Jurnal Biodjati 9(1): 54-65, May 2024

e-ISSN : 2541-4208
p-ISSN : 2548-1606

JURNAL BIODJATI

http://journal.uinsgd.ac.id/index.php/biodjati

Propagation of Cardamom (*Amomum compactum)* Using Vitamin B1, Indole Butyric Acid and Their Combinations Ex Vitro

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Received: January 17, 2024
Revise from: February 04, 2024
Accepted: April 15, 2024

DOI: 10.15575/biodjati.v9i1.33327

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Abstract. *Cardamom (Amomum compactum) is an aromatic spice plant with numerous benefits, widely used in cooking, medicine, and beverages. The high demand for cardamom remains unmet due to the lengthy germination period required for cardamom seeds and the inability of cardamom shoots to thrive when planted independently from the mother plant. The presence of the mother plant significantly impacts cardamom nurseries utilizing shoots, making it challenging to obtain large quantities of nursery transplants. Growth stimulants, such as vitamin B1 and Indole Butyric Acid (IBA), are required to enhance vegetative growth in plants. Vitamin B1 (IPI brand) is applied due to its ease of accessibility and cost-effectiveness. Meanwhile, IBA is utilized for its accessibility, stable chemical content, and prolonged efficacy. This research aims to determine the optimal concentration of vitamin B1, IBA, and their combination to enhance the growth of mother and tiller shoots of cardamom ex vitro. The research employed a two-factorial Randomized Complete Block Design, with vitamin B1 concentrations of 21.5% and 43% and IBA concentrations of 0.75 ppm and 150 ppm. The treatment V1I1 (vitamin B1 21.5% and IBA 75 ppm) on mother plant shoots maintained a survival rate of 67% up to 12 Weeks After Planting (WAP). The interaction between vitamins B1 and IBA exhibited no significant effect on all parameters of mother shoots and tillers; however, vitamin B1 significantly influenced the vegetative growth of cardamom mother shoots. Vitamin B1 at 43% produced a significantly higher number of leaves compared to 21.5%. Thus, vitamin B1 at 43% is recommended for cardamom propagation, while vitamin B1 at 21.5% has the potential to enhance the average growth of tiller shoots across all parameters.*

Keywords: *Medicinal ingredient, transplants, vegetative growth*

Citation
Salsabila, A. M., Devy, L., & Dasumiati. (2024). Propagation of Cardamom (*Amomum compactum*) Using Vitamin B1, Indole Butyric Acid and Their Combinations Ex Vitro. *Jurnal Biodjati*, 9(1), 54-65.

INTRODUCTION

Cardamom is one of the world's most economically valuable and aromatic spices, it's comes from the *Zingiberaceae* family with the genus Amomum, and there's only *Amomum compactum* that's the originates from Indonesia, so it is better known as java cardamom (Setyawan et al., 2014). This species originally grew wild in the forests of Java Island and is now widely cultivated in various parts of Indonesia (Silalahi, 2017). The cardamom has used for fragrance, cosmetics, food, beverage, and traditional medicine (Hani & Octavia, 2020). It contains essential oils such as cineole, terpinyl, monoterpenes, sesquiterpenes, limonene, alpha-pinene, myrcene, sabinene, alpha-terpineol, borneol, and chamfer which can be used as antipyretic (Evizal, 2013), antidepressant (Supriani, 2019), antibacterial, anticancer (Droop et al., 2013), antifungal, gastroprotective, antioxidant (Silalahi, 2017), antifungal, gastroprotective, anti-inflammatory, anti-asthma, immunomodulatory, and acute renal failure (Alkandahri et al., 2021).

The demand for java cardamom in the world is predicted to rise along with increased consumption of cardamom (Suhartini et al., 2021). Indonesia is one of the largest cardamom exporting countries to the world. It can be seen the increase in demand for cardamom exports in Indonesia from 2019 - 2022, with an average increase of 34.13%, the highest increase occurring in 2022, namely 82% (Direktorat Statistik Distribusi et al., 2022). The increase in demand for cardamom exports in Indonesia is estimated to have not met market demand. This can be caused by several factors, one of which is the availability of cardamom seeds.

