of the leaves and midrib of *S. palmifolium*, as well as the gibberellin hormone treatment, which affected the wet weight of the leaves and midrib of *S. palmifolium*. In addition, the interaction between light intensity and gibberellins also affected the wet weight of leaves and midribs of *S. palmifolium*.

The treatment of 75% paranet light intensity and 10 ppm gibberellin hormone was the combination treatment that had the highest effect on the wet weight of leaves and midrib of *S. palmifolium* plants. The wet weight of leaves and plant midrib at 75% paranet light intensity (under shade) was heavier than the wet weight at 100% light and 0 ppm gibberellin hormone. Apart from the plants being at 100% dry light intensity, the wet weight yield in the shade was due to the soil's high moisture and moisture content.

Bulbs wet weight

After harvesting and separating the bulbs from the leaves and midrib, the wet weight of the bulbs was determined. The 100% light intensity treatment resulted in the bulbs' highest average wet weight. The lowest light intensity and gibberellins were treated with 75% paranet light intensity and 20 ppm gibberellin hormone. The *S. palmifolium* plant bulb had the highest wet weight in the 100 % ppm light intensity and 20 ppm gibberellin hormone treatments. Table 1 contains statistics on the average wet weight of *S. palmifolium* bulbs.

The ANOVA analysis revealed that light intensity affected the wet weight of *S. palmifolium* bulbs. On the other hand, Gibberellins did not influence the wet weight of *S. palmifolium* bulbs. The interaction between treatment combinations affected *S. palmifolium* bulb weight.

The combination of 100% light intensity and 20 ppm gibberellin hormone had the greatest effect on the wet weight of *S. palmifolium* bulbs. Bulb wet weight at 100% light intensity resulted in more weight than treatment with paranet shade. Meanwhile, gibberellin concentrations were significantly higher than in the control condition. Wet weight under the shade of paranet reduces plant weight which was thought to be because the results of the photosynthesis process were distributed to the process of plant growth and vegetative development (Ekawati 2020). The concentration of gibberellins must follow the dose to be effective for plant growth and development. Therefore, the concentration of growth regulators must be given according to the dose so that the plant production process is not hampered and works properly (Farida and Rohaeni 2019).

The dry weight of leaves and midribs

The leaves and midribs that have been harvested and the wet weight were known, then dried using an oven to get the dry weight. The highest average dry weight of leaves and midribs of *S. palmifolium* was treated with 75% paranet light intensity and 10 ppm gibberellin hormone (G10C75). In comparison, the lowest average was 100% light intensity and 0 ppm gibberellin hormone (G10C100) of 0, 5 grams (Table 1).

Based on the ANOVA results, it was known that light intensity affected the dry weight of leaves and midrib of *S. palmifolium*, the same effect as the hormone gibberellin on the dry weight of leaves and midrib of *S. palmifolium*. Therefore, the interaction of light intensity treatment and gibberellin hormone affected the dry weight of leaves and midribs of *S. palmifolium*.

The most effective treatments on leaf and midrib dry weight were 75% paranet light intensity treatment and 10 ppm gibberellin hormone. These results showed that the dry weight of leaves and midribs was more in paranet shaded conditions than in full light intensity conditions. In addition, the gibberellin concentration treatment resulted in a heavier leaf and midrib dry weight than the control treatment (0 ppm gibberellin hormone). Dry and wet weight will show high yields proportional to the number of leaves (Salfia et al., 2020). The wet weight and the weight of leaves and plant midribs would increase due to many leaves. The leaves and midribs will absorb water and nutrients and be used in photosynthesis. As a result of photosynthesis, the wet and dry weights of leaves and midribs of plants would grow.

Bulb dry weight

After drying the wet weight of *S. palmifolium* bulbs in an oven, the dry weight was determined. According to Table 1, the treatment with 100 % light intensity resulted in the highest mean dry weight of *S. palmifolium* bulbs at 11.45 g. In contrast, the treatment with 20 ppm gibberellin hormone resulted in the lowest mean dry weight at 11.45 g. On the other hand, the treatment with 75% light intensity and 20 ppm gibberellin hormone resulted in the lowest mean dry weight of *S. palmifolium* bulbs at 8.64 g.

