CELL BIOLOGY & DEVELOPMENT
Volume 6, Number 2, December 2022
Pages: 51-60
E-ISSN: 2580-4499
DOI: 10.13057/cellbioldev/t060201

Physiological characteristics of *Sisyrinchium palmifolium* with fertilization treatment and IAA hormone

ELIZA NUR ALIFAH, WIDYA MUDYANTINI♥, SOLICHATUN
Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: widyamudyantini@yahoo.com

Manuscript received: 1 May 2022. Revision accepted: 10 August 2022.

Abstract. *Alifah EN, Mudyantini W, Solichatun. 2022. Physiological characteristics of* Sisyrinchium palmifolium *with fertilization treatment and IAA hormone. Cell Biol Dev 6: 51-60. Dayak* onion (*Sisyrinchium palmifolium* L., Syn.: *Eleutherine palmifolia* L. Merr.) is a typical Central Kalimantan, Indonesia medicinal plant. Optimizing the function of the *S. palmifolium* is done to increase cultivation and community interest; more fertilization and growth regulator treatments are needed to accelerate plant growth. In this study, the physiological properties of S. palmifolium will be examined regarding fertilization and the IAA (Indole Acetic Acid) hormone. CRD factorial pattern with four levels of fertilization variation (soil; soil + chicken manure (1:1); soil + vermicompost fertilizer (1:1); soil + chicken manure + vermicompost (1:1:1)) and three levels of hormone concentration (0 ppm; 100 ppm; 200 ppm) resulting in 12 treatment combinations which are used in this experiment. It was repeated three times for each therapy. It was shown that the number and length of leaves, the number of flowers and their flowering time, bulb weights, chlorophyll content, and flavonoid levels were all correlated with the number of leaves. The data were examined for significant changes between the treatments using the Analysis of Variant (ANOVA) and Duncan's Multiple Test (DMRT) at a 5% significance level. The physiological and biochemical features were altered by fertilization and the IAA hormone. The IAA hormone and fertilization on *S. palmifolium* enhanced the number of leaves, their width, the ratio of shoot roots to roots, and flavonoids. The maximum yields of wet weight, dry weight, and leaf carotenoids were obtained with vermicompost (1: 1) and a hormone at 200 ppm (P2H2) adding. Combining vermicompost treatment with the IAA hormone produced the highest level of flavonoids (P2H0).

Keywords: Biochemical, fertilization, hormones, physiological, *Sisyrinchium palmifolium*

INTRODUCTION

Indonesia is a country rich in medicinal plant germplasm. *Sisyrinchium palmifolium* L (Syn.: *Eleutherine palmifolia* L. Merr.), also known as a *Dayak* onion or *bawang Dayak*, is a native plant of Central Kalimantan, Indonesia. *S. palmifolium* is not very popular in contemporary Indonesian society. The majority are unaware of the functions and benefits of *S. palmifolium* as a medicine for various diseases, despite their potential as medicinal raw materials. The *Dayak* community has used *S. palmifolium* as a medicinal plant for generations. According to Utami and Desty (2013), *S. palmifolium* contains alkaloids, saponins, triterpenoids, steroids, glycosides, tannins, phenolics, and flavonoids used as raw materials in the manufacture of pharmaceuticals. *S. palmifolium* is used in traditional medicine to treat various conditions ranging from constipation to intestinal inflammation, dysentery, jaundice, hypertension, hypercholesterolemia, and diabetes mellitus. The bulbs and leaves of plants are frequently used medicinally.

Given the enormous potential of *S. palmifolium* as a multifunctional medicinal plant, efforts must be made to increase public awareness of the *S. palmifolium* plant. Among the efforts that can be made is applying appropriate cultivation techniques via fertilization to increase soil fertility or enhances a plant's quality and quantity. Therefore, fertilization is critical to the growth and production of *S. palmifolium*. At the moment, farmers prefer chemical fertilizers to organic fertilizers. While chemical fertilizers are considered more effective than organic fertilizers, excessive chemical fertilizer application can negatively affect soil fertility. Therefore, organic fertilizers are one way to reduce reliance on chemical fertilizers.

Organic fertilizers have several advantages, including the ability to improve the chemical and physical properties of the soil, soil water absorption, the effectiveness of soil microorganisms as food sources for plants, and the fact that they are environmentally friendly, less expensive, and improve production quality. In addition, organic matter could increase the number of nutrients available to plants (Pranata 2010). Moreover, to boost the growth of *S. palmifolium*, organic fertilizers such as manure and vermicompost can be employed. According to Jasmine et al. (2019), chicken manure enhances the quantity of *S. palmifolium* tillers. According to Aryani et al. (2019), vermicompost fertilizer can enhance shallot growth and production by improving soil structure and nutrient absorption.

Another strategy is to supply growth regulators to assist with substandard *S. palmifolium* growing. Fertilization, helped by hormones, is critical for plant growth and metabolic efficiency. External growth regulators can stimulate plants' development; hence, IAA (Indole Acetic Acid) is a growth regulator promoting growth (Wijayati et al. 2005). According to Pranata (2010), the IAA hormone is one of the most significant types of auxin. These hormones perform various tasks, including accelerating plant growth, assisting in developing early roots, and promoting stem and leaf elongation. Exogenous administration of the IAA hormone is crucial for eliciting stimulation and effect, notably on plant growth and physiological parameters. Mandang (1993) believes that the combination of exogenous and endogenous auxin can accelerate root development.

Hormones must be administered at the appropriate dose; the hormone supports optimal plant development at ideal concentrations. For example, Mondal and Alam (2003) observed that employing IAA at a 200 ppm concentration yielded the greatest results for all *Allium cepa* L. growth parameters, including leaf number, bulb diameter, average bulb weight, and bulb yield. Therefore, *S. palmifolium* fertilized with IAA should demonstrate a physiological characteristic of accelerated growth.

The objectives of this study were (i) to ascertain the effect of fertilization on the physiological characteristics of the *S. palmifolium*, (ii) to ascertain the effect of the IAA hormone on the physiological characteristics of the *S. palmifolium*, (iii) to ascertain the effect of fertilization and the IAA hormone on the physiological characteristics of *S. palmifolium*, (iv) to ascertain the most effective combination of treatments for increasing *S. palmifolium* growth.

MATERIALS AND METHODS

Ingredient

The research was carried out at the Universitas Sebelas Maret Integrated Laboratory, FMIPA Biology Integrated Laboratory, Surakarta, Central Java, Indonesia, from October 2020 to March 2021. The material needed is *S. palmifolium*.

Procedure

The experiment design was a Completely Randomized Design (CRD) with a factorial pattern consisting of two factors, namely fertilization variation consisting of four levels and hormone concentration consisting of three levels, to obtain 12 treatment combinations. Fertilization consisted of soil (control), soil + chicken manure fertilizer (1:1), soil + chicken manure fertilizer + vermicompost fertilizer (1:1), and soil + chicken manure fertilizer + vermicompost fertilizer (1:1:1). The hormone concentrations were 0, 100, and 200 ppm.

Preparation of *S. palmifolium* bulb

The *S. palmifolium* is taken directly from the Kelurahan Besar, Pontianak District, West Kalimantan, Indonesia. The *S. palmifolium* bulbs were selected uniformly, i.e., with the same harvest age (± five months) and initial weight (5-12 grams).