One of the reasons why export demand is not met is the length of time it takes for cardamom to grow through seeds (seed germination) and requires more planting material if vegetatively (rhizome cutting), because it must include the mother plant to plant shoots (Evizal, 2013). One of the efforts to increase the production of cardamom seeds can be done ex vitro. Ex vitro is a vegetative propagation technique outside the laboratory under controlled conditions; this technique is more profitable because it is simple, the seeds produced quality, as well as more time and cost-efficient (Bioteknologi, 2014; Elpawati et al., 2018).

The shoots as explants without including the mother plant with the application of vitamin B1 and Indole Butyric Acid (IBA) is thought to support the growth process of cardamom shoots. It can be used as a seeding solution. The application of vitamin B1 can accelerate plant growth by acting as a catalyst and coenzyme (Munir et al., 2016) and reducing stress in plants (Yusof, 2019). Meanwhile, IBA is classified as an auxin type of plant growth regulator (PGR) that plays a role in stimulating rooting (Suryanti et al., 2013), cell division, and shoot multiplication. Therefore, it is necessary to experiment with vitamin B1, IBA and their combination to obtain optimal results in an effort to produce cardamom seeds quickly and in large quantities.

MATERIALS AND METHODS

This research is using experimental approach. Data collection was carried out from January to April 2023. The research took place at the screen house of the Industrial, Agro and Biomedical Technology Development Laboratory (LAPTIAB), National Research and Innovation Agency (BRIN), PUSPIPTEK, Serpong, South Tangerang.

The tools used in this study were including polybags (25 x 20 cm), hoe, soil scoop, measuring tape, stationery, cell phone camera, knife, label, beaker glass, Chlorophyll meter (SPAD-502Plus), IRRI Leaf Colour Chart, soil meter, analytical scales, magnetic stirrer and stirring bar, drum sterilizer, paranet 55%, ruler, dropping and measuring pipette, tissue, measuring cylinder, Erlenmeyer, volumetric flask, plastic container. Meanwhile, the materials were planting media (soil, husks and goat manure), 36 cardamom mother shoots of uniform size, IPI brand vitamin B1, PhytoTech Labs brand IBA, ecoenzyme 1% solution from fruit with the Soulqua brand, aquadest, tap water and 1M KOH.

The experimental design was Two-Factor Randomized Block Design (RBD). The first factor was immersion of the mother shoots in vitamin B1, which consisted of 2 levels, namely concentrations of 21.5% and 43%. The second factor is immersion of the mother shoots in IBA, which consists of 3 levels, namely 0 ppm, 75 ppm, and 150 ppm. Each treatment was repeated six times, so there were total 36 experimental units. Each experimental unit consisted of 1 cardamom mother shoot. Thus, a total of 36 cardamom shoots were used in this study.

Experiment Preparation

1.Preparation of planting media

Planting media is prepared by taking subsoil from the LAPTIAB garden. The subsoil was obtained by hoeing the soil to a depth of about 35 cm. The obtained subsoil was then mixed with husks and goat manure in a ratio of 1:1:1 and then the planting medium was sterilized by steaming the soil in a sterilization drum for 4 hours (Yuraida, 2021). The sterilized planting medium is put into a 20 x 25 cm polybag using a soil scoop.

2.Preparation for making treatment solutions

Making vitamin B1 21.5% solution (V1) was done by dissolving half a grain (107.5 mg) and vitamin B1 43% solution (V2) was done by dissolving 1 grain (215 mg) of vitamin B1 which has previously been ground, put it into a beaker glass that containing 250 ml of distilled water for each treatment and stirring using a magnetic stirring bar. To make 75 ppm IBA solution, 37.5 ml of the 1000 ppm IBA and to make 150 ppm IBA solution, 75 ml of the 1000 ppm IBA stock solution was taken using a measuring pipette and added to a 250 ml volumetric flask. Distilled water was then added until it reached the 250 ml limit line indicated on the measuring flask..