Light intensity and gibberellin hormone therapy affected the dry weight of *S. palmifolium* bulbs. The effect of light intensity treatment and gibberellins on the dry weight of *S. palmifolium* bulbs was considerable. The dry weight of the bulbs that had the most influence on the treatment combination's results was 100% light intensity, and a gibberellin concentration of 20 ppm was known. The dry weight of *S. palmifolium* bulbs was greater under control light intensity (100% light intensity) than under paranet shade stress conditions. Giving gibberellins led to a

greater dry weight of *S. palmifolium* bulbs than the control behavior (0 ppm).

Table 1 shows the wet and dry weights of *S. palmifolium* bulbs grown in shadow yielded a lighter weight than those grown in full sun. It was because shade-grown plants develop faster and have fewer leaves, resulting in a lighter wet and dry weight for the bulbs (Ekawati 2020). However, it differed with the wet and dry weights of leaves and midribs, which were lower since some plants without shade have dried up over the last week.

The terms "dry weight" and "wet weight" were used to describe plants' nutritional content and metabolic activity. If the weight gained were significant, the nutritional content and metabolic activity were enough. The dry weight parameter compares the photosynthesis-respiration balance in plants (Sari et al., 2020).

The plant's dry weight was gained through the photosynthetic light response mechanism. Photosynthesis occurs in the mesophyll of the leaf. Photosynthesis is a process that requires sunshine energy. Plant photosystems absorb vast amounts of sunlight, converting it to oxygen and carbon dioxide for the dark reaction. Starch and energy from the light reaction are accumulated in the dark process. The effects of photosynthetic assimilation will be sent to all plant organs, including leaves, bulbs, and roots. Larger photosynthetic assimilation will produce larger plant organs (Salisbury and Ross 1995).

Ratio shoot root

Based on Table 1, the highest mean shoot root ratio of *S. palmifolium* was obtained when the plants were under 50% light intensity. The highest average shoot root ratio was treated with 50% light intensity and 0 ppm gibberellin hormone. A 100% light intensity treatment and 0 ppm gibberellin hormone were the lowest average root shoot ratio for *S. palmifolium* plants. The shoot root ratio of plants under paranet shade was higher than under conditions of 100% light intensity. The control treatment with 0 ppm gibberellin concentration resulted in a higher shoot root ratio than the 10 ppm and 20 ppm gibberellin concentrations.

The ANOVA results show that light intensity affects the shoot root ratio of *S. palmifolium* plants. The gibberellin hormone had the same effect on the shoot root ratio of *S. palmifolium* plants. The interaction of treatment combinations also affected the shoot root ratio of *S. palmifolium* plants. The most influential shoot root ratio was the ratio after treatment with 50% paranet light intensity and 0 ppm gibberellin hormone.

The shoot root ratio increased in proportion to the increase in roots and number of leaves. The shoot root ratio was defined in plant growth as an important factor in determining plants' ability to absorb nutrients and metabolic processes. The dry weight ratio of shoot roots was used to determine the absorption of nutrients by the roots circulated to the plant canopy (Rudiansyah et al., 2017).

Plants need a sufficient shoot root ratio to circulate nutrients to all plant parts. Plant growth factors, namely genetics, influenced the shoot root ratio. Endogenous hormones act as precursors (Wiraatmaja 2017). The shoot root ratio of plants was influenced by the dry weight of the leaves, midribs, and bulbs of *S. palmifolium* plants. Another factor that affected plant growth and development was the environment. The environment will stimulate hormones to express genes so that they can change the development and metabolism of these plants. For example, gibberellins' concentration affected the growth rate of shoots or roots. If the concentration of gibberellins was increasing, the growth increased, but the diameter of the wee was getting narrower. This situation caused the plant not to experience additional shoot root weight (Rudiansyah et al., 2017).

Chlorophyll content

Based on Table 1 presented, it can be seen that the mean leaf chlorophyll content of the *S. palmifolium* plant ranges from 1.88 to 6.66 mol. The highest mean leaf chlorophyll content of *S. palmifolium* was treated with 50% paranet light intensity and 10 ppm gibberellin hormone. In contrast, the lowest leaf chlorophyll level was treated with 100% light intensity and 20 ppm gibberellin hormone. Treatment under paranet shade resulted in a higher mean leaf chlorophyll content than treatment with *S. palmifolium* without shade (100% control light intensity). Meanwhile, the control gibberellin concentration treatment (0 ppm) resulted in a lower mean leaf chlorophyll content than the 10 ppm gibberellin concentration.

