International Journal of Agricultural Technology 2022Vol. 18(6):2585-2596
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Growth and productivity of Java Cardamom (*Amomum compactum* Soland ex. Maton) to shade and nitrogen supply

Rini, A. A.[1], Aisyah, S. I.[2], Prioseoryanto, B. P.[3] and Nurcholis, W.[1,4*]

[1]Department of Biochemistry, Faculty of Mathematic and Natural Science, Bogor Agricultural University (IPB University), Bogor 16680, Indonesia; [2]Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agricultural University (IPB University), Bogor 16680, Indonesia; [3]Division of Veterinary Pathology, Faculty of Veterinary Medicine, Bogor Agricultural University (IPB University), Bogor 16680, Indonesia; [4]Tropical Biopharmaca Research Center, Bogor Agricultural University (IPB University), Bogor 16128, Indonesia.

Rini, A. A., Aisyah, S. I., Priosoeryanto, B. P. and Nurcholis, W. (2022). Growth and productivity of Java cardamom (*Amomum compactum* soland ex. Maton) to shade and nitrogen supply. International Journal of Agricultural Technology 18(6):2585-2596.

Abstract Java cardamom (*Amomum compactum* Soland ex. Maton) is an herbal medicinal plant that used for a long time and one of the country's export commodities with the third-highest economic value after saffron and vanilla. The results showed no interaction between shade treatment and nitrogen fertilizer dose on the agromorphological characters and productivity of Java cardamom. The 75% shade gave the highest value to the variables of plant height, number of leaves, also stems and leaves productivity of Java cardamom. In comparison, 50% shade gave the highest value in terms of tillers and rhizome productivity.

Keywords: Agromorphological, Java Cardamom, Split-Plot Design

Introduction

Indonesia is one of the countries with biodiversity wealth in the plants such as cardamom, known as the "Queen of Spices" (Rajathi *et al.,* 2017). Cardamom comes from *Elettaria*, *Amomum*, and *Aframomum*, which are included in the *Zingiberaceae* family (Silalahi, 2017; Hartady *et al.,* 2020). *Amomum compactum* is a tropical and subtropical plant that grows and develops in Asian contries, such as Sri Lanka, India, Nepal, Indonesia, Guatemala, and Tanzania (Garg *et al.,* 2016; Abu-Taweel, 2018). Meanwhile, Indonesia has Java (*Amomum compactum* Soland ex. Maton) and true cardamom (*Elettaria cardamomum* (L.) Maton; syn. *Amomum cardamomum* L.) species of this plant. Java cardamom belongs to *Amomum*, the second-largest genus after *Alpinia*, which also comes from the family *Zingiberaceae* and the order *Zingiberales* (Setyawan *et al.,* 2014; Hartady *et al.,* 2020).

[*]**Corresponding Author:** Nurcholis, W; **Email**; wnurcholis@apps.ipb.ac.id

Cardamom (*Amomum compactum*) is an herbal medicinal plant being used as spice (Sukandar *et al.*, 2015). It can act as a phlegm thinner, removes water from the stomach, cleanses the blood, and warms the body. It can also fight constipation, diarrhea, dyspepsia, vomiting, pain, headaches, epilepsy, cardiovascular disease (Tambunan, 2017), and being used for aromatherapy (Juwitaningsih *et al.*, 2020). Several studies have reported that cardamom fruit (seed and pod) (Abu-Taweel, 2018), seed (Garza *et al.*, 2021), rhizome (Winarsi *et al.*, 2021)) and leaves (Winarsi *et al.*, 2014) have pharmacological activities such as antibacterial (Mierza and Sudewi, 2020), antibiofilm (Cui *et al.*, 2020), antioxidant (Nurcholis *et al.*, 2021), antimutagenic (Saeed *et al.*, 2014), anti-inflammatory (Garza *et al.*, 2021), antihypertensive (Kanthlal *et al.*, 2021), anticarcinogenic (Singh *et al.*, 2018) and anticancer (Ashokkumar *et al.*, 2019).

Java cardamom (*A. compactum* Soland ex. Maton) is one of the Indonesia's export commodities with the third-highest economic value after saffron and vanilla (Rani *et al.*, 2018). Based on the data from the Central National Statistics Agency (BPS) in 2017, the average production was 90.787 tons, from 43.62 ha. However, in 2018 and 2019, cardamom experienced a decrease in average output and harvested area by 81,724 tons and 40.77 ha, with an average production of 72,529 tons and 37.46 ha. On the other hand, the average production and harvested area increased by 94,490 tons and 41.84 ha in 2020. These data indicate that Indonesia is still experiencing various problems related to the unstable productivity of cardamom plant production. Furthermore, the plants require a humid climate, sunlight (Mathew and James 2017), and fertile soil with an altitude of 600-1,200 m above sea level with an annual rainfall of 1,500-4,000 mm and temperatures range from 10-35℃ (Zakir, 2019). The light intensity factor (shade) can also affect cardamom plants' growth and development.