3.Preparation of planting material

The cardamom mother plant was obtained from the LAPTIAB BRIN Serpong garden. Before being planted in the LAPTIAB BRIN Serpong garden, java cardamom mother plants were obtained from cardamom farmers in Purwabakti Village, Pamijahan District, Bogor Regency (106,640LS; 6,700BT; 657.9 masl). Cardamom shoots with the same size were selected from the mother plant which is around 12 months old, has healthy rhizomes (not wrinkled). Cardamom shoots are cleaned of root hairs and cut from the mother plant using a knife (leaving a small amount of rhizome on the shoot). Washed the cardamom shoot using running tap water and then dried it using tissue.

Growth Stimulants Application and Shoot Plantation

Soaking is done by placing the prepared shoot a solution of vitamin B1 and IBA according to the treatment that has been designed for 15 minutes. Soaking for the combination of vitamin B1 and IBA is carried out by mixing the two solutions with a volume of 250 mL each to 500 ml for each combination. After soaking for 15 minutes, the cardamom shoots were dried using tissue, and the cardamom shoots were planted in polybags that had previously been prepared and filled with planting medium.

Watering, Ecoenzyme Application and Plant Tending

Watering treatment of cardamom shoots with coenzyme is carried out after the shoots are planted in the planting medium. Watering was repeated once a week when observations were made. Ecoenzyme 1% solution was made by dissolving 108 ml of the coenzyme solution in 10.800 ml of water in a bucket and pouring it onto the cardamom mother shoots that had been planted in 36 polybags with 300 ml of ecoenzyme solution on each polybag. The concentration was chosen according to recommendations from the coenzyme manufacturer on the packaging label and previous optimization results from the BRIN research team. Polybags are arranged in a screen house that has been installed with paranet 55%; preparation was carried out in accordance with the research layout that had previously been created. Cardamom plant tending includes watering tap water and cleaning the plant media from weeds, which is carried out as needed (Kementrian Pertanian, 2019).

Observation Parameters

Observations were made on survival rates and vegetative growth. Observations of vegetative growth of cardamom plants originating from shoots were grouped into two groups for each parameter (except the number of tiller shoots). The first group is plants that originate from the initial shoots of cardamom that are planted or originate from the mother plant, from now on referred to as mother shoots. The second group is parameters that originate from additional shoots or new shoots that appear after planting the mother shoot, which is referred to as tiller shoots. The observed characters were including survival rate. According to Suzuki & Jacalnc (1986), Survival Rate (SR) can be calculated using a formula:

$$\text{Survival rate (SR)} = \frac{(\text{Number of shoots planted} - \text{Number of shoots that died}) \times 100\%}{\text{Number of shoots planted}}$$

The other observation parameters, namely colour of shoots and leaves, this observation was carried out using IRRI Leaf Colour Chart. Number of leaves and tiller shoots, the calculation of the number of leaves was done by counting the number of leaves that had completely opened. Length and width of leaves was measured from tip to base of the leaf vertically (for length) and measured from tip to the other tip in the middle of the leaf horizontally (for width). The last observation is total chlorophyll content, was measured using a chlorophyll meter (SPAD-502 Plus Konica Minolta). The parameters observations were carried out once a week until 12 weeks after planting (WAP).

Data analysis

Data analysis was carried out using Analysis of Variance (ANOVA) for all parameters, except for SR, leaf and shoot colour. If there is a significant difference between treatments, then proceed with the middle-value test using Duncan's Multiple Range Test (DMRT) at a = 5%. The data was analyzed using Statistical Analysis Software (SAS) version 8.2.

