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# The Effect of Seaweed Extract Biostimulant on Growth and Yield of Eggplant (*Solanum melongena* L.)

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**ABSTRACT**

Eggplant possesses high economic value with various nutritional contents such as minerals and vitamins that are benefical for human health. However, productivity decline due to environmental stress poses a challenge in global market demand fulfillment. The application of biostimulants represents one solution to enhance the growth and yield of eggplant (*Solanum melongena* L.). This research aimed to examine the effect and optimal concentration of biostimulant application on eggplant plants. The study was conducted in cultivation fields located in Nanggela Village, Kuningan Regency, West Java, from July to October 2025. This experiment used Randomized Block Design (RBD) with nine biostimulant concentration treatments and three replications, resulting in 27 experimental plots, each measuring 3,5 x 1,5 meters, consisting 14 plants and a 50 cm spacing between plots, 50 cm spacing between plants, and 60 cm spacing between rows. The vegetative phase observation parameters included root length, root volume, plant height, stem diameter, number of leaves, leaf area, leaf area index, plant dry weight, and relative growth rate, while the generative phase parameters included number of fruits, fruit diameter, fruit length, fruit weight, and yield weight per plant. The data obtained were analyzed using one-way analysis of variance (ANOVA), followed by the Scott-Knott cluster analyses to determind significant differences among treatments. The results showed that biostimulants had a significant effect on growth and development aspects. Specifically, biostimulant application significantly affected both vegetative and generative parameters. The best vegetative characteristics were obtained in K1 (1,0 ml/l), K2 (1,5 ml/l), and K3 (2,0 ml/l) treatments, while the optimal generative characteristics were produced in K1 (1,0 ml/l), K2 (1,5 ml/l), K4 (2,5 ml/l), and K7 (4,0 ml/l) treatments.

**Keywords**: Biostimulant, *Ecklonia Maxima*, Eggplant, Growth, Yield

## 1. INTRODUCTION

Indonesia has strategic potential in developing high-value horticultural commodities, supported by optimal agroclimatic conditions. One of the widely cultivated horticultural commodities with high economic value is eggplants (*Solanum melongena* L). This plant belongs to the *solanaceae* family and the *solanum* genus (Taher et al., 2017; Sharma dan Kaushik, 2021), which can be cultivated in various regions with tropical and subtropical climates (Amiri Rodan et al., 2020), and can be found throughout the world, particularly in Asian countries, the Middle East, and around the Mediterranean basin (Yarmohammadi et al., 2021).

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In general, eggplant production in Indonesia remains relatively low and has not been able to fulfill market demands. Data from Indonesia Central Bureau of Statistics show an increase from 676.339 ton in (2021), to 691.738 ton in (2022), and 699.896 ton in (2023), representing an increase of approximately 3,48% with harvested areas of 44.5 ha, 43.7 ha and 47.0 ha. However, eggplant productivity often experiences significant decline due to various limiting factors closely related to its growth requirements, particularly environmental stress including various abiotic factors such as drought and high temperature (David-Rogeat et al., 2024).

Regarding its growth requirements, eggplant is classified as a thermophilic plant species that requires optimal temperatures to support its growth phases with a temperature range between 22°C - 30°C, however this phase becomes inhibited when temperatures exceed 35°C (Liu et al., 2023). Futhermore, higher temperature caused a reduction in soil moisture content, which can directly affect plant growth by impacting the roots ability to obtain water (Nida et al., 2024), thereby causing physiological disorders (Niu dan Xiang, 2018), that have negative effect on plant growth and yield.

Therefore, efforts to overcome abiotic stress and optimalize the growth and productivity of eggplant, can be undertaken through the use of biostimulants (Parmar et al., 2023; Prisa dan Spagnuolo, 2023), which are derived from various biological materials that can be applied through roots, leaves or even a combination of both, thereby stimulating natural processes to enhance nutrient efficiency, growth and stress tolerance (Yakhin et al., 2017). These biological materials can be found in various extracts, such as seaweed extracts (*Ascophyllum nodosum*, *Ecklonia maxima*, *Macrocystis pyrifera* and *Durvillea potatorum*), which have been proven to increase plant vigor by supplying hormonal stimuli such as cytokinins and auxins (Battacharyya et al., 2015; Mazurenko et al., 2025), as well as providing tolerance to abiotic stress abiotik (Colla et al., 2017; La Bella et al., 2021).

Based on the explanation, the use of seaweed-based fertilizer products aims to enhance germination, deeper root penetration, nutrient absorption, and crop yields in cultivated plants (Ammar et al., 2022). As a results, scientiest have found that seaweed and its derivates are an effective natural biostimulants for increasing agricultural productivity in a sustainable way. This potential lies in various compositions of bioactive compounds, such as phytohormones (auxins, cytokinins, and gibberellins) as well as other growth promoters (Yao et al., 2020). Therefore, biostimulants derived from *Ecklonia maxima* extract have been shown to improve quality in crops such as lettuce (La Bella et al., 2021), and spinach (Rouphael et al., 2018), as well as enhance


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stress tolerance in maize plants (EL Boukhari et al., 2020). These findings strengthen the position of seaweed as an ecology-based solution in addresing global food security challlenges. The aims of this study is to examine the effect of *Ecklonia maxima* seaweed extract from the commercial product branded Basfoliar Aktiv® on the growth, yield, and quality of eggplant.