Sunlight has an essential role in plant growth, especially in physiological activities, through its intensity, quality, and duration of irradiation. These three properties affect plant growth through stomata opening, chlorophyll formation, anthocyanin formation, leaves and stems temperature changes, cell wall permeability, nutrient absorption, protoplasmic transparency, and movement (Aji *et al*., 2015; Susilawati *et al*., 2016). In addition, the shade will result in lower sunlight received by plants, encouraging more significant vegetative growth than no shade condition. Light controls photosynthesis, leaves temperature, water balance in plants, and photomorphogenesis (Busaifi, 2017). Meanwhile, shade affects the height, the number of leaves, leaves length and width, as well as productivity (Sholehah *et al*., 2018). Fertilization adds nutrients to plants during and development. Nitrogen fertilizer is one of the supporting factors in forming protoplasm, proteins, and nucleic acids, with an essential role in the growth and development of all living tissues (Damanik *et al*., 2019). Additionally, it affects plant growth, appearance, color, and crop yields. Nitrogen elements will increase the number of tillers, accelerate plant height growth, affect leaves' width and length, and increase protein and fat levels (Pramitasari *et al*., 2016).

Shading is one method for distinguishing the intensity of light received by the plant beneath. It is an essential factor affecting plants' growth and production. This is because sunlight provides an energy source for photosynthesis which causes the carbohydrate content to decrease at low light or dark intensity (Khusni *et al*., 2018). The nutrient plays an essential role in biochemical and physiological functions since vital processes in plants are related to proteins and nitrogen elements (Leghari *et al*., 2016; Suwarto *et al*., 2021). However, there has been no research on the effect of shade and dose of nitrogen fertilizer on the agromorphological characters of Java cardamom. Shading and proper nitrogen fertilizer application can be considered a cultivation technique to increase production yields on cardamom plants. The study aimed to obtain information on the effect of shading, the application of nitrogen fertilizer doses on agromorphological characters, and the productivity yields of Java cardamom.

Materials and methods

Preparation of the research groups

The research was conducted in March-September 2021 at the Biopharmaceutical Conservation and Cultivation Unit Garden, Tropical Biopharmaca Research Center, Cikabayan, Bogor Agricultural University, Bogor, West Java, Indonesia, with a latitude of –6.54713 ° east longitude 106.71665 ° and an altitude of 141 m a.s.l. It used a split-plot design based on Sholehah *et al.* (2018) with 2 treatment factors: the intensity of the shade and the dose of nitrogen fertilizer. Shade intensity consists of 0%, 25%, 50%, and 75% shade levels as the main plot. The dose of nitrogen fertilizer as sub-plots consisted of 0 g/polybag, 0.9 g/polybag, and 1.36 g/polybag. Each study was conducted 3 times with 12 treatment combinations and a 50 cm x 50 cm plant distance.

The combination of treatments in this study was T1 treatment (without shade + 0 gr nitrogen fertilizer dose); T2 (without shade + dose of 0.9 gr nitrogen fertilizer); T3 (without shading + 1.36 gr dose of nitrogen fertilizer); T4 (25% shading + 0 nitrogen fertilizer dose); T5 (shade 25% + dose of 0.9 gr nitrogen fertilizer); T6 (shade 25% + dose of nitrogen fertilizer 1.36 gr); T7 (shade 50% + dose of nitrogen fertilizer 0 g); T8 (shade 50% + dose of 0.9 gr nitrogen fertilizer); T9 (shade 50% + dose of nitrogen fertilizer 1.36 gr); T10 (shade 75% + dose of nitrogen fertilizer 0 g); T11 (shade 75% + dose of 0.9 gr nitrogen fertilizer); T12 (75% shade + 1.36 gr nitrogen fertilizer dose).