RESULTS AND DISCUSSION

1. Growth Response of Cardamom Plants Derived from Mother Shoots

The difficulty of seeding without a mother plant is proven by the results of this study, which showed a decrease in the survival rate (SR) percentage. SR is an index of a population's survival ability for a certain predetermined period (Indriani et al., 2015). The inability of shoots to survive without a mother plant is an obstacle for farmers in vegetative propagation efforts and is considered inefficient. The purpose of including the mother plant in propagation is to provide nutritional intake for the shoots to grow, the rhizome's size will influence its contents so that the stored energy will influence subsequent growth (Adi et al., 2015). Differences in the SR percentage of cardamom mother shoots at 12 WAP (Table 1) could occur due to differences in the ability to absorb nutrients and the roots formed. The factors that influence the ability of plants to live are internal factors of the plant, root length, number of roots and root hairs formed, which influence the ability to absorb nutrients (Suryawan et al., 2016). The longer the plant roots, the more opportunities for root hairs to form so that nutrient absorption is maximized and the position of a plant will be stronger.

The application of 75 ppm IBA was able to increase SR percentage of cardamom mother shoots at 12 WAP compared to using only vitamin B1. It can be seen in treatment VII1 (67%), which has a higher SR than V1I0 (50%) and control V2I0 (33%) (Table 1). The percentage of SR V2I1 (50%) showed higher results than control V2I0 (33%). Application of 150 ppm IBA can decrease SR of shoots at 12 WAP. This can be seen in the V1I2 treatment (17%) having a lower SR than V1I0 (50%) and V2I0 controls (33%). The SR of V2I2 (17%) also showed lower results than control V2I0 (33%) (Table 1).

The highest SR in the V1I1 treatment (67%) could occur because the application of 21.5% vitamin B1 and 75 ppm IBA was able to synergize with endogenous PGR so that it was able to maintain the viability of cardamom shoots. Applying vitamin B1 at the appropriate concentration will increase the plant's ability to survive by preventing stress (Yusof, 2019). It can also speed up metabolism by being a catalyst and coenzyme (Munir et al., 2016). Each plant has a different concentration of vitamin needs, and giving appropriate exogenous vitamins will increase growth by helping hormones work; for example giving 1 mL/l vitamin B1 to Dendrobium Schulleri J.J Smith gives the best results for survival up to 100% at the acclimatization stage of 8 WAP (Puspita, 2022), while in Dendrobium laxiflorum J.J Smith a concentration of 0.1 ppm is the best concentration for survival up to 75.66% (Amalia et al., 2013). The application of IBA is also able to increase the survival capacity of plants by accelerating root growth, so optimal nutrient absorption occurs in the planting medium (Patty, 2019). The need for exogenous ZPT in plants is also different; for example, giving auxin (2,4-D) 1 ppm in basic media gives the best results in the survival of mango ginger plants (*Curcuma zedoaria* Rosc.) up to 77.77%, while in white ginger plants (*Curcuma mango* Val.) concentration of 2 ppm gave the best results reaching 44.44% at the end of the observation (Isra' et al., 2020).

The lowest SR was shown in the V1I2 and V2I2 treatments (17%). The low SR percentage can occur due to the use of 150 ppm IBA, which is too high, thereby inhibiting root growth. The application of exogenous IBA must use the right concentration because plants have different optimum concentrations, but generally, the concentration of the IBA solution used is 5-100 ppm (Candace, 2000; Putri & Ramli, 2020). Soaking croton plant cuttings (*Codiaeum variegatum*) with 150 ppm IBA showed the lowest percentage of live cuttings (77.78%) at 60 day after treatment (DAT). This is also in line with research by (Merliyoga, 2022), giving IBA 150 ppm showed poor survival and rhizome sprouting ability (37.04%) in red ginger (*Zingiber officinale* Var. Rubrum) compared to other treatments (Putri & Ramli, 2020).

The application of vitamin B1 and IBA not only influences the survival of cardamom mother shoots, but also can stimulate vegetative growth such as shoot height, number of leaves, length and width of leaves (Table 1 & 3). The growth of a plant can be observed by testing the growth parameters of plant height, number of leaves, number of shoots, leaf colour and chlorophyll content (Agwi et al., 2017). Growth in plant height, length and width of cardamom mother shoot leaves showed no significant effect on the application of vitamin B1, IBA and their combination at 12 WAP among the treatments, the application of vitamin B1 without the addition of IBA to the V2I0 control has the potential to produce the best average plant height (22.9 cm), length (7.0 cm) and leaf width (3.9 cm) compared to other treatments

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(Table 1). The application of IBA reduces the average of these parameters (Table 1). It can occur because the endogenous auxin content of cardamom shoots is high, so the addition of IBA will inhibit plant vegetative growth. According to (Alitalia, 2008), inappropriate addition of exogenous PGR can occur when the mother plant used as an explant has a high accumulation of endogenous auxin so that the growth of the explant is disrupted. Auxin that is too high will synthesize the hormone ethylene, which inhibits growth hormone (Wakidah & Rahayu, 2020).

