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EXTRACT OF MORINGA LEAF AND SEAWEED AS BIOSTIMULANT FOR INCREASING SUCCESS AND GROWTH OF COCOA (Theobroma cacao L.) SHOOT GRAFTING

Muhammad Rizki Ramdani[1], Rusdi Evizal[1*], Lestari Wibowo[2], Sri Ramadiana[1]

[1]Department of Agrotechnology, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia
[2]Department of Plant Protection, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia

[*] Corresponding Author. E-mail address: rusdi.evizal@fp.unila.ac.id

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ABSTRACT

Cocoa (Theobroma cacao L.) is a plantation crop that contributes to Indonesia's economy through export value and serves as the main source of income for farmers in major production centers. Grafting technology is widely used to increase productivity; however, its success rate remains low. The use of biostimulants derived from moringa leaf extract and seaweed extract offers an alternative solution to improve the success and growth of cocoa grafts. This study aimed to determine the effect of type and concentration of biostimulants on the success and growth of cocoa grafts. The research was conducted from December 2024 to February 2025 in Labuhan Dalam, Tanjung Senang District, Bandar Lampung City. A non-factorial randomized complete block design (RCBD) was used, consisting of 7 treatments and 3 replications. The treatments included a control (0 ml/l), moringa leaf extract at 150 ml/l, 300 ml/l, and 450 ml/l, as well as seaweed extract at 150 ml/l, 300 ml/l, and 450 ml/l. Data were analyzed using ANOVA and tested with the Least Significant Difference (LSD) at a 5% significance level. The results showed that the application of biostimulants had a significant effect on the time of shoot emergence, number of shoots, shoot length, shoot diameter, and leaf greenness. However, the treatments did not significantly affect the number of leaves, number of flushes, fresh weight of shoots, or dry weight of shoots. All biostimulant applications resulted in a 100% grafting success rate. The best concentration of both moringa leaf and seaweed biostimulant extracts was 300 ml/l.

1. INTRODUCTION

Cocoa (Theobroma cacao L.) is a plantation crop that plays an important role in Indonesia's economy as a source of foreign exchange through its export value. In 2022, cocoa ranked as the third largest export commodity after oil palm and rubber (Rohmah, 2022). In several regions, cocoa serves as the main source of income for farmers (Evizal and Prasmatiwi, 2023), including in Lampung Province (Septiana et al., 2020; Sugiatno et al., 2022).

The MCC02 cocoa clone excels in terms of quality, quantity, and resistance to pests and diseases. According to Sabahannur et al. (2023), per 100 g, this clone contains 6.68% moisture, 52.99% fat, a pH of 5.43, and 7.93% titratable acidity, which meet the requirements of both the national and export cocoa industries According to Balittri (2021), the productivity of the MCC02 clone is approximately 3,132 kg/ha/year, and it is resistant to vascular streak dieback and pod rot diseases, as well as moderately resistant to cocoa pod borer. This makes it more adaptable for cultivation under various land conditions

Cocoa can be cultivated in almost all regions of Indonesia. According to BPS (2021), 1.42 million hectares (99.63%) of cocoa plantations were managed by smallholders, 4,995 hectares (0.35%) by private estates, and 264 hectares (0.02%) by state-owned enterprises. Global demand for cocoa continues to increase. According to Setiawati (2024), in March 2024, the price of dry cocoa beans rose by 140.23%, reaching IDR 159,667,200 per ton. Therefore, cocoa plays the potential role to improve farmers' wealth and also the national economy.

In Indonesia, cocoa productivity is still relatively low. According to Nurul (2016), the actual cocoa production is less than 50% of its potential, at around 500 kg/ha/year, while the potential yield can reach 1,500–2,000 kg/ha/year. High pest and disease pressure is one of the main causes of low cocoa productivity (Millaty, 2017). Another factor is that farmers do not use superior planting materials (Ibnu, 2022), due to limited access to quality seeds or seedlings.

Grafting is widely used by farmers to increase cocoa productivity. According to Limbongan and Fadjry (2013), grafting is a technique that unites two plant clones to form a new individual plant with superior traits or rehabilitate plantations to support the productivity. However, according to Arlianzy et al. (2022) and Suryan (2021), the main challenge in cocoa grafting is its low success rate.