Observation of agromorphological characters

Observation of agromorphological characters observed with the growth of Java cardamom included plant height, number of leaves and tillers, as well as productivity results in the form of fresh and dry weights of Java cardamom. Measurement of plant height was measured from the base of the stem to the tip of the highest plant leaves. Meanwhile, the number of leaves was calculated by counting, except for those still budding. The number of tillers was measured by counting the existing ones. Agromorphological characteristics of Java cardamom were conducted every 1st month after planting. Measurement of productivity results in fresh and dry weight was carried out by weighing the Java cardamom plant's leaves, rhizomes, and stems separately. The dry weight was obtained from the leaves, rhizomes, and stems after being dried in sunlight for ± 3 days. Productivity yield measurements were carried out after the Java cardamom was 12 months old.

Data analysis

Quantitative character analysis and productivity results were performed using Analysis of Variance (ANOVA) based on split-plot design with a significance level of $\alpha = 5\%$. This method determined the effect of shade treatment and nitrogen fertilizer dose. Further testing with Duncan's multiple range test (DMRT) was conducted using IBM SPSS statistics version 25.0 when there was a significant effect on the observed parameters.

Results

Agromorphological Characters of Java cardamom

Observations on the agromorphological characters of Java cardamom were shown by measuring plant height (Table 1), number of leaves (Table 2), and number of tillers (Table 3). Each of these growth parameters was observed and measured once every 1st month after the planting period for 7th months. The Analysis of Variance (ANOVA) results using the split-plot design method on the agromorphological characters of Java cardamom showed no interaction effect of shade treatment and nitrogen fertilizer dose on the agromorphological characters.

Plant height

The shade had significantly affected on plant height and increased every month for all treatments, while fertilizer dose had no significant effect (Table 1). Plant height at 1st month after planting (MAP) ranged from 14.82 cm (without shade) to 30.28 cm for the 75% shade, with significant affected between 0% and 75% shade ($P<0.05$). The highest and lowest palnts heights at 2nd MAP were 39.47 cm for 75% shade and 18.70 cm for 0% shade. At 3rd and 4th MAP, the highest plant height of 75% shade treatment was 39.27 and 47.02 cm, respectively and the lowest in the no-shade treatment was 19.30 cm and 24.10 cm. At 5th MAP, the highest and lowest plant height were 52.90 cm for 50% shade and 29.77 cm for 0% shade. At 6th MAP, the plant height ranged from 33.46 cm for 0% shade to 58.82 cm for 75% shade. The last measurement at 7th MAP obtained 75% shade treatment, where the tallest plant had a height of 64.18 cm.

Based on plant height observations on Java cardamom, 75% shade treatment had significantly affected than 50%, 25% shade, and 0% for 7th MAP ($p<0.05$). In contrast, nitrogen fertilizer treatment had not significantly affected on plant height (Table 1).

Table 1. Effect of shading and fertilization on Java cardamom plant height

Treatment	Plant Height (cm)						
	1MAP	2MAP	3MAP	4MAP	5MAP	6MAP	7MAP
Shade							
No shade	14.82[a]	18.70[a]	19.30[a]	24.10[a]	29.77[a]	33.46[a]	37.29[a]
25% shade	24.71[b]	35.78[b]	35.57[b]	38.17[b]	42.02[b]	46.23[b]	49.92[b]
50% shade	28.33[bc]	36.52[b]	36.34[b]	43.72[c]	52.90[c]	53.41[c]	56.29[b]
75% shade	30.28[c]	39.47[b]	39.27[b]	47.02[c]	48.57[c]	58.82[c]	64.18[c]
Dose of Nitrogen fertilizer (g/*polybag*)							
0	23.26[a]	31.22[a]	31.73[a]	36.98[a]	40.89[a]	45.25[a]	49.14[a]
0.9	25.79[a]	33.85[a]	33.68[a]	39.94[a]	45.44[a]	49.06[a]	53.29[a]
1.36	24.56[a]	32.78[a]	32.45[a]	37.84[a]	43.62[a]	49.06[a]	53.34[a]
Mean	24.53	32.62	32.62	38.25	43.32	47.98	51.92
Interaction	ns	ns	ns	ns	ns	ns	ns

The same letter in the same column shows that the results are not significantly different fro the 5% DMRT test results (ns = not significant at $P>0.05$).

Number of leaves

In the agromorphological character, the plant had fluctuated the number of leaves in certain months after the planting period. The shade treatment was significantly affected the number of leaves (Table 2). In contrast, the dose of nitrogen fertilizer had not significantly affected on the number of leaves except at 2nd MAP. The number of leaves in 1st month after planting (MAP) ranged from 3.51 for 0% shade to 6.21 for 50% shade, which gave a significant effect on each treatment ($p<0.05$).