In relation to this matter, a study conducted by Hussein et al. (2019) examined the effects of a bistimulant derived from *Ecklonia maxima* seaweed extract, marketed under the brand name Basfoliar Aktiv® on pepper sweet plants (*Capsicum annum*) using treatments consisting of 1 mL, 2 mL, and 3 mL consentrations. The results showed that the application of Basfoliar Aktiv® at a concentrations 2 mL significantly increased vegetative growth parameters compared to the control treatment, with plant height reaching 97 cm compared to the control treatment at approximately 79.7 cm, and leaf number reaching 131.7 leaves/plant compared to the control treatment at approximately 93.3 leaves/plant. A study conducted by Albbas and Khudair (2023) resulted that the application of Basfoliar Aktiv® at higher concentrations of 4 mL and 8 mL exerted significant effects on the growth and development of mallow plants (*Malva* sp.). The results indicated that the application of Basfoliar Aktiv® at a concentration of 8 mL yielded the best results for vegetative growth and flowering of mallow plants. This study aims to investigate the effect of Basfoliar Aktiv® application at concentrations ranging from 1 mL to 4.5 mL on eggplant (*Solanum melongena* L.) in order to determine the optimal concentration for plant growth and development so that it can be used as a reference for eggplant farmers in Kuningan Regency, West Java, as well as other regions with similar environmental conditions.

## 2. RESEARCH METHODS

This research was conducted in Nanggela Village, Kuningan Nanggela Village, Kuningan Regency, West Java, from July to October 2025. With high altitude elevation of 200 – 300 masl, a tropical climate with temperature range of 24-33°C (average 28°C), and an annual rainfall of 2,500 - 3,000 mm, classfied as a wet month category. Soil analysis results indicated that the soil in this area had a moisture content of 3%, C-organic of 1.33% (low), cation exchange capacity (CEC) cmol(+)/kg (moderate), C/N ratio of 8,9:1 (low), total N of 0,15% (low), $P_2O_5$ of 145 mg/100g (very high), $K_2O$ of 14 mg/100g (low), Mg of 1.37 cmol(+)/kg, Zn of 0.97 mg/kg, and Cu of 0.92 mg/kg (Agro Chemistry Laboratory, 2025). The tools used in this research included a hand sprayer, measuring cup, measuring tube, roll meter, scale, caliper, mobile phone, and stationery. The materials used were Mustang F1 variety eggplant seeds, NPK Mutiara fertilizer, Basfoliar Aktiv®


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biostimulant, and distilled water. The research method using a Randomized Block Design (RBD) consisting nine treatments, each replicated three times, resulting 27 experimental plot units: K0 (control), K1 (1.0 ml/l), K2 (1.5 ml/l), K3 (2.0 ml/l), K4 (2.5 ml/l), K5 (3.0 ml/l), K6 (3.5 ml/l), K7 (4.0 ml/l), and K8 (4.5 ml/l). The treatments were applied five times on 14, 28, 42, 56, and 70 days after planting (DAP).

The experiment commenced with land preparation and the plot mapping measuring 3.5 meters by 1.5 meters, with 50 cm spacing between plot. Each plot consisted of 14 plants with 50 cm spacing between plants, and 60 cm spacing between rows, in accordance with the methods applied by local eggplant farmers. The observations included a range of vegetative phase parameters, such as root length, root volume, plant height, stem diameter, number of leaves, leaf area, leaf area index, plant dry weight, and relative growth rate. As well as generative phase parameters, such as number of fruits, fruit diameter, fruit length, fruit weight and yield weight per plant. Data from the experiment were analyzed using analysis of variance (ANOVA). If the analysis indicates a significant difference, post-hoc testing was conducted using the Scott-Knott clustering analyses at a 5% significance level (Roem, 2017).

## 3. RESULTS AND DISCUSSION

Based on the results of the study, the application of *Ecklonia maxima* seaweed extract biostimulant on eggplant plants has been proven to have a significant effect on every growth and yield parameter, and has been proven to enhance plants tolerance to limiting factors, such as low water absorption capacity of the soil, lack of rain from July to October, unstable groundwater availability, and extreme temperature fluctuations in August and September. The application of the seaweed extract biostimulant *Ecklonia maxima* had a significant effect on various vegetative growth parameters of eggplant plants, including root length, root volume, plant height, stem diameter, number of leaves, leaf area, leaf area index, plant dry weight, and relative growth rate, as well as having a significant effect on various generative growth parameters of eggplant plants, including number of fruits, fruit diameter, fruit length, fruit weight, and yield weight per plant.

The enhancement in vegetative growth is closely related to the content of liquid seaweed extract from *Ecklonia maxima* seaweed, which contains phytohormones such as cytokinin (Gyogluu Wardjomto et al., 2023), which plays an important role in controlling aspects of plant development such as shoot and root meristem development, vascular bundle formation, secondary growth, and florogenesis.  (Svolacchia dan Sabatini, 2023).