Every type of plant produces phytohormones to stimulate growth (Asra et al., 2020). According to Bulgari et al. (2019) and Jardin (2015), moringa leaves and seaweed contain various plant growth regulators PGRs and bioactive compounds that can regulate plant physiological processes, such as stimulating growth, increasing tolerance to biotic and abiotic stress, and are inexpensive, easily available, and environmentally friendly. This indicates that moringa leaves and seaweed have potential as biostimulants to replace synthetic plant growth regulators.

2. MATERIALS AND METHODS

The study was conducted in Labuan Dalam Village, Tanjung Senang District, Bandar Lampung City (5°21'23.9"S 105°15'26.3"E), from December 2024 to February 2025. The tools used included knives, branch scissors, and a blender. The materials consisted of MCC02 propelegitim seedlings, MCC02 cocoa scions, moringa leaves (Moringa oleifera), and seaweed (Eucheuma cottonii).

The experimental design in Randomized Complete Block Design (RCBD) with seven treatments and three replications. The treatments were: control 0 ml/l The treatments were: control 0 ml/l (T0), moringa leaf extract at 150 ml/l (T1), 300 ml/l (T2), and 450 ml/l (T3), seaweed extract at 150 ml/l (T4), 300 ml/l (T5), and 450 ml/l (T6). Each experimental unit consisted of 3 plants, making a total of 63 plants used.

The research procedures included preparation, treatment application, maintenance, observation, and data analysis. Rootstocks were three months old with a stem diameter of approximately [diameter missing] mm and a height of about 50 cm, free from pests and diseases, obtained from the Ari seed nursery, Natar, South Lampung. The growing medium consisted of soil, compost, and rice husk in a 1:1:1 ratio. Scions were collected from farmers' gardens in Wiono Village, Gedong Tataan, Pesawaran, with the following criteria: superior plagiotropic shoots, upward growth angle of approximately 45º, diameter of 5–7 mm, greenish-brown color, dormant condition, and free from pests and diseases. Scions were cut about 50 cm from the branch tip.

Biostimulants were freshly prepared before application by blending 1 kg of fresh moringa leaves or seaweed with 1 liter of water, then squeezing and filtering the mixture. The extract was diluted according to the treatment concentration. Moringa leaves were obtained from farmers' gardens near the research site, and seaweed was purchased fresh from the market.

Before grafting, scions were soaked in the biostimulant solution for 30 minutes, while the control group was soaked in water. Foliar spraying was performed at 28 days after grafting (DAG), with 14-day intervals for a total of four applications. The spray volume was adjusted based on calibration results.

Grafting was carried out by cutting the rootstock stem and leaving four leaves, then splitting it 2–4 cm. Scions with three buds were cut into a 'V' shape about 2–3 cm long and inserted into the rootstock, tied, and covered. The grafted seedlings were arranged at the research site.

Maintenance included watering every 3–4 days, fertilizing with 2 g of NPK per polybag every 30 days, weeding, and mechanical and physical pest and disease control when symptoms appeared. Grafting success was observed from 5 to 30 DAG, and growth was measured every 14 days starting at 28 DAG.

Observed variables included grafting success percentage, time of shoot emergence, number of shoots, shoot length, shoot diameter, number of leaves, leaf greenness, number of flushes, fresh weight, and dry weight of shoots. Data were analyzed using ANOVA and further tested with the Least Significant Difference (LSD) at a 5% significance level.

3. RESULTS AND DISCUSSION

The results showed that soaking the scions before grafting, followed by foliar spraying with biostimulants derived from moringa leaf and seaweed extracts, had a significant effect on shoot emergence time, number of shoots, shoot length, shoot diameter, and leaf greenness (Table 1). However, these treatments did not have a significant effect on the number of leaves, number of flushes, fresh shoot weight, and dry shoot weight. All biostimulant treatments resulted in a 100% grafting success rate. The growth appearance of cocoa seedlings following the application of seaweed extract biostimulant is presented in Figure 1.

Table 1. Effect of Scion Soaking and Upper Stem Spraying Using Biostimulants on the Success Rate and Growth of Cocoa Shoot Grafting

Research Variable	Significance
Grafting Success (%)	ns
Shoot Emergence Time (DAG)	*
Number of Shoots	*
Shoot Length (cm)	* (28 DAG)
Shoot Diameter (mm)	*
Number of Leaves (leaves)	ns
Leaf Greenness (SPAD)	*
Number of Flushes	ns
Fresh Shoot Weight (g)	ns
Dry Shoot Weight (g)	ns

Note: (*) indicates significant difference at the 5% level; (ns) indicates no significant difference at the 5% level. DAG is days after grafting.