At 2nd MAP, there was significantly affected on shade treatment and nitrogen fertilizer dose on the number of leaves. The leaves for shade treatment ranged from 5.44 for 0% shade to 7.89 for 50% shade. While the effect of fertilizer dose on Java cardamom ranged from 6.22 for N fertilizer dose 1.36 g to 7.18 leaves for dose 0.9 g). The number of leaves at 3rd MAP ranged from 5.41 for 0% to 7.89 for 50% shade. At 4th MAP, the number of leaves was ranged of 5.56 for 0% shade to 8.18 for 75% shade. The leaves at 5th MAP had averaged range of 6.11 for 25% shade to 7.99 for 50% shade. At 6th MAP, the leaves ranged from 5.96 for 0% to 8.89 for 75% shade. The number of leaves up to 7th MAP was ranged of 6.31 for 25% shade to 9.09 for 75% shade.

Table 2. Effect of shading and fertilization on the number of leaves of Java cardamom plants

Treatment	**Number of Leaves (leaves)**						
	1MAP	2MAP	3MAP	4MAP	5MAP	6MAP	7MAP
Shade							
No shade	3.51[a]	5.44[a]	5.41[a]	5.56[a]	7.20[ab]	5.96[a]	6.72[a]
25% shade	5.48[b]	6.46[b]	6.88[b]	5.67[a]	6.11[a]	6.59[a]	6.31[a]
50% shade	6.21[c]	7.89[c]	7.89[c]	7.58[b]	7.99[b]	7.65[b]	7.48[b]
75% shade	4.94[b]	7.26[bc]	7.26[bc]	8.18[b]	7.96[b]	8.89[c]	9.09[c]
Dose of Nitrogen fertilizer (g/*polybag*)							
0	4.81[a]	6.90[ab]	6.90[a]	6.93[a]	7.34[a]	7.05[a]	7.07[a]
0.9	5.36[a]	7.18[b]	7.16[a]	6.62[a]	7.18[a]	7.51[a]	7.60[a]
1.36	4.93[a]	6.22[a]	6.53[a]	6.69[a]	7.42[a]	7.26[a]	7.53[a]
Mean	5.03	6.76	6.86	6.75	7.31	7.27	7.40
Interaction	ns	ns	ns	ns	ns	ns	ns

The same letter in the same column shows that the results are not significantly different from the 5% DMRT test results (ns = not significant at $P>0.05$).

Number of tillers

The shade treatment was significantly affected in the number of tillers (Table 3). In contrast, the nitrogen fertilizer dose had not significantly affected in the number of tillers.

The number of tillers increased in the treatment without and with shade by 25% each month. In comparison, for the treatment with 50% and 75% shade, there was decreased in the number of tillers at the 5th and 6th months after planting. The number of tillers at 1st month after planting (MAP) ranged from 0.67 tillers for 0% shade to 1.96 tillers for 25% shade. The number of tillers in 2nd MAP ranged from 1.06 tillers for 0% shade to 2.95 tillers for 50% shade. At 3rd MAP, it ranged from 1.06 tillers for 0% shade to 3.18 tillers for 25% shade. The number of tillers at 4th MAP ranged from 1.72 tillers for 0% shade to 4.05 tillers for 50% shade.

Table 3. Effect of shade and fertilization on the number of tillers of Java cardamom

Treatment	**Number of Tillers (Tillers)**						
	1MAP	2MAP	3MAP	4MAP	5MAP	6MAP	7MAP
Shade							
No shade	0.67[a]	1.06[a]	1.06[a]	1.72[a]	2.65[a]	3.09[a]	4.69[b]
25% shade	1.96[b]	2.78[b]	3.18[b]	3.64[b]	5.58[b]	7.07[b]	8.14[c]
50% shade	1.78[b]	2.95[b]	2.95[b]	4.05[b]	2.11[a]	6.86[b]	8.28[c]
75% shade	1.05[a]	1.59[a]	1.58[a]	1.93[a]	5.38[b]	2.82[a]	3.16[a]
Dose of Nitrogen fertilizer (g/*polybag*)							
0	1.36[a]	2.28[a]	2.28[a]	2.8[a]	4.23[a]	5.04[a]	6.21[a]
0.9	1.50[a]	2.15[a]	2.14[a]	2.89[a]	3.81[a]	5.00[a]	6.12[a]
1.36	1.24[a]	1.85[a]	2.15[a]	2.82[a]	3.76[a]	4.84[a]	5.87[a]
Maen	1.37	2.09	2.19	2.84	3.93	4.96	6.07
Interaction	ns	ns	ns	ns	ns	ns	ns

The same letter in the same column shows that the results are not significantly different from the 5% DMRT test results (ns = not significant at P>0.05).