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Biostimulants work in a similar way to hormones. Extracts of *Ecklonia maxima* contain cytokinins, which stimulate cell division and root elongation. This is also in line with Moncada et al. (2022) research on lettuce and tomato plants treated with Kelpak®, a biostimulant product that is also based on or contains extracts of the seaweed *Ecklonia maxima*. The biostimulant affects vegetative growth enhancement through cell division stimulation, leaf expansion, and increased total plant biomass accumulation. The study showed that the application of 100 µg $L^{-1}$ *Ecklonia maxima* extract increased tomato plant height by 22% and leaf area by 44%. In addition, biostimulants can enhance photosynthesis efficiency and nitrogen metabolism. Biostimulants accelerate chlorophyll biosynthesis and nitrogenase enzyme activity, supporting plants to assimilate nutrients more efficiently.

Biostimulants based on seaweed extracts have been proven to enhance plant growth and yield. Plant species and growth phase can influence the action of biostimulants. Plant species and growth phase influence the effectiveness of biostimulants. Leafy plants (such as lettuce) respond more quickly than fruit plants (such as tomatoes or eggplants) due to physiological differences (Moncada et al., 2022). Environmental conditions can also affect the work of biostimulants, especially light, temperature, and water availability. Biostimulants work more effectively in suboptimal conditions by increasing stress level tolerance (Kocira et al., 2019). At excessively high concentrations, biostimulants can be toxic or cause physiological saturation in plants. This condition occurs due to an imbalance in natural hormones, particularly auxin and cytokinin, which in excessive doses will suppress cell division, inhibit nutrient absorption, and trigger oxidative stress.

**Vegetative Phase (Growth)**

**Root Length (cm)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average root length at 42 and 84 days after planting.


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Table 1. Average Root Length at 42 and 84 DAP

| Treatment | Root length (cm) | | | |
|---|---|---|---|---|
| | 42 DAP | | 84 DAP | |
| K0 (0,0 ml/l) | **15.03** | **d** | 22.00 | b |
| K1 (1,0 ml/l) | 13.67 | b | 19.40 | a |
| K2 (1,5 ml/l) | **14.10** | **d** | **25.83** | **d** |
| K3 (2,0 ml/l) | **14.63** | **d** | 21.80 | b |
| K4 (2,5 ml/l) | 13.57 | b | 21.47 | a |
| K5 (3,0 ml/l) | 14.27 | c | 23.20 | c |
| K6 (3,5 ml/l) | 13.87 | b | 21.33 | a |
| K7 (4,0 ml/l) | 13.17 | b | 23.23 | b |
| K8 (4,5 ml/l) | 12.50 | a | 22.47 | b |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 1, at 42 DAP, K0 (0.0 ml/l), K2 (1.5 ml/l), and K3 (2.0 ml/l) treatments showed the highest results of 15.03 cm, 14.10 cm, and 14.63 cm. At 84 DAP, K2 (1.5 ml/l) treatment showed the highest results of 25.83 cm, an increase of 17.4% compared to the control (K0). Long plant roots indicate that the plant is able to absorb water and nutrients well and is able to withstand drought stress. Control treatment plants (without biostimulants) may experience mild physiological stress, such as growth hormone limitations or low nutrient absorption efficiency. Under these conditions, plants often show an adaptive response in the form of root elongation to expand the area for water and nutrient absorption. In addition, microclimate conditions such as soil pH, moisture, and local nutrient distribution can also affect the early growth of control plants. At suboptimal concentrations, biostimulants can stimulate excessive canopy formation, thereby inhibiting root growth and resulting in lower root length values compared to the control (Battacharyya et al., 2015). Better root system development may contribute to the efficiency of cytokinin synthesis in plants and affect the yield obtained (Benítez García et al., 2020; Rouphael dan Colla, 2020).

**Root Volume (ml)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average root volume at 42 and 84 days after planting.


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Table 2. Average Root Volume at 42 and 84 DAP