Figure 1. Growth appearance of cocoa seedlings following application of seaweed extract biostimulant.

3.1 Grafting Success Percentage

The grafting success percentage ranged from 89% to 100% (Figure 2). The high success rate observed in this study was attributed to the optimal grafting techniques employed, such as the precise quality and cutting of the scions, as well as strong and tight binding. These factors increased the contact area between the cambium of the rootstock and the scion. This finding is consistent with Ariani et al. (2018), who stated that grafting success largely depends on the ability of cambial cells to proliferate and form callus tissue that unites the scion and rootstock. Therefore, optimizing grafting techniques can improve the success rate of cocoa shoot grafting.

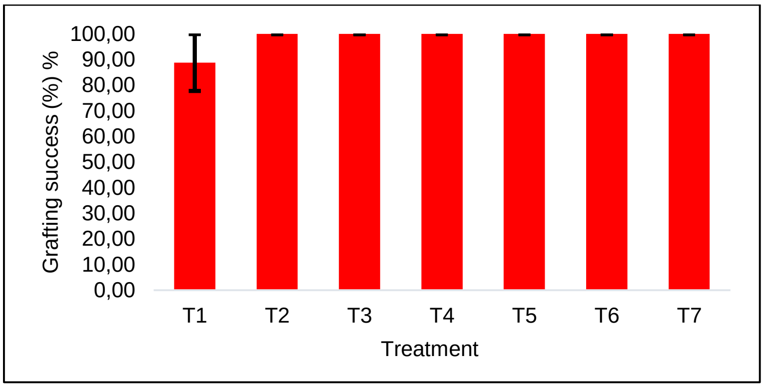

Figure 2. Effect of biostimulant application on grafting success rate up to 70 day after grafting (DAG).

Moringa leaves contain auxin-IAA at 662,17 ppm, 161,37 ppm cytokinins kinetin and 55,5 ppm zeatin, as well as gibberellin-GA3 at 417.88 ppm. Meanwhile, seaweed extract from *Eucheuma cottonii* contains at 160 ppm IAA, 128 ppm GA3 and 110 ppm GA7, 117 ppm zeatin, and 117 ppm kinetin (Tini et al., 2022; Sedayu et al., 2013). These PGRs contribute to enhancing cell proliferation and minimizing oxidative stress after grafting, which accelerates callus formation and wound healing at the graft union. This is reflected in the 100% grafting success rate observed in the biostimulant treatments, although the difference was not statistically significant.

The union process between the scion and rootstock in cocoa shoot grafting begins with the plant's response to the wound, which triggers callus formation at the graft site. Callus develops from the activity of parenchyma cells undergoing dedifferentiation. This stage is influenced by hormonal balance. Auxin plays a role in callus formation by stimulating cell division and the development of xylem and phloem tissues (Nanda and Melnyk, 2018), while cytokinins stimulate cell differentiation and the formation of new vascular tissues (Schaller et al., 2015). After callus formation, tissue reorganization occurs to form cambium from both parts of the plant. The cambial tissue then develops into new xylem and phloem tissues that function as channels for water and nutrient transport. Besides hormonal factors, the size and shape of the scion cut, the sharpness and cleanliness of tools, and post-grafting care significantly affect the success rate of shoot grafting. A graft is considered successful when the tissues unite perfectly, indicated by the scion remaining fresh and showing growth indicators such as shoot emergence.

3.2 Shoot Emergence Time

The treatment with 300 ml/l moringa leaf extract resulted in the fastest shoot emergence time (Table 2). This indicates an increase in hormonal activity and metabolism within the tissue due to the plant's response to PGRs contained in the biostimulant. According to Anjarsari (2023), cytokinins and gibberellins can induce the growth of dormant shoots. These compounds effectively minimize stress caused by cutting wounds and stimulate tissue regeneration by activating meristematic activity, leading to faster shoot growth on the scion. This is consistent with the findings of Amriyanti and Ajiningrum (2019), who reported that zeatin, dihydrozeatin, and isopentenyladenine in moringa leaf extract play roles in regulating the cell cycle and stimulating shoot formation. Additionally, the use of 200 ppm cytokinin and 3.0 ml/l Atonik has been proven to accelerate shoot emergence time in cocoa grafting (Jalaluddin et al., 2023; Roswanjaya et al., 2020).