The number of plant leaves showed that the results had no significant effect on the interaction of vitamin B1 and IBA but had a significant effect on the single application of vitamin B1 at 12 WAP. The results of the 5% DMRT showed that the application of 43% vitamin B1 was more optimal in increasing the average number of mother shoot leaves than the application of 21.5% vitamin B1 (Figure 1). It can be seen in 43% vitamin B1, showed that the average number of leaves is higher, such as in the V2I0 (3.7 leaves), V2I1 (1.7 leaves) and V2I2 (3.0 leaves) treatments. Meanwhile, the application of 21.5% vitamin B1 resulted in a lower average number of leaves as occurred in the V1I0 (0.7 leaves), V1I1 and V1I2 (0 leaves) at 12 WAP (Table 1). The large number of leaves formed will influence the photosynthesis process and plant biomass production (Andrian et al., 2022). Plant's growth will be faster if it has lots of leaves for the plant's photosynthesis process (Sari et al., 2019). It is in accordance with research results, which show that the highest average plant height has the highest average number of leaves (Table 1).

The colour of shoots parameters showed a similar result with code 2 for all treatments at 12 WAP (Table 2). The green colour of the shoot indicates that there is chlorophyll content in the shoot (Mawaddah et al., 2021). Observing the colour of the shoots is necessary to determine the condition of the shoots (without the mother plant) after planting; code 2 seen on the IRRI Leaf Colour Chart Meter shows the shoots are growing well, there are no visible signs of death and have the potential to be used as seeds, so that it can be seen that the treatment given are suitable for roots growth.

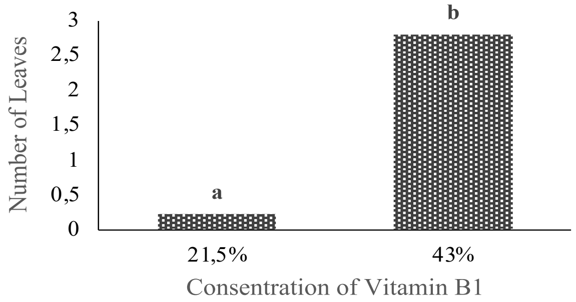

Figure 1. Average number of cardamom mother shoot leaves when applying vitamin B1 with different concentration at the age of 12 week after planting

The colour of leaves parameter in the V2I0 treatment showed code 4, while the V1I0, V2I1 and V2I2 treatments showed code 3 (Table 2). Differences in leaf colour can be influenced by the chlorophyll contained in them; the greener the leaf colour, the more chlorophyll it is likely to contain (Rachman, 2023). Green leaves can be an indicator of adequate nutrition, thus influencing the formation of leaf chlorophyll and indicating that a plant is growing normally or that there are no signs of death until the end of the observation. The application of vitamin B1 or as known as thiamine can affect leaf colour because, in the plant cell respiration process, thiamine in the form of thiamine pyrophosphate plays a role in the formation of chloroplasts which affects leaf colour (Widiastoety et al., 2009). The results of measuring the chlorophyll content of mother shoot leaves had no significant effect at 12 WAP.