Preparation of treatment media and hormone concentration

Planting media was soil with fertilizer in four types of treatments. As it was readied, it was put into polybags. The IAA hormone was made with a concentration of 100 ppm (0.1 gram) and 200 ppm (0.2 gram), which was added with a small amount of 70% alcohol solvent and 1 liter of distilled water.

Soaking *S. palmifolium* bulbs and planting

The *S. palmifolium* bulbs were soaked in IAA hormone according to the concentration of each treatment (0 ppm; 100 ppm; 200 ppm). Immersion is carried out at the same interval for 40 minutes (Alpriyan and Karyawati 2018). The soaking of the *S. palmifolium* bulbs was calculated using a stopwatch. The bulbs that had been soaked in the IAA hormone were then planted in polybags containing the media with the treatment. Finally, *S. palmifolium* bulbs were soaked on their basal plates.

Parameter measurement

The observed growth parameters included the number of leaves and the leaf width. Both measurements were carried out once a week until harvest time. The number of tiller bulbs was calculated at harvest, while the wet weight and shoot-root ratio were measured post-harvest.

Chlorophyll and carotenoid levels

The levels of chlorophyll and carotenoids in the leaves were carried out by taking *dayak* leeks. First, 0.1 grams was crushed and added with 70% alcohol for as much as 20 ml of the leaves. Next, the finely chopped leaves were filtered using a funnel in a test tube with Whatman filter paper no. 42 (Prastyo and Laily 2015). Next, the levels of chlorophyll and carotenoids in tubers were assessed by crushing 1 gram of tubers, adding 20 mL of 70% alcohol, and filtering with Whatman No. 42 filter paper. Next, the obtained filtrate was put into a cuvette of as much as 3 mL. Finally, the cuvette was inserted into a UV-Vis spectrophotometer with wavelengths of 480 nm, 645 nm, and 663 nm. According to Hendry and Grime (1993), the measurement of chlorophyll and carotenoid levels is as follows:

$$\text{Chlorophyll a} = 12.7(A.663) - 2.69(A.645)$$
$$\text{Chlorophyll b} = 22.9(A.645) - 4.68(A.663)$$
$$\text{Total Chlorophyll Level} = 8.02(A.663) + 20.2(A.645)$$

$$\text{Carotenoid } \mu\text{mol/g} = \frac{(A480 + 0.114 \text{ x } A663 - 0.638\text{x}A645) \text{ x V x } 10^3}{112.5 \text{ x } 0.1 \text{ x } 10}$$

Flavonoid level

The quercetin standard was weighed at 0.06 mg, 0.08 mg, 0.010 mg, 0.012 mg, and 0.014 mg and dissolved in 10 mL of aquabides to produce a quercetin solution with a concentration of 6 ppm, 8 ppm, 10 ppm, 12 ppm, and 14 ppm. In addition, 1 mL of 2% $AlCl_3$ and 120 mM potassium acetate was added. At room temperature, samples were incubated for one hour. Then, at a maximum wavelength of 435 nm, the absorbance was measured using the UV-Vis spectrophotometric method (Stankovic 2011).

Total flavonoid content of S. palmifolium *bulb*

The resulting extract was diluted in 1 mL of 96 % PA ethanol to dissolve any remaining extract residue on the porcelain cup. Next, the solution was transferred to a test tube, adding 1 mL of 2% $AlCl_3$ solution and 1 mL of 120 mM potassium acetate. At room temperature, samples were incubated for one hour. Finally, the absorbance was determined using the UV-Vis spectrophotometric method at a maximum wavelength of 435 nm (Stankovic 2011).

Data analysis

The data were analyzed using Analysis of Variance (ANOVA) and continued with Duncan's Multiple Range Test (DMRT) at the 5% test level to determine the significant difference between treatments.

RESULTS AND DISCUSSION

Number of leaves

Leaves are one of the plant organs that have an important role in photosynthesis. Observations on leaf organs included the number of leaves, leaf length, and leaf width. All three are important factors in plant growth. Therefore, the number of leaves is closely related to photosynthesis in plants. The number of leaves is calculated when the leaves are fully developed until harvest time. Data on the number of leaves are presented in Table 1.

The ANOVA findings indicated that fertilizer affected the number of leaves (Appendix 1). There was no effect of the IAA hormone on the number of leaves. This condition is most likely due to an insufficient concentration of hormones, which prevents the *S. palmifolium* plant from growing more leaves. The mixture of fertilizer and hormones substantially increased the number of leaves (Table 1). The largest number of leaves was seen when vermicompost (1:1) was combined with the IAA hormone 0 ppm (P2H0). The standard deviation for some treatments, such as P2H0, was excessive, owing to the death of some repetitions. Because vermicompost is high in nutrients, one of which is nitrogen, it influences the rising number of leaf parameters. Nitrogen absorbed by plants is necessary for the production and growth of vegetative parts such as leaves, which allows for a rise in the number of leaves in this study.

Additionally, vermicompost contains phosphorus and other nutrients necessary for developing plants' vegetative components. According to Rekha et al. (2018), vermicompost balances macro and micronutrients, and nutrient uptake benefits plant nutrition, growth, photosynthesis, and leaf chlorophyll content. As Mulat (2003) argues, applying vermicompost fertilizer can also improve the soil's physical properties, such as structure, permeability, water holding capacity, and chemical properties, such as boosting the soil's ability to absorb cations. Vermicompost can stimulate vegetative plant growth, particularly leaf development, increasing the number of leaves. The increased leaf count results in photosynthesis, which increases photosynthesis results. Figure 1 depicts the weekly average statistics for the number of leaves on the *S. palmifolium*.

Based on Figure 1, it can be seen that the number of leaves of *S. palmifolium* plants always increases every week. The available macronutrients supported the increase in the number of leaves. Still, in the final week of observation, several treatments experienced a decrease in the number of leaves caused by internal and external factors that affect plant growth and development. The main external influencing factor was climate change. Plant physiology is disturbed by climate change factors, such as extreme temperatures (too high or too low) and too high rainfall. The erratic weather could disrupt the nutrient transport process, which will affect the growth and development of the *S. palmifolium* plant.

Leaf length

Observation of leaf length is needed as an indicator of plant growth. Therefore, leaf length calculation was carried out on the leaves that appeared first. Leaf length data are presented in Table 1.

According to the ANOVA results, neither fertilizer nor IAA hormone had a statistically significant effect on leaf length. Additionally, the interaction of fertilizers and hormones had no significant influence on leaf length (Table 1). It could be because the plant requires macronutrients and micronutrients, which were not supplied by chicken manure or vermicompost. Cell division and differentiation could normally occur if sufficient macronutrients such as nitrogen were available during vegetative growth. The given IAA hormone concentration was less than optimal for improving leaf length characteristics. IAA is a hormone required for cell elongation and division. Mondal and Alam (2003) indicated the treatment of 200 ppm IAA hormone to *A. cepa* affected all growth metrics except plant height. Figure 2 depicts data on the weekly mean leaf length of the *S. palmifolium.*