The number of tillers at 5th MAP decreased in 50% shade treatment and ranged from 2.11 to 5.58 for 25% shade in the current month. At 6th MAP, it decreased and increased in the 75% and 50% shade treatments. The number of tillers in those months ranged from 2.82 for 75% shade to 7.07 tillers for 25% shade. On the other hand, at 7th MAP, the number of leaves increased in each treatment ranged from 3.16 for 75% shade to 8.28 tillers for 50% shade.

Productivity of Java cardamom

The fresh and dry weight of the plant parts were the leaves, stems, and rhizomes of each treatment. Two replications of the fresh and dry outcomes of the treatment without shade were obtained. The 3rd replication of the Java cardamom plant had died before harvesting due to extreme weather changes. There was no interaction between shade and nitrogen fertilizer dose in each plant part’s average fresh and dry weight.

Table 4. Fresh weight and dry weight of Java cardamom plants

Treatment	Fresh Weight (g)			Dry Weight (g)		
	Plant part			Plant part		
	Leaves	Rhizome	Stems	Leaves	Rhizomes	Stems
Shade						
No Shade	102.50a	104.83a	208.83a	29.00a	23.00ab	37.17a
25% shade	92.67a	178.56ab	393.11ab	24.67a	37.22bc	62.22ab
50% shade	159.00a	221.33b	449.67b	47.22ab	43.00c	65.56ab
75% shade	265.67b	130.89a	506.22b	70.56b	21.22a	78.11b
Dose of Nitrogen fertilizer (g/polybag)						
0	161.27a	155.91a	391.18a	42.55a	31.36a	57.27a
0.9	171.45a	179.73a	457.45a	50.18a	34.27a	60.09a
1.3	146.45a	155.82a	369.00a	39.64a	29.91a	71.36a
Mean	157.00	161.01	396.49	43.40	31.43	61.68
Interaction	ns	ns	ns	ns	ns	ns

The same letter in the same column shows that the results are not significantly different from the 5% DMRT test results (ns = not significant at P>0.05).

The 75% shade treatment increased the fresh and dry weight of the leaves and stems of the Java cardamom plant, while the highest was found in the plant's rhizome at the 50% shade treatment. The highest fresh and dry leaves weights in the 75% shade treatment were 265.67 g and 70.56 g, respectively. On the contrary, the lowest fresh and dry leaf weights were found in the 25% shade treatment, with 92.67 g and 24.67 g. The rhizomes' highest fresh and dry weight were in the 50% shade treatment having an average of 221.33 g and 43.00 g, respectively. The rhizomes' lowest fresh and dry weight were 104.83 g and 21.22 g in the 0% and 75% shade treatment. The stems' highest fresh and dry consequences were in the 75% shade treatment with fresh weights of 506.22 g and 78.11 g. Meanwhile, the lowest consequences were in the 0% shade treatment with fresh weights of 208.83 g and 37.17 g, respectively.

Discussion

The tested plants in the 75% shade had the highest height because they received less sunlight when compared to the 50%, 25%, and 0% shade treatment, causing the plants to be taller. Low light intensity will increase auxin levels in the apical meristem, stimulating the elongation of plant cells (Khusni *et al.*, 2018). It is due to the auxin moves to the shaded part and activate the elongation zone resulting in acceleration of plant height in the shady part (Sholehah *et al.*, 2018). It is related to Prasetyo (2004), which showed that the highest growth of Java cardamom (*A. compactum* Soland ex. Maton) plant height was obtained by 35% and 70% shade treatment compared to 0% shading. Sholehah *et al.* (2018) also reported that plant growth of *Ocimum basilicum* L. was highest at 25% shade compared to shade.

The 75% shade treatment had significantly differed with more leaves than the 50%, 25%, and 0% shade for 7th months after planting ($p<0.05$). in contrast, nitrogen fertilizer treatment had not significantly affected in the number of leaves, except in the 2nd month. The speed of photosynthesis is influenced by changes in light intensity to encourage leaves to adapt, one of which is in the mesophyll and epidermis (Sholehah *et al.,* 2018). The higher the level of shade, the lower the light intensity received by plants, resulting in microclimate changes such as temperature, air, and humidity around the planting area. The low intensity of sunlight and humidity causes the air temperature under the paranet shade to be lower and higher than outside the shade (Yuliawati *et al.,* 2014).