| Treatment | Root Volume (ml) | | | |
|---|---|---|---|---|
| | 42 DAP | | 84 DAP | |
| K0 (0,0 ml/l) | 1.23 | a | 5.50 | b |
| K1 (1,0 ml/l) | 2.07 | b | 5.03 | a |
| K2 (1,5 ml/l) | **2.97** | **c** | **8.70** | **d** |
| K3 (2,0 ml/l) | 1.70 | a | 7.33 | c |
| K4 (2,5 ml/l) | 2.03 | b | 6.60 | b |
| K5 (3,0 ml/l) | 1.80 | a | 4.97 | a |
| K6 (3,5 ml/l) | 2.23 | b | 5.93 | b |
| K7 (4,0 ml/l) | 1.53 | a | 5.97 | b |
| K8 (4,5 ml/l) | 1.60 | a | 6.50 | b |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 2, at 42 DAP, K2 (1.5 ml/l) treatment showed the highest result of 2.97 ml, an increase of 141% compared to the control (K0). At 84 DAP, K2 (1.5 ml/l) treatment showed the highest yield of 8.70 ml, an increase of 58.2% compared to the control (K0). Large root volume indicates that the plant is able to absorb water and nutrients effectively and is resistant to stresses that inhibit root growth, such as drought stress. The increase is caused by the root water absorbtion mechanism, which is influenced by the root surface area through the transformation of the epidermal tissue that has stopped elongating and differentiated to form root hairs (Saleh, 2019). The increase in root volume is key to water and nutrient absorption, which is directly related to the nutritional status of plants. Therefore, the better nutritional status of plants treated with biostimulants compared to plants not treated with biostimulants is largely related to the modulation of the root system, including the increase of root biomass, root length and diameter, and lateral root branching. (Colla et al., 2017; Di Mola et al., 2019; Rouphael et al., 2017). Recent research has shown that biostimulant applications containing *Ecklonia maxima* can increase the length and biomass of the roots of various horticultural crops, including eggplants, due to increased natural hormonal activity (Constantin et al., 2023).

**Plant Height (cm)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average height at 42 and 84 days after planting.


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Table 3. Average Plant Height at 42 and 84 DAP

| Treatment | Plant Height (cm) | | | |
|---|---|---|---|---|
| | 42 DAP | | 84 DAP | |
| K0 (0,0 ml/l) | **12.50** | **d** | 28.90 | b |
| K1 (1,0 ml/l) | 9.90 | b | 32.97 | c |
| K2 (1,5 ml/l) | **12.90** | **d** | **42.13** | **d** |
| K3 (2,0 ml/l) | 9.33 | a | 27.87 | b |
| K4 (2,5 ml/l) | 11.17 | c | 32.70 | b |
| K5 (3,0 ml/l) | 10.50 | b | 29.07 | b |
| K6 (3,5 ml/l) | 10.87 | c | 24.43 | a |
| K7 (4,0 ml/l) | 8.93 | a | 26.10 | a |
| K8 (4,5 ml/l) | 11.20 | c | 26.20 | a |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 3, at 42 DAP, K0 (0.0 ml) and K2 (1.5 ml/l) treatments showed the highest results of 12.50 cm and 12.90 cm, K2 treatment showed an increase of 3.2% compared to the control (K0). At 84 DAP, K2 (1.5 ml/l) treatment showed the highest result of 42.13 cm, an increase of 45.78% compared to the control (K0). A higher K0 value compared to several treatments does not mean that the biostimulant is ineffective, but indicates that the plant's response to the biostimulant is non-linear, following a physiological "dose-response" curve. At a certain point (usually at a medium dose), the highest stimulating effect occurs, whereas at very low or high doses, the effect may decrease or even become negative. A high plants height indicate that it respond well to environmental factors such as light, temperature, water, and nutrients. The cytokinin hormone contained in *Ecklonia maxima* extract plays a role in increasing cell division and elongation activity in stem meristem tissue. The combination of these natural hormones can stimulate plant stem growth and increase photosynthetic efficiency by increasing leaf surface area (Mystkowska, 2022). Therefore, optimal plant height growth reflects a balance between root and canopy growth, so that biostimulants from *Ecklonia maxima* can increase the availability of nutrients and water absorbed by the roots, which are then mobilised to the vegetative tissues to accelerate stem growth (Miceli et al., 2021).

**Stem Diameter (mm)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average stem diameter at 42 and 84 days after planting.

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Table 4. Average Stem Diameter at 42 and 84 DAP

| Treatment | Stem Diameter (mm) | | | |
|---|---|---|---|---|
| | 42 DAP | | 84 DAP | |
| K0 (0,0 ml/l) | 4.67 | b | 9.07 | c |
| K1 (1,0 ml/l) | 5.70 | c | 9.53 | c |
| K2 (1,5 ml/l) | **6.07** | **d** | **10.57** | **d** |
| K3 (2,0 ml/l) | 4.17 | a | 8.10 | b |
| K4 (2,5 ml/l) | 5.17 | b | 8.50 | b |
| K5 (3,0 ml/l) | 4.87 | b | 7.20 | a |
| K6 (3,5 ml/l) | 5.37 | c | 7.47 | a |
| K7 (4,0 ml/l) | 4.80 | b | 8.03 | b |
| K8 (4,5 ml/l) | 4.93 | b | 7.27 | a |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 4, at 42 DAP, K2 (1.5 ml/l) treatment showed the highest result of 6.07 mm, an increase of 29.98% compared to the control (K0). At 84 DAP, K2 (1.5 ml/l) treatment showed the highest result of 10.57 mm, an increase of 16.54% compared to the control (K0). A large stem diameter indicates how actively plant cells divide to form xylem and phloem tissue. This is due to the presence of nutrients and phytohormones that can stimulate its development. This is in line with Immanen et al. (2016) which shows that auxin and cytokinin can provide different but interrelated stimulation to cambium activity.

**Number of Leaves**

The analysis indicate that the application of biostimulants had a significant effect on the plants average number of leaves at 42 and 84 days after planting.