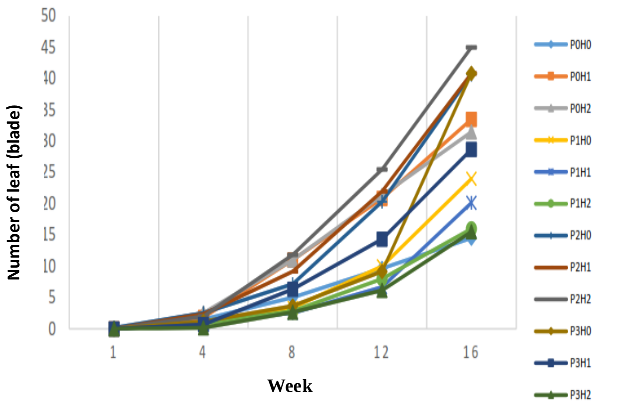


Figure 1. The weekly average number of leaves of *Sisyrinchium palmifolium* after fertilization and IAA hormone treatment

Table 1. Number of leaves of *Sisyrinchium palmifolium* at harvest after fertilization and IAA hormone treatment

Type of fertilizer	Hormone concentration (ppm) ± SD 0	100	200
Number of leaves			
P0	6.67 ± 6.42^{a}	25.00 ± 9.54^{abc}	9.33 ± 5.03^{a}
P1	19.00 ± 2.64^{ab}	23.67 ± 9.60^{abc}	42.33 ± 14.50^{cd}
P2	48.00 ± 18.52^{d}	39.33 ± 13.87^{bcd}	34.00 ± 15.72^{bcd}
P3	20.00 ± 12.12^{abc}	33.33 ± 14.50^{bcd}	20.33 ± 5.13^{abc}
Leaf length			
P0	31.00 ± 16.64	48.03 ± 0.06	40.67 ± 2.52
P1	42.67 ± 0.57	40.50 ± 4.36	43.50 ± 1.32
P2	43.10 ± 1.56	40.20 ± 4.70	43.17 ± 2.02
P3	33.73 ± 3.40	39.23 ± 1.25	42.33 ± 2.88
Leaf width			
P0	2.00 ± 0.86^{abcd}	2.43 ± 0.12^{cde}	1.50 ± 0.10^{a}
P1	2.20 ± 0.17^{bcde}	3.07 ± 0.11^{f}	2.73 ± 0.20^{ef}
P2	2.36 ± 0.32^{bcde}	1.83 ± 0.15^{abc}	1.80 ± 0.20^{ab}
P3	2.03 ± 0.25^{abcd}	2.76 ± 0.20^{ef}	2.50± 0.36^{def}
Flower number			
P0	0.00 ± 0	3.00 ± 6.16	5.80 ± 6.34
P1	0.00 ± 0	2.80 ± 3.42	2.20 ± 4.92
P2	4.00 ± 4.64	4.00 ± 5.48	3.20 ± 4.32
P3	2.80 ± 3.27	0.00 ± 0	0.60 ± 1.34
Number of tillers			
P0	3.60 ± 3.51^{a}	8.00 ± 1.73^{cd}	7.20 ± 2.39^{bcd}
P1	7.00 ± 1.60^{abc}	8.00 ± 2.12^{cd}	3.80 ± 3.11^{ab}
P2	8.80 ± 2.77^{cd}	10.80 ± 2.77^{d}	8.40 ± 1.52^{cd}
P3	6.20 ± 2.49^{abc}	9.20 ± 2.86^{cd}	6.60 ± 2.30^{abc}
Wet weight (grams)			
P0	19.05 ± 14.76 ^{ab}	42.23 ± 15.44^{cd}	42.54 ± 6.74^{cd}
P1	20.82 ± 10.16^{ab}	26.69 ± 2.07^{b}	15.24 ± 4.87^{a}
P2	38.06 ± 1.59^{c}	37.96 ± 1.65^{c}	48.20 ± 1.22^{d}
P3	18.32 ± 2.28^{ab}	27.21 ± 0.61^{b}	13.72 ± 0.54^{a}
Dry weight (grams)			
P0	8.39 ± 6.50^{ab}	16.20 ± 3.37^{f}	17.28 ± 2.06^{f}
P1	8.46 ± 0.88^{ab}	11.20 ± 0.86^{bcd}	6.65 ± 3.35^{a}
P2	14.95 ± 1.99^{ef}	12.23 ± 0.83^{cde}	23.14 ± 0.48^{g}
P3	9.06 ± 4.56^{abc}	13.83 ± 1.65^{def}	6.44 ± 1.07^{a}
Shoot-root ratio			
P0	0.27 ± 0^{a}	0.54 ± 0.05^{a}	0.30 ± 0.05^{a}
P1	1.97 ± 0.35^{bc}	2.86 ± 0.27^{de}	1.84 ± 0.09^{bc}
P2	1.55 ± 0.13^{b}	1.49 ± 0.01^{a}	2.43 ± 0.13^{cd}
P3	2.77 ± 1.5^{de}	3.46 ± 0.32^{f}	2.53 ± 0.25^{cd}
Total chlorophyll (mg/g) leaves			
P0	10.9869 ± 3.90^{d}	3.2172 ± 1.69^{abc}	4.0710 ± 1.14^{abc}
P1	2.0761 ± 1.52^{a}	2.5562 ± 0.05^{ab}	3.3856 ± 1.24^{abc}
P2	3.7365 ± 1.15^{abc}	3.9356 ± 1.26^{abc}	6.2437 ± 0.73^{c}
P3	4.2247 ± 2.61^{abc}	3.0112 ± 0.80^{abc}	5.8188 ± 2.97^{bc}
Total chlorophyll (mg/g) bulbs			
P0	2.5249 ± 0.85^{a}	3.5163 ± 1.03^{abc}	6.1868 ± 0.41^{d}
P1	5.6906 ± 2.46^{d}	4.9855 ± 2.04^{bcd}	5.3133 ± 1.25^{cd}
P2	3.4882 ± 0.21^{abc}	1.5498 ± 0.31^{a}	2.3588 ± 1.10^{a}
P3	1.8735 ± 0.15^{a}	3.0276 ± 0.63^{ab}	2.5661 ± 0.36^{a}
Carotenoids (mg/g) leaves			
P0	18.5559 ± 4.53^{cd}	12.2481 ± 1.83^{abc}	10.6084 ± 3.29^{ab}
P1	7.3706 ± 1.22^{a}	7.5383 ± 1.17^{a}	11.1962 ± 3.22^{ab}
P2	14.4574 ± 2.70^{bcd}	15.9487 ± 3.57^{bcd}	19.1647 ± 6.96^{d}
P3	12.1711 ± 0.52^{abc}	14.3905 ± 2.90^{bcd}	13.3263 ± 4.38^{abcd}
Carotenoids (mg/g) bulbs			
P0	57.3879 ± 4.97^{cd}	54.5748 ± 9.22^{bcd}	61.5276 ± 1.95^{d}
P1	44.1941 ± 14.38^{abcd}	37.1034 ± 2.66^{ab}	39.0421 ± 17.26^{ab}
P2	39.5984 ± 1.63^{abc}	35.9126 ± 8.97^{a}	41.4039 ± 15.47^{abc}
P3	30.9099 ± 7.27^{a}	42.6914 ± 0.41^{abc}	44.3153 ± 8.35^{abcd}
Levels of flavonoid (mgQE/g)			
P0	8.3176 ± 0.30^{a}	8.3994 ± 0.21^{ab}	8.4847 ± 0.22^{abc}
P1	8.5458 ± 0.19^{abc}	8.4462 ± 0.17^{ab}	8.6766 ± 0.15^{abc}
P2	8.8454 ± 0.44^{c}	8.7593 ± 0.05^{bc}	8.2912 ± 0.14^{a}
P3	8.4113 ± 0.16^{ab}	8.5419 ± 0.11^{abc}	8.3588 ± 0.06^{ab}