Leaves become wider and thinner when shaded because the mesophyll layer contains a thinner palisade layer and has smaller cells. The mesophyll and epidermal cells in the Java cardamom plant will adapt to shaded conditions and tolerate light (Mathew and James, 2017). It is related with Bramantyo *et al.,* (2013), who stated that plants' response to shade can be characterized which based on leaf growth. Leave sizes increase with decreasing light intensity due to rising levels of shade treatment. In each treactment, the number of leaves fluctuated for 0%, 25%, 50%, and 75% shade. The number of leaves decreased in the 3rd and 6th month after planting for the treatment without shadow. The reduction of the number of leaves for the 25% shade treatment happened in the 4th month after planting. In the 50% shade treatment, there was decreased in the number of leaves at the 4th and 6th months after planting. While in the 75% shade treatment, there was decreased in the number of leaves in the 5th month after planting. It is occurred because there is a transition period from summer to the rainy season, which caused the leaves to rot and turn yellow, affecting the number of leaves when measured. The increased light intensity affects the rate of photosynthesis due to the production of ATP and NADPH is relatively high. Therefore, the rate of photosynthesis increases photosynthate production and the number of leaves of the Java cardamom plant (Yuliawati *et al.,* 2014).

Based on the results on the number of tillers resulted in Java cardamom during the 7th month after planting, for example, 50% shade treatment had the highest number of tillers with an average of 8.28 tillers. Meanwhile, the lowest number of tillers was found in the 75% shade treatment, with an average of 3.16 tillers. It is related with Alagupalamuthirsolai *et al.* (2019), who stated of that 50% shade produced more physiologically active saplings compared to 75% on *Elettaria cardamomum* (L.) Maton (small cardamom). Additionally, Goh *et al.* (2018) also reported that 50% shade produced more tillers than 0% on *Zingiber zerumbet* (L.). This fluctuating growth occurred due to unexpected environmental conditions of agricultural land, namely temperature conditions to rainfall in several months of the study, which affected the growth of the number of tillers. The level of sunlight intensity is correlated with the rate of photosynthesis of plants. The air temperature under the paranet shade is lower and has higher humidity due to the low intensity of sunlight. Air temperature affects the rate of diffusion of liquids in plants. Furthermore, water viscosity increases when the air temperature drops, which affects the photosynthesis process. It can also inhibit root growth and the number of tillers in Java cardamom plants.

Adapting the Java cardamom to different sunlight intensities to maintain photosynthetic capacity caused changes in the accumulation of organic matter and biomass (Sholehah *et al.,* 2018). The 75% shade caused the plant height to produce the highest fresh weight of leaves and stems compared to other treatments. In contrast, the low sun intensity caused the temperature to decrease, which inhibited root growth, affecting the number of tillers and rhizomes. Therefore, sunlight is very influential in photosynthesis and plant growth compared to other environmental factors (Cheng *et al.,* 2014; Li *et al.*, 2014). Shade treatment affected the agromorphological characterstics, plant height, number of leaves, number of tillers, and productivity of Java cardamom. The 75% shade gave the highest value for plant height, number of leaves, and productivity of leaves and stems. Meanwhile, 50% shade gave the highest value on variables number of tillers and damped dry weight rhizome.

Acknowledgements

This research was supported by PDUPT research program of IPB University (1925/IT3.L1/PN/2021).

References

Abu-Taweel, G. M. (2018). Cardamom (*Elettaria cardamomum*) perinatal exposure effects on the development, behavior and biochemical parameters in mice offspring. Saudi Journal of Biological Sciences, 25:186-193.

Aji, I. M. L., Sutriono, R. and Yudistira. (2015). Pengaruh media tanam dan kelas intensitas cahaya terhadap pertumbuhan benih gaharu (*Gyrinops versteegii*). Jurnal Media Bina Ilmiah, 9:1-10.

Alagupalamuthirsolai, M., Ankegowda, S. J., Murugan M., Sivaranjani, R., Rajkumar, B. and Akshitha, H. J. (2019). Influence of light intensity on photosynthesis, capsule yield, essential oil and insect pest incidence of small cardamom *(Elettaria cardamomum* (L.) Maton). Journal of Essential Oil Bearing Plants, 22:1172-1182.

Ashokkumar, K., Murugan, M., Dhanya, M. K. and Warkentin, T. D. (2019). Botany, traditional uses, phytochemistry and biological activities of cardamom [*Elettaria cardamomum* (L.) Maton]–a critical review. Journal of Ethnopharmacology, 246:112244.