The analysis of variance showed that the light intensity treatment did not affect the leaf chlorophyll content of *S. palmifolium*. Furthermore, the gibberellin hormone also did not affect the chlorophyll content of the leaves of *S. palmifolium* plants. Therefore, the interaction between light intensity treatment and gibberellins did not affect leaf chlorophyll levels.

Table 1 presents data on the average chlorophyll content of *S. palmifolium* bulbs. The highest chlorophyll content of *S. palmifolium* bulbs was the treatment of 50% paranet light intensity and 10 ppm gibberellin hormone; meanwhile, the 100% light intensity treatment and 10 ppm gibberellin hormone was the lowest chlorophyll content of *S. palmifolium* plant bulbs. The average yield of bulb chlorophyll content under shade conditions was higher than bulb chlorophyll content under 100% light intensity (control). The results of ANOVA analysis showed that light intensity did not affect the chlorophyll content of *S. palmifolium* bulbs. The gibberellin hormone also did not affect the chlorophyll content of *S. palmifolium* bulbs. The interaction between the two treatments did not affect the chlorophyll content of *S. palmifolium* bulbs.

Table 1 shows that the chlorophyll content of the leaves of *S. palmifolium* plants was higher than that of the bulbs of *S. palmifolium*. The highest chlorophyll content in the leaves and bulbs of *S. palmifolium* was found in the same combination of treatments, namely 50% paranet light intensity and 10 ppm gibberellin hormone. The result of chlorophyll content under 100% light intensity was lower than the light intensity under the paranet shade. Plants that absorb full light intensity produce lower total chlorophyll

content than plants that absorb limited light. Full light intensity functions to carry out photosynthesis and increase metabolic processes (Wulandari et al. 2016). Plant pigments' content was influenced by light intensity, temperature, and soil pH (Hasidah et al., 2017). Absorption of small amounts of light intensity for the photosynthesis process produced a greater amount of chlorophyll to be optimal for absorbing light (Salisbury and Ross 1995). Enzymes that play a role in chlorophyll synthesis can increase their role with light stimulation. Light accelerates the catalytic process of the chlorophyllase enzyme in converting protochlorophyllide into protochlorophyll a (Hasidah et al. 2017).

Carotenoid level

The carotenoids level in the leaves of *S. palmifolium* were measured for absorbance using a UV-Vis spectrophotometer. The results showed that the average carotenoid content showed that the highest leaf carotenoid content was the combination of 75% paranet light intensity treatment and 0 ppm gibberellin hormone. In comparison, 100% light intensity treatment and 10 ppm gibberellin hormone were the lowest average leaf carotenoid content (Table 1). The mean levels of leaf carotenoids in the control condition (100% light intensity) resulted in lower levels than the light intensity treatment under the paranet shade. Moreover, the mean leaf content in the control condition of the gibberellin hormone concentration was higher than in the treatment with the gibberellin hormone concentration.

The analysis of variance showed that the light intensity treatment affected the carotenoid levels in the leaves of *S. palmifolium* plants. The same thing happened to treat gibberellins hormones, affecting the carotenoid levels in the leaves of *S. palmifolium* plants. The interaction between the light intensity treatment and the gibberellin hormone affected the carotenoid levels in the leaves of *S. palmifolium* plants.

The average carotenoid content of *S. palmifolium* bulbs presented in Table 1 showed that the carotenoid content was in the range of 19.97-43.28 mol. The highest levels of carotenoids in *S. palmifolium* bulbs were treated with 50% paranet light intensity and 0 ppm gibberellin hormone at 43.28 mol. The mean carotenoid content of *S. palmifolium* bulbs was higher when treated under paranet shade than under full light intensity (100% light intensity). The average carotenoid levels' average results given the gibberellin hormone were lower than the control treatment (gibberellin hormone 0 ppm).

Based on the analysis of variance, it was known that the light intensity affects the carotenoid content of the bulb of *S. palmifolium.* On the other hand, the gibberellin hormone does not affect the carotenoid levels of *S. palmifolium* plant bulbs. Therefore, the interaction between the light intensity treatment and the gibberellin hormone affected the carotenoid levels of *S. palmifolium* plant bulbs.