Note: Numbers accompanied by the same letter in the row/column show no significant difference (P>0.05) in the 5% DMRT test. P0 : Ground (Control). P1 : Soil + Chicken manure Fertilizer (1:1) P2 : Soil + Vermicompost (1:1). P3 : Soil + Chicken Manure + Vermicompost (1:1:1) SD: Standard deviation

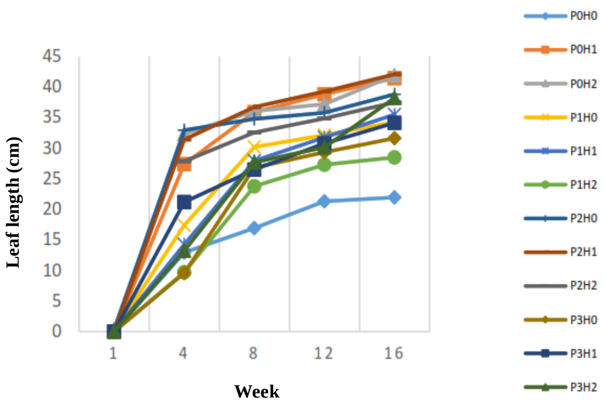


Figure 2. Weekly average of leaf length of *Sisyrinchium palmifolium* after fertilization and IAA hormone treatment

As illustrated in Figure 2, the length of the leaves of the *S. palmifolium* plant rises week after week. In contrast, the leaves that were initially generated appear to fall after the 16th week in some treatments. Compared to other plant organs, leaves have a limited growth rate (they grow to a particular size and then stop abruptly) (Loveless 1991). The nutrients collected in the early to midweeks of the plant period were sufficient to carry out cell elongation. However, the nutrients obtained began to deplete dramatically in the last week. The decreased nutrients taken by the *S. palmifolium* plant and other environmental conditions resulted in a fall in leaf length parameters over the last week.

Leaf width

Besides being a place for photosynthesis, leaves also serve as respiration organs. Additionally, the leaf width parameter must be considered. Leaf width and leaf length metrics are inextricably linked. Table 1 contains statistics on leaf width.

ANOVA revealed that fertilizer or IAA hormone affected leaf width, and combining fertilizers and hormones increases leaf width (Table 1). The interaction between manure treatment and 100 ppm IAA hormone (P1H1) resulted in the greatest leaf width value. The control combination with 200 ppm IAA hormone (P0H2) resulted in the smallest leaf width value of 1.5 cm. Sutedjo (2008) asserts that chicken manure contains the highest concentration of nitrogen required by plants to establish vegetative parts such as leaves. Hanaa and Safaa (2019) found that 100 ppm IAA increased plant growth and physiological parameters such as leaf area and chlorophyll content. Figure 3 shows data on the weekly mean leaf width of the *S. palmifolium*.

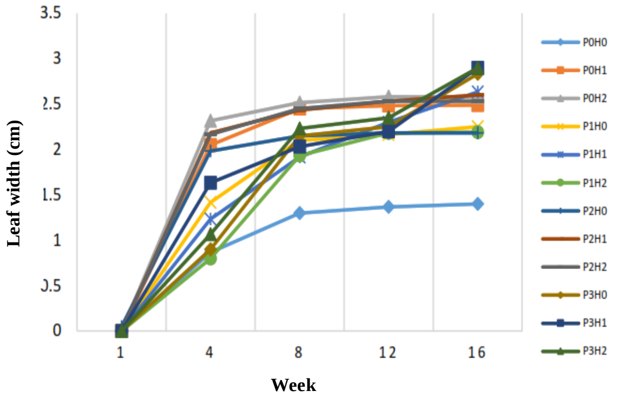


Figure 3. The weekly mean of leaf width of *Sisyrinchium palmifolium* after fertilization and IAA hormone treatment

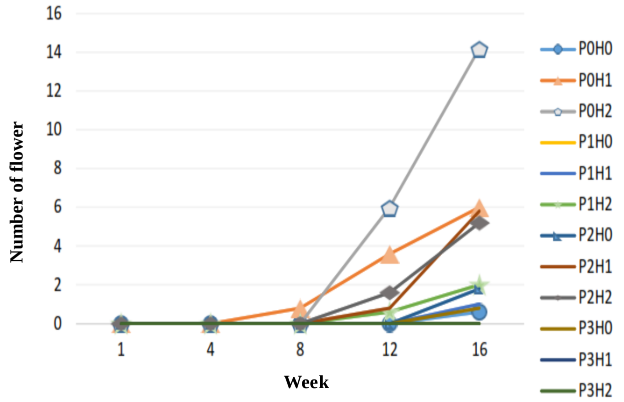


Figure 4. Average flower number of *Sisyrinchium palmifolium* at the end of fertilization and IAA hormone treatment

Based on Figure 3, the width of the leaves of the *S. palmifolium* plant always increases, but after the 16th week, some of the leaves were found to fall in the last week of observation due to limited growth. The nutrients absorbed from the fertilizer content began to decline, resulting in a drop in leaf width at the end of the observation. External growth and development factors such as temperature and sunlight also contributed to a reduction in leaf width.

In general, fertilization and the IAA hormone affected the number of leaves and leaf width of *S. palmifolium* plants. However, chicken manure or vermicompost could stimulate plant growth compared to controls because both types of fertilizers had enough nutrients to stimulate *S. palmifolium* growth. Additionally, the IAA hormone could boost plant growth parameters. Srivastava (2002) asserts that this hormone regulates numerous aspects of plant growth and development.

Number of flowers

Flowers are a form of self-reproduction. Therefore, metrics relating to the number of flowers were observed from blossoming through harvest. In general, fertilization and Indole Acetic Acid hormone did not affect flowering characteristics. Table 1 contains information on the amount of interest.

According to the ANOVA results, neither fertilizer nor the IAA hormone affected the flowering (Appendix 4). Additionally, the interplay of fertilizers and hormones did not influence the number of flowers (Table 1). It could be because fertilization and the IAA hormone have a reduced effect on flowering. Fertilizer increases the availability of phosphorus (P) nutrients, which stimulates flowering, but if applied excessively, it can also impede the *S. palmifolium* plant's generative phase. The *S. palmifolium* plant's flower development is not boosted by nutrition and hormone absorption. Internal and external factors have a greater influence on the appearance of flowers than the treatment used. Figure 4 illustrates the average number of flowers on the *S. palmifolium* plant.

As illustrated in Figure 4, the flowering amount always increases each week. Flowers begin to appear on *S. palmifolium* plants in week 8 or within two months. The control treatment with 200 ppm IAA hormone produced optimum results compared to other treatments. The presence of flowers shows that the *S. palmifolium* plant has entered a reproductive phase. Therefore, the hormone IAA at a concentration of 200 ppm is considered ideal for flower development. The IAA auxin hormone could influence the growth of roots, stems, and flowers (Agboola et al. 2014). It exhibited the highest graph on the number of flowers in the soil treatment alone (the control), likely due to the inhibited nutrients in fertilizers, such as phosphorus (P). Phosphorus stimulates the production of various proteins and accelerates the development of flowers and fruit.