Tabel 2. Effect of Moringa Leaf and Seaweed Extract Biostimulants on Shoot Emergence Time

Biostimulant Treatment	Shoot Emergence Time 0–30 DAG	
	Original Data	Logarithmic Transformation
Control 0 ml/l	16.00	1.19 b
Moringa leaf extract 150 ml/l	14.67	1.16 ab
Moringa leaf extract 300 ml/l	7.67	0.88 a
Moringa leaf extract 450 ml/l	10.67	1.02 ab
Seaweed extract 150 ml/l	10.67	1.02 ab
Seaweed extract 300 ml/l	10.00	0.99 ab
Seaweed extract 450 ml/l	12.33	1.09 ab
LSD 0.05	8.13 *	0.27 *

Note: Means followed by the same letter are not significantly different based on LSD test at 5% significance level. DAG is days after grafting.

3.3 Number of Shoot

The treatment with seaweed extract biostimulant at 150 ml/l had a significant effect on the number of shoots. According to Aziz et al. (2024), *Eucheuma cottonii* seaweed contains cytokinins zeatin at 11.52 mg/kg, kinetin at 7.04 mg/kg, and auxin at 32.24 mg/kg. This concentration of seaweed extract optimally stimulates shoot initiation, resulting in the highest number of shoots across all observation periods (Table 3). Other treatments were suspected to be less effective in stimulating growth significantly due to suboptimal concentrations. According to Kularathne et al. (2021), at low concentrations, PGRs effectively regulate physiological processes such as protein synthesis and cell division. Besides concentration, this condition is also influenced by the scions consisting of three buds that had already begun growth in the early phase.

Tabel 3. Effect of Moringa Leaf and Seaweed Extract Biostimulants on Number of Shoots

Biostimulant Treatment	Number of Shoots at 28–70 DAG			
	28 DAG	42 DAG	56 DAG	70 DAG
Control 0 ml/l	1.67 b	1.67 b	1.67 b	1.67 b
Moringa leaf extract 150 ml/l	2.33 ab	2.33 ab	2.33 ab	2.67 ab
Moringa leaf extract 300 ml/l	2.33 ab	2.33 ab	2.33 ab	2.33 ab
Moringa leaf extract 450 ml/l	3.33 ab	3.33 ab	3.33 ab	3.33 ab
Seaweed extract 150 ml/l	3.67 a	3.67 a	3.67 a	3.67 a
Seaweed extract 300 ml/l	2.67 ab	2.67 ab	2.67 ab	2.67 ab
Seaweed extract 450 ml/l	2.33 ab	2.33 ab	2.33 ab	2.67 ab
LSD 0.05	1.63 *	1.63 *	1.63 *	1.65 *

Note: Means followed by the same letter are not significantly different based on LSD test at 5% significance level. DAG is days after grafting.

The number of shoots did not increase from 28 to 56 days the plant growth regulators grafting (DAG), with only a few treatments showing an increase at 70 DAG. This is because plants are more responsive to biostimulants during the early growth phase to stimulate meristematic cell activity in forming primary shoots. The PGR content in the seaweed extract affects the plant's physiological processes and is the main factor driving the increase in shoot number. This aligns with Fitriani and Ruslan (2021), who reported that auxin in shallot extract enhances shoot growth in cocoa grafting by stimulating meristematic cell activity in stems and shoots.

3.4 Shoot Length

Biostimulants derived from moringa leaf and seaweed extracts had a significant effect on increasing shoot length at 28 DAG (Table 4). The longest shoots were obtained from the treatment with 450 ml/l moringa leaf extract across all observation periods. The increase in shoot length is suspected to be caused by the PGRs in the biostimulants, which effectively stimulate cell division and tissue differentiation, thereby enhancing shoot elongation. The influence of biostimulants is more dominant during the early growth phase, as meristematic cell activity is very high during this period, making the plant's response to exogenous stimuli such as biostimulants more pronounced. This is consistent with Kouassi et al. (2017), who reported that a combination of auxins 2,4-D and 2,4,5-T can stimulate cell division and callus induction, while kinetin promotes cell differentiation and shoot development during somatic embryogenesis in cocoa plants.