Carotenoid levels of plants under paranet were higher than those with less than 100% light intensity. This result was allegedly due to plants that received full light, which increased the metabolic process for the photosynthesis process. Factors that affect the process of photosynthesis are the amount of light intensity absorbed, permanent pigments that absorb light, and complementary pigments such as carotenoids (Wulandari et al., 2016). Higher carotenoid content under paranet shade. The genetics of the plant also influenced carotenoids in plants. Each plant has genetic differences, affecting gene expression ability in the carotenoid synthesis process (Hasidah et al. 2017).

Light also plays a role in the process of carotenoid biosynthesis. In carotenoid biosynthesis, the enzyme mRNA level will increase if the enzyme were stimulated for its catalysis by light. For example, carotenoid hydroxylase (CH) and phytoene synthase (PSY) enzymes that function in carotenoid biosynthesis. Therefore, the light will increase the mRNA carotenoid hydroxylase and phytoene synthase levels, then phytoene (components of carotenoids) will increase so that carotenoid levels will increase too (Hasidah et al. 2017).

Flavonoid level

The flavonoid content of the *S. palmifolium* plant was obtained from the crushed part of the *S. palmifolium* bulb, then dissolved, and the absorbance was calculated using a UV-Vis spectrophotometer. The flavonoid content of the bulb of *S. palmifolium* was in the range of 0.64-0.67%. The highest flavonoid content of *S. palmifolium* bulb was obtained on the treatment combination of 75% paranet light intensity and 10 ppm gibberellin hormone 0.67%. The lowest flavonoid content of *S. palmifolium* was treated with 100% light intensity and 10 ppm gibberellins. The average levels of flavonoids did not affect the control treatment. The data on the average flavonoid content of *S. palmifolium* bulbs are presented in Table 1.

The ANOVA results indicated no effect of light intensity on the flavonoid content of *S. palmifolium* bulbs. Similarly, gibberellin hormone administration did not influence the flavonoid content of *S. palmifolium* plant bulbs. As a result, there was no effect of the interaction between the two treatments on the flavonoid content of S. palmifolium bulbs.

The light intensity affects the flavonoid content of *S. palmifolium* plants. Through flavonoid production, light can raise overall flavonoid levels. Flavonoids are synthesized via two distinct pathways: the polyketide pathway (malonic pathway/three acetate units) and the phenylpropanoid pathway (shikimate pathway). The polyketide pathway begins with the interaction of acetyl CoA with CO to form malonate CoA. Additionally, acetyl CoA combines with malonic CoA to form acetoacetyl CoA. Acetoacetyl CoA is formed and reacts with malonate CoA to generate poly acetyl. Next, this poly acetyl product will react with and condense the phenylpropanoid pathway product. The reaction results of the two pathways will produce flavonoid compounds (Mariana et al., 2013). The phenylpropanoid pathway reaction will use shikimic acid using phosphoenolpyruvate and erythrose. Shikimic acid was converted to phenylalanine and tyrosine. The resultant phenylalanine will release NH_3 and form cinnamic acid. Tyrosine will produce derivative cinnamic acid compounds

(Julianto 2019). Plants' most significant phenolic compounds were flavonoids (Taiz and Zeiger 2012).

Flavonoids have an important role as growth regulators. Flavonoids are critical for the long-term viability of plant physiological processes. Gibberellins have a crucial role in the production of flavonoids (Kim et al., 2009). Secondary metabolite production and chlorophyll synthesis occur in plants (Sukartini and Syah 2009). High light intensity is suggested to promote the accumulation of the wet and dry weight of *S. palmifolium.* Plant weight accumulation due to respiration and photosynthesis decreased flavonoid levels (Sari et al. 2020). This condition can occur due to chlorophyll production inhibiting the activity of flavonoid synthesis (Hasidah et al., 2017).

The calibration curve for quercetin in Figure 5 indicates that the higher the concentration, the greater the absorbance. The standard quercetin curve yielded the regression equation y = 0.0574x + 1.5737 with an R2 value of 0.9198. The quercetin calibration curve equation is a reference point for determining the total flavonoid concentration in a sample.