Table 5. Average Number of Leaves at 42 and 84 DAP

| Treatment | Number of Leaves | | | |
|---|---|---|---|---|
| | 42 DAP | | 84 DAP | |
| K0 (0,0 ml/l) | 6.67 | b | 23.67 | b |
| K1 (1,0 ml/l) | 7.00 | b | 23.67 | b |
| K2 (1,5 ml/l) | **8.33** | **d** | **44.00** | **d** |
| K3 (2,0 ml/l) | 6.00 | a | 18.67 | b |
| K4 (2,5 ml/l) | 6.67 | c | 23.67 | c |
| K5 (3,0 ml/l) | 6.33 | a | 11.67 | a |
| K6 (3,5 ml/l) | 7.67 | c | 16.00 | a |
| K7 (4,0 ml/l) | 7.00 | b | 18.67 | b |
| K8 (4,5 ml/l) | 6.33 | a | 19.00 | b |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 5, at 42 DAP, K2 (1.5 ml/l) treatment showed the highest yield of 8.33 leaves, an increase of 24.89% compared to the control (K0). At 84 DAP, K2 (1.5 ml/l) treatment

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showed the highest yield of 44 leaves, an increase of 94.09% compared to the control (K0). The number of leaves is a key indicator of photosynthesis rate in energy production for further growth. Leaf development is influenced by the application of a biostimulant containing extracts of *Ecklonia maxima*, which contains cytokinin, thereby inducing endogenous cytokinin synthesis in the treated plants (Wally et al., 2013). This is in line with Miceli et al. (2021) and Lefi et al. (2023) research which reported that the application of biostimulants containing *Ecklonia maxima* extract to lettuce and cucumber plants can increase endogenous cytokinin levels and increase the number of leaves. Several studies have shown that the *Ecklonia maxima* application through the leaves can increase growth and yield in plants such as lettuce and young spinach, as well as improving plant quality (Di Mola et al., 2019; Rouphael et al., 2018).

**Leaf Area (cm$^2$)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average leaf area at 42 and 84 days after planting.

Table 6. Average Leaf Area at 42 and 84 DAP

| Treatment | Leaf Area (cm$^2$) | | | |
|---|---|---|---|---|
| | 42 DAP | | 84 DAP | |
| K0 (0,0 ml/l) | 243.15 | b | 688.01 | b |
| K1 (1,0 ml/l) | 252.54 | b | 967.34 | c |
| K2 (1,5 ml/l) | **405.51** | **c** | **1238.35** | **d** |
| K3 (2,0 ml/l) | 219.47 | a | 713.85 | b |
| K4 (2,5 ml/l) | 287.02 | b | 712.39 | b |
| K5 (3,0 ml/l) | 198.82 | a | 470.22 | a |
| K6 (3,5 ml/l) | 256.33 | b | 572.74 | a |
| K7 (4,0 ml/l) | 223.57 | a | 787.84 | b |
| K8 (4,5 ml/l) | 234.90 | a | 590.00 | b |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 6, at 42 DAP, K2 (1.5 ml/l) treatment showed the highest result of 405.51 cm2, an increase of 66.77% compared to the control (K0). At 84 DAP, K2 (1.5 ml/l) treatment showed the highest result of 1238.35 cm2, an increase of 79.99% compared to the control (K0). Leaf area is a key indicator of a plant's efficiency in capturing more sunlight for photosynthesis. This indicates that the application of biostimulants from *Ecklonia maxima* seaweed extract at optimal concentrations can efficiently stimulate leaf growth, particularly in terms of leaf area. This is in line with Miceli et al. (2021) research which shows that the application of *Ecklonia maxima*


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extract can increase the number of leaves and photosynthetic efficiency through an increase in total chlorophyll content.

**Leaf Area Index**

The analysis indicate that the application of biostimulants had a significant effect on the plants average leaf area index at 42 and 84 days after planting.

Table 7. Average Leaf Area Index at 42 and 84 DAP

| Treatment | Leaf Area Index | | | |
|---|---|---|---|---|
| | 42 DAP | | 84 DAP | |
| K0 (0,0 ml/l) | 0.107 | b | 0.275 | b |
| K1 (1,0 ml/l) | 0.101 | b | 0.387 | c |
| K2 (1,5 ml/l) | **0.162** | **c** | **0.495** | **d** |
| K3 (2,0 ml/l) | 0.088 | a | 0.286 | b |
| K4 (2,5 ml/l) | 0.115 | b | 0.285 | b |
| K5 (3,0 ml/l) | 0.080 | a | 0.188 | a |
| K6 (3,5 ml/l) | 0.103 | b | 0.229 | a |
| K7 (4,0 ml/l) | 0.089 | a | 0.315 | b |
| K8 (4,5 ml/l) | 0.094 | a | 0.236 | a |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 7, at 42 DAP, K2 (1.5 ml/l) treatment showed the highest result of 0.162, an increase of 51.4% compared to the control (K0). At 84 DAP, K2 (1.5 ml/l) treatment showed the highest result of 0.495, an increase of 80% compared to the control (K0). The leaf area index value is an indicator of a plant's ability to utilise solar energy for photosynthesis. In this study, the application of the seaweed extract biostimulant *Ecklonia maxima* has the potential to increase the leaf area index, as the natural growth regulators such as auxin and cytokinin contained in the extract are capable of stimulating leaf formation and expansion (Moncada et al., 2022). The substances contained in the extract, particularly cytokinin, play a role in stimulating cell division, resulting in an increase in leaf area (Immanen et al., 2016; Wadas dan Dziugieł, 2020), as resulted in this study.