Bramantyo, J., Samanhudi. and Rahayu, M. (2013). Pengaruh naungan dan cekaman air terhadap pertumbuhan dan hasil purwoceng (*Pimpinella pruatan* Molk.) di Tawangmangu. Program Studi Agroteknologi Fakultas Pertanian Universitas Sebelas Maret Surakarta, 1-12.

Busaifi, R. (2017). Korelasi tingkat naungan dan cekaman air terhadap variabel laju pertumbuhan relatif *Ageratum conyzoides* Linn. Journal of Applied Agricultural Sciences, 1:154-162.

Cheng, L. X., Tang, C. P., Vance, P. J., White, F., Zhang, J. and Shen. (2014). Interaction between light intensity and phophorus nutrition affect the phosphate-mining capacity of white lupin (*Lupinus albus* L.). Journal of Experimental Botany, 65:2995-3003.

Cui, H., Zhang, C., Li, C. and Lin, L. (2020). Inhibition mechanism of cardamom essential oil on methicillin-resistant Staphylococcus aureus biofilm. Journal LWT-Food Science and Technology, 122:2-7.

Damanik, R. N., Armita, D. and Koesriharti. (2019). Pengaruh kerapatan naungan dan dosis pupuk nitrogen pada pertumbuhan, hasil dan kandungan antosianin pada bayam merah (*Amaranthus tricolor* L.). Jurnal Produksi Tanaman, 7:1521-1529.

Garg, G., Sharma, S., Dua, A. and Mahajan, R. (2016). Antibacterial potential of polyphenol rich methanol extract of Cardamom (*Amomum subulatum*). Journal of Innovative Biology, 3:271-275.

Garza, G. R. C., Luevano, J. H. E., Rodrigurze, A. F. B., Montes, A. C., Hernandez, R. A. P., Delgado, A. J. M., Villarreal, S. M. L., Rodriguez, J. R., Casas, R. M. S., Velazquez, U. C. and Luis, O. E. R. (2021). Benefits of cardamom (*Elettaria cardamomum* (L.) Maton) and Turmeric (*Curcuma longa* L.) extracts for their applications as natural anti-Inflammatory adjuvants. Journal MDPI, 10:2-17.

Goh, S., Abdullah, T. L., Hassan, S. A. and Stanslas, J. (2018). Breaking dormancy and effects of shade level and NPK fertilizer rates on yield of *Zingiber zerumbet* (L.) Smith (Lempoyang). Agriculture MDPI, 8:198.

Hartady, T., Balia, R. L., Syamsunarno, M. R. A. A., Jasni, S. and Priosoeryanto, B. P. (2020). Bioactivity of *Amomum Compactum* Soland Ex Maton (Java Cardamom) as a natural antibacterial. Systematic Reviews in Pharmacy, 11:384-387.

Kanthlal, S. K., Arya, V. S., Bindhu, P. P., Vijayakumar, M., Rema Shree, A. B. and Uma, D. P. (2021). Aqueous extract of large cardamom inhibits vascular damage, oxidative stress, and metabolic changes in fructose-fed hypertensive rats. Clinical and Experimental Hypertension Journal, 43:622-632.

Khusni, L., Hastuti, R. B. and Prihastanti, E. (2018). The Impact of Shade to the Growth and the Antioxidant Activity of Red Spinach (*Alternanthera amoena* Voss.). Jurnal Buletin Anatomi dan Fisiologi, 3:62-70.

Leghari, S. J., Wahocho, N. A., Laghari, G. M., Laghari, A. H., Bhabhan, G. M., Talpur, K. H., Bhutto, T. A., Wahocho, S. A. and Lashari, A. A. (2016). Role of nitrogen for plant growth and development: A Review. Advances in Environmental Biology, 10:209-218.

Li, T. L., Liu, C., Jiang, Y., Liu, L. and Shi. (2014). Effect of mutual shading on the regulation of photosynthesis in field-grown sorghum. The Journal of Photochemistry and Photobiology B, 137:31-38.

Mathew, L. and James, P. P. (2017). Problems and prospects of cardamom cultivation in idukki district. SSRG International Journal of Economics and Management Studies, 4:37-44.

Mierza, V. and Sudewi. (2020). Antibacterial activity mouthwash preparation ethanol extract of cardamom (*Amomum compactum* Sol. Ex Maton) for growth of bacteria Staphylococcus Aureus and Streptococcus Mutans. Journal of Pharmaceuutical and Sciences (JPS), 3: 51-57. https://doi.org/10.36490/journal-jps.com.v3i1.45.