Stomata density

Stomata density was obtained from observing stomata on the lower epidermis of the leaves of *S. palmifolium* plants. The average leaf stomata density of *S. palmifolium* (Table 1) was found in the observation area with 100% light intensity treatment and 0 ppm gibberellin hormone of 183.43/mm^2. The average stomatal density was at least 50% paranet light intensity treatment, and 10 ppm gibberellin hormone was 105.30/mm^2. The mean leaf stomata density of *S. palmifolium* resulted in higher data in the control treatment. It shows that the treatment of light intensity under the shade and the concentration of gibberellins do not affect the amount of stomatal density.

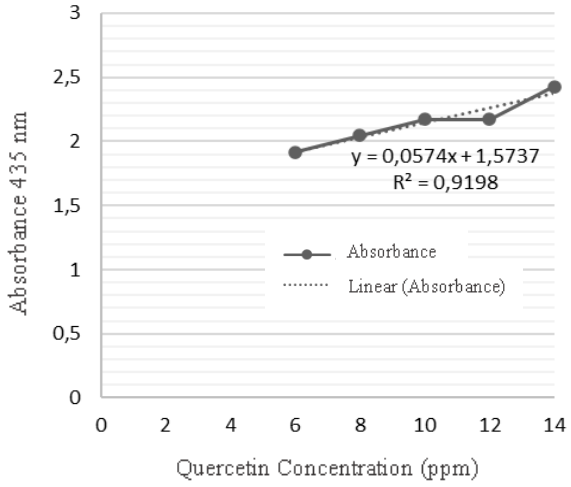

Figure 5. Quercetin calibration curve at a maximum wavelength of 435 nm

Based on the analysis of variance, light intensity affects the stomata density of *S. palmifolium* leaves. However, the gibberellin hormone also did not affect the stomata density of the leaves of *S. palmifolium* plants. Therefore, the interaction between the combination of light intensity treatment and gibberellins did not affect the stomata density of *S. palmifolium* leaves.

Full light intensity resulted in higher leaf stomata density than low light intensity. The reason was that sunlight received at a high frequency would increase the rate of photosynthesis, respiration, and metabolism. Based on research Bowen (1991) states that the process of photosynthesis will increase if many stomata are open. If many stomata were open, much carbon dioxide would enter the light reaction process of photosynthesis. Photolysis of water produces hydrogen, which will be used for the dark reaction, and oxygen, which is released for respiration. In addition, the photosynthesis stage also produces glucose which could be distributed and accumulated in plant organs. A lot of carbon dioxide will increase the production of flavonoids through respiration. As a result of the Krebs cycle, acetyl CoA will react with CO in the polyketide cycle to produce poly acetyl compounds and react-condensate with the results of the phenylpropanoid pathway to form flavonoid compounds (Mariana et al. 2013). This condition correlates with the fact that the more stomata were open, the more photosynthate accumulation in plants increased.

In conclusion, 50% paranet light intensity affects the growth of *S. palmifolium* plants. The increased parameters were leaf number, length, wet leaf weight, midrib, bulb, shoot root ratio, chlorophyll, and carotenoid content of *S. palmifolium* bulbs. The concentration of gibberellins at 10 ppm affected the growth and flavonoid content of *S. palmifolium* plants. Growth parameters included leaf length, width, midrib and bulb wet weight, leaf and midrib wet weight, and leaf and bulb chlorophyll content. The interaction of light intensity and gibberellin hormone affected the growth of *S. palmifolium* plants. It was shown on leaf length parameters, wet weight of leaves, midrib, and bulbs, wet weight of leaves and midribs, wet weight of bulbs, dry weight of leaves and midribs, dry bulb weight, shoot root ratio, as well as leaf and bulb carotenoid content. The interaction of light intensity treatment did not affect the growth and flavonoid content of *S. palmifolium* plants, including the number of leaves, leaf width, flowering time, number of flowers, number of tillers, chlorophyll content, leaf stomata density, and flavonoid content of *S. palmifolium* plants. The combination of 50% paranet light intensity and 10 ppm gibberellin hormone affected the growth of *S. palmifolium* plants. This interaction can increase the parameters of leaf length, wet weight of leaves, midrib, bulbs, and chlorophyll content of leaves and bulbs of *S. palmifolium* plants.

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