Table 4. Effect of Moringa Leaf and Seaweed Extract Biostimulants on Shoot Length

Biostimulant Treatment	Shoot Length (cm)			
	28 DAG	42 DAG	56 DAG	70 DAG
Control 0 ml/l	3.27 b	4.50 a	4.93 a	5.20 a
Moringa leaf extract 150 ml/l	5.53 ab	6.30 a	6.53 a	6.93 a
Moringa leaf extract 300 ml/l	4.63 ab	4.90 a	5.10 a	6.77 a
Moringa leaf extract 450 ml/l	6.90 a	7.37 a	7.60 a	8.27 a
Seaweed extract 150 ml/l	4.73 ab	5.33 a	5.50 a	5.87 a
Seaweed extract 300 ml/l	6.83 a	6.80 a	5.93 a	7.10 a
Seaweed extract 450 ml/l	4.72 ab	5.83 a	5.83 a	7.37 a
LSD 0.05	3.42 *	ns	ns	ns

Note: Means followed by the same letter are not significantly different based on LSD test at 5% significance level. DAG is days after grafting.

No significant effect on shoot length was observed during the later growth phases, possibly because the plants entered a more stable physiological state, where external factors such as nutrient availability and environmental conditions play a greater role in determining growth rate. This aligns with Bomdzele and Molua (2023), who reported that unstable temperature and rainfall negatively affect cocoa productivity, while factors such as land use and pesticide application contribute to maintaining plant growth stability.

3.5 Shoot Diameter

Application of biostimulants derived from moringa leaf and seaweed extracts was proven to increase the diameter of cocoa graft shoots (Table 5). These biostimulants contain various plant growth regulators; Basmal et al. (2015) reported that *Sargassum peripendula* seaweed contains auxin at 127.48 ppm, gibberellin at 131.11 ppm, and cytokinins kinetin and zeatin at 68.77 ppm and 82.41 ppm, respectively. The plant growth regulators in moringa leaf and seaweed extracts enhance physiological activity in shoots by stimulating cell division and new tissue growth. This process results in an increase in shoot diameter due to the greater number and size of cells forming the shoot tissues. This is consistent with Calvo et al. (2014), who stated that auxin, cytokinin, and gibberellin hormones regulate various physiological processes and have been shown to promote growth in various plants.

Table 5. Effect of Moringa Leaf and Seaweed Extract Biostimulants on Shoot Diameter

Biostimulant Treatment	Shoot Diameter (mm) at 70 DAG
Control 0 ml/l	2.17 b
Moringa leaf extract 150 ml/l	2.83 ab
Moringa leaf extract 300 ml/l	3.03 ab
Moringa leaf extract 450 ml/l	3.67 a
Seaweed extract 150 ml/l	3.20 ab
Seaweed extract 300 ml/l	3.47 a
Seaweed extract 450 ml/l	3.67 a
LSD 0.05	1.14 *

Note: Means followed by the same letter are not significantly different based on LSD test at 5% significance level. DAG is days after grafting.

3.6 Number of Leaf

The treatment with 450 ml/l moringa leaf extract produced the highest number of leaves across all observation periods. However, statistically, it was not significantly different from the other treatments. This is suspected to be related to the biostimulant extraction method used in this study, which employed only water as the solvent. Water as a solvent may not optimally dissolve the PGRs and bioactive compounds in moringa leaves and seaweed, thus limiting the effectiveness of the biostimulants in influencing physiological processes, particularly leaf growth. This aligns with Sofiana et al. (2024), who reported that factors affecting the quantity and types of phytohormones isolated include extraction method, solvent type, pH, temperature, and extraction duration.

Data analysis using the standard error of the mean (SEM) at 42 and 70 DAG showed that the SEM error bars of the control did not overlap with those of all treatments (Figure 4), indicating a significant treatment effect. This is likely due to the high content of PGRs in the biostimulants. Mashamaite et al. (2022) reported that moringa leaves contain zeatin ranging from 5 to 200 $\mu g \cdot g^{-1}$, which plays a role in stimulating leaf growth. Hartatie and Safira (2022) also reported that application of moringa leaf extract significantly increased the number of leaves in sugarcane variety VMC 86-550. This suggests that moringa leaf extract biostimulants have the potential to positively influence leaf growth, although their effectiveness depends on concentration and extraction technique.