**Plant Dry Weight (g)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average dry weight at 42 and 84 days after planting.


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Table 8. Average Plant Dry Weight at 42 and 84 DAP

| Treatment | Plant Dry Weight (g) | | | |
|---|---|---|---|---|
| | 42 DAP | | 84 DAP | |
| K0 (0,0 ml/l) | 2.46 | a | 22.46 | b |
| K1 (1,0 ml/l) | 2.57 | b | 28.16 | c |
| K2 (1,5 ml/l) | **3.76** | **c** | **36.75** | **d** |
| K3 (2,0 ml/l) | 2.01 | a | 19.10 | b |
| K4 (2,5 ml/l) | 3.06 | b | 22.47 | b |
| K5 (3,0 ml/l) | 2.31 | a | 11.97 | a |
| K6 (3,5 ml/l) | 2.59 | b | 14.41 | a |
| K7 (4,0 ml/l) | 2.06 | a | 19.23 | b |
| K8 (4,5 ml/l) | 2.49 | b | 16.65 | b |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 8, at 42 DAP, K2 (1.5 ml/l) treatment showed the highest yield of 3.76 grams, an increase of 52.85% compared to the control (K0). At 84 DAP, K2 (1.5 ml/l) treatment showed the highest yield of 36.75 grams, an increase of 63.62% compared to the control (K0). Plant dry weight is an indicator of total plant growth from the accumulation of photosynthetic biomass, and is closely related to phytohormone activity in the plant body. Cytokinin plays a role in prolonging leaf life and increasing cell division, while auxin and gibberellin promote stem and root elongation. The interaction between hormones contained in the biostimulant/*Ecklonia maxima* can increase the efficiency of nutrient use and the allocation of photosynthates to all plant organs, resulting in an increase in total dry weight. This is in line with Miceli et al. (2021) research, which explains that the application of *Ecklonia maxima* extract in biostimulants can increase biomass productivity in horticultural crops through the optimisation of carbon and nitrogen metabolism. the study by Constantin et al. (2023) also showed an increase in plant dry weight and eggplant yield of more than 30% after the application of a biostimulant based on *Ecklonia maxima*. Thus, the increase in dry weight of plants in K2 indicates that the appropriate concentration of biostimulants can maximise the efficiency of photosynthesis, energy metabolism and overall vegetative growth of eggplants.

**Relative Growth Rate (g/day)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average relative growth rate at 42 until 84 days after planting.

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Table 9. Average Relative Growth Rate at 42 until 84 DAP

| Treatment | Relative Growth Rate 42 – 84 DAP | |
|---|---|---|
| K0 (0,0 ml/l) | 0.0487 | c |
| K1 (1,0 ml/l) | **0.0533** | **d** |
| K2 (1,5 ml/l) | **0.0492** | **d** |
| K3 (2,0 ml/l) | 0.0483 | c |
| K4 (2,5 ml/l) | 0.0423 | b |
| K5 (3,0 ml/l) | 0.0368 | a |
| K6 (3,5 ml/l) | 0.0412 | b |
| K7 (4,0 ml/l) | 0.0445 | b |
| K8 (4,5 ml/l) | 0.0456 | c |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 9, at 84 DAP, K1 (1.0 ml/l) and K2 (1.5 ml/l) treatments showed the highest results of 0.0533 g/day and 0.492 g/day, an increase of 1.03-9.45% compared to the control (K0). Relative growth rate is an indicator of plant growth through the measurement of mass increase per unit of biomass over time, and is a measure of efficient organic matter productivity. These findings are in line with the results of Miceli et al. (2021) research, which reported that the application of the biostimulant *Ecklonia maxima* can increase plant physiological efficiency through increased photosynthesis and nutrient absorption rates. Recent research also confirms that regular use of seaweed-based biostimulants can increase the relative growth rate of various horticultural crops without causing toxic effects (Constantin et al., 2023).

**Generative Phase (Yield)**

**Number of Fruits**

The analysis indicate that the application of biostimulants had a significant effect on the plants average number of fruits of each plant at 84 days after planting.