Nurcholis, W., Putri, D. S., Husnawati, Aisyah, S. I. and Priosoeryanto, B. P. (2021). Total flavonoid content and antioxidant activity of ethanol and ethyl acetate extracts from accessions of Amomum compactum fruits. Annals of Agricultural Sciences, 66:58-62.

Juwitaningsih, T., Jahro, I. S. and Sari, S. (2020). Evaluation of north sumatera cardamom seed (*Amomum compactum*) extract as antibacterial and anticancer. Journal of Physics: Conference Series, 1485:012019.

Rani, B., Sawaswat, R., Prasad, M., Khan, A. A., Chharang, H. and Maheshwari, R. K. (2018). Cardamom (*Elettaria cardamomum*): a spice of prominent healthcare. Journal of biological and chemical research, 35:194-199.

Rajathi, A. A., Sundarraj, A. A., Leslie, S. and Pragalyaashree, M. M. (2017). Processing and medicinal uses of cardamom and ginger – a review. Journal of Pharmaceutical Sciences and Research, 9:2117-2122.

Saeed, A., Sultana, B., Anwar, F., Mushtag, M., Alkharfy, K. M. and Gilani, A. H. (2014). Antioxidant and antimutagenic potential of seeds and pods of green cardamom (*Elettaria cardamomum*). International Journal of Pharmacology, 10:461-469.

Setyawan, A. D., Wiryanto, Suranto, Bermawie, N. and Sudarmono. (2014). Comparisons of isozyme diversity in local Java cardamom (*Amomum compactum*) and true cardamom (*Elettaria cardamomum*). Nusantara Bioscience, 6:94-101.

Sholehah, D. N., Suhaertono. and Lesmana, A. (2018). Growth and essential oil content of basil (*Ocimum basilicum* L.) on different shading and phosphate fertilizers rate. Jurnal Agron. Indonesia, 46:197-201.

Singh, R., Kaushik, R. and Jaglan, V. (2018). Antibacterial and antioxidant activity of green cardamom and rosemary extract in food products: A brief review. The Pharma Innovation Journal, 7:568-573.

Silalahi, M. (2017). Bioaktivitas amomum compactum soland ex maton dan perspektif konservasinya. Jurnal Pro-Life. 4:320-328.

Sukandar, D., Hermanto, S., Amelia, E. R. and Zaenudin, M. (2015). Aktivitas antibakteri ekstrak biji kapulaga (Amomum Copactum Sol. Ex Maton). JKTI, 17:119-129.

Susilawati, Wardah. and Irmasari. (2016). Pengaruh berbagai intensitas cahaya terhadap pertumbuhan semai cempaka (*Michelia champaca* L) di persemaian. Jurnal ForesSains, 14:59-66.

Suwarto, Adi, D. D., Lubis, I. and Sugiyatna. (2021). The nitrogen use efficiency of an upland rice ipb 9. Jurnal Agron. Indonesia, 49:23-28.

Tambunan, L. R. (2017). Isolasi dan identifikasi komposisi kimia minyak atsiri dari biji tanaman kapulaga (*Amomum Cardamomum* Willd). Jurnal Kimia Riset, 2:57-60.

Pramitasari, H. E., Wardiyati, T. and Nawawi, M. (2016). The influence of nitrogen fertilizer dosage and plant density level to growth and yield of kailan plants (*Brassica oleraceae* L.). Jurnal Produksi Tanaman, 4:49-56.

Prasetyo. (2004). Budidaya kapulaga sebagai tanaman sela pada tegakan sengon. Jurnal ilmu-ilmu pertanian Indonesia. 6:22-31.

Winarsi, H., Sasongko, N. D., Purwanto, A. and Nuraeni, I. (2014). Effect of cardamom leaves extract as antidiabetic, weight lost and hypocholesterolemic to alloxan-induced sprague dawley diabetic rats. International Food Research Journal, 21:2253-2261.

Winarsih, H., Nuraeni, I., Roslenina, A. and Andreas, A. (2021). Sensory and antioxidant evaluation of functional drinks based on Cardamom rhizomes (*Amomum cardamomum* willd.). Journal Food Research, 4:2169-2175.

Yuliawati, Rahayu, A. and Rochman, N. (2014). Shading and several urea doses effect on the growth and vegetative production of alfalfa (*Medicago Sativa* L.). Jurnal Pertanian, 5:43-51.

Zakir, M. (2019). Review on breeding method and achievements of cardamom (*Elettaria cardamomum* Soland ex. Maton) and future prospects. International Journal of Research in Agriculture and Forestry, 6:16-23.

(Received: 24 May 2022, accepted: 30 October 2022)