3.7 Leaf Greenness

Biostimulants derived from moringa leaf and seaweed extracts have been proven to increase leaf greenness due to the presence of PGRs such as auxin, cytokinin, and gibberellin, as well as bioactive compounds that influence the physiological processes of grafted plants, including photosynthesis, which leads to increased leaf greenness. This is consistent with the findings of Bhattacharyya et al. (2015) and Hönig et al. (2018), who reported that cytokinins play a role in enhancing chlorophyll content by stimulating chloroplast biogenesis, inhibiting chlorophyll degradation, and delaying leaf senescence by maintaining photosystem structure and function as well as increasing antioxidant enzyme activity. The treatment with 300 ml/l moringa leaf extract produced the highest level of leaf greenness (Table 6), indicating that this treatment is highly effective in enhancing leaf greenness. Additionally, Amriyanti and Ajiningrum (2019) reported that the application of 30% moringa leaf extract optimally increased growth and chlorophyll content in soybean plants..

Table 6. Effect of Moringa Leaf and Seaweed Extract Biostimulants on Leaf Greenness

Biostimulant Treatment	Leaf Greenness at 70 DAG (SPAD units)
Control 0 ml/l	29.33 b
Moringa leaf extract 150 ml/l	40.46 a
Moringa leaf extract 300 ml/l	42.53 a
Moringa leaf extract 450 ml/l	41.93 a
Seaweed extract 150 ml/l	37.90 ab
Seaweed extract 300 ml/l	40.24 a
Seaweed extract 450 ml/l	40.87 a
LSD 0.05	8.38 *

Note: Means followed by the same letter are not significantly different based on LSD test at 5% significance level. DAG is days after grafting.

3.8 Fresh Shoot Weight

Biostimulants derived from moringa leaf and seaweed extracts did not significantly affect the fresh weight of grafted shoots (Figure 3). This is likely because the plant's endogenous hormones are sufficient to regulate its physiological processes, and the concentrations used in this study were not optimal to significantly influence physiological processes related to increasing fresh shoot weight. According to Nardi et al. (2016), the effectiveness of biostimulants in enhancing plant growth highly depends on the application concentration; inappropriate concentrations may result in suboptimal effects or even inhibit growth.

Another possible reason is the plant's differential physiological response to biostimulant stimuli. While biostimulant application showed significant effects on other parameters, it did not affect fresh shoot weight. This indicates that different parts of the plant may respond variably to exogenous stimuli. Although not statistically significant, higher concentrations of seaweed extract biostimulant tended to increase fresh shoot weight, with the highest fresh shoot weight observed in the 450 ml/l seaweed extract treatment.

3.9 Dry Shoot Weight

The application of biostimulants derived from moringa leaf and seaweed extracts did not show a significant effect on the dry weight of shoots, as the concentrations used were not yet optimal. As a result, environmental and genetic factors played a more dominant role in influencing growth direction, including the increase in dry shoot weight. This finding is consistent with Zaroh and Asmono (2023), who reported that biostimulants, when applied at the appropriate concentration, can significantly improve seedling growth due to the optimal action of hormones in regulating growth direction.

Dry shoot weight tended to increase with the application of higher concentrations of seaweed extract (Figure 3). This suggests an increase in biomass accumulation in the shoots, likely due to the influence of plant growth regulators and bioactive compounds contained in the extracts. According to Al-Juthery et al. (2020), seaweed extracts from *Kappaphycus alvarezii*, *Gracilaria edulis*, *Ascophyllum nodosum*, and *Sargassum* spp. are rich in micro- and macronutrients, polysaccharides, proteins, polyunsaturated fatty acids, polyphenols, phytohormones, and osmolytes, all of which have been proven to enhance the growth of various plants. These compounds have strong potential to increase shoot biomass when applied at the right concentration.