Table 10. Average Number of Fruits of Each Plant at 84 DAP

| Treatment | Number of Fruits | |
|---|---|---|
| K0 (0,0 ml/l) | 10.33 | c |
| K1 (1,0 ml/l) | **12.33** | **d** |
| K2 (1,5 ml/l) | **12.33** | **d** |
| K3 (2,0 ml/l) | 9.33 | b |
| K4 (2,5 ml/l) | 11.33 | c |
| K5 (3,0 ml/l) | 7.67 | a |
| K6 (3,5 ml/l) | 7.67 | a |
| K7 (4,0 ml/l) | **12.33** | **d** |
| K8 (4,5 ml/l) | 8.00 | a |


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Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 10, at 84 DAP, K1 (1.0 ml/l), K2 (1.5 ml/l), and K7 (4.0 ml/l) treatments showed the highest yield of 12.33 fruits, an increase of 19.36% compared to the control (K0). The number of fruits is an important indicator of productivity and yield, as well as the plant's response to environmental conditions. The increase in fruit number at low to medium concentrations suggests that the *Ecklonia maxima*-based biostimulant enhanced floral induction and fruit development through the activity of endogenous phytohormones, particularly cytokinins and auxins. This finding demonstrates that the application of biostimulants at optimal concentrations promotes floral initiation and improves fruit set success. These findings are consistent with those reported by Constantin et al. (2023), who demonstrated that the application of *Ecklonia maxima*-based (Kelpak) biostimulants to eggplant significantly increased fruit yield compared to the control treatment. Furthermore, Ali et al. (2021) stated that the natural cytokinin content in seaweed extracts plays a key role in promoting cell division and floral differentiation, thereby contributing to increased overall fruit yield. Therefore, despite the absence of statistically significant differences among treatments, the upward trend in fruit number observed under biostimulant application highlights its potential in enhancing the productivity of eggplant.

**Fruit Diameter (mm)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average fruit diameter of each plant at 84 days after planting.

Table 11. Average Fruit Diameter of Each Plant at 84 DAP

| Treatment | Fruit Diameter (mm) | |
|---|---|---|
| K0 (0,0 ml/l) | 45.97 | a |
| K1 (1,0 ml/l) | 49.10 | b |
| K2 (1,5 ml/l) | 47.40 | a |
| K3 (2,0 ml/l) | 46.25 | a |
| K4 (2,5 ml/l) | **62.55** | **c** |
| K5 (3,0 ml/l) | 49.33 | b |
| K6 (3,5 ml/l) | 49.53 | b |
| K7 (4,0 ml/l) | 49.30 | b |
| K8 (4,5 ml/l) | 45.16 | a |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 11, at 84 DAP, K4 (2.5 ml/l) treatment showed the highest result of 62.55 mm, an increase of 36.07% compared to the control (K0). Fruit diameter is an indicator of quality

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and fruit weight. A large fruit diameter indicates that the plant is able to thrive in certain environmental conditions. This finding suggests that K4 (2.5 ml/L) represents the optimal concentration for promoting fruit enlargement. At higher concentrations such as K5 to K8 showed a decline in fruit diameter. Miceli et al. (2021) reported that the application of *Ecklonia maxima* extract to lettuce plants enhanced fruit size through improved physiological performance and photosynthetic efficiency. Similarly, Rana et al. (2023) found that the application of seaweed extract to kiwi plants increased fruit diameter and quality by enhancing carbohydrate accumulation and maintaining hormonal balance during fruit development. Therefore, the increase in fruit diameter at specific biostimulant concentrations observed in the present study is likely associated with the stimulatory effects of natural cytokinins contained in *Ecklonia maxima*, which promote cell expansion and prolong the fruit-filling phase.

**Fruit Length (cm)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average fruit diameter of each plant at 84 days after planting.

Table 12. Average Fruit Length of Each Plant at 84 DAP

| Treatment | Fruit Length (mm) | |
|---|---|---|
| K0 (0,0 ml/l) | 21.68 | c |
| K1 (1,0 ml/l) | **23.19** | **f** |
| K2 (1,5 ml/l) | 20.44 | a |
| K3 (2,0 ml/l) | 22.38 | e |
| K4 (2,5 ml/l) | **23.88** | **f** |
| K5 (3,0 ml/l) | 20.87 | b |
| K6 (3,5 ml/l) | 21.95 | d |
| K7 (4,0 ml/l) | 21.63 | c |
| K8 (4,5 ml/l) | 20.56 | a |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 12, at 84 DAP, K1 (1.0 ml/l) and K4 (2.5 ml/l) treatments showed the highest results of 23.19 cm and 23.88 cm, an increase of 6.96-10.15% compared to the control (K0). Large fruit length is an indicator that the plants avoided drought stress and were able to survive extreme temperatures. This finding indicates that the cytokinin content in the *Ecklonia maxima* based biostimulant contributed to prolonging the cell division phase in fruit tissues, thereby enhancing fruit elongation. Furthermore, this pattern demonstrates that the application of biostimulants at optimal concentrations can stimulate physiological processes during the fruit


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development phase. These results are consistent with the findings of Kocira et al. (2018), who reported that the application of *Ecklonia maxima* extract (Kelpak SL product) increased tomato fruit size and weight by enhancing protein synthesis, chlorophyll content, and photosynthetic efficiency. In addition, in the study Ali et al. (2021) explains that cytokinin in seaweed extract plays a role in plant cell division and elongation, which contributes to an increase in the size of organs such as fruit. Thus, the increase in fruit length in the biostimulant treatment shows that *Ecklonia maxima* is able to support plant generative growth through optimal hormonal and physiological mechanisms.