Number o tiller bulbs

The number of tiller bulbs on a plant is a measure to indicate the health of the plant. The quantity of tiller bulbs harvested reflects the plant's excellent output. Fauzi et al. (2018) state that onion plants have a disc-shaped basal plate. The basal plate contains buds that can develop into lateral shoots or tillers; these tillers can generate new basal plates and bulbs. Table 1 contains information on the number of tiller bulbs.

According to the ANOVA results, the fertilizer and the IAA hormones affected the number of tiller bulbs produced by *S. palmifolium* plants (Appendix 5), contributing to crop production growth. Fertilizer-hormone interactions also affected all treatments (Table 1). The interaction between vermicompost fertilizer treatment and the IAA hormone 100 ppm (P2H1) resulted in the maximum number of tillers, whereas the control (P0H0) resulted in the lowest number of tillers (3.60). It was because vermicompost contained more NPK nutrients than chicken manure. The fertilizer application and the IAA hormone at 100 ppm were supposed to be best for raising the number of *S. palmifolium* tillers. Bulb formation would increase in a favorable climate, allowing bulbs to create new shoots and grow and develop into tillers. The average number of tiller bulbs produced by the *S. palmifolium* plant is depicted in Figure 5.

As shown in Figure 5, the highest yield was achieved with vermicompost fertilizer combined with 100 ppm of the IAA hormone. Vermicompost contains a variety of vital macronutrients, one of which is important for meristematic growth and the synthesis and transfer of photosynthetic products for production and storage in plants (seeds, fruits, and tubers), particularly potassium (K) (Havlin et al. 2005). Because the roots could take the 100 ppm of IAA hormone, optimal root conditions influenced the effective absorption of nutrients necessary for the *S. palmifolium* plant's development and productivity. In addition, optimal light intensity and environmental conditions were critical for creating blooms and bulbs in *S. palmifolium* seedlings.

Wet mass

Wet weight is a growth parameter that is often used and important to study. Therefore, the wet weight of the plant was measured after harvesting before the plant lost water. Table 1 contains information about the wet weight of *S. palmifolium* plants.

ANOVA revealed that fertilizer influenced the wet weight of the *S. palmifolium* plant. In addition, the IAA hormone increases wet weight. Therefore, the interplay of fertilizer and hormones affects the *S. palmifolium* plant's wet weight (Table 1). For example, adding vermicompost fertilizer with the IAA hormone at 200 ppm (P2H2) resulted in the highest wet weight value. In contrast, the lowest treatment consisted of a mixture of soil amended with chicken manure and vermicompost containing IAA hormone at 200 ppm (P3H2).

The amount of water absorbed by plants, particularly bulbs, affects the rise in wet weight. For example, the lowest yield of 13.72 grams was obtained when the three treatments were combined with the IAA hormone at 200 ppm (P3H2). On the other hand, the wet weight of the plant indicated high yields due to the fast rate of water absorption, which promoted cell elongation and expansion. The wet weight is determined by the water content of the harvested *S. palmifolium* plant. Figure 6 shows data on the average wet weight of *S. palmifolium* plants.

Based on Figure 6, adding vermicompost fertilizer with the IAA hormone at 200 ppm showed the highest yield. Vermicompost fertilizer is rich in N, P, and K nutrients, which *S. palmifolium* plants need for growth and development. According to Fauzi et al. (2018), sufficient nutrient content causes biosynthesis to run smoothly so that the produced carbohydrates are greater, increasing the wet weight of the plant. Therefore, 200 ppm of IAA hormone could support plant growth and trigger cell enlargement, providing the highest graphic results.

Dry weight

Growth can also be measured by measuring plant dry biomass. Dry weight indicates the accumulation of organic compounds that plants have successfully synthesized from inorganic compounds. The accumulation in question is especially CO_2 carried out during plant growth and development. Dry weight data are presented in Table 1.

Based on the ANOVA results, it was shown that fertilizer affected the dry weight of the *S. palmifolium* plant (Appendix 7). In addition, the IAA hormone affects increasing dry weight parameters. Therefore, the interaction of fertilizers and hormones affects the dry weight of *S. palmifolium* plants (Table 1). The addition of vermicompost fertilizer with the IAA hormone at 200 ppm (P2H2) showed the highest dry weight value. The lowest treatment was a combination of soil added with both types of fertilizers with the IAA hormone at 200 ppm (P3H2) of 6.44 grams. Data on the average dry weight of *S. palmifolium* plants are presented in Figure 7.

Figure 7 shows that adding vermicompost fertilizer with the IAA hormone at 200 ppm showed high yields. Vermicompost fertilizer provides nutrients in balanced amounts and increases the organic matter content to benefit plants. The availability of nutrients increases the rate of photosynthesis so that photosynthate can increase, and photosynthate can be translocated to all parts of the plant; as a result, it can increase dry weight (Dwijoseputro 1981). According to Nurhidayati et al. (2019), the dry weight of plants is a representation of wet weight, which is a condition that states the amount of accumulation of organic matter contained in plants without the water content.

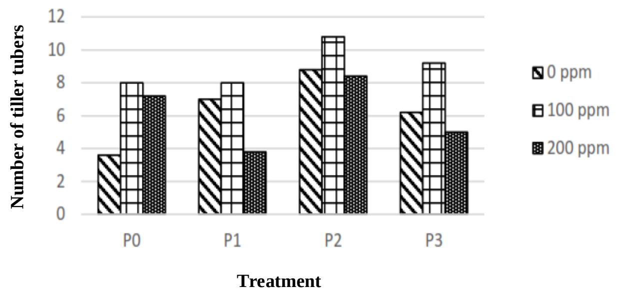


Figure 5. The average number of tiller bulbs of *Sisyrinchium palmifolium* at the end of fertilization and IAA hormone treatment

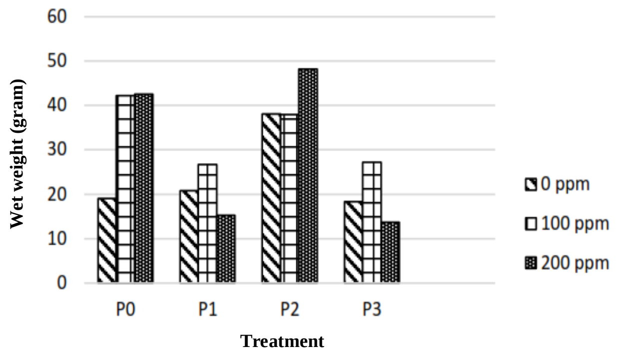


Figure 6. Average wet weight of *Sisyrinchium palmifolium* after fertilization and IAA hormone treatment

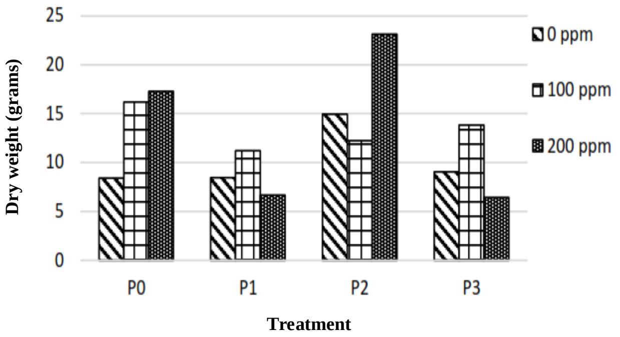


Figure 7. The average dry weight of *Sisyrinchium palmifolium* after fertilization and IAA hormone treatment