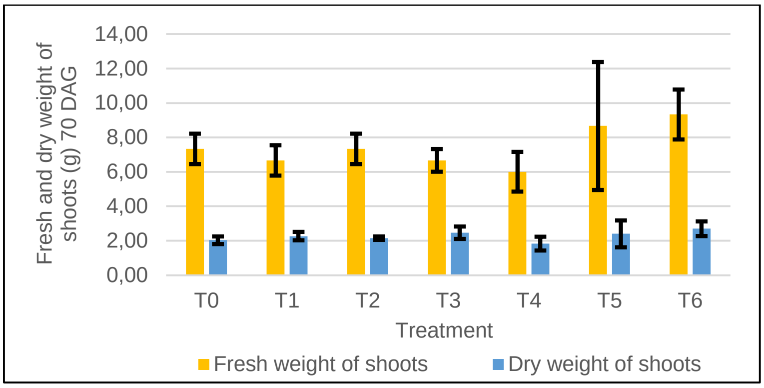

Figure 3. Effect of biostimulant application on fresh and dry shoot weight.

3.10 Number of Leaf Flush

Plants treated with biostimulants experienced two flush cycles, whereas untreated plants only had one flush cycle (Figure 4). However, statistically, this difference was not significant. The biostimulants derived from moringa leaf and seaweed extracts were not able to significantly stimulate flush growth in cocoa plants because genetic and environmental factors played a more dominant role in determining the flush cycle. This is consistent with Sari and Susilo (2013), who reported that plant genotype significantly influences the flushing pattern in 21 cocoa clones from the Puslitkoka collection. Additionally, Prawoto (2014) stated that the intensity of flushing in cocoa plants is strongly affected by environmental factors, particularly temperature fluctuations and cultural technical treatments.

Plants with different numbers of shoots exhibited the same flush pattern: two flushes with biostimulant treatment and one flush without treatment. This indicates that the flushing pattern in cocoa shoot grafting still occurs naturally. Setiyono (2014) reported that after the shoot growth phase, cocoa leaf buds return to dormancy for a certain period and will sprout again in response to environmental stimuli. Therefore, the number of shoots does not affect the flush cycle. This aligns with Amelia and Hariyono (2018), who found that the application of the plant growth regulator Atonik did not affect flush emergence timing, but shading intensity influenced the transition of flushes to mature leaves.

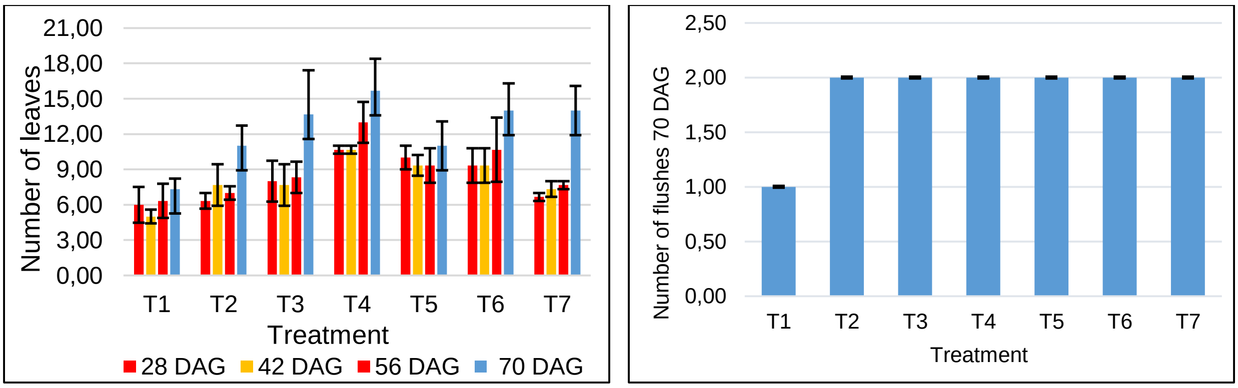

Figure 4. Effect of biostimulants on number of leaves and number of flushes.

4. CONCLUSION

Soaking the scions followed by foliar spraying with biostimulants derived from moringa leaf and seaweed extracts significantly enhanced the growth of cocoa shoot grafts. This was evidenced by faster shoot emergence, and increased number, length, and diameter of shoots. However, the biostimulants did not have a significant effect on the number of leaves, number of flushes, fresh weight, or dry weight of the shoots. All biostimulant treatments achieved a 100% grafting success rate. The optimal concentration for both moringa leaf and seaweed biostimulants was 300 ml/l. Moringa leaf extract accelerated shoot emergence time (7.67 days after grafting) and increased leaf greenness (42.52 SPAD units), while seaweed extract improved shoot length (6.83 cm), shoot diameter (3.44 mm), and leaf greenness (40.24 SPAD units).

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