Table 1. Survival rate (SR), average height of plant, number of leaves, length and width of leaves cardamom mother shoots at the age of 12 WAP thanks to the application of vitamin B1, Indole Butyric Acid and their combination

Treatment	Survival Rate(%)	Height of Plant (cm)	Number of Leaves (sheet)	Length of Leaves (cm)	Width of leaves (cm)
V1I0	50	7.6 ± 9.9	0.7 ± 1.2	2.6 ± 4.4	1.4 ± 2.4
V1I1	67	2.2 ± 1.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
V1I2	17	2.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
V2I0	33	22.9 ± 20.7	3.7 ± 3.2	7.0 ± 6.0	3.9 ± 2.8
V2I1	50	15.0 ± 7.0	1.7 ± 2.1	3.1 ± 2.8	1.8 ± 1.6
V2I2	17	18.0 ± 0.0	3.0 ± 0.0	6.9 ± 0.0	3.3 ± 0.0

Table 2. Average shoot colour, leaves colour and chlorophyll content of cardamom mother shoots at the age of 12 WAP due to the application of vitamin B1, Indole Butyric Acid and their combination

Treatment	Colour of Shoots	Colour of Leaves	Total Chlorophyll Content
V1I0	2.0 ± 0.0	3.0 ± 0.0	2.6 ± 4.4
V1I1	2.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
V1I2	2.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
V2I0	2.0 ± 0.0	4.0 ± 0.0	7.0 ± 6.0
V2I1	2.0 ± 0.0	3.0 ± 0.0	3.1 ± 2.8
V2I2	2.0 ± 0.0	3.0 ± 0.0	6.9 ± 0.0

2.Growth Response of Cardamom Plants from Tiller Shoots

The treatment given in cardamom propagation efforts triggers not only the growth of mother shoots but also the growth of tiller shoots. The tiller shoots that grow are then observed for shoot height, number of leaves, length, and width of leaves, the colour of shoots and leaves, and leaves chlorophyll content. The growth tiller shoots showed no significant effect on all observation parameters 12 WAP. However, the V1I0 treatment can potentially trigger better growth than the control (V2I0) for all observed parameters.

The application of IBA was unable to improve the number of shoots and decrease the growth instead, it's shown that V2I2 treatment was not able to trigger the growth of tiller shoots at 12 WAP (Table 3). It can happen because IBA has more influence on root initiation than cardamom sprouting. Applying IBA to flowering ginger (*Curcuma* sp.) has not been able to increase the number of shoots significantly because IBA initiates roots more quickly than shoots (Almafri, 2021). Another factor that can influence this is the use of an inappropriate combination of vitamin B1 and IBA concentrations with endogenous phytohormones in cardamom shoots, which inhibits the emergence of shoots. PGR, such as IBA at a certain concentration, should be able to cause cell division and the reproduction of new shoots (Wudianto, 2000). However, new shoots can be delayed if the PGR concentration is not used correctly, resulting in unfavourable interactions between endogenous and exogenous PGR (Widyawati, 2010). Using an inappropriate concentration of vitamin B1 can also be an obstacle to the growth of new shoots or tiller shoots because each plant has a different optimal supplement dose (Rika et al., 2016). Plant also has phytohormones at different levels, so the use of vitamin B1 can increase growth or even not have any influence on a plant (Syahrani et al., 2022); this is also due to different genetic factors in plants (Sari et al., 2019). The number of tiller shoots that form can affect the height of the shoots. Many shoots tend to reduce the average plant height due to competition for the use of nutrients in the planting medium (Table 3). According to Mawaddah et al. (2021), the number of shoots formed can influence the difference in shoot height of ginger plants. Generally, the average height of the shoots produced will decrease. This is because the energy required for shoot elongation initiates other new shoots (Ramesh & Ramassamy, 2014; Bella et al., 2016).

The number of leaves parameter shows different average values, although there is no significant difference. The V1I0 treatment (5.0 leaves) can produce more leaves than the V2I0 control (2.7 leaves). The application of IBA shows a decrease in the number of cardamom shoot leaves, which can occur when the exogenous auxin concentration is too high. In contrast, the endogenous auxin level is sufficient. The properties of auxin can induce ethylene, which inhibits organ growth if given in excess amounts. Generally, auxin will work optimally if given at a concentration interval of 10-8–10-3 M (Asra et al., 2020) or 1-3 ml/L to increase plant growth (Adnan et al., 2017). Differences in the number of leaves can also be caused by genetics, such as leaf primordia, and environmental factors, such as water availability and nutrients (Nurzaman et al., 2020).