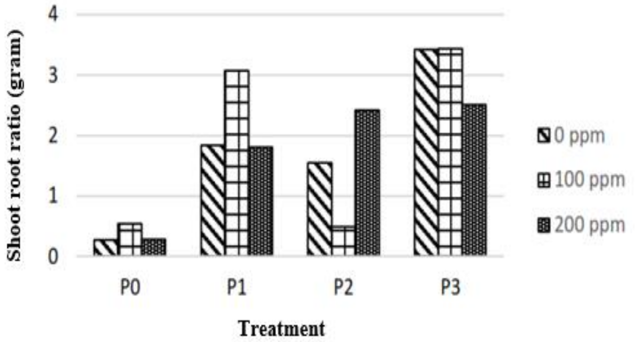


Figure 8. The average shoot-root ratio of *Sisyrinchium palmifolium* after fertilization and IAA hormone treatment

Organic fertilizers such as vermicompost are rich in nutrients to support growth and development to maximize the process of water transport to all parts of the plant and can affect the wet and dry weight. The sunlight intensity is also one factor that can increase the wet and dry weight of *S. palmifolium* plants. Heavy rainfall occurs almost every day in the last two months of the planting season. It is thought to trigger the sub-optimal size of the bulb weight due to the inhibition of plant metabolic processes. Rosmawaty et al. (2019) determined that the optimal dry weight of the *S. palmifolium* plant (5 months harvesting age) is between 19.00 and 23.00 grams.

Plant root canopy ratio

Wet weight, dry weight, and shoot-root ratio on *S. palmifolium* generally showed varying results. The shoot-root ratio shows the growth balance between the crown and roots. The shoot-root ratio value in this study was not too large because the growth of the *S. palmifolium* plant was more dominant towards the roots. The shoot-root ratio data can be presented in Table 1.

Based on the ANOVA results, fertilizer increased the shoot-root ratio of *S. palmifolium* plants. On the other hand, the Indole Acetic Acid hormone did not affect the shoot-root ratio. Therefore, the interaction of fertilizer and hormones increases the shoot-root ratio of *S. palmifolium* plants (Table 1). The combination treatment of soil added with chicken manure and vermicompost (1:1:1) with the IAA hormone at 100 ppm (P3H1) showed the highest shoot-root ratio value. In contrast, the lowest treatment was the control (P0H0) of 0.27. The data on the average shoot-root ratio of the *S. palmifolium* is presented in Figure 8.

Figure 8 shows the result the ratio that was undergone the treatment was higher than the control. Soil treatment plus both types of fertilizers with the IAA hormone at 100 ppm showed the graph of the highest shoot-root ratio. Both manure and compost contain high N, P, and K elements, so their interaction can give high yields on shoot and root weight and shoot-root ratio. Therefore, the concentration of the IAA hormone at 100 ppm was thought to be the optimum concentration for increasing the shoot-root ratio of *S. palmifolium* compared to other concentrations.

Total chlorophyll level

Chlorophyll plays an important role in photosynthesis, and the pigment is needed in a plant's photosynthesis. Therefore, the parameters of total chlorophyll and carotenoids measured were obtained from the leaves and bulbs of the *S. palmifolium*. Data on the total chlorophyll content of leaves and bulbs are presented in Table 1.

The ANOVA results showed that fertilizer or IAA hormone affected the total chlorophyll count of *S. palmifolium* leaves (Appendix 9). Therefore, the interaction of fertilizers and hormones affects the total chlorophyll of *S. palmifolium* leaves (Table 1). The control treatment (P0H0) showed the highest total leaf chlorophyll value, while the lowest treatment was the addition of chicken manure with the IAA hormone at 0 ppm (P1H0), which was 2.0761 mg/g. Data on the average total chlorophyll of the leaves of *S. palmifolium* are presented in Figure 9.

The results of ANOVA showed that fertilizer affected the total chlorophyll count of the *S. palmifolium* bulb (Appendix 10). The IAA hormone did not affect the total chlorophyll of bulbs. The interaction of fertilizers and hormones affects the total chlorophyll of the *S. palmifolium* bulb (Table 1). The control treatment with IAA hormone at 200 ppm (P0H2) showed the bulbs' highest total chlorophyll value. The lowest treatment was the addition of vermicompost fertilizer with 100 ppm IAA hormone (P2H1) of 1.5498 mg/g. The IAA hormone at 200 ppm is thought to favor chlorophyll formation. Data on the average total chlorophyll of the *S. palmifolium* bulb are presented in Figure 9.

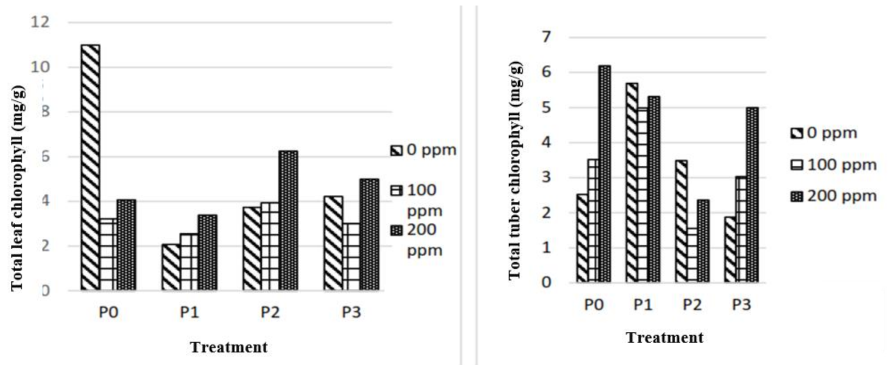
Figure 9 shows that the control treatment had a high yield of leaf chlorophyll, while the control combination with 200 ppm IAA hormone showed the highest yield of bulb chlorophyll. Leaves play a very important role in the photosynthesis process because they contain chloroplasts, so the chlorophyll content in the leaves is greater than the bulbs. The control treatment (soil only) showed high yields compared to the treatment with the addition of fertilizer, even though chicken manure or vermicompost was rich in nutrients. These results were caused by the condition of the *S. palmifolium* plants harvested for further testing. The control treatment showed a greener color than the other treatments. It is because treatment leaves in some parts are deficient in nutrients (yellowing). Muhuria et al. (2006) reported that the greener a leaf, the higher the chlorophyll content. Nutrients that play a role in photosynthesis, such as phosphorus absorption, may be low, so the formation of chlorophyll is disrupted. IAA hormone synthesis may also indirectly affect the chlorophyll content.

Carotenoid level

Carotenoids are companion pigments for chlorophyll, which play a role in absorbing light energy for photosynthesis. Carotenoids are a group of yellow, orange, or red pigments commonly found in plants. The content of carotenoids and chlorophyll vary in plant species. Leaf and bulb carotenoid data are presented in Table 1.