**Fruit Weight (g)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average fruit weight of each plant at 84 days after planting.

Table 13. Average Fruit Weight of Each Plant at 84 DAP

| Treatment | Fruit Weight (g) | |
|---|---|---|
| K0 (0,0 ml/l) | 147.35 | a |
| K1 (1,0 ml/l) | **183.21** | **d** |
| K2 (1,5 ml/l) | 155.92 | b |
| K3 (2,0 ml/l) | 152.51 | b |
| K4 (2,5 ml/l) | **181.69** | **d** |
| K5 (3,0 ml/l) | 164.97 | c |
| K6 (3,5 ml/l) | 166.46 | c |
| K7 (4,0 ml/l) | 166.94 | c |
| K8 (4,5 ml/l) | 145.82 | a |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 13, at 84 DAP, K1 (1.0 ml/l) and K4 (2.5 ml/l) treatments showed the highest results of 183.21 g and 181.69 g, an increase of 23.31-24.34% compared to the control (K0). High fruit weight is an indicator of optimal biomass accumulation and photosynthetic yield, as well as plant resistance to certain environmental conditions. The increase in fruit weight at concentrations of 1.0–2.5 ml/l indicates that the application of the biostimulant *Ecklonia maxima* has a positive effect on fruit formation and filling. The cytokinin content in this extract plays a role in increasing the translocation of photosynthetic products to fruit organs and slowing down the tissue ageing process. The results of this study are in line with the findings reported by (Constantin et al., 2023). The study showed that the application of a biostimulant based on *Ecklonia maxima* (Kelpak product) can increase fruit weight and total eggplant yield by up to 32.37% compared to

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the control. These findings confirms that the natural cytokinin and auxin content in seaweed extract plays an important role in increasing protein synthesis and enzymatic activity that supports fruit biomass formation. The increase in average fruit weight was associated with nutrient absorption efficiency and increased photosynthesis rates, which resulted in more optimal carbohydrate translocation to generative organs. Based on the consistency of this research data with these results, it can be concluded that the biostimulant extract of *Ecklonia maxima* has real potential to increase the weight of eggplant yields.

**Yield Weight Per Plant (kg)**

The analysis indicate that the application of biostimulants had a significant effect on the plants average yield weight of each plant at 84 days after planting.

Table 14. Average Yield Weight of Each Plant at 84 DAP

| Treatment | Yield Weight (kg) | |
|---|---|---|
| K0 (0,0 ml/l) | 1.51 | b |
| K1 (1,0 ml/l) | **2.21** | **d** |
| K2 (1,5 ml/l) | 1.89 | c |
| K3 (2,0 ml/l) | 1.49 | b |
| K4 (2,5 ml/l) | **2.17** | **d** |
| K5 (3,0 ml/l) | 1.29 | a |
| K6 (3,5 ml/l) | 1.36 | a |
| K7 (4,0 ml/l) | **2.13** | **d** |
| K8 (4,5 ml/l) | 1.17 | a |

Note : Average values followed by the same letter in the same column are not significantly different based on Scott-Knott's cluster analyses at the 5% level.

Based on Table 14, at 84 DAP, K1 (1.0 ml/l), K4 (2.5 ml/l), and K7 (4.0 ml/l) treatments showed the highest yields of 2.21 kg, 2.17 kg, and 2.13 kg, an increase of 41.06-46.36% compared to the control (K0). Yield weight per plant indicates the efficiency of photosynthesis, biomass allocation, and the plant's ability to adapt to certain environmental conditions. This indicates that low to medium concentrations of biostimulants can improve overall crop yields. This can be explained by the role of natural cytokinins and auxins from *Ecklonia maxima* in improving photosynthetic efficiency, nutrient uptake, and fruit formation. In line with research by Constantin et al. (2023) and supported by Duri et al. (2025) emphasises that the application of seaweed biostimulants contributes to an increase in the total yield of eggplants through the optimisation of nutrient absorption and an increase in leaf chlorophyll content. The synergistic effect between natural hormones and increased carbon metabolism makes biostimulants effective in enhancing the


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fruit filling phase and increasing productivity. Thus, the optimal concentration of the biostimulant *Ecklonia maxima* in this study was found to support an increase in the yield of eggplants, particularly at concentrations of 1.0 ml/l, 2.5 ml/l and 4.0 ml/l.

## 4. CONCLUSION

Based on the results of the analysis, the research can be concluded as follows:The application of seaweed extract (*Ecklonia maxima*) had a significant effect on the growth and yield of purple eggplants.

The Scott-Knott's cluster analyses at the 5% level showed that concentrations of K1 (1.0 ml/l), K2 (1.5 ml/l), and K3 (2.0 ml/l) are optimal for the vegetative phase. Concentrations of K1 (1.0 ml/l), K2 (1.5 ml/l), K4 (2.5 ml/l), and K7 (4.0 ml/l) are optimal for the generative phase.

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Agricultural Science
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