The colour of the cardamom shoots showed with code 2 in all treatments (Table 4). Code 2 in tiller shoots can be influenced by the age of the shoots, which are still relatively young at 12 WAP, so the chlorophyll content in the shoots is still relatively small. This can be an indicator that the shoots have the potential to remain alive until the end of the observation because there are no signs of plant death or adequate nutrition. The healthy plants grow normally and have the potential to develop into new seeds. The colour of leaves showed the dominant color with code 3 in all treatment except V1I0 treatment showed the dominant color with code 4 (Table 4). Differences in leaf colour occur due to differences position of the leaves exposed to sunlight, the ability of nutrients and plant genetics (Esteban et al., 2015). The colour of the leaves affects the chlorophyll content of the leaves in them. This can be seen in the observation results, which show that the colour of cardamom leaves with a higher colour code on the IRRI Leaf Colour Chart and the SPAD chlorophyll meter also have a higher chlorophyll content (Table 4). The chlorophyll content of leaves affects the rate of photosynthesis (Rachman, 2023), which is directly proportional to plant growth (Hazra et al., 2019).

Table 3. Average height of shoots, number of leaves, length and width of leaves cardamom tiller shoots at the age of 12 WAP due to the application of vitamin B1, Indole Butyric Acid and their combination

Treatment	Number of Tiller Shoots	Height of Plant (cm)	Number of Leaves (sheet)	Length of Leaves (cm)	Width of leaves (cm)
V1I0	1.7 ± 1.8	10.0 ± 6.0	5.0 ± 2.6	7.6 ± 4.0	4.7 ± 2.0
V1I1	1.2 ± 2.4	10.5 ± 10.6	3.6 ± 5.7	6.2 ± 4.1	3.4 ± 2.1
V1I2	1.0 ± 0.0	7.4 ± 0.0	3.0 ± 0.0	2.9 ± 0.0	1.5 ± 0.0
V2I0	1.3 ± 1.5	6.1 ± 7.7	1.8 ± 2.3	2.3 ± 3.9	1.2 ± 2.0
V2I1	0.8 ± 1.2	9.1 ± 8.8	1.3 ± 1.8	4.9 ± 4.6	2.6 ± 2.4
V2I2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

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Table 4. Average height of shoots, number of leaves, length and width of leaves cardamom tiller shoots at the age of 12 WAP due to the application of vitamin B1, Indole Butyric Acid and their combination

Treatment	Colour of Shoots	Colour of Leaves	Total Chlorophyll Content
V1I0	2.0 ± 0.0	4.0 ± 0.0	41.5 ± 24.0
V1I1	2.0 ± 0.0	3.0 ± 0.0	28.8 ± 26.0
V1I2	2.0 ± 0.0	3.0 ± 0.0	32.3 ± 0.0
V2I0	2.0 ± 0.0	3.0 ± 0.0	29.0 ± 30.8
V2I1	2.0 ± 0.0	3.0 ± 0.0	27.0 ± 22.1
V2I2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the application of vitamin B1 21.5% and IBA 75 ppm is the best concentration to maintain the survival rate (SR) of cardamom mother shoots up to 67%, while the application of vitamin B1 43% has the potential to increase the best vegetative growth of the shoots cardamom brood at 12 WAP and second, application of 21.5% vitamin B1 has the potential to produce growth. The best vegetative activity for cardamom seedling shoots at 12 WAP.

AUTHOR CONTRIBUTION

A.M.S. conducted the research, wrote the manuscript, and collected and analyzed the data. L.D. designed the research and analyzed the data. D provides direction in writing articles.

ACKNOWLEDGMENTS

This study was supported by the National Research and Innovation Agency (BRIN) and Biology Program, Faculty of Science and Technology UIN Syarif Hidayatullah Jakarta. We would also like to thank all parties who have helped both materially and non-materially.

CONFLICT OF INTEREST

The authors declare that in writing this article, there is no conflict of interest.

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