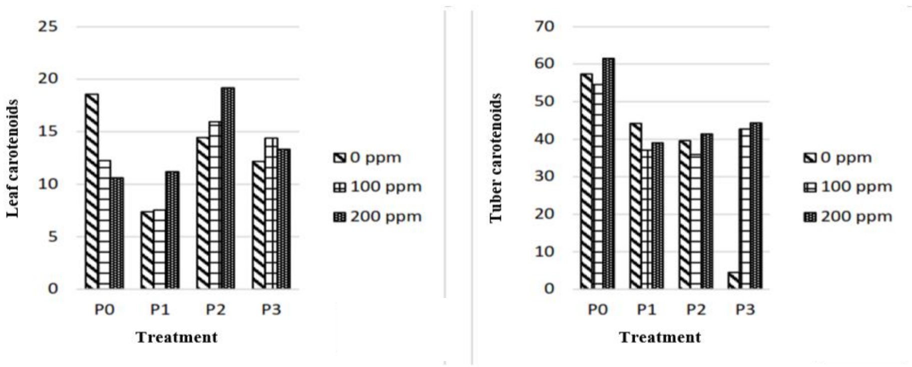
Based on the results of ANOVA, it was shown that fertilizer affected the carotenoid content of the leaves of the *S. palmifolium* plant. On the other hand, the IAA hormone did not affect leaf carotenoids. It is presumably because the exogenously applied IAA hormone was less able to trigger an increase in leaf carotenoid levels. The interaction of fertilizers and hormones affects leaf carotenoids (Table 1). The addition of vermicompost fertilizer with the IAA hormone at 200 ppm (P2H2) showed the highest leaf carotenoid values, while the combination treatment with chicken manure with the IAA hormone at 0 ppm (P1H0) was the lowest at 7.3706 mg/g. The average data for carotenoids in the leaves of *S. palmifolium* is presented in Figure 10.

ANOVA showed that fertilizer affected the carotenoid content of *S. palmifolium* bulbs. IAA hormone did not affect tuber carotenoids. IAA hormone transport to affect the increase in tuber carotenoid levels may not run optimally, and the concentration of hormones received by plants is less than optimal. According to Asra et al. (2020), after being synthesized, auxin will be translocated to all parts of the plant, but not all parts get the same concentration. The part close to the synthesis site gets higher auxin, while the high concentration of IAA hormone can inhibit the formation of carotenoids. The interaction of fertilizers and hormones affects the carotenoids of tubers (Table 1). The control treatment with the hormone IAA at 200 ppm (P0H2) showed the highest tuber carotenoid values, while the interaction of the combination of chicken manure and vermicompost (1:1:1) with the hormone IAA at 0 ppm (P3H0) was the lowest at 30.9099 mg/g. The average carotenoid data of *S. palmifolium* bulbs shows in a histogram in Figure 10.



A B

Figure 9. Average total leaf chlorophyll (A), total chlorophyll of *Sisyrinchium palmifolium* bulb (B) after fertilization, and IAA hormone treatment



A B

Figure 10. Average leaf carotenoids (A), bulb carotenoids of *Sisyrinchium palmifolium*, (B) after fertilization and IAA hormone treatment

Figure 10 shows that the highest graph of leaf carotenoids was shown in the addition of vermicompost fertilizer with 200 ppm IAA hormone. The control combination treatment with 200 ppm IAA hormone was the highest graph for bulb carotenoids. The carotenoid content was greater in the *S. palmifolium* bulbs because the red pigment of the bulbs was very dominant. Vermicompost fertilizer application can improve soil structure so that the root system and nutrient absorption process run more optimally. Optimal absorption of nutrients can cause physiological processes to run well, so the carotenoid levels are quite large. In another study, the application of exogenous IAA also increased the concentration of photosynthetic pigments, including total chlorophyll and carotenoids (Singh and Prasad 2015).

Carotenoids as photosynthetic light energy absorbers generally increase when the chlorophyll content decreases (Yang et al. 2014). Chlorophyll and carotenoids are labile and easily degraded. Internal and external factors in plants affect the levels of chlorophyll and carotenoids. For example, environmental temperatures that are too extreme due to climate change can inhibit the formation of pigments because various environmental factors easily degrade, such as chlorophyll.

Bulb flavonoid levels

Flavonoids are one of the secondary metabolites of plants that have an important role. The flavonoid content of the *S. palmifolium* extract was measured at a wavelength of 435 nm. The flavonoid levels were calculated using the quercetin curve's previously measured linear regression equation. Based on the measurement results of the quercetin standard curve, the equation y = 0.1544x + 1.7821 with a correlation value (R^2) = 0.9684, a correlation value close to 1 indicates that there is a relationship between the concentration of quercetin solution and the absorbance value. According to Kelly (2011), quercetin is a standard solution because it belongs to the flavonoid group, which can react with $AlCl_3$ to form complexes. The measurement of flavonoid levels shows in Table 1.

ANOVA results showed fertilizer or IAA hormone did not affect flavonoid levels in *S. palmifolium* plants (Appendix 12). It could be due to the plant's inability to carry out IAA hormone transport optimally and the long stage of flavonoid formation. The interaction of fertilizers and hormones affects the levels of flavonoids (Table 1). The interaction treatment of vermicompost fertilizer with IAA hormone 0 ppm (P2H0) showed the highest flavonoid value, while the addition of vermicompost fertilizer (1:1) with the IAA hormone at 200 ppm (P2H2) the lowest was 8,291 mgQE/g. Data on the average flavonoid content of *S. palmifolium* is presented in Figure 11.

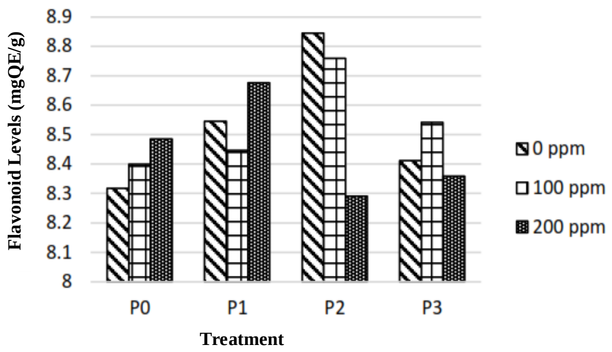


Figure 11. Average flavonoid content of *Sisyrinchium palmifolium* after fertilization and Indole Acetic Acid hormone treatment

Figure 11 shows that adding vermicompost fertilizer with 0 ppm IAA hormone showed the highest flavonoid content. Vermicompost fertilizer showed the highest yield on the flavonoid content of *S. palmifolium* bulbs. It could be because this fertilizer was rich in nutrients, so it could trigger the formation of secondary metabolites. In a different study by Putri et al. (2018), vermicompost fertilizer gave the best results and could increase the content of flavonoid compounds. High N uptake also encourages the enzymes that form flavone compounds to run more optimally to increase the phenolic and flavonoid content. The high flavonoid content proves that the *S. palmifolium* is a medicinal plant that can be used to treat various diseases. The lowest flavonoid levels were found at 200 ppm IAA hormone concentration. The administration of the IAA hormone is thought to be more directed at increasing the growth and development of the *S. palmifolium* plant so that it does not affect the secondary metabolite content of *S. palmifolium* bulbs (flavonoids). Precursors in IAA formation (tryptophan) may also begin to decrease. Their synthesis does not run optimally, causing the hormone to have less effect on the biosynthesis of secondary metabolites (flavonoids).

This study concluded that (i) fertilization affected leaf width, wet weight, dry weight, total chlorophyll content, leaf and bulb carotenoids, and flavonoid content. In addition, fertilizer affected the increase of the number of leaves, the number of tiller bulbs, and shoot-root ratio; (ii) IAA (Indole Acetic Acid) hormone affected increasing leaf width, the number of tiller bulbs, wet weight, and dry weight; (iii) the interaction of fertilization and the IAA (Indole Acetic Acid) hormone increase the number of leaves, leaf width, shoot-root ratio, and levels of flavonoids in *S. palmifolium* bulbs; (iv) the most optimal combination of treatments to increase the growth of *S. palmifolium* was a combination of soil and vermicompost fertilizer (1:1) with the IAA hormone of 200 ppm concentration (P2H2). The highest flavonoid level was in the combination of vermicompost fertilizer treatment with 0 ppm hormone (P2H0).

REFERENCES

Agboola DA, Ogunyale OG, Fawibe OO and Ajiboye AA. 2014. A review of plant growth substances: Their forms, structures, synthesis and functions. J Adv Lab Res Biol 5 (4): 152-168.

Alpriyan D, Karyawati AS. 2018. Pengaruh konsentrasi dan lama perendaman hormon auksin pada bibit tebu (*Saccharum officinarum* L.). J Produksi Tanaman 6 (7): 1354-1362. [Indonesian]

Aryani N, Kus H, Didin W, Ainin N. 2019. Peningkatan produksi bawang merah dan beberapa sifat kimia tanah ultisol akibat aplikasi vermikompos dan pupuk pelengkap. J Trop Upland Resour 1 (1): 145-160. DOI: 10.23960/jtur.vol1no1.2019.18.

Asra R, Ririn AS, Mariana S. 2020. Hormon tumbuhan. In: Atikah TA, Tatik W, Ellis N, Saputera, Doppy RN. 2021. Inovasi Teknologi. UKI Press, Jakarta. [Indonesian]

Dwijoseputro D. 1981. Pengantar Fisiologi Tumbuhan. PT. Gramedia, Jakarta. [Indonesian]

Fauzi M, Hapsoh, Erlida A. 2018. Pengaruh pupuk kascing dan pupuk p terhadap pertumbuhan dan hasil bawang merah (*Allium ascalonicum* L.). J Online Mahasiswa 5 (2): 1-14. DOI: 10.35308/jal.v5i1.1963. [Indonesian]

Hanaa H, Safaa A. 2019. Foliar application of IAA at different growth stages and their influenced on growth and productivity of bread wheat (*Triticum aestivum* L.). J Phys 1294: 1-7. DOI: 10.1088/1742-6596/1294/9/092029.

Havlin JL, Samuel LT, Werner LN, James DB. 2005. Soil Fertility and Fertilizer: An Introduction to Nutrient Management. Pearson Education, Inc, New Jersey.

Hendry GA, Grime JP. 1993. Methods on Comparative Plant Ecology (A Laboratory Manual). Chapman and Hall, London. DOI: 10.1007/978-94-011-1494-3.

Jasmin P, Siti H, Tatang A. 2019. Pengaruh abu janjang kelapa sawit dan pupuk kandang ayam terhadap pertumbuhan dan hasil bawang *Dayak* pada tanah gambut. J Sains Mahasiswa Pertanian 8 (3): 1-8. [Indonesian]

Kelly GS. 2011. Quercetin. Altern Med Rev 16 (2): 172-194.

Loveless AR. 1991. Prinsip-Prinsip Biologi Tumbuhan untuk Daerah Tropik. PT Gramedia Pustaka Utama, Jakarta. [Indonesian]

Mandang JP. 1993. Peranan Air Kelapa dalam Kultur Jaringan Tanaman Krisan (*Chrysanthemum morifolium* Ramat.). [Disertasi]. Institut Pertanian Bogor, Bogor. [Indonesian]

Mondal MF, Alam MS. 2003. Effects of set size and growth regulators on growth and yield of onion. J Bangladesh Agric Univ 1 (1): 7-12.

Muhuria L, Kartika NT, Nurul K, Trikoesoemaningtyas, Didy S. 2006. Adaptasi tanaman kedelai terhadap intensitas cahaya rendah: Karakter daun untuk efisiensi penangkapan cahaya. Bul Agron 34 (3): 133-140. DOI: 10.24831/jai.v34i3.1292. [Indonesian]

Mulat T. 2003. Membuat dan Memanfaatkan Kascing Pupuk Organik Berkualitas. Agromedia Pustaka, Jakarta. [Indonesian]

Nurhidayati T, Hery P, Sucipto H. 2019. Tanaman Tembakau pada Cekaman Genangan. Deepublish, Yogyakarta. [Indonesian]

Pranata AS. 2010. Meningkatkan Hasil Panen dengan Pupuk Organik. PT AgroMedia Pustaka, Jakarta. [Indonesian]

Prastyo KA, Laily AN. 2015. Uji Konsentrasi Klorofil Daun Temu Mangga (*Curcuma mangga* Val.), Temulawak (*Curcuma xanthorrhiza*), dan Temu Hitam (*Curcuma aeruginosa*) dengan Tipe Kertas Saring yang Berbeda Menggunakan Spektrofotometer. Seminar Nasional Konservasi dan Pemanfaatan Sumber Daya Alam 1 (1): 188-191. [Indonesian]

Putri DP, Widyastuti Y, Dewi WS, A. Yunus. 2018. The effect of shade and vermicompost application on yield and flavonoid levels of tempuyung (*Sonchus arvensis*). Earth Environ Sci 142: 1-10. DOI: 10.1088/1755-1315/142/1/012055.

Rekha GS, Patherl KK, Devan E, Mundarath PS, Vellaore NM. 2018. Effects of vermicompost and plant growth enhancers on the exo-morphological features of *Capsicum annum* (Linn.) Hepper. Intl J Recycl Org Waste Agric 7: 83-88. DOI: 10.1007/s40093-017-0191-5.

Rosmawaty T, Hasan BJ, Mardaleni, Charles S. 2019. Produksi dan kandungan flavonoid umbi tanaman bawang *dayak* (*Eleutherine palmifolia*) dengan pemberian NPK 16:16:16 pada berbagai umur panen. J Dinamika Pertanian 35 (3): 111-118. DOI: 10.25299/dp.2019.vol35(3).4574. [Indonesian]

Singh S, Prasad SM. 2015. IAA alleviates Cd toxicity on growth, photosynthesis and oxidative damages in eggplant seedlings. Plany Growth Regul 77: 87-98. DOI: 10.1007/s10725-015-0039-9.

Srivastava LM. 2002. Plant Growth and Development. Hormones and the Environment. Academic Press, Oxford.

Stankovic M. 2011. Total phenolic content, flavonoid concentration and antioxidant activity of *Marrubium peregrinum* L. Extracts. Kragujevac J Sci 33: 63-72.

Sutedjo MM. 2008. Fertilizers and Fertilization Way. Rineka Reserved, Jakarta.

Utami P, Desty EP. 2013. The Miracle of Herbs. PT AgroMedia Pustaka, Jakarta. [Indonesian]

Wijayati A, Solichatun, Sugiyarto. 2005. Pengaruh asam indol asetat terhadap pertumbuhan, jumlah dan diameter sel sekretori rimpang tanaman kunyit (*Curcuma domestica* Val.). Biofarmasi 3 (1): 16-21. DOI: 10.13057/biofar/f030104. [Indonesian]

Yang H, Jinwen L, Jingping Y, Hua W, Junliang Z, and Junjun H. 2014. Effect of nitrogen application rate and leaf age on the distribution pattern of leaf SPAD readings in the rice canopy. Plos One 9 (2): e88421. DOI: 10.1371/journal.pone